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Current Status, Issues, Policies and Scenario of Wind Energy in India

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***Abstract*—**The aim of the paper is to highlight the estimated wind power potential, various policies initiative by Indian Government to promote renewable energy, the current technological development in the field and various technical issues encountered in the smooth operation of these resources for overall development of wind energy particularly in Indian energy sector. This paper elaborates the provisions of electricity acts, policies and initiatives taken and being adopted by the Indian Government to promote the renewable energy sector. Various technical challenges technical challenges of wind power plants during installation and operation have been discussed. The impact of addition of renewable sources on power quality and emission reduction has been discussed. The criterion for the size and location of various wind units installation has been discussed. The research and development scope for the wind power potential growth have been provided. The paper explores the wind potential, electricity acts, polices, issues etc. of the upcoming energy sector to incite researchers to take up the various issues which come across the generation from the wind generators.

Keywords- *wind power technologie; renewable energy; electricity act; technical issues; benefits of wind power plants*

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I. INTRODUCTION

The prime building block for development of any nation is energy. The sustained economic, social and industrial growth of country depends upon the energy availability and usage. To sustain the large energy requirement for large population, and to meet out the energy demands of fast growing economy, India has to explore all energy resources (conventional and non conventional) and enhance its energy capabilities rapidly. Generally, in India energy production heavily depends upon fossil fuels like coal and oil which degrade the environment. With very limited resources of fossil fuels it becomes very important and challenging to meet the energy requirements. Renewable energy resources have the potential to curtail the carbon emission problem arises by the use of the fossil fuel in power generation and can supplement the power shortage in India [1].

Indian Government has taken many initiatives and establishes various government organizations like Indian Renewable Energy Development Agency Limited (IREDA), Ministry of New and Renewable Energy (MNRE) and state agencies to enhance its generation capacity through renewable energy sources. These agencies initiate various reforms in the existing Electricity Acts (EA). Enactment of the EA 2003, 2005, 2006 provides generation based incentive (GBI), renewable purchase obligation (RPO) along with the renewable energy certificate (REC), feed in tariff (FIT), nation clean energy fund (NCEF), restructuring the power systems and electricity boards for improving the efficiency of power systems [2].

India is one of the highly potential countries of Asia and at present placed at 5th position globally in energy generation with installed capacity of 288.66 GW (as on March, 2016 including all resources) [3]. The distribution of total installed capacity sector-wise and resource-wise is presented in Fig. 1. India also stands at 5th place globally after Germany, China, America and Spain in installed capacity of wind power (26.915 GW) [4].

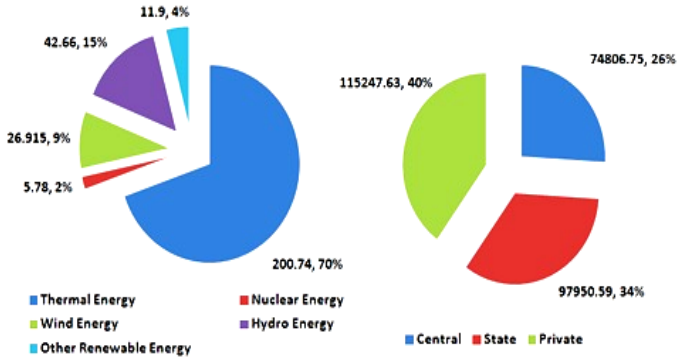

Figure 1. The distribution of total installed capacity sector-wise and resources-wise

Although, wind power is highly used cleanest form of renewable energy, but it has some technical as well as environmental issues like uncertainty and stochastic nature, high installation cost (high percentage of transportation cost) and grid connectivity. The use of existing transmission lines for power transmission from remote located wind plants sometimes leads to power congestion. Wind power also exhibits many advantages like zero carbon dioxide emission, security of supply, lesser running cost and land friendly with large potential worldwide. The wind energy will play an important role in reducing the dependency on fossil fuels for energy requirements.

