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Forecast and Performance of Wind Turbines

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Abstract: Problem statement: Wind energy industry is a nonprofit organization that works hands-on with local and community based wind projects, providing technical support to create an understanding of wind energy opportunities for rural economic benefit. This study provides a detailed vision of the global wind power market and the Indian wind market in particular. It also helps in analyzing and forecasting key metrics relating to the installed capacities, market size and growth. **Approach:** It helps lay the foundation to build markets for locally owned wind projects in the southeast of Tamil Nadu as well as to help rural landowners and communities benefit more from corporate owned wind projects. As part of this effort, this study organizes state, regional and national wind energy for aimed at moving the wind energy policy and project development dialogue forward, especially regarding community wind projects. **Results:** This study is designed to give an overview of the wind energy industry and the many benefits and challenges to wind power development in India today. Yet most research in the wind industry remains focused on near term issues, while energy system models that focus on century-long time horizons undervalue wind by imposing exogenous limits on growth. This study fills a critical gap in the literature by taking a closer look at the importance, growth and tariff of large-scale wind. The report helps to comprehend the wind turbine industry and the regulatory framework regarding the wind market in India. It offers interesting results on the market share of the top manufacturers in the India wind turbine industry. Additionally, it also provides the profiles of ten major wind turbine companies in India. **Conclusion/Recommendations:** This has been an ongoing process to discover the best combination for a given environment in which the wind turbine has to operate and with various challenges met, India would be in a better position to develop and carry forward its own determined initiatives to better the prospects of the wind turbine technology in the coming years. This sectoral innovation systems framework is especially useful tool for analyzing the growth of wind turbine industry and in its essence to preserve the environment with reduction in carbon dioxide emissions.

Key words: Wind power, wind energy, wind turbine, turbine industry, installed capacities, rural landowners, wind energy, remains focused, large-scale wind

INTRODUCTION

Nearly two decades ago the Indian economy was snatched back from the brink of a composite economic crisis. The Indian Government undertook some hard-hitting liberalization measures that would have been unthinkable in a business as usual political landscape. Largely as a result of those actions, today India is in a position to be counted as one of the 'emerging economies'. Successive governments have looked towards locking in an average economic growth rate of at least 6-8%, up from 3.5% from the 1950s through the 1980s. The original objective of the 11th Five Year Plan (2007-2012) was to achieve a GDP growth rate of 9% over this period. This was revised to 8.1% last year by the Planning Commission. Electricity demand has continuously outstripped production and a peak energy shortage of around 12.7% prevailed in 2009-10. To meet this shortfall as well as the National Electricity Policy target of 'Electricity for All by 2012, the cleanest options available to India are Renewable Energy Technologies (RETs). For the government to seriously consider meeting its promise of electricity for all by 2012, renewable energy options including wind power will have to play a crucial role in India's emerging energy mix. Not only are they

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environmentally sound but also their project gestation periods are significantly shorter than those for thermal or nuclear power plants.

According to the Ministry of New and Renewable Energy (MNRE), today the share of renewable based capacity is 10.9% (excluding large hydro) of the total installed capacity of 170 GW in the country, up from 2% at the start of the 10th Plan Period (2002-2007). This includes 13,065.78 MW of wind, 2,939 MW of small hydro power, 1,562 MW of (bagasse based) cogeneration, 997 MW of biomass, 73.46 MW of 'waste to power' and 17.80 MW of solar PV for grid connected renewable at the end of 2010. The originally stated cumulative target for the current plan period was to add 92 GW of new capacity of which about 14 GW was to come from renewable sources. Given the right mix of regulatory and institutional support, renewable sources could meet the proposed capacity addition of 14 GW from renewable energy before the end of the 11th five year plan-period (2007-2012) (GWEC, 2011). This would bring the total share of renewable energy sources upto 15% of the new installed capacity in the 11th plan-period.

India's position in world ranking: Wind energy sector in India has grown at a tremendous rate over the last one decade. It now contributes over 70% of the total renewable energy installed capacity in India. The growth has been a result of variety of incentives being offered by various state governments. Governments in states with significant wind energy resources have been offering financial incentives like tax breaks, preferential feed-in tariffs and duty waivers to wind energy project developers. And while the wind energy sector is the most mature among all the renewable energy sectors in India, there is still a massive scope of expansion in this sector. The wind energy resources have been gravely underestimated at around 49 GW. The wind resources estimation done by the Indian government was based on the mast heights of 50 m whereas today wind turbines with hub heights of over 80 meters are available. According to the World Institute of Sustainable Energy India's onshore wind energy resources are between 65-100 GW.

