Wind Power Handbook On
Promoting Grid Connected Wind Power Projects in SARI

USAID SOUTH ASIA REGIONAL INITIATIVE FOR ENERGY
(USAID SARI/ENERGY)

CONTRACT NUMBER 386-C-00-07-00033-00; TASK ORDER US0254.1-PO—10-0639

September 10, 2010
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1. Site selection for wind projects

The site selection for a wind project is subject to -- a. wind resource, b. land availability and, c. power evacuation requirements. However, wind resource is the basic requirement and starting point of site selection. The site with good wind data is further assessed on the basis of land and the power evacuation criteria. In the case of India, sites with wind power density of 200 W/m2 or above are allowed to be developed by the Centre for Wind Energy (C-WET) under the Ministry of New and Renewable Energy (MNRE).

The selection of site for starting wind resource assessment is done based on available wind data, typically meteorological wind measurements, to gauge the wind resource availability. The regional or national wind atlas, if available, can also provide such information. These mesoscale atlas is developed using the mesoscale wind resource mapping techniques like KAMM by RISO National Laboratory. The mesoscale wind mapping in the South Asian countries was also undertaken under the "Global Solar and Wind Energy Resource Assessment" (SWERA) project and the data is available at the SWERA website http://swera.unep.net/

2. Assessing the wind data

a) Estimation of wind speeds and wind power density

A precise knowledge of wind characteristics at a prospective site is essential for successful planning and implementation of wind energy projects. The basic information required for this is wind speed and wind direction of prevailing wind at different times. Primarily, ecological indicators are often helpful to identify contender site. Meteorological data from nearby wind station gives idea about wind spectra available at the site although, a thorough and accurate monitoring of wind speed and direction is essential before undertaking site development. Many precise instruments are available these days for meteorological data collection.

Typically after carrying out wind resource survey at site, wind mast is installed. Usually it is installed at such a location that it represents average elevation of site. Wind mast consists of typical meteorological instruments mounted at different heights such as anemometer, wind vane, pressure and temperature sensors, data recorders etc. The number of masts representing the sites depends on the terrain of the site. For complex terrain, more wind masts are required, but for flat terrain one wind mast can be used to represent approximately 10 km radius area considering mast location as the centre.

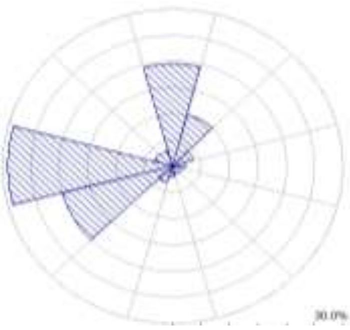
Long-term wind speed and wind direction data collected at site is used to estimate annual energy production, along with other meteorological parameters.

Multiple measurement heights are encouraged for determining a site's wind shear characteristics, conducting turbine performance simulations at several turbine hub heights, and for back-up. The wind measurements at the same height as that of the turbine hub height give most accurate energy estimations. In the absence of such measurements, the measurements at two different heights are used to extrapolate the wind resource at the hub height.

Fig. 1: An 80m wind mast
(Photo courtesy: Suzlon Energy Ltd.)

Typically, wind data is collected in average 10 minutes interval. Probability distribution function is calculated based upon hourly wind speed availability. Also, wind rose is calculated to decide predominant wind direction. Figure 2 below shows wind rose and wind speed frequency distribution. There are different softwares available commercially, which check this wind data for errors and process it to appropriate file formats. Some of such softwares are WAsP, WindPro, GH Windfarmer etc. These days wind flow modelling is also supported by CFD tools such as WindSim, Meteodyne etc.

Meteorological data can also be collected from federal meteorological institutes in that country, NASA also maintains similar database. But, the data collected at site by installing wind mast for multiple years is the most bankable data and is required before developing any wind power project. Mesomaps can be another meteorological information source. These are available commercially, developed by different institutes such as RISO Lab, AWS Truepower, 3Tier etc. Mesomaps are resultant of simulating numerical weather models along with wind flow models. Accuracy of mesomaps varies due to climate and topographical changes.



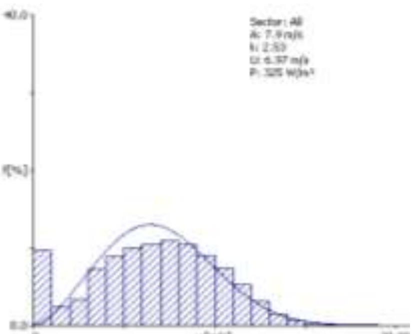


Figure 2 a) Wind Rose b) Probability Distribution Function

Source: Actual wind measurements at Database Torangally in Karnataka, India

Wind power density (WPD) is a calculation of the effective power of the wind at a particular location. The wind power density, measured in watts per square meter, indicates how much energy is available at the site for conversion.

Estimates of the wind resource are expressed in wind power classes ranging from Class 1 to Class 7, with each class representing a range of mean wind power density or equivalent mean wind speed at specified heights above the ground.

Table 1: Wind power class and wind power density

	30 m (98 ft)		50 m (164 ft)	
Wind Power Class	Wind Power Density (W/m^2)	Wind Speed m/s (mph)	Wind Power Density (W/m^2)	Wind Speed m/s (mph)
1	≤160	≤5.1 (11.4)	≤200	≤5.6 (12.5)
2	≤240	≤5.9 (13.2)	≤300	≤6.4 (14.3)
3	≤320	≤6.5 (14.6)	≤400	≤7.0 (15.7)
4	≤400	≤7.0 (15.7)	≤500	≤7.5 (16.8)
5	≤480	≤7.4 (16.6)	≤600	≤8.0 (17.9)
6	≤640	≤8.2 (18.3)	≤800	≤8.8 (19.7)
7	≤1600	≤11.0 (24.7)	≤2000	≤11.9 (26.6)

Source: Wind Resource Handbook, NREL

It is also important to understand monthly wind variation, since energy generation is rational with wind availability in that month. Typical monthly wind variation graph is as shown in the figure below:

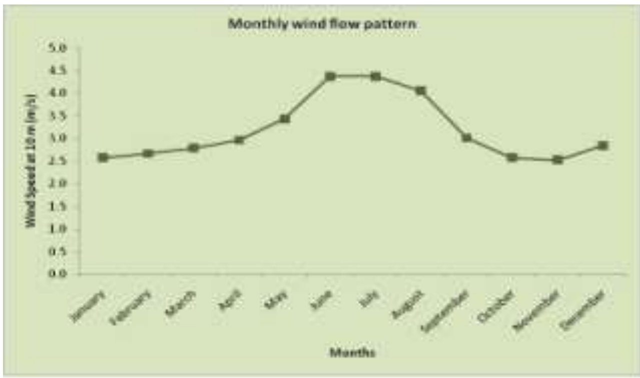


Fig 2: Typical monthly wind variation
Source: NREL Database

b) **Other parameters**

There are few parameters which have direct or indirect impact on energy estimation. These can be broadly considered as follows:

- Site specific air density
- Topographic effect
- Availability of grid
- Availability of machine
- Seasonal wind variation

c) **Estimation of power production**

There are many dedicated softwares available for estimation of wind energy. The Wind Atlas Analysis and Application Program (WAsP) developed by RISO lab, Denmark, is the most widely used wind flow modelling software.

Information regarding wind resource, topography, turbine locations, site specific power curves etc. is provided in specific file formats to the software. The software simulates climatology with given topography considering available generation technology and projects energy estimation at a given location.

Nowadays other sophisticated softwares using CFD calculations are also used to estimate energy more accurately.

d) **Probability analysis**

Since wind flow is erratic in nature and sensitive to seasonal variations, significant amounts of variations are involved in AEP prognosis. Hence, it is required to plot different scenarios for appropriate fund flow visibility. Financial modelling needs a comprehensive understanding of the project assumptions in combination with the performance of a sensitivity analysis in order to define an agreed base case. The result of an energy yield prediction in terms of an AEP is called the P50. In a layman's term, the probability of reaching a higher or lower annual energy production is 50:50.
A risk assessment includes the quantification of the project specific uncertainties and the whole range of exceedance probabilities (Pxx) of the wind farm's annual energy production. P75 is the annual energy production which is reached with a probability of 75%. The risk that an annual energy production of P90 is not reached is 10%. Both values are widely used by banks and investors as the base in their financing decisions.

3. Availability of infrastructure

a) **Land**

To avail land at potential wind resource is a major aspect of wind power project development. It is very essential for a project developer to get litigation free land for smooth project operation.

Typically there are two types of lands available for project execution, one is private land and the other is government land.

Private land can be selected on point basis subject to the consent of the owner of land. Typically private land is bought by a developer.

Government land is further categorised as forest land and revenue land which is typically leased to developer for certain stipulated time period. Usually lease period is more than the life span of the project.

b) Power evacuation

The land availability along with the wind resource decides the size of the wind power project that can be developed at a particular site.
Electricity generated at turbine location needs to be transmitted to substation. For this, developers usually establish internal grid network at lower level and at substation level it is stepped up to appropriate state/national voltage level. The next step is checking availability of the nearby grid for evacuation of power and checking possibility and viability of laying the evacuation line from the wind project till the nearest grid substation. The length of the evacuation line and the total wind power project capacity at the site decides the technical details for the evacuation line like the voltage level, type of conductor etc. Since transmission loss is expected during electricity transmission a very precise material selection and line design is necessary to optimize the installation cost, maintenance cost of evacuation network and transmission loss.

c) Accessibility

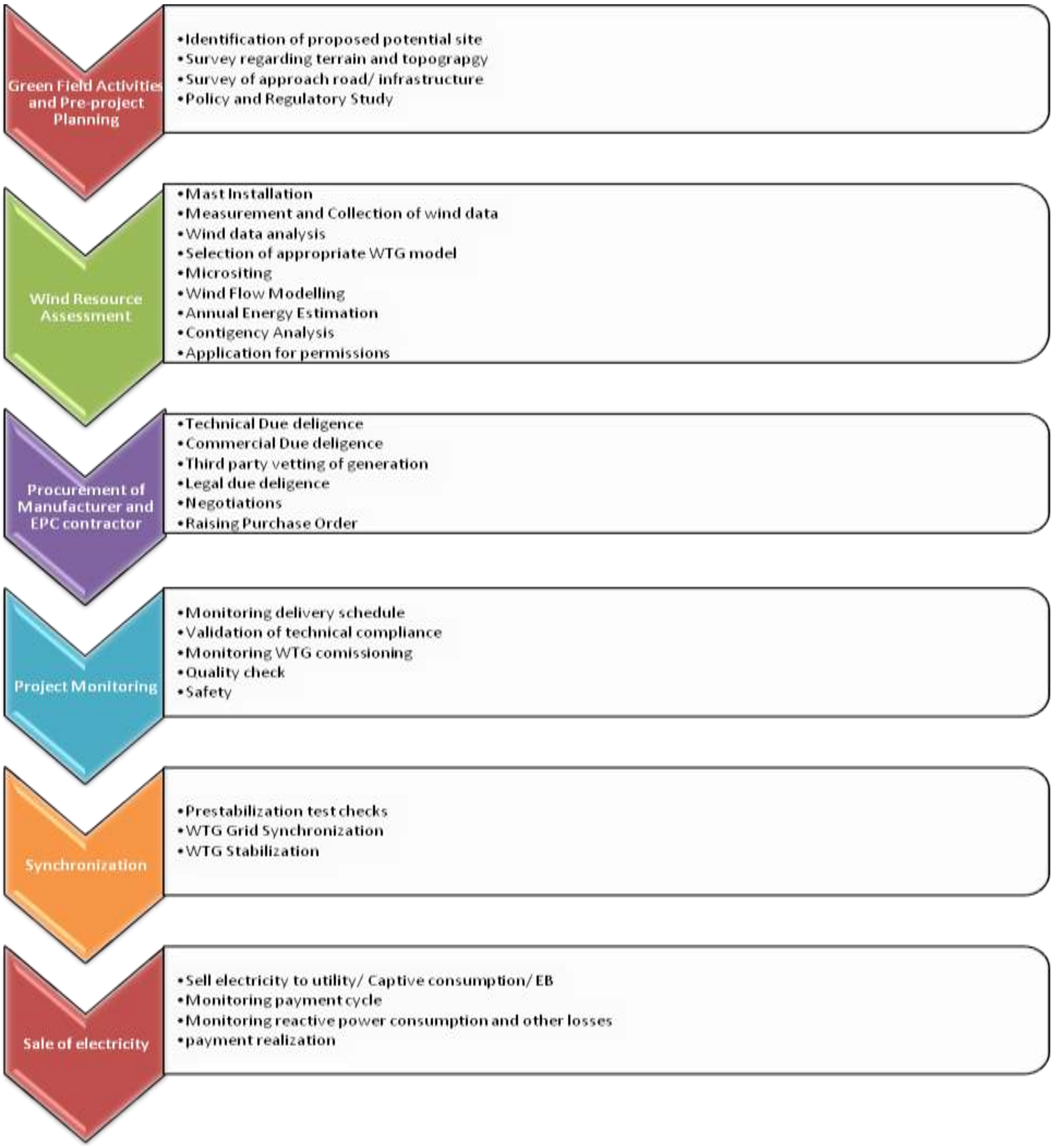
Accessibility is a very important aspect to develop any wind farm project. A detailed survey is necessary before considering site development. It is often essential to get knowledge on curvature of road, slope of terrain, type of approach roads, and type of soil etc. to avoid logistical delays.
It is also useful to study rain pattern as there might be cases when there is sufficient infrastructure available and site can't be assessed due to heavy rain delaying commissioning schedule.

4. Permissions required

There are various permissions required at different project stages which vary from region to region and country to country and hence cannot be generalized. Typically following permissions are considered during project execution:

- Approval of site
- Clearance from the Ministry of Environment and Forests
- NOC by state renewable energy department
- NOC by transmission company
- Clearance by aviation department
- Statutory local clearances such municipal corporations, telecom, defence etc.
- Grid connection approval

Typical steps involved to develop a windfarm



Technology / Wind turbine Selection (Mr. R. Balaji) 2

1. Introduction

Today in India, there are wind turbines ranging from 250 kW to 2100 kW and these are installed in different locations that are compatible with the required wind speed of the turbine. At the preliminary stage of wind turbine selection and erection, wind measurement is done through wind resource assessment. In terms of turbine technology, market in India has many variants with different capacities and they are -- (1) with gearless technology where the wind turbine is coupled 'a synchronous generator and the power generated is fed through an electronic inverter system; (2) with conventional gearbox technology with two winding induction generators -- At low wind speed the first winding kicks in and at high speed the second winding induction generator produces power; (3) With single winding generator for the entire range of wind speed and; (4) there are some which are tailored for low wind regime.

Selection of the technology is called "techno commercial evaluation". The developer should clearly know what is the purpose of his investment, meaning (a) is it for purely generating green energy, which will be used for captive consumption; (b) is it purely for investment purpose; or (c) is it for investment and captive usage purpose. Depending upon the requirement selection needs to be processed. For example, if the investment is purely a "financial investment then it has to be evaluated on the equity IRR basis, which is relatively low, as compared to other forms of energy such as Biomass / Hydel, etc. If the appetite is large, then the investor can go in for higher efficiency and higher cost technology there by being relatively assured of good performance of the turbine. It is only after this decision that one can think of selection parameters, which is another big exercise. Here one needs to pay more attention to the technology performance in terms of the plant load factor (PLF) and grid conditions and availability. What are the site characteristics in the location offered, whether the grid is available for over 92-95%, past performance of the grid etc. are some of the important issues to be considered in this regard. The investor should also consider the credibility of the equipment supplier in terms of his assurance for any technology failure, location disturbance and operations & maintenance. The investor perhaps can look for some kind of insurance policy to safe guard against force majeure situations. By and large the main issue comes up only on land. On making the first advance payment, the equipment supplier qualifies for the land title registration in the investor's name, the legal entanglement of the land could well be removed and the rest is only the process and supervision of the construction of the project like any other.

