Wind Energy Information
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Renewable Enerngy and Environment

Wind Energy Informtion

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Chapter-1

Basics of Wind Energy

Growing concern for the environmental degradation has led to the world's interest in renewable energy resources. Wind is commercially and operationally the most viable renewable energy resource and accordingly, emerging as one of the largest source in terms of the renewable energy sector.

1.1 What is wind energy?

Wind is the natural movement of air across the land or sea. Wind is caused by uneven heating and cooling of the earth's surface and by the earth's rotation. Land and water areas absorb and release different amount of heat received from the sun. As warm air rises, cooler air rushes in to take its place, causing local winds. The rotation of the earth changes the direction of the flow of air.

1.2 Benefits of Wind Energy

- Reduces climate change and other environmental pollution
- Wind energy can be utilised as a shield against ever increasing power prices. The cost per kwh reduces over a period of time as against rising cost for conventional power projects.
- Diversifies energy supply, eliminates imported fuels, provides a hedge against the price volatility of fossil fuels. Thereby provides energy security and prevention of conflict over natural resources
- One of the cheapest source of electrical energy.
- Least equity participation required, as well as low cost debt is easily available to wind energy projects.
- A project with the fastest payback period.
- A real fast track power project, with the lowest gestation period; and a modular concept.
- Operation and Maintenance (O&M) costs are low.
- No marketing risks, as the product is electrical energy.
- Creates employment, regional growth and innovation
- Reduces poverty through improved energy access
- Fuel source is free, abundant and inexhaustible
- Delivers utility-scale power supply

1.3 Limitations

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

1.4 Basic Technology

Wind electric generator converts kinetic energy available in wind to electrical energy by using rotor, gearbox and generator. The wind turbines installed so far in the country are predominantly of the fixed pitch ‘stall’ regulated design. However, the trend of recent installations is moving towards better aerodynamic design; use of lighter and larger blades; higher towers; direct drive; and variable speed gearless operation using advanced power electronics. Electronically operated wind turbines do not consume reactive power, which is a favourable factor towards maintaining a good power factor in the typically weak local grid networks.

State-of-the-art technologies are now available in the country for the manufacture of wind turbines. The unit size of machines is going up from 55-100 kW in the initial projects in the 1980’s, to 2000 kW. Wind turbines are being manufactured by 12 indigenous manufacturers, mainly through joint ventures or under licensed production agreements. A few foreign companies have also set up their subsidiaries in India. Which some companies are now manufacturing wind turbines without any foreign collaboration. The current annual production capacity of domestic wind turbine industry is about 1500 MW. The technology is continuously upgraded, keeping in view global developments in this area.

The progress of phased indigenisation by leading manufacturers of wind electric generators upto 500 kW has led to 80% indigenisation level. Import content is high in higher capacity machines, since vendor development of higher capacity machines will take some time. The industry has taken up indigenised production of blades and other critical components. Efforts are also being made to indigenise gearboxes and controllers. Wind turbines and wind turbine components are exported to the US, Australia, and Asian countries. The wind industry in the country is expected to become a net foreign exchange earner by 2012.

1.5 Major Components

Components of wind electric generator

Main components of a wind electric generator are:
1. Tower
2. Nacelle
3. Rotor
4. Gearbox
5. Generator
6. Braking System
7. Yaw System
8. Controllers
9. Sensors

1.6 Essential requirements for a wind farm

An area where a number of wind electric generators are installed is known as a wind farm. The essential requirements for establishment of a wind farm for optimal exploitation of the wind are
1. High wind resource at particular site
2. Adequate land availability
3. Suitable terrain and good soil condition
4. Proper approach to site
5. Suitable power grid nearby
6. Techno-economic selection of WEGs
7. Scientifically prepared layout

1.7 The wind power generation process

In a Wind Electric Generator a set of turbine blades mounted on a metallic hub, to seize power from the up-stream wind. This in turn drives the generator to produce electric power. The generator, along with its associated components is housed in a common enclosure, called the nacelle. In the most widely used configuration, the blades are held with their axis horizontal to the ground in what is known as horizontal-axis WEG, whereas the distinct feature of vertical-axis WEG lies in vertical positioning of the blades with one of their ends resting at ground level. For horizontal-axis WEG, the turbine blades (and also the nacelle) are mounted on the tower, for better reach to un-obstructed wind. The power captured by the turbine blades is transferred to the generator through the drive train. Since in most of the WEGs, the rotor (rotating parts including the blades, hub, etc) moves at a fixed (and slow) rpm (revolution per minute), a gearbox is included in the drive train, which increases the speed at the generator end of the shaft. There are however a few design options where the rotor spped is either variable or the generator is direct drive. The latter makes use of gearbox redundant.

A mechanical brake disc is mounted on the shaft to work as back-up for aero-dynamic braking system attached to the blades a yaw mechanism (multi-motor drive using 2 to 6 number of small motors) turns the nacelle and the rotor assembly to face the wind as it changes its direction. This change is sensed by a wind vane which is mounted on the top of the nacelle along with an anemometer also mounted on the top to monitor wind speed.

The WEGs are designed for un-attended operation with minimum maintenance and provided with comprehensive control system housed in the control panel placed at/close to the base of the tower. The system's working is based on continuous monitoring of various parameters and working conditions and also include protection against internal machines faults. The commercial models of WEGs usually deliver rated power at around 12 to 14 m/s (called the rated wind speed) since it does not pay to design for very strong wind, which is a rare event. The power control features incorporated in the machines manoeuvre to extract optimum output from the wind within its entire speed range upto 25 m/s, beyound which all operations are stopped to avoid structural overload under severe weather. This is the cut-out wind speed and measured as the 10-minute average for IEC Wind Class-I and II WEGs. For IEC Wind Class-III WEGs, the cut-out value is in the range of 17-20 m/s.

Turbine Blade:
A modern wind turbine blade is a hollow cantilever structure with very high load bearing capacity. The blade is usually made of fibre-glass reinforced plastic (FRP) or wood epoxy laminates. The design is based on the aerodynamic principles developed for aeroplanes and helicopters, but has been adopted with modifications to cope with the specific properties of wind as seen in its changing speed and directions. The geometric shape of a turbine blade is such that the air moving across its upper surface is faster than that traversing its lower part. As a result, the pressure is lower on the upper surface creating an upward thrust. This is the lift phenomenon, which drives the blades through the air. Opposite to lift is drag. This is due to the air resistance which occurs when the areas of the blade facing the direction of motion is increased. A correct balance between these two phenomena is needed for optimum use of the wind power.
The rotating blades interface with the wind at an angle, known as the angle of attack, which is a function of the blade's angle to the plan of rotation (called the pitch). This also depends on the "apparent wind" arising due to a shift in the direction of the natural flow of the wind caused by rotation. A change in the angle of attack provides a means to control the wind power.

Since the tip of the blade moves faster than the parts close to its root, it requires to be shaped with an edge-wise “twist” during manufacture so that the angle of attack is maintained unchanged. Simultaneously, the blade tapers the tip to keep the ‘lift’ constant along its entire length. Use of both two-bladed and three-bladed systems is preferred by the WEG manufacturers. The two-bladed option, although dynamically well balanced, has to withstand very high cyclic load unless provided with “teeter bearing” to alleviate the blade and tower head loading. In three-bladed rotor, gyroscopic forces developed are balanced enough and requires no “teeter”. It also delivers smooth output and works at slightly higher efficiency. Two-bladed option however offers reduction in both fabrication and maintenance cost.

Generator

Two basic types of generators are used for the WEGs. These are: synchronous and asynchronous. The latter is more commonly known as induction generator, and mostly used because of robustnesss of construction (using ‘squirrel cage’ rotating part) and cost economy.

In both these options, there is a cylindrical shaped ‘stator’ (so called because it doesn’t rotates) inside which a rotor is placed. The stator is essentially the same for both types of machines. The windings embedded in the stator are connected to three-phase supply. As alternating current (a.c.) passes through the winding, magnetic fields are induced with changes in magnitude.

By symmetrical arrangement of the windings around the stator, this changing magnetic field gives the effect of a rotating field as if produced de to the physical presence of 2, 4 or even more number of magnetic poles depending upon the generator speed. Thus, change in number of ‘poles’ provides a means to vary the rpm of the machine. For example, the machine with ‘4-pole’ connected to three-phase supply at 50 Hz. Frequency rotates at 1500 rpm and that of 6-pole at 1000 rpm. Frequency change (instead of keeping it fixed at 50 Hz) is another method of changing machine rpm.

In synchronous machine, the magnetic field on the rotor could be created in two ways: (a) by using magnet(s), in which case it is a ‘permanent magnet’ machine; or, more commonly (b) by feeding the windings would on the rotor with direct current (d.c) to produce an electromagnet in what is called the ‘wound-rotor’ machine. In synchronous machine, the rotor magnetic field tries to align itself to the rotating magnetic field created by the stator making it (the rotor) to rotate at the same speed of the rotating field, so called the synchronous machine. The ‘wound rotor’ type synchronous machine has the advantage of controlling the generator voltage or the power factor by adjusting the rotor magnetic field by externally changing the current fed through the slip rings. If the machine is operating as a generator, and more torque is applied to the shat (say, by coupling with wind turbine), the rotor will advance slightly relative to the rotating magnetic field (with leading power factor), but in steady-state operation the speed is firmly held by the supply frequency.

The important point of induction machine is that it acts as a motor(i.e. converts electrical power to mechanical power) when the rotor speed is slightly less than the rotating field. It works as a generator, if the rotor speed is slightly above the synchronous speed. The power transmitted is directly proportional to this speed difference, hence it is also called ‘asynchronous’ machine. This difference in speed is the ‘slip’, which at full power output is around 1%.

Squirrel-cage induction generators are more commonly used in WEGs. These however draw reactive power from the supply grid, which is not desirable especially in weak network. The reactive power consumption is compensated by providing capacitor banks.

Drive Mechanism
Different options for fixed speed and variable speed operations are briefly mentioned below:

(a) Fixed Speed Drive
It uses squirrel-cage induction generator, in either single-speed or dual-speed version, connected to the supply grid via a gearbox. This arrangement is commonly referred to as a fixed speed drive though the speed is not exactly constant but changes marginally due to change in generator slip with power generation.
The advantage of fixed speed drive lies in its relatively simple construction, but has to be quite robust to withstand the fluctuating wind load since variation of wind speed directly transferred into the drive train leading to structural stress. Depending on the strength of the grid, the resultant power fluctuation may cause undesired ‘flicker’.

(b) Semi-variable Speed Drive
So called since the speed range is marginally variable in 1.1 to 1 ratio. Here, the ‘variable slip’ concept is advantageously used by introducing a resistance in series with the rotor resistance of the induction generator by using fast-acting power electronics. This concept has been successfully commercialized by Vestas under their ‘optislip’ trade name. A number of WEGs ranging from 600 kW to 2.75 MW have been equipped with this system. This is a cost effective option though the operation is limited to a narrow variable speed.