Policies announced by the Central government are also likely to fuel capacity addition in the wind energy sector. The state governments have been obligated to procurement a set minimum percentage of their energy consumption from renewable energy sources, under the Renewable Purchase Obligation (RPO). The state governments can set their own targets but need to increase those targets by at least one percent every year. The states which fail to fulfill their RPOs must purchase Renewable Energy Certificates from renewable energy-based power plants. Many states with substantial wind energy resources have announced wind-specific RPO targets.

Several major wind energy technology companies have set up base in India. Companies like GE Wind, Gamesa, Enercon, Siemens, Suzlon, Kenersys and Vestas have launched latest and state-of-the-art products for the project developers. Therefore, it is safe to say that capacity addition in the wind energy sector in India is likely to continue at a rapid pace. However, whether the installed capacities projected in the GWEC report are achieved would depend on the government policies in the medium to long-term. According to experts in wind energy in India, the performance in 2008 is hardly surprising, given the problems on the ground in different States. Local issues and tariffs continue to be the main problem areas for the wind energy sector in the country (The Hindu Business Line, 2011).

Worldwide wind capacity reached 215,000 Megawatts (MW) by the end of June 2011. The first six months of 2011 added 18,405 MW of wind power capacity. This increase represents 15% more than in the first half of 2010, when only 16,000 MW were added. Global wind capacity grew by 9.3% within six months and by 22.9% on an annual basis. According to the report, five countries-China, the United States, Germany, Spain and India-continue to do the market and the demand for wind power. Together, those countries comprise 74% of the global world capacity. China continues to dominate the world market for wind power. In the first half of 2011, it added 8 GW of capacity while the United States added 2.3 GW. Table 1 shows the position of India globally which provides the details of capacity addition in 2011.

Wind energy currently meets 5.3% of the EU's electricity consumption from an installed capacity of 84.3 GW. The European Wind Energy Association's scenarios show that wind energy in 2020 should meet 15.7% of EU electricity demand from 230 GW and by 2030, 28.5% from 400 GW. Indeed, EWEA believes wind energy can provide half of Europe's power by 2050, with the remainder from other renewable sources. To ensure the continued buoyancy of the wind energy sector and the path to 100% renewable in 2050, EU renewable legislation is needed now for the period after 2020. This should follow the successful legislation so far by setting an ambitious, binding renewable target for 2030.

In the second half of 2011, an additional capacity of 25500 MW is expected to be erected worldwide, which would bring new annual installations to 43'900 MW, compared with 37'642 MW in the year 2010. The total installed wind capacity is projected to reach 240'500 MW by the end of this year. This capacity can cover almost 3% of the electricity demand all over the world (Half Yearly Report, 2011).

Table 1: Ranking of top ten countries according to total capacity

Position	Country	Total capacity by June 2011(MW)	Added capacity firs half 2011 (MW)	Total capacity end 2010 (MW)	Added capacity half 2010 (MW)	Total capacity end end 2009 (MW)
1	China	52,800	8,000	44,733	7,800	25,810
2	USA	42,432	2,252	40,180	1,200	35,159
3	Germany	27,981	766	27,215	660	25,777
4	Spain	21,150	480	20,676	400	19149
5	India	14,550	1,480	13,065	1,200	11,807
6	Italy	6,200	460	5,797	450	4,850
7	France	6,060	400	5,660	500	4,574
8	United kingdom	5,707	504	5,203	500	4,092
9	Canada	4,611	603	4,008	310	3,319
10	Portugal	3,960	260	3,702	230	3,357
Rest of the world	29,500	3,200	26,441	2,750	21,852	
Total	215,000	18,405	196,682	16,000	159,766	

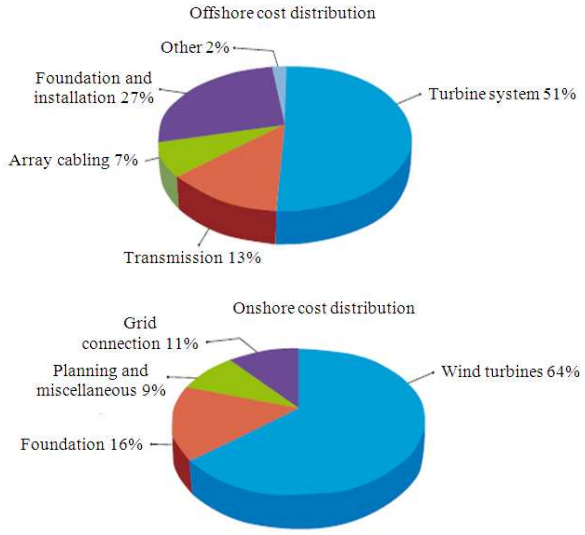

Fig. 1: Cost distribution of offshore and onshore wind projects

Offshore prospects in India: While designing wind turbines for offshore applications, it is important to note several other additional important factors. The foremost is of course the sea state and marine conditions. Other equally important aspect is the evacuation arrangements and the operation and maintenance aspects. Unlike the onshore projects, the cost of wind turbine forms only about 60-64% of the project cost. The evacuation facilities will range between 20-25% depending on the distance from the shore and as to whether on AC or DC bus is employed. High voltage DC transmission can be considered as an alternative for transmitting power for distances more than 50k m sec from the shore. Foundations again are expected to cost less on a per KW basis for larger wind turbines as the water depth goes up. Foundation costs will be in the range of 25-27% of the project cost. Project management and other expenditure will be at about 9%. The detailed economics of offshore and onshore wind power projects are given in Fig. 1.

