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A Review: Repowering of Indian Wind Farms

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ABSTRACT: This paper represents the powering prospective need of wind farm in the Indian power sector. This is done by creating the repowering potential analysis for small and big size of the wind farm generator. Energy is the most important element of socio-economic development and nation's economic growth. Renewable energy sources can play an enormous role to fulfill this need of energy. These sources will not only improve independency of energy but also helps in many ways such as mitigation of climate revolutionize, rapid progress of rural areas, improved health status and will be the best way to move towards sustainable improvement. Renewable energy sources like wind energy are identified by International Energy Agency as key element to reduce fossil fuels dependency and helpful tool to fight global warming. Wind energy is definitely a form of solar energy produced by differential heating on the earth surface. Wind's kinetic energy can be captured and converted in to electricity via wind turbines.

Keywords: Integration of wind power, wind-turbine generators, Repowering technology, power quality.

I. INTRODUCTION

Wind Power has a long history in India. For close to two decades the sector has witnessed a number of challenges, opportunities and changes. Over this time, the industry has made path breaking enhancement in turbine efficiency and reliability. Today we have turbines that offer a viable investment in low wind sites while also ensuring improved reliability. This advancement in technology also offers another lucrative opportunity. RePowering!!.

Wind turbines that are over 15 years old cover a landscape that could easily be called the 'Gulf of Wind Energy in India'. These turbines hardly do justice to the potential that this region houses. The performance has been below, and it has been found that most of the turbines that are underperforming are in wind sites, which have much lower speeds. It is therefore natural to explore the option of replacing these with modern turbines that could offer better returns and more power than before. In Tamil Nadu, about 60 per cent of small wind turbines (<400 kW) installed before the year 2000 are operating with plant load factor (PLF) ranging from 10 to 15 per cent, whereas the new technology wind turbines can operate at a PLF range of 27 to 32 per cent in the same sites [13].

India wind energy sector has shown the potential growth in the area concerned for the repowering as it has lost the rating in total installed capacity in comparison to china. Due to this in the last two years the installation capacity is decreasing [14]. Investments into the sector have increased significantly to development of the wind energy market. The share of renewable energy was 7.7% in the cumulative installed capacity in MW.

In India as per the Indian government by 2012 expects renewable energy to contribute 10% of the total power generation capacity and have 4%–5% share in total electricity generation. It is estimated that 6,000 MW of additional wind power capacity will be installed in India by 2012. As per the report of global data the wind market repowering installed capacity grew by 24994 MW in the 2011, and the compound annual growth rate (CAGR) is estimated of 23.3 %. The market across the world seems tremendous growth for the re-powering of wind farm. The strong economic growth expected in near future calls for substantial addition to India's Generating capacity. Fossil fuels and hydro-electricity will continue to play a dominant role in the energy sector of the country in the next few decades. As per the wind farm industry growth the older technology replace the newer technology and big size machines replace the new small size machine this will lead to development of the technology trends. For the same the integration of the plant unit is required [15]. How wind technology has advanced over the years is the repowering of the world's first wind turbines in Altamont Pass, California is a kind of example.

Non-renewable, fossil fuel resources therefore need to be used prudently. Being limited and non-renewable, fossil fuel resources therefore need to be used prudently. Use of fossil fuels also leads to environmental problems such as global warming and climate change. At, the same time the existing technologies of production, transmission and distribution of electricity as well as end-use have inherent inefficiencies. It is, therefore, imperative to diversify the country's energy supply [16].

A. Challenges for Repowering

- **Turbine ownership:** Repowering will reduce the number of turbines and there may not be one-to-one replacement.
- Thus, the issue of ownership needs to be handled carefully.
- **Land ownership:** Multiple owners of wind farm land may create complications.
- **Power Purchase Agreement:** PPAs were signed with the state utility for 10, 13 or 20 years and the respective electricity board may not be interested in discontinuing or revising the PPA before its stipulated time.
- **Electricity evacuation facilities:** The current grid facilities are designed to support present generation capacities and may require augmentation and upgrading.
- **Additional costs**: The additional decommissioning costs for old need to be assessed.
- **Disposal of old turbines:** There are various options such as scrapping, buy–back by the government or manufacturer, or export. Local capacity may need to be developed.
- **Incentives**: One of the primary barriers to repowering is the general lack of economic incentive to replace the older WTGs. In order to compensate for the additional cost of repowering, appropriate incentives are necessary.
- **Policy package**: A new policy package should be developed which would cover additional project cost and add-on tariff by the State Electricity Regulatory Commissions (SERCs) and include a repowering incentive (on the lines of the recently introduced generation-based incentive scheme by MNRE) [17].