(c) Variable Speed Drive
This can be achieved by decoupling electrical grid frequency and mechanical rotor frequency. To this end, power electronic converters are used, such as AC/DC/AC converter combined with advanced control systems.
In ‘double-fed’ induction machines the stator is directly connected to the grid as in case of fixed-speed machine, but the rotor winding is fed at variable frequency via. A electronic converter which makes variable speed operation possible. The range is about 1.5 or 2 to 1 and only to part of the output power flows through the frequency converter (typically 25 or 30%).

One advantage of the design is the use of the type of generator, which is a standard market product. It also requires a smaller converter with favourable cost factor. There is however the need of a rather maintenance-intensive gearbox in the drive train. (Examples 600 kW to 2.0 MW Dewind, 600 kW to 1.5 MW NEG Micon, 600 kW to 1.3 MW Nordex, 850 kW Pioneer Gamesa).
The wide range variable speed drive (speed variation in 2.5 to 3.0 to 1 ratio) provides maximum flexibility in WEG operation. The gearbox is still needed. The size of power

electronic converter is also bigger with higher cost. Both induction and synchronous generators could be used. The energy generation pattern of variable speed drive shows significantly less fluctuation than from fixed speed system. This is mainly due to rotor inertia, which does not response immediately to minor and/or transient variation of wind speed bringing in a stabilizing effect on generated power (Example: 250 kW Logerwey, 600 kW to 750 kW REpower).

(d) Direct Drive

With no gearbox used, all direct drive WEGs are variable speed. The generator is directly engaged with the rotor and rotates at low rpm achied by adopting multi-pole design (ring-shaped) synchronous generator, which could be both permanent magnet or would rotor type. The variable speed is possible due to power electronic converter for change of frquency before connecting the generator to the fixed frequency supply grid. (Example : 600 kW Enercon, 750 kW Emergya wind/Jeumant, 900 kW/1500 kW GE Wind Energy).

The drawbacks of direct drive design are use of large and complex ring generator and large electronic-converter through which 100% of the power generation has to pass.

Power Control

Power from wind is influenced by three factors. The are:

1) Air density (which varies with altitude and temperature). The change in kinetic energy of wind is proportional to air density. Power output of WEG is usually referred to at 1225 g/m^3, which is the air density under the standard temperature and at the altitude of the mean sea level (m.s.l).
2) Rotor Area – i.e. the area intercepted by rotating blades. Power received from wind depends upon this swept area. Since the rotor area increases with the square of the rotor diameter (declared in the manufacturer's catalogue), a WEG with twice as large rotor diameter will theoretically receive four times energy.
3) Wind speed – the power in wind varies with the cube of the wind speed. If the wind speed is twice as high it contains eight times more power.

The output characteristic of a WEG is established through type test carried out with refernce to the wind speed and is declared by the manufacturer as the power curve for use in estimating generation under site specific wind conditions.

WEG is designed to extract optimum power covering its entire speed range but at the same time not to exceed the rated output and other limiting parameters. The operating efficiency of the rotor depends on the tip speed ratio, which is the ratio of the rotor blade speed and this could reach optimum value at one wind speed, (or at two speeds for two-speed WEG). For variable speed, on the other hand, the change in tip speed ratio depends on both wind speed and rotor speed. For maximum rotor efficiency, the rotor speed is controlled to maintain the tip speed ratio normally at 6 to 8. Because of this flexibility, a variable speed drive option could generate more energy for the same wind speed regime.

Several control techniques have been developed which are based on two distinct approaches. These are:

(a) Stall Control
(b) Pitch control

In stall control, the rotor blades are fixed at an angle. The blade profile is shaped such that at high wind speed turbulence is created to cause a collapse in aerodynamic efficiency to limit the power output. This behaviour is intrinsic to the blade design without separate control system to maintain output from the turbine blades constantly close to the rated value beyond the rated wind speed.

In stall-regulated configuration there are chances of overshooting the power output since the system depends on atmospheric condition. Generators used for WEGs are mostly designed for class F insulation but operation is restricted to class b to allow higher margin on temperature rise. For optimum efficiency, the setting of the blades may be adjusted twice in a year but this is a labour incentive exercise, which is generally avoided. The stall system may have a provision to open-up the tip of the blade to act as a “fail-safe” braking as supplementary to the mechanical brake. However, because of the metal components, the tip-brake also carries more risks to lighting strike.

The basic advantage of stall control is that it requires a few moving parts and easy dominated the market in sub-MW range. Setting isolated examples, 1.3 MW Nordex and 1.5 MW NEG-Micon models have been developed on this control concept.
In pitch control the blades are gradually turned out of the wind so that the angle of attack changes and the aerodynamic efficiency is reduced depending upon the wind speed. The pitch mechanism is usually activated by hydraulic-power or electric motor drive. It however reacts with a certain time log and builds-up considerable peak load when guest wind hits the blade. ‘Optislip’ control, patented by Vestas, is provided with an electronic circuitry where the generator slip may be temporarily increased to fast speed up the rotor (upto 10% of its nominal rpm) for operating at higher efficiency and advantageously store energy developed under gusty condition to release the same on normalcy.

A relatively recent innovation is active stall (or semi-pitch) concept where, instead of only the tip portion, the full blade can be turned along its longitudinal axis. On reaching the rated output, the blade changes its alignment to result in which is called “deeper stall” effect whereby excess energy in the wind is wasted to keep the output constant for all wind speeds between the rated and cut-out wind speed. An advantage of this arrangement is better start-up characteristics. In some system, the blades are programmed to pitch at a fixed steps depending upon the wind. (Combi-stall system developed by Bonus is also a type of active stall control).

A current trend is for active pitch which is in fact the pitch control provided separately for individual blade, and is getting increased acceptance for WEGs in MW range, specially used for off-shore application. In general fixed speed WEGs use stall for technical reasons, while variable speed turbines are usually provided with pitch control.

Chapter-2

Wind Energy, Environment and Sustainable Development

Most wind energy projects require an Environmental Impact Assessment (EIA) under national law, which allows the full details of environmental costs and benefits of a project to be scrutinized in the public domain. Whilst wind energy is a clean technology, it is not without impact on the environment. The main issues are:

2.1 Environmental Aspects

No energy source is free of environmental effects. As the renewable energy sources make use of energy in forms that are diffuse, larger structures, or greater land use, tend to be required and attention may be focused on the visual effects. In the case of wind energy, there is also discussion of the effects of noise and possible disturbance to wildlife - especially birds. It must be remembered, however, that one of the main reasons for developing the renewable sources is an environmental one - to reduce emissions of greenhouse gases.

2.2 Noise

Almost all sources of power emit noise, and the key to acceptability is the same in every case - sensible siting. Wind turbines emit noise from the rotation of the blades and from the machinery, principally the gearbox and generator. At low wind speeds wind turbines generate no noise, simply because they do not generate. The noise level near the cut-in wind speed (see Figure 13.3) is important since the noise perceived by an observer depends on the level of local background noise (the masking effect) in the vicinity. At very high wind speeds, on the other hand, background noise due to the wind itself may well be higher than noise generated by a wind turbine. The intensity of noise reduces with distance and it is also attenuated by air absorption. The exact distance at which noise from turbines becomes "acceptable" depends on a range of factors. As a guide, many wind farms with 400-500 kW turbines find that they need to be sited no closer than around 300-400 m to dwellings.

2.3 Television and Radio Interference

Wind turbines, like other structures, can scatter electro-magnetic communication signals, including television. Careful siting can avoid difficulties, which may arise in some situations if the signal is weak. Fortunately it is usually possible to introduce technical measures - usually at low cost - to compensate.

2.4 Birds

The need to avoid areas where rare plants or animals are to be found is generally a matter of common sense, but the question of birds is more complicated and has been the subject of several studies. Problems arose at some early wind farms that were sited in locations where large numbers of birds congregate - especially on migration routes. However, such problems are now rare, and it must also be remembered that many other activities cause far more casualties to birds, such as the ubiquitous motor vehicle.
In practice, provided investigations are carried out to ensure that wind installations are not sited too near large concentrations of nesting birds, there is little cause for concern. Most birds, for most of the time, are quite capable of avoiding obstacles and very low collision rates are reported where measurements have been made.

2.5 Visual effects

One of the more obvious environmental effects of wind turbines is their visual aspect, especially that of a wind farm comprising a large number of wind turbines. There is no measurable way of assessing the effect, which is essentially subjective. As with noise, the background is also vitally important. Experience has shown that good design and the use of subdued neutral colours - "off-white" is popular - minimises these effects. The subjective nature of the question often means that extraneous factors come into play when acceptability is under discussion. In Denmark and Germany, for example, where local investors are often intimately involved in planning wind installations, this may often ensure that the necessary permits are granted without undue discussion. Sensitive siting is the key to this delicate issue, avoiding the most cherished landscapes and ensuring that the local community is fully briefed on the positive environmental implications.

2.6 Integration into supply networks

Electricity systems in the developed world have evolved so as to deliver power to the consumers with high efficiency. One fundamental benefit of an integrated electricity system is that generators and consumers both benefit from the aggregation of supply and demand. On the generation side, this means that the need for reserves is kept down. Consumers benefit from a high level of reliability and do not need to provide back-up power supplies. In an integrated system the aggregated maximum demand is much less than the sum of the individual maximum demands of the consumers, simply because the peak demands come at different times.

Wind energy benefits from aggregation; it means that system operators simply cannot detect the loss of generation from a wind farm of, say, 20 MW, as there are innumerable other changes in system demand which occur all the time. Numerous utility studies have indicated that wind can readily be absorbed in an integrated network until the wind capacity accounts for about 20% of maximum demand. Beyond this, some modest changes to operational practice may be needed, but there are no "cut-off" points. Practical experience at these levels is now providing a better understanding of the issues involved.

Chapter-3

Setting Up a Wind Energy Project

Following procedural steps shall be a useful guideline to examine whether the project proposal is viable both in technical and financial terms, as also ensure trouble-free implementaion.

3.1 Management Decision

Company Outlook

- Company's business outlook and its consistency with present operation.
- A diversification project
- Capacity to absorb accelerated depreciation benefits under sections 32 and 80-IA of Income Tax Act 1961
- State incentives (which vary from state-to-state). Interaction with state Nodal Agency for application procedures and eligibility criteria.
- Size of investment proposed
- Financial viability of the project
- Arrangement of Finance
- Interest rate on loan
- Selection of competent Technical Consultancy Firm for the project.

Power Requirement

- In-house power requirement, its criticality of use an future demand;
- Installed capacity of proposed windfarm, whether for captive consumption, or planning for fully/partly sale to the state utility/third party.
- Wheeling/banking

3.2 Small Size Project

If the size of the project envisaged is small e.g. upto 5.0 MW installed capacity, the best option is to take advantage of facilities being provided by experienced windfarm developers. The small investor just has to arrange for funds and reap benefits.
The developer develops a large size windfarm, where several investors can install Wind Turbines. In this process developer does the following:

- Selection of suitable site for development of windfarm
- Acquisition of land
- Feasibility study
- Preparation of Detailed Project Report
- Sanction of Project

- Development of Infrastructure viz. Approach Road, Internal Roads, Grid Extension.
- Supervision of Construction, Erection and Commissioning of Wind electric Generators along with associated Civil and Electrical works.
- Operation and Maintenance of windfarm during full life-time of Wind electric Generators.
- Performance Monitoring and Improvements.