This paper organized as: Section II discusses the wind power technologies. Section III presents the wind energy statistics and current scenario in India. Section IV discusses the Government initiatives and policies for promotion of renewable energy (RE). Section V discusses various technical and environmental issues. Section VI discusses the benefits of the wind energy generation. Section VII discusses the achievements. Section VIII presents the scope of wind energy sector in India. Section IX summarizes the main findings of the paper and concludes.

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II. WIND POWER TECHNOLOGIES

Uneven heating of the earth surface and atmosphere by solar energy received from sun produces temperature gradient which initiates the movement of air (cooler air replaces the hotter air). This form of energy is indirect from of solar energy [5]. Wind turbine tapped the Kinetic energy of the wind and converts it into the rotating energy which further converted in electrical energy by the wind generators. The turbine is installed at more than 30 to 50 meter height range above the surface of earth, because at this height the wind moves faster and less turbulently [4]. Horizontal axis wind turbine (HAWT) and Vertical axis wind turbines (VAWT) are the two types of wind turbines available for generation as shown in Fig. 2 [6-8].

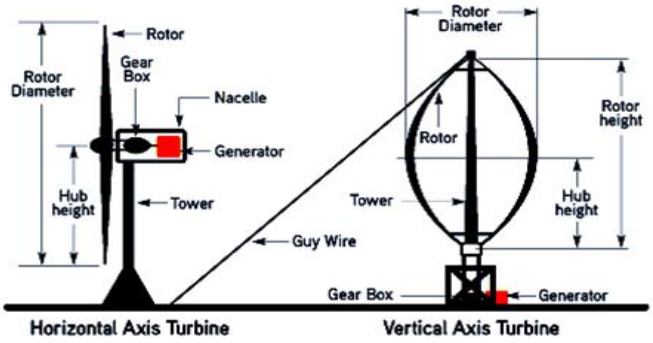

Figure 2. Wind turbines design

Wind turbines of various capacities starting from few hundred watts to several watts are available. Up to 50 KW capacity wind turbines are used in homes, offices, schools, commercial building and other standalone applications. Wind turbines of higher rating than 50 KW in multiple numbers are used in wind farms to generate bulk power.

III. INDIAN WIND POWER STATUS AND CURRENT SCENARIO

Tropical position of India along with 7517 KM of coastline and water territorial about 12 nautical miles into the sea makes wind energy a favorite renewable energy resource as temperature difference remains throughout the year [9]. India can be divided into many regions based upon the wind power density distribution shown in Fig. 3 [4].

The total wind power potential in India at 50 meter hub height for wind power is more than 200 W/m^2 with 1 percent land availability is estimated to be 48561 MW [1][4]. At 80 meter and 100 meter hub height the wind power potential expected to be 100GW and 302GW respectively. Table I wind power potential (estimated) of potential states of India [1][4]. Presently, total wind installed capacity of India is 26.915 GW (9.32%) out of the 288.66 GW from all sources [10].

Presently there are approximately 300 plus potential sites in nine, wind potential states out of which 82 are fully working. To monitor the wind potentials across the country Government established 665 monitoring stations. Indian government has planned to have energy for all. Exponentially increase in the installed capacity of wind power is witnessed year wise since the start of wind power generation. In December 2013 the wind installed capacity was 20.15 GW which increased to 22.465 GW by on December 2014 and as on March 2016 it rises to new height of 26.915 GW. Whereas, the total renewable energy from all sources as on March 2016 is 38.821 GW. Table II shows the sector-wise and fuel wise installed capacity [11-12]. Growth of wind installed capacity in recent years in India (2005-2016) is shown in Fig. 4 [13-16].

