A Review on Wind Power in India

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Abstract

Increased recognition of the contribution that renewable energy (RE) can make to energy independence, climate change mitigation, rural development, improved health and lower health costs (linked to air pollution), is shifting RE from the fringe to the mainstream of sustainable development[1]. The use of electricity has grown since it can be used in variety of applications as well as it can be easily transmitted, the uses of renewable energy like wind and solar is rising. [2]. Wind energy is a mature and rapidly growing renewable energy technology. It provides a cost-effective and scalable alternative to conventional energies, both in developing and developed countries. By the end of 2011 the cumulative global installed capacity stood at 238 GW. The global capacity will grow to 280 GW by the end of 2012 and may reach 490 GW by 2016, according to industry projections [3].

Keywords- *wind energy, wind farms*

1. Introduction

As energy consumption rises with increase in population and living standards, the need to expand access to energy in new ways is growing as is the awareness of the environmental costs [1]. Climate change, dwindling reserves of fossil fuels and shortage of electricity have prompted the government to give an impetus to renewable energy sources [5]. Wind energy is a clean, eco-friendly, renewable resource and is non-polluting [2]. The confidence on wind power can be realized from the recent growth of wind power at global level. Several countries have set specific target to meet substantial portion of their domestic energy demand from wind while many others have initiated large scale R&D [4]. Wind energy, with an average growth rate of 30%, is the fastest growing source of renewable energy in the world.

India has a potential capacity of over 45,000 MW out of which 1869 MW has been extracted from this eco-friendly source [5]. India is one of the five largest wind energy markets in the world today. Renewable energy sources (excluding large hydro) represent 12.2% of India's installed capacity, with 70% of this contribution coming from wind energy [3].

Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface and rotation of the earth. The earth's surface is made of different types of land and water. These surfaces absorb the sun's heat at different rates, giving rise to the differences in temperature and subsequently to winds. During the day, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises and the heavier, cooler air rushes in to take its place, creating winds. At night, the winds are reversed because the air cools more rapidly over land than over water. In the same way, the large atmospheric winds that circle the earth are created because the land near the earth's equator is heated more by the sun than the land near the North and South Poles. Humans use this wind flow for many purposes: sailing boats, pumping water, grinding mills and also generating electricity. Wind turbines convert the kinetic energy of the moving wind into electricity [1].

The technology of wind power, both on-shore and off-shore installations, has seen continuous development since the last two decades. Commercially viable wind energy converters of various capacities, Kilowatt to Megawatt class, have proved to be able substitutes for the conventional sources of power [6].

2. Origin of Wind Power

Wind has been used as a natural source of energy for many years. The use of wind energy dates back to the dawn of civilisation when sailing

vessels were powered by the wind. The first simple sailboats were set afloat in Egypt about 5,000 years ago[7].Wind power has long been recognized and used effectively by humankind, with the Babylonians and Chinese harnessing the power of the wind for their irrigation needs as early as 2,000 B.C. The first rudimentary windmills were recorded as early as 1 A.D [8]. Around the year 700 AD, the first wind machines rotating around a vertical axis were employed to grind grain [7].

Denmark was the first country to use the wind for generation of electricity. The Danes were using a 23 m diameter wind turbine in 1890 to generate electricity. By 1910, several hundred units with capacities of 5 to 25 kW were in operation in Denmark [28]. In 1891, a Dane by the name of Poul LaCour built the first electricity-generating wind turbine. It was improved by Danish engineers and used to supply energy during energy shortages in World War I and World War II. The wind turbines built by the Danish company F.L Schmidt (now a cement machinery maker) in 1941-1942 can be considered the forerunners of modern wind turbines, and other companies, such as the American Palmer Putnam began building turbines as well, modifying the number of blades and tower height[10]. The first offshore wind farm is in Cape Cod, Massachusetts. The world's largest wind farm is the Horse Hollow Wind Energy Center, in Texas, with 421 wind turbines that have the capability to provide electricity for 220,000 homes per year [8].

The following graph shows the increase in wind power capacity over few decades.