About 53% of electric power in India is generated from coal and lignite based steam thermal plants, which contribute a lot to air pollution. The need of the hour is a cleaner and renewable source of energy, in which off shore wind power can play a major role. The onshore wind power potential for India has been estimated as 15000 MW (<60 m depth). There are many potential sites in Indian waters and still this huge potential remains untapped (Awesome Inc., 2011).

India is blessed with a coastline of about 7, 600 km. Under a National wind monitoring programme, winds have been measured at 54 locations on the coastline In Wind Chronicle, 2008/09. The western coastline has modest potential at sea level. Measurements along the coastal Kerala and Karnataka have shown marginal site indicating that winds are rather poor in the first hundred meters. Elevated hills of Goa also exhibit similar trends. Coastline around Gujarat has reasonable potential, but is prone to cyclonic conditions that can be very severe. East coast also has a modest potential but is prone to cyclonic conditions, which is again not very comfortable situation.

The southern tip of India starting from Kanyakumari up to Rameshwaram has shown some promising values. Rameshwaram indicates wind power density of 603 W m^{-2} at 50 m agl and Kanyakumari has shown wind power density in the range of 370 W m^{-2} at 30 m agl. Table 2 and 3 indicates the wind characteristics at Kanyakumari and Rameshwaram at different altitude from ground level for the period of January 2010 to December 2010.

New players: The wind turbine equipment industry in the country is currently undergoing a change with the new players entering the market. Many companies, some with European tie-ups, have either set up turbines of 1 MW and above, or are in the process of doing so.

Table 2: Wind characteristics at kanyakumari station

	Level m agl 10 m		Level m agl 30 m	
Month	Wind speed (m/sec)	Wind power density (W/m^2)	Wind speed (m/sec)	Wind power density (W/m^2)
January	5.07	187.0	8.06	473.1
February	4.60	174.4	6.73	289.1
March	4.93	169.1	6.05	237.9
April	4.89	135.0	5.57	193.3
May	6.63	248.6	7.71	383.8
June	7.16	281.3	8.37	447.8
July	7.78	336.7	8.98	515.1
August	7.92	357.4	9.18	558.4
September	6.02	297.1	6.90	443.1
October	4.93	188.1	6.48	343.1
November	3.23	33.4	6.17	212.7
December	1.85	69.9	3.44	380.4
Annual	5.42	206.5	6.97	373.1

Table 3: Summary of wind data at rameshwaram

Month	Wind speed at 20 m agl	Wind power density at 20 m agl (W/m^2)	Peak wind speed (m/sec)	Lull hours wind speed (m/sec)	Prevailing direction
January	7.25	293.0	23.24	6.110	NE
February	5.74	161.8	15.86	16.11	NE
March	4.80	107.0	15.19	34.72	NE
April	4.96	137.8	27.71	36.38	S/SW
May	7.49	358.6	21.45	12.77	S/SW
June	8.83	546.3	20.55	8.610	SW
July	7.51	367.2	22.34	14.72	SW
August	6.69	256.4	18.10	11.94	S/SW
September	6.76	288.7	19.66	18.61	S/SW
October	5.51	177.2	21.67	30.55	S/SW
November	6.60	234.1	21.45	15.55	NE
December	7.55	325.7	19.20	6.110	NE

With the good wind sites already taken, these companies are marketing turbines that are ideal for low or medium wind sites. Some of the new players that have forayed into the market include WinWind, a subsidisry of the sterling group; Regen Powertech, a tie-up with Vensys of Germany; Leitner Shriram, a JV between Shriram EPC and Leitwind of Holland; Lanco, collaboration with German company, Sanjay Ghodawat Group, a licensing arrangement with an Austrian company and Kenersys, a Bharat Forge Group Company.

Central Arecanut and Cocoa Marketing and Processing co-operative Ltd. is preparing to become self sufficient in power consumption by setting up a wind energy plant at Hoovina Hadagali in Bellary district of Karnataka. They have signed a Memorandum of Understanding with Suzlon for setting up a 1.25MW plant that will generate electricity for the consumption of the factory. Approximately Rs.7 Crores is expected to be invested in this project and the generation cost will be around Rs.1.78 per unit, to which another 7% will be added as wheeling charge. In all, we will get power at Rs.2.30 a unit, which will control the cost.