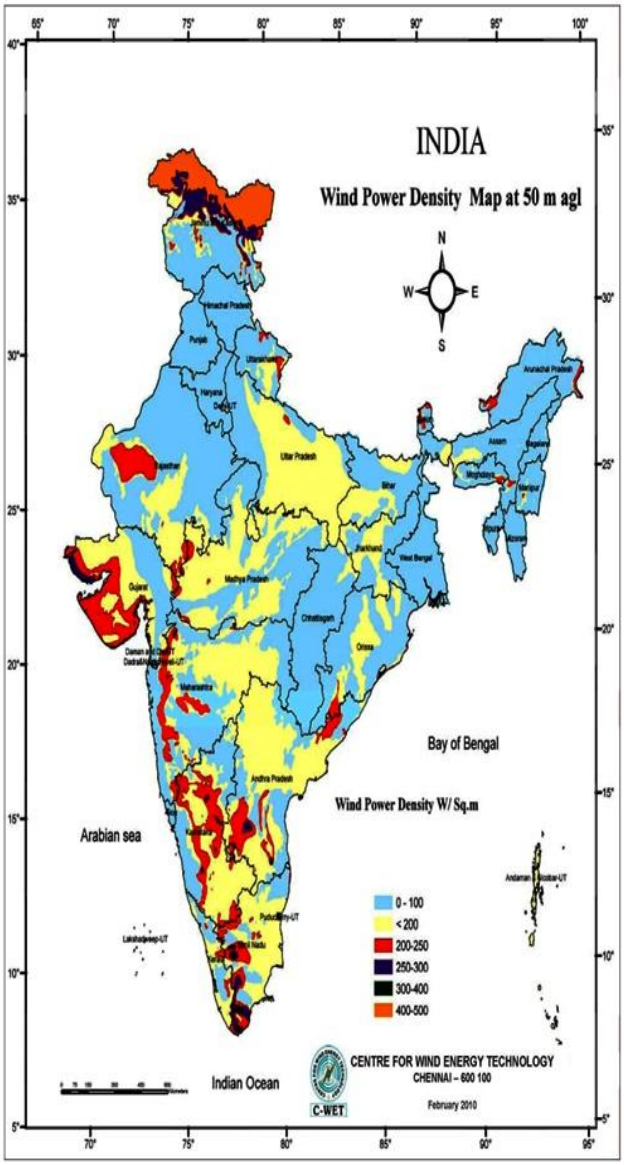

Figure 3. Wind power density distribution of various states of India

TABLE I. WIND POWER POTENTIAL (ESTIMATED) OF WIND POTENTIAL STATES OF INDIA

Potential of Wind Power		
S.No.	**State**	**Potential (MW)**
1	KARNATKA	11531
2	GUJRAT	10645
3	ANDHRA PRADESH	8968
4	TAMILNADU	5530
5	RAJASTHAN	4858
6	MAHARASHTRA	4584
7	KERALA	1171
8	MADHYA PRADESH	1019
9	ORISSA	255
Total Potential		48561

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TABLE II. SECTOR-WISE AND FUEL WISE INSTALLED CAPACITY

Total installed capacity			
Sector		**Generation in MW**	**Contribution in %**
State		97951	33.9
Central		74847	25.9
Private		115868	40.1
		288665	100
Fuel		Generation in MW	Contribution in %
Total Thermal		201360	69.76
	Coal	175858	60.92
	Oil	994	0.34
	Gas	24509	8.49
Hydro		42703	14.79
Nuclear		5780	2
R.E.S.(MNRE)		38822	13.45
Total		288665	100
RES include mini hydal, micro hydal, wind energy, biomass, urban waste and industrial waste.			

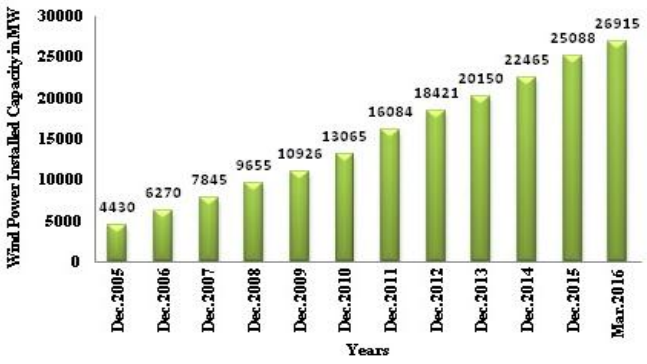

Figure 4. Wind power growth

IV. INITIATIVES AND POLICIES TO PROMOTE WIND ENERGY

The social and economic development of a nation is indexed by the energy demand. Since Independence Indian power sector undergoes a noticeable growth in installed electricity capacity but there is a continuous deficit of over 10 percent for the last few years mainly due to economic growth, urbanization, growing population. The deficit also increases due to mismanagement, lack of implementations, large technical and commercial losses. Generation in India is mainly done using conventional sources. To overcome the power shortage and to make power system more reliable Indian government comes up with various electricity policies time to time, to enhance the reliability of power system. Prior to the electricity act 2003 the other existing legislations are Electricity (supply) act 1948, Indian Electricity act 1910 and electricity regulatory commission act 1998 [16-19]. Table III shows the policies and tariff plans for various wind potential in active states of India.

