Penerbit Akademia Baru

Journal of Advanced Review on Scientific Research
ISSN (online): 2289-7887 I Vol. 23, No.1. Pages 1-15, 2016

Greener Energy: Evaluating Wind Energy Potential in Pakistan

M. A. Khattak[*, 1,a] , *A. Mukhtar* [2,b] *and A. F. Rafique* [3,c]

[1]Department of Nuclear Engineering, Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310 Skudai Johor, Malaysia
[2]Faculty of Engineering & Technology, HITEC University, Taxila Pakistan
[3]Aeronautical Engineering Department, Faculty of Engineering, King Abdulaziz University Jeddah - 21589, Kingdom of Saudi Arabia
[a,*] *muhdadil@utm.my*, [b] *aniquemukhtar@hotmail.com*, [c]*afrafique@kau.edu.sa*

Abstract –*Energy is a necessary ingredient for socio-economic development and economic growth. Renewable energy sources like wind energy is indigenous and can help in reducing the dependency on fossil fuels. Wind is the indirect form of solar energy and is always being replenished by the sun. Wind is caused by differential heating of the earth's surface by the sun. It has been estimated that roughly 10 million MW of energy are continuously available in the earth's wind. Wind energy provides a variable and environmental friendly option. Energy is inevitable for human life and a secure and accessible supply of energy is crucial for the sustainability of modern societies. The country is facing severe energy crisis due to shortage of electricity and gas supply. About two-third of the total electricity is generated from fossil fuels. Pakistan heavily depends on imported energy due to limited indigenous reserves and production of oil. The production, transportation, transformation and consumption of fossil fuels also adversely affect the quality of the environment. This shows that Pakistan must develop alternate, indigenous and environment friendly energy resources, like wind energy, to face these challenges. This paper presents the market penetration forecasts of wind power in Pakistan under different policy scenarios. The survey concludes that the country's total technical potential of wind power generation could be exploited by the year 2030. The development and utilization of wind power would reduce the pressure on oil imports, protect the environment from pollution and improve the socio-economic conditions of the people of Pakistan.*

Keywords: Wind energy, Environment friendly, Pakistan, Survey, Energy security, Sustainable energy supply

1.0 INTRODUCTION

Energy policy is the manner and the country's strategy in which a given entity (often governmental) decides to address issues of energy development along with the development of the energy industry to sustain its growth including energy production, distribution and consumption. The attributes of energy policy may include legislation, international treaties, incentives to investment, the country's targeted energy generation, guidelines for energy conservation, strategies to stimulate the energy industry, taxation and other public policy techniques as well as the focus on new (usually renewable) energy sources. However, there are many countries that do not have specific policies on wind energy, which means that wind energy, if any, has not yet been explored as an alternative[1,2].

The use of dispersed energy assets is increasingly being pursued as a supplement and an alternative to large conventional central power stations[3]. In recent years, wind energy has become one of the most economical renewable energy technologies. Today, electricity

generating wind turbines employ proven and tested technology, and provide a secure and sustainable energy supply. At good, windy sites, wind energy can already successfully compete with conventional energy production. Many countries have considerable wind resources, which are still untapped.

A technology which offers remarkable advantages is not used to its full potential:

- Wind energy produces no greenhouse gases.
- Wind power plants can make a significant contribution to the regional electricity supply and to power supply diversification.
- A very short lead time for planning and construction is required as compared to conventional power projects.
- Wind energy projects are flexible with regard to an increasing energy demand - single turbines can easily be added to an existing park.
- Finally, wind energy projects can make use of local resources in terms of labor, capital and materials.

2.0 WIND ENERGY: OVERVIEW

The first commercial wind energy converters entered service back in the 1980s, although the wind energy boom as such did not begin until the mid-1990s, when the total installed wind generation capacity in the world was only 5,000 MW. Since then the installed capacity has increased at double-digit rates of annual growth. By the end of 2006 global installed capacity had reached 74,233 MW. Currently the industry is enjoying a boom with 239,000 MW installed globally as at 2011. Almost without exception, the installed systems are used to generate electricity. The largest market at present is still Europe, where some 48,545 MW (65%) is installed; of this, 22,000 MW is located in Germany (figures from end of 2006). Germany is also a leader among the system manufacturers. Four German companies are counted among the world's major manufacturers, and the German component industry supplies gearboxes, clutches and other assemblies to numerous producers in other countries.

Global wind power markets have been for the past several years dominated by three major markets: Europe, North America (US), and Asia (China and India). While these three markets still accounted for 86% of total installed capacity at the end of 2009, there are signs that this may be changing. Emerging markets in Latin America, Asia and Africa are reaching critical mass and we may be surprised to see one or more of them rise to challenge the three main markets in the coming years[4]. It remains a matter of dispute whether wind energy would still be competitive without promotional support, it is beyond doubt that the wind industry has made considerable progress. While in the early 1990s the cost of systems still averaged almost 1,300 EUR/kW, in the meantime specific investment costs have fallen to around 900 EUR/kW. The advantages of mass production have been further boosted by considerable increases in the efficiency of turbines (greater hub height, larger rotor diameter etc.), which have improved the economics of wind energy. There are now turbines on the market with a rated output of up to 6 MW, for example. This trend further illustrates that the growth market in the wind industry is mainly seen in electricity generation and grid feed-in. GWEC predicts that in 2013, five years

from now, global wind generating capacity will stand at 332 GW, up from 120 GW at the end of 2008. During 2013, 56.3 GW of wind generating capacity will be added, more than double the annual market in 2008. The year-on-year growth rates during this period will average 22%, which is modest compared to an average increase of 28% over the last ten years [5].