Shiriram EPC has tied up with Holland based company Leitwind, to manufacture 1.5 MW capacity wind turbine generators at its Gummdipoondi plant near Chennai. The new company called Leitner Shriram, will manufacture 120 wind turbines per year and raised the capacity to 250 wind turbines from 2010.

WinDForce Management Services Pvt. Ltd. has reported identification of nearly 3,000MW executable wind farm investment in India. This achievement comes in less than a year of the company launched and is in addition to the achievement of the first 25MW wind farm project being implemented by WinDForce is nearing completion.

Generation of wind power: Energy is a major input for overall socio-economic development. Use of fossil fuels is expected to fuel the economic development process of a majority of the world population during the next two decades. However, at some time during the period 2020-2050, fossil fuels are likely to reach their maximum potential and their price will become higher than other renewable energy options on account of increasingly constrained production and availability. Therefore, renewable energy since are expected to play a key role in accelerating development and sustainable growth in the second half of the next century, accounting to 50-60% of the total global energy supply.

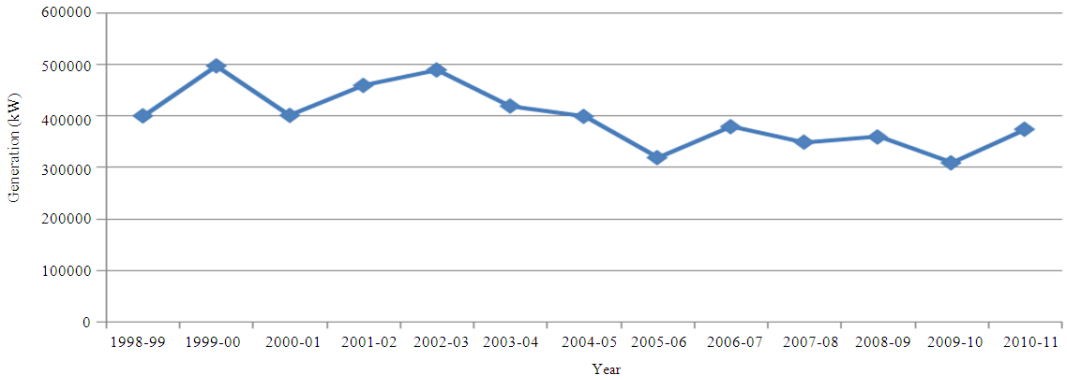

Fig. 2: Muppandal-225kW wind turbines generation details for the period of 1998-2011

After the creation of a separate Ministry in 1992, special emphasis was given in the Eighth Plan to generation of grid quality power from renewables. The total installed capacity of power from renewables today stands at nearly 1350 MW with contribution from wind power of nearly 1000 MW.

Ministry of Non-conventional Energy Sources (MNES) are implementing the world's largest wind resource assessment programme, which forms the backbone of their wind exploitation efforts. Preliminary estimates indicate a potential of about 20,000 MW. Scientific surveys are being intensified to identify specific viable and potential sites. A recent study undertaken to re-assess the potential, places it at about 45,000 MW. Assuming a grid penetration of 20%, a technical potential of about 9,000 MW is already available for exploitation in the potential States. 160 sites have so far been identified in 13 States. Survey work is in progress in 24 States.

To strengthen the wind energy technological infrastructure in the country, the Government of India has set up a "Centre for Wind Energy Technology" at Chennai along with a "Wind Turbine Test Station" at Kayathar in Tuticorin District. The Government of Tamil Nadu helped in the establishment of the centre by offering lands at Chennai and Kayathar. The centre will serve as the technical focal point for Wind Power Development in the whole country with the main aim of providing support in the areas of R and D, Wind Resource Assessment, Type approval, certification, training. To the industry, developers, investors and government authorities in the wind energy sector.

In Muppandal station, monthly generation of 225KW (49 machines) wind turbine average generation details for the period of 1998-2011 is plotted in Fig. 2.

For the purpose of easy comparison, the daily generation has been converted to kilowatt hours per megawatt basis under ideal conditions of 100% grid availability and 100% machine availability. The daily generation details of 0.500MW Ramco Industries Ltd.(RIL-1) at Aralvaimozhi pass, 1.25MW Ramco Industries Ltd.(RIL-2) at Aralvaimozhi pass, 1.5MW ACC Ltd. (ACC) at Aralvaimozhi pass, 1.50MW VVD and Sons Pvt Ltd. (VVD Sons) at Aralvaimozhi pass, 0.250MW Tamilnadu Newsprint and Papers Ltd.(TNPL-1) at Shengittah pass, 0.750MW Tamilnadu Newsprint and Papers Ltd.(TNPL-2) at Shengittah pass, Rangamma Steels and Malleables(RSM) AT Palghat pass and 0.230MW Rajinikanth Foundation(RF) at Karnataka are plotted in Fig. 3-5 the month of September, October and November 2008.