B. The Wind Power Development

The contribution from wind power in a global electricity context, at the beginning of 2006, stands at 59,322 MW. Around 70% of the world wind power capacity is installed in Europe. By the end of 2005, wind energy has achieved the European Commission's target for 2010, five years ahead of the time. Wind power plays a significant part in the power production mix of Denmark, Germany, Spain, and some other countries. Denmark today has the highest wind power penetration level in the world – during off-peak, wind power can reach such a high penetration level that it can meet the total Danish demand. Germany leads the world in installed wind power capacity most of that is located outside the load centers [6, 12]. Currently (2006) wind power contributes about 20% of Denmark's total power and 6% of the total Germany power supply. Due the continuing high growth rate, Spain now has more than 10GW of installed wind power than 67% of the world market for wind energy plants is shared by European manufactures, about 18% by the USA manufactures and 6.1% by suppliers in India.

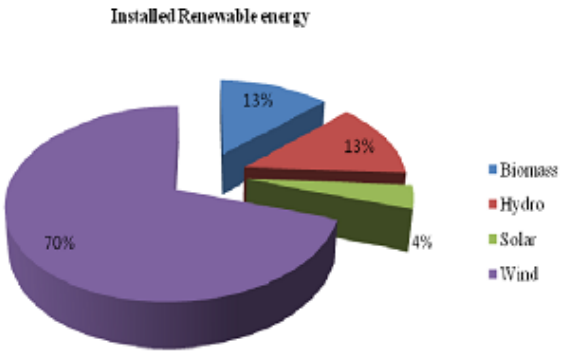

Fig. 1. Renewable Power Sector in India (Source: MNRE).

As per MNRE (Fig. 1), wind power accounts for the largest share of renewable power installed capacity i.e.70 percent (2012), as compared to the other renewable sources.

Nowadays, the large manufacturers of wind turbines in the world market have attempted to expand towards new markets as in Asia, Latin America and Caribbean countries, and the demand for installation of wind power plants in these countries has grown. Asia registered strong development, mainly driven by the markets in India and China. [5] The present and progressive scale of integration has to a head serious concern about the impact of such a scale of wind penetration on the future safety, stability, reliability and security of the electricity system.

C. Repowering in India

The average size of a wind turbine has increased from .77MW in 2004 to 1MW in 2009 and the MW-class turbine now comprise over half of the new wind power capacity installed in the country. One of the immediate benefits after repowering the old wind turbines is that more electricity can be generated from the same site. Inspite of lack of policy and incentive, there are many problems which are faced during repowering such as disposal of old machines, fragmented land ownership in existing wind farms, clarity on the feed-in tariff offered to newly repowered projects and constrained evacuation of the extra power generated. A study on repowering potential conducted by WISE (World Institute of Sustainable Energy) for the Ministry of New and Renewable Energy estimated India's Current repowering potential at approximately 2,760 MW [13].

D. Wind Study and Micro siting

Micrositing is necessary for the optimisation of wind farm layout and locating new turbines as per the norms specified by respective state regulatory authorities. Since there would already be an existing wind farm, site prospecting is not an issue and it only needs to be validated with current wind/meteorological data to finalise the capacity and number of new wind turbine generators (WTG) that need to be replaced.[13] Micrositing for a RePowering site would be a real challenge for the site personnel due to the presence of existing wind turbines in and around the site. Apart from maintaining the correct distance between the machines being proposed, it should be ensured that none of these machines violates the norms regarding inter-machine distance prevalent in the corresponding state. Any discrepancy in the micrositing of the existing machines would adversely affect the micrositing of the new wind turbines.

E. Removal of Existing Turbines

It is important to decide on the number and capacity of older machines to be removed as per the micrositing details. Economic feasibility/viability is an important factor influencing the capacity and quantity of older machines to be removed based on the RePowering factor. The removal of older running machines should be timed and planned properly to avoid any generation losses and at the same time.