Graphical representation of worldwide wind energy capacity are shown in figure 1, 2 &3.

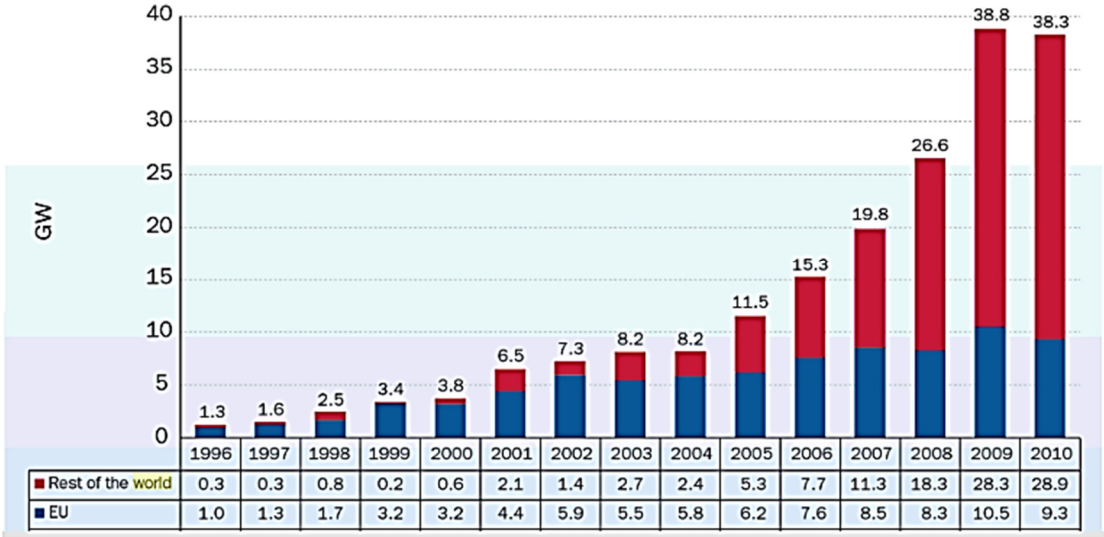

Figure 1 Global Wind Energy Capacity (1996-2010)[6].

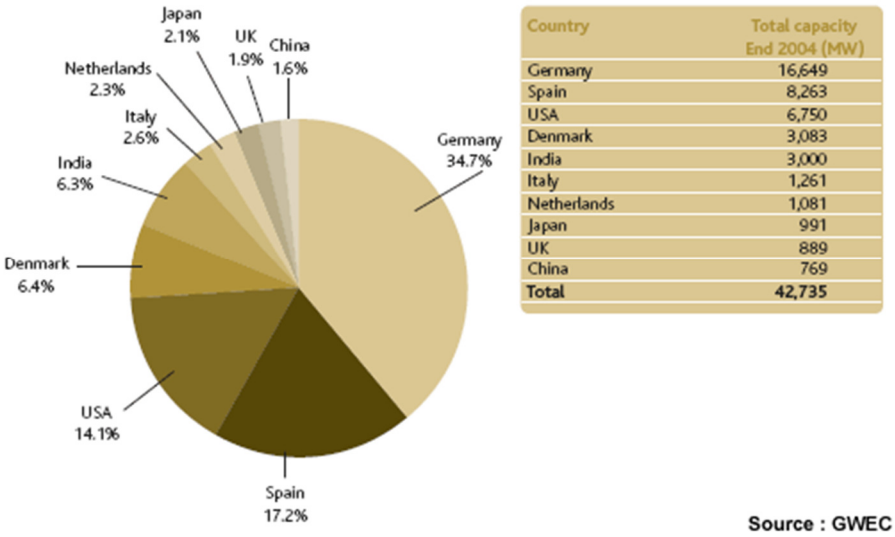

Figure 2 Top Ten Win Power Market 2004: Cumulative MW Installed [7]