Energy production estimates: The amount of energy that a wind turbine makes each year depends on many factors, but the significant ones are the wind speed at hub-height and the size and type of turbine. The Table 4 gives a rough estimate of the amount of energy that a commercial-scale wind turbine could make. This information may be used to estimate the impact of site choice (i.e., varying wind speeds) and turbine choice (e.g., varying sizes.)

Table 5 details the new industry targets which outline that the annual installation rate will continue to increase, but at lower rates.

The high growth of the last years has been based mainly on the German and Spanish markets. Market forecasts for the next few years indicate that annual installation will stabilise in Spain and will decrease in Germany. A 3.5% increase in annual installation is assumed for the year 2003, which decreases gradually to 1.3% in 2010. This corresponds to a 25.7% increase in total installed capacity in 2003 gradually decreasing to 10.3% in the year 2010. Table 6 summarizes the monthly generation details for advanced horizontal axis 1.25 MW wind turbines in wind farms, since the date of commissioning.

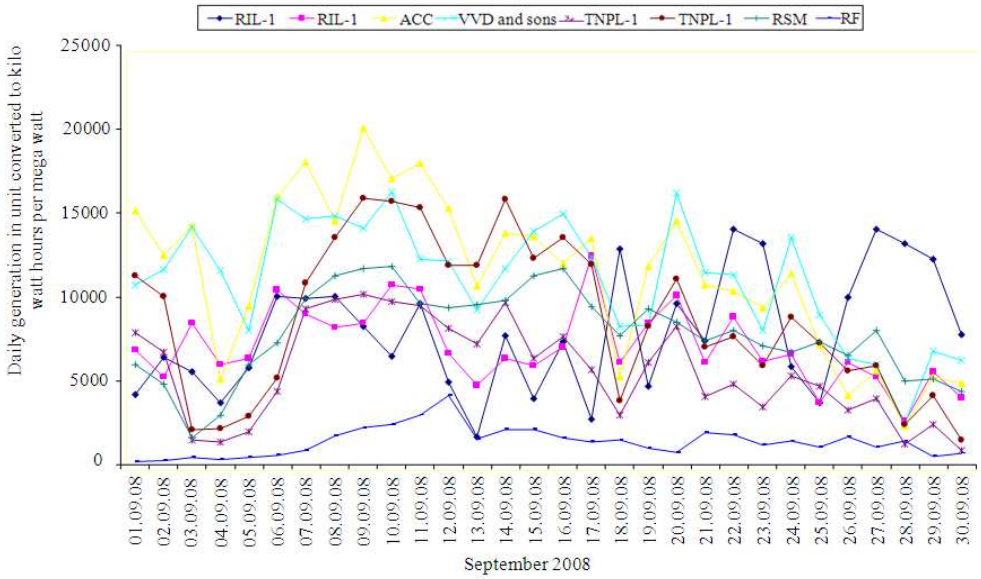

Fig. 3: Wind Monitor graph for the month of September 2008

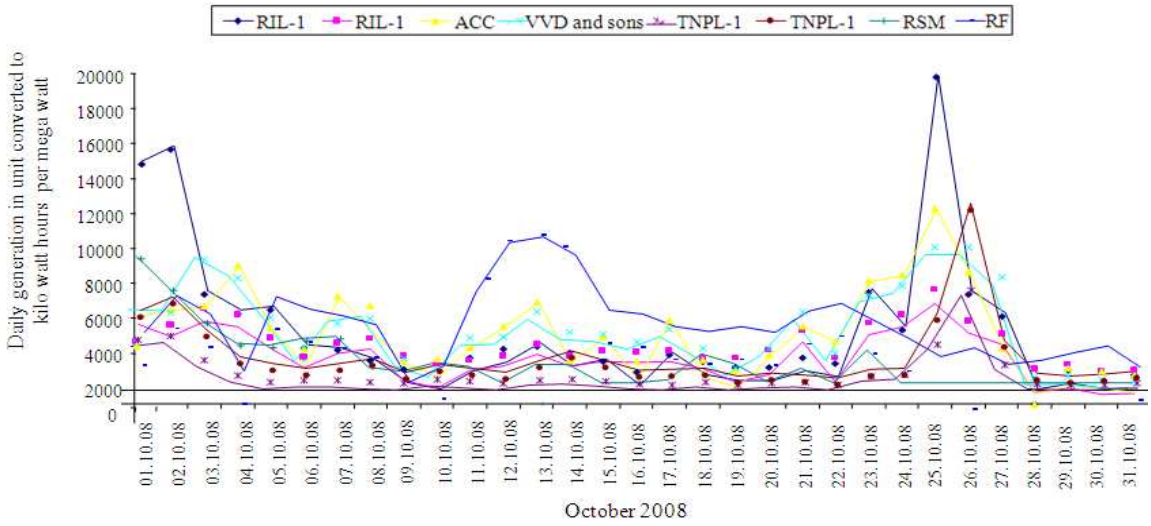

Fig. 4: Wind Monitor graph for the month of October 2008

Table 4: Estimated power generation of 1.5-1.8 MW wind turbine

