International Journal of Electrical and Electronics Engineers
Vol. No. 9, Issue No. 01, January-June 2017
ISSN (O) 2321-2055
ISSN (P) 2321-2045

WIND ENERGY DEVELOPMENT AND ITS PROSPECTS IN INDIA – A REVIEW

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ABSTRACT

Energy is an essential ingredient in all human activities; it progressed with human history and development of society. Classification of energy sources is non-renewable or not sustainable like natural gas, oil, coal and nuclear and sustainable or potentially renewable like wood and bio fuel, non-deployable like wind, solar, hydroelectric and geothermal. India is sanctified with an immense amount of renewable energy resources and wind energy is one of the promising sources for energy supply option. This paper presents the current status, potential of wind energy, and different support program adopted by government to promote power generation from wind in India.

Keywords: Wind energy; wind power, potential, installed capacity, scheme, and generation.

I. INTRODUCTION

The actions of human beings have led to deterioration of resources on the earth in less than two centuries of industrial revolution. However, world relies mostly on fossil fuels, the adverse effect of climate change effect like global warming, temperature rise, rising sea level, extinction of species led to the need for alternate energy sources. World consumes 23.5 million GWh approximately in a year. The primary energy consumption in India is the third biggest after China and USA surpassing Japan and Russia with a global share of 5.3% in the world's power sector. It is predicted to be the second largest contributor in global energy demand by 2035 accounting for 18% of the rise in global energy consumption. India has an installed capacity of 320 GW and power sector has a growth rate of 9.88%. Renewable power plants constituted 30% of total installed capacity and non renewable power plants constituted the remaining 70%. India's CO_2 emissions in 2016 continued to increase by 6.24% to about 2.25 billion tonnes making it the third largest CO_2 emitting country [1].

In 2016 amount of CO_2 emissions avoided by wind power globally was 608 million tones. Developing countries can play a vital role by emphasizing on renewable energy for reducing the sudden climate change. Through Intended Nationally Determined Contribution (INDC) Government of India has committed to slash carbon emission intensity of its GDP at a particular point by 33-35% by 2030, from the 2005 levels and by 2030 generate 40% of its power from non fossil fuels. To meet the target of INDC a target of 175 GW Renewable power by 2022 will be achieved. This includes 100 GW of solar capacity, 60 GW of wind capacity, 10 GW of biogas and 5 GW from small hydro projects taking into account share of renewable energy to the total installed capacity.

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Renewable energy with no fuel cost is a growing component of electricity grids around the world due to its contributions to long terms energy security, energy system de-carbonization and expansion of energy access to new energy consumers in the developing world. Wind and solar generation both experience intermittency, a combination of non controllable variability, partial unpredictable and depend on resources that are location dependent because the presence of wind and sunlight are both temporarily and spatially outside human control.

There are huge benefits in moving away from oil. Integrating wind and solar generation resources into the electricity grid involves managing other controllable operations that may affect many other parts of grid. Also, grid operators must track loads demand for electricity on the consumption side of the grid to ensure that generation matches load at all times. Reliable electricity supply is continually becoming more and more essential for society and blackouts are becoming more and more costly whenever they occur.

II. BACKGROUND IN WIND POWER

India is blessed with an immense amount of wind potential with an estimated potential of 102.77 GW with a contribution of 14% in the global wind scenario by the end of 2016. For reducing the impact of CO_2 emissions on the environment green technologies are developed of which wind power is the most promising growing sector. Wind exists everywhere on earth and with considerable energy density. Windmills were first used in Persian 2,800 years ago. The concept of windmills reached Europe through the crusaders. Windmills first appeared in England in AD 1137 [11]. Renewable energy sector in India has made remarkable progress growing from 3.3% (2002) of the total generation capacity to 15% (2017), of this about two third is from wind and the balance is from small hydro, solar biomass and waste to energy and other sources. In India in the last two decades the hub height (80-120m) and rotor diameter (25-80m) of wind projects have increases fourfold and the average wind turbine generator rating increased almost tenfold. Wind farm plant load factor now range from 20-50 % for onshore and 30-45 % for offshore sites. India presents a reliable, well diversified, fast growing and profitable market opportunity for renewable energy. India seeks to tap its long coastline of 7,600 km for offshore wind, but current candidates are the western coast of Gujarat and Southern tip from Rameshwaram to Kanyakumari in Tamil Nadu.