A. Electricity act 2003

The act 2003 replaces all prior acts and promotes generation of power from non-conventional energy resources and co-generation. Under Sections 86 (1) (e) and 61 (h) the responsibility of SERCs is to provide suitable guidelines for connecting to grid, fixing the share of total power to be consumed of a distribution licensee, purchase of renewable power from renewable energy plants, selling of power to any, tariff determination for these sources. This act also promote the private players participation in power generation, rationalization of tariffs, electricity boards re-bundling, punishments for power thefts, policies regarding the subsidies in power for various sectors [16][20].

B. National electricity policy 2005

After electricity act 2003, Indian Government comes up with new electricity policy called national electricity policy (NEP) in February 2005. Clauses 5.12, 5.12.2, 5.12.3 of the NEP 2005 suggested a number of conditions to promote and enhancing the energy capacities from renewable energy resources. NEP 2005 guided the respected commissions to promote the renewable energy generation by providing more subsidies to energy generation from RES, fixing deferential prices among conventional and non conventional resources and competition among the producers with condition that purchase and selling is done through the competitive bidding [16][20].

C. National electricity tariff policy

In January 2006 the National electricity tariff policy (NETP) was introduced by Indian Government. Section 86(1)(e) of EA 2003, NETP permits the promotion of power generation from renewable resources by State Electricity Regulatory Commissions (SERCs) by distribution licenses with minimum percentage of renewable Purchase Obligation along with tariff plans in time bounded manner in respective regions. The main aim of tariff policy is to enhance the reliability, power quality and system efficiency by promoting fair competition among the various power generating companies provided that all the purchase done by bidding process [16][20-21].

D. The Energy Conservation Act 2001

The guidelines for conservation and efficient use of energy are provided by Energy Conservation Act 2001. The Bureau of energy efficiency (BEE) is formed after this act in India. The bureau acts as the nodal agency to develop the policies and strategies required for energy conservation. This act promotes awareness among consumers regarding the benefits of energy conservation and to use energy more efficiently [16].

E. Other Initiatives of the Government

Tariff Based Bidding.
Ultra Mega Projects.
Allocation of Captive Coal Blocks.
Policy for Hydro.
Incentives for generation of green energy.
Tax rebates.

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Financial support for setting up the renewable energy generating stations.
Initiate the Private Sector Participation in Transmission of energy.
National Action Plan for Climate Change.
Re-structured Power Development and Reform Program during XI Plan.
Rajiv Gandhi Grameen Vidyutikaran Yojana.
Demand Side Management Initiatives.
Human Resource Development – Adopt an ITI scheme.
Provision of National Electricity Fund (NEF) for Distribution Scheme.
IT Based Project Monitoring [3][16][22-23].

V. Technical Issues with Wind Power

A. Power Quality

Due to the unpredictable and inconsistent natures of wind causes various power quality problems like voltage dips, voltage swells, frequency variations, harmonics, low power factor and flickering of voltage etc. The wind turbines are highly inductive in nature which is the main cause of low power factor issue. Stability problem also there if these wind turbines draws more reactive power from grid [24].

B. Installation Cost

The installation cost (commissioning to generation) of wind power plant is very high as compared to the other conventional and nonconventional power plants. As these plants are located in remote places therefore the infrastructure provided to install and bring power from remote areas is costly. But the running cost is running cost which is very small as compared to the installation cost [25].

C. Size and Location

The land used to install the wind power plants in remote area is either forest land, agricultural land or the free land. To find the perfect location is very tedious and time consuming because it needs complete check and analysis of the availability of wind for a year including (social, environmental and economic factors), possibility to upgrade wind plants to increase the plant capacity, upgrade the roads, vicinity of grid. Where, the size of wind plant depends upon the power to be generated from the plant [25].

