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Compressive Study on Importance of Wind Power in India

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Abstract: Wind power is the conversion of wind energy into a useful form of energy. The total amount of economically extractable power available from the wind is considerably more than present human power use from all sources. Since wind speed is not constant, a wind farm's annual energy production is never as much as the sum of the generator nameplate ratings multiplied by the total hours in a year.

I. INTRODUCTION:

Wind power is the conversion of wind energy into a useful form of energy. The construction of wind farms is not universally welcomed because of their visual impact, but any effects on the environment from wind power are generally less problematic than those of any other power source. The intermittency of wind seldom creates problems when using wind power to supply up to 20% of total electricity demand. Power management techniques such as exporting and importing power to neighboring areas or reducing demand when wind production is low, can mitigate these problems. Small wind facilities are used to provide electricity to isolated locations and utility companies increasingly buy back surplus electricity produced by small domestic wind turbines. Wind mills are typically installed in favourable windy locations. Humans have been using wind power for at least 5,500 years to propel sailboats and sailing ships. In July 1887, a Scottish academic, Professor James Blyth, undertook wind power experiments that culminated in a UK patent in 1891. The modern wind power industry began in 1979 with the serial production of wind turbines. These early turbines were small by today's standards, with capacities of 20–30 KW each. Since then, they have increased greatly in size, with the Enercon E-126 capable of delivering up to 7 MW, while wind turbine production has expanded too many countries.

The Earth is unevenly heated by the sun, such that the poles receive less energy from the sun than the equator; along with this, dry land heats up (and cools down) more quickly than the seas do. The differential heating drives a global atmospheric convection system reaching from the Earth's surface to the stratosphere which acts as a virtual ceiling. Most of the energy stored in these wind movements can be found at high altitudes where continuous wind speeds of over 160 km/h (99 mph) occur. Eventually, the wind energy is converted through friction into diffuse heat throughout the Earth's surface and the atmosphere. The total amount of economically extractable power available from the wind is considerably more than present human power use from all sources. The potential of wind power on land and near-shore is to be 72 TW, equivalent to 54,000 MToE (million tons of oil equivalents) per year, or over five times the world's current energy use in all forms. The potential takes into account only locations with mean annual wind speeds ≥ 6.9 m/s at 80 m. The study assumes six 1.5 megawatt, 77 m diameter turbines per square kilometer on roughly 13% of the total global land area.

II. OBJECTIVES

1. To compressive study on world wise wind power importance
2. Analytical study on wind power generation and utilization growth between countries
3. Cost Analysis of Wind power generation

Wind power usage countries:

In worldwide, many thousands of wind turbines are operating, with a total capacity of 1,94,400 MW. Europe accounted for 48% of the total in 2009. World wind generation capacity is more than doubling about every three years. In 2010, Spain became Europe's leading producer of wind energy, achieving 42,976 GWh. However, Germany holds the first place in Europe in terms of installed capacity, with a total of 27,215 MW at

December 31, 2010. Wind power accounts for approximately 21% of electricity use in Denmark, 18% in Portugal, 16% in Spain, 14% in the Republic of Ireland, and 9% in Germany (*Table 1*). According to Global Wind Energy Council (GWEC) figures in 2007 shows that an increase of installed capacity of 20 GW, taking the total installed wind energy capacity to 94 GW, up from 74 GW in 2006. Despite constraints facing supply chains for wind turbines, the annual market for wind continued to increase at an estimated rate of 37%, following 32% growth in 2006. In terms of economic value, the wind energy sector has become one of the important players in the energy markets, with the total value of new generating equipment installed in 2007 reaching US$36 billion. Although the wind power industry was impacted by the global financial crisis in 2009 and 2010, a BTM Consult five year forecast up to 2013 projects substantial growth. Over the past five years the average growth in new installations has been 27.6 percent each year. In the forecast to 2013 the expected average annual growth rate is 15.7 percent. More than 200 GW of new wind power capacity could come on line before the end of 2013. Wind power market penetration is expected to reach 3.35 percent by 2013 and 8 percent by 2018.