Renewable Energy (RE) has become an important part of electrical generation in many countries and its importance is continuing to increase. The amount of renewable generation in particular wind and solar is growing rapidly and their capacities are growing in size and complexity. To integrate large amounts of RE power plants successfully, a number of issues need to be addressed, including design and operation of the power system, grid infrastructure issues and grid connection of RE power. To investigate the effects of RE on the grid, detailed simulation exercise of power system dynamics is a must.

For the first time in four decades, despite rising energy use global carbon emissions associated with energy consumption remained stable in 2016.Whereas previous emissions decreases was associated with downturns in the global economy, the carbon stabilization in 2016 has been attributed to increased penetration of renewable energy and improvements in energy efficiency.

There is rising awareness worldwide that renewable energy and energy efficiency are critical not only for addressing climate change, but also for creating new economic opportunities, and for providing energy access to the billions of people still living without modern energy services. For rural electrification programmes

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renewable are vital elements in many countries, and dozens of international actors were involved in advancing energy access through renewable during 2014.

Wind energy advantages are clean environment, unlimited supply perennial, zero Green House Gas (GHG) emission, decentralization, enables rural/ island electrification, create employment opportunities, social development etc. Wind energy is gaining importance throughout the world, currently five countries – Germany, USA, Denmark, India and Spain concentrates more than 83% of worldwide wind energy capacity in their countries. India is the fourth largest country in terms of total installed capacity of wind power, with large reserves of untapped potential that spells out a great opportunity for this sector to grow exponentially. As per result statistics wind energy generated has grown at a rate of more than 30% over the past decade, an increase of 200 GW in the past 5 years and cumulative global installed capacity has reached 487 GW at February 2017. Around 17-19% global electricity would be supplied by wind power in 2030.

It is clear that wind will play a leading role in decarbonisation and is now a mainstream source of energy supply. India is the second largest wind market in Asia. Total grid connected renewable energy installations in the country reached 50018 MW. Thus, 2015 was a big year for the big markets, China, U.S., Germany and Brazil of which all set new records in wind energy generation. India set a new national record with 3612 MW of new installations in the year 2015. In 2016 India added 3472 MW bringing the Country's total to 29151 MW as on March 2017 [5, 6].

III. WIND POWER MARKET

Following are the key observations of Wind Power Market.

- In 2016, over 54 GW was added bringing the global to around 487 GW as compared to 11.5 GW in 2005 (as shown in fig. 1). It was another record year for wind power which added more capacity than any other renewable technology despite policy uncertainty in key markets. Around 85 countries had seen commercial wind activity by the end of 2014, 74 had more than 10 MW of capacity in operation and 24 had more than 1GW [7].

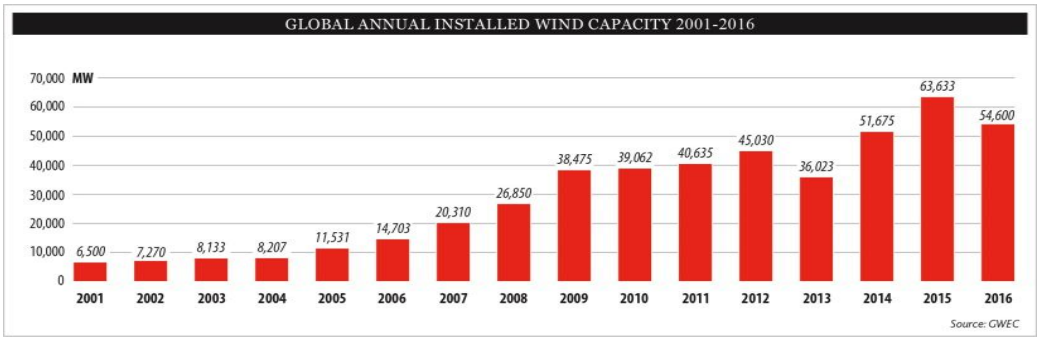

Figure 1 Wind Power Global Capacity 2005-2016

- Since 2009, for the first time the majority of new capacity was installed in the OECD (Organization for Economic Co-operation and Development) due largely to the United States. Developing and emerging economies are moving firmly into the mainstream however, China and United States together accounted for nearly 70% of the global market in 2014 followed distantly by Germany, India and the United Kingdom. Others in the top 10 for capacity added were Italy, Brazil and Canada.
- Asia is the world's largest regional wind power with an overall total installed capacity of 175.8 GW [8].