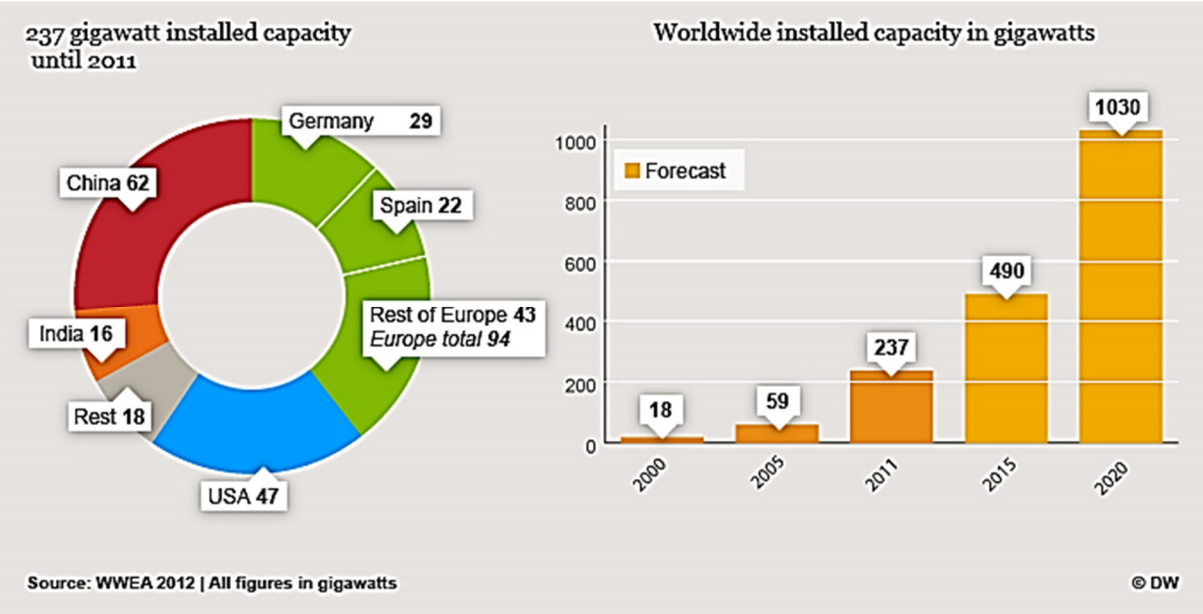

Figure 3 Wind Energy is Being Used Worldwide Source [8]

3.0 REGIONAL DEVELOPMENT IN ASIA

China became the largest wind power market measured by annual installations in 2009, and the largest cumulative installer of wind power capacity in the world in 2010. By 2010, total installed capacity exceeded 40,000 MW, and by 2020, it is estimated that about 200,000 MW of wind power capacity will need to be installed in order to meet China's target for non-fossil energy consumption.[9]

The wind turbine market in China has experienced exponential growth in the past few decades, and became the global market leader[10]. By the end of 2009, there were 70 Wind Turbine Manufacturers in the Chinese wind turbine market including 29 state-owned and state-holding enterprises, 23 private enterprises, 10 foreign-owned enterprises and 8 joint ventures[11].

In Iran utilization of wind energy is still in its initial stages of development. By 2009, Iran had wind power installed capacity of 91 MW[12]. Sixty eight sites to evaluate the most important characteristics of wind energy in the studied sites[12]. In Malaysia the utilization of wind energy sources is limited due to low average wind velocity in the whole country[13]. India now ranks 4th in the world after Germany, Spain and USA in wind power generation with an installed wind power capacity of 4434.5 MW[14]. In India, the wind power generation has gained a high level of attention and acceptability compared to other renewable energy technologies[15].

4.0 INTRODUCTION: WIND POWER IN PAKISTAN

About two-third of Pakistan's population lives in rural areas and majority of them have no access to natural gas and electricity. The per capita electricity consumption is only 460 kWh. Pakistanis are facing acute electricity shortage, which is continuously soaring and has crossed 6000 MW level, with the rise of mercury. People are forced to stay without electricity for more

than 12–14 h in cities and around 16 h in rural areas. Natural gas and oil has 32.3% and 35.3% share in total conventional power generation (91,616 GWh) in 2008–09 as shown in Fig. 4. In renewables, hydropower has 30.3% contribution in total conventional electricity generation in Pakistan[16,17].

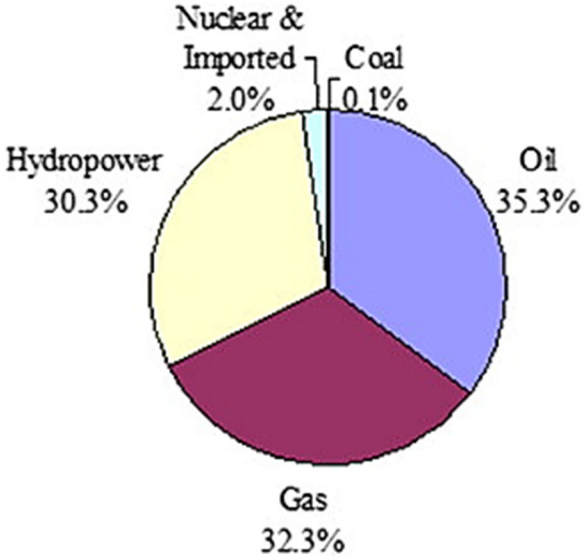

Figure 4 Conventional power generation in Pakistan[17]