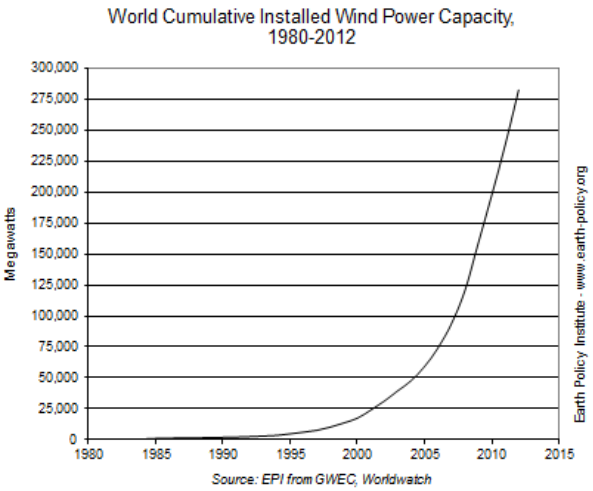


Figure1: World Cumulative Installed Wind Power Capacity 1980-2012

One of the most important milestones of the wind energy history coincides with the USA government involvement in the wind energy research and development (R&D) after the oil crisis of 1973. Following, in the years between 1973 and 1986, the commercial WT market evolved from domestic and agricultural (1-25 kW) to utility interconnected wind farm applications (50-600 kW). In this context, the first large-scale wind energy penetration outbreak was encountered in California, where over 16,000 machines, ranging from 20 to 350 kW (a total of 1.7 GW), were installed between 1981 and 1990, as a result of the incentives (such as the federal investment and energy credits) given by the USA government. In northern Europe on the other hand, wind farm installations increased steadily through the 80s and the 90s, with the higher cost of electricity and the excellent wind resources leading to the creation of a small but stable market [9].

The early technology development in Denmark (cooperatives) and Germany started with the engagement of local farmers who were encouraged to produce their own electricity. This scheme significantly facilitated the creation of a basic industry prior to 1980, from which the modern wind industry grew. It also facilitated the adoption of the technology at a later stage, as long as the local communities were kept strongly involved [3].

3. Wind Power in India

India is one of the five largest wind energy markets in the world today. Renewable energy sources (excluding large hydro) represent 12.2% of India's installed capacity, with 70% of this contribution coming from wind energy [4].As far back as 1950's wind energy was being used in India to pump water for domestic use and irrigation and as an alternative to diesel pump-sets [10].

The desire for energy self-sufficiency was a major driver for the development of new and renewable energy after the two oil crises of the 1970s. The sudden increase in the price of oil, uncertainties associated with its supply, and the adverse impact on the balance of payments eventually led to the establishment of the Commission for Additional Sources of Energy (CASE) under the Department of Science & Technology in 1981[4]. Then in the 6th National Five-Year Plan (NFYP) the Government of India introduced the National Windmill Demonstration Program, which, continued throughout the 7th NFYP (1985-1990), and saw the installation of hundreds of units of 12 PU-500 wind pumps for shallow water pumping. Today, India's energy demand is expected to require an extra 150, 000 MW of installed electricity by 2012 and the

government is looking to wind energy to help solve hat supply problem [10].

Current wind technology can be separated into three types. First there are wind pumps, which use mechanical energy from wind mainly for water-pumping purposes (used for drinking and irrigation). Then, there is wind energy generators (WEGS's), connected to turbines, which are used to produce electricity, to be distributed on electricity grids and are meant for rural and/or urban use. Lastly, there are wind-electric battery chargers that produce electricity and store it in batteries [10].

In 1986, the first wind farm with 10 turbines of 55 KW each was installed at Mullakkadu to demonstrate the techno-economic viability of wind power and to attract private investments in wind mills. This was later expanded to a wind farm with a total installed capacity of 1.15 MW [24].

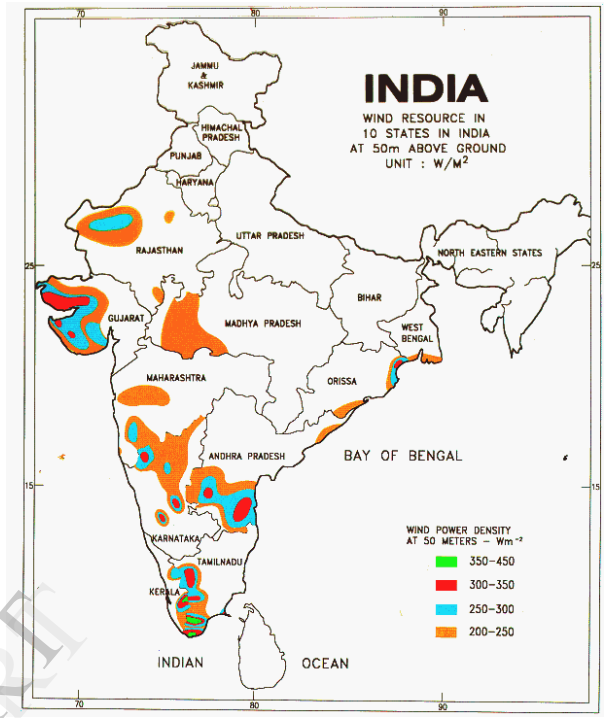
There are a growing number of wind energy installations in states across India. As of March 2013, the states of India had a cumulative installed capacity of 19051.46 MW [11].