2. Wind Turbine Technology (WTT)

The evolution of modern wind turbines is a story of engineering and scientific skill. In the last 20 years, turbines have increased in size from 250 kW to 5000 kW and beyond, the cost of energy has reduced and the industry has moved from an idealistic fringe activity to an acknowledged component of the power generation industry. At the same time, the engineering base and computational tools have developed to match machine size and volume. This is a remarkable story, but it is far from finished: Many technical challenges remain and more spectacular achievements are set to follow.

S. No.	Indian Manufacturers	Capacity (kW)	Model	Rotor Diameter (Meter)	Hub Height (Meter)	Cut in wind speed	Cut out wind speed	Rated wind speed	Survival wind speed
1	Vestas Wind Technology India Pvt. Ltd.	1650	V-82	82	70 / 78 / 80	3.5 m/s	20 m/s	14 m/s	52.5
2	Elecon Engineering Company Ltd.,	600	T600-48	48	50/55/60	3.5 m/s	22 m/s	11.5 m/s	55.3/55.8 m/s
3	Enercon (India) Ltd.,	800	E-48	48	75	2.0 m/s	25 m/s	14 m/s	---
			E-53	53	73/75	3.0 m/s	25 m/s	12 m/s	57 m/s
4	GE Wind Energy INDIA,	1500	GE 1.5sleel	70.5	64.7/85	4 m/s	25 m/s	12 m/s	---
5	M/s Pioneer Wincon Private Ltd.	750	W755-48	48	50	4.0 m/s	25 m/s	14 m/s	---
6	Suzlon Energy Ltd.,	1500	S82 V3-1500	82	78	4.0 m/s	20 m/s	14 m/s	52.5 m/s
		2100	Suzlon S88 V3A-2100	88	80	4 m/s	25 m/s	14 m/s	59.5 m/s
7	M/s Shriram EPC Ltd.,	250	SEPC 250 T	28.5	41.2	4 m/s	23 m/s	14 m/s	58 m/s
8	M/s RRB Energy Ltd,	500	V39-500	47	50	4.0 m/s	25 m/s	14 m/s	56 m/s
		600	Pawan Shakthi-600	47	50	4.0 m/s	25 m/s	16 m/s	70 m/s
9	M/s Southern Wind Farms Limited	225	GWL 225	29.8	45	4.0 m/s	25 m/s	15 m/s	60 m/s
10	Regen Powertech Pvt Ltd	1500	V 77	76.84	80	3 m/s	22 m/s	11.8 m/s	52.5 m/s
11	Kenersys India Pvt. Ltd.	2000 kW	K82	82	80	3.5 m/s	25 m/s	---	---
12	WinWind Power Energy Pvt. Ltd.	1000	WinWinD 1 MW	60	70	4 m/s	20 m/s	11.5 m/s	---
14	M/s. Gamesa Wind Turbines Private Limited,	1500	G57-850 kW						
15	M/s Global Wind Power Limited,	750 kW	NORWIN 750	47	65	3-4 m/s	25 m/s	---	60 m/s
16	M/s Leitner Shriram Manufacturing Ltd.,	1350	LTW77-1.35	77	65	3 m/s	25 m/s	10.6 m/s	---
17	M/s. Siva Windturbine India Private Ltd., 250 kW	250	SIVA 250/50	30	50	4 m/s	25 m/s	14 m/s	----

The above table is only a representation of the equipment available in India. This gives a general character of the turbine technology and its salient features in the given wind speed locations. The investor cannot decide on the basis of these parameters as he needs to do independent WRA and assess it thoroughly before making any decision.

3. Wind Turbine Selection (WTS)

Selection of a wind turbine largely depends upon its economic viability. While the technical superiority in terms of its successful working is indeed a requirement, the cost also is equally important. What is significant to see here is, whether the vendor of the turbine is offering a comprehensive EPC, which includes absolute study of wind resource assessment (WRA) of the said land for establishing wind speed that corresponds to the rating of the turbine and that could enable the said turbine to generate the maximum. In the Indian context, it is the turbine supplier who gives the configuration of the turbines, while studying the WRA. However, in the event the developer has the source of procurement of wind turbines, then he needs to share it for the WRA study. WRA exclusively matches the turbine design for the location. It matches the given turbine space for the said location and if the location is not suitable, it could perhaps recommend a different location. It is necessary to know here that, when the turbine is designed, it is designed for a specific range of wind speed and it does not work vice versa.

4. Site Selection (SS)

Wind energy developers are interested in the energy that can be extracted from the wind, and how this varies with location. Wind is ubiquitous and in order to make the choice of potential project sites an affordable and manageable process, some indication of the relative size of the "wind resource" across an area is very useful. It is best accomplished through an independent WRA that draws together all known information on the site such as wind data, wind direction, wind regime, wind velocity, etc. With this, the micrositing is done at the site based on the diameter of the blade of the turbine.

There has been a paradigm shift in evaluating the above, WTT/WTS/SS under WRA. This new phenomenon is called "Probability of Exceedence" factor and it is done on a scale of P50/P75/P90. In the planning and financing stage of a wind farm project, a risk assessment is required quantifying all risks related to the wind farm financing, and it is called "technical due diligence". Financial modelling needs a comprehensive understanding of the project assumptions in combination with the performance of sensitivity analysis in order to define an agreed base case. The result of an energy yield prediction in terms of Annual Energy Production (AEP) is called the P50. The probability of reaching a higher or lower annual energy production is 50:50. A risk assessment includes the quantification of the project specific uncertainties and the whole range of exceedance probabilities (Pxx) of the wind farm's annual energy production. P75 is the annual energy production which is reached with a probability of 75%. The risk that an annual energy production of P90 is not reached is 10%. Both values are widely used by banks, funding institutions and investors globally as base case in their financing decisions.

In order to reduce the financial risk of a wind farm, special attention should be given to the operation and maintenance contract i.e., long-term warranties including availability warranties in terms of loss in energy production and performance warranties i.e., wind farm performance in relation to a reference wind mast. In both the above, enhanced flow models should be used for energy yield prediction and calculation of the wind farm power curve, which are validated for the type of terrain.

To conclude, in several wind farm projects in a portfolio of an investor, the risk can be mitigated by including wind farms in different wind regimes and by using different turbines of different capacities, with reduced performance uncertainties. If the power curve of a specific type of turbines is verified four times (according to my experience, in some cases we have measured more than a dozen times) the uncertainty of the power curve can be reduced by a factor of 2. From the funder's point of view, it is preferable when the P90 or P75 due to lower risks goes up even if the P50 slightly goes down by the applied measures.

5. Computer modelling

On a broader scale, wind speeds can be modelled using computer programmes, which describe the effects on the wind parameters such as elevation, topography and ground surface cover. These models must be primed with some values at a known location, and usually this role is fulfilled by local meteorological station measurements or other weather-related recorded data or extracted from numerical weather prediction models, such as those used by national weather services.

6. Constraints

Most wind energy resource studies start with a top-level theoretical resource, which is progressively reduced through consideration of so-called constraints. These are considerations which tend to reduce the area that in reality will be available to the wind energy developer. For instance, these can be geographically-delineated conservation areas, areas where the wind speed is not economically viable, or areas of unsuitable terrain. Areas potentially available for development are sequentially removed from the area over which the energy resource is summed.

By and large, post commissioning warranty and guarantee assumes significance for the smooth running of the project. Most of the parts are covered under manufacturer's warranty, which precisely means that "at any point of time within the defined period when the defect surfaces it shall be replaced". On the other hand, the guarantee covers the life of the technology.

7. Commissioning, Operation and Maintenance

Once construction is completed, commissioning will begin. It generally covers all activities after all components of the wind turbine are installed. Depending upon the capacity of the turbine, infrastructure available at site and location, commissioning of an individual turbine can take from as few as 6 hours to 2 days. Commissioning tests will usually involve standard electrical tests for the electrical infrastructure as well as the turbine, and inspection of routine civil engineering quality records. Careful testing at this stage is vital if a good quality wind farm is to be delivered and maintained.

The WTG availability is usually in excess of 95 per cent. This value means that for 95 per cent of the time, the turbine will be available to work if there is adequate wind. This value is superior to values quoted for conventional power stations. It will usually take a period of some six months for the wind farm to reach full, mature, commercial operation and hence, during that period, the availability will increase

from a level of about 80-90 per cent after commissioning to the long-term level of 95 per cent or more.
Operation & Maintenance costs include regular maintenance, repairs, spare parts and administration. The O & M cost which used to be 50 to 60 paise per unit (just over 1 cent of USD) has been reduced to (just over ½ cent of USD) which is 20 to 25 paise per unit or even less. Manufacturers over the years have aimed to shrink this cost significantly through development of new turbine designs requiring fewer regular services and thereby reducing downtime. The trend towards manufacturing of larger wind turbines also reduces O & M costs per kWh produced.

THE SCOPE OF ROUTINE OPERATION

During the tenure of this contract; this wind farm shall be completely operated and manned by the equipment supplier.

The equipment supplier will provide daily generation data for each WTG through a website and also inform the customer about his ID & password for accessing the website. Depending upon the requirement and the equipment supplier, there could be an option to sign the O&M contract for a period of 10 years as well and in such a case, the developer will have to spell the contract terms and conditions.

The equipment supplier will perform Routine Maintenance of WTG as per the standard practice by and on behalf of the OWNER at site for 10 years from the date of commissioning of machine. The essence of the contract is to improve and maintain the reliability of the WTG and to strive to achieve yearly Machine availability of 95%.

During the tenure of this contract no agency other than the equipment supplier's personnel shall be permitted to repair or tamper with the WTG covered under this contract. Any breach of this condition will be a sufficient ground to terminate this agreement and the equipment supplier shall not be under any obligation to refund any part of the amount already paid and shall besides be at liberty to pursue any other remedies available to him.

Preventive maintenance / Predictive maintenance:

The equipment supplier shall maintain the WTG as per the checklist recommended in its maintenance manual. Further it shall deploy at site its service personnel as required to carry out the above Maintenance from time to time. Operations part consists of deputing necessary manpower to operate the wind power project at the optimum capacity (@ 95% machine availability and highest grid availability). Operations procedures such as preparation to starting, running, routine operations with safety precautions, monitoring etc., shall be carried out as per the O&M manufacturer's instructions to have trouble free operation of the complete system. Monthly energy output of each wind turbine shall be recorded by the operator and reports shall be prepared on performance of the project indicating wind electric generator-wise production, downtime, capacity factor and WTG availability etc. and these figures shall be computed for the total wind power project as well.

The supplier shall draw the preventive maintenance schedules and attend to the breakdowns keeping in view that annual wind electric generator (WEG/WTG) availability is always more than 95%. The supplier shall carry out the periodical

WEG maintenance as given in the manufacturer's service manual. Regular periodic checks of the WTG shall be carried out as a routine preventive maintenance during low wind period. In order to meet the maintenance requirements, stock of consumables are to be maintained as well as various spares as recommended by the manufacturer.

8. Ranking Methodology

This aspect largely requires comprehensive study of both commercial and technical superiority. One needs to study different technologies, its past working in the said locations. The generation data of similar locations elsewhere will give an idea of the nature of working of those turbines and this when comprehended with WRA, will give the output of the actual performance. These generation figures should then be used for assessing and ranking different technologies with the price being offered.

Illustration:

Location: AA

	Equipment Supplier	Capacity of Wind turbine (in kW)	Generation Per Turbine (in lakh units)	Genera-tion in units (Per MW)	Cost of Turbine (in mn Rs) `	PLF %	Cost per MW (in mn Rs.)	Cost per kWhr `	Ranking Methods	
									cost	**PLF**
1	A	600	15.00	25.00	30.50	28.54	50.83	20.33	1	3
2	B	800	20.00	25.00	42.50	28.54	53.13	21.25	2	3
3	C	225	5.00	22.22	12.00	25.37	53.33	24.00	3	4
4	D	250	5.00	20.00	13.20	22.83	52.80	26.40	4	5
5	E	1000	24.62	24.62	65.60	28.11	65.60	26.64	5	2
6	F	250	4.50	18.00	12.30	20.55	49.20	27.33	6	6
7	G	1650	42.00	25.45	117.50	29.06	71.21	27.98	7	1

plf: plant load factor

From the above table it is clear that WTG supplier A has the cheapest cost while the supplier G has the highest PLF. It all depends upon the investor / developer to what kind of risk appetite and business model and returns are envisaged. From my experience, I would ideally look at investment on the project which could give me around 16-17% equity IRR and cost per kW hr not to exceed ` 24 for megawatt class turbine all inclusive, excluding the O&M after the warranty period.

9. Economics of Wind Power

Wind power is developing rapidly at both European and global levels. Over the past 15 years, the global installed capacity of wind power increased from around 2.5 GW in 1992 to just over 152 GW during mid June 2010, an average annual growth of more than 25 per cent. Owing to ongoing improvements in turbine efficiency and higher fuel prices, wind power is becoming economically competitive with conventional power production, and at sites with high wind speeds on land, wind power is considered to be fully commercial.

A specimen case study of debt funding on "project cash flow" gives an insight of the working of wind farm project on Independent Power Producer model.

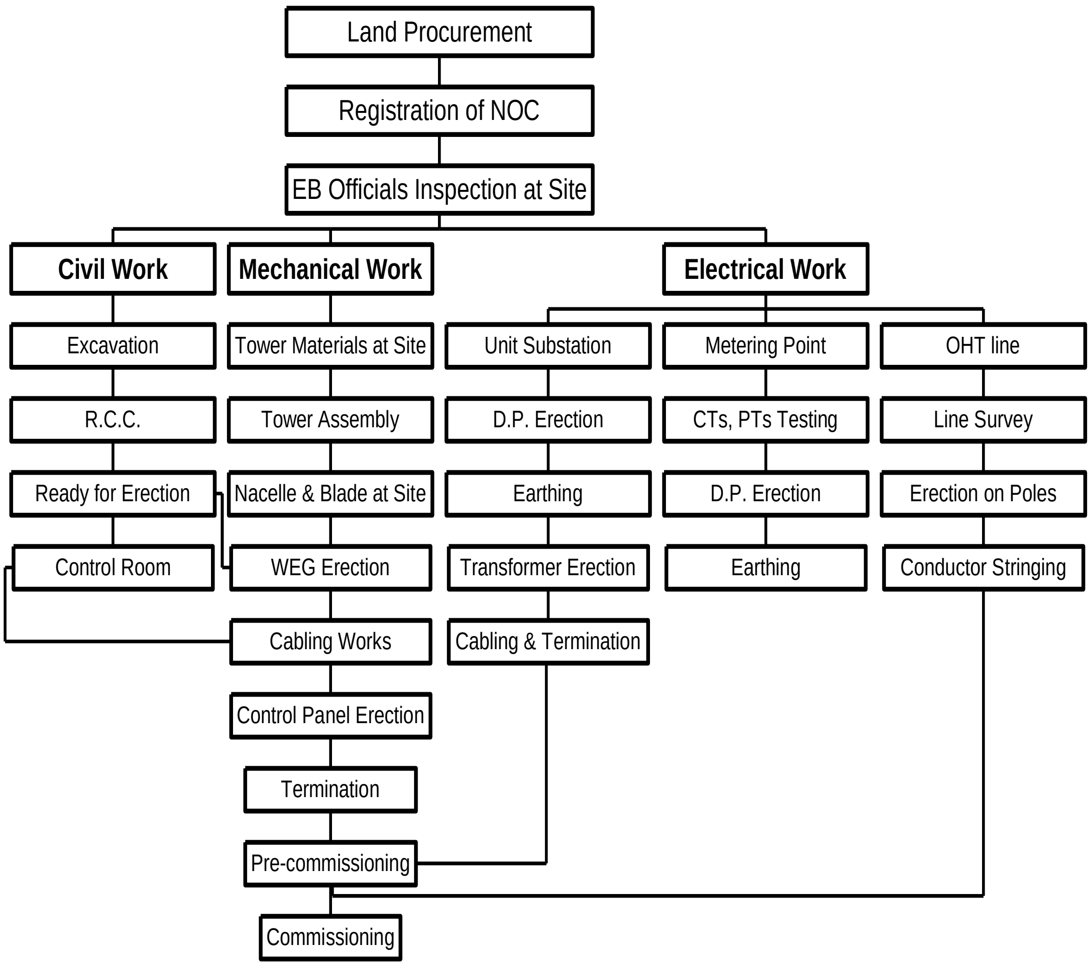
The cash flow/spread sheet basically denotes 2 issues and they are --- (a) for the lender, which clears brings out the DSCR (Debt Service Coverage Ratio) & Project IRR, and (b) for the equity investor, the Equity IRR. This needs to be clearly arrived at without any ambiguity. The lender of the debt may look at a tenor of 10 years and could expect the DSCR of an average of 1.30 with a minimum of over 1 in any of the 10 years. This precisely means "The DSCR is a ratio used to analyze the amount of debt that can be supported by the cash flow generated from the project" which should be ideally more than the amount borrowed on average during the tenor of the debt.