Table-1 Top 10 Wind Power Usage Countries

Rank	Country	Wind Power Capacity (in MW)	Share in Total	Country	Electricity Generation EU countries (in GWh)	Share in Total
1	China	44,733	26%	Spain	42,976	33%
2	United States	40,180	24%	Germany	35,500	27%
3	Germany	27,215	15%	United Kingdom	11,440	9%
4	Spain	20,676	12%	France	9,600	7%
5	India	13,066	8%	Portugal	8,852	7%
6	Italy	5,797	4%	Denmark	7,808	6%
7	France	5,660	3%	Netherlands	3,972	3%
8	United Kingdom	5,204	3%	Sweden	3,500	3%
9	Canada	4,008	3%	Ireland	3,473	3%
10	Denmark	3,734	2%	Greece	2,200	2%
	Total	170,273	100%	Total	129,321	100%

Source: Global Wind Energy Council (GWEC) in March, 2011

Offshore wind power refers to the construction of wind farms in bodies of water to generate electricity from wind. Better wind speeds are available offshore compared to on land, so offshore wind power's contribution in terms of electricity supplied is higher. As of October 2010, 3.16 GW of offshore wind power capacity was operated, mainly in Northern Europe. According to BTM Consult, more than 16 GW of additional capacity will be installed before the end of 2014 and the UK and Germany will become the two leading markets. Offshore wind power capacity is expected to reach a total of 75 GW worldwide by 2020, with significant contributions from China and the US. In a wind farm, individual turbines are interconnected with a medium voltage (often 34.5 KV), power collection system and communications network. At a substation, this medium-voltage electric current is increased in voltage with a transformer for connection to the high voltage electric power transmission system. The surplus power produced by domestic micro generators can, in some jurisdictions, be fed into the network and sold to the utility company, producing a retail credit for the micro generators' owners to offset their energy costs.

Grid management

Induction generators, often used for wind power, require reactive power for excitation, so substations used in wind-power collection systems include substantial capacitor banks for power factor correction. Different types of wind turbine generators behave differently during transmission grid disturbances, so extensive modeling of the dynamic electromechanical characteristics of a new wind farm is required by transmission system operators to ensure predictable stable behavior during system faults. In particular, induction generators cannot support the system voltage during faults, unlike steam or hydro turbine-driven synchronous generators. Doubly-fed machines generally have more desirable properties for grid interconnection. Transmission systems operators will supply a wind farm developer with a grid code to specify the requirements for interconnection to the transmission grid. This will include power factor, constancy of frequency and dynamic behavior of the wind farm turbines during a system fault.

Capacity factor

Since wind speed is not constant, a wind farm's annual energy production is never as much as the sum of the generator nameplate ratings multiplied by the total hours in a year. The ratio of actual productivity in a year to this theoretical maximum is called the capacity factor. Typical capacity factors are 20–40%, with values at the upper end of the range in particularly favourable sites. For example, a 1 MW turbine with a capacity factor of 35% will not produce 8,760 MWh in a year (1 × 24 × 365), but only (1 × 0.35 × 24 × 365) produced 3,066 MWh, averaging to 0.35 MW. Online data is available for some locations and the capacity factor can be calculated from the yearly output. Unlike fueled generating plants, the capacity factor is affected by several parameters, including the variability of the wind at the site, but also the generator size- having a smaller generator would be cheaper and achieve higher capacity factor, but would make less electricity (and money) in high winds. Conversely a bigger generator would cost more and generate little extra power and, depending on the type, may stall out at low wind speed. Thus an optimum capacity factor can be used, which is usually around 20-35%. In a 2008 study released by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, the capacity factor achieved by the wind turbine fleet is shown to be increasing as the technology improves. The capacity factor achieved by new wind turbines in 2004 and 2005 reached 36%.

Penetration

Wind energy "penetration" refers to the fraction of energy produced by wind compared with the total available generation capacity. There is no generally accepted "maximum" level of wind penetration. The limit for a particular grid will depend on the existing generating plants, pricing mechanisms, capacity for storage or demand management, and other factors. An interconnected electricity grid will already include reserve generating and transmission capacity to allow for equipment failures; this reserve capacity can also serve to regulate for the varying power generation by wind plants. Studies have indicated that 20% of the total electrical energy consumption may be incorporated with minimal difficulty. These studies have been for locations with geographically dispersed wind farms, some degree of dispatchable energy, or hydropower with storage capacity, demand management, and interconnection to a large grid area export of electricity when needed. Beyond this level, there are few technical limits, but the economic implications become more significant. Electrical utilities continue to study the effects of large (20% or more) scale penetration of wind generation on system stability and economics. At present, a few grid systems have penetration of wind energy above 5%: Denmark (values over 19%), Spain and Portugal (values over 11%), Germany and the Republic of Ireland (values over 6%). But even with a modest level of penetration, there can be times where wind power provides a substantial percentage of the power on a grid. For example, in the morning hours of 8 November 2009, wind energy produced covered more than half the electricity demand in Spain, setting a new record.