3.3 Large Size Project

If the size of the project is more than 5.0 MW, it is considered worth-while to follow the following procedure.

Feasibility Study

- Selection of competent technical consultancy organization having experience in all the fields related to windfarm development.
- Selection of suitable site, preferably from among those identified by government agency based on wind data monitoring or by an experienced consultant.
- Availability of land adequate for the proposed installed capacity.
- Acquisition of land, government or private. Its availability and cost.
- Analysis of wind data and assessment of potential at the selected site.
- In case wind data is not available from a near-by monitoring mast, immediate action is to install a mast for monitoring wind condition (Anemometry for minimum one year and reference of general wind condition)
- Study land features and soil conditions
- Study grid and power evacuation facility with particulars on nearby sub-station(s) and the grid quality (capacity, voltage, failure data etc) as also the scope for future expansion plan.
- The extent of grid extension required and modification in upstream EHV sub-station
- Approach road and transport facitlity
- Water source and other infrastructure.

Preparation of DPR

Detailed Project Report (DPR), prepared by an expert consultancy organization should include specific activities enumerated below, in addition to those covered in feasibility study:

- Capacity of windfarm
- Mode of project financing
- Site identification finalised based on assessment that the wind potential have WPD (wind power density) more than 200 W/m^2 at 50 m above ground level.
- Purchase/acquisition of land (Govt. land/Private land).

- Interaction with WEG manufacturers/their representatives, for budgetary price and machine particulars.
- Detailed contour survey of the site and to further assess the land pattern for and around the windfarm area.
- Annual estimated generation for different option of WEGs
- Grid and power evacuation facility to examine requirement of capacity enhancement of existing sub-station and grid. The cost of grid extension if required, should also be studied.
- Windfarm layout drawing showing location of WEGs, internal road, unit sub-stations, over-head lines, metering station etc.
- Estimated project cost and cash flow statement.
- Selection of WEGs preferably out of the latest list published by C-WET (Centre for Wind Energy Technology).

3.4 Project Implementation Stage

- Retaining services of expert consultancy organization
- Micro-siting of WEGs
- No Objection Certificate, to obtain from State Nodal Agency or the State Electricity Board/Regulatory Commission.
- Acquisition of land.
- Power Purchase Agreement with State Nodal Agency/State Electricity Board/Third Party.
- Submitting proposal for loan
- Soil testing
- Preparation of bid document, techno-commercial evaluation of bids and selection of equipment.
- Preparation of Bar chart showing project activities.
- Engaging experienced contract for site work.
- Preparatory work at site – arranging for water and electricity during construction. Creating of storage facility.
- Insurance of material in store/during erection.
- Construction of approach/internal roads.
- Erection and commissioning activities.
- Safety Certificate from the Chief Electrical Inspector to Government (CEIG) prior to commission of the grid and the windfarm.
- Training of operating and maintenance of the windfarm during erection and commissioning.
- Observation on performance of the WEGs and other equipment.
- Handing over/Taking over of the windfarm.

Project flow diagram [*Fig.1*] below depicts various stages involved in the wind farm development projects including management inputs, DPR selection and approvals, supplier selection, construction, etc.

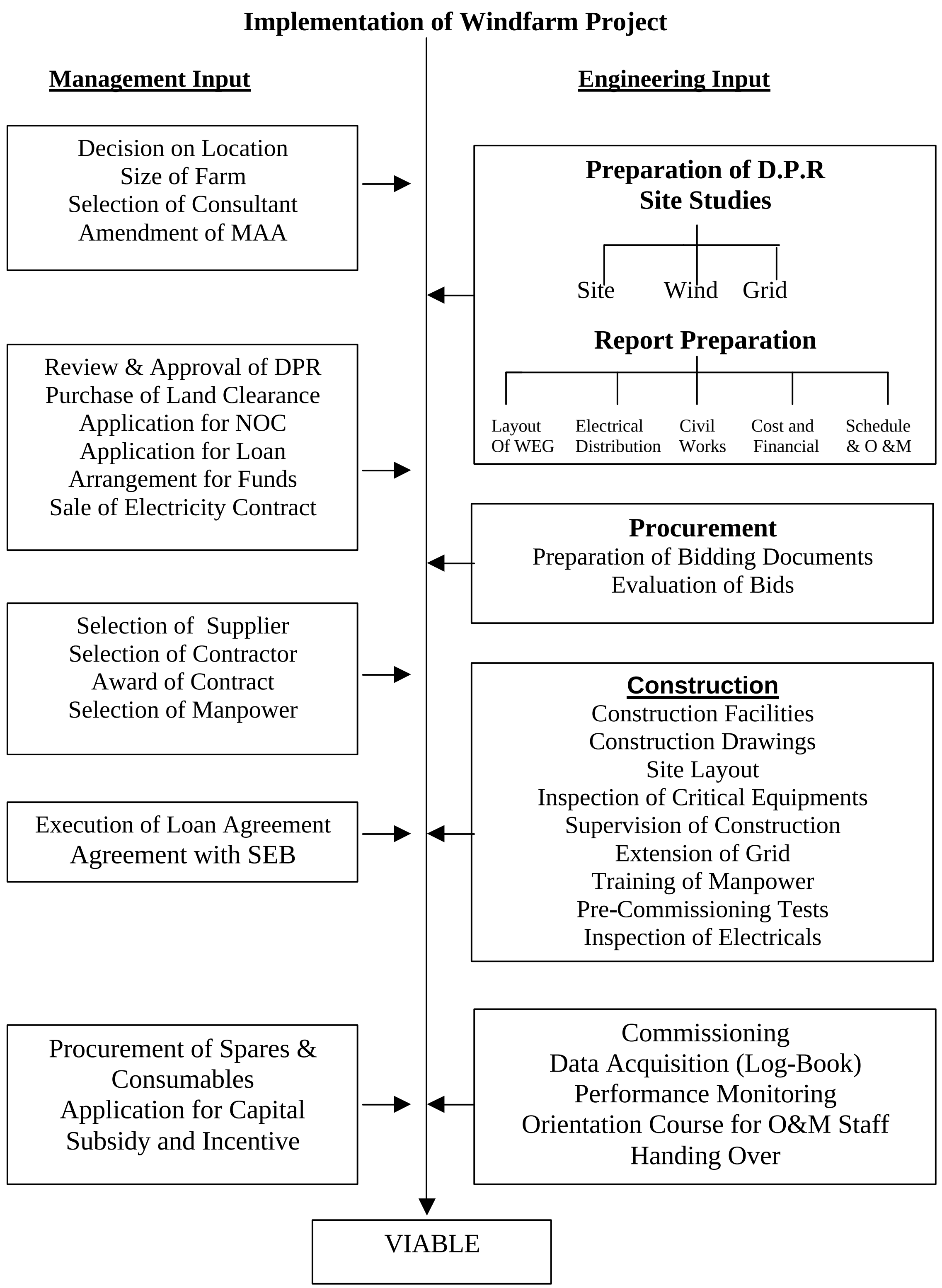

Figure-1: *Implementation of Windfarm Project*

Chapter-4

Cost of Wind Power

To ensure sustained and healthy growth of Wind Energy Sector, it is necessary to rationally evaluate the cost of generation and to determine a selling rate which should be acceptable to consumers and attractive for investor.

The cost of wind energy can be calculated as per standard practice followed by Institute of Cost Accountants but the assumptions of parameters must be realistic-particularly regarding expected generation at site.

The selling/purchase rate would however, vary for three different mode of use/sale of wind energy:

- Captive consumption
- Third Party sale
- Sale to Utility

4.1 Cost of Wind Energy

The cost of wind energy generation varied from site to site depending on the wind resource and also on year-to-year basis due to yearly variation in wind speed. The cost can be calculated accurately provided the assumptions are realistic corresponding to wind resource and market conditions. Further, there are certain parameters [*Table -1*] which would influence the cost of wind energy project installations.

Table-1: *Parameters for wind power cost calculations*

	Parameter	**Assumption**
a)	Capital Cost	The Capital Cost varies between Rs 40 Mill. To Rs 50 Mill. Per MW depending on the technology of Wind Turbine.
b)	Capacity Utilization Factor (CUF) (Annual Generation)	It varies from 18% to 30% (average of few years) and more depending on wind resource at particular site and the technology of Wind Turbine. The CUF is the net after deducting internal consumption.
c)	Operation & Maintenance (O&M)	This cost includes manpower, consumables, spares, breakdown maintenance, insurance and also all other statutory duties and expenses. As the turbines are supplied under warranty, the O&M cost would be @1.5% of capital cost for first 2 years and subsequently @2% per year with 5% annual escalation.
d)	Interest on Debt	This varies depending on the credit rating of borrowers. To attract large number of Investors and in consideration of market tend, the reasonable rate would be @11%
e)	Loan Repayment Schedule	This varies from institution to institution. However this being an infrastructure project, repayment period of ten year may be considered. The repayment schedule can be structured to match with revenue inflow.

f)	Debt Equity Ratio	Depending of Financial Institution and credit rating of borrower, this may be : 65:35 70:30 75:25 An average figure for 70.30 may be considered.
g)	Return on Equity	As per Govt. of India guidelines for Private Sector participation it should be minimum 16% though a higher return may be justified in view of uncertainties involved in wind flow pattern.
h)	Rate of Depreciation	For the sake of simplicity the most common system of Straight Line Method (SLM) @5.28% may be considered. While 5.28% depreciation under SLM method is suitable for calculation of cost, the rate should be higher in first 10 years if loan is to be repaid in 10 years.
i)	Deration due to Ageing	The efficiency of any rotating machine reduces due to ageing. A simplified nom of one time deration by 5% after 10 years may be considered to estimate net saleable energy.
j)	Wheeling & Banking charges	There are not applicable against sale to utility as the power is fed directly to the grid. The internal consumption should be deducted from the generation to arrive at net CUF.
k)	Income Tax Liability	To take full advantage of Accelerated rate of Depreciation and Infrastructure project under Section 80 IA of Income Tax Act, only Minimum Alternate Tax (MAT) @ 7.5% plus surcharge plus cess may be considered for first 15 years and then full tax @30% plus surcharge plus cess for independent new projects.
l)	Income Tax benefit through Accelerated Depreciation	This factor is never considered by mature Private Sector Industry while evaluating the business proposal since: i) This benefit is available for many other investments. ii) There is uncertainty and rate may be reduced. iii) This is a deferred tax liability. This short time gain is usually availed against sudden profit in existing business. To attract large-scale investment it is more prudent to consider this benefit along with 80 IA.

Source: Indian Wind Power Directory, 2005

The capital cost and Capacity Utilization Factor (CUF) are very much inter-related. The capital cost varies with the technology. A more efficient Turbine produces more energy but is also costlier. Further the CUF widely varies with the site.

In view of above mentioned two factors it is more rational to take into consideration cost per kWh produced instead of independently considering capital cost and CUF. Keeping in view the wind resource scenario of the country, the Cost-CUF relationship are given in [*Table-2*].