D. Noise

The large size wind turbines produce noise when large blades cut the air. Humming sound is produced by the magnetic circuits in the induction generator. These noises can be sometime very disturbing, irritating. In the night periods the noise is more prominent then the day times due to that fact that in the day time the noise is suppressed by other existing noises [25].

E. Congestion/ reactive power requirements

The power generated by remotely located wind power plants transmitted over long distances using the existing transmission structures. Because Separate transmission structures construction is not economical. Firstly the power generated from wind generators is not continuous and depends upon the wind speed. Sometimes wind generators generate more power and the transmission lines over burdened (power congestion). Secondly wind generators always draw the reactive power from the grid at the time of start and also draw reactive power from source (grid) as the wind generators are induction generators. Reactive power draw causes the power quality problems in the existing power systems [24].

VI. Benefits of Wind Power Plants

A. Environmental

The power demand globally increases day by day. To keep pace with the demand more power stations are to be planted. The power produced from green energy resources are free from the pollutants and do not produce the green house gases. To have the healthy environment more and more renewable energy plants are introduced [21].

B. Emission targets

Under the Kyoto Protocol clean development mechanism each country forced to reduce its greenhouse gases emission (different targets for different countries). Power production from wind plants does not require fossil fuel which releases highest percentage of greenhouse gases to the environment. Therefore Wind power generation is the best and most suitable forms of energy generation under present circumstances among all other resources. Wind renewable resources have tremendous capability to reduce the CO_2 emission to the environment. Out of the total CO_2 emission approximately 40 percent is produced by the power sector globally. To meet the emission targets globally we must promote and generate energy from wind [16][26].

C. Operation Cost

The operating cost of the wind turbines includes the maintenance, labour and transport charges to carry the damaged parts to the remote location of the turbines. Running cost is less as compared to other conventional and non conventional energy plants. It further reduces as new efficient wind turbines are generated using new technologies [25].

D. RPO

Renewable purchase obligation (RPO) introduced but states to promote the energy generation from the renewable energy resources. The RPO for various states varies from 1% to 15% percent depending upon the potential. This RPO concept actually helps to keep environment free from pollutant gases and acts as an additional source of income to the renewable energy producers [20].

Feed in Tariff/ payback is better: Wind Energy producer has the benefit of both consuming energy generated by itself and selling it in the market through the feed in tariff process to get better pay offs. It is made compulsory for all power producers to generate 5% of their energy requirement from the renewable resources which increased to 15 % by 2020 by national action plan for climate change. If they generate excess energy they can be paid back handsomely under feed in tariff plans [16].

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TABLE III. POLICIES AND TARIFF PLANS FOR VARIOUS WIND POTENTIAL ACTIVE STATES OF INDIA

State	Buy-Back Cost (Rs/KWh)	Percentage of Energy Wheeling	Reactive Power Incentives (Paisa/KVArh)	Banking allowed (Yes/No)	Third Part Sales (Allowed/Not Allowed)	Subsidy
Andhara Pradesh	3.50 (Fixed for 10 years)	5	Upto 10% -10 Above 10% -25	No	Yes allowed	Only to Industry
Tamil Nadu	3.39 (Fixed)	5	Upto 10% -25 Above 10% -50	Yes, @ 5% for financial year	Yes allowed	Nil
Karnataka	3.40 (Fixed for 10 years)	5	40	Yes, @ 2% of input energy	Yes allowed	5 Years exemption on electricity duty
Kerala	3.14 (Fixed for 20 years)	SCRC will decide	-	SCRC will decide	Yes allowed	Nil
West Bengal	4	7.5	20	-	Yes allowed	Nil
Gujarat	3.50 (Fixed for 20 years)	4	Upto 10% - 10 Above 10% - 20	Yes, With monthly settlement Surplus energy sold to utility as per the existing tariff rate	Yes allowed	Electricity duty exempted
Madhya Pradesh	Year wise rates I year - 4.03 II year - 3.86 III year - 3.69 IV year - 3.52 (V – XX) year - 3.36	2	27	Yes, Proposals are invited from DISCOM	Yes allowed	Electricity duty exempted for 5 Years
Maharashtra	I year - 3.50 (II – XIII) year rise @ 15 paisa per year	2 + 5% for Loss in Transmission and Distribution	25	12 Months	Yes allowed	Subsidy for making approach Road Subsidy for Power evacuation Subsidy on Electricity Duty Subsidy on Loan for Cooperative Societies
Rajasthan	4.25 (for three district Barmer, Jaisalmer & Jodhpur) 4.50 (for all other districts)	50 for 33 KV + 3.6% surcharge for transmission	5.75 with rise of 0.25 paisa per year	Not allowed in December, January and February Months Allowed in April to March in two groups	Yes allowed	Electricity duty exempted for7 Years @ 50%

