Wind Energy - The Worlds Fastest Growing Renewable Energy Resource- An Overview.

Md. Moyeed Abrar

Abstract— Energy is a major input for overall socio-economic development of any society. Wind energy is the fastest growing renewable energy resource. As the most mature and presently the most cost effective renewable energy source, wind energy is generally recognized as a key solution in the fight against climatic change and the desire to free society from its dependence on fossil fuels. Wind technology has improved significantly over the past two decade, and wind energy has become increasingly competative with other power generation options. Of all renewable energy sources wind power occupies a unique place due to the combination of two attributes: technological preparedness and the fact that is inherently site specific. The wind direction is found using a Wind vane and the wind speed is measured using a Wind guage or Anemometer. In this paper a general overview is presented on the importance of wind energy in power generation. The paper also focuses on the production of wind power using the related technology-wind turbines and discusses the role of wind energy as a key renewable source in India.

Index Terms— Anemometer, Power generation, Renewable energy resource, Wind energy, wind turbine, Wind vane, role of wind energy as a key renewable source in India.

1 INTRODUCTION

WIND is air on the move. Each air molecule has kinetic energy because it is moving. The energy of the wind is the combined kinetic energy of all the molecules. Wind is caused by the uneven heating of the earth's surface by radiant energy from the sun. Since the earth's surface is made of very different types of land and water, it absorbs the sun's energy at different rates. Water usually does not heat or cool as quickly as land because of its physical properties. An ideal situation for the formation of local wind is an area where land and water meet. During the day, the air above the land heats up more quickly than the air above water. The warm air over the land expands, becomes less dense and rises. The heavier, denser, cool air over the water flows in to take its place, creating wind. In the same way, the atmospheric winds that circle the earth are created because the land near the equater is heated more by the sun than land near the north and south poles.

Wind is called a free renewable source of energy because the wind will blow as long as the sun shines. At present wind power is not only the cheapest renewable energy technology, but also the only one ready now for large scale deployment[1]. Technologies such as large scale solar power, geothermal, wave and tidal energy are very promising, but are not ready for mass deployment.

The direction of the wind is found using a weather vane or wind vane. A wind vane points towards the direction of the wind. A wind vane is shown in fig 1. The wind direction is the direction from which the wind blows, not the direction towards which the wind moves. A south wind blows from the south towards the north. Similarly, the north wind blows from the north towards the south.

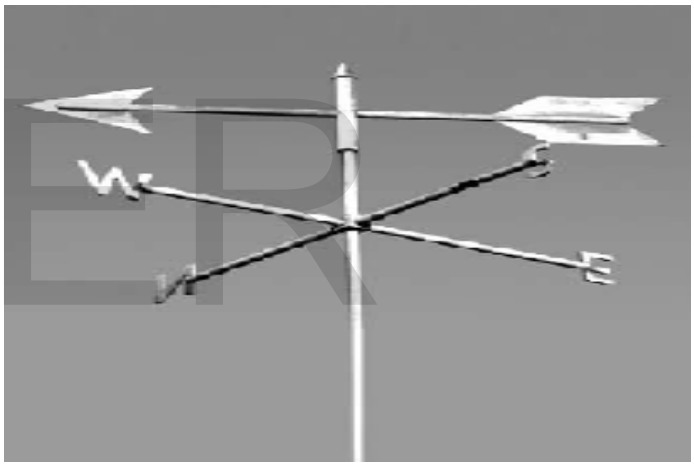

Fig. 1. A Wind vane.

The speed of the wind is measured using a device called wind guage or anemometer as shown in fig.2.The anemometer has three arms that spin on top of a shaft. Each arm has a cup on its end. The cups catch the wind and spin the shaft. The harder the wind blows, the faster the shaft spins. A device inside counts the number of rotations per minute and converts that figure into miles per hour. A display on the anemometer shows the speed of the wind.

Wind energy investment is growing rapidly because governments have set clean energy targets and it is set to become an important supplier of electricity in India and worldwide.[2],[3].

Wind power is not an all encompassing solution able to replace all other forms of electricity generation. However it will play a significant role in the nation's policy towards helping divert the worst effects of anthropogenic (human induced) climate change and for ensuring energy security in future decades [1],[2],[3].

- *Md. Moyeed Abrar, M-tech Scholar Digital electronics, Visvesvaraya technological University, Karnataka India, PH. No +91-9738335322. Email:moyeed.abrar@gmail.com.*

Fig. 2. Wind guage/Anemometer.

The rest of the paper is organized as follows: section 2 describes the production of wind power using wind turbines. Section 3 focusses on the current state of wind power in India. Section 4 includes the advantages and disadvantages of wind energy. Section 5 summarizes the paper and presents the concluding remark with scope for future work.

2 PRODUCTION OF ELECTRICITY USING WIND TURBINES.

Electricity is produced using wind energy through wind turbines. A wind farm will contain many identical wind turbines. Wind turbines use blades to capture the winds kinetic energy.When the wind flows through the blades of a turbine, they rotate and spin, powering a rotor inside a generator and producing electricity.

2.1 Wind Turbine- Construction and Working

Wind turbines are the systems that harness the kinetic energy of the wind for useful power. Most wind turbines comprises of the following key parts: foundation, tower, nacelle, blades, shafts, gears, generator and a cable. This is shown in figure 3. These parts work together to convert the winds energy into electricity.

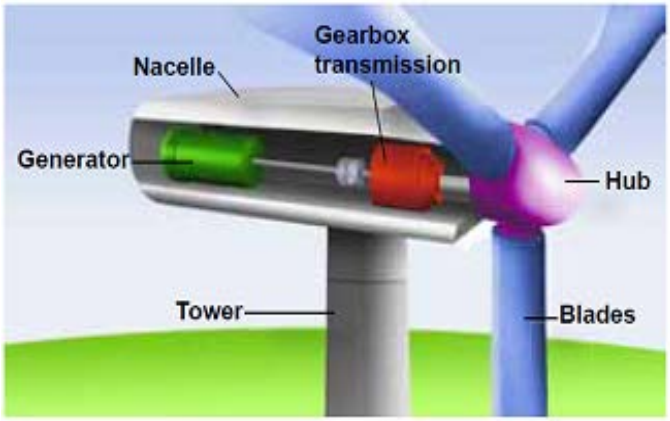

Fig. 3. A Wind turbine.

The foundation holds the turbine in a place in the ground. A wind turbine has to have a strong foundation to handle strong winds and to support the overall height and length of the blades. Generation equipment is kept in the tower. The tower raises the blades and generation equipments high above the ground into the smoother, stronger wind currents. Access to the nacelle and rotor is through the tower. The nacelle is the heart of the turbine, where the generator, gearbox and the rotor are held. The generator inside the nacelle is use to convert the wind energy into electrical energy. Most wind turbines have three blades that are attached to the rotor. The longer the blades and faster the wind speed, the higher the possible output power.

The wind blows and pushes against the blades on top of the tower making them spin. The turbine blades are connected to a low speed drive shaft. When the blades spin, the shaft turns. The shaft is connected to a gearbox. The gears in the gearbox increase the speed of the spinning motion on a high speed drive shaft. The high speed drive shaft is connected to a generator. As the shaft turns inside the generator, it produces electricity. The electricity is sent through a cable down the turbine tower to a transmission line as illustrated in fig.4.

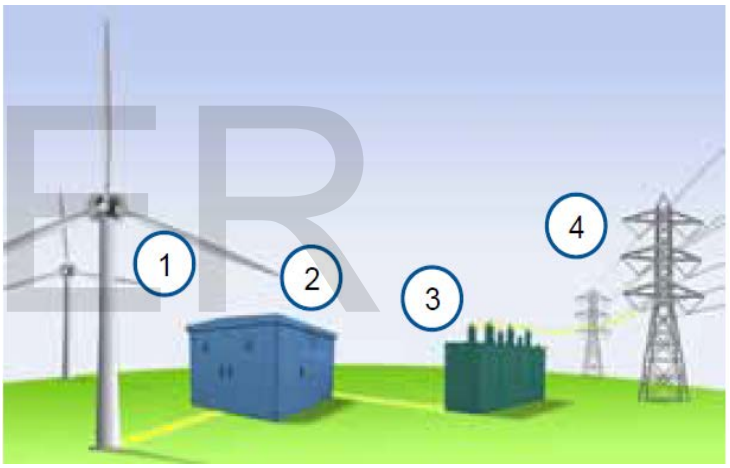

Fig. 4. Wind turbines transferring power to Electricity grid.

1= Rotating generator converts wind energy to electricity.
2= Transformer increases voltage for transmission to subs tation.
3=Substation increases voltage for transmission over long distances.
4= Transmission to the grid.

The amount of electricity that a turbine produces depends on its size and speed of the wind. There are different sizes of wind turbines. A small turbine can provide power to one home where as large wind turbines produce enough electricity to power upto 800 to 1000 homes. Large wind turbines are sometimes grouped together to provide power to the electricity grid. The grid is the network of power lines connected together across the entire country.

2.2 Wind Power plants

Wind power plants or wind farms, are clusters of wind turbines used to produce electricity. A wind farm usually has number of wind turbines scattered over a large area as shown in fig. 5. Choosing the location of a wind farm is known as siting a wind farm. The wind speed and direction must be studied to determine where to put the turbines. Practically, the wind speed increases with height, as well as over open areas with no wind breaks [5].

Turbines are usually built in rows facing into the prevailing wind. The space is wasted if the turbines are placed too far apart. If the turbines are too close together, they block each others wind. Before choosing a site for wind farm, it is neccessary to measure the winds in an area for a large period of time. The site must have strong, steady winds [15]. The best sites for

Fig. 5. A wind farm.

Wind farms are on hill tops, on the open plains, through mountain passes and near the coasts of oceans and lakes.

The wind blows stronger and steadier over water than over land. There are no obstacles on the water to block the wind. There is a lot of wind energy available offshore. Offshore wind farms are built in the shallow waters off the coast off major lakes and oceans. Off shore turbines produce more electricity than turbines on land but they are costly to built and operate.

3 WIND ENERGY IN INDIA

India is the fifth largest annual wind power market in the world and provides great business opportunities for both domestic and foreign investors. India is competing with the leading producers of wind power in the World as can be seen from the wind generation capacity in fig.6.

The Indian wind power sector experienced record annual growth in 2011 with the addition of more than 3 Giga watts of new installations to reach a total of 16,084 MW. Diverse incentives supported by a long term policy and regulatory framework at the central and state levels have played a crucial role in achieving this goal. Wind power is now increasingly accepted as a major complementary energy source for securing a sustainable and clean energy future for India [6].

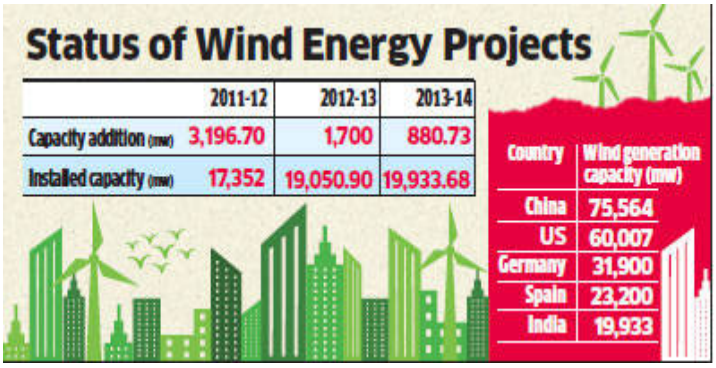

Fig. 6. India ranking fifth in annual wind power market.

In 2012 despite a slowing global economy, India's electricity demand continued to rise. Electricity shortages are common, and over 40% of the population has no access to modern energy services. As of march 2012, renewable energy accounted for 12.2% of total installed capacity, up from 2% in 1995. Wind power accounts for about 70% of this installed capacity. By the end of august 2012, wind power installations in India had reached 17.9GW. This is due to the rise in growth of wind farms as shown in fig. 7.

Fig. 7. Wind farms increasing at a rapid rate in India

The gaph shown in fig. 8 shows the year wise installation of wind energy in India since 2006 till 2013.

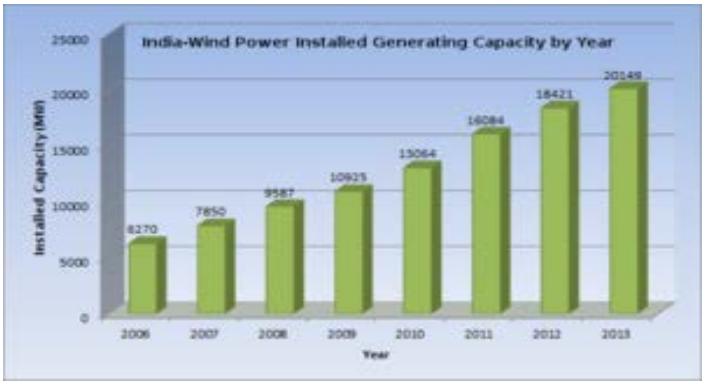

Fig. 8. Growth of wind energy sector in India

Historically, wind energy has met and often exceeded the targets set for it under both the 10th five year plan (2002-2007)

and the 11th five year plan (2007-2012) periods. During the 10th plan period the target set was of 1,500 MW whereas the actual installations were 5,427 MW. Similarly during the 11th plan period the revised target was for 9,000 MW and the actual installations were much higher at 10,260 MW. The report of the subgroup for wind power development appointed by the Ministry of New and Renewable Energy (MNRE) to develop for the 12th plan period (April 2012 to March 2017) fixed a reference target of 15,000 MW in new capacity additions, and an aspirational target of 25,000 MW. Therefore in India, there is a significant untapped potential for wind power, as a result of which many wind farms are coming into existence [6].The state of Tamil Nadu is leading in growth of wind farms as is evident from the wind farm of Kayathar as shown in fig. 9

Fig. 9. Wind farm Kayathar in Tamil Nadu state.

3.1 Current Status of Wind energy in India

The states of Tamil Nadu, Maharashtra, Karnataka and Gujrat have been the leaders in terms of total wind installations in India. The states of Rajasthan, Madhya Pradesh, and Kerala are quickly catching up. By the end of 11th plan period in March 2012, the total installed capacity had reached a total of 17,351.6 MW [13].The fig.10 gives an updated wind status of different locations in India from Indian wind atlas. An important aim of wind atlas is to give suitable data of wind power for determining the potential sites for large electricity production after the wind turbine installations. The wind atlas has been prepared with the help of national laboratory for sustainable energy.

Interestingly, more than 95% of the nation's wind energy development to date is concentrated in just five states in Southern and Western India- Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra and Gujrat. These five states accounted over 85% of the total installed capacity at the end of the last plan period. The windfarm of Kapatgudda in Karnataka state and the windfarm of Dhule in Maharashtra state are shown in fig.11 and fig. 12 respectively. Rajasthan is another emerging state with rising wind turbine installations as shown in fig. 13.

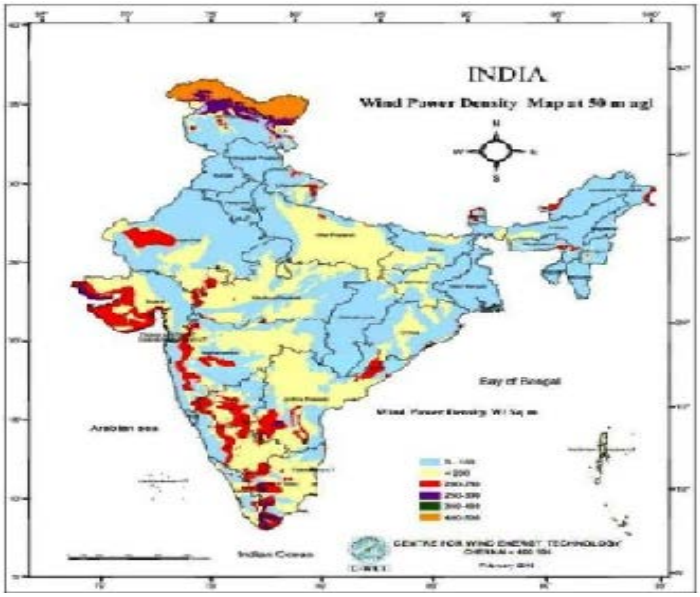

Fig. 10. Wind power density map not to scale from Indian Wind atlas.

Fig. 11. Wind farm in Kapatgudda, Karnataka.

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Fig. 12. Wind farm in Dhule, Maharashtra

Fig. 13. Rajasthan's rising wind turbine installations.

Fig. 14. Off shore wind turbines in Dhanushkodl of Tamil Nadu state.

As of 31st December 2013 the installed capacity of wind power in India was 20,149 MW. The state level wind power is shown in table 1.

TABLE 1
STATE LEVEL WIND POWER

Sl. No	State	Capacity in MW (as on 31-12 -2013)
1.	Tamil Nadu	7154
2.	Gujarat	3,093
3.	Maharashtra	2976
4.	Karnataka	2113
5.	Rajasthan	2355
6.	Madhya Pradesh	386
7.	Andhra Pradesh	435
8.	Kerala	35.1
9.	Orissa	02
10.	West Bengal	1.1
11.	Other states	3.20
TOTAL= 20,149 MW		

3.2 Off shore Wind Power Development in India.

India has a long coastline of over 7500 kilometers. In April 2012 the Ministry of New and Renewable energy (MNRE), constituted an offshore wind energy steering committee under the chairmanship of the secretary, MN RE, to drive offshore wind power development in India in a planned manner.

The government is looking to prepare a time bound action plan for the development of offshore wind energy, especially in the coastal states of Tamil Nadu, Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Kerala, Odisha and West Bengal. A policy and guidelines for offshore wind are likely to be announced by the MNRE in the near future. [13]

The state of Tamil Nadu is likely to take a lead in harnessing its offshore wind resources and is in the process of installing a 100metre mast for wind measurements in Dhanushkodl.

According to the Centre for wind energy technology C-WET, as per the preliminary assessment conducted by the Scottish Development International (SCI), Tamil Nadu has a Potential of about 1GW in the north of Rameswaram and another 1 GW in the south of Kanyakumari. SCI under the guidance of CWET conducted a detailed survey of the region to assess various parameters required for installing offshore wind farms [5].The technical feasibility study looked at offshore wind energy potential in favourable areas in the southern peninsula and Kutch region in Gujarat.

Fig. 15. Offshore wind farm in Kutch region, Gujarat.

3.3 India Growth Scenarios for 2020 and 2030.

Under the International Energy Agency (IEA) new policies scenario, India's wind power market would shrink considerably from the current annual additions of around 3,000 MW to only 1,900 MW per year by 2020. The result would be a total installed capacity of 32 GW by 2020 and 66 GW by 2030. Wind power would then produce close to 81 TWh every year by 2020 and 174 TWh by 2030, and save 48 million tons of carbon di oxide (co_2) in 2020 and 105 million tons in 2030. Investment in Wind power in India would also drop from the current levels of € 3.7 billion per year to only € 2.4 billion by 2020[7],[13].

According to the Advanced Global Wind Energy Outlook (GWEO) scenarios, the wind development in India could go

much further. By 2020 India could have almost 89 GW of wind power in operation, supplying 219 TWh of electricity each year, while employing over 179,000 people in the sector and saving almost 131million tones of co_2 emissions each year. Investment by then would have reached a level of €13 billion per year.

With the acute need for electrification and higher energy production in the Country, wind energy is going to provide an increasingly significant share of the renewables based capacity, thereby raising its standard a big deal[3],[4],[7].

4. ADVANTAGES AND DISADVANTAGES OF WIND ENERGY.

4.1 Advantages of Wind energy

1) Wind energy is a renewable resource, so it will never run out.
2) The wind is free and with modern technology it can be captured more efficiently.
3) Wind power is produced with the help of wind generators normally known as wind turbines. Once the wind turbine is built, the energy it produces does not cause green house gases or heat emissions or other pollutants.
4) Once a wind farm is constructed, the land can still be used for other purposes, such as farming or agriculture. Many people find wind farms an interesting feature of landscape.
5) Remote areas that are not connected to electricity power grid can use wind turbines to produce their own supply.

4.2 Disadvantages of Wind energy

1) The major drawback for wind power is that it is not available as a smooth, reliable and uninterrupted supply, i.e. it is intermittent.
2) The strength of wind is not constant and it varies from zero to storm force. This means that wind turbines do not produce the same amount of electricity all the time. There will be times when they produce no electricity at all.
3) Most of the people notice that the wind turbines are not pleasant or interesting to look at and are unsightly structures. They disfigure the countryside and are generally ugly.
4) Many of the countrymen feel that the countryside should be left untouched without the large wind turbine structures being built.
5) Wind turbines are noisy. These can generate the same level of noise as that of a car travelling at 80 mph.

5 CONCLUSION AND SCOPE FOR FUTURE WORK.

All electricity generation systems require some amount of energy for their manufacture, construction and operation. It is important to consider how this energy requirement compares with the expected energy output of the system over its lifetime. If the former is almost on a par with the latter, the system is clearly not a sustainable choice, environmentally or economically. In terms of energy payback wind power do compare favourably with other power generation systems.

The following areas may be considered as scope for future work.

- Grid interactive renewable production systems.
- Awareness about the use of low power wind turbine for home electricity supply.
- Cost effective measures to overcome voltage fluctuation problems from wind generation stations and to improve the sensitivity of wind turbine for generating power at very low wind speed.
- Furthermore, there is significant potential for technological development in wind energy- particularly relative to other, more mature systems-which could further improve the cost effectiveness and performance of installations.
- However, for India to reach its potential and to boost the necessary investment in renewable energy it will be essential to introduce comprehensive, stable and long term support policies, carefully design to ensure that they operate in harmony with existing state level mechanisms so as to avoid reducing their effectiveness.
- Scope for research and development in the area of wind technology has also been identified for future work.

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REFERENCES

[1] L.Gertmar, L.Liljestrand and H. Lendenmann. "Wind energy powers that can be successor generation in Globalization", IEEE transactions on energy conversion, 2007.

[2] Shi, L.B; Grad.Sch. at Shenzhen, Tsinghua university, Shenzhen, China; Wang, C.; Yao, L.Z; Wang, L.M." *Optimal power flow with consideration of wind generation cost*".Power system technology (POWERCON), 2010 International conference, Hangzhou.

[3] N. Golait, R.M. Moharil and P.S. Kulkarni, "Wind electric power in the World and perspectives of its development in India". Renewable and Sustainable Energy Reviews, pp. 233-247, 2009.

[4] Bhadra S.N., K.D, "Wind Electrical systems", Oxford University press, 2010, India.
[5] Dr. S Gomathinayagam, a report on "Powering the Windy Sites", Centre for Wind Energy Technology, Chennai.
[6] A report on "Strategic plan for new and renewable energy sector for the period 2011-17", published in 2011 by ministry of new and renewable energy, govt. of India.
[7] Indian wind energy association (IWEA).
[8] Singh, S.N., Dept. of Electrical Eng., IIT Kanpur, India; Singh, B.; Ostergaard, J."Renewable energy generation in India: Present scenario and Future prospects". Power and Energy society general meeting 2009. PES'09 IEEE.
[9] International energy agency (IEA) 2009.IEA Wind energy: annual report p-9.
[10] Caixia Wang; Dept. of Electrical Engg., Tsinghua University, Beijing, China; Zongxiang Lu; Ying Qiao. "*A consideration of Wind Power Benefits in Day-Ahead Scheduling of Wind Coal Intensive Power Systems*". H.Power systems, IEEE transactions (volume: 28, Issue:1)
[11] G. Bathurst, J. Weatherill and G. Strbac, "Trading wind generation in short term energy markets", IEEE transactions on Power systems, vol.17, pp.782-789.
[12] Stavros A. Papathanassiou, PhD thesis summary "Contribution to the analysis of variable speed wind turbines with induction generator".
[13] A report on "India wind energy outlook 2012".
[14] "Common concerns about Wind power", centre for sustainable energy, May 2011.
[15] Zijun Zhang university of Iowa PhD dissertation on "Performance optimization of wind turbines".

BIBLIOGRAPHY

Md. Moyeed Abrar has successfully completed his M-Tech in Digital electronics from Appa Institute of Engineering and Technology, Gulbarga, Karnataka in July 2013. He has completed B.E in Electrical and Electronics from PDA College of Engineering, Gulbarga, affiliated to Visvesvaraya Technological University, Belgaum, Karnataka. His research areas of interests are Power and Energy systems, Digital Circuits and logic design, Electrical machine design, Control systems.