Table-2: *Cost-CUF relationship*

Technology	Capital Cost per MW	Capacity Utilization Factor			
		Wind Resource	**Low**	**Medium**	**High**
		Wind Power Density (WPD) at 50 mtr.	200 to 300 W/m2	300 to 400 W/m2	400 W/m2 & above
		Number of Stations identified	132	45	31
Orthodox	Rs 40 Mill.		18%	20%	22%
Modified	Rs 45 Mill.		20%	22%	24%
Improved	Rs 50 Mill.		22%	24%	26%
Cost/kWh			Rs 25.50	Rs 22.50	Rs 20.50

Usually there is lot of misunderstanding regarding financial benefit accruing out of accelerated depreciation under Income Tax Act and it should be understood clearly.
The benefit of tax saving through high rate of accelerated depreciation is real only if the taxable income is substantially high to absorb the accelerated rate of depreciation. In wind energy project, the revenue income is so low that the benefit of accelerated depreciation cannot be availed. Therefore to avail this benefit, the Investor must have very high taxable income from other business(es).

The net rate of tax saving can at the most be 25.245% of eligible investment made in wind power project after consideration of MAT. Typically if an investment of Rs 400 Lacs has been made in wind power project, the maximum tax saving of prevailing rate of 80% can be Rs 80.78 Lacs if Investor has taxable income of Rs.360 Lacs in some other business in that particular year. Further, this tax saving of Rs 82.6 Lacs can be availed only if the wind power project is commissioned before September otherwise in the first year tax saving shall be only Rs. 40.39 Lacs.

Factoring of tax saving benefit in determining the purchase rate for wind energy would mean:

a) Wind power project is not viable as Independent Power Project (IPP)
b) The wind power project solely dependent on balance Sheet of Promoter Company with very high tax liability
c) If the profit earned by the promoter in the other business drops, it shall affect the financial viability of wind power project.
d) If wind power project is largely dependent on profit from other business then it is no more a bankable proposition.
e) Initial saving of Income Tax would mean higher tax rate in subsequent years.

Benefit of high accelerated depreciation is available for may other project/activities e.g. investment in pollution control, energy conservation etc. A promoter would surely prefer the tax benefit through such activities which are statutory requirements and / or mean direct financial saving in his existing business operation.

To avail the accelerated depreciation benefit through wind power project would probably be the least preferred option in view of variation in energy output from wind power project. As per statutory provisions, accelerated rate of depreciation –if claimed initially should be treated as deferred tax liability and should be clearly indicated in the Balance Sheet. In subsequent year if there be any profit this deferred tax liability shall get adjusted. In reality it is therefore only a short term cash availability through tax saving and this has to be paid back in subsequent years whenever there is higher profit.

Finally it is to be clearly understood that accelerated rate of depreciation is basically an incentive which means that it is an added attraction for an otherwise financially viable and bankable investment. This incentive being an added attraction the rate may be gradually reduced by Govt. of India.

Detailed year-to-year cost of generation is calculated on the basis of assumptions/ parameters as mentioned above and provided in [*Table-3*]. The cost varies from Rs 4.49/kWh to Rs 3.38/kWh and the average of 20 years works out to be Rs 3.86/kWh (rounded off Rs 3.90/kWh)

4.2 Selling/Purchase Rate

The selling rate if based on the actual cost of generation would be quite front-loaded and may have significant impact on the existing tariff. The selling rate based on the average cost of energy would not be acceptable since the debt cannot be serviced within a period of 10 years. To avoid initial negative impact and also to ensure bankability of the project in terms of debt servicing initially the tariff should be lower than the cost of generation [Table-4] but higher than the average cost.

Table-3: *Cost calculation*

Project Cost	:	Rs 40 Mill	Loan 70%	:	Rs 28 Mill
			Equity 30%	:	Rs 12 Mill
O&M Rate (first 2 years)	:	1.50% of Capital cost	Interest Rate	:	11.00%
From 3rd year	:	2% + 5% escalation	MAT Rate	:	8.415% MAT/IT on Return On Equity
Generation	:	1.75 Mill. KWh 5% derating after 10 years	IT Rate	:	33.660%
			Depreciation Rate	:	5.28%

Table-4: *Cost of generation*

Year	Outflow						Unit Rate Total outflow Generation (Rs./kWh)	Outstanding Loan (Rs. Mill.)
	O&M	Interest on Loan	Depreciation on SLM	Return on Equity	MAT/ IT	Total		
	(In Rs. Mill.)							28.000
1	0.600	3.080	25.888	1.920	0.162	7.874	4.49	25.888
2	0.600	2.848	23.776	1.920	0.162	7.641	4.36	23.776
3	0.800	2.615	21.664	1.920	0.162	7.609	4.34	21.664
4	0.840	2.383	19.552	1.920	0.162	7.417	4.23	19.552
5	0.882	2.151	17.440	1.920	0.162	7.226	4.12	17.440
6	0.926	1.918	15.328	1.920	0.162	7.038	4.02	15.328
7	0.972	1.686	13.216	1.920	0.162	6.852	3.91	13.216
8	1.021	1.454	11.104	1.920	0.162	6.668	3.81	11.104
9	1.072	1.221	8.992	1.920	0.162	6.487	3.70	8.992
10	1.126	0.989	6.880	1.920	0.162	6.308	3.60	6.880

11	1.182	0.757	4.768	1.920	0.162	6.132	3.68	4.768
12	1.241	0.524	2.656	1.920	0.162	5.959	3.58	2.656
13	1.303	0.292	0.544	1.920	0.162	5.789	3.48	0.544
14	1.368	0.060	2.112	1.920	0.162	5.622	3.38	
15	1.437		2.112	1.920	0.162	5.630	3.38	
16	1.509		2.112	1.920	0.646	6.187	3.72	
17	1.584		2.112	1.920	0.646	6.262	3.76	
18	1.663		2.112	1.920	0.646	6.341	3.81	
19	1.746		2.112	1.920	0.646	6.425	3.86	
20	1.834		2.112	1.920	0.646	6.512	3.91	
			42.240	38.400			77.16	

Average of 20 years + Rs 3.86/kWh

There can be number of options to determine the selling price which would avoid too much of font-loading and at the same time ensure that the project is profitable and bankable.

Initially a comparatively lower rate may be considered with escalation till loan is repaid and subsequently after repayment of loan the rate can be substantially lower. To ensure simplicity in terms of administration of the tariff two flat rates may be considered – one for first 10 years during loan repayment period and other for balance life of WEG after repayment of loan. A typical cash-flow has been prepared and furnished in Table-4 C which considers first 10 year rate to be 45 paise per unit higher than the average cost and 60 paise lower than the average cost for balance 10 years life of WEG.

The proposed norm would ensure:

a) Banability
b) Profitability
c) Simplicity in administration
d) Lower front loading

The purchase price as proposed above would hold good only if timely payment is received from the utility. As the interest constitutes the main cost, delay in receipt of payment would mean larger interest liability and the project would turn unviable. The ideal arrangement to guarantee timely payment would be opening of irrevocable revolving Letter of Credit by the Utility

4.3 Comparative Cost

As has been mentioned earlier, fairness demands that the cost of Wind Energy should be compared with cost of energy from a Thermal Power Station (TPS) likely to be commissioned in near future and also at the point of use of energy.

Recent proposals submitted by utility to Central Electricity Authority (CEA) for approval indicates that the cost of energy shall be

Rs 2.50/kWh from a 500 MW Steam Turbine at pithead
Rs 3.00/kWh from a 200 MW Steam Turbine of pithead

The cost of energy produced at pithead will increase substantially at point of use due to line loss in Extra High Voltage (EHV) system and wheeling expenses as charged by Transmission Company (PGCL).

The energy losses at different voltage level. Even if only 8.12% loss in EHV system is considered and 13 paise wheeling charge levied by PGCL is taken into consideration, the cost of conventional energy at 33 kV level would minimum Rs. 2.83/kWh.

The cost of energy from Thermal Power Station is bound to increase due to inevitable increase in cost of fossil fuel, transportation, salary and overhead expenses etc. even for a new power station. Under most conservative assumption, the annual increase would be more than @55 while more realistic assumption may be @7%. Internationally also it is accepted that cost of fossil fuel generation would increase @7%.

As there is no fuel cost involved, the rate of escalation for wind power would be quite low in view of nominal O&M expenses. Realistic comparison should however be on the basis of levelized cost for 20 years. The comparative levelized cost is indicated in [*Table-5*] below:

Table-5: *Comparative localised cost of wing power generation*

Discounting Factor	**Wind Energy @Rs.4.35/kWh for first 10 years and @Rs 3.30/kWh for balance 10 years**	**Energy from Thermal Power Station Rs 2.83/kWh + escalation @7%**
11.0%	4.0765	4.6207

It can be clearly seen that even at a high discounting factor of 11% wind power would be always cheaper. The gestation period of wind power project is quite low and capacity addition is possible within 6 months. The over all cost advantage through additional availability of power to mitigate the shortage shall be a favourable factor. Besides, wind Power Projects are usually at remote locations. The advantage of tail-end feeding-which improves the power system and reduceds loss-needs to be considered for comparative evaluation.

4.4 Possibilities of Cost Reduction

The proposed purchase rate of wind energy can be decreased if
(i) Capital cost per kWh produced is lower
(ii) Interest rate is lower
(iii) Debt equity ratio is 75.25
(iv) Carbon credit is available

For purpose of costing it has been assumed that the capital cost would be Rs 400 Lacs/MW and generation would be 17.52 Lacs/MW/year. This effectively means that capital cost/kWh shall be 400 / 17.52 + Rs 22.83/kWh. If the capital cost per kWh gets reduced by Re 1.0, the average cost of generation would be Rs 3.69 instead of Rs 3.86 as indicated.

If the interest rate is reduced from 11% to 10%, the average cost would work out to be Rs 3.80 kWh instead of Rs. 3.86/kWh.

In consideration of wind power project being an infrastructure project, if higher debt is made available to ensure debt equity ratio of 75.25, the average cost would work out to be Rs 3.73/kWh instead of Rs 3.86/kWh/

At present the Carbon Credit is being traded at around Rs. 30 pasie per kWh. There is however a substantial expenditure involved in certification of project and trading of credit. The trading rate is likely to increase in next two years. Availability of this benefit shall substantially bring down the purchase rate of wind energy.

4.5 Economic Impact

Instead of comparing the energy sources on cost to cost basis, in to-days context, it is more appropriate to take into consideration the social and environmental benefits.

There are quite a few extra-ordinary advantages of wind energy:

- Pollution free
- Perennial
- Conserves fossil fuel
- Improves grid quality and efficiency
- Extremely low question period
- Rural development

Unfortunately these benefits have not been quantified in financial terms and therefore cannot be adequately factored in favour of wind energy. Throughout the world it is acknowledged that there are some external costs involved (damage to environment) in fossil fuel based power generation. It is also well-known that some indirect/hidden support is provided for fossil fuel power generation. Unfortunately these issues have not been quantified and cannot be properly loaded to arrive at realistic cost of fossil fuel based energy.