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- China maintained its top position in 2015 by adding 30.8 GW of new wind power capacity to the grid which is the highest annual number for any country.

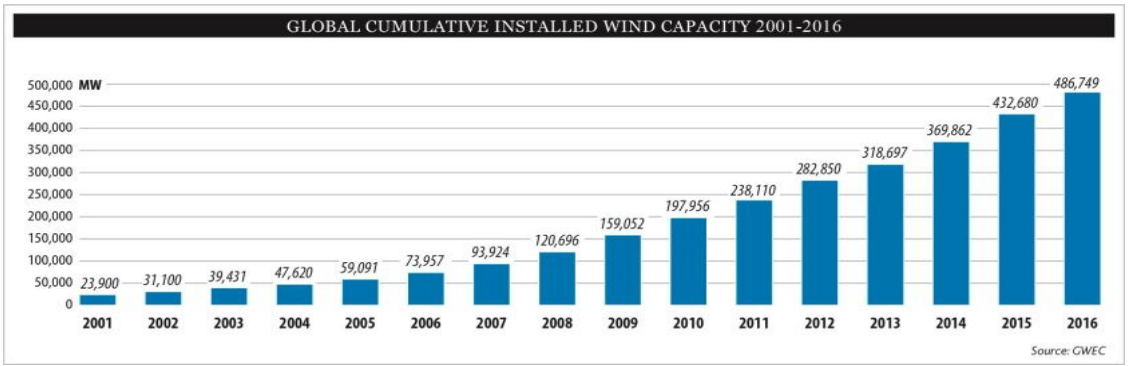

Figure 2 Annual & Global cumulative offshore wind capacity

Atleast 870,000 small scale turbines or more than 755 MW were operating worldwide at the end of 2013 and during 2014 another 255 MW were added. Figure 2 shows the annual and global cumulative offshore wind capacity.

The Ministry has adopted plans to carry out realistic assessment of wind resource in North Eastern region by installing 200 wind monitoring station ranging from 50 m to 80 m height. The Figure below shows the 50 m wind monitoring station installed at Rombagre, Meghalaya.

Figure: 3 Wind monitoring station installed at Rombarg, Meghalaya

Wind energy continues to dominate renewable energy industry in India. The Indian government in 12th five year plan (2012-2017) has planned to add 15,000 MW of wind power in this period. During the year 2013-14 the 2079 MW wind power projects were commissioned and 24 billion units power was generated from wind power projects [9].

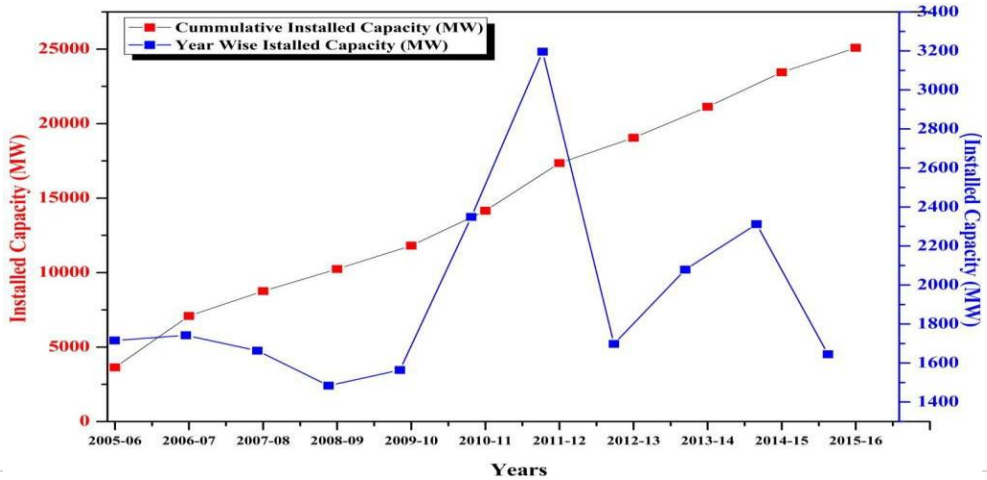

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Figure 4 Cumulative and year wise wind power installed capacity (MW)