Annual average wind speed	Estimated capacity factor (%)	Estimated energy/yr per 1.5-1.8 MW turbine in MWh
6.0 m sec^{-1}	22-25	3,320-3,500
6.5 m sec^{-1}	27-30	3,920-4,190
7.0 m sec^{-1}	31-34	4,500-4,880
7.5 m sec^{-1}	35-9	5,150-5, 54

Thus the maximum annual energy production from 1.25MW wind turbine was estimated as 4272707 kWhr in 2005-2006.The annual energy production since its date of commissioning is plotted in Fig. 6. Based on these real calculations, we concluded that the number of wind electric generators installed by m/sec. Suzlon Energy Ltd. in Aralvaimozhi, Kanyakumari District is 486 and its total generation detail is tabulated in Table 7 since 2004. At the end of 2011, the company has planned to install 480 additional wind Turbines but due to confidence and wind availability, the Suzlon Energy Ltd. has installed 486 wind generators before Sep'11 with the average grid availability of more than 90%.

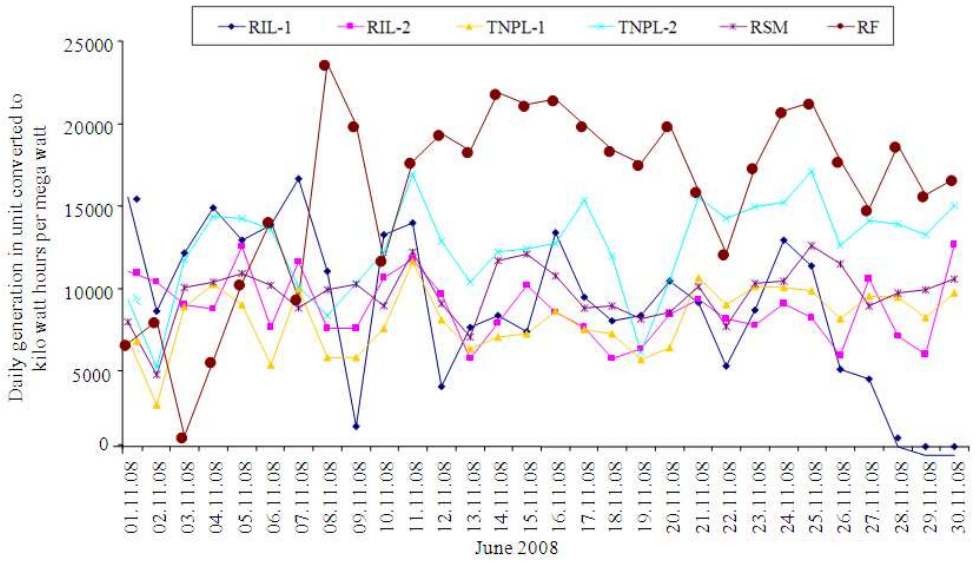

Fig. 5: Wind Monitor graph for the month of November 2008

Table 5: Wind power target projections

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
New capacity (MW)		4.500	5.700	5.900	6.100	6.300	6.450	6.60	6.750	6.900
Cumulative capacity (MW)	12.800	17.300	23.000	28.900	35.000	41.300	47.750	54.35	61.100	68.000
Annual growth of new capacity	26.7%	3.5%	3.4%	3.3%	2.4%	2.3%	2.3%	2.2%		

Table 6: Generation details of 1.25MW wind turbine since the date of commissioning