Chapter-5

Global Status of Renewable Energy

5.1 Introduction

Renewable energy supplies 17 percent of the world's primary energy consumption, counting traditional biomass, large hydropower and "new" renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels). Traditional biomass, primarily for cooking and heating, represents about 9 percent [*Table-6*] and is growing slowly or even declining in some regions as biomass is used more efficiently or replaced by more modern energy forms. Large hydropower is slightly less than 6 percent and growing slowly, primarily in developing countries. New renewables are 2 percent and growing very rapidly in developed countries and in some developing countries.

Table 6: *Renewable Energy Contribution to Global Primary Energy, 2004*

Renewable energy types	**Contribution**	
Large hydro power	5.7%	--
New Renewables	2.0%	Hot waster heating – 0.7% Biofuels – 0.2% Power generation – 1.2%
Traditional biomass	9.0%	--

Renewable energy competes with conventional fuels in four distinct markets: power generation, hot water and space heating, transport fuels, and rural (off-grid) energy. In power generation, renewable energy comprises about 4 percent of power-generating capacity and supplies about 3 percent of global electricity production (excluding large hydropower). Hot water and space heating for tens of millions of buildings is supplied by solar, biomass, and geothermal. Solar thermal collectors alone are now used by an estimated 40 million households worldwide. Biomass and geothermal also supply heat for industry, homes, and agriculture. Biomass transport fuels make small but growing contributions in some countries and a very large contribution in Brazil, where ethanol from sugar cane now supplies 44 percent of automotive (non-diesel) fuel consumption for the entire country. In developing countries, 16 million households cook and light their homes from biogas, displacing kerosene and other cooking fuel; more than 2 million households light their homes with solar PV; and a growing number of small industries, including agro-processing, obtain process heat and motive power
from small-scale biogas digesters.

The fastest growing energy technology in the world has been grid-connected solar PV, with total existing capacity increasing from 0.16 GW at the start of 2000 to 1.8 GW by the end of 2004, for a 60 percent average annual growth rate during the five-year period. During the same period, other renewable energy technologies grew rapidly (annual average) as well:

wind power 28 percent, biodiesel 25 percent, solar hot water/heating 17 percent, off-grid solar PV 17 percent, geothermal heat capacity 13 percent, and ethanol 11 percent. Other renewable energy power generation technologies, including biomass, geothermal, and small hydro, are more mature and growing by more traditional rates of 2–4 percent per year. Biomass heat supply is likely to grow by similar amounts. These growth rates compare with annual growth rates of fossil fuel-based electric power capacity of typically 3–4 percent (higher in some developing countries), a 2 percent annual growth rate for large hydropower, and a 1.6 percent annual growth rate for nuclear capacity during the three year period 2000–2002.

Table 7: *Renewable Energy Indicators*

Indicator Power generation	**Existing capacity by 2004** (GW)	**Comparison Indicators** (GW)
Large hydropower	720	World electric power capacity =3,800
Small hydropower	61	
Wind turbines	48	
Biomass power	39	
Geothermal power	8.9	
Solar PV, off-grid	2.2	
Solar PV, grid-connected	1.8	
Solar thermal power	0.4	
Ocean (tidal) power	0.3	
Total renewable power generation capacity (excluding large hydropower)	160	

Existing renewable electricity capacity worldwide totaled 160 GW in 2004, excluding large hydro has been shown in the [*Table-7*]. Small hydro and wind power account for two-thirds of this capacity. This 160 GW compares to 3,800 GW installed capacity worldwide for all power generation, is truly marginal. Developing countries as a group, including China, have 70 GW (44 percent) of the 160 GW total, primarily biomass and small hydro power. The European Union has 57 GW (36 percent), a majority of which is wind power.

5.2 World Renewable Energy Targets

Policies to promote renewable energy existed in a few countries in the 1980s and early 1990s, but renewable energy policy began to emerge in many more countries, states, provinces, and cities during the late 1990s and early 2000s. Many of these policies have exerted substantial influence on the market development.

Policy targets for renewable energy exist in at least 45 countries worldwide. By mid-2005, at least 43 countries had a national target for renewable energy supply, including all 25 EU countries [*Table-8*]. The EU has Europe-wide targets as well: 21 percent of electricity and 12 percent of total energy by 2010. In addition to these 43 countries, 18 U.S. states (and the District of Columbia) and 3 Canadian provinces have targets based on renewables portfolio standards (although neither the United States nor Canada has a national target). An additional 7 Canadian provinces have planning targets.Most national targets are for shares of electricity production, typically 5–30 percent. Electricity shares range from 1 percent to 78 percent. Other targets are for shares of total primary energy supply, specific installed capacity figures, or total amounts of energy production from renewables, including heat.Most targets aim for the 2010–2012 timeframe.

Table 8: *Worlwide renewable energy targets*

Country	RE target (%) by 2020		Country	RE target (%) by 2020
Total (EU-25)	21.0		Latvia	49.3
Hungary	3.6		Sweden	60.0
Malta	5.0		Austria	78.0
Estonia	5.1		Australia	9.5 TWh of electricity annually by 2010
Luxembourg	5.7		Brazil	3.3 GW added by 2006
Belgium	6.0		Canada	3.5% to 15%
Cyprus	6.0		China	10% of electric power capacity by 2010
Lithuania	7.0		Dominican Republic	500 MW wind power capacity by 2015
Poland	7.5		Egypt	14%
Czech Republic	8.0		India	10% during 2003–2012
United Kingdom	10.0		Israel	5% of electricity by 2016
Netherlands	12.0		Japan	1.35% of electricity by 2010 besides Geothermal and Large hydro
Germany	12.5		Korea	7% of electricity by 2010
Ireland	13.2		Malaysia	5% of electricity by 2005-6
Greece	20.1		Mali	15% of energy by 2020
France	21.0		New Zealand	30 PJ of added capacity by 2012
Italy	25.0		Norway	7 TWh from heat and wind by 2010
Denmark	29.0		Philippines	4.7 GW total existing capacity by 2013
Spain	29.4		Singapore	50,000 m2 of solar thermal by 2012
Slovak Republic	31.0		South Africa	10 TWh added final energy by 2013
Slovenia	33.6		Switzerland	3.5 TWh from electricity and heat by 2010
Finland	35.0		Thailand	8% of total primary energy by 2011
Portugal	45.6		United States	5% to 30%

A few other developing countries are likely to announce targets in the near future. China’s target of 10 percent of total power capacity by 2010 (excluding large hydropower) implies 60 GW of renewables capacity given projected electric-power growth. China also has targets for 2020, including 10 percent of primary energy and 12.5 percent of power capacity, 270 million square meters of solar hot water, and 20 GW each of wind and biomass power. Thailand is targeting 8 percent of primary energy by 2011 (excluding traditional biomass). India is expecting 10 percent of added electric power capacity, or at least 10 GW of renewables, by 2012. The Philippines is targeting nearly 5 GW total by 2013, or a doubling of existing capacity. South Africa in 2003 set a target of 10 TWh of additional final energy from renewables by 2013, which would represent about 4 percent of power capacity. The Mexican legislature was considering in 2005 a new law on renewable energy that would include a national target.

Chapter-6

Wind Energy Development

The attractions of wind as a source of electricity which produces minimal quantities of greenhouse gases has led to ambitious targets for wind energy in many parts of the world. More recently, there have been several developments of offshore wind installations and many more are planned. Although offshore wind-generated electricity is generally more expensive than onshore, the resource is very large and there are few environmental impacts. Whilst wind energy is generally developed in the industrialised world for environmental reasons, it has attractions in the developing world as it can be installed quickly in areas where electricity is urgently needed. In many instances it may be a cost-effective solution if fossil fuel sources are not readily available. In addition there are many applications for wind energy in remote regions, worldwide, either for supplementing diesel power (which tends to be expensive) or for supplying farms, homes and other installations on an individual basis.

6.1 Global scenario

Over the last decade significant progress has been made in harnessing wind for power generation in different parts of the world, particularly in the USA, Europe, China and India. The technical feasibility of using wind as a source of power generation has now been established and wind energy has emerged in the near term as the most promising renewable energy technology for generating electricity. The growth in energy demand, the limitations of supply and increasing cost of fossil fuel generation, and environmental concerns make wind power a competitive option in countries which have a good wind resource base. Wind

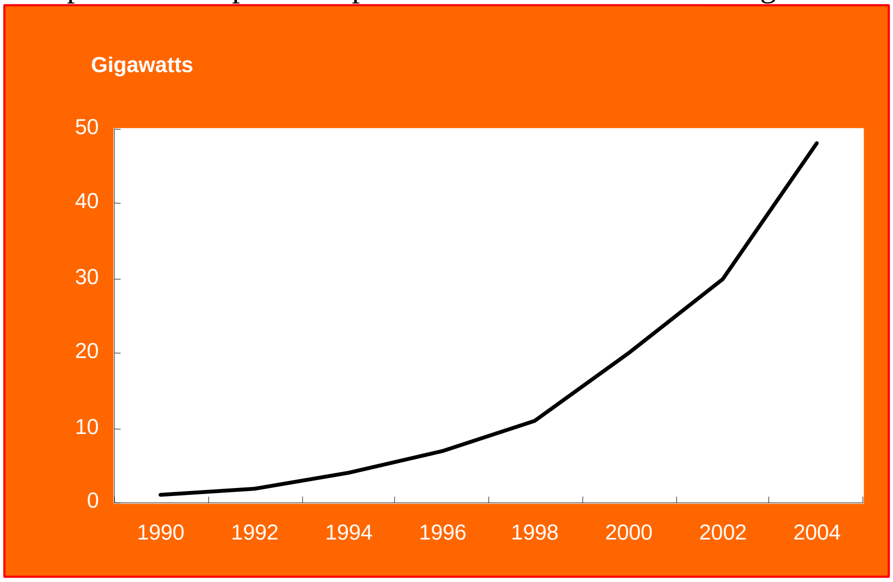

Figure-2: *Wind power, existing world capacity, 1999/2004* power installations world-wide have crossed 50,000 MW in 2005. A total capacity of about 36650 MW has come up in Europe; 7000 MW in USA; and 3740 MW in India. India is now the fourth largest wind power generator in the world after Germany, Spain and USA.

Wind power markets are concentrated in a few primary countries, with Spain, Germany, India, the United States, and Italy leading expansion in 2004 [*Fig. 2*]. Several countries are now taking their first steps to develop large-scale commercial markets, including Russia and other transition countries, China, South Africa, Brazil, and Mexico.

As per the recent data released by Global Wind Energy Council (GWEC), the global wind energy sector experienced installation of 11,769 megawatts (MW) in the year 2005, which represents a 43.4% increase in annual additions to the global market, up from 8,207 MW in the previous year. The total value of new generating equipment installed was over €12 billion, or US$14 billion. The total installed wind power capacity now stands at 59,322 MW worldwide, an increase of 25% compared to 2004.