According to Asian Development Bank and World Bank assessment, the recent floods in Pakistan inflicted $9.5 billion in damage to infrastructure, crops and property[17]. Conservative estimates presented in the World Bank report suggest that environmental degradation costs the country at least 6% of GDP per year. These environmental damage costs are not included in the price of electricity, but are paid for by people either directly or indirectly through taxes, health expenditures, insurance premiums, and through reduced quality of living[18,19]. Thus the country spends huge amount on the degradation of the environment which adversely affects every sector of the national economy. This shows that Pakistan must develop indigenous and environment friendly energy resources to meet its future energy needs in a sustainable way. Wind power is one of the alternatives which can meet the growing energy demand in Pakistan without degrading the environment.[20-22]. Using wind turbines is one of the cheapest option for reducing CO2 emissions from power generation.[23]

However, Wind power is a significant alternate source of energy in these times of energy crisis. Advances in wind turbine technology and identification of rich wind resources in many areas improve prospects for the wind power industry. This motivates researchers for the analysis and prediction of wind power generation [24-28] .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 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, 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) of independent power producers (IPPs) and captive generation by industry (over 1,500 MW),

which is based entirely on natural gas, furnace oil, or diesels. 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. Pakistan is basically an energy deficient country. Pakistan's per capita energy consumption, 3894 kWh as against the world average of 17620 kWh, gives it a ranking of 100 amongst the nations of the world[29].

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.

5.0 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 parts of the world.

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.

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 mph and 22 mph 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 (figure 5 & 6). Wind speed 5–7 m/s persists in coastal regions of Sindh and Balochistan provinces and in a number of North West frontier valleys[30]. According to a survey, Pakistan possesses more than 20,000 MW of economically viable wind power potential. But by the end of year 2003, not a single wind energy conversion system with a generating capacity above 500 W had been installed in the country.

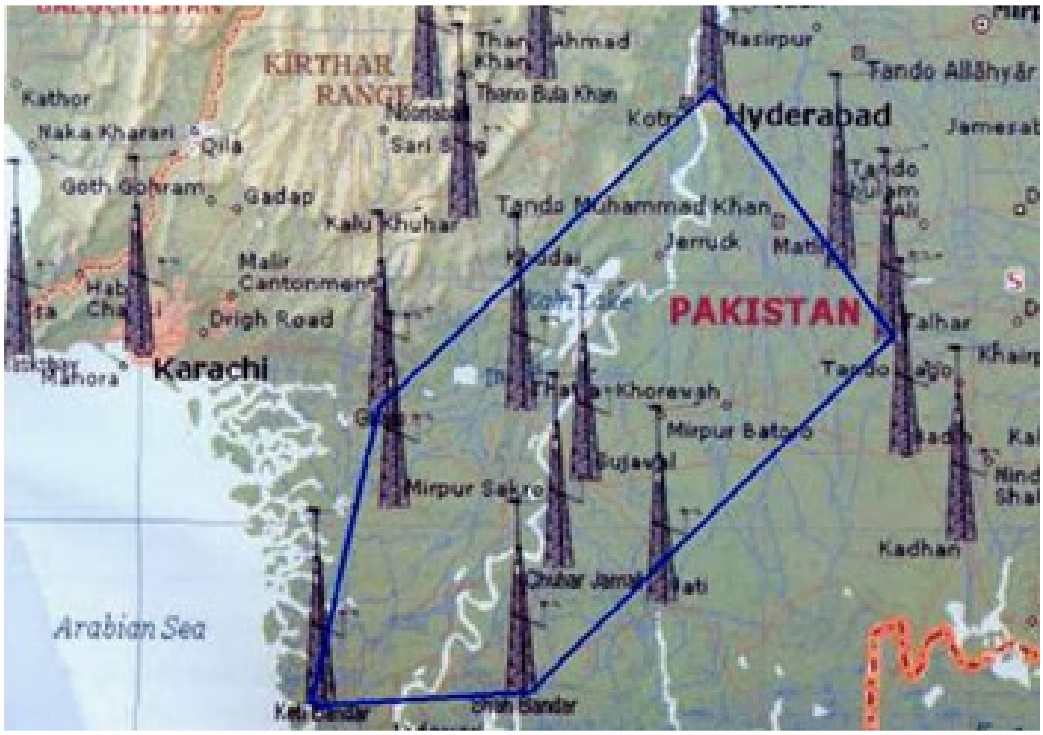

Figure 5 Wind Mills Assessment for Coastal Areas of Pakistan[31]

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.