In 2004-2005		In 2005-2006		In 2006-2007		In 2007-2008		In 2008-2009		In 2009-2010		In 2010-2011		In 2011-2012	
Month	Genera-tion	Month	Genera-tion	Month	Genera-tion	Month	Genera-tion	Month	Genera-tion	Month	Genera-tion	Month	Genera-tion	Month	Genera-tion
----	----	5-Apr	101894	6-Apr	144268	7-Apr	73108	8-Apr	135368	9-Apr	62159	10-Apr	85662	11-Apr	100664
-----	----	5-May	521040	6-May	413312	7-May	250130	8-May	324860	9-May	351394	10-May	406162	11-May	386188
4-Jun	423463	4-Jun	474929	6-Jun	523320	7-Jun	396696	8-Jun	375086	9-Jun	325641	10-Jun	436246	11-Jun	398426
4-Jul	381617	5-Jul	447175	6-Jul	573657	7-Jul	416359	8-Jul	491604	9-Jul	311026	10-Jul	388624	11-Jul	416326
4-Aug	181032	5-Aug	590542	6-Aug	550475	7-Aug	374777	8-Aug	390843	9-Aug	335549	10-Aug	412668	11-Aug	388947
4-Sep	373844	5-Sep	495728	6-Sep	240766	7-Sep	360700	8-Sep	255348	9-Sep	318857	10-Sep	368852	11-Sep	344128
4-Oct	161051	5-Oct	229536	6-Oct	179926	7-Oct	166860	8-Oct	203901	9-Oct	142414	10-Oct	182614	----	----
4-Nov	142098	5-Nov	343054	6-Nov	238329	7-Nov	69066	8-Nov	106078	9-Nov	204517	10-Nov	193412	----	----
4-Dec	390215	5-Dec	341143	6-Dec	340363	7-Dec	119633	8-Dec	390182	9-Dec	306164	11-Dec	322126	----	----
4-Jan	408584	6-Jan	335008	7-Jan	221232	8-Jan	241094	9-Jan	336753	10-Jan	350412	11-Jan	281264	----	----
5-Feb	218715	6-Feb	217217	7-Feb	191657	8-Feb	174608	9-Feb	182234	10-Feb	162864	11-Feb	178326	----	----
5-Mar	120299	6-Mar	175441	7-Mar	110531	8-Mar	54418	9-Mar	70173	10-Mar	90412	11-Mar	88412	----	----

Table 7: Growth rate of wind turbines in aralvaimozhi by suzlon energy Ltd

Categories	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	Up to till now
Total machines	32.00	82.00	220.00	325.00	399.00	408.00	426.00	441.00	462.00	486.00
Total generation	6554812.00	157372390.00	411853599.00	568491716.00	874894829.00	472099150.00	494833202.00	656171122.00	724166184.00	73189234.00
Average generation	468201.00	3814682.00	3156441.00	2384354.00	2721134.00	1255535.00	1230928.00	1562312.00	2386334.00	2754126.00
Average m/c Avail	96.08%	96.87%	97.68%	96.39%	97.77%	98.42%	94.36%	95.23%	96.84%	97.63%
Average Grid Avail	91.86%	96.38%	92.84%	91.05%	92.87%	92.13%	96.48%	91.34%	94.86%	95.40%

Based on the real calculations, we arrived that for the total wind electric generators installed, the expected economic life for the wind farm is 30 years, based on manufacturers field experience of nearly 15 years. Periodic replacement or refurbishment of major subsystems such as rotor blades or generator windings are assumed to be necessary during the 30-year period, although not all manufacturers claim to require blade replacement in that period. Some researchers feel that sufficient data on component cycle loads, composite material performance prediction and extended operation over a 30-year period do not currently exist to make accurate predictions of lifetime as long as 30 years.

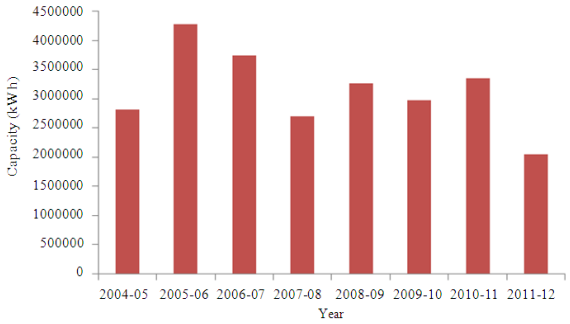

Fig. 6: Energy production summary of 1.25MW wind turbine

MATERIALS AND METHODS

The international energy agency predicts that by 2030, more than 28% of the world's energy consumption will be in India and China.

The energy consumption by India and China exceeds that of the US and therefore, it is essential that a significant part of that energy comes from renewable sources. There has been rapid growth in the installation of wind power in India, especially towards the southern and western states. Almost all the big global manufacturers of wind turbines are present in India with regard to design installation and production of their turbines.

This has contributed to India being the fifth largest installation base for wind turbines in the world as of 2009 (Purohit and Purohit, 2009).

The ministry of new and renewable energy stated the country's wind power potential is 45GW, over the three times of the present installed capacity of 14,550 MW. It is estimated that 6,000MW of additional wind power capacity will be installed by 2012. Wind power currently accounts 6% of total installed capacity, 1.6% of the country's power.

The Indian Government has announced a generation based incentive for wind energy projects that entitles new wind energy projects to access a benefit of Rs.500 per MWh for the next ten years. This is expected to significantly boost the wind energy capacity addition in the country by providing parity to investors who were not in a position to access the existing fiscal incentives.