How did that developer select his equipment? What factors were important to him?

The selection of the equipment for the project depends on a lot of factors and most important of them are:

(i) Whether the equipment supplier has established presence in the market and if so, how long
(ii) What is the total capacity installed by them in the market
(iii) What is the performance of the equipment
(iv) Whether the equipment has performed, as promised by the manufacturer\
(v) If not, what is the deviation that has been recorded both in terms of the performance, O&M, etc.

PROJECT IMPLEMENTATION FLOW CHART



1. Introduction

The end-user device receives power from power generating sources through open access provision of the electricity grid. To ensure reliable and secured power to the electricity consumers, grid has to be planned, erected and operated efficiently. Grid connectivity standards, transmission planning criteria and Grid code defines the guidelines for achieving optimal operation of the system. Wind power plants, as a part of power system elements, have to fulfil the requirements as defined in the code documents. Wind power integration has to satisfy the technical need of grid reliability, security and quality. By its nature, wind generator is a variable power device; the individual unit size of wind generator is very small, also it may act as inductive load. Keeping these into account, grid connectivity standards, transmission planning criteria, grid code, grid operation and grid commercial issues are specified. The respective government agencies have to take necessary actions to help eliminate barriers to wind power development keeping in view the above-mentioned characteristics of wind power. The special requirements for wind farm integration with grid are briefly described.

2. Transmission

2.1 Transmission System

The electricity generated by wind generators (WEGs) is transmitted to load centres through transmission lines. To minimize the transmission loss High Voltage (HV) and/or Extra High Voltage (EHV) Transmission System is adopted. Various levels of voltage transmission are put in place with the help of transformers. Parallel operation of the system enables system reliability and it also minimizes transmission loss.

For effective operation and maintenance Substations are formed. A Substation facilitates switching operations. (A Substation is basically a switching station. It is also called a switch yard. Most substations are equipped with a voltage step-up facility is there in most of

System energy accounting and protection have been taken care of by current transformers, potential transformers, relays, meters etc. Circuit Breakers, Isolators, Earth switches, Lightning arrestors, earthing system etc. are all substation equipment. These equipment enable operation, maintenance and protection from the context of both transmission and distribution entities.

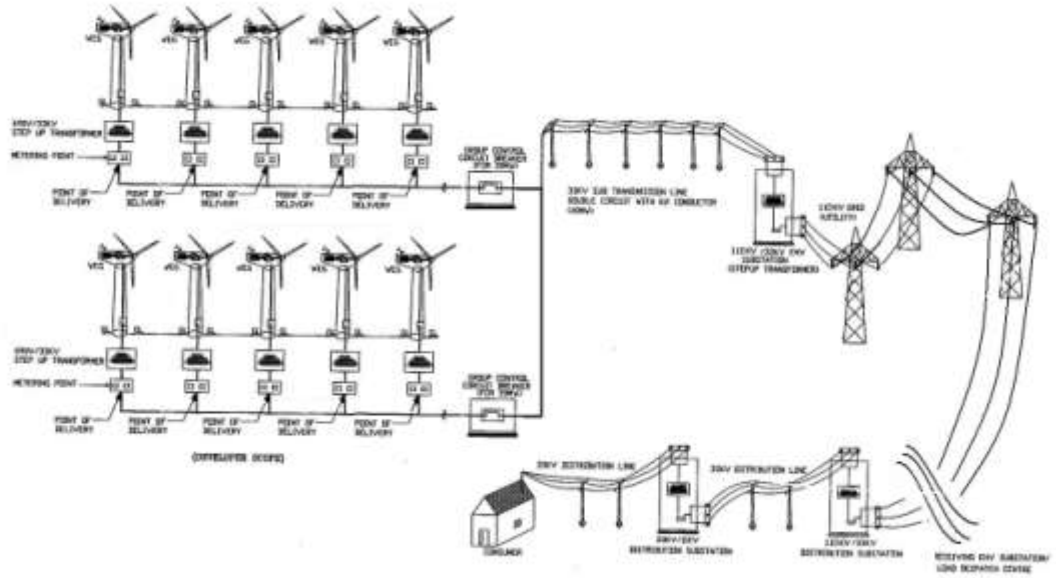


Figure1: Schematic Diagram of a WEG - Generation End to Consumer End

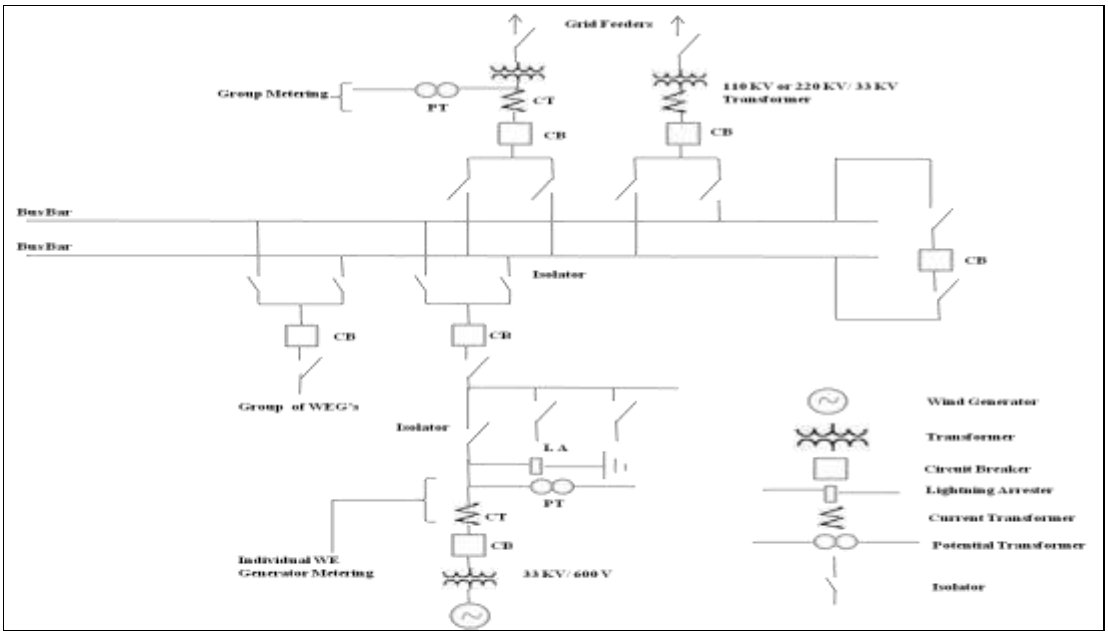


Figure 2: Single Line Diagram - Scope of WEG

The transmission system is planned and erected/strengthened well in advance so that electrical energy generated is transmitted without any constraints. Here, wind power backing down for want of evacuation system must be avoided. The reason behind this is that in developing countries, in certain cases, the transmission evacuation system may not commensurate with wind power growth. Wind power has to compete with conventional power for evacuation preference.

For transmission lines which connect the wind farm pooling sub-station to the main grid system, transmission planning criteria can be relaxed to minimise evacuation cost. Norms for Surge Impedance Loading (SIL) may also be relaxed taking into account the distance. Besides, the need for adopting N-1grid security can be addressed on a case to case basis.

The surge impedance loading (SIL) of a transmission line is the MW loading of a transmission line at which a natural reactive power balance occurs. Transmission lines produce reactive power (Mvar) due to their natural capacitance. The amount of Mvar produced is dependent on the transmission line's capacitive reactance (X_C) and the voltage (kV) at which the line is energized. A transmission line's surge impedance loading or SIL is simply the MW loading (at a unity power factor) at which the line's Mvar usage is equal to the line's Mvar production. The line length is not a factor in the SIL or surge impedance calculations. Therefore, the SIL is not a measure of a transmission line's power transfer capability as it does not take into account the line's length nor does it consider the strength of the local power system. The value of the SIL to a system operator is realising that when a line is loaded above its SIL it acts like a shunt reactor - absorbing Mvar from the system - and when a line is loaded below its SIL it acts like a shunt capacitor - supplying Mvar to the system.

SIL specifies limit on loading the transmission lines. However, short lines (less than 100 km) can be loaded more than 2.5 times the SIL. Wind power evacuation lines may be generally less than 100 km. Therefore, lines can be designed for higher SIL which helps minimize project cost.

The N-1 Criterion (as per the UCTE grid code) is a rule according to which elements remaining in operation after failure of a single network element (such as transmission line / transformer or generating unit, or in certain instances a bus bar) must be capable of accommodating the change of flows in the network caused by that single failure.

To ensure grid security, as per the above criteria there may a need for duplication of wind power evacuation system. Considering the poor CUF in the case of wind power, the N-1 criterion may be relaxed to minimise project cost.

2.2 Transmission Tariff

For transmission of electrical energy from generator to the load element, transmission system is required. For installation and proper upkeep of the Transmission System, a transmission service provider needs financial resource. The required revenue is to be collected by way of transmission charges which may be collected from Transmission System Users, such as generators and distribution companies. Government designated agencies may compute the transmission tariff based on financial norms including capital cost employed, debt-equity ratio, rate of return. Interest on working capital, O & M charges, depreciation cost etc.

2.3 System Impact Study

When a wind plant is connected to grid, as the individual unit size is small compared to conventional generators, it may not pose problems to grid operation. However, considering the higher penetration level of wind plants, it may cause operational constraints such as voltage fluctuation due to reactive power mismatch, frequency excursion attributable to changes in wind velocity, harmonics associated with control and conversion devices, self excitation at the time of line tripping etc.

It may be noted here that permissible penetration level depends on various factors such as the type of generation mix, regulatory reserve profile, load curve, load profile, nature of ancillary service etc. Defining a specific limit can be attempted at a later stage.

In order to ensure reliable, secured quality power, System Impact Study is needed to evaluate the required compensation. Also, in a market-based system operation environment, the regulator has to satisfy with the level of compensation claimed by transmission service provider in the interest of wind power development and the electricity consumer. Installation of Low Voltage Ride Through (LVRT) for wind power plants is generally recommended by the service provider. However, the necessity has to be demonstrated by the service provider if there is a need.

(The need for LVRT facility, requirement of reactive power compensation, power quality problems and self excitation issues attributable to wind plants etc. may warrant System Impact Study.)

3. Grid Code & Grid Connectivity Standards

3.1 Terminology (Prefer to move this section as an appendix)

Ancillary Services	In relation to power system (or grid) operation, the services necessary to support the power system (or grid) operation in maintaining power quality, reliability and security of the grid, e.g. Active power support for load following, reactive power support, black start, regulating frequency during high wind power availability
Bulk Power Transmission Agreement (BPTA)	An agreement between TSUs and transmission service providers as specified by regulating agencies.
Connectivity	Wind Farms connectivity with Transmission/ Distribution System
Connection point	A point at which a Wind Farm connects to the Transmission /Distribution network
Connection agreement	An agreement between a Transmission /Distribution Licensee and the Transmission Service providers. A Connection agreement shall be signed by the applicant in accordance with the respective Government Authority's Regulations.
Control Area	An electrical system bounded by interconnections (tie lines), metering and telemetry which controls its generation and/or load to maintain its interchange schedule with other control areas whenever required to do so and contributes to frequency regulation of the synchronously operating system.
LDC	Load Dispatch Centre
Power Purchase Agreement	An agreement between the Distribution Company or bulk power users (Industry) and wind farm owners as specified by regulatory agencies.
Transmission Planning Criteria	The policy, standards and guidelines issued by the authorised Government agency for the planning and design of the transmission system
Transmission System User (TSU)	A person who has been allotted transmission capacity rights to access an intra-state transmission system pursuant to a Bulk Power Transmission Agreement, except as provided in the Transmission Open Access Regulations.
WTG	Wind Turbine Generator
Wind Farm	A Wind farm is a group of WTGs that are connected at a Pooling grid Sub-station
Wind farm owner	Entity having legal right of the Wind farm

4. Frequency control

Add some text for frequency control

4.1 Forecast and Scheduling

Scheduling of wind energy sources can be considered keeping in view the penetration level. Wind plants can be subjected to forecast and scheduling. However, if there is a deviation in the actual from the scheduled figure, wind farm shall not be asked to pay unscheduled interchange charge. WTGs are required to pay unscheduled interchange charges from 01/01/2011 in India.

4.2 Ancillary services

For large-scale integration of WTG electricity to the grid, and for improved grid operation, variable nature of wind generation has to be supplemented by ancillary services. Since power output from WTGs is variable depending on the wind input, grid operator needs steady output for smooth grid operation. Ancillary service can supply back up generation at the time of need and absorb surplus power of grid when wind power is in excess of demand. Pumped storage hydro is one such example. In such a case,
LDC has to enter into an agreement with ancillary service providers.

4.3 Load despatch Centre (LDC)

The system operator (LDC) shall make all efforts to evacuate the available wind power and treat as a must-run station. However, the system operator may instruct the wind generator to back down generation on consideration of grid security and if the safety of any equipment or personnel is endangered the wind generator shall comply with the same. For this, a Data Acquisition System facility shall be provided for transfer of information to the concerned LDC. Further explanation can be found under Section 9 (SCADA).

5. Reactive Power Management

5.1 Power Factor Design

Conventional Synchronous Generators inherently provide reactive power, whereas most induction-type generators used by wind plants currently can only provide reactive power through the addition of external devices. Wind plants are required to operate within a specified power factor range to help balance the reactive power needs of the transmission system. Large wind plants maintain a power factor within the range of 0.95 leading to 0.95 lagging to be measured at the high voltage side of the wind plant substation transformer. Wind plants should have the capability to provide sufficient dynamic voltage support to interconnect to the transmission system, if the System Impact Study shows that dynamic capability is necessary for system reliability. Dynamic reactive capability can be achieved by systems with a combination of true dynamic capability plus switched shunt capacitors and reactors.

5.2 Voltage Control

LDC may direct a wind farm to curtail its reactive power draw-down/injection in case the security of grid or safety of any equipment or personnel is endangered. During the wind generator start up, the wind generator shall ensure that the reactive power draw-down (inrush currents in the case of induction generators) shall not affect the grid performance.

5.3 Reactive Power Pricing

In a market-based environment, reactive power absorption by WEG beyond a defined limit has to be priced. Likewise, reactive power generation more than nominal value by the generator to support the grid operation at the time of need, has to be compensated. Regulators have to address this issue after taking necessary input from LDC and the transmission service provider.

6. Harmonics and voltage flicker

Harmonics control and measurements shall be taken in accordance with methodologies of IEC 61400-21 or IEEE STD 519-1992. As regards voltage flicker, the IEC61000-4-15(IEC, 1997) and IEC 61000- 4-15(IEC, 2003) standards shall be followed.

7. Protection Scheme

Wind farms connected at transmission system shall remain connected to grid during system fault. Reactive power compensation equipment must also remain connected during system fault.

