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Wind Energy : Analysis of the Technological Potential and Policies in India

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***Abstract*- In recent years, India has emerged as one of the leading destinations for investment in wind energy sector due to high potential for generation of wind energy. Hence this sector has shown impressive growth in the past few years. Now, India has one of the largest programs in the world for deploying wind power. India has been rated as one of the most promising country for wind power development. This sector is rapidly expanding and offers the potential advantage for sustainable development. Present paper explores about the wind energy in the country and the policy, legislative and regulatory measures, which are being implemented and to be modified for the sustainable growth in the energy sector. This review would be useful for wind power planners to assess the future impacts of increasing wind energy capacity in the grids and design appropriate strategies for technical capacity and expansion planning.**

Keywords- Wind power Potential, Technologies, Policy Measures and Wind Energy Sector

I. INTRODUCTION

Wind is the fastest-growing energy technology in the world and it is the global energy success story of the 21st century. The pace of progress has been rapid for such a young industry. In the last 30 years growth rates exceeded expectations, and a record capacity of turbines was installed internationally (1).

Wind energy for electricity production today is a mature, competitive, and virtually pollution free technology widely used in many areas of the world (2). Wind technology converts the energy available in wind to electricity or mechanical power through the use of wind turbines (3). The function of a wind turbine is to convert the motion of the wind into rotational energy that can be used to drive a generator. Wind turbines capture the power from the wind by means of aerodynamically designed blades and convert it into rotating mechanical power. Wind turbine blades use airfoils to develop mechanical power (4).

In the power starved developing countries, wind power is the viable source of electricity, which can be installed and transmitted very rapidly, even in remote, inaccessible and hilly areas (5). Electricity generation from wind never depletes and never increases in price. The electricity produced by these systems could save several billion barrels of oil and avoid many million tons of carbon and other emissions (6).

II. GLOBAL WIND ENERGY MARKET

Wind power has now established itself as a mainstream electricity generation source, and plays a central role in an increasing number of countries' immediate and longer term energy plans. After 15 years of average cumulative growth rates of about 28%. The commercial wind power installations in about 80 countries at the end of last year totalled about 240GW, having increased by more than 40 times over that same period. Twenty two countries have more than 1,000 MW installed capacity. This development was led by the China, US, Germany, Spain and India, and it brought global cumulative installed capacity to 2, 82,482 MW (as of 30 June 2012). The top five countries in terms of cumulative installed capacity are China (75,564 MW), the US (60,007 MW), Germany (31,332 MW), Spain (22,796 MW) and India (18,421 MW). In terms of economic value, Wind power could supply up to 12% of global electricity by 2020, creating 1.4 million new jobs and reducing CO_2 emissions by more than 1.5 billion tons per year, more than 5 times today's level. By 2030, wind power could provide more than 20% of global electricity supply. Today, China, the US, Germany, Spain and India are the wind energy key market players at global level (7.8.9).

III. WIND ENERGY IN INDIA

India ranks as the world's seventh largest energy producing country and fifth largest energy consuming country. India is also the fifth largest oil and seventh largest gas importer in the world. Due to increasing gaps between domestic energy demand and supply, India's incremental energy demand for the next decade is projected to be among the highest in the world. Under these conditions, in order to gain energy independency and obtain healthy sustainable growth India must invest in renewable energy sector. The geographical location and its climate provide various advantages for renewable energy investments and production in India. Therefore, in order eliminate dependency and tackle environmental problems related to the consumption of fossil fuels, India must start investing in renewable such as wind, solar, biomass and geothermal [10]. Feasibility studies confirmed that India has a great potential for wind energy production [11]. The total potential estimated by the Centre for Wind Energy Technology (C-WET) at around 45 GW, and was recently increased to 48.5 GW [12]. The Indian Wind Turbine Manufacturers Association (IWTMA) estimates that the potential is around 65-70 GW. The World Institute for Sustainable Energy, India (WISE) considers that with larger turbines, greater land availability and expanded resource exploration, the potential could be as big as 100 GW [4.5]. The comprehensive wind mapping exercise initiated by MNRE, which established a countrywide network of 1050 wind monitoring and wind mapping stations in 25 Indian States (13.15).