During the 2015-2016, four 50 m level wind monitoring station were commissioned in the region, so far 52 monitoring stations have been installed at 20 m, 25 m and 50 m level to carry out an assessment of wind resource available in the region with the joint efforts of NIWE and state nodal agencies.

IV.WIND POWER INDUSTRY

The target mandated by National Action Plan on Climate Change (NAPCC) envisages major contribution of Renewable Energy, especially from wind to the tune of as much as 50 GW by 2020. The wind power generation capacity in India as per the official estimation by National Institute of Wind Energy (NIWE) which is based on the Ministry of New & Renewable Energy (MNRE) funded long term wind resource measurement programme, is 49.13 GW. One should notice that the declared potential is based on measured wind data in various heights in different locations in India ranging from 20 m mast to 50 m mast [3, 4].

Since April 2011, to enable wind power projects in area having low or moderate wind power potential using wind turbines of higher hub heights in the range of 80-120 meter with modern technologies are in progress, for harnessing low wind region with the capacity of 200 watt per sq. m. with 2% area of land availability in potential areas for setting up wind farms at 9MW/Sq. km.

Addition of 30,000 MW of renewable energy power with as much as 20,000 MW by wind alone has been envisaged in the 12^{th} five year plan (2012-2017). With such phenomenal growth, the wind sector is sure to meet the target set by NAPCC, in India. By way of having 21% of all worlds CDM projects which is 72 %. India ranks second in the world.

Under both the 10^{th} Plan (2002-2007) and 11^{th} Plan (2007-2012) periods wind energy has met and often exceeded the targets set for it. The target set was of 1,500 MW whereas the actual installations were 5,427 MW during the 10^{th} Plan and similarly during the 11^{th} Plan period the revised target was for 9,000 MW and the actual installation were much higher at 10,260 MW. The report of the sub-group for wind power development appointed by the Ministry of New and Renewable Energy to develop the approach paper for the 12^{th} Plan period (April 2012 to March 2017) fixed a reference target of 15,000MW in new capacity additions, and aspirational target of 25,000 MW. Importantly, the report recommends the continuation of the Generation Based Incentive Scheme (GBIS) during the 12^{th} Plan period. The report also prioritized the issue of transmission, which was a weak link in the value chain until now.

4.1 Offshore wind power status in India

The initial assessment and wind resource data collected along the coastline of Rameshwaram and Kanyakumari in Tamil Nadu and Gujarat Coast have shown a promising potential for the development of offshore wind power. A preliminary measurement suggests a possible potential to establish around 1 GW capacity wind farm along the coastline of Rameshwaram and Kanyakumari in Tamil Nadu. To exploit the resources from the offshore there are two important maritime areas where offshore wind farm can be deployed:

- Indian territorial waters, approximately up to 12 nautical miles (nm) from the baseline

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- Beyond 12 nm and 200 nm (Exclusive Economic Zone) [10]

V.WIND POWER SUPPORT PROGRAM IN INDIA

A financial outlay of $44.79 million has been expensed in R&D in wind energy sector by the government in 11th Plan. In 12th five-year plan period (2012-2017) government has approved an outlay of $539 million for New and Renewable Energy Programmes, which is almost 3 times that for 11th five-year plan period. In April 2012, the accelerated depreciation of 80% (AD) and the generation-based incentive (GBI) of INR 500/MWh (EUR 5.9/MWh) both were closed. The GBI scheme was restarted by the government in late 2013. The Indian government is fully supportive and providing incentives, duty free import and acceleration depreciation to all the investors including private investors in wind energy sector. The various state government and central government agency are providing banking facilities, capital subsidy and electricity tax exemption. The government has come up with some schemes they are as follows [14]:

A. Generation Based Scheme: This scheme was stopped in April 2012, but later on in 2013 it was extended upto March 2017 in revised form. Under the scheme, a GBI will be provided to wind electricity producers @ Rs. 0.50 per unit of electricity fed into the grid for a period not less than 4 years and a maximum period of 10 years with a cap of Rs. 100 Lakhs per MW. The total disbursement in a year will not exceed one fourth of the maximum limit of the incentive i.e. Rs. 25.00 Lakhs per MW during first four years. The GBI scheme is applicable for entire 12th plan period having a target of 15,000 MW. This scheme is available for wind turbines commissioned on or after 01.04.2012 and for entire 12th plan period. In this scheme all wind power producers are required to register themselves with IREDA. The incentive is over and above the tariff that may be approved by the State Electricity Regulatory Commissions (SERC's) in various states [2]. The Figure 5 shows the fund released by the government for the wind power program under Generation Based Scheme.

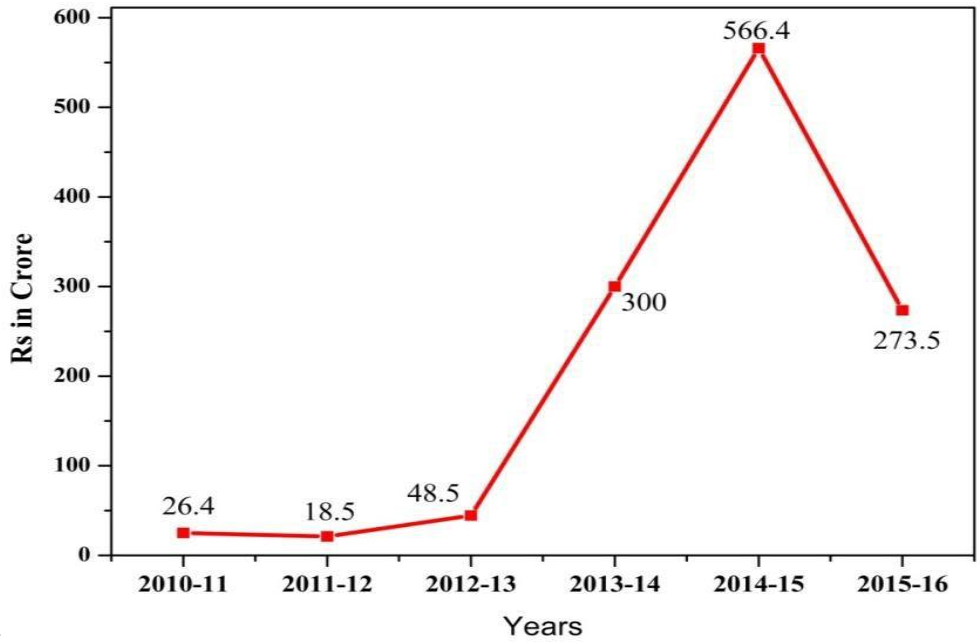

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Figure 5 Fund released for wind power programme under GBI scheme [9]

B. State Wise Tariff for Wind Power: The State Electricity Regulatory Commission (SERC) has announced different tariffs for the purchase of power from wind power projects in different states.

C. Renewable Energy Certificate Scheme: It began in February 2011 and about 10.12 millions RECs had been issued by the REC registry as of March 2014. Almost 52% of total capacity of4470 MW accounts for wind power under REC registry. The issuance fee of an REC has been reduced from INR 10 to INR 4 per certificate by the Central Electricity Regulatory Commission (CERC). The new fee is effective from 1 April 2014.[12, 13]

D. National Wind Energy Mission: The government is planning to initiate a National Wind Energy Mission (NWEM) sometime in 2014. This mission includes the promotion of onshore as well as offshore wind power generation and small wind turbine systems (<100 kW). This mission will encourage and enhance development in wind sector. The government of India is targeting to have a generating capacity of 100 GW by 2022 through this mission. In budget 2014-2015 the government provided full exemption of Special Additional Duty of 4 % of various part and material necessary for manufacturing wind-operated generators, and also increased the clean energy cess from INR 50 to INR 100 per tonne for promoting and financing. The continuous requests of various stakeholders forced the government to restore the Accelerated Depreciation (AD) scheme to attract investment in wind energy projects. Additionally government with an aim to attract wind power component manufacturing industry, offered concession on Basic Customs Duty from 5% to 10% of forged steel rings used in the production of bearing of wind-operated generators. The Excise duty was brought down from 12% to Nil on forged steel rings used in the manufacture of bearings of wind-operated electricity generators [**15**].