Wind farms connected at transmission level shall be provided with Low Voltage Ride Through (LVRT) capability. However, this may be decided by the appropriate government agency taking into account the penetration level. The cost would have to be addressed appropriately in the generation tariff.

All the grid-connected WTGs must have a protection system to protect the wind farm equipment as well as the grid, such that no part system shall remain unprotected during faults. The protection schemes shall be coordinated with respective grid protection committee. A WTG is to be protected against short circuit and earth fault generally.

8. Metering and communication requirements

To ensure appropriate real-time communications and data exchanges between the wind power producer and the grid operator, supervisory control and data acquisition system shall have to be in place. For this purpose, necessary metering arrangements have to be provided by the wind farm owners at the respective interface with transmission / distribution system, as specified by the appropriate government agencies. These metering arrangements are required for the purpose of operation control, protection arrangement and the settlement of both reactive and active energy exchanges. In the case of open access transaction the generator or the receiving utility would pay the transmission/wheeling charges as decided by tariff regulatory agencies.

9. Supervisory Control and Data Acquisition (SCADA)

Transmission Providers generally do not require wind generators to have remote supervisory control and data acquisition (SCADA) capability because of their small size and minimal effects on the transmission system. However, with the increasing number of large wind plants connecting to transmission systems, SCADA capability is needed to acquire wind farms operating data and ensure the safety and reliability of the transmission system during normal, system emergency, and system contingency conditions.

10. Balancing and Settlement Code

Distribution company or bulk power users (industry) shall have to enter into a power purchase agreement with the wind farm owners as specified by regulatory agencies. Also, for using transmission line of the transmission service provider, an agreement (BPTA) is needed between the users and the transmission company. A copy of these agreements shall be made available with the system operator (LDC) for making necessary balancing.

For every control area, there is a need for a Balancing and Settlement Mechanism. Through this mechanism the energy transfer by the wind farms would be accounted and energy received by the recipient utility shall be identified based on the power purchase agreement as available with the Load Despatch Centre. Transmission loss sharing, Transmission / wheeling charges would be accounted based on the BPTA agreement. The balancing authority has to prepare weekly or monthly statement towards settlement and the copies have to be given to the TSUs. Based on the statement the payment may be made by the recipient utility to the wind farm owners within the time frame specified by the Regulating Agencies.

11. Regulatory Requirements

11.1 General

The interconnection requirements for wind power facilities larger than specified size, 5, 10 or 20 MW based on grid capacity need to be specified by Regulating Agencies.
While formulating the rule, the technical differences in the design and operational characteristics of wind generating technology, development of wind generating resources and ensuring reliability shall have to be kept in view.

The final rule provides that wind generators must meet the following conditions, if the transmission service provider demonstrates they are needed. First, if needed, a large wind generating facility must remain operational during voltage disturbances on the grid. Second, large wind plants must, if needed, meet the same technical criteria for providing reactive power to the grid as required of conventional large generating facilities. Third, the final rule provides for supervisory control and data acquisition (SCADA), if needed, to ensure appropriate real-time communications and data exchanges between the wind power producer and the grid operator. The requirements can be worked out by the service provider based on the System Impact Study and the same can be finalised by the Regulator after technical scrutiny and discussion.

The different WTG designs available may be grouped into four main categories:

a) Conventional Induction Generator (Constant Speed Drive).
b) Double-fed asynchronous generator (Variable Speed Drive)
c) Gearless Synchronous generator with back to back frequency converter
d) Advanced gearless design with permanent magnet generator

11.2 Connectivity by Generators to Transmission System

The transmission service providers have to prepare the connectivity framework in concurrence with the regulatory agencies.

The application for connectivity with the transmission system by WEG would have to cover the information as tabulated.

A	General	
1	Name of the Generating Company	
2	Name of Power Station, Nos. of units, unit size, location	
3	Generating Company Officer-in-charge for co-ordination of work – Name and Designation	
4	Point of Connection to intra-State Transmission System, single line diagram of the proposed connection to be furnished.	
5	Name of Transmission Licensee with whom system's connection is required or any existing connection to be modified	
6	Evacuation system indicating number of feeders and voltage levels	

B	Construction Schedule of Pooling Sub-Station					
	Name of Pooling Station	**Group Of Units & Size**	**Commencement**	**Completion**	**Date of Pooling Sub-Station Commissioning**	**Date of commercial operation**

C	Inter-Connection	
1	Generation voltage, step-up voltage for connection	
2	Details of feeder protection on outgoing feeders to be connected to Transmission Licensee system for evacuation of power.	
3	Start-up power requirement and black-start sequence and process.	
4	Requirement of power for construction and voltage	

C	**Generator**	
1	Metering system provided on lines indicating ownership and responsibility for joint meter reading, sealing and calibration etc. As per Metering Code	
2	Details of feeder protection on outgoing feeders	
	Copy of Power Purchase Agreement /MOU for power purchase and Transmission Service Agreement for evacuation by Transmission Licensee.	
	Copy of Power Purchase Agreement /MOU for power purchase and Transmission Service Agreement for evacuation by Transmission Licensee.	
3	Confirmation to the effect that all conditions outlined in the Connection Agreement, Site Responsibility Schedule shall be complied with by the user applying for new connection or modification of existing connection.	
	Detailed Planning Data (Generation) in compliance to Grid Code for new connection	
	Details of relay schemes provided for Generator Protection, Generator Transformer Protection and Unit Auxiliary Transformer Protection Details of data acquisition and control system for unit being inter- connected.	
	Confirmation to the effect that Standard Planning Data (Generation) in compliance to Grid Code for new connection	

11.3 Bulk Power Transmission Agreement

The Transmission Service Providers (TSPs) may prepare model Bulk Power Transmission Agreement in concurrence with regulatory agencies.

The Bulk Power Transmission Agreement between the WEG and the transmission service provider (TSPs) would have to address the following points:

Key Points to consider in a Bulk Power Transmission Agreement

1.	Bank Guarantee towards Security Deposit
2.	Establishment of Letter of Credit
3.	Fee and Charges of Load Dispatch Centre
4.	Billing and Delay in Payments Scheduling and drawl by TSU
5.	Balancing power pricing
6.	Assessment of available transmission capacity
7.	Dedicated Transmission System
8.	Non-Utilization of Open Access Capacity
9.	Assignment of Transmission Capacity
10.	Surrender of Transmission Capacity
11.	Metering
12.	Energy losses
13.	Transmission Constraints
14.	Compliance of Grid Code
15.	Transmission Performance Standards

Engineering, Procurement and Construction (EPC) (Suzlon) 4

The contracting for wind power projects depends upon the prevailing model of implementation of wind projects in the country. In case of European countries the project developer is responsible for identification and development of the site, micrositing, selection of turbine manufacturer and erection and commissioning of turbines with development of allied infrastructure of roads and power evacuation facility. In some countries like India, wind turbine manufacturer also acts as project developer and provides end-to-end solutions from selection of site till post sales services such as O & M. Thus depending on the prevailing market model the model for EPC would be different.

Feasibility Report

Irrespective of the implementation model the feasibility report is a good starting point for exploring the investments in wind power. This feasibility report would even cover the prevailing implementation practice for wind power projects in the country. On the technology front it covers the types and availability of different turbines in the country. However, the feasibility report would not be limited to the market model and cover the basic factors like possible sites, availability of authentic wind resource data, possible energy generation, availability of the infrastructure. Further the feasibility report also includes the prevailing policy environment, structure of power industry, facilities given to wind projects including the incentives, tariff and grid connectivity standards.

Based on the feasibility report the decision to peruse the project is taken.

Detail Project Report (DPR)

DPR is the basic documentation requirement for any financing institution. A wind power project requires higher upfront investment and hence the project is very cost sensitive. Parameters such as capacity factor, tariff, capital cost ("CAPEX"), O & M cost ("OPEX"), tax structure etc. have major impact on project viability. Since in majority of the cases wind power projects are partly financed by banking institutes, private equity firms, and venture capitals they require complete understanding on techno-commercial aspects of the project before financing. Also, the developer must understand overall project viability before entering into such long-term contracts as his project economics are solely dependent on financial viability of the project.

Typically DPR encompasses vital techno-commercial project aspects based upon which developer and/or financial institutes try to obtain thorough project insights. Following aspects are usually deemed to be part of DPR:

1. **Brief information regarding project**: This section typically provides information on site location, developer information, brief information on financial institution, type of turbine proposed for project, total MW capacity planned etc.

2. **Detailed Site Information**: This section usually deals with exact location of site, approach to site (nearest rail, road and airport etc.), marking of site on appropriate maps, type of flora and fauna in the vicinity etc.

3. **Environmental Impact Assessment (EIA)**: This section deals with probable impacts of proposed wind power project.

4. **Details regarding selected manufacturer**: In this information capabilities of selected manufacturer, justification on selection of particular manufacturer etc. are provided.

5. **Type of Turbine Model used**: In this section detailed information is provided on type of wind turbine model considered for project, power curve and detailed technical information on product and technical validation analysis.

6. **Wind Resource Study**: Under this section details are provided regarding the wind flow pattern, wind flow modeling, suitability of selected turbine type for available wind resource, annual energy production (AEP) estimation etc.

7. **Land details**: Under this section information is provided on type of land proposed for wind power project, details on land availability i.e. whether land is available with developer or it is under procurement or under approval phase (for the government land), whether it is purchased or leased etc.

8. **Micrositing details**: Details are provided on exact location of proposed wind turbines consisting of UTM coordinates, zone, elevation etc.

9. **Evacuation details**: This section consists of single line diagram, proposed substation capacity and layout, location of substation from proposed wind farm, details on evacuation line, metering arrangement, ownership details (i.e. owned by developer or government etc.)

10. **Policy and Regulatory Study**: Details on policy and regulatory environment are provided in this section. It broadly highlights tariff structure, tariff consistency, policy stability, other incentives, tax benefits, structure for sale of electricity, CDM etc. This section also highlights permissions and approvals required to setup a wind power project at proposed location and insights regarding actual payment realization time from utility.

11. **Commissioning Schedule**: This section provides information on realistic schedule for turbine commissioning. It is usually in the form of Gantt or pert chart.

12. **Financial Outlook**: This section assesses techno-commercial project viability detailing CAPEX, OPEX, working capital, debt: equity, interest rate, capacity factor, tariff, tax structure, other incentives etc. Results of this analysis are usually indicated in terms of IRR, NPV, DSCR etc.

13. **SWOT analysis**: This section normally investigates strength, weaknesses, opportunities and major project threats. This section summarises project details.

14. **Contingency analysis**: This section is for assessing project risks by varying parameters considered during financial outlook. Various possible combinations of parameters are worked out to optimize project viability and to achieve realistic economic outlook.

15. **Conclusion/ salient features:** This section concludes the DPR highlighting advantages and disadvantages of project and proposes way forward for the project activity.

Availability of such DPR mitigates technical and commercial risks for wind power project and helps the developer, investor and financial institutions in appropriate decision making.

The contents of the DPR can vary depending upon the implementation model of a wind project. Primarily there are two implementation models -- a. The land acquisition and other infrastructure development is undertaken by the investors or project developer and turbines are procured from turbine manufacturer b. the turbine manufacturers also act as project developers and undertake the entire process. In India, which has about 11000 MW of wind capacity installed, the second implementation model is prevalent.

Preparation of Bid Document

Depending upon the implementation model the bid document and contracting for wind power projects varies. In case the land has been procured and the contracting is being done for the project then the components involved in bidding are:

1. **Carrying out Micrositing, Projection of Annual Generation**
   This involves the detailed study of the site, the type of land use and land cover which affects wind generation. The analysis of the wind data, if the wind measurements have been undertaken at the site, and the annual energy generation from the proposed project is to be estimated.

2. **Supply of Equipment**
   The technical parameters of the wind turbines are to be supplied along with the bid, this involves the power curve for the wind turbine, specifications of other components like step up transformer, generator etc.

3. **Development of Infrastructure – Grid, access roads etc.**
   The development of road infrastructure for erection of wind turbines is to be undertaken. The designing and development of power evacuation network from the wind turbines to the nearest grid point is to be undertaken. This also involves obtaining necessary permissions, approvals involved e.g. connectivity with the grid, construction of access roads etc. At projects of high capacity a dedicated control centre for monitoring of wind turbines is also to be developed.

4. **Erection and Commissioning of Wind Turbines**
   Erection of wind turbines as per the micrositing details is to be undertaken. This will also involve the foundation for the turbines as per the soil conditions. The commissioning of the project is to be undertaken as per the prevailing practice in the country and the local utility.

5. **Operation and Maintenance of the Wind Project**
   The turbine supplier may provide a limited period free operation and maintenance service. The project bid may include the operation and maintenance services for the period after the free O&M period. This could also be designed for a fixed period with agreed upon annual increase in the cost.

In case the bids are invited for the wind projects where project location/site is not fixed, the bidding requires the bidders to submit turnkey bids with complete projects at different sites. In case of India where the turbine manufacturers are involved in project development this type of bidding is prevalent. All the above components of projects are combined together in this case and offered as a single bid. This involves the identification of site, acquisition of land and necessary permissions, development of infrastructure, supply and erection of turbines.

Evaluation of Bids

The bid evaluation is normally done in two stages -- A) Technical evaluation and b) Financial evaluation. The bids which qualify in the technical evaluation are further evaluated on the financial basis. In case of technical evaluation there could be a minimum qualifying criteria or the bid can be technically ranked, and the top three or four are further evaluated on financial parameters.

A) Technical Evaluation

In order to evaluate and rate the bids an evaluation criteria needs to be prepared. The evaluation criteria can be selected from the various parameters requested from the bidders in the bid. These important criteria can be broadly divided in the following categories (arranged in the descending order of importance):

1. *Energy Generation*
   In the case of energy generation, the important parameter is the net annual energy generation from the proposed project. In case the project bids are for different capacity annual net generation per MW can be used for evaluation.

2. *Machine related*
   The machine related parameters are of two types, namely (i) those related to the experience of the offered machine in the country and its certification and (ii) those related to salient features (electrical/ mechanical/safety etc) of the machine.

   Parameters related with experience of the turbine model offered in the country may include the number of machines installed and the number of years the machine is being offered.

   The machine features which may be included in the evaluation criteria are:

   - **Status of Certification**
     The turbines offered must have a necessary type test certificate from the appropriate authority in the country. In the absence of such a certification process in the country, an international certificate can also be considered.

   - **Machine Size**
     Higher capacity wind turbines offer optimum land use and lower O&M costs and hence are preferred.

   - **Generator Type**
     The synchronous generators have definite advantages in terms of efficiency and thus are preferred.

- **Geared/Gearless**
  The gearless machines have highest energy capture thus are preferred.
- **Startup**
  Machines with soft start mechanism present less problem to the grid in which the turbines are connected and hence preferred.

- **Reactive Power Control**
  The turbines with the dynamically varying control systems are preferred as these systems have better reactive power control than the mechanically switched control systems.

- **Class of Machine**
  The class of machines is an indicator of whether the wind turbine is designed to operate in that class of wind regime. The definition of the wind turbine classes is given in IEC safety standards (IEC 61400). Along with the other parameters the class defined by the annual average wind speed at the hub height is given in the table below.

WTG class	I	II	II	IV
Annual avg. wind speed (m/s)	10	8.5	7.5	6

  Depending upon the wind resource at the site the wind turbine class is to be checked.

- Power Regulation
  The active pitch control technique has better control on the output power from the wind turbine and thus is preferred.

3. *Bidder related.*
   The experience of bidders in terms of installation of wind farms in the country as well as the O&M capability can be included as the evaluation criteria.

B) Financial Evaluation

After the technical evaluation, the financial evaluation is undertaken involving the bids which were selected in the technical evaluation. The best criteria for financial evaluation is to compare per unit cost of generation from the wind power project.