This effort made it possible to assess the national wind potential and identify suitable areas for harnessing wind power for commercial use, and 216 suitable sites have been identified. As a result of this grid-connected total installed capacity in 2012 was 18,635 MW (16.17). Most of this is from commercial projects. There are a number of Indian companies with foreign collaborators (Suzlon, Enercon, Vestas, REPL, BHEL) who are manufacturing and marketing wind turbines and generators. The wind resources of India have been mapped (data from 1000 monitoring stations throughout the country). A potential site is considered viable in case the average winds speeds at a height of 50m is above 200W=m2. Wind speeds are high during the monsoon months (June to August) with relatively weak winds during the rest of the year. The viability of wind is critically dependent on the capacity factor that is site specific. The average capacity factor for wind installations in India can be computed by dividing the average power generation by the sum of the rated capacities of all the installations. Although there are various advantages of wind energy, which is highly documented in the literature there are also some serious disadvantages that this renewable energy source upholds. Therefore, before making any judgment and future plans for the utilization of this renewable energy source these disadvantages must be well understood (17).

Wind energy development activities were started in India during 1960s, with a small 4.9 diameter meter conventional multi-vane wind mill it was developed by National Aeronautical Laboratory (NAL) and then Sail-type windmills were developed under a project initiated by NAL during 1976–1977 (19, 20). Early wind applications were mostly for small scale irrigation purposes in rural areas. During the 1982 Department of Non-conventional Energy Sources (DNES) was established to take part in development activities. The Department had the responsibility of formulating policies, programmes for development of new renewable R&D in the sector. In 1992, DNES became the Ministry of Non-conventional Energy Sources (MNES). And in October2006, the Ministry was re-christened as the Ministry of New and Renewable Energy (MNRE) (18, 21). During the period from 2002 to 2012, the growth momentum in the Indian wind energy sector picked up.

The pace of development was marked by formulation of right regulatory framework, incentive mechanism, flourishing component manufacturing industry, emergence of local players and coming in of multinational companies as well as technology advancement. During this period India saw massive addition in its wind power capacity (Table 2). When come to potential and development of Wind power in India has been concentrated in a few regions, Tamil Nadu, Maharashtra, Gujarat, Rajasthan and Karnataka, West Bengal, Madhya Pradesh and Andhra Pradesh start to catch up, especially the southern state of Tamil Nadu, which maintains highest installations, and along partly driven by new policy measures (17).

Table :1 Wind Power Potential and Development in India

S. No	*States*	*Wind Potential (MW)*	*Cumulative Installations (MW)*
1	Andhra Pradesh	8,968	245.5
2	Gujarat	10,645	2,966.3
3	Karnataka	11,531	1,933.5
4	Kerala	1,171	35.1
5	Madhya Pradesh	1,019	376.4
6	Maharashtra	4,584	2,733.3
7	Rajasthan	4,858	2,070.7
8	Tamil Nadu	5,530	6,987.6
9	Others	255	3.2
10	**Total**	**48,561**	**17,351.6**

Source: www.mnre.gov.in. As on 2012

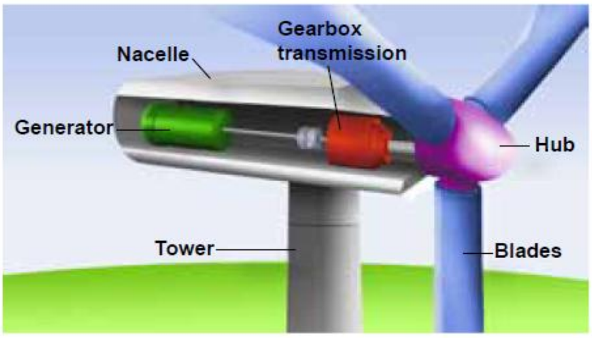
IV. WIND ENERGY TECHNOLOGIES IN INDIA

At the beginning of the 21st century, due to Increasing negative effects of fossil fuel combustion on the environment in addition to limited stock have forced many countries to explore and change to environmentally friendly alternatives that are renewable to sustain the increasing energy demand. Changing to renewable sources and implementation of effective conservation measures would ensure sustainability. Currently, wind energy is one of the fastest developing renewable energy source technologies across the globe. The major reason for this interest in wind energy technologies is the bulk availability of this resource without any cost (21).

In order to increase the efficiency of wind turbines most of the system components must be enhanced. The research and development focuses on the turbine components. Distributed generation is not a widespread generation area in India. Commercial wind turbine type is the most common configurations. Horizontal wind turbines are design to work on upcoming wind spectra and systems, which utilize reverse current is very rare. The most important advantage of upwind systems is the elimination of wind turbulence, which is most common in down wind machines. However, horizontal systems require yaw and pitch mechanisms and advanced breaks to control the upwind and produce the required power output. According to many researchers, upwind horizontal wind turbines are the most suitable systems to be operated at India. Vertical axis systems are designed to operate where, rotor shaft is arranged vertically. The most important advantage of these systems when compared to horizontal axis wind turbines is that these systems do not require to be pointed directly into upwind to be effective. In locations where the speed of the wind changes instantaneously these systems can be used. However, vertical axis systems have low rotational speed and higher costs compared to horizontal axis wind turbines (22).