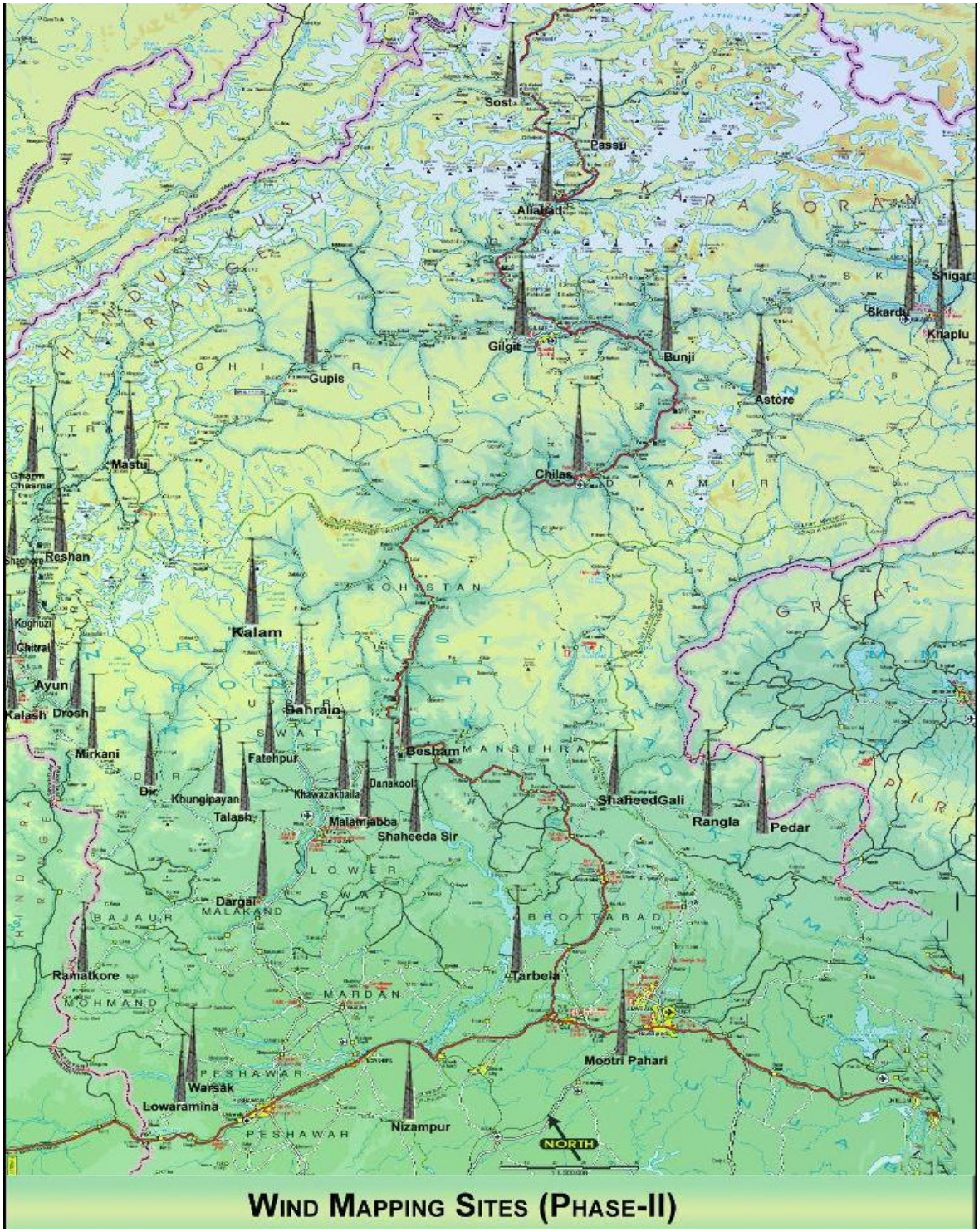

Figure 6 Pakistan Metrological Department Survey Report for Wind Mills of Northern Areas of Pakistan

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 8 below is available in the general area from Hyderabad to Kati Bandar having immense potential to generate electricity.

Pakistan's coastline extends 1050 km, 250 km falling in Sindh and 800 km in Balochistan. Pakistan Meteorological Department has measured and recorded the wind speed and direction at 45 locations in the coastal areas, under wind mapping project. Based on this data, wind power generation potential has been estimated using a reference wind turbine and wind duration curves and the results are presented in Figure 8. Most locations in the coastal area of Sindh and Balochistan have theoretical potential around 2000–3000 FLH (full load hours) and 1000–1500 FLH respectively. A 15 MW wind power plant would generate about 28–40 GWh and 12–20 GWh of electricity per year at different locations in the coastal belt of Sindh and Balochistan respectively [21,22,32]

Sindh	Power generation		Balochistan	Power generation	
	GWh	FLH		GWh	FLH
Jamshoro	1.89	3154	Ramra	0.40	669
Hyderabad	1.59	2643	Ormara	0.83	1375
Gharo	1.70	2827	Jiwani	0.75	1257
Ketibander	1.83	3044	Pasni	0.65	1090
Nooriabad	1.74	2895	Gawadar	0.63	1044
Shahbander	1.32	2192	Turbat	0.37	610
Mirpursakro	1.36	2267	Aghore	1.10	1835
Jati	1.37	2280	Basol	0.67	1110
Badin	1.06	1766	Gaddani	1.06	1758
Baghan	1.39	2309	Hoshab	0.66	1098
Chohar Jamali	1.35	2255	Hubchoki	0.91	1517
Golarchi	1.23	2048	Liari	0.99	1650
Kadhan	0.94	1561	Makola	0.53	885
Matli	1.34	2226	Managi	0.84	1400
Sajawal	1.32	2198	Mand	0.35	574
Talhar	1.51	2524	Nalent	0.36	592
Thano Bula Khan	1.31	2182	Othal	0.69	1142
Thatta	1.73	2886	Phore	0.77	1287
DHA Karachi	1.41	2358	Pishukan	0.59	987
Hawksbay	1.08	1798	Winder	0.77	1285

Figure 7 Theoretical potential of wind power in the coastal areas of Pakistan[21]

An evaluation of the wind resource available at Kati Bandar on the coast of Sindh [33], shows that it is a class 4 wind power site, indicating its suitability for both large and small wind power projects. During summer six months April–September, there are strong sustainable winds mostly from Southwest and during this high capacity factor of 32–50% could be achieved.