For the west coast state, which has an estimated wind power potential of 4,584MW, this would be the highest ever addition in any year to date. Also during the second quarter (July-September) of the current financial year, two onshore wind projects in India were approved. Both projects are in the state of Karnataka, the first project is an 18MW wind farm near Arasinagundi while second is a 21MW wind farm near Anabaru.

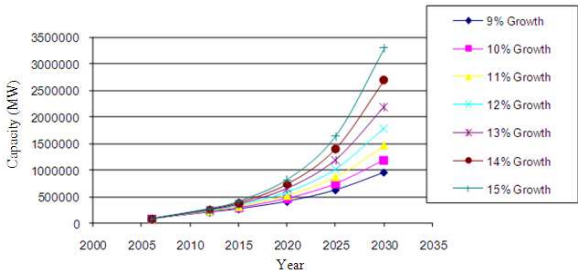

Fig. 7: Projections of installed capacity in India

The International Energy Agency predicts that the world's energy needs will be about 60% higher than now (International Energy Outlook, 2009). Over the last four years or so, India has added more than 6,300MW of wind power generation capacity accounting for more than 60% of the total installed capacity of 9,645 MW. The Fig. 7 presents the total installed capacity needed in India assuming at 9, 10, 11, 12, 13, 14 and 15% growth rates. Even if we go by the lowest growth rate of 9%, situation becomes rather alarming by 2020.

RESULTS AND DISCUSSION

Most of the research activities resulting in the new generation of wind turbines are currently being done abroad. This needs to change, as India is not short of fine minds that can take over the mantle. This needs to be facilitated by the industry to carry out these activities within the manufacturers or augmented capacities but certainly within the country. This will assist in the development of more indigenous manufacturers with the capabilities of research and development strengthening and spreading the same within the country.

The implementation of this principle has become more important in the context that there have been issues pertaining to the design done abroad vis-à-vis the requirements pertaining to Indian conditions especially with grid frequency variation, number of grid outages, temperature. One might argue that the Indian conditions could be handled abroad but the core challenge of strengthening minds for research and design activities of wind turbines in India will certainly not be met. This will also assist in another core issue of designing wind turbines suited for lower wind regimes as the availability of most of the potential first class sites is slowly reducing even though re-powering and intercropping concepts are being looked into. The collective initiatives taken will assist India to continually improve the technology without looking for technical aid from outside the country.

In India, the procedures for testing and certification were put in place in the late 90's with the focus on evaluating the design to ensure safe and optimal performance and also for improving the efficiency of wind turbines. Most of the wind turbines introduced in the market during that period were designed elsewhere with more focus on the conditions prevailing in those countries however design changes are needed to be made in the Indian context. Testing of wind turbine is undertaken by Centre for Wind Energy Technology (C-WET) in India. However, testing of major components especially the blades requires major financial resources and is yet to be established. The inter exchange of information during a certification process in India may not be comparable to a growing overseas wind industry due to many reasons. The design of a wind turbine results in design documents which are needed as to be understood for presenting to an agency as per the requirements for evaluating in the light of when these documents were generated and under the gambit of which IEC standard and so on. Therefore, creating awareness and submission of the design documents is also a challenge for the successful certification process in India.

India has gained a lot of experience in ocean technology but is yet to install its first offshore wind turbine. There are a number of offshore wind farms abroad near the coasts of Denmark and Sweden and India is likely to draw upon the experience of these wind farms to establish its first offshore wind turbine. However, establishing an offshore wind turbine and demonstrating its viability is a challenge that India will have to take head on the near future

CONCLUSION

The modern technology, wind turbine players and development of the wind turbine industry in India emphasizes India's unique strategy of interactive learning for developing wind turbine industry. It clearly indicates as solution to meet the Global requirements through wind turbine industry. The growth clearly shows that how the Indian Government, Non renewable energy sectors and Tamil Nadu help the private sectors to increase the production of wind turbines. Knowledge of the wind velocity at different sites could be used to estimate the wind power, average machine generation and grid availability. This attempts to assess the India's gross potential, position in the world market, wind resource and variation of wind speed with respect to site, different growth rate. Preliminary resource investigation at Rameshwaram and Kanyakumari indicates modest wind along the coastal line. However, it was found that whatever offshore data collected was not continuous and lot of uncertainty was involved as most of it was extrapolated. As such further investigations are required for validation of data collected with an objective to examine the feasibility for setting up of demonstration wind offshore wind farm. This has been an ongoing process to discover the best combination for a given environment in which the wind turbine has to operate and with various challenges met, India would be in a better position to develop and carry forward its own determined initiatives to better the prospects of the wind turbine technology in the coming years. This sectoral innovation systems framework is especially useful tool for analyzing the growth of wind turbine industry and in its essence to preserve the environment with reduction in carbon dioxide emissions.

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