Wind power has been converted to electrical power by using a gearbox and an induction generator. Turbines generally have a three-stage gearbox which is constituted gears and parallel shafts. Various control techniques found in the literature is analysed based on power optimization. Some of these techniques are fixed or dynamic pitch speed controlled wind turbines, pitch-angle controlled wind turbines, and torque controller using stator current demand. In order to improve stability and reliability of wind farm, static reactive power compensator (STATCOM) and dynamic braking resistor (DBR) is used (25).

Figure: 1. Wind Turbine



Source: www.environment.nsw.gov.au

Table: 2. Technology of Manufacturers offering Class II and Class III wind turbines in India

Sl. No	Manufacturer	Rating (kW)	Drive	Speed	Generator	Class
1	Enercon	800	Gearless	Variable	Synchronous	II-S
2	GE Wind	1,500	Gear	Variable	DFIG	II A
3	GE Wind	1,600	Gear	Variable	DFIG	II
4	Suzlon	1,250/2,100	Gear	Fixed	Asynchronous	II A/III
5	Suzlon	1,500	Gear	Fixed	Asynchronous	III A
6	Suzlon	2,250	Gear	Variable	DFIG	II B
7	Vestas India	1,650/1,800	Gear	Variable	Asynchronous	II B/ III A
8	RRB Energy	1,800	Gear	Variable	Asynchronous	II/III
9	Gamesa	850	Gear	Variable	DFIG	II A/III B
10	Gamesa	2,000	Gear	Variable	DFIG	II A/III A
11	Global Wind Power Limited	2,500	Gear	Variable	Synchronous	III A
12	Inox Wind Limited	2,000	Gear	Variable	DFIG	III B
13	Kenersys India	2,000	Gear	Variable	Synchronous	II A
14	Leitner-Shriram	1,350/1,500	Gearless	Variable	Synchronous	II A/III A
15	ReGenPowertech	1,500	Gearless	Variable	Synchronous	III A/III B
16	WinWinD	1,000	Gear	Variable	Synchronous	III B

Source: WISE, 2012

Above Table.2 shows Wind turbine technology in India led to huge investments in the sector and emerging as a major wind turbine-manufacturing hub due to increased domestic demand and expansion of the in-house manufacturing capacity as resulted in attracting many new manufacturers into the fray. Today Indian manufacturers are engaging in the global market by taking advantage of lower manufacturing costs in India (17). There are 16 manufacturers of wind turbines making about 45 models. India has an annual wind turbine production capacity of around 4000 MW, which can be expanded upto 8000 MW, if market demands in the near future more than 20 wind turbine manufacturers and turbine suppliers would be operating from India (12).

Considerably, Wind turbine sizes in the early and mid-1980s, the typical wind turbine size was less than 100 kW. By the late 1980s and early 1990s, turbine sizes had increased from 100 to 500 kW. Further, in the mid-1990s, the typical size ranged from 750 to 1000 kW. And by the late 1990s, the turbine size had gone up to 2500kW. Now turbines are available with capacities up to 3500kW to 5000kW. These technical knowhow maturities has helped for low wind regimes in Most parts of India except in pockets in the State of Tamil Nadu have low wind regimes(14).

Low wind regimes are requiring the design of turbine components but also in generator configuration. The turbine design and development objective is to reduce the cost of energy (COE). Turbine manufacturers usually utilize two parallel approaches of reducing production costs and maximizing power capture, thus optimizing performance and reducing the COE. Market forces in the low-wind-regime market already endorse this approach (25).

Leading manufacturers like Suzlon, Vestas, Enercon, RRB Energy including newer entrants like Gamesa, GE, Siemens, Regen Powertech and WinWinD have set up production facilities in India. The trend is markedly clear as shown in table; most of the new manufacturers offer Class III machines that are more suitable for low wind regimes. Manufacturers now offer Class II and Class III machines with newer technologies and higher power capture capabilities (4.15.17).

V. WIND ENERGY POLICY MEASURES IN INDIA

I. *Regulations*

India has been very proactive in harnessing wind energy and initiated wind power programme as early as 1983. Some of the key Authorities governing wind energy in India are (18).