F. Current State of RePowering In India

For 18.98 GW of installed capacity through WTG's in India, currently there are approximately 35,500 number of wind turbines. T 225 kW to 2000 kw each. Out of these, a large area is covered by more than 8,500 small wind turbines (<500 kW capacity).The number of WTG's installed before 2002 stands at approximately 4400 (amounting to approximately 1.38 GW of installed capacity)while the number before 1997 stands at approximately 2663 (amounting to approximately 0.69 GW of installed capacity). Present day repowering solution targets old WTG's with a capacity of 500 kW or less. Therefore, the number of WTG's that can be repowered stand at 2663 if WTG's older than 1997 are targeted and at 4400 if WTG's older than 2002 are targeted with Tamilnadu and Gujarat being the maximum contributors while Andhra Pradesh, Maharashtra, Rajasthan and Karnataka not far behind. Those WTG's which have a capacity of 500 kW or less but have not completed 10 years since commissioning are not assumed to be available for repowering as yet. In India, repowering projects have been initiated at 2 sites till date LMW (Laxmi Machine Works) near Coimbatore and Fenner India near Nagercoil. [12] The LMW Coimbatore site had 29 WTG's of 300 kW capacity each and 2 WTG's of 500 kW capacities each prerepowering, which are planned to be repowered in phases to a final number of 15 WTG's of 850 kW capacities each. In phase 1, 8 WTG's of 300 kW capacity each and 2 WTG's of 500 kW capacities each have been replaced with 4 WTG's of 850 kW capacities each. At the Fenner India Nagercoil site, 11 WTG's of 225 kW capacities each have been replaced with 3 WTG's of 850 kW capacities each. Let us look in Table 1 at the change in installed capacity and potential electricity generation for a sample period of 1 year for these 2 sites. As can be seen from the table above, with an increase in the installed capacity of just 1.28% (for both sites combined), the total potential increase in the electricity generation for a sample period of 1 year will be 52.25% (for both sites combined). However, these sites have not been completely repowered yet which when done will lead to a much higher % increase in electricity generation. If a commonly accepted thumb rule is believed, repowering of old WTG's results in double the installation capacity and triple the energy output with half the infrastructure. If we use this capacity of these wind turbines range expanding use of renewable energy sources as a component of energy [5-4].

G. Wind Turbine Research Station

NIWE/CWET owned R&D infrastructure machines at Kayathar comprises of first generation 9 WTGs of 200 kW capacity which are 22 years old and in operation, one 600 kW constant speed WTG, and one latest generation WTG of 2000 kW (variable speed) capacity

are kept in operation with continuous monitoring for research on experimental techniques and measurements.[2] A novel battery operated vehicle has been converted by the technical staff of WTRS, NIWE/CWET for solar charging instead of charging from grid [3]. This people-cum-material mover in the site can be operated by any unskilled person and it is fully now powered with solar energy showcasing the carbon emission reduction possible in avoiding fossil fuel powered vehicles.

Table 1. Installed Capacity and Electricity Generations of Coimbatore Nagercoil.

Site	Pre Repowering Installed Capacity (MW)	Electricity Generation assuming a CUF of 16.42% (Million Units)	Post Repowering Installed Capacity (MW)	Electricity Generation assuming a CUF of 25% (Million units)
LMW Coimba-tore	**3400**	**4891**	**3400**	**7447**
Fenner India Nagercoil	**2475**	**3560**	**2550**	**5420**

(Source : Energetica India, Nov-Dec13)

Table 2: Installed Capacity and Electricity Generations.

Site	Installed Capacity (GW)	CUF	Electricity Generation (BU)
Pre-repowering	**1.38**	**16.42%**	**1.98**
Post-repowering	**2.76**	**25.00%**	**6.04**

(Source : Energetica India, Nov-Dec13)

To serve as the technical focal point for wind power development in India, for promoting and accelerating the pace of utilization of wind energy and support the growing wind power sector in the country. To develop and strengthen the facilities and capabilities, evolve strategies, promote, conduct, co-ordinate and support research and development programmes to achieve and maintain reliable and cost effective technology in wind power systems. To analyze and assess wind resources, based on the data available from various sources and prepare wind energy density maps / wind atlas / reference wind data. To prepare and establish Indian standards on wind turbines and to develop and implement certification system in India, and to establish world class facilities, conduct and coordinate testing of complete wind power systems and components according to internationally accepted test procedures and criteria, whereby the total performance that includes power performance, power quality, noise level, dynamics and operation and safety systems is tested according to agreed protocols. [9][11]To accord type approval/type certification to wind turbines in accordance with Type Approval Provisional Scheme TAPS 2000 (amended).

(i) To undertake Human Resource Development programmes for the personnel working in the wind energy sector.

(ii) To promote commercial exploitation of know-how, know-why results and offer various consultancy services to the customers.

(iii) To promote the development and commercialization of any other wind energy systems including stand-alone systems.
(iv) To carry out any other activity in the field of renewable energy for R&D as may be assigned to it by the Ministry of New and Renewable Energy (MNRE) from time to time [8].

H. Wind Resource Assessment

The Unit has been implementing Nationwide Wind Resource Assessment program sponsored by the Government of India, in association with State Nodal Agencies. In order to extend support to the industry and developers the Unit takes up validation exercises, technical due diligence studies, micrositing and evaluation of production estimates of the proposed wind farms [3]. The Ministry of New and Renewable Energy Winds have been measured at seven hundred & three locations for periods ranging from one to five years since 1986. As on March 2013, ninety two stations are in operation in fifteen States and One Union Territory. During 2012-13, a total number of thirty eight wind monitoring stations were commissioned. Details of new Wind Monitoring Stations installed and in operation are given in the following [4].