6.0 WIND DATA ANALYSIS

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.

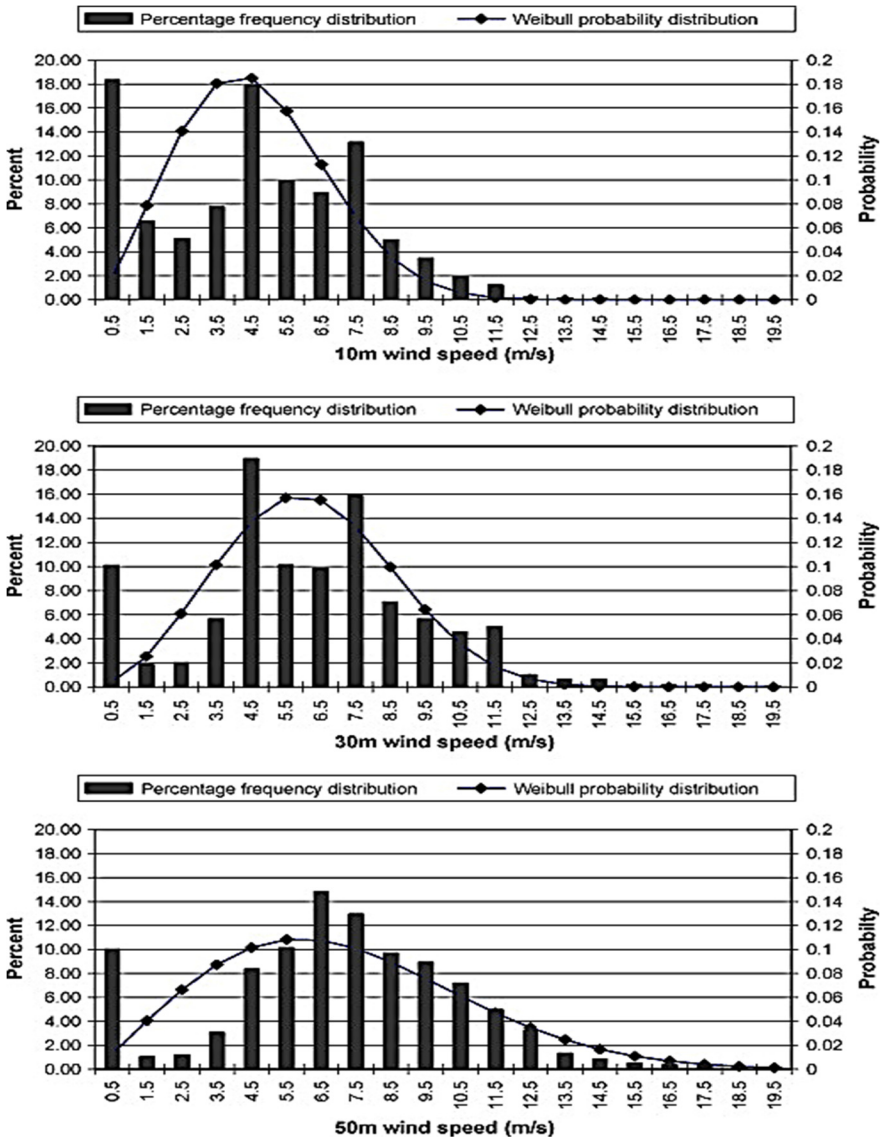

Figure 8 Weibull distributions of wind speeds for different heights at Kati Bandar over the year [33]

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.

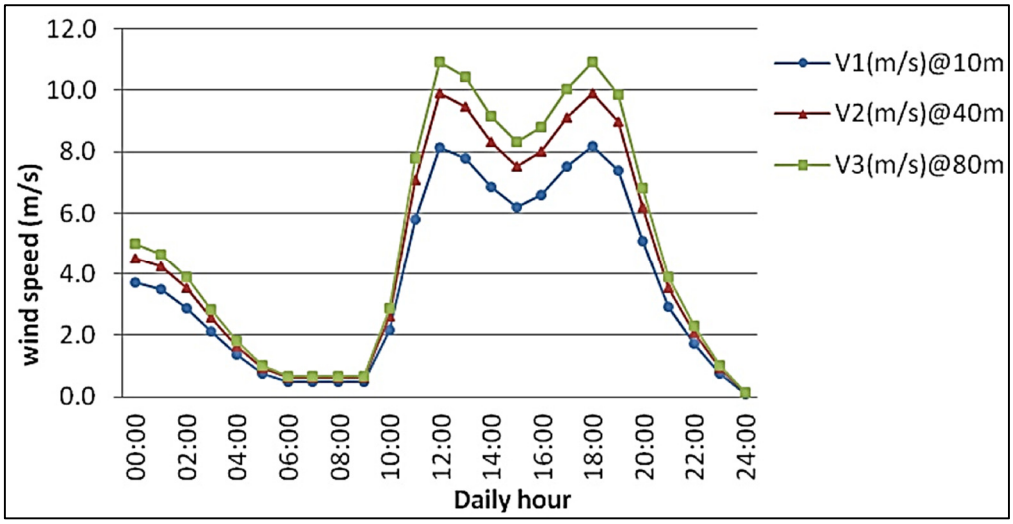

Figure 9 Pakistan Metrological Department Survey Report

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, installat ion 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 capacities 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.