Introduction:

A financial model for a wind energy project is required for the purposes of investment analysis and decision making, cash flow projections, raising debt funding and performance monitoring. As in the case of any other financial model, basic cash flows are projected and various scenarios are built up. Important financial ratios are computed and profit and loss account and balance sheet are projected. Thus, a financial model will be made before the investment is committed and will be used during the life of a project to monitor its performance against the forecast.

Typically, wind turbines have a design life of 20 years and therefore cash flows forecasts are made for 20 years. Depending on requirement, a shorter or longer forecast could be modelled. Further, an important decision while building up the model is to decide on discrete time periods that the model will depict or consider. The financial model could be built on monthly, quarterly or annual basis. Thus, the cash flows would be forecasted for every month, quarter or year for the life of the project. An annual model may provide a quick assessment regarding project viability whereas a quarterly model will be more accurate and aid in detailed analysis. On the other hand, monthly models are rarely used since they become complex and do not add too much value in analysis.

The financial model will begin with laying down important data points and assumptions regarding the project which can be put separately in the model as an input. This helps in revisiting the analyses in case a critical assumption changes. The data point and assumptions to be considered range from technical concepts such as the business model of the project (fixed tariff PPA, merchant sale or captive consumption etc) to technical modalities such as generation estimates, along with all the other essential financial parameters such as debt-equity ratio, interest rates etc.

Therefore, it may be worthwhile to take an in-depth look at the essential parameters that help in building of the financial models. The following sections throw light on the various parameters involved.

1. GENERAL PARAMETRES

a) Business Model

A wind energy project can be operated under one of several possible business models. The business model defines the sales arrangement for electricity generated, mechanism of payment, credit period and impacts the revenue generated by the project. The most common business models are discussed hereunder:

i) Power Purchase Agreement

A wind energy generator can choose to enter into a contract for sale of electricity with an offtaker, who is usually either a utility or a consumer. Such contract is called a Power Purchase Agreement or Energy Purchase Agreement. The offtaker would buy the electricity generated and pay the generator as per pricing determined under the contract. Usually, State owned utilities purchase the wind energy on a long-term basis at a predetermined rate from the generators.

ii) Merchant Sale

Under this arrangement, a bilateral agreement is signed between the project sponsor and any other third party (and not the EB). The project sponsor is paid at a rate mutually decided upon by the two parties. The rate may vary depending on various factors such as time of day and demand etc or may be fixed.

iii) Captive Consumption

As the name suggests, own consumption of the electricity by the investor makes for this type of the wind business model. Specifically, when the investor is estimated to have high electricity consumption (mostly in manufacturing and industrial set up), then this mode of wind business may be adopted. The project sponsor gets a set off on the monthly energy bills to the extent of electricity generated and fed into the grid. Any surplus generation is paid for at the ongoing tariff rate (in whichever State operated). In India, captive route for wind energy is the second most preferred option, after Sale to EB model.

2. CAPITAL EXPENDITURE

Capital expenditure for any wind farm project includes expenses towards plant and machinery, civil works, erection and commissioning, evacuation infrastructure, cost of land and associated infrastructure such as access roads etc. The Central Electricity Regulatory Commission (CERC), in its latest order towards calculation of RE Tariff assumes a capital cost of Rs 467 lakhs/ MW (inclusive of all the above mentioned factors).

For the purpose of a financial model, any future capital expenditure such as on refurbishment of turbines after several years of operation also needs to be considered wherever applicable. In case the project sponsor does not enter into a comprehensive O&M contract, he may need to budget for future capital expenditure which may result from breakdown of any major components. However, forecasting such capital requirement is difficult and will be invariably based on history of wind turbines being used.

3. ELECTRICITY GENERATION

Estimating the electricity generation from a wind energy project is the most critical part of the financial model. The generation estimates are based on wind data observed at the site and should be computed for various probabilities such as P50, P75, P90 and P95. The P50 generation would estimate for electricity generation which has 50% probability of being achieved. Different probability estimates help to forecast differing cash flow scenarios.

Various factors significantly impact the generation potential of any WTG. These factors are discussed below:

i) Generation estimation at P50/P90

Annual electricity production (AEP) is one of the essential parameter having direct impact on overall project viability. Since wind flow is erratic in nature and sensitive to seasonal variations, significant amounts of variations are involved in AEP prognosis. Hence, it is required to plot different scenarios for cash flow forecasting. The simplest financial models will use only P50 as the single generation estimate and forecast cash flow on this basis. More sophisticated models will use other generation estimates as well.

A risk assessment includes the quantification of the project specific uncertainties and the whole range of exceedance probabilities (Pxx) of the wind farm's annual energy production. P75 is the annual energy production which is reached with a probability of 75%. The risk that an annual energy production of P90 is not reached is 10%. Both these values are widely used by banks and investors as base in their financing decisions. Further, P90 or P95 cash flow forecasts will help determine the working capital requirements under worst case scenarios.

ii) Expected yearly project output

Expected yearly project output depends largely on the PLF/ CUF of the model installed. However, per MW CUF estimates can be made available from the recently released CERC tariff guidelines. The CERC tariff guidelines have adopted an approach of a zone wise tariff, which assumes different CUF levels for different zones. These are mentioned as under (on a per MW basis):

Annual Wind Power Density (W/m2)	CUF
200 – 250	20%
250 – 300	23%
300 – 400	27%
> 400	30%

It may be noted that the annual expected output from the projects can be derived from the above mentioned CUFs. However, it may please be noted that annual mean wind power density specified above shall be measured at 50 m hub height.

iii) De-rating of Generation

Extreme operational conditions beyond designed limits often result in underperformance of turbine components. Over the years, turbine output may fall below expected generation. To reflect this fall in output and therefore revenues, a suitable de-rating factor may be used in the financial model. Usually, de-rating may be applied after 10-12 years of operation. The gross generation of turbine (P50) may reduce by 1-2 % in absolute terms due to de-rating. However, the actual de-rating will depend on actual operating conditions and maintenance of turbine.

iv) Seasonality of Generation

A wind turbine will not produce the same amount of energy during the whole year. There will be seasonal variation owing to wind patterns. Typically, in southern India, about 60% of annual generation may be achieved in 6 months of peak wind whereas the lowest 1 or 2 months may generate only 5% of annual output.

If the financial model is prepared on quarterly or monthly basis, this seasonal variation in generation needs to be taken into account. If the financial model is being prepared on annual basis, these variations may be ignored.

4. REVENUE MODELING

Depending on the business model chosen, the project revenues will be forecasted. The revenues from the project may have more than one component emanating from sale of electricity, carbon credits, other regulatory incentives etc. The quantum as well as timing of actual cash inflows will depend on relevant contracts and incentive structures. In case of captive consumption, the total cost savings in energy bill is substituted for revenue and the timing will be same as the timing of payout in case of consumption from grid.

The most critical factors in forecasting revenues are – generation estimates (P50, P75, P90 etc), seasonality of generation, billing cycle and credit period. Typically bills against electricity generation are raised on a monthly basis and actual revenue is credited to the concerned in the time frame of 15 days to 3 months, depending upon power purchase agreement (PPA). Therefore, the revenue cash inflows are to be modelled accordingly.

Additional sources of revenue in India (apart from the revenue from sale of electricity) are discussed below:

(Annexure I: State-wise Tariffs for wind energy projects in India, for Sale to EB)

i) Generation Based Incentives

The Generation Based Incentives (GBI) scheme has been recently announced by MNRE (As on 17th Dec, 2009). This scheme has been designed in order to encourage and aid the entry of Independent Power Producers in the Indian market, who were not seen to be as forthcoming as the other customer segments. The key features of this scheme are:

a) GBI will be available to all investors who do not avail the Accelerated Depreciation benefits for their projects

b) The per unit incentive to be made available has been pegged at Rs 0.50 per kWh

c) Applicable for Sale to EB and Captive Consumption business models. Also in the case of captive consumption, it will only be available to the extent of surplus available for sale to EB

d) Applicable cap of Rs 62 lakhs per MW

e) Co-existent with AD until the announcement of DTC or end of the five year plan, whichever is earlier

Thus, revenue from GBI can be modelled as Rs 0.50 per kWh generated from the project. The payments will be made every 6 months and cashflow timings should be modelled accordingly.

ii) Renewable Energy Certificates

Most recently, tradable Renewable Energy Certificates (REC) have been introduced in the Indian markets. The RECs have been inducted into the system in order to aid RPO fulfillment by those States, which are not well endowed in terms of good wind resources.

Under the framework set for these tradable RE certificates, the owner of the RECs would be entitled to trade them in the open market, using the power trading exchange as the potential platform. The open market transaction would lead to effective price realization of the certificate. However, in order to safeguard against any risks for this budding market, CERC has set in place, a floor and a forbearance price for these certificates. The floor price for RECs has been set at Rs 1.50/ unit and forbearance price is that of Rs 3.9 / unit. (Where 1 REC = 1 MWh)

The REC revenues therefore need to be modelled between these two prices. Depending on the optimistic, most likely or pessimistic scenarios being adopted in the model, the price can be assumed between these limits. However, since the REC pricing will vary over the life of the project, it will not be possible to correctly forecast prices and a conservative approach in assuming the prices is recommended.

iii) Carbon Credits

The wind projects are eligible for issue of carbon credits under the Clean Development Mechanism (CDM) under the Kyoto protocol. If a project chooses to apply for CDM registration, it may forecast CDM revenues depending on the number of CERs likely to be generated by the project. However, as in the case of REC, prices of CERs vary and it is difficult to forecast a correct price. Moreover, CDM registration process involves several steps and is time consuming. Therefore, CDM revenues are likely to materialize later in the life of the project.

Further, depending on the regulatory structure and PPA, part of CDM revenues may need to be shared with electricity offtaker. If applicable, financial model should make a provision for this. As per CERC, 100 % of the gross proceeds on account of CDM benefits are to be retained by the investor in the first year after the data of commercial operation of the project. However, in the second year, the sharing arrangement between the generation company and concerned beneficiary shall be 10% every year till it reaches 50%, where after the proceeds shall be shared in equal proportion between the parties. Therefore, for Indian projects, CDM revenues shall be forecasted accordingly.

5. PROJECT EXPENSES (Other than Capital Cost)

Apart from the capital expenses, wind energy projects, like any other power projects do entail an array of items which demand financial outlays. They are listed as under:-

i) Operation and Maintenance Charges

A project sponsor may opt for outsourcing the operation and maintenance of a wind farm or may choose to do it himself. In case O&M is outsourced, the expenses are known for the period of O&M contract. O&M charges differ across various wind turbine manufacturers - some charge it as a % of sale price, some link it to performance of the turbine (link it to generation). However, the most common convention is to charge for O&M services at a flat rate (fixed amount). As per the recent CERC guidelines on tariff determination for wind energy, O&M expenses for wind projects have been assumed at Rs 6.87 crore with an escalation clause of 5.72% (y-o-y).

ii) Repair and Refurbishment costs

If the O&M contract is comprehensive and covers all repairs and replacements of major components, additional expenses need not be budgeted. However, in case O&M contract is not comprehensive, additional maintenance and repair expenses may need to be budgeted.

iii) Regulatory Charges Payable

In some jurisdictions, project sponsors may have to pay additional regulatory charges for wind energy projects. Typically, these charges relate to safety inspection, meter reading charges etc. All applicable charges along with frequency of payment need to be taken as a cash outflow in the financial model.

iv) Depreciation

In order to ensure successful replacement of asset at a future date, depreciation allowances are accommodated in project costs. As per CERC, for computation of depreciation, salvage value is assumed to be 10% and the depreciation is allowed for 90% of total capital cost. The depreciation rate for the first 10 years is assumed at 7% per annum and the remaining depreciation shall be spread over the remaining useful life of the project from the 11^{th} year onwards. Depreciation is chargeable from the first year of operation.

6. FINANCING OF PROJECT

A project sponsor may choose to adopt a debt-equity mix based on project economics as well as sponsor's own financial strength and resources. The wind energy projects can be funded on the basis of sponsor's balance sheet or could opt for off balance sheet funding. The financial charges (interest), tenure of debt, repayment structure etc will depend on type of financing structure adopted. The key parameters to consider in financing of projects are discussed below:

i) Debt Equity Mix

In balance sheet funding, a strong project sponsor can obtain up to 70% of project cost in debt. The sponsor may choose to opt for a lower level of debt depending on its balance sheet strength and other funding requirements. In case of off balance sheet funding, actual level debt will depend on project cash flows. Typically, lenders will specify debt-service-coverage-ratio (DSCR) requirements for P50, P75 and/or P90 generation level and will provide debt funding accordingly. Therefore, in case of project financing, debt level needs to be determined based on forecasted cash flows.

ii) Sources of Finance

As mentioned above, the most common type of funding is a balance sheet funding which is by and large extended by financial institutions. Largely all projects in India have been on balance sheet funding and they are done on terms of finance as per the bank.

iii) Loan Tenure

Loan tenure of 7–10 years can be taken to be a reasonable approximation of actual deal structure for any wind farm project. CERC, for tariff determination, has assumed loan tenure of 10 years.

iv) Moratorium

Generally left to the discretion of the financing body, moratorium could be 1-2 years, for a typical wind project. However, interest is chargeable during this period. Further, moratorium could include or exclude payment of interest. Usually, moratorium is provided only for capital repayments and interest is payable during the moratorium period.

v) Interest

Interest payable will depend on market conditions as well as financing structure. Balance sheet funding will usually result in lower rate of interest whereas off balance sheet funding will lead to higher costs. Further, interest could be payable monthly, quarterly, semi-annually or annually.

For tariff determination, CERC assumes average long-term prime lending rate (LTPLR) of State Bank of India prevalent during the year plus 150 basis points.

Apart from interest, project sponsor may have to pay financing costs such as processing fees etc for raising debt. Typically, these costs may be 1-2% of debt raised and will be incurred at the time of debt drawdown and should be modelled accordingly.

vi) Debt Payment Schedule and DSCR computation

After the debt moratorium period is over, debt repayments will begin. Usually, banks and other lending agencies would require quarterly repayments of interest and capital. Debt service coverage ratio is an important ratio to be computed since in case of off balance sheet financing, lenders will depend heavily on it to finance the project. Therefore, in case of project financing, different scenarios for DSCR under various levels of generation need to be computed. Further, DSCR should be computed for each year of debt tenure as well as an overall average DSCR is required to be computed. The formula for computation is:

$$DSCR = \frac{\text{Cash available for debt service}}{\text{(Capital repayment + Interest for the period)}}$$

Where Cash available for debt service = Net profit + Depreciation + Interest (on long-term loan)

7. TAXATION

i) Applicable tax on profits

The tax computation should be made according to applicable tax provisions and should take into account any tax holiday or other benefits available to the project. Further, tax computation may also depend on project sponsor's tax structure and other tax obligations. For a simple analysis without considering tax benefits (useful for comparison between different investment alternatives), a fixed effective cash tax rate may be assumed to computed net profit after taxes. For a detailed analysis, tax computations need to be carried out. A detailed discussion of the tax computations is beyond the scope of this paper.

ii) Tax Incentives and Credits as applicable

In most tax jurisdictions, wind energy projects have certain tax incentives available. In India, wind energy projects are eligible for accelerated depreciation (80% of project cost) and a 10 year tax holiday. In some jurisdictions, production tax credits are available. The financial model should incorporate applicable tax incentives depending on the project structure and jurisdiction.