VII. ACHIEVEMENTS IN WIND POWER SECTOR

The main causes of these rise in environmental temperature is the use of conventional energy resources for generation of energy. The by-product likes Carbon and other pollutants like CO_2, SO_2, and NOx from convention fuels adversely affect the environmental conditions which causes global problems like global warming, ozone depletion, air pollution, water pollution [26] etc. Intergovernmental Panel of United Nations states that

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for last 30 to 40 years temperature rise is very high and estimated to be in the range of 0.2^o to 0.3^o. While temperature of surface globally increased by 0.3^o to 0.6^o since the late nineteenth century. These adverse effects can be minimized or controlled by shifting toward renewable energy resources from conventional energy sources for energy generation [27].

The wind power technical potential of India is large and expected to increase in near future. At present India stands at 5^{th} position in world for wind installed capacity of 26.915 GW [3]. Being the cleanest/greenest form of renewable energy it can help in big way to keep our environment free from pollutant as no byproduct generated while producing power as compared to generation from fossil fuel. It is expected that grid connected installed capacity of wind energy reaches 142 GW by 2040 from present installed capacity of 26.915 GW [16]. Table IV gives the expected rate of CO_2 equivalent emission.

TABLE IV. EXPECTED RATE OF CO_2 EQUIVALENT EMISSION

Years		
CO_2 equivalent emission (in Tons)	Upto 2020	Upto 2030
	2 to 2.5	3.to 3.5

In areas like health, agriculture and water resources, infrastructure development in the coastal areas and forests the Government of India is spending two and a half percent of GDP for minimizing the carbon emission. A significant amount of carbon dioxide emissions can be reduced by using renewable energy resources.

Therefore to fulfill the energy demand in future and to control the carbon dioxide emission, it is required to enhance the potential of clean energy in India [20].

VIII. SCOPE OF WIND ENERGY IN INDIA

India is facing an acute energy gap between the energy generation and energy demand. Due to the difference in the generation and demand limits the growth (industrial and economic) of the country. Fossil fuels are still dominantly used for power generation, which is the main contributor to environmental problems globally: climate change and air pollution. The renewable energy resources are the only solution to these problems, which produces energy without causing any degradation in the environment. India is a large developing country with tremendous wind energy potential along with other renewable energy resources. India stands at 5^{th} position with installed capacity of 26.915 GW globally out of a total technical potential of 48.561 GW [1][4] which likely to be increased in near future as new potential sites will be explored. To mitigate the environmental issues, Indian government introduced a number of policies to promote the wind energy at present and harnessing it in near future. By investing more in the research and development of these energies makes it cost effective in long run as compared conventional power generations.

IX. CONCLUSION

India is the fastest growing developing nation with large energy requirements. Energy balance between the demand and supply can be made possible by adding the massive renewable based energy production capacities. Wind energy is the solution for many problems like shortage of power, to mitigate the fuel (fossil fuel) price hikes, environment degradation, and import of fuel.

The living and working standards of the villages and industry sector can be improved by providing uninterrupted electricity. Wind power installed capacity going to increase in near future many a folds in India as well as worldwide as wind resources has huge potential across the globe. The wind renewable energy has all the potential to become the leading renewable energy resource when its issues are addressed and resolved. More direct and indirect incentives must be provided by the Government to promote the wind energy.

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