7.0 JHIMPIR WIND ENERGY PROJECT (FFCEL)

Fauji Fertilizer Company Energy Limited is building 49.5 MW wind Energy Farm at Jhimpir near Karachi. Contract of supply of mechanical design was awarded to Nordex and Descon Engineering Limited. Nordex a German wind turbine manufacturer. In the end of 2011 49.6 MW will be completed. *Pakistani Govt.* also has issued LOI of 100 MW Wind power plant to FFCEL. Pakistani Govt. has plans to achieve electric power up to 2500 MW by the end of 2015 from wind energy to bring down energy shortage.

Figure 10 Jhimpur Wind Farm

Foundation Wind Energy I Limited and Foundation Wind Energy II (Private) Limited

Fauji Foundation is under process of achieving financial close for two wind projects (50MWs each) at Gharo, Thatta District. The EPC contractors are Nodded and Descon with Nordex as the lead contractor. Once the aforementioned projects reach financial close, these will have 15 months for being fully operational (i.e., dispatch of energy under EPA).

Year	Generation Plan (MW)	Cumulative Wind Energy capacity (MW)
2010	680	680
2011	200	880
2012	200	1 080
2013	150	1 230
2014	200	1 430
2015	250	1 680
2016	250	1 930
2017	400	2 330
2018	400	2 730
2019	500	3 230
2020	500	3 730
2021 – 2030	5 970	9 700

Figure 11 Projection for Wind Energy Development in Pakistan (Source: Alternative Energy Development Board 2009)

8.0 CONCLUSION

It is noticed that energy policy could help increasing wind power generation as well as stimulating the energy industry. It may be stated that without specific energy policy, a country would not be able to solve the acute problems like reducing greenhouse gases (GHGs) emission, scarcity of energy, etc. wind energy, which is a type of renewable energy, has the potential to be utilized for power generation. Power generated by wind energy is not just relatively simpler but is also much more environmental friendly compared to power generation using non-renewable sources like the fossil fuels and coals. Considering that energy usage worldwide has been increasing throughout the years, switching to wind energy can be a viable move.

From the study, it is obvious that almost all countries that utilize wind energy for power generation have policies specific to wind energy. Some of the success stories include wind energy utilization in USA, Canada, Denmark, Germany, Turkey, Australia, China, Japan, and South Korea.

The high dependency of the energy sector on fossil fuels in Pakistan, with the attendant high contribution to many environmental issues, urges the exploitation of clean, renewable and sustainable energy sources. There is considerable potential of wind power in Pakistan. Wind power is considered as one of the clean alternatives which could meet the growing energy demand of the country without degrading the environment. Wind power is the fastest growing renewable energy sector in the world but Pakistan has been slow in exploiting its vast wind power resource.

REFERENCES

[1] Birol, Fatih. "World energy outlook." Paris: International Energy Agency (2008).

[2] Saidur, R., M. R. Islam, N. A. Rahim, and K. H. Solangi. "A review on global wind energy policy." Renewable and Sustainable Energy Reviews 14, no. 7 (2010): 1744-1762.

[3] Carrasco, Juan Manuel, Leopoldo Garcia Franquelo, Jan T. Bialasiewicz, Eduardo Galván, Ramón C. Portillo Guisado, Ma Ángeles Martín Prats, José Ignacio León, and Narciso Moreno-Alfonso. "Power-electronic systems for the grid integration of renewable energy sources: A survey." Industrial Electronics, IEEE Transactions on 53, no. 4 (2006): 1002-1016.

[4] Council, Global Wind Energy. "Global wind energy outlook 2012." GWEC, November (2012).

[5] Council, Global Wind Energy. "Global wind 2008 report." Global Wind Energy Council, Brussels, Belgium, and Greenpeace, Amsterdam, The Netherlands (2009).

[6] European Wind Energy Association. Pure power-wind energy targets for 2020 and 2030. Ewea, 2011.

[7] Global Wind... Report. Global Wind Energy Council, 2005.

[8] Zhang, Peter. Small Wind World Report 2012. WWEA; CWEA, 2012.

[9] Wang, Zhongying, Haiyan Qin, and Joanna I. Lewis. "China's wind power industry: policy support, technological achievements, and emerging challenges." Energy Policy 51 (2012): 80-88.

[10] Ru, Peng, Qiang Zhi, Fang Zhang, Xiaotian Zhong, Jianqiang Li, and Jun Su. "Behind the development of technology: The transition of innovation modes in China's wind turbine manufacturing industry." Energy Policy 43 (2012): 58-69.