8. PROFITABILITY & RATIOS

After forecasting the cash flows, profits and balance sheet items may be computed and forecasted for the period of the financial model. Several important ratios may also be computed for the purpose of investment analysis, funding and other purposes. Some of the most important ratios are discussed hereunder:

i) Project IRR / NPV

Project IRR is the most commonly used investment analysis tool. Most firms have a target project IRR below which investments are not made. Therefore, computing project IRR provides a quick go, no-go decision for the project. For a detailed analysis, however, net present value may be computed from the free cash flow to the equity. The NPV computation will depend on firm's discount rate. However, it will be better to apply a discount rate which reflects the project risk and not the risk in project sponsor's business (as reflected in firm's discount rate).

ii) Payback period

Project pay back period may be computed from the following formula:

Payback period = Project cost / Net annual cash inflow

However, in case of wind energy projects, net annual cash inflow will vary from year to year in case debt repayments are on declining balances. In such a case, the financial model will have to sum up net annual cash flows till it matches the project cost. The period where the two amounts are equal will be the payback period.

iii) Equity IRR / ROE

Equity IRR may be computed based on free cash flow to equity similar to project IRR. ROE may be computed as:

ROE = Net Income / Shareholder's equity

iv) Profitability index

Profitability index = Present value of cash inflows / Initial cash outlay

v) Levelised cost of generation

The levelised cost of generation can be used to determine whether a fixed tariff is profitable for the project or not. It is also used by regulatory authorities to fix the feed-in tariffs.

Levelised cost can be computed by calculating total cost per kWh for every year and then discounting it to obtain the NPV. This NPV is then spread over life of project at a constant discount rate to obtain levelized cost of generation per kWh. In Excel, PMT function can be used to compute the levelized cost as:

Levelized cost = -PMT (discount rate, period, NPV) *

* (-) sign is needed since PMT computes payments required to pay a loan at a constant interest rate

Annexure I: State-wise tariffs for wind energy - For Sale to EB

S. No	State	Tariff Fixed by the Commission (Rs/ kWh)	Remarks
1	Tamil Nadu	3.39	Fixed
2	Maharasthra	5.07	In line with CERC guidelines, for the lowest wind zone
3	Karnataka	3.70	Applicable for 10 years
4	Andhra Pradesh	3.50	
5	Gujarat	3.56	
6	Rajasthan	3.83	For Jaisalmer, Balmer, Jodhpur
		4.03	For other districts
7	Madhya Pradesh	4.35	
8	Kerala	3.14	
9	West Bengal	4.00	Fixed, to be used as a cap

1. Legal Framework

The electricity sector, the activities of generation, transmission and distribution of electricity are governed by the legal framework that exists in a particular country. The legal framework provides the basic set of rules, institutional arrangement to govern the sector. In most of the cases where the acts are old, there may not be specific mention or provisions for power generation from renewable energy sources and hence such projects are governed by the provisions of the existing Act regarding generation, pricing etc. Some of the recent Acts dealing with electricity do have specific provisions for renewable energy based power generation. One of the recent Acts is the Indian Electricity Act 2003 which has very specific provisions for promotion of power generation from renewable energy sources and has led to development of the regulatory framework in India.

Electricity Act, 2003:

The Act provides for policy formulation by the Government of India and mandates the State Electricity Regulatory Commissions (SERCs) to take steps to promote renewable and non-conventional sources of energy within their jurisdiction.

Section 3 of the EA 2003 clearly mandates that formulation of the National Electricity Policy, National Tariff Policy and Plan thereof for development of power systems shall be based on optimal utilization of all resources including renewable sources of energy. The provisions related to renewables are:

- **Section 3 : Policy Formulation**
- 3.(1) The Central Government shall, from time to time, prepare the national electricity policy and tariff policy, in consultation with the State Governments and the Authority for development of the power system based on optimal utilization of resources such as coal, natural gas, nuclear substances or materials, hydro and renewable sources of energy.
- **Section 61 : Tariff Principles**: The Appropriate Commission shall, subject to the provisions of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the following, namely – (h) The promotion of co-generation and generation of electricity from renewable sources of energy.
- **Section 86: Promotional measures for Renewable Energy**: The State Commission shall discharge the following function, namely "(e) promote co-generation and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee".

The Act also recognized that to ensure provision of electricity to all, the strategy of grid expansion may not always be the best strategy and therefore visualized the development of mini-grid and off-grid applications through community participation. The Act, removed the requirement of license for notified rural areas. Further, Section 4 of the Act mandated the Central Government to develop policies for rural electrification and off-grid applications:

"The Central Government shall, after consultation with the State Governments, prepare and notify a national policy, permitting stand-alone systems (including those based on renewable sources of energy and non-conventional sources of energy) for rural areas"

The Government of India, after extensive consultation process, notified the National Electricity Policy on February 12, 2005 and National Tariff Policy on January 6, 2006. Further, the Government also announced the Rural Electrification Policy on August 23, 2006 and, over time, policies for stand-alone systems using renewable sources of energy and non-conventional sources of energy were formulated.

National Electricity Policy

Provision 5.12 of the NEP stipulates several conditions in respect of promotion and harnessing of renewable energy sources. The salient features of the said provisions of NEP are given below:

"5.12.1 Non-conventional sources of energy being the most environment friendly there is an urgent need to promote generation of electricity based on such sources of energy. For this purpose, efforts need to be made to reduce the capital cost of projects based on non-conventional and renewable sources of energy. Cost of energy can also be reduced by promoting competition within such projects. At the same time, adequate promotional measures would also have to be taken for development of technologies and a sustained growth of these sources.

5.12.2 The Electricity Act 2003 provides that co-generation and generation of electricity from non-conventional sources would be promoted by the SERECs by providing suitable measures for connectivity with grid and sale of electricity to any person and also by specifying, for purchase of electricity from such sources a percentage of the total consumption of electricity in the area of a distribution licensee. Such percentage for purchase of power from non-conventional sources should be made applicable for the tariffs to be determined by the SERCs at the earliest. Progressively the share of electricity from non-conventional sources would need to be increased as prescribed by the State Electricity Regulatory Commissions. Such purchase by distribution companies shall be through a competitive bidding process. Considering the fact that it will take some time before non-conventional technologies compete, in terms of cost, with conventional sources, the Commission may determine appropriate differential prices to promote these technologies.

5.12.3 Industries in which both process heat and electricity are needed are well suited for cogeneration of electricity. A significant potential for cogeneration exists in the country particularly in the sugar industry. SERCs may promote arrangements between the co-generator and the concerned distribution licensee for purchase of surplus power from such plants. Cogeneration system also needs to be encouraged in the overall interest of energy efficiency and also grid stability."

National Tariff Policy

The National Tariff Policy 2006 framed under Section 3 of EA 2003 elaborates the role of regulatory commissions, the mechanism for promoting use of renewable energy, time for implementation, etc. The following is an excerpt of the relevant portions.

"(1) Pursuant to provisions of Section 86(1)(e) of the Act, the Appropriate Commission shall fix a minimum percentage for purchase of energy from such sources taking into account availability of such resources in the region and its impact on retail tariffs. Such percentage for purchase of energy should be made applicable for the tariffs to be determined by the SERCs latest by April 1, 2006. It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission.

(2) Such procurement by Distribution licensees for future requirements shall be done, as far as possible, through competitive bidding process under Section 63 of the Act within suppliers offering energy from same type of non-conventional sources. In the long-term, these technologies would need to compete with other sources in terms of full costs.

(3) The Central Commission should lay down guidelines within three months for pricing non-firm power, especially from non-conventional sources, to be followed in cases where such procurement is not through competitive bidding."

2. Regulatory Initiatives

In accordance with the principles specified in the Electricity Act 2003, and the National Tariff Policy, the various SERCs have developed a framework for development of renewable energy in their respective states.

Wind Energy Tariff across States:

Feed-in tariffs/preferential tariffs **(FIT):** Feed-in tariff is the world's most successful policy mechanism for stimulating rapid development of renewable energy. The electricity utilities are obligated to buy electricity from renewable sources at rates prescribed by the Government or the Regulator. The feed-in tariff mechanism was first introduced in USA in 1978. The Government of India introduced feed-in tariffs in 1994/1995 when the Ministry of New and Renewable Energy specified uniform feed-in tariff of Rs. 2.25 per unit with an escalation of 5% per annum for all types of RE sources.

The national tariff policy enacted under Section 3 of the Electricity Act, 2003, provided for preferential tariff determination by State Electricity Regulatory Commissions for different types of renewable energy sources after taking into account the potential of RE sources, impact on retail tariff, etc. In due course of time, the SERCs have determined generic tariff for wind energy sources on a normative basis. Tariff orders for wind power have been issued by SERCs of Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, Rajasthan and West Bengal.

Renewable Purchase Standard Framework across States:

While Section 61(h) is important from the perspective of the determination of preferential tariffs, probably the most important section in the Act from the perspective of renewable energy is Section 86(1)(e). With careful reading, this sub-Section could be easily divided into three parts:

(i) Suitable measures for connectivity to the grid

(ii) Sale of Electricity to any person

(iii) Buying a specified percentage of the total consumption of electricity in the area of a distribution licensee from renewable sources.

So far, most SERCs have put significant emphasis on the last part of this important sub-Section (specified percentage) while virtually ignoring the first two parts. Key aspects to be addressed as part of RPS regulations include:

(i) premise for percentage specification,

(ii) eligible entities for applicability of percentage,

(iii) applicable control period, and

(iv) enforcement mechanism.

Many States have issued RPS orders or regulations specifying the percentages for mandatory procurement of energy from renewable sources. RPS percentages have been specified for different control periods.

3. Incentives offered by Central & State Governments:

Central Government incentives - Incentives offered by the Central Government for wind power are in the form of tax benefits, both direct and indirect. Direct tax benefits include accelerated depreciation, income tax holidays, and deduction in taxable income, while indirect tax benefits include exemption from excise duty and reduced custom duties. Other incentives include concessional (low interest) loans.

Direct Tax Benefits :

Accelerated depreciation – The Government of India currently allows accelerated depreciation at the rate of 80% in the first year on a written-down value (WDV) basis for wind power equipment under Section 32 Rule 5 of the Income Tax Act. Income tax holiday - Section 80 1A of the Income Tax Act offers a 10-year tax holiday for all infrastructure projects.

Deduction in Taxable Income : Under Section 10(23G) of the Income Tax Act, income from an infrastructure capital fund or company or a cooperative bank (from the assessment year 2002-03) by way of dividends, interest, or long-term capital gain from investments made in infrastructure business, etc. was exempt until the assessment year 2006-07; this exemption has been extended until the assessment year 2008-09.

Indirect Tax Benefits:

Exemption from excise duty: The following devices are exempt from excise duty:

Wind-operated electricity generator, its components and parts thereof
Water-pumping wind mills, wind aero-generators and battery chargers.

Customs duty reduction - The components of wind power machinery that attract Customs duty are given below:

- Wind-operated electricity generators upto 30 kW and wind –operated battery chargers up to 30 kW
- Parts of wind-operated electricity generators for manufacturer of wind-operated electricity generators, viz., special bearing; gear box; yaw components; sensor; brake hydraulics; flexible coupling; brake calipers; wind turbine controllers and parts of the goods specified above.
- Blades for rotors of wind-operated electricity generators for the manufacture or maintenance of wind-operated electricity generators
- Parts for the manufacture or maintenance of blades for the rotor of wind-operated electricity generators, and
- Raw materials for the manufacture of blades the rotors of wind-operated electricity generators.

Sales tax exemption/reduction in central sales tax and general sales tax is available on sale of renewable energy equipment in various States:

Concessions:

IREDA provides concessions on loans for wind power projects. Projects set up in the north-east, Chhatisgarh, Jammu and Kashmir, Jharkahand, Sikkim and Uttaranchal and on islands and estuaries are eligible for the following concessions:

(a) Rebate of 0.5% a year on the rate of interest
(b) 50% exemption from payment towards;
    - Registration fee
    - Inspection charges
    - Legal charges (other than those incurred on recovery)
    - Expenditure incurred on nominee director(s)
    - Front-end fee

Generation-based incentive:

The Ministry of New and Renewable Energy announced on 26th June 2008 that it would provide through IREDA, a generation-based incentive of Rs. 0.50/kWh for 10 years to the eligible project promoters for grid-interactive wind power projects. IREDA will disburse the generation-based incentives to the generator on half-yearly basis through e-payment. This incentive will be over and above the applicable tariff approved by the respective State commissions. The main objectives of the guidelines issued have been stated as follows:

- To encourage IPPs, NGOs, registered companies, etc. who will not avail of the accelerated depreciation benefit under the IT Act for making investment in wind power projects
- To encourage actual generation instead of capacity addition to ensure optimum use of resources
- To seek grid stabilization.

Under this scheme of the MNRE, only those power producers who will not avail of accelerated depreciation benefit under the Income Tax Act will be eligible for the GBI benefit. This GBI scheme will be applicable only for those IPPs whose installed capacity is more than 5 MW and whose capacities were commissioned for sale of power to the grid after announcement of this scheme are eligible. Those who set up capacities for captive consumption, third party sale, wheeling and banking of power and merchant power plants are not eligible. The scheme will be reviewed when projects aggregating to 49 MW estimated to generate about 0.9 billion units of electricity are registered by IREDA. The GBI scheme has been welcomed by all the stakeholders and MNRE has received a huge response to the scheme. Further extension of this demonstration scheme is being sought by the stakeholders, and the MNRE is working on this at present.

4. Latest Regulatory Developments:

The mechanism of renewable energy certificates: It will be very difficult to implement the mechanisms suggested by CERC in their present form because of technical and behavioral reasons. In the context of renewable energy, the best way to enable inter-state sale of RE is through an appropriate commercial settlement mechanism. Physical transaction of electricity is governed by the laws of physics and does not differentiate between electricity generated through conventional and renewable energy sources. With the inter-connected transmission system, electricity generated at one part can be consumed by the consumer in the other part of the country but the only issue will be commercial settlement of energy injection and consumption.

In this regard, renewable energy certificate (REC) offers a suitable mechanism for commercial settlement. The REC is a market-based instrument to promote renewable energy and facilitate meeting the obligations related to energy portfolio, and it can make the renewable electricity market stable and predictable by maximizing the benefits of renewable generation while reducing costs. Besides, introduction of a tradable REC would provide an additional source of revenue to generator of RE-based power. Apart from this, REC could also be used by those States that do not have substantial RE resources to meet their RPO.

A) Existing Policies and Regulations

A sound policy and regulatory framework is essential for developing adequate renewable based capacity in India. Legislative as well as policy initiatives over the past few years have been stressing on the need to promote renewable energy. Foremost amongst them is the Electricity Act, 2003. The Tariff Policy, 2005 stressed that a minimum percentage of energy, as specified by the SERCs, was to be purchased from renewable energy sources by April 1, 2006. There were no specific provisions that would promote renewable or non-conventional sources of energy prior to the enactment of the Electricity Act, 2003. In Electricity Act, 2003, under Section 86(1) (e), it is elaborated that not only the distribution licensees but also all the consumers including open access consumer and captive consumers have to purchase power from renewable energy to the extent the percentage specified by the State Electricity Regulatory Commission (SERC) thereof. The relevant extract of Section 86 (1) (e) of the Electricity Act, 2003, is as under:

"86. The State Commission shall discharge following functions, namely -
*(e) promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with grid and **<u>sale of electricity</u>** to any person, and also specify, for purchase of electricity from such sources, a percentage of total consumption of electricity in the area of distribution licensee."*

Hence, the State Commission has been mandated to promote renewable energy by:

- Provisions of suitable measures for connectivity with grid;
- Provisions of suitable measures for sale of electricity to any person; and
- By way of specification, for purchase of electricity from such sources, a percentage of total consumption of electricity in the area of distribution licensee;

The Act has provision for policy formulation by the Government of India (GoI). Hence, National Electricity Policy notified on February 12, 2005 under Clause 6.4 (1) states that:

*"Pursuant to provisions of section 86 (1) (e) of the Act, the Appropriate Commission shall **<u>fix a minimum percentage for purchase of energy</u>** from such **<u>sources taking into account availability of such resources in the region</u>** and its impact on retail tariffs. Such percentage for purchase of energy should be made applicable for the tariffs to be determined by the SERCs latest by April 1, 2006."*

The current policy framework for renewable energy comprises a mix of fiscal incentives, financial incentives and policy directives.