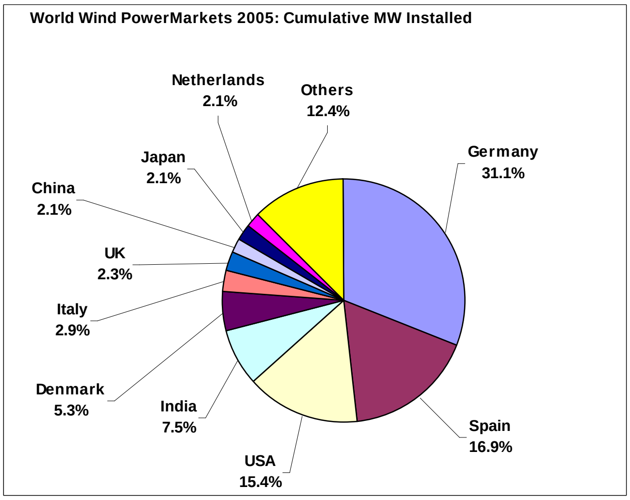

Figure – 3: *World wind power market in 2005*

The countries with the highest total installed capacity are Germany (18,428 MW), Spain (10,027 MW), the USA (9,149 MW), India (4,430 MW) and Denmark (3,122) are depicted in the [*Fig.3*]. India has thereby overtaken Denmark as the fourth largest wind market in the world. A number of other countries, including Italy, the UK, the Netherlands, China, Japan and Portugal have reached the 1,000 MW mark of installed capacity. In terms of new installed capacity in 2005, the US was clearly leading with 2,431 MW, followed by Germany (1,808 MW), Spain (1,764 MW), India (1,430 MW), Portugal (500 MW) and China (498 MW). This development shows that new players such as Portugal and China are gaining ground.

Table-9: *Cumulative installation (MW) in the wind power market*

Country	**Cumulative installed end 2002 (MW)**	**Cumulative installed end 2003 (MW)**	**Cumulative installed end 2004 (MW)**	**Cumulative installed end 2005 (MW)**	**Growth rate 2004-05 (%)**	**Contribution in world production (%)**
Germany	11,968	14,612	16,620	18,428	10.87	31.0
Spain	5,043	6,420	8,263	10,027	21.34	16.9
USA	4,674	6,361	6,718	9,149	36.18	15.4
India	1,702	2,125	3,000	4,430	47.66	7.5
Denmark	2,880	3,076	3,083	3,122	1.26	5.3
Italy	806	922	1,261	1,717	36.16	2.9
UK	570	759	889	1,353	52.19	2.3
China	473	571	769	1,267	64.75	2.1
Japan	486	761	991	1,231	24.21	2.1
Netherlands	727	938	1,081	1,219	12.76	2.1
Top 10	29,329	36,545	42,735	51,936	21.53	87.6
World (Total)	32,037	40,301	47,912	59,322	12.81	100

Source: Global Wind Energy Association, December 2005

Europe is still leading the market with over 40,500 MW of installed capacity at the end of 2005 [*Table-9*], representing 69% of the global total. In 2005, the European wind capacity grew by 18%, providing nearly 3% of the EU's electricity consumption in an average wind year.

Despite the continuing growth in Europe, the general trend shows that the sector is gradually becoming less reliant on a few key markets, and other regions are starting to catch up with Europe. The growth in the European market in 2005 only accounted for about half of the total new capacity, down from nearly three quarters in 2004.

Nearly a quarter of new capacity was installed in North America, where the total capacity increased by 37% in 2005, gaining momentum in both the US and Canada. The US wind energy industry broke earlier annual records of installed capacity with installing nearly 2,500 MW, which makes it the country with the most new wind power.

Asia has also experienced strong growth of over 49% of installed capacity, bringing the continent up to a total of over 7,135 MW. In 2005, the continent accounted for 20% of new installations. The strongest market here remains India with over 1,430 MW of new installed capacity, which takes its total figure up to 4,430 MW. The Chinese market has been boosted in anticipation of the country's new Renewable Energy Law, which entered into force on 1 January 2006. As a result, nearly 500 MW of new capacity was installed in 2005, more than double the 2004 figure. This brings China up to 1,260 MW of capacity, thereby passing the 1,000 MW mark which is often deemed critical for sustained market growth.

The Australian market nearly doubled in 2005 with 328 MW of new installed capacity, bringing the total up to 708 MW. “The 2007 implementation of a state based market mechanism and a commitment by state governments to establish an emissions trading scheme will provide financial incentives to continue this growth,” said Dominique Lafontaine, CEO of AusWind.

The relatively young African market saw a steady continuation of its growth, with an installation figure double that of 2004. The main countries experiencing growth are Egypt (230 MW, up from 145 MW) and Morocco (64 MW, up from 54 MW).

The overall picture confirms that the right political framework is crucial to sustain the growth of wind power around the world and to open new markets. Some 48 governments have already introduced laws and regulations to support the development of renewable energies, but this effort needs to be increased if the benefits of wind energy are to be reaped around the world.

6.2 Wind power industry trends

Wind technologies fall into two distinct types: large turbines, designed to supply electricity to the grid, typically 1-3 MW rated capacity with blade diameters of 60-100 meters, and small turbines rated from around 3 kW up to around 100 kW. As wind technology has matured, large wind turbines have become increasingly standardized. All are now broadly similar three bladed designs. However, the potential for innovation has not been exhausted. There is scope for cost reductions through site optimization and innovations in blade and generator design and in grid connection using power electronics. Offshore wind power is still in its infancy and large potential cost reductions exist.

Typical wind turbines produced today are in the 1-3 MW scale, although the 600 kW scale is still common in India and China. European manufacturers have introduced new wind-turbines in the 5 MW range, and achieved an evolution of cost per kW of installed capacity from 1,650 Euro/kW in 1986 to about 850 Euro/kW in 2004. At present little offshore wind capacity is installed anywhere in the world. As with onshore developments during the 1990s, Europe is the lead, with all the world’s operating offshore capacity and ambitious plans for future development in the 2006-2007 timeframe. The first large-scale offshore wind farm (160 MW) was completed in 2002 in Denmark.

Wind technology costs have declined 12-18% for each doubling of global capacity, with costs of wind-generated electricity falling from about 46 cents/kWh in 1980 (in the US) to 4-5 cents/kWh at good sites today. Technology development and cost reduction have been driven primarily by feed-in policies in just a few countries: Germany, Denmark, and Spain. The German Wind Energy Association (BWE) estimated that the costs of wind power in Germany fell in real terms by 55% between 1991 and 2004. How to make the machines bigger is still the number-one technological issue in the turbine industry, with the current philosophy being that the larger the turbine, the greater its cost effectiveness. The average size of turbines installed increased by only around 3% to 1.25 MW in 2004, with the three-blade, three-stage gear box design remaining the most popular. Some progress is being made in producing a single-geared generator, with German company Enercon being the only one to commercially produce them at present. 5 MW turbines remained the largest available but so far only three prototype units have been installed worldwide.

During 2003-2004, there were six competitively-bid wind projects in China and Canada , totaling almost 2,000 MW, that show winning-bid prices from 4.1-4.8 eurocents/kWh, considerably lower than most present feed-in tariffs. However, competitive bidding in new markets may not reflect commercially viable prices if aspiring market entrants underbid to gain market entry or mis-bid due to insufficient experience.

Wind power markets remain fragmented by country. That is, the wind market is not yet a global market but really a collection of national markets, each growing fairly independently. Wind power has become a mainstream commercial investment in about 8-10 primary countries (including Denmark, Germany, India, Italy, Netherlands, Spain, the United Kingdom, and the United States). Several countries are now taking their first steps to develop large-scale commercial markets, including Russia and other transition countries of Europe, China, South Africa, Brazil, and Mexico. In the case of China, most wind power investments historically have been donor or government driven, but a shift to private investors has been underway in recent years. Several other countries are at the stage of demonstrating wind farm installations, looking to develop commercial markets in the future. The global market for small-scale wind turbines has been growing rapidly in recent years. Small-scale wind turbines (typically 100-1,000 W) provide power for homes and remote locations. The largest installed base of small-scale turbines is an estimated 230,000 in Inner Mongolia in China, for household use. Sales of small wind turbines were estimated to be 13,000 in 2005, totaling 14 MW (an average of 1 kW per turbine), bringing total small wind capacity to 30 MW. Manufacturers are aiming to reduce hardware costs by 20 percent to $1,700 per installed kW by 2010; and the average size of small wind turbines has doubled from 500 W in 1990 to 1 kW in 2004.

The wind power industry produced more than 6,000 wind turbines in 2004, at an average size of 1.25 MW each. The top six manufacturers are Vestas (Denmark, merged with NEG Micon in 2004), Gamesa (Spain), Enercon (Germany), GE Energy (USA), Siemens (Denmark, merged with Bonus in 2004), and Suzlon (India). In China, there are two primary turbine manufacturers, Goldwind and Xi’an Nordex, with market shares of 20 percent and 5 percent respectively (75 percent of the market being imports).

Global industry progress has been closely related to turbine size, with the average installed turbine increasing from 500 kW in 1995 to 1,300 kW in 2004. The U.S. and European wind industries now produce turbines in the 1,000–3,000 kW range, but production of 600–1,000 kW sizes is still common in India and China. European manufacturers have introduced prototype wind turbines in the 5,000 kW range. Making larger turbines is still the number-one technological issue in the turbine industry. The industry has continued to make innovations in materials, electronics, blade and generator design, and site optimization, and these innovations offer further potential for cost reduction.

Wind power has the potential to make a major contribution to the world's increasing energy demand. EWEA projects that 180 GW of wind energy could be generating 425 TWh per annum by 2020. In the process it would save an annual 215 million tonnes of carbon dioxide by 2020. Wind Force 12, a publication by the Global Wind Energy Council (GWEC), EWEA and Greenpeace, shows that 12% of the world's electricity can be supplied by wind power in 2020 if political and policy changes are being pursued, so that technical, economic or resource limitations are minimised. In brief, wind energy industry by 2020 will develop into such a stage that it would fulfill the following in Europe:

- Enough electricity to satisfy 12% of global demand
- Creation of over 2 million jobs
- Installed capacity of 1.2 million MW of wind power generating 3,000 Terawatt hours
- Annual investment value of more than € 80 billion
- Annual saving of 1,800 million tonnes of carbon dioxide

6.3 Wind Energy Development in India

In the early 1970s, the DST (Department of Science and Technology) looked after the implementation of programmes like solar and wind, while the agriculture and rural development ministry implemented biogas and cook stove programme at the national level. This arrangement continued, until 1982, when on the recommendation of the CASE (Commission for Additional Sources of Energy), the Government of India established a separate DNES (Department of Non-conventional Energy Sources) to coordinate the development and promotion of a broad range of renewable energy programmes and technologies.

Initially, technologies were promoted through design and development support, and through the establishment of large-scale demonstration programme. Through these programmes, a RET manufacturing base was created. The devices and the subsidies were channeled to consumers through state-level "nodal agencies" that were responsible for after-sales service and consumer support.

The Wind power programme in India was initiated towards the end of the Sixth Plan, in 1983-84. The original impetus to develop wind energy in India came from the then Department of Non-Conventional Energy Sources, now known as the Ministry of Non-Conventional Energy Sources (MNES). Its purpose was to encourage a diversification of fuel sources away from the growing demand for coal, oil and gas required to feed the country's rapid economic growth.