Table 3.1

State	Capacity as on 31.03.2013(MW)
Tamil Nadu	7162.18
Gujarat	3174.58
Maharashtra	3021.85
Rajasthan	2684.65
Karnataka	2135.50
Andhra Pradesh	447.65
Madhya Pradesh	386.00
Kerala	35.10
Others	4.30
Total	**19051.46**

The potential is far from exhausted. Indian Wind Energy Association has estimated that with the current level of technology, the 'on-shore' potential for utilization of wind energy for electricity generation is of the order of 102 GW. The unexploited resource availability has the potential to sustain the growth of wind energy sector in India in the years to come [25].

Tamil Nadu has the distinction of 719 MW (75% of total) wind farms at the end of September 1998 (2). Andhra Pradesh has 58 MW (6%) and Gujarat has 168.64 MW, or 16% of the total capacity installed. The map below shows details on wind-farm distribution [10].



Source: Ministry of Non-Conventional Energy Sources (www.mnes)
Figure 2: Wind Farm Distribution in India

3.1 Future Wind Power Plants in India

The future Wind Power Plants in India are as follows [23].

1. 102.4 MW Sipla Wind Farm will be located at Jaisalmer District (Rajasthan) CLP.
2. 50.4 MW Narmada Wind Farm at Nallakonda (Andhra Pradesh), CLP.
3. 200 MW Wind Farm in Tamil Nadu by Techno Electric & Engineering Company Ltd (TEECL).
4. Caparo is building 500 MW Wind Farms in Rajasthan, Gujarat and Maharashtra, has placed a $1.2 billion order with Suzlon.
5. 56-megawatt Tuppadahalli wind farm by Accionia.
6. 50MW wind farm Amreli district of Gujarat by Orient Green Power Company.
7. 84 MW Wind Farm in Maharashtra by Orient Green Power Company.
8. 33 MW wind farm Vellappaneri Wind Farm by Beta Wind Farm which is a 100 per cent subsidiary Orient Green Power.

4. Advantages of wind power

The advantages of wind energy are rather obvious and follow their renewability [12].

Wind energy relies on the renewable power of the wind, which can't be used up. Wind is actually a form of solar energy; winds are caused by the heating of the atmosphere by the sun, the rotation of the earth, and the earth's surface irregularities [18].

Wind energy is cheap and is largely dependent upon the manufacturing, distribution and building of turbines for the initial costs. The U. S. DOE estimates wind energy can be produced for as low as 4 to 6 cents per kilowatt hour. Wind energy replaces electricity from coal-fired power plants and thus reduces greenhouse gases that produce global warming [19].

More and more studies have confirmed that wind power will save consumers money. Even the Wall Street Journal has finally started to acknowledge the fact [30].

Wind energy is available worldwide and though some countries may be "windier" than others, the product is not like oil that has to be transported on tankers to the far regions of the earth [19].

The longer term potential of wind power will become more apparent as experience is gained in the production and operation of machines [20].

Compared to the environmental impact of traditional energy sources, the impact of wind power is relatively minor. It consumes no fuel, emits no air pollution (unlike fossil fuel) and while may cover a large area of land it is compatible with other land uses i.e., agriculture. Wind Power Density (WPD) is used to select locations for wind energy development. The WPD is a calculation relating to the effective force of the wind at a particular location, frequently expressed in term of the elevation above ground level over a period of time, taking into account velocity and mass [21].

Wind energy has an impact on other sectors, both in terms of job creation and in giving them business. And when you use wind energy, you need less fuel from other countries: wind saved the EU €5.71 billion on fuel in 2010 [22].