VI. MEASURES TO INCREASE WIND PENETRATION

1. **Resource assessment:** The correct assessment of wind resource potential, sustainability of the project over the designed life time, project feasibility will indirectly boost the energy generation through wind. It is required to make sure the quality of the data recorded at a particular site. The new commercially available remote sensing instrument such as Sonic Detection and Ranging (SODAR) and Light Detection and Ranging (LiDAR) can play a vital role in accurate assessment of wind resources at higher heights.
2. **Repowering and intercropping:** The project developer may opt for intercropping and repowering of wind turbine based on the improved wind turbine technology which may increase the annual energy production from old wind farm.
3. **Grid integration:** The electricity regulatory commission order should be strictly followed for the strengthening of grid connectivity and evacuation arrangement. An accredited certifying authority should certify all wind turbines for the compliance of grid regulation including power quality, low voltage

ride, active/reactive power control and other requirement as regulations and standards.

4. **Hybridization:** The use of hybrid technologies (linking wind energy with other renewable and storage technologies) in line with the policy issued by the state/central government may result in reduced intermittency and efficient utilization of transmission infrastructure and may also increase capacity utilization factor.
5. **Offshore development:** The successful development of offshore wind power technology would increase the share of wind energy to a larger extent in total renewable energy capacity of the country. The regulatory authorities should formulate policy framework and support program in manner that it should attract investors, academician, research personal and public sectors.
6. **Metering and real time monitoring:** It is necessary to focus on net metering policy and real time monitoring to encourage and attract the local population to adopt renewable energy technology. The installation of Availability Based Tariff (ABT) meter with telecommunication facility at substation can play a major role in accurate metering. The vital grid parameters on real time basis should be prudently send to state/regional load center.
7. **Flexible rules and regulations:** The flexibility in rules and regulations (land clearance, different state tariffs, different state laws and regulations, minor disputes, legal proceedings) will impart positive effect in the development of wind farm projects and will encourage the deployment of wind power projects.

VII.CONCLUSION

By installing wind turbines carbon footprint has been reduced to an enormous amount. India has been leading in the fourth place in terms of wind energy generation as compared to fifth in 2014. The latest development is the 88.4 m, 8 MW nominal capacity and 180 m rotor diameter for offshore wind applications. Wind power is a main pillar of tomorrow's energy supply in India. It generates clean and environmental-friendly electricity, creates jobs and reduces risks on several levels comparatively from other unconventional source of energy. It still affects animals and human life, such as noise and visual impacts. The increasing energy demand cannot be fulfilled much longer by fossil fuel, alternative fuels are required to limit the probability of collapsing of climate, spreading of war for natural resources and to meet the energy demand. India's growing energy demand results in the enhancement and development of renewable energy. There is a huge potential to generate energy from renewable sources like solar and wind. India has an immense potential of wind energy too, but there is still some barriers in wind power development in the country.

India has a lot to learn from European countries to make the country self dependent and self sufficient to fulfill unending desire for energy. Various researchers have concluded that cost of production of wind power decreases with increase in size of wind turbine, hence it is important to develop technologically superior and efficient wind turbines to minimize cost of wind power. While most of the development has been concentrated on onshore, offshore wind power is comparatively new sector which require needful attention, testing and its specific machines need further development. The government of India is actively promoting, participating and launching new policies in wind energy sector to encourage investor. China is a leading producer of wind power in Asia due to its renewable energy law and in short India will have to

improve technology, supportive policies towards wind power and proper understanding between producers and investors to become the leader in wind energy generation.

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