A market-oriented strategy was adopted from inception, which has led to the successful commercial development of the technology. The broad based National programme includes wind resource assessment activities; research and development support; implementation of demonstration projects to create awareness and opening up of new sites; involvement of utilities and industry; development of infrastructure capability and capacity for manufacture, installation, operation and maintenance of wind electric generators; and policy support.

The programme aims at catalyzing commercialisation of wind power generation in the country. The Wind Resources Assessment Programme is being implemented through the State Nodal Agencies, Field Research Unit of Indian Institute of Tropical Meteorology (IITM-FRU) and Center for Wind Energy Technology (C-WET). MNES undertook an extensive study of the wind regime, establishing a countrywide network of wind speed measurement stations. These have made it possible to assess the national wind potential and identify suitable areas for harnessing wind power for commercial use. The total potential for wind power in India is estimated at about 45,000 MW.

R&D activities are undertaken through research institutions, national laboratories, universities and industry for development of cost-effective technologies and systems for improvement in quality of power generation from wind power projects.

Private investors and developers came forward to set up commercial wind power projects in different parts of the country during the late 1980s and early 1990s. However, the journey through the 1990s has not been smooth for the wind industry. There had been many ups and downs stemming from policy changes as well as lack of a uniform policy in the wind sector. The industry also got affected by the overall recession and economic slowdown. Today, the wind industry is addressing a matured market with quality products and the customers are highly discerning and extremely conscious with regards to the cost of energy generated per kW installed capacity.

In the 1990s, the importance of renewable energy sources as environmentally benign decentralised energy systems, especially for rural areas, was recognized by the government, and a new thrust was given to renewable energy efforts in the Eighth Five-Year Plan. In the new scheme, much greater reliance was placed on developing market linkages and promoting commercialization by involving private sector, rather than public investment, and providing more fiscal and tax incentives. In 1992, MNES was restructured to provide more coordinated approach toward policies, programmes, strategies and institutions involved in the renewable energy programmes, and to provide market linkages for the commercialization of RETs. Now, high priority was accorded to generation of grid quality power from wind energy, small hydropower, bio-energy and solar energy. Secondly, rural energisation was undertaken through enhanced use of different RE devices.

Currently, a three-fold strategy has been pursued by the government for promotion of RE sources through private sector involvement. These include:

- providing budgetary resources by government for demonstration projects.
- extending institutional finance from the *Indian Renewable Energy Development Agency (IREDA)* and other financial institutions for commercially viable projects, with private sector participation; and external assistance from international and bilateral agencies.
- promoting private investment through fiscal incentives, tax holidays, depreciation allowance, facilities for wheeling and banking of power for the grid and the remunerative returns for the power provided to the grid.

The current policy environment has been instrumental in creating one of the largest and most diverse renewable energy programs in the world, with a broad technological base and large human capacity.

6.4 Wind Resource Assessment and Potential in India

Wind as a natural phenomenon is known for change in speed and direction of motion throughout day and nigh which become more pronounced with seasonal and yearly cycles. The power output from Wind Electric Generator (WEG) is very sensitive to wind speed to which its turbine blades are exposed. Theoretically, power available in wind varies as the cube of the wind speed. In practice, however, the power output from WEG rises almost linearly at lower range of the speed, thereupon following a drooping characteristic to reach its rated power at the specified wind speed (normally between 14 to 16 m/s). The power curve defines the output characteristic of WEG and is largely determined by blade aerofoil shape and geometry and the efficiency of drive train components such as the generator and the gearbox. Wind speed at a site is influenced by the terrain and by the height above ground. Wind moving across the earth's surface encounters friction influencing its flow- both by reducing the speed and at the same time increasing the level of turbulence. This effect becomes quit prominent while passing over or around mountains, hills, trees, buildings and other type of obstruction in its path. Wind speed generally increases with height above the ground. However there could be exceptional cases where wind speed decreases with height due to special geographical features.

Wind speed at a height could be projected from an empirical formula using the Power Law Index (PLI), which is derived from wind speed data at two known heights, at the same location.

The power producing capacity of a particular WEG depends roughly on the size of the blade deciding the swept area to intercept the wind. However for evaluating its performance, the energy generated over a time period (say one year) is more relevant which depends upon the wind speed and its duration at a particular site. Thus, without adequate wind speed, the rated capacity of WEG remains under-utilised. The Capacity Factor (CF) is a measure for the level of utilization which is defined simply as the ratio of the actual energy produced by a WEG in a year to the energy output of the machine had it operated at its rated power for the entire year. A reasonably good CF is 0.25 to 0.30 though around 0.40 is attainable at some selected sites.

Wind resource is expressed in terms of annual average power per unit area, which is known as Wind Power Density or WPD. The primary requirement for successful implementation of wind power development programme rests on proper assessment of these natural resources.

Winds in India are influenced by the strong south-west summer monsoon, which starts in May-June and the weaker north-east winter monsoon, which starts in October. During the period March-August, the wind speeds are uniformly strong over the whole Indian

Peninsula, except the eastern peninsular coast. Wind speeds during the period November–March are relatively weaker, though higher winds are available during a part of this period on the Tamil Nadu coastline.

Some typical PLI's at different location in India are given in [*Table-10*] below. Negative PLI signifies decrease of winds

Table-10: *PLI's at different location in India*

Location	PLI	Wind Speed in kmph at height of	
		10m	30 m
Ayikudy, Tamil Nadu	0.23	18.2	23.5
Harshnath, Rajasthan	0.44	13.9	22.5
Muppandal, Tamil Nadu	0.22	21.9	27.6
Poolavadi, Tamil Nadu	0.20	18.4	23.0
Vengurla, Maharashtra	0.36	10.6	15.7
Dandi, Gujarat	0.37	11.2	16.9
Sultanpet, Tamil Nadu	-0.01	19.1	19.0*
Ramakalamedu, Kerala	-0.01	30.0	29.7

*At 20 m height

So far, 540 wind monitoring stations have been established in 24 States and 3 Union Territories with 65 wind monitoring stations presently in operation as on March 2005. Out of 540 stations established so far, 218 stations have shown annual average wind power density more than 200 W/m2 at 50 m above ground level, which is considered to be benchmark criteria for establishment of windfarm. Study for more sites is being taken up in a phased manner every year. Apart from the study being carried out by C-WET, some Government and Private organizations have also established wind monitoring stations in their areas. Stretch of elevated land area and locations close to seashore or the valleys are preferred sites for windfarm where wind power potential is likely to be on the higher side.

Earlier the height of wind monitoring masts was kept at 20 m or 25 m. The current trend however has been to erect 30 m masts and at some places upto 50 m and beyond, commensurate with the growing number of installing WEGs of higher ratings and hub heights. At a few places tall wind masts (50 m and above) have been installed, some by the manufacturers.

The energy generation by a machine are usually calculated by using frequency distribution of wind speed which shows the percentage of time the wind blows at various wind speed over the course of an average year. In absence of wind data in frequency distribution form, there are two common wind distributions used to make energy calculations for the WEGs. These are Weibull distribution and a variant of the Weibull called the Rayleigh distribution, which is considered to be more accurate for sites with high average wind speeds. Since the wind data used for energy generation by frequency distribution is specific for the mast location, it requires to be processed further taking into consideration the land features at the near-by area identified for establishing a windfarm. This calls for micro survey of the area at a closer contour interval to gather detailed information on the land feature including surface roughness and major obstacles, if any. Computer-based WA^{S}P or similar software programme would help to work out more realistic energy output at a specific site considering the influence of local land features on the wind.

Wind Resource assessment programme is being implemented in the country through the Centre for Wind Energy Technology (C-WET), an autonomous Institution of the Ministry, in co-ordination with State Nodal Agencies (SNAs). Around 1150 wind monitoring/ mapping stations were set-up in 25 States and Union Territories, out of which 50 Wind monitoring stations are in operation with the remaining stations having been closed after collection and analysis of data.

About 97 master plans have been completed taking into account the zone of influence around each mast. 211 wind monitoring stations in 13 states and Union Territories having a mean annual wind power density greater than or equal to 200 W/m^2 at 50 m height above ground level have been identified for wind power development. Wind resource and wind shear assessment at five selected wind locations with 120 m anemometry mast is under implementation. Six handbooks on "Wind Energy Resource survey in India" have so far been published covering 208 sites. The seventh volume of Handbook covering wind data for 26 stations is ready for publication. It is also proposed to prepare a Wind Atlas for India, which will give overall potential in various States, as well as identify high windy areas and specific sites for setting up wind power projects.

The wind power potential of India as per the revised estimates of MNES has been assessed at around 45,000 MW. The technical potential is estimated about 13,000 MW, assuming 20 per cent grid penetration, which will go up with the augmentation of the grid capacity in the windy states. The state-wise gross and technical potential assessment are given in the [*Table-11*].

Table-11: *Estimated state-wise wind power potential in India*

Sl. No.	State	Gross Potential (MW)
1	Andhra Pradesh	8275
2	Gujarat	9675
3	Karnataka	6620
4	Kerala	875
5	Madhy Pradesh	5500
6	Maharashtra	3650
7	Orissa	1700
8	Rajasthan	5400
9	Tamil Nadu	3050
10	West Bengal	450
	Total	**45195**

Source: MNES, New Delhi

Out of the total Indian wind power potential of 45195 MW, about 12875 MW capacity has already been installed. Potential windy locations have been identified in the flat coastal terrains in Tamil Nadu, Kerala, Gujarat, Lakshadweep, Andaman & Nicobar Islands, Orissa and Maharashtra. Favourable sites have also been identified in some inland locations of

Karnataka, Andhra Pradesh, Madhya Pradesh, West Bengal, Uttaranchal and Rajasthan. Following *Figure -4* shows installation of the wind power plants in major states.

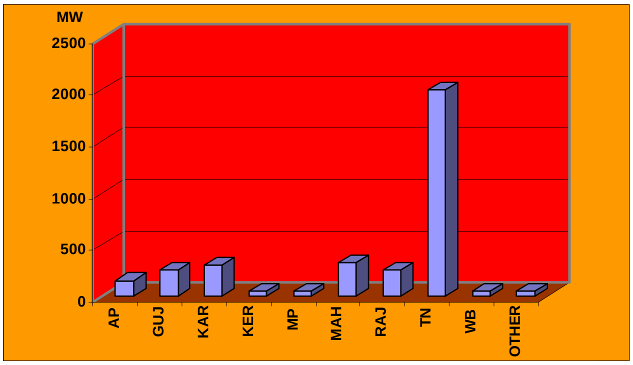

***Fig-4**: State-wise wind power installation (April 2005)*

6.5 Wind Industry Growth

India's wind energy sector registered impressive growth and expansion during 2004-05. Total installed capacity stood at 3,595 MW in March 2005, an increase of more than 1,112 MW over the previous year. India now occupies an enviable position as the wind leader in Asia, and has maintained its world ranking as the fourth largest producer in the world. The growth witnessed during 2004 was also the highest ever in a single year, a massive 45 per cent increase over the previous year. Even so, given the country's vast potential, progress could be further accelerated. With the change in government policy focus, wind energy sector is witnessing a progressive trend as shown in the *Figure-5*.

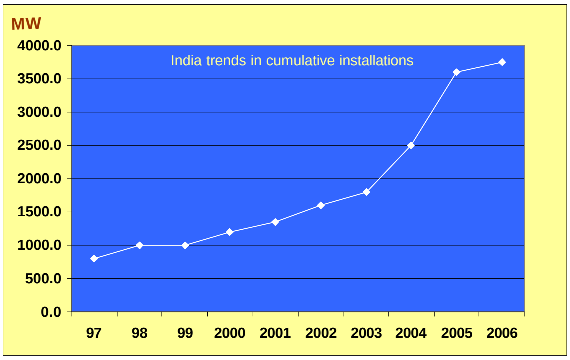

Fig-5: *Cumulative wind energy installed capacity*

According to preliminary information received from various sources, installed capacity of wind power in India is likely to cross 5200 MW by 31.03.2006. This means a capacity addition of more than 1600 MW during the financial year 2005-06.

Chapter-7

Government Programme in Wind Energy in India

7.1 Fiscal Incentives and Promotional Policies

Fiscal incentives being offered by the Central Government include tax holidays, concessional customs tariffs and 80% accelerated depreciation. The present policies of fiscal and financial incentives have generated significant interest in the private sector.
• *Direct taxes – 80 per cent depreciation in the first year of installation of a project.*
• *Tax holiday for 10 years.*

Guidelines were issued by the Ministry and IREDA (Indian Renewable Energy Development Agency) to all concerned States for announcement of polices as shown in [*Table-12,13*] relating to wheeling, banking, third party sale and buy back of power at a minimum purchase price of Rs 2.25 (base year 1994-95), with 5% annual escalation. Nine potential States have already announced polices for private sector participation. Other States have been requested to announce their policies. With the restructuring of the power sector and with the formation of Central Electricity Regulatory Commission (CERC) and State Electricity Regulatory commission (SERC), they are now fixing power tariffs and allied conditions.

Andhra Pradesh Electricity Regulatory Commission, Maharashtra Electricity regulatory Commission, Karnataka Electricity Regulatory Commission and Madhya Pradesh Electricity Regulatory Commission have declared the policies for wind power purchase.

The Maharashtra State Electricity Regulatory Commission (MERC) has passed order for making purchase of electricity generated by renewable sources obligatory for all utilities in Maharashtra. This Renewable energy Purchase Obligation (RPO) is applicable from financial year 2004-05.

Karnataka Electricity Regulatory Commission has also directed that each distribution licensee shall purchase a minimum quantum of 5% and maximum quantum of 10% electricity annually from renewable sources expressed as a percentage of its total consumption.

Madhya Pradesh Electricty Regulatory Commission has fixed a target of 0.5% of total annual consumption in the area of supply for all licensees subject to availability as minimum purchase requirement from wind energy.

Orissa Electricity Regulatory Commission has ordered to Power Grid Corporation and power distribution companies to buy 200 million units of green power during financial year 2005-06 at a cost of exceeding the highest cost of thermal power in eastern region.

Table-12: *Financial Incentives for Wind Power*

Sl No	Programme/Scheme	Amount of Subsidy
1	Financial Assistance for Wind Power Demonstration projects provided to SNAs/state Governments/SEB	60% of the cost of wind turbine equipment, maintenance spares, and erection commissioning, subject to eligibility and benchmark cost of Rs 3.50 crore/MW

Source: MNES

Table-13: *IREDA Financial Incentives for Wind Power*

Category	Interest Rate % pa	Repayment (max) (yrs)	Moratorium (max) (yrs)	Min. Promoter's Contribution %	Lending Norms
Project Financing					
Development of wind farms on lease basis	11.50	10	1	30	Up to 70% of total project cost
Development of wind farms on ownership basis	11.00	10	1	30	Up to 70% of total project cost
Development of wind farms by machine suppliers/manufacturers up to 10 MW/party/ year on built, operate, own, lease, transfer basis	11.50	10	1	30	Up to 70% of total project cost
Development of wind farms/estates with minimum station capacity of 10 MW by co-operative sector/Public/Joint/Private sector on built, operate, own, lease, transfer basis subject to following conditions: i. Applicant having minimum net worth Rs. 100 crores ii. Applicant having AAA or equivalent rating.	11.25	10	1	30	Up to 70% of total project cost
Development of demonstration of off-shore wind farm capacity of 10 MW by co-operative sector/Public/Joint/Private sector on built, operate, own, lease, transfer basis subject to following conditions: i. Applicant having minimum net worth Rs. 100 crores ii. Applicant having AAA or equivalent rating.	11.00	10	2	30	Up to 70% of total project cost
Equipment Financing					
Wind Electric Generators up to 1 MW capacity	12	10	1	25	Up to 75% of the cost of eligible equipment (Eligible equipments comprise WEG, Tower, control panel, transformer and reactive power compensator)

Source: MNES

7.2 Market Development Programme Initiatives

The current level of capacity addition have been achieved in India due to the market development initiatives taken up by the Ministry of Non-conventional Energy Sources (MNES) during initial phases of implementation a few of which are still continuing. The market development initiatives of the MNES include:

- A comprehensive wind mapping programme, largest in the world.
- Analysis, compilation and publishing of wind speed and wind energy data.
- Setting up of demonstration wind power projects.
- Issuing guidelines to the State Electricity Boards to formulate policies towards grid interfacing of wind power, banking and wheeling arrangements and the purchase rate of electricity from the windfarms.
- Policy if accelerated depreciation, concessional import duty etc.
- Encouragement towards development of indigenous wind turbine manufacturing facilities.
- Involvement of multilateral and bi-lateral agencies in setting up demonstration projectc.
- Setting up of Indian Renewable Energy Development Agency (IREDA) and enabling soft financing to windfarm projects through it.

The experience over the last twenty years has significantly enhanced knowledge and understanding not only wind regimes in India but also of the technology, operation and maintenance, project development and policy environment, Significant outcomes have been:

- Wind energy has emerged as economically viable means of electricity generation and competes well with conventional power generation.
- Indigenous development of world-class wind turbines in the range of 225 kW to 2.00 MW by Indian wind turbine manufacturers.
- Identification of high wind areas in the country such as Muppandal, Chtiradurga etc.
- Emergence of new potential areas initially with mediocre wind speeds at 20 m height (say 5 m/s annual average) but higher wind speeds at 50 m or above, the height of which modern megawatt class wind turbines are installed.
- Greater clarity on grind interfacing issues.
- Greater clarity on Policy environment needed for wind power development.

7.3 Policy Impacts

One result of these incentives has been to encourage industrial companies and businesses to invest in wind power. An important attraction is that owning a wind turbine assures them of a power supply to their factory or business in a country where power cuts are common. Wind farms in India therefore often consist of clusters of individually owned generators. More than 97% of investment in the wind sector in India has come from the private sector.

Over the past few years, however, both the government and the wind power industry have succeeded in injecting greater stability into the Indian market. This has encouraged larger private and public sector enterprises to invest. It has also stimulated a stronger domestic manufacturing sector; some companies now source more than 80% of the components for their turbines in India. This has resulted both in more cost effective production and in creating additional local employment. Most recently, some Indian manufacturers have started to export their products. About ten wind turbine manufacturers are currently offering their products on the Indian market. The geographical spread of Indian wind power has so far been concentrated in a few regions, especially the southern state of Tamil Nadu, which accounts for more than half of all installations. This is beginning to change, with other states, including Maharashtra, Gujarat, Rajasthan and Andhra Pradesh, starting to catch up. The result is that wind farms can be seen under construction right across the country, from the coastal plains to the hilly hinterland and sandy deserts.

Besides, wind power development has transformed the social structure in the potential areas by way of improvement in life style due to availability of power, income generation, employment generation and improvement in infrastructure. The wind power activities have provided ample opportunity for employment in manufacture, installation, operation and maintenance of wind power projects.

The Indian government now envisages a capacity addition of around 5,000 MW by 2012. If the present expansion rate is maintained, this target will easily be surpassed.

Over the last 20 years, following barriers have been identified which retards the pace of implementation of wind power development, and it was found that there are urgent need to:

- Generate data on wind monitoring of 70 meter height above ground level for higher capacity wind turbines
- Undertake studies to develop plans for power evacuation
- Undertake grid penetration studies for higher penetrations
- Study of logistics with regard to transportation and handling of large wind turbines
- Participation of major corporates and Public Sector Units
- Long term PPAs
- Establishing mechanism for bulk trading of wind power
- Augmentation in wind turbine manufacturing capacity
- Bring down Capital Cost per kWh
- Single window facility for timely clearances at State level
- Long term stable policies in the States
- Advocacy with Banks, Fls and Corporates to expand financing base
- Address issues related to securitization
- Create awareness on positive aspects of windfarms

Chapter-8

Wind Energy Applications (Success stories)

Folwoing are some of the case studies of wind power plant development and power generation systems.

a) WIND PARKS IN CHINA GOING ON STREAM

In Yingkou in Liaoning province, Nordex set up two wind parks with high output capacity in cooperation with its Chinese partners. The scope of the project comprised the delivery of turbines, the design of the wind parks through to installation, service and maintenance. The ecologically-clean electricity derived using modern wind turbines is fed into the region's central electricity network without producing additional CO2 emissions or generating other harmful by-products.

For details please log onto
http://www.german-renewable-energy.com/Renewables/Navigation/Englisch/Windkraft/case-studies,did=114234.html

b) ZAFARANA WIND PARK, EGYPT

A wind-measuring programme for the whole of Egypt was carried out in order to draw up a wind atlas for the country. The results revealed especially favourable location conditions for wind parks along the Red Sea due to the high average wind speeds along the coast. The power generation potential has been estimated at around 3,000 MW. Alongside the pilot wind park at Hurghada, the construction of a wind park at Zafarana with an installed total capacity of 160 MW has been prepared in an Egyptian, German and Danish development project joint venture - the largest single project planned together by these partners to date.

For details please log onto
http://www.german-renewable-energy.com/Renewables/Navigation/Englisch/Windkraft/case-studies,did=114232.html

c) WIND-DIESEL HYBRID SYSTEM AT WALES

Wales in Alaska has among the best wind resources in the world -- a Class 7 -- with an average wind speed of nearly 20 mph. Extreme winds here on this peninsula are rare, so it is expected to be a very productive site. A wind-diesel hybrid research and development system was installed in Wales with funding from the federal Environment Protection Agency, the federal Department of Energy, the State of Alaska Energy Authority, and the Alaska Science and Technology Foundation. This innovative hybrid project incorporated two 65 kW wind turbines, 3 diesel generators, 2 electric dump loads, a rotary power converter, and a battery bank.

Overall, the hybrid system has performed quite well. The beauty of this hybrid system is that any excess wind power above what is required to meet the primary village electric demand is sent to one or both of two electric boilers that were installed as part of the project. As a result