Variability and intermittency

Electricity generated from wind power can be highly variable at several different timescales: from hour to hour, daily, and seasonally. Annual variation also exists, but is not as significant. Related to variability is the short-term (hourly or daily) predictability of wind plant output. Like other electricity sources, wind energy must be ‘scheduled’ and forecasting methods are used, but predictability of wind plant output remains low for short-term operation. Because instantaneous electrical generation and consumption must remain in balance to maintain grid stability, this variability can present substantial challenges to incorporating large amounts of wind power into a grid system. Intermittency and the non-dispatchable nature of wind energy production can raise costs for regulation, incremental operating reserve, and could require an increase in the already existing energy demand management, load shedding, or storage solutions or system interconnection with HVDC cables. At low levels of wind penetration, fluctuations in load and allowance for failure of large generating units require reserve capacity that can also regulate for variability of wind generation. Wind power can be replaced by other power stations during low wind periods. Transmission networks must already cope with outages of generation plant and daily changes in electrical demand. Systems with large wind capacity components may need more spinning reserve. Pumped-storage hydroelectricity or other forms of grid energy storage can store energy developed by high-wind periods and release it when needed. Stored energy increases the economic value of wind energy since it can be shifted to displace higher cost generation during peak demand periods. The potential revenue from this arbitrage can offset the cost and losses of storage; the cost of storage may add 25% to the cost of any wind energy stored, but it is not envisaged that this would apply to a large proportion of wind energy generated. In particular geographic regions, peak wind speeds may not coincide with peak demand for electrical power and hot days in summer may have low wind speed and high electrical demand due to air conditioning. Some utilities subsidize the purchase of geothermal heat pumps by their customers, to reduce electricity demand during the summer months by making air conditioning up to 70% more efficient.

A report on Denmark's wind power noted that their wind power network provided less than 1% of average demand 54 days during the year 2002. Wind power advocates argue that these periods of low wind can be dealt with by simply restarting existing power stations that have been held in readiness or interlinking with HVDC. Electrical grids with slow-responding thermal power plants and without ties to networks with hydroelectric generation may have to limit the use of wind power. Three reports on the wind variability in the

UK issued in 2009, generally agree that variability of wind needs to be taken into account, but it does not make the grid unmanageable; and the additional costs, which are modest, can be quantified. A 2006 International Energy Agency forum presented costs for managing intermittency as a function of wind-energy's share of total capacity for several countries, as shown in *Table 2*:.

Table – 2 Increase in System Operation Costs (*Euros per M.W*)

Country	Germany	Denmark	Finland	Norway	Sweden
10% SOC Increase Wind Share	2.5	0.4	0.3	0.1	0.3
20% SOC Increase Wind Share	3.2	0.8	1.5	0.3	0.7
Variance	*0.7*	*0.4*	*1.2*	*0.2*	*0.4*
Change Percentage	*28%*	*100%*	*400%*	*200%*	*133%*

Capacity credit and fuel saving

Many commentators concentrate on whether or not wind has any "capacity credit" without defining what they mean by this and its relevance. Wind does have a capacity credit, using a widely accepted and meaningful definition, equal to about 20% of its rated output. This means that reserve capacity on a system equal in MW to 20% of added wind could be retired when such wind is added without affecting system security or robustness. But the precise value is irrelevant since the main value of wind is its fuel and CO_2 savings. According to a 2007 Stanford University study published in the Journal of Applied Meteorology and Climatology, interconnecting ten or more wind farms can allow an average of 33% of the total energy produced to be used as reliable, base load electric power, as long as minimum criteria are met for wind speed and turbine height.