[11] Zhao, Zhen-yu, Guang-zheng Sun, Jian Zuo, and George Zillante. "The impact of international forces on the Chinese wind power industry." Renewable and Sustainable Energy Reviews 24 (2013): 131-141.

[12] Alamdari, P., O. Nematollahi, and M. Mirhosseini. "Assessment of wind energy in Iran: A review." Renewable and Sustainable Energy Reviews 16, no. 1 (2012): 836-860.

[13] Ali, Rosnazri, Ismail Daut, and Soib Taib. "A review on existing and future energy sources for electrical power generation in Malaysia." Renewable and Sustainable Energy Reviews 16, no. 6 (2012): 4047-4055.

[14] Mabel, M. Carolin, and E. Fernandez. "Analysis of wind power generation and prediction using ANN: a case study." Renewable Energy 33, no. 5 (2008): 986-992.

[15] Mabel, M. Carolin, and E. Fernandez. "Growth and future trends of wind energy in India." Renewable and Sustainable Energy Reviews 12, no. 6 (2008): 1745-1757.

[16] Uqaili, Mohammad Aslam, Khanji Harijan, and Mujeebuddin Memon. "Prospects of renewable energy for meeting growing electricity demand in Pakistan." In Renewable Energy for Sustainable Development in the Asia Pacific Region, vol. 941, no. 1, pp. 53-61. AIP Publishing, 2007.

[17] Harijan, Khanji, Mohammad A. Uqaili, Mujeebuddin Memon, and Umar K. Mirza. "Forecasting the diffusion of wind power in Pakistan." Energy 36, no. 10 (2011): 6068-6073.

[18] Nguyen, Khanh Q. "Internalizing externalities into capacity expansion planning: The case of electricity in Vietnam." Energy 33, no. 5 (2008): 740-746.

[19] Barbir, F., T. N. Veziroğlu, and H. J. Plass. "Environmental damage due to fossil fuels use." International journal of hydrogen energy 15, no. 10 (1990): 739-749.

[20] Harijan, Khanji, Muhammad Aslam Uqaili, and Mujeebuddin Memon. "Renewable energy for managing energy crisis in Pakistan." In Wireless Networks, Information Processing and Systems, pp. 449-455. Springer Berlin Heidelberg, 2008.

[21] Harijan, Khanji, Mohammad A. Uqaili, Mujeebuddin Memon, and Umar K. Mirza. "Assessment of centralized grid connected wind power cost in coastal area of Pakistan." Renewable Energy 34, no. 2 (2009): 369-373.

[22] Harijan, K., M. A. Uqaili, M. D. Memon, and U. K. Mirza. "Potential of centralized gridconnected wind power in coastal area of Sindh, Pakistan." In Proceedings of the World renewable energy congress-IX, vol. 19, p. 25. 2006.

[23] Ilkan, M., E. Erdil, and F. Egelioglu. "Renewable energy resources as an alternative to modify the load curve in Northern Cyprus." Energy 30, no. 5 (2005): 555-572.

[24] Vogiatzis, N., K. Kotti, S. Spanomitsios, and M. Stoukides. "Analysis of wind potential and characteristics in North Aegean, Greece." Renewable energy 29, no. 7 (2004): 1193-1208.

[25] Hepbasli, Arif, and Onder Ozgener. "A review on the development of wind energy in Turkey." Renewable and Sustainable Energy Reviews 8, no. 3 (2004): 257-276.

[26] Shata, AS Ahmed, and R. Hanitsch. "Evaluation of wind energy potential and electricity generation on the coast of Mediterranean Sea in Egypt." Renewable Energy 31, no. 8 (2006): 1183-1202.

[27] Li, Shuhui, Donald C. Wunsch, Edgar A. O'Hair, and Michael G. Giesselmann. "Using neural networks to estimate wind turbine power generation." Energy conversion, ieee transactions on 16, no. 3 (2001): 276-282.

[28] Kariniotakis, G., Stavrakakis, G., and Nogaret, E., "Wind power forecasting using advanced neural networks models "Energy conversion, ieee transactions on, **11**,(1996): 762-767.

[29] Kariniotakis, G. N., G. S. Stavrakakis, and E. F. Nogaret. "Wind power forecasting using advanced neural networks models." Energy conversion, ieee transactions on 11, no. 4 (1996): 762-767.

[30] Sheikh, Munawar A. "Energy and renewable energy scenario of Pakistan." Renewable and Sustainable Energy Reviews 14, no. 1 (2010): 354-363.

[31] Elliott, Dennis. "Wind resource assessment and mapping for Afghanistan and Pakistan." National Renewable Energy Laboratory. Golden, Color, USA (2011).

[32] Harijan, Khanji, Mohammad A. Uqaili, Mujeebuddin Memon, and Umar K. Mirza. "Potential of on-shore wind power in the Coastal Areas of Balochistan, Pakistan." Wind Engineering 34, no. 2 (2010): 167-179.

[33] Ullah, Irfan, and Andrew J. Chipperfield. "An evaluation of wind energy potential at Kati Bandar, Pakistan." Renewable and Sustainable Energy Reviews 14, no. 2 (2010): 856-861.