- Ministry of New and Renewable Energy(MNRE)-Government of India
- Indian Renewable Energy Development Agency (IRDA for financing)
- Centre for Wind Energy Technology (for assessment testing and certification)
- State Electricity Regulation Commissions (SERCs)

II. *Incentives Offered To Investors*

- Accelerated depreciation of up to 80% of the project cost if the project is commissioned before 30 September of the financial year, or 40% if the project is commissioned before 31 March of the financial year
- Exempted from income tax on all earnings generated from the project for any single 10-year period during the first 15 years of the project's life
- Soft loans from IREDA, Finance up to 70% of the eligible project cost
- Moratorium period up to one year
- Generation Based Incentives (GBIs) for Grid based Wind Power Projects (26).

III. *Generation Based Incentives*

Generation Based Incentives (GBIs) aims at attracting large private and foreign direct investment to the Wind Power Sector. IREDA is the nodal agency for the implementation of GBI. Key features of this incentive scheme are as follows (28. 29).

- Incentive of Rs 0.50 /kWh through IREDA with a total cap of INR 6.2 million /MW spread over a minimum of 4 yrs (i.e. an annual cap of INR 1.55 million/MW)
- Grid connected wind power projects can avail either accelerated depreciation or GBI
- Incentive is over and above the feed-in tariff specified by the respective SERCs
- Applicable only for captive and not for third party sale and merchant plants

IV. *Key Policy Governing Investment In Wind Energy Sector*

a) Electricity Act, 2003**:** Provides support for renewable sources, it needs to play important role in the energy developmental activities.

b) NATIONAL TARIFF POLICY-2006:Mandates SERCs to fix a minimum percentage of energy purchase from renewable sources, Takes into account availability of such resources in the region and its impact on retail tariff

VI. STATE WISE TARIFF FOR WIND POWER

At present, thirteen SERCs have declared preferential feed–in tariffs (FITs) for purchase of electricity generated from wind power projects. All the SERCs have adopted a ‘cost plus’ methodology to fix the FITs, which varies across the States depending upon the State’s resources, project cost and more importantly the tariff regulations of SERCs. A brief comparison of wind power related tariff polices in key states is given in the Table.3. Currently the SERCs unfortunately are not following the CERC tariff regulation. Some States have preferential tariffs for wind that are only marginally higher than the normal power costs. This raises concerns about the basis of the state-specific tariff calculation exercise, which is typically based on very conservative assumptions of capital costs, O&M costs, etc.; often very different from current costs of the industry. The SERCs need to adopt the tariff prescribed by the Central Electricity Regulatory Commission as was done by the Maharashtra Electricity Regulatory Commission. This is essential to ensure adequate return on equity for the investors. To achieve the comprehensive and long-term planning there is an urgent need for adopting a uniform tariff regime for wind power development across the country (17. 27).

Table: 3. State-wise Comparison of Feed-in-tariff Policy for Wind power in India

S. No	States	Current tariff rates per kWh	Details of available tariff rates	RPS Targets (% for wind)
1	Andhra Pradesh	INR 4.70	Constant for 25 years for the PPAs to be signed by 31-03-2015	5% for all RE (2012-2013)
2	Gujarat[a]	INR 4.23	No escalation for 25 years of project life	5.5% for wind (2012-2013)
3	Haryana	Wind Zone I– INR 6.14 Wind Zone II– INR 4.91 Wind Zone III– INR 4.09 Wind Zone IV–INR 3.84	Tariff is for FY 2012-13	3% for all RE (2012-2013)
4	Karnataka*	INR 3.70	No escalation for 10 years	7-10% (2011-12) for all Non-Solar
5	Kerala	INR 3.64	No escalation for 20 years of project life	3.63% (2012-2013) for all RE
6	Madhya Pradesh[a]	INR 4.35	No escalation for 25 years of project life	4% for wind (2012-2013)
7	Maharashtra	Wind Zone I– INR 5.67 Wind Zone II- INR 4.93 Wind Zone III– INR 4.20 Wind Zone IV– INR 3.78	No escalation for 13 years	8% for all RE (2012-2013)
8	Orissa	INR 5.31	No escalation for 13 years	5.5% for all RE (2012-2013)
9	Punjab	INR 5.07 (for zone I)	No escalation for 10 years	2.9% for all RE (2012-2013)
10	Rajasthan[a]	INR 4.46 & 4.69 (for FY 2011-12)	No escalation over project life of 25 years	7.5% for wind (2011-2012)
11	Tamil Nadu	INR 3.51	No escalation for 20 years of project life	9% for all RE (2011/12)
12	Uttarakhand	Wind Zone IV– INR 3.20* Wind Zone II– INR 4.35* Wind Zone III– INR 3.65* Wind Zone I– INR 5.15*	INR 5.65 for the first 10 years & INR 3.45 11th year onwards INR 4.75 for 1st 10 year & INR 3.00 for 11th year onward INR 3.95 for 1st 10 year & INR 2.55 for 11th year onward INR 3.45 for 1st 10 year & Rs.2.30 for 11th year onward	5.05% for all RE (2012/13)
13	West Bengal	INR 4.87	No escalation for 10 years	4% for all RE (2012/13)