Economics

Wind power has negligible fuel costs, but a high capital cost. The estimated average cost per unit incorporates the cost of construction of the turbine and transmission facilities, borrowed funds, return to investors, estimated annual production, and other components, averaged over the projected useful life of the equipment, which may be in excess of twenty years. Energy cost estimates are highly dependent on these assumptions so published cost figures can differ substantially. A British Wind Energy Association report gives an average generation cost of onshore wind power of around 3.2 pence per KW·h (2005). Cost per unit of energy produced was estimated in 2006 to be comparable to the cost of new generating capacity in the US for coal and natural gas: wind cost was estimated at $55.80 per MW·h, coal at $53.10/MW·h and natural gas at $52.50. Other sources in various studies have estimated wind to be more expensive than other sources. In 2009 study on wind power in Spain by Gabriel Calzada Alvarez Universidad Rey Juan Carlos concluded that each installed MW of wind power led to the loss of 4.27 jobs, by raising energy costs and driving away electricity-intensive businesses. The U.S. Department of Energy found the study to be seriously flawed, and the conclusion unsupported. The presence of wind energy, even when subsidized, can reduce costs for consumers (€5 billion/yr in Germany) by reducing the marginal price by minimizing the use of expensive 'peaker plants'. The marginal cost of wind energy once a plant is constructed is usually less than 1 cent per KW·h. In 2004, wind energy cost a fifth of what it did in the 1980s, and some expected that downward trend to continue as larger multi-megawatt turbines were mass-produced. However, capital costs have increased. For example, in the United States, installed cost increased in 2009 to $2,120 per kilowatt of nameplate capacity, compared with $1,950 in 2008, a 9% increase. Not as many facilities can produce large modern turbines and their towers and foundations, so constraints develop in the supply of turbines resulting in higher costs.

III. INCENTIVES

More than 6,000 wind turbines in the Altamont Pass Wind Farm, in California, United States developed during a period of tax incentives in the 1980s, this wind farm has more turbines than any other in the US. Wind energy in many jurisdictions receives financial or other support to encourage its development. Wind energy benefits from subsidies in many jurisdictions, either to increase its attractiveness, or to compensate for subsidies received by other forms of production which have significant negative externalities. In the US, wind power receives a tax credit for each kW·h produced; at 1.9 cents per kW·h in 2006, the credit has a yearly inflationary adjustment. Another tax benefit is accelerated depreciation. Many American states also provide incentives, such as exemption from property tax, mandated purchases, and additional markets for "green credits". Canada and Germany also provide incentives for wind turbine construction, such as tax credits or minimum purchase prices for wind generation, with assured grid access. These feed-in tariffs are typically set well above average electricity prices. The Energy Improvement and Extension Act of 2008 contain extensions of credits for wind, including micro turbines. Secondary market forces also provide incentives for businesses to use wind-generated power, even if there is a premium price for the electricity.

IV. ENVIRONMENTAL EFFECTS

Compared to the environmental impact of traditional energy sources, the environmental impact of wind power is relatively minor. Wind power consumes no fuel, and emits no air pollution, unlike fossil fuel power sources. The energy consumed to manufacture and transport the materials used to build a wind power plant is equal to the new energy produced by the plant within a few months. While a wind farm may cover a large area of land, many land uses such as agriculture are compatible, with only small areas of turbine foundations and infrastructure made unavailable for use. There are reports of bird and bat mortality at wind turbines as there are around other artificial structures. The scale of the ecological impact may or may not be significant, depending on specific circumstances. Prevention and mitigation of wildlife fatalities, and protection of peat bogs, affect the sitting and operation of wind turbines. There are anecdotal reports of negative effects from noise on people who live very close to wind turbines. Small-scale wind power is the name given to wind generation systems with the capacity to produce up to 50 kW of electrical power. Individuals may purchase these systems to reduce or eliminate their dependence on grid electricity for economic or other reasons, or to reduce their carbon footprint. Wind turbines have been used for household electricity generation in conjunction with battery storage over many decades in remote areas. A new Carbon Trust study into the potential of small-scale wind energy has found that small wind turbines could provide up to 1.5 terawatt hours (TW·h) per year of electricity (0.4% of total UK electricity consumption), saving 0.6 million tonnes of carbon dioxide (Mt CO_2) emission savings. This is based on the assumption that 10% of households would install turbines at costs competitive with grid electricity, around 12 pence (US 19 cents) a kW·h. Distributed generation from renewable resources is increasing as a consequence of the increased awareness of climate change. The electronic interfaces required to connect renewable generation units with the utility system can include additional functions, such as the active filtering to enhance the power quality.