Financial and Fiscal Incentives

- Special preferential tariffs determined by various SERCs for each of the major renewable energy technology.
- Concessional import duty on certain components.
- Accelerated depreciation.
- Tax holiday for renewable based generation projects under Section 80 (IA).
- Subsidized debt available through IREDA
- Generation based incentives for wind and solar projects on a pilot basis.

Policy Framework

- Wheeling, banking and buyback arrangements to enable sale and use of wind and solar power since generation from these RE sources is difficult to schedule accurately.
- Favourable policies for setting up manufacturing facilities for wind power
- Renewable portfolio standards enforced by certain states.

Identifying the responsibilities for developing the renewable energy market is one of the biggest steps towards market development. The Renewable Energy Certificate mechanism is also implemented to overcome the mismatch between the renewable energy resources available in the region and the renewable purchase obligations (RPO).

i) Tariff Regulations:

The Central Electricity Regulatory Commission, in its recently published Tariff Regulations for renewable energy, has ensured unwavering support for renewable energy based power generation. The Capital cost norms will be determined and the tariff fixed upfront for the whole tariff period, and the normative capital costs will be provided for renewable based projects. These projects would also be given preferential tariff treatment during the period of debt repayment. In addition to adopting a levellised tariff structure, the Regulations provide for developers of new and renewable technologies to approach the CERC for project specific tariffs.

ii) Metering

ABT compatible and Real time ToD meters with online reading features are required to be installed at interface metering system capable of energy accounting for each block of 15 minutes time. These shall be provided at both supplier as well as drawal point.

iii) Infrastructure Development

The developer shall bear the cost of project switchyard and interconnection facilities at the project site upto the point of energy metering. The utilities will bear the cost of transmission lines and associated facilities beyond the point of energy metering for the evacuation of power. In some States the developer(s) provides an interest free advance to the utilities, equivalent to an amount of 50% of the cost of works to be carried out by the utilities for power evacuation purposes. In case there is more than one developer sharing the transmission line/ evacuation facilities to be set up by the utilities the advance amount shall be shared amongst the developer(s) in equal proportion. The utilities shall refund the interest free advance to the developer(s) in five equal installments spread over a period of five years, commencing from one year after the date of commissioning of the respective projects.

CDM for wind projects

(Mr. Mahesh Vipradas)

In the year 1992, many countries joined an International Treaty – the United Nations Convention on Climate Change (UNFCCC) to address the Climate Change issue and its implications. This being a common but differentiated responsibility the developed countries, mentioned in the Annex I&II of the convention, are having emission reduction commitments. The Clean Development Mechanism (CDM), developed in 1997 in the Conference of Parties under UNFCCC, is a market mechanism which helps in sustainable development of the developing countries.

The Clean Development Mechanism (CDM) as defined in Article 12 of the Kyoto Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex I of UNFCCC) to implement an emission-reduction project in developing countries. The mechanism is the first global, environmental investment and credit scheme of its kind, providing standardized emissions offset instrument called Certified Emission Reduction (CER).

In order to participate in the CDM, there are certain eligibility criteria that countries must meet. All Parties must meet three basic requirements: Voluntary participation in the CDM, the establishment of a National CDM Authority, and ratification of the Kyoto Protocol.

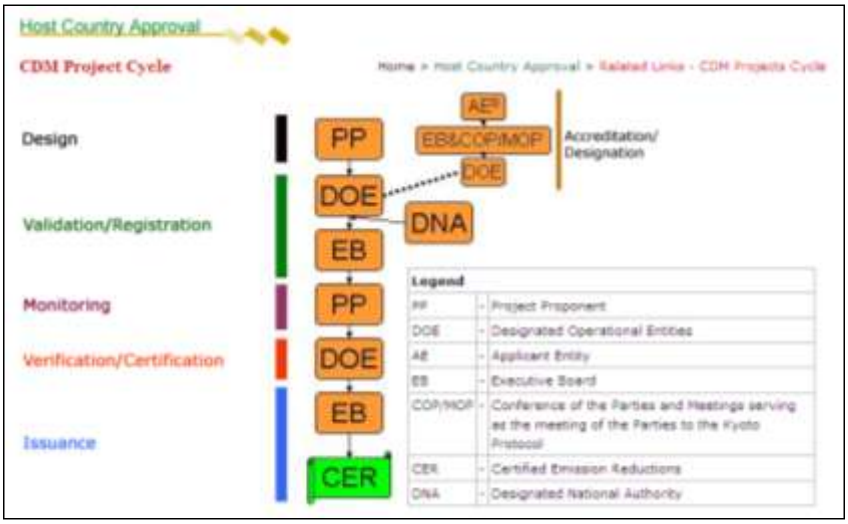
The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the UNFCCC. The Executive Board supervises the operation of CDM and has the final say on whether a project is approved or not and lays out procedures and guidelines for CDM. The figure below outlines the procedures involved for a successful CDM project.

The CDM Project Cycle

The CDM project cycle starts with the development of Project Concept Note (PCN). The PCN then can be submitted to the National CDM Authority. The National CDM authority, based on the PCN, provides the host country with approval for the project. A typical wind CDM PCN contains basic information about the project like capacity planned, location details, etc. The host country approval is an essential step for registration of the project with CDM EB.

The most important step in development of CDM projects is the development of Project Design Document (PDD). The PDD provides all the information about the project. The PDD also provide description of the baseline methodology and how the project satisfies the additionality criteria. “Additionality” means that the project is additional to what would have happened in the normal course with existing policies and technological development, in other words to prove that the project would not have happened without CDM benefits

Fig 1: The CDM Project Cycle



Baseline:

The baseline is the emissions from scenario if the proposed CDM project is not implemented. The baseline has to be developed for the project. However, there are number of baseline methodologies which are already approved by the CDM EB which can be directly used if the project is similar to the project for which the baseline is approved. For projects with capacity less than 15 MW, defined as small-scale projects, there is an approved simplified methodology "ACM 002" which most of the wind projects can use. The ACM 002 provides different options for choosing a baseline for small-scale projects. However, for development of the baseline data related to emissions from other generating sources, primarily thermal power generation, are required in addition to the generation data.

A number of consultants provide expert services in assisting the CDM project development. Details of some of the CDM consultants are given in table 1 below.

Table 1: Companies/Orgs Providing CDM Services for Wind Power in the SARI region

Sl. No.	Address	Contact Details
1	Zenith Corporate Services (P) Ltd. 10-5-6'B, "My Town PLAZA" Masab Tank, Hyderabad 500028 mohan@zenithenergy.com	91-40-23376630
2	Development Alternatives B-32, Tara Crescent, Qutab Institutional Area, New Delhi – 110016	91-11-26134103
3	IDFC Infrastructure Development Finance Company Ltd. Capital Court, 2nd Floor, Olof Palame Marg, Munirka, New Delhi- 110067	91-11-46006100
4	Eaga India Pvt. Ltd. T2-1A & 8C Millennium City, Information Technology Park DN62, Sector V, Salt Lake, Kolkata-700091	91-33-30128485 Fax: +91-33-30128586

Sl. No.	Address	Contact Details
5	Sustainable Energy Solutions Private Limited, 3778, IIIrd floor, Netaji Subhash Marg, New Delhi - 110 002	91-9350871056 +91-11-23271056 oncer@vsnl.com
6	Ernst & Young Pvt Ltd. 15th Floor, Jolly Makers Chambers-2, Nariman Point, Mumbai - 400021	91-22-40356335 Fax: +91-022-67498200 91-9820108838 chaitanya.kalia@in.ey.com www.ey.com/india
7	Winrock International India 788, Udyog Vihar, Phase-V, Gurgaon - 122 001	91-124-4303821 91-124-4303862 kalipada@winrockindia.org
8	MECON Limited, Vivekananda Path, Ranchi - 834002	91-651-2482197 91-9431706960 aksaxena@meconlimited.co.in gmmktg@meconlimited.co.in
9	MITCON Consultancy Services Ltd. LG-9, Somdutta Chambers- II, Building No 9, Bhikaji Cama Place, New Delhi - 110066	91-11-460 32 31 4 Fax:+91-11-460 32 31 5 9811498970 Email: mitcon@gmail.com
11	Asia Carbon Emission Management India Pvt Ltd. D-101, Sector-12, Plot-10, Vrindavan Gardens, Dwarka, New Delhi- 110075	91-11-45053318 91-09810145290 anik@asiacarbon.com
14	Senergy Global Ltd. Ground Floor, Eros Plaza, Eros Corporate Tower, Nehru Place, New Delhi-110019	+91-124-430-5500 Fax: +91-11-430-5555 mail@senergyglobal.com
15	Emergent Ventures India Pvt. Ltd. , 5th Floor, Universal Trade Tower, Gurgaon- Sohna Road, Sector 49, Gurgaon- 122001, Haryana, India	91 124 4353100 Fax +91 124 4102980 Email contact@emergent-ventures.com
16	Deloitte Level 7, Tower B, Building 10, DLF Cyber City, DLF City, Phase II, Gurgaon 122 002	91 (124) 679 2000 Fax: +91 (124) 679 2012
17	PricewaterhouseCoopers Pvt. Ltd. Building 8, 7th & 8th floor, Tower B, DLF Cyber City, Gurgaon 122002, Haryana, India	91 124 4620000/3060000 Fax: +91 124 4620620
19	Asia Carbon D-101, Brindawan Garden Plot no. 10, Sector 12, Dwarka New Delhi - 110075	Tel: + 91 11 45053318 / 9 Fax: + 91 11 45053318
20	Gensol SCO 11, 2nd Floor, Sector 11, Panchkula - 134111, Haryana, India	Ph: +91-172-4246200 Fax: +91-172-4246220

The development of CDM project and actual construction of project can happen in parallel. The best time to initiate the CDM project development is right at the time of project conceptualization and certainly before investment decision. Table 2 below provides the approximate time for different steps involved in CDM project development till issuance of CERs.

Table 2: Approximate time lines for CDM cycle

S. No	CDM Project Cycle	Time Schedule
1.	Preparation of Project Idea Note (PIN) and Project Concept Note (PCN)	2 Weeks
2.	Preparation of Project Design Document (PDD)	8 Weeks
3.	Host Country Approval	6 Weeks
4.	Public Web-hosting	4 Weeks
5.	Site Visit for Validation	1 Week
6.	Addressing Draft Validation Report (DVR)	20 Weeks
7.	Request for Registration	4 – 8 Weeks
8.	Web hosting at UNFCCC	4 weeks
9.	Registration	2 Weeks
10.	Monitoring	52 Weeks
11.	Preparation of Monitoring Report	1 Week
12.	Site Visit for Verification	1 Week
13.	Web-hosting of Verification Report	2 Weeks
14.	Request for Issuance of CER	2 Weeks
15.	Issuance of CER	2 Weeks
Total Time Required for getting CDM Revenue		110 Weeks

Wind Energy and CDM

In the renewable energy sector, one of the major beneficiaries of CDM is the wind energy sector especially in countries like India and China. By August 2009, installed capacity of the projects that have applied for CDM amounted to more than 30,000 MW. Out of which, almost 10,000 MW were already registered.

In case of wind power projects, like any other renewable energy projects, the high initial investment with longer payback period increases the risk. To overcome the risk various governments have provided different incentives. Registration of wind power project as CDM also provides an additional revenue through sale of CERs generated from the project. As per a number of financial analyses, it has been found that CDM revenue is capable of raising the return on a wind project by 3-4%[1]. Thus CDM would help those projects become viable which fall just below the viability benchmark in terms of IRR.

Recent issues

Of late, wind power projects have been put under the scanner by the CDM Executive Board (EB). The primary reason for this has been firstly, the continuous changes in the modalities and procedures of the CDM EB in an attempt to the make the entire system more stable and secondly the huge inflow of non-additional wind projects under CDM. In view of this, a lot of changes were done to the existing rules and regulations for CDM projects.

The figure below shows the decreasing trend of the number of wind power projects in the CDM pipeline. When it comes to India, about 755 MW of wind power projects have not seen the light of day under CDM. They have either been rejected by the EB, withdrawn, given a negative validation report by the DOEs or have themselves terminated the validation due to

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[1] http://cd4cdm.org/Publications/WindCDM.pdf

existing circumstances. Out of these, projects comprising almost 600 MW had started their validation during 2006-2008. Clearly, the frequent and drastic changes brought about during this time have adversely affected the projects in the pipeline.

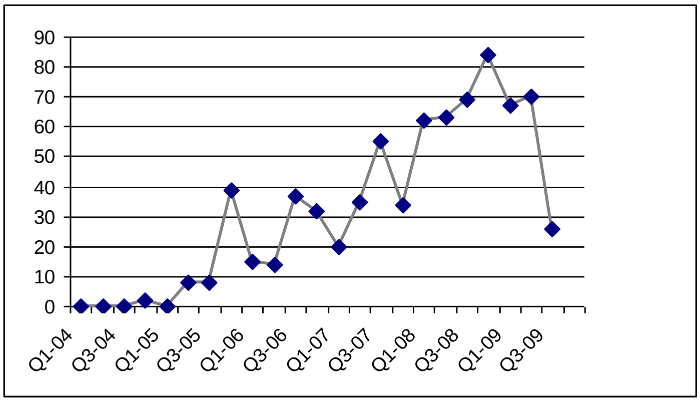

Fig 2: Number of wind power projects under CDM over the years[2]

The paragraph highlights some of the major issues faced by the wind projects under CDM:

Serious consideration of CDM revenue –

Recently, the Board also released a guideline to establish that the project promoters considered CDM as one of the critical sources of revenue before investing in the project. This is also termed as prior/serious consideration of CDM. The guideline greatly affected those projects which either started the process of CDM late or have not been able to finish their validation till now. The guideline, a mere one-page document, leaves a lot of things open to interpretation. The worst affected are the projects which were already in the pipeline or in the advanced stages of validation. As a result of the release of this guidance, the validation for existing projects was started all over again. There have been a number of cases when even after submission of number of official documents; the project promoters have not been able to convince the DOEs. The result again has been either rejection of the project or delay in project execution.

Common Practice Analysis –

The Common Practice Analysis is an additional test that the large-scale projects (above 15 MW) need to face following the financial additionality. The test basically needs to establish the fact that wind power projects without CDM are not a common practice in the state. For CDM wind power projects, this becomes a problem especially in the Indian States of Tamil Nadu, Karnataka and Maharashtra which have the highest number of installations. However, this would not be a major problem in regions of other South Asian countries as installed wind capacities are limited in these countries. Although most of these installations have applied for CDM, there is no transparent data regarding this. With the increasing stringency of the CDM Board, this is likely to be an overbearing problem in the future unless the issue of lack of data is looked into quickly.

Increased transaction costs and other procedural issues

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[2] CDM pipeline

The transaction costs in getting a project registered have seen a multifold rise. This can be attributed to the increase in the number of rules and regulations in CDM as mentioned above and simultaneous rise in the number of CDM projects. This is so especially in the case of validation/verification fee which has increased by at least 50% over the past four years. This issue is further magnified because of the fact that CER prices have been witnessing a considerable downfall. If this trend continues for a longer time, small-scale project promoters might not feel encouraged to apply for CDM revenue at all.

Table 3: typical costs for CDM project

S. No	Description	Cost
1	Project Development Charges	10000- 15000 US$ + Success Fee 0.5-5%
2	Validation Charges	13000 – 20000 US$ (one-time fee)
3	Monitoring & Verification Charges	8500 - 10000 US4 (Every Year)
4	UNFCCC Registration Charges	0.1 US$/CER up to 15,000 CERs, 0.2 US$/CER after 15,000 CERs
		No charges if Annual Average is less than 15,000 CERs
5	Adaptation Fund Fee to UNFCCC	2% CERs per annum
6	Carbon Exchange Fee (If CER transacted through Exchange)	2 – 5 % of CER transacted

Voluntary Emission Reductions (VER) – A feasible alternative

Due to the above procedural and technical issues associated with the CDM modalities and procedures, lot of promoters, especially with older installations, are steadily moving towards other voluntary standards. The voluntary standards make up for a good alternative as the rules and regulations are not as stringent as CDM and thus the time taken for revenue realization is far lesser than CDM projects. Initially, the voluntary market was looked at only for the pre-registration credits or for projects rejected by CDM. Now, an increasing number of people are taking a conscious decision to move ahead with the voluntary carbon market for their projects.