** RPS for Bangalore Electricity Supply Company Ltd. (BESCOM), Mangalore Electricity Supply Company Ltd. (MESCOM), and Calcutta Electricity Supply Company Ltd. (CESC) is 10% while for Gulbarga Electricity Supply Company Ltd. (GESCOM)< Hubli Electricity Supply Company Ltd. (HESCOM), and Hukeri, it is 7%. a. RPS percentage specified only for wind Conversion Rate: $1.00=INR. 53.50*

VII. WIND ENERGY SECTOR ANALYSIS

Table.5: SWOT ANALYSIS

Strengths: Continuing demand- supply gap Escalation in the cost of fossil fuel-based power generation Availability of soft loans and government incentives Project gestation period is significantly shorter than conventional sources	**Weakness:** Low capacity utilization of the wind generation plants (PLF: 18-23%) Rising land costs and developmental issues Forced outages due to technical factors such as weak grid integration, mechanical problems etc.
Threats: Risk of obsolescence in case of technological innovations in other forms of energy Wind power subsidies may be rationalized or pegged down	**Opportunities:** Substantial untapped market (current utilisation: 24%) CDM credits for clean technologies attractive productivity of existing installations by re-powering existing ones

VIII. MAJOR ISSUES AFFECTING THE WIND ENERGY SECTOR IN INDIA

a) Wind alone cannot replace traditional methods of power generation because the wind is uncontrollable and it cannot supply modern reliable power. Wind power provides only extra energy; it does not produce base-load electricity.

b) The huge untapped wind power potential in the country, due to few challenges plague the wind power sector in India which includes withdrawal of GBI and AD schemes, wind power evacuation issues, land acquisition problems for exclusive installation and issues of grid integration.

c) Technological issues in relation to Lack of transmission infrastructure and Estimation of effective turbine capacity not deterministic, Investment related aspects like, Capital Expenditure much more as compared to conventional sources

d) Regulatory issues in the relation to Complexity of subsidy structure and involvement of too many agencies such as MNRE, IREDA, SERCs etc.,

e) At present, there are several financial and fiscal incentives provided to the wind power producers at the federal and state government level; however, unstable policies of the state governments as observed in the past and poor institutional framework increase the risk associated in the wind sector.

IX. CONCLUSION

In this paper a study on the Technological Potential and Policies in India has been carried. In India, the major solution to the dependency on Thermal, Nuclear and Hydro energy resources is domestic production, development and operation of renewable energy resources. Wind energy is the most important resource of renewable energy resources. There are lessons to be learned both in the success of wind in India and in examining how it needs to overcome these stumbling blocks.

First and foremost the initiative for wind power adoption must come from the government. The energy sector needs to be highly deregulated to allow alternate energy producers to shoulder most of the financial burden and also to really encourage the development using a market-based approach. Through, wind mapping activities to determine the best windy sites for installation, and build private sector confidence in wind energy. It must provide the right fiscal incentives, in the form of tax breaks for example, as India did, in order to spur installation. Yet another weakness in the system is the manner of fixation of tariff and RPOs by SERCs without any reference to the CERC regulations. The target of 15 per cent of renewable power by 2020 can be achieved only if the wind sector is allowed to grow without brakes and policy withdrawals. The government needs to take an objective view on policies and regulations and ensure stability and continuity of the same over a period.

The second major thing that needs to occur is for the institutional infrastructure to be established as early as possible. Also, with local production of wind equipment and the involvement of the community that the technology will be serving, there will be a sense of ownership that is crucial to the survival of such projects and urgent need is research and development in the area of wind technology for future acceleration.

A third point would be that as well as rewarding capital investment, there must be corresponding reward for actual generation of electricity, else performance of turbines will be low, and will both cause financial loss for the entrepreneurs and burden the local electricity boards, whose grids will suffer as a consequence.

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