V. WIND POWER SCENERIO AND POLICY IN INDIA

Since the 2003 Electricity Act, the wind sector has registered a compound annual growth rate of about 29.5%. The central government policies have provided policy support for both foreign and local investment in renewable energy technologies. The key financial incentives for spurring wind power development have been the possibility to claim accelerated depreciation of up to 80% of the project cost within the first year of operation and the income tax holiday on all earnings generated from the project for ten consecutive assessment years. In December 2009 the Ministry for New and Renewable Energy (MNRE) approved a Generation Based Incentive (GBI) scheme for wind power projects, which stipulated that an incentive tariff of Rs 0.50/kWh (EUR 0.8 cents/USD 1.1 cents) would be given to eligible projects for a (maximum) period of ten years. This scheme is currently valid for wind farms installed before 31 March 2012. However, the GBI and the accelerated depreciation are mutually exclusive and a developer can only claim concessions under one of them for the same project. Although the projected financial outlay for this scheme under the 11th Plan Period (2007-2012) is Rs 3.8 billion (EUR 61 million/USD 84 million), the uptake of the GBI has been slow due to the fact that at the current rate it is still less financially attractive than accelerated depreciation. Currently 18 of the 25 State Electricity Regulatory Commissions (SERCs) have issued feed-in tariffs for wind power. Around 17 SERCs have also specified state-wide Renewable Purchase Obligations (RPOs). Both of these measures have helped to create long-term policy certainty and investor confidence, which have had a positive impact on the wind energy capacity additions in those states.

Table-3 Total Installed Capacity in India

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
MWs	220	1,456	1,702	2,125	3,000	4,430	6,270	7,845	9,655	10,926	13,065
Trend%	100%	662%	774%	966%	1364	2014	2851	3566	4389	4966%	5939%

Table – 3 revealed that India had a record year for new wind energy installations in 2010, with 2,139 MW of new capacity added to reach a total of 13,065 MW at the end of the year. Renewable energy is now 10.9% of installed capacity, contributing about 4.13% to the electricity generation mix, and wind power accounts for 70% of this installed capacity. Currently the wind power potential estimated by the Centre for Wind Energy Technology (C-WET) is 49.1 GW, but the estimations of various industry associations and the World Institute for Sustainable Energy (WISE) and wind power producers are more optimistic, citing a potential in the range of 65- 100 GW. Historically, actual power generation capacity additions in the conventional power sector in India have been fallen significantly short of government targets. For the renewable energy sector, the opposite has been true, and it has shown a tendency towards exceeding the targets set in the five-year plans. This is largely due to the booming wind power sector. Given that renewable energy was about 2% of the energy mix in 1995, this growth is a significant achievement even in comparison with most developed countries. This was mainly spurred by a range of regulatory and policy support measures for renewable energy development that were introduced through legislation and market based instruments over the past decade. The states with highest wind power concentration are Tamil Nadu, Maharashtra, Gujarat, Rajasthan, Karnataka, Madhya Pradesh and Andhra Pradesh. Today the Indian market is emerging as one of the major manufacturing hubs for wind turbines in Asia. Currently, seventeen manufacturers have an annual production capacity of 7,500 MW. According to the WISE, the annual wind turbine manufacturing capacity in India is likely to exceed 17,000 MW by 2013. The Indian market is expanding with the leading wind companies like Suzlon, Vestas, Enercon, RRB Energy and GE now being joined by new entrants like Gamesa, Siemens, and WinWinD, all vying for a greater market share. Suzlon, however, is still the market leader with a market share of over 50%. The Indian wind industry has not been significantly affected by the financial and economic crises. Even in the face of a global slowdown, the Indian annual wind power market has grown by almost 68%. However, it needs to be pointed out that the strong growth in 2010 might have been stimulated by developers taking advantage of the accelerated depreciation before this option is phased out.

The development of wind power in India began in the 1990s, and has significantly increased in the last few years. Although a relative newcomer to the wind industry compared with Denmark or the US, India has the *fifth* largest installed wind power capacity in the world. Table 4 reveals that as of 31st March 2010 the installed capacity of wind power in India was 11806.69 MW, mainly spread across Tamil Nadu (4906.74 MW). It is estimated that 6,000 MW of additional wind power capacity will be installed in India by 2012. Wind power accounts for 6% of India's total installed power capacity, and it generates 1.6% of the country's power. India is preparing wind atlas. India is the world's fifth largest wind power producer, with an annual power production of 11806.69MW. The worldwide installed capacity of wind power reached 157,899 MW by the end of 2009. USA (35,159 MW), Germany (25,777 MW), Spain (19,149 MW) and China (25,104 MW) are ahead of India in fifth position. The short gestation periods for installing wind turbines, and the increasing reliability and performance of wind energy machines has made wind power a favored choice for capacity addition in India. The essential requirements for establishment of a wind farm for optimal exploitation of the wind are High wind resource at particular site, adequate land availability, Suitable terrain and good soil condition, Proper approach to site, Suitable power grid nearby, Techno-economic selection of WEGs, Scientifically prepared layout.