Currently, two standards are dominant in the voluntary market - The Voluntary Carbon Standard (VCS) and the Chicago Climate Exchange (CCX). The downside, in this case, is that since the standards are not as high in quality as CDM, the price that these VERs fetch is quite low as compared to CERs. Presently, a Voluntary Carbon Unit (VCU) and a Carbon Financial Instrument (CFI) is being traded at approximately 4€ and $2, respectively, as compared to a CER which is being traded at around 14€ (spot market price as on 5th September 2010).

Currently, under CDM the time is just right for the recently commissioned projects or the projects to be commissioned in the near future. Such projects are likely to be registered with minimum difficulty. With more and more experts predicting a bright future for CDM post 2012, the wind power projects are only likely to be benefited from this association. An interesting standard, which the wind power investors should now look into, is the new Gold Standard. The Gold Standard is a qualifying standard for a usual CDM project with focus on sustainable development. A gold standard project is likely to earn a premium of at least 3-4€/ CER above the usual CER prices.

The gap between the potential and achievement of wind power installations in the SARI region is more than 83,000 MW. It is important for SARI country governments to consider

CDM as a powerful tool to further augment private sector investment in wind power. The issues that have been pointed above can be smoothened to a large extent by the right and timely actions of the government.

CDM best practice

Besides proving the project to be additional, on the technical and financial merits of the project, there are certain practices which would facilitate the registration of a CDM project. An early intimation to the CDM executive board and to the National CDM Authority about possibility of developing a project, which may be even at a conceptual stage, is a requirement which proves that the project was conceived with CDM in mind. Further, documentation is the key as the facts and figures mentioned in the CDM PDD need, possibly third party, documentary proof. The timely appointment of consultant and validation agency increases probability of registration of the project.

Two case studies from India and the South Asian region

a.	India: Wind farm developed for Captive use	9
b.	Sri Lanka: Grid connected (Senok Wind Farm)	

Wind Project in India for Captive use

Name of the Owner: Oil and Natural Gas Corporation Ltd.
Off Taker: Oil and Natural Gas Corporation Ltd.
Location: 51 MW Wind Power Project at Jakhau Site, District Kutch, Gujarat

Project Description

The Oil and Natural Gas Corporation decided to invest in wind energy to include clean energy source in its portfolio as well as to minimize its electricity cost.

A tender was floated by ONGC for development of a wind power project in Gujarat on a turnkey basis. The project size, of about 50 MW, is decided based on the total electricity consumption of ONGC plants and office i.e. the energy generation from wind power project was to be completely used in the facilities of ONGC. The project, after carrying out the technical and financial due diligence, was awarded to Suzlon Energy Ltd. at the proposed wind site in Gujarat. The project is of 51 MW capacity with 34 number of 1.5 MW capacity wind turbines supplied by Suzlon Energy Ltd. The land at the proposed site was already been procured by Suzlon, and wind resource assessment was carried out for almost a year. Based on wind resource assessment, the site with expected annual electricity generation was offered under the tender. One of the reasons for selecting this particular site is possibility to install all turbines at one location/site. The main parameter used for selecting the bid, out of the technically qualified bids, was the life cycle cost of power generation proposed by different bidders. The clearances were also obtained by Suzlon as a part of turn key project.

The activities in project development included site identification, supply of turbines, site development, erection of wind turbines, development of electrical lines and substation for evacuation of power, obtaining necessary permissions and approvals and commissioning of the project. The project was commissioned in September 2008 and has been in operation since then.

Equipment Package

The equipment package included - Nacelle Assembly, Tower, Hub, Blade Set, Power Panel, DP VCB Yard, and Electrical Lines. 34 nos. of WTGs of 1.5 MW each with Induction generator.

Project Time Line

The project was completed in the time period of eight months from the receipt of the order from ONGC Ltd.

Wind Regime

The annual average wind power density at the Jakhau site where the project is located is 311 W/m^2 measured at the height of 50m from ground level.

Power Generation Estimation

Based on the wind regime at the site, turbine characteristics and micro-siting of the turbines at the site, the annual power generation is estimated to be 2928000 kWh/turbine i.e., the capacity utilization factor is 22%. The average annual electricity production from the wind project is 32,30,000kWh/turbine i.e., the project is operating at a capacity factor of 24.5%

Grid Interconnection

The 51-MW wind farm is connected to the 33/220 kV substation situated at the project site. This substation has been developed as part of the wind project by Suzlon. The 220 kV Nani Sindhodi substation is further connected, through a 220kV line, with the substation of Gujarat Electricity Transmission Company (GETCo) located at Nani Khakad which is about 30km away from the wind project location. The power evacuation cost till the 33/220 kV substation were included in the capital cost. The evacuation lines from the wind turbines till the 33/220 kV S/S and the substation are maintained by Suzlon.

Costs

The total project cost for the 51-MW wind project was about 3070 million Indian Rupees. The power generated from the wind project is wheeled and consumed at different locations, 98 plants/offices of ONGC, i.e. used as captive power replacing the power supplied to these facilities from the local distribution companies. The 4% of power generated from the project is deduced as wheeling charges, i.e. charge for utilizing the grid infrastructure, from generation by wind power project while giving the credit of generation. In other words the 96% electricity generated from the wind project is deducted from the electricity consumed at different ONGC facilities and bill is raised for the remaining consumption by the local distribution company. The 4% deduction also includes the wheeling and transmission losses. By using the wind power at its different location ONGC reduced the purchase of power from the distribution utility at the industrial rate of power which is about Rs. 6.00/kWh.

In addition to the lower cost of power from the wind project, the project is expected to receive additional revenues from sale of carbon credits as the project is a registered CDM project.

Incentives

The incentive mechanisms used by the project are:

1. Concessional open access charges of 4% of generation, for wind power project for use of grid infrastructure for wheeling of electricity from point of generation to points of use. For other wheeling transaction, involving generation from conventional sources, the open access charges are higher e.g. the transmission charge is about 2000 Rs/MW/day and 18% of generation deducted as loss.

2. Special provision of banking of energy. In the case of wind power the power generation cannot be scheduled resulting in excess generation in real time than the

consumption in the case of captive use. Such excess generation is “banked” with the distribution company and the consumer gets the credit when the generation is less than the consumption during the same month from the “banked” electricity.

List of WTG manufacturers in India with contact information

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The Centre for Wind Energy Technology is a technical focal point for wind energy technologies established by the Union Ministry of New and Renewable Energy at Chennai in 1998. A Wind Turbine Testing Station has also been established at Kayathar, Tamil Nadu, with technical and financial support from DANIDA, a Government of ***Denmark agency.***

The list of manufacturers has been drawn up by the Centre for Wind Energy Technology (C-WET) with models of wind turbines of unit capacity 225 kW and above that have obtained type approval/certificate from designated certification agencies or under testing and certification, as per the information received from the manufacturers.

S. No.	Indian Manufacturers with Addresses	Contact Person in India	Model Rotor Diameter / Hub Height (in meter)	Capacity
1	**Vestas Wind Technology India Pvt. Ltd.** 298, Rajiv Gandhi Salai, Old Mahabalipuram Road, Sholinaganallur, Chennai 600 119, India Website www.vestas.com Tel +91 44 2450 5100 Fax +91 44 2450 5101 Email: vestas-india@vestas.com	**Shri Arvind Kaul** **Managing Director**	**V-82 – 1.65 MW** **RD : 82 m** **HH : 70 / 78 / 80 m** **Tower Type : Tubular steel**	**1650 kW** **Available (06.02.2013)**
2	**Elecon Engineering Company Ltd.,** P.O. Box No:6 Anand Sojibra Road Vallabh Vidyanagar, **Gujarat - 388 120**. Tel : 91-02692-237016/236513/236516 Fax : 91-02692-236527	**Mr. V.D.Kalani, - HONY. SECY.** **General Manager (WED),IWTMA** **Email: vdkalani@mhe.elecon.com**	**1600-48** **RD : 48 m** **HH : 50/55/60 m** **Tower type : Tubular**	**600 kW**

S. No.	Indian Manufacturers with Addresses	Contact Person in India	Model Rotor Diameter / Hub Height (in meter)	Capacity
3	**Enercon (India) Ltd.,** Plot No. A-9, CTS No. 700 Plot Veera Industral.Estate., Veera Desai Road, Andheri West, Mumbai - 400 053. Tel.: 91-022-66924848 Fax.: 91-022-66990940, 67040473	**Mr. Yogesh Mehra,** **Managing Director.** **Email:** ymehra@enerconindia.net	**E-48 RD : 48 m** **HH : 50/56/57/65/75/76 m** **Tower type : for HH 50/56/57/765/76 m** **Tubular steel & 75 m – pre cast concrete** ______________ **E-53 m HH : 73/75 m** **Tower type : For HH** **73 m – steel & 75 m – concrete tower**	**800 kW** ______________ **800 kW**
4	**GE Wind Energy INDIA,** A-1, Golden Enclave Corporate, Towers, #3rd Floor, Airport Road, **Bangalore**-560 017 Tel:91-080-25289979 Fax.:91-080-25203860	**Mr. Anand Bansal** **Chief Executive** **Email:** anand.bansal@ps.ge.com	**GE 1.5sle** **RD : 77 m** **HH : 80 m** **Tower type : Tubular Steel**	**1500 kW**
5	**M/s Pioneer Wincon Private Ltd.** 30/1A. Harrington Chambers, 2nd Floor, "B" Block Abdul Razak, 1st Street, Saidapet, Chennai-600 015 Ph : 044-24314790 Fax: 044-24314789	**Mr. D.V. Giri,** **President - CHAIRMAN-IWTMA** **Email:** dvgiri@pioneerwincon.com	**Pioneer P250/29** **RD : 29.6 m** **HH : 50 m** **Tower type : Latice**	**250 kW**

S. No.	Indian Manufacturers with Addresses	Contact Person in India	Model Rotor Diameter / Hub Height (in meter)	Capacity
6	**Suzlon Energy Ltd.,** 5th Floor Godrej Millenium Building 9 Koregaon Park Pune - 400001. Tel : 020- 40122000 Fax : 020- 40122100	**Mr. Tulsi Tanti** **Chairman, Managing Director.** **E-mail: cmd@suzlon.com**	**Suzlon S82V3-1500 kW** **RD : 82 m** **HH : 78 m** **Tower type : Tubular steel**	**1500 kW**
			Suzlon S88 V3A-2100 kW **RD : 88 m** **HH : 80 m** **Tower type : Tubular steel**	**2100 kW**
7	**M/s Shriram EPC Ltd.,** Vangaram Road Ayanambakkam **Chennai - 600 095** Ph : 044-26533313 Fax : 044-26532780	**J.Jawahar** **DGM-Marketing** **Email: energy@shriramepc.com**	**SEPC 250 T** **RD : 28.5 m** **HH : 41.2 m** **Tower type : Lattice**	**250 kW**
8	**M/s RRB Energy Ltd,** GA – 1/B-1, Extension Mohan Cooprerative Industrial Estate Mathura Road, New Delhi 110 044 Tel: 011- 40552222 Fax: 011-40552200 Web: www.rrbenergy.com	**Mr.Sarvesh Kumar** **DY.Managing Director** **E-mail: pawanshakthi@rrbenergy.com**	**V39-500 with 47m rotor diameter** **RD: 47 m** **HH : 50 m** **Tower type : Tubular steel & LatticekW**	**500 kW**
			Pawan Shakthi-600 kW **RD : 47 m** **HH : 50 m** **Tower type : Latice**	**600 kW**
9	**M/s Southern Wind Farms Limited** No 15, Soundarapandian Salai, Ashok Nagar, **Chennai-600 083** Tel.: 044-39182618 Fax.: 044-39182636	**Mr. M. N. Sudhindra Rao, Chief Executive Officer**	**GWL 225** **RD : 29.8 m** **HH : 45 m** **Tower type : Tubular**	**225 kW**

S. No.	Indian Manufacturers with Addresses	Contact Person in India	Model Rotor Diameter / Hub Height (in meter)	Capacity
10	**L M GLASFIBRE (INDIA) Pvt. LTD.** Plot 61/62 Kasaba Indl Area, **Hoskote - 562 114** Tel.: 91-080-7971532 / 1700 / 1701 Fax.: 91-080-7971320.	**Mr. Nirmal Kumar Gupta** **CEO** **Email : nkg@lm.co.in**		
11	**Regen Powertech Pvt Ltd** New No.28, College Road Chennai -600006 Tamilnadu 30280200-206 Email: madhusudan@regenpowertech.com	Mr Madhusudan Khemka President & CEO	**VENSYS 77** **RD : 76.84 m** **HH : 75 m/85 m** **Tower Type : Tubular steel**	**1500 kW**
12	**Kenersys India Pvt. Ltd.** Muttha Towers, Don Bosco Road, Yarwada, 411006, Pune, India. Phone : +91 (0)20 410619-0 Fax : +91(0)20 410619-99	Mr. Bhushan Joshi Bhushan.joshi@kenersys.com	K82 RD : 82 m HH : 80m Tower type : Tubular	**2000 kW**
13	**WinWind Power Energy Pvt. Ltd.** Sterling Tower 327, Anna Salai, Chennai-600006.	Mr. Dinesh Agarwal Dinesh.agarwal@winwind.in	WinWinD 1 MW RD : 60 m HH : 70 m Tower type : Tubular steel	**1000 kW**
14	**M/s Chranjjeevi Wind Energy Limited,** **26-A, Kamaraj Road, Mahalingapuram,** **Pollachi-642002**	Phone : 04259-224438 Fax : 04259-224437	CWEL 30/250kW RD : 29.8 m HH : Tower type : Lattice50 m	**250 kW**
15	**M/s Essar Wind Power Pvt. Ltd.,** **Essar House, 11 K.K. Marg,** **Mahalaksmi,** **Mumbai-400034**	Phone : 022-66601557 Fax : 022-23544787	REpower MD77 RD : 76.5 m HH : 85 m Tower type Tubular Steel	**1500 kW**

S. No.	Indian Manufacturers with Addresses	Contact Person in India	Model Rotor Diameter / Hub Height (in meter)	Capacity
16	**M/s. Gamesa Wind Turbines Private Limited, No. 489, G.N.T. Road, Thandal Kazhani Village, Vadagarai (Post), Red Hills, Chennai-600052.**	Phone : 044-30989898 Fax : Nil	G57-850 kW RD : 58 m HH : 444/55/65 m Tower type : Tubular Steel	**850 kW**
17	**M/s Global Wind Power Limited, 301, Satellite Silver, 3rd Floor, Andheri Kurla Road, Marol, Andheri (East), Mumbai-400059.**	Phone : 022-39918500 Fax : 022-39918521	NOR WIL 750 kW RD : 47 m HH : 65 m Tower type : Tubular Steel	**750 kW**
18	**M/s Leitner Shriram Manufacturing Ltd., No. 5, T.V. Street, Off. Spurtank Road, Chetpet, Chennai-600031.**	Phone : 044-27926000 Fax : 044-27924944	Leitner LTW77-1.35 MW RD : 76.6 m HH : 65 m Tower type : Tubular steel	**1350 kW**
			Leitwind LTW77-1.5 MW RD : 75.6 m HH : 65 m Tower type : Tubular steel	**1500 kW**
19	**M/s. Siva Windturbine India Private Ltd., 12A, Kandampalayam, Perundurai, Erode-(DIS) Pin - 638052**	Phone : 04294-220017 Fax : 04294-220137	SIVA 250/50 RD : 30 m HH : 50 m Tower type : Lattice	**250 kW**

INDIAN WIND ENERGY ASSOCIATION
PHD House, 3rd Floor
Opp. Asian Games Village
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