Table 3: Status of Wind Monitoring Stations (2012-13).

S.No.	State	Number Of Stations		
		Established till 30.09.2014	in Operation	s > 200 W/m²
1.	Andaman & Nicobar	19	--	03
2.	Andhra Pradesh	90	10	42
3.	Arunachal Pradesh	09	03	--
4.	Assam	07	01	--
5.	Bihar	06	01	--
6.	Chhattisgarh	07	--	--
7.	Goa	04	--	--
8.	Gujarat	83	13	40
9.	Haryana	06	--	--
10.	Himachal Pradesh	06	--	--
11.	Jammu & Kashmir	24	--	02
12.	Jharkhand	03	--	--
13.	Karnataka (MNRE Stations)	72	14	19
	(KPCL Stations)	18	--	07
14.	Kerala	29	--	17
15.	Lakshadweep	09	--	09
16.	Madhya Pradesh	44	07	07
17.	Maharashtra	140	16	35
18.	Manipur	11	03	--
19.	Meghalaya	03	--	--
20.	Mizoram	05	01	--
21.	Nagaland	03	--	--
22.	Odisha	19	09	06
23.	Punjab	10	--	--
24.	Pondichery	05	01	--
25.	Rajasthan	48	12	08
26.	Sikkim	04	--	--
27.	Tamil Nadu	89	16	47
28.	Tripura	05	--	--
29.	Uttarakhand	17	02	01
30.	Uttar Pradesh	14	03	--
31.	West Bengal	10	--	01
Total		819	112	244

(Source:-http://www.windpowerindia.com)

I. Wind Energy Program in Madhya Pradesh

Economic and efficient implementation and operation of Wind Power Project calls for high quality technical input in terms of identification of site, micrositing of WEG, grid evacuation etc. Qualified and experienced staff is also needed to ensure trouble-free and efficient operation and maintenance. To facilitate investment for Wind Electricity Generation by small Investors, a Joint Sector Company-M.P. Wind farms Limited (MPWL) was promoted to provide:

(i) Comprehensive design, engineering, project supervision and implementation services along with necessary infrastructure facilities at most reasonable cost.

(ii) To provide lifetime operation and maintenance services in a most cost effective manner through highly competent team of engineers and technicians.

With such resource available from one single agency, the Investors are required to only arrange for investment [18].

Table 4: Wind Monitoring Stations at Madhya Pradesh.

S.No.	Site	Dist.
1	Jamgodrani	Dewas
2	Kukru	Betul
3	Mahuriya	Shajapur
4	Mamatkhera	Ratlam
5	Nagda	Dewas
6	Sendhawa	Sendhawa
7	Bariyapani	Barwani

(Source: - http://www.mprenewable.nic.in/winde.html)

J. Private Wind Monitoring Scheme

(i) Permission for carrying out wind monitoring at self identified locations by the private institutions is being given by MPUVN on a first come first serve basis.

(ii) For identification of sites, Survey of wind potential carrying out feasibility studies the prospective entrepreneurs can select any site anywhere in Madhya Pradesh except the areas under previous monitoring as given in this programme.

(iii) The concerned parties are the responsible to carry out the entire work of wind survey and monitoring finding out wind power potential and carry out feasibility studies at their cost. the parties are being allowed to carry out wind monitoring and other survey and investigation only in the area allotted to them.

(iv) The proposal is governed under the policy notifications issued by MP Government and MNRE circular no. 51/9/2007-WE dated 20.06.2008 for wind measurement & subsequent development by private sector.

(v) After completing wind monitoring, survey and submitting the feasibility report, if it is found viable to establish the wind farm project, then the party will be required to submit separate application in prescribed format to MP Urja Vikas Nigam Ltd., along with detailed feasibility report Registration and Processing fee for project which may be considered for according 'in principal' approval to set up the wind farm project [11].

Table 4: Year Wise Installation.

Up to 2003-04	**21.69 MW**
2004-05	6.25 MW
2005-06	11.20 MW
2006-07	17.45 MW
2007-08	69.00 MW
2008-09	25.1 MW
2009-10	16.6 MW
2010-11	46.50 MW
Total	213.79 MW

(Source: - http://www.mprenewable.nic.in/winde.html)

CONCLUSIONS

Wind power has a major part to play in the development of renewable energy sources that is being pursued for energy and environmental policy reasons. The replacement of older wind turbines with new, high-performance turbines (repowering) is particularly important here. At the same time, repowering can also be used to reorganize wind-power locations in order to better integrate them into the planning of residential areas in municipalities. These information contain basic information regarding the detailed of wind power and repowering. Repowering refers to the refurbishment of older turbines; this has generally been accomplished by installing fewer, larger turbines. Repowering stands for replacement of old wind turbine with more powerful and modern turbines.

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