Table-4 State-wise Wind Power Generation & Installed Capacity in India up to 31st March 2010

State	Wind Power Capacity (in MW)	Percentage to Total	Cumulative Generation (MU)	Percentage to Total	Cumulative Installed Capacity (MW)	Percentage to Total
Gujarat	4906.74	41%	8016	11%	1934.6	16%
Karnataka	2077.70	18%	9991	13%	1517.2	13%
Maharashtra	1863.64	16%	11790	15%	2108.1	17%
Tamil Nadu	1472.75	12%	41100	53%	5073.1	42%
Other States	1485.86	13%	6053	08%	1492.8	12%
Total	11806.69	100%	76950	100%	12125.8	100%

Source: WISE, January, 2011

Tamil Nadu (4132.72 MW): Tamil Nadu is the state with the most wind generating capacity: 4889.765 MW at the end of the March 2010. Not far from Aralvaimozhi, the Muppandal wind farm, the largest in the subcontinent, is located near the once impoverished village of Muppandal, supplying the villagers with electricity for work. The village had been selected as the showcase for India's $2 billion clean energy program which provides foreign companies with tax breaks for establishing fields of wind turbines in the area. In february 2009, Shriram EPC bagged INR 700 million contract for setting up of 60 units of 250 KW (totaling 15 MW) wind turbines in Tirunelveli district by Cape Energy. Enercon is also playing a major role in development of wind energy in India. In Tamil Nadu, Coimbatore and Tiruppur Districts having more wind Mills from 2002 onwards,specially, Chittipalayam, Kethanoor, Gudimangalam, Poolavadi,Murungappatti (MGV Place),Sunkaramudaku,KongalNagaram,Gomangalam, Anthiur are the high wind power production places in the both districts.

Maharashtra (2077.70 MW)

Maharashtra is second only to Tamil Nadu in terms of generating capacity. Suzlon has been heavily involved. Suzlon operates what was once Asia's largest wind farm, the Vankusawade Wind Park (201 MW), near the Koyna reservoir in Satara district of Maharashtra.

Gujarat (1863.64 MW)
Samana in Rajkot district is set to host energy companies like China Light Power (CLP) and Tata Power have pledged to invest up to Rs.8.15 billion ($189.5 million) in different projects in the area. CLP, through its India subsidiary CLP India, is investing close to Rs.5 billion for installing 126 wind turbines in Samana that will generate 100.8 MW power. Tata Power has installed wind turbines in the same area for generating 50 MW power at a cost of Rs.3.15 billion. Both projects are expected to become operational by early next year, according to government sources. The Gujarat government, which is banking heavily on wind power, has identified Samana as an ideal location for installation of 450 turbines that can generate a total of 360 MW. To encourage investment in wind energy development in the state, the government has introduced a raft of incentives including a higher wind energy tariff. Samana has a high tension transmission grid and electricity generated by wind turbines can be fed into it. For this purpose, a substation at Sadodar has been installed. Both projects are being executed by Enercon Ltd, a joint venture between Enercon of Germany and Mumbai-based Mehra group. ONGC Ltd has commissioned its first wind power project. The 51 MW project is located at Motisindholi in Kutch district of Gujarat. ONGC had placed the EPC order on Suzlon Energy in January 2008, for setting up the wind farm comprising 34 turbines of 1.5-mw each. Work on the project had begun in February 2008, and it is learnt that the first three turbines had begun production within 43 days of starting construction work. Power from this Rs 308 crore captive wind farm will be wheeled to the Gujarat state grid for onward use by ONGC at its Ankleshwar, Ahmedabad, Mehsana and Vadodara centres. ONGC has targeted to develop a captive wind power capacity of around 200 MW in the next two years.