5. Disadvantages of wind power

Wind's intermittent nature leads to probably the chief problem with wind power: its unpredictability [12]. The major disadvantages can be listed as follows:

5.1 Wind Turbines Kill Birds

Wind turbines are usually made of blades that rotate continuously and fiercely. Due to the fact that the blades are usually placed high up in the air, they are known to kill birds that fly over it. Attempts have been made to prevent more birds from dying as they paint the blades with conspicuous colors so that the birds can see and avoid them [15].

5.2 Strength of wind

The strength of the 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 [16].

5.3 The Energy Density of Wind Is Low

Due to the fact that wind is diffuse and it is also spread over a wide area, so as to be able to produce large quantities of electricity it is mandatory that the number of turbines used cover a large area. Since many turbines have to be used, the costs of setting up a wind farm are so high [15].

5.4 This Form of Energy is not efficient

The turbines do not have the ability to extract a hundred percent of the energy that is found in the blowing wind. Research shows that turbines extract only fifty nine percent of the wind energy that passes through them. This makes them very inefficient [15].

5.5 The Energy that is Produced Can't Be Stored in Large Scale

Considering the fact that it is impossible to have wind blowing daily, it is important that the energy storage of this system be sufficient. Seeing as it is not, this shortcoming contributes greatly to the insufficiency of wind energy [15].

5.6 The Turbines are Noisy

One of the reason as to why most people avoid using this form is energy is that the

machinery that is used for the production of electricity is very noisy. Although this form of energy is preferred as it does not pollute the environment, the noise that is usually produced in the process of producing electricity is too much: it can be a nuisance [15].

5.7 Construction

Wind turbine construction can be very expensive and costly to surrounding wildlife during the build process [17].

5.8 This Form of Energy is suited to be set Up in Specific Places

Wind farms can only be set up on specific places. This limits the use of this form of energy to specific places. The best place to set up a wind farm is in the coastal regions. The reason as to why turbines are placed in the coastal region is due to the fact that coastal regions are always windy. This means that regions which are located hilly areas may not be able to benefit from this form of energy. The place where the turbines are placed ought to have a lot of wind blowing if any electricity is to be produced [15]

5.9 Land Use

One of the main disadvantages of wind energy is that large tracks of land are needed to so that the appropriate number of turbines can be installed. One of the major reasons as to why the installation of turbines is considered to be a waste of time is because the electrical energy that is usually produced is too little to warrant the wastage of huge tracks of land [15].

5.10 Local Opposition

Despite economic and environmental benefits of wind power, some wind projects face local grassroots opposition to development [29].

6. Issues and Challenges

There are several challenges in the development of wind power. The challenges of financial and technical aspects need to be addressed on priority basis [13, 14].

6.1 Financial Challenges

At present, a number of green energy projects are under planning and implementation stage with the government. As the success of a new technology is always associated with question mark, which creates some obstacles that can prevent its growth and development. This uncertainty results in high financial burden for further research and development work for that technology.

6.2 Technical Barriers

Firstly, there is a state of uncertainty in some technologies due to unavailability of reliable power supply in developing countries. Secondly, it may not be able to serve competitively with more established options. Following issues may be considered as technical barriers that can prevent the growth as,

- Optimal power pricing produced from the wind energy sources.
- Quality and the state of being consistent issues.
- Cost of improvement in existing technology.
- Current production level needs to be changed significantly.
- Availability of financial schemes for wind energy based projects.

6. Conclusion

It is not an exaggeration to state that 'Humanity is facing a choice between a peaceful decision on its common energy future or wars for resources in the near future. Currently 1.4 billion people do not have access to reliable electricity in developing countries with about 85% of those in rural areas (WWF, 2011), with 404 million people in India still without access to electricity (IEA, 2010) [27].

Though wind power has few limitations and disadvantages, it is still one of the promising renewable energy sources. India is one of the key emerging economies yet a highly vulnerable country to both climate change and energy market fluctuations. Wind power, through its scalability and speed of deployment, can not only help reduce India's carbon footprint but also help towards achieving energy security by reducing its dependence on fossil fuel imports in the long term. It is important for the government to conduct an in-depth study of true costs of developing a low carbon green economy in the near future [27].

Despite increased international interest in investing in the sector, few transactions have been completed recently. We can expect M&A in the country's renewable energy sector to heat up, especially in the wind sector [26].

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