Karnataka (1472.75 MW)
There are many small wind farms in Karnataka, making it one of the states in India which has a high number of wind mill farms. Chitradurga, Gadag are some of the districts where there are a large number of Windmills. Chitradurga alone has over 20000 wind turbines.The 13.2 MW Arasinagundi (ARA) and 16.5 MW Anaburu (ANA) wind farms are ACCIONA'S first in India. Located in the Davangere district (Karnataka State), they have a total installed capacity of 29.7 MW and comprise a total 18 Vestas 1.65MW wind turbines supplied by Vestas Wind Technology India Pvt. Ltd. The ARA wind farm was commissioned in June 2008 and the ANA wind farm, in September 2008. Each facility has signed a 20-year Power Purchase Agreement (PPA) with Bangalore Electricity Supply Company (BESCOM) for off-take of 100% of the output. ARA and ANA are Acciona's first wind farms eligible for CER credits under the Clean Development Mechanism (CDM). ACCIONA is in talks with the World Bank for The Spanish Carbon Fund which is assessing participation in the project as buyer for CERs likely to arise between 2010 and 2012. An environmental and social assessment has been conducted as part of the procedure and related documents have been provided. These are included below, consistent with the requirement of the World Bank's disclosure policy.

Rajasthan (1088.37 MW)
Gurgaon-headquartered Gujarat Fluorochemicals Ltd is in an advanced stage of commissioning a large wind farm in Jodhpur district of Rajasthan. A senior official told Projectmonitor that out of the total 31.5 mw capacity, 12 mw had been completed so far. The remaining capacity would come on line shortly, he added. For the INOX Group company, this would be the largest wind farm. In 2006-07, GFL commissioned a 23.1-mw wind power project at Gudhe village near Panchgani in Satara district of Maharashtra. Both the wind farms will be grid-connected and will earn carbon credits for the company, the official noted. In an independent development, cement major ACC Ltd has proposed to set up a new wind power project in Rajasthan with a capacity of around 11 mw. Expected to cost around Rs 60 crore, the wind farm will meet the power requirements of the company's Lakheri cement unit where capacity was raised from 0.9 million tpa to 1.5 million tpa through a modernisation plan. For ACC, this would be the second wind power project after the 9-mw farm at Udayathoor in Tirunelveli district of Tamil Nadu. Rajasthan is emerging as an important destination for new wind farms, although it is currently not amongst the top five states in terms of installed capacity. As of 2007 end, this northern state had a total of 496 mw, accounting for a 6.3 per cent share in India's total capacity.

Madhya Pradesh (229.39MW)
In consideration of unique concept, Govt. of Madhya Pradesh has sanctioned another 15 MW project to MPWL at Nagda Hills near Dewas. All the 25 WEGs have been commissioned on 31.03.2008 and under successful operation.

Kerala (27.75 MW)
The first wind farm of the state was set up at Kanjikode in Palakkad district. It has a generating capacity of 23.00 MW. A new wind farm project was launched with private participation at Ramakkalmedu in Idukki district. The project, which was inaugurated in April 2008, aims at generating 10.5 MW of electricity. The

Agency for Non-Conventional Energy and Rural Technology (ANERT), an autonomous body under the Department of Power, Government of Kerala, is setting up wind farms on private land in various parts of the state to generate a total of 600 mw of power. The agency has identified 16 sites for setting up wind farms through private developers. To start with, ANERT will establish a demonstration project to generate 2 mw of power at Ramakkalmedu in Idukki district in association with the Kerala State Electricity Board. The project is slated to cost Rs 21 crore. Other wind farm sites include Palakkad and Thiruvananthapuram districts. The contribution of non-conventional energy in the total 6,095 mw power potential is just 5.5 per cent, a share the Kerala government wants to increase by 30 per cent. ANERT is engaged in the field of development and promotion of renewable sources of energy in Kerala. It is also the nodal agency for implementing renewable energy programmes of the Union ministry of non-conventional energy sources.

West Bengal (1.10MW)

The total installation in West Bengal is just 1.10 MW as there was only 0.5 MW addition in 2006-2007 and none between 2007–2008 and 2008–2009. Bengal – Mega 50 MW wind energy project soon for country. Suzlon Energy Ltd plans to set up a large wind-power project in West Bengal Suzlon Energy Ltd is planning to set up a large wind-power project in West Bengal, for which it is looking at coastal Midnapore and South 24-Parganas districts. According to SP Gon Chaudhuri, chairman of the West Bengal Renewable Energy Development Agency, the 50 MW project would supply grid-quality power. Gon Chaudhuri, who is also the principal secretary in the power department, said the project would be the biggest in West Bengal using wind energy. At present, Suzlon experts are looking for the best site. Suzlon aims to generate the power solely for commercial purpose and sell it to local power distribution outfits like the West Bengal State Electricity Board (WBSEB). Suzlon will invest around Rs 250 crore initially, without taking recourse to the funding available from the Indian Renewable Energy Development Agency (Ireda), said Gon Chaudhuri. He said there are five wind-power units in West Bengal, at Frazerganj, generating a total of around 1 MW. At Sagar Island, there is a composite wind-diesel plant generating 1 MW. In West Bengal, power companies are being encouraged to buy power generated by units based on renewable energy. The generating units are being offered special rates. S Banerjee, private secretary to the power minister, said this had encouraged the private sector companies to invest in this field.

VI. SUPPORT FRAMEWORK FOR WIND ENERGY

There has been a noticeable shift in Indian politics since the adoption of the Electricity Act in 2003 towards supporting research, development and innovation in the country's renewable energy sector. In 2010, the Indian government clearly recognized the role that renewable energy can play in reducing dependence on fossil fuels and combating climate change, and introduced a tax ("cess") of Rs.50 (~USD1.0) on every metric ton of coal produced or imported into India. This money will be used to contribute to a new Clean Energy Fund. In addition, the MNRE announced its intention to establish a Green Bank by leveraging the Rs 25 billion (EUR 400 million / USD 500 million) expected to be raised through the national Clean Energy Fund annually. The new entity would likely work in tandem with the Indian Renewable Energy Development Agency (IREDA), a government-owned non-banking financial company. In keeping with the recommendations of the National Action Plan on Climate Change (NAPCC) the MNRE and the Central Electricity Regulatory Commission (CERC) have evolved a framework for implementation of the Renewable Energy Certificate (REC) Mechanism for India.1 This is likely to give renewable energy development a further push in the coming years, as it will enable those states that do not meet their RPOs through renewable energy installations to fill the gap through purchasing RECs.

VII. OBSTACLES FOR WIND ENERGY DEVELOPMENT

With the introduction of the Direct Tax Code2, the government aims to modernize existing income tax laws. Starting from the fiscal year 2011-12, accelerated depreciation, the key instrument for boosting wind power development in India, may no longer be available. Another limitation to wind power growth in India is inadequate grid infrastructure, especially in those states with significant wind potential, which are already struggling to integrate the large amounts of wind electricity produced. As a result, the distribution utilities are hesitant to accept more wind power. This makes it imperative for CERC and SERCs to take immediate steps toward improved power evacuation system planning and providing better interface between regional grids. The announcement of India's Smart Grid Task Force by the Ministry of Power is a welcome first step in this direction

Advantages:

The capital cost is comparable with conventional power plants. For a wind farm, the capital cost ranges between 4.5 crores to 6.85 crores per MW, depending up on the type of turbine, technology, size and location, Construction time is less, Fuel cost is zero, O & M cost is very low, Capacity addition can be in modular form, there is no adverse effect on global environment and the whole system is pollution free and environment friendly.

Limitation:

Wind machines must be located where strong, dependable winds are available most of the time, Because winds do not blow strongly enough to produce power all the time, energy from wind machines is considered "intermittent," that is, it comes and goes. Wind towers and turbine blades are subject to damage from high winds and lighting. Rotating parts, which are located high off the ground can be difficult and expensive to repair, Electricity produced by wind power sometimes fluctuates in voltage and power factor, which can cause difficulties in linking its power to a utility system, The noise made by rotating wind machine blades can be annoying to nearby neighbors and People have complained about aesthetics of an avian mortality from wind machines.

Suggestions:

1. Despite growing worldwide demand for wind energy, present wind technology is not optimized and there are still significant challenges
2. The gains are seeking require new innovations in fluid dynamics, control, materials, manufacturing, structures, and electric power distribution, as well of new ways of engaging the public in appreciating and accepting this technology, the associated transmission infrastructure and its effects on reducing climate change. Design and analysis tools need to be developed.
3. Common computer codes need to be shared and refined in an open collegial way that cannot occur in industry. Researchers need to disseminate, debate, and share results openly, accelerating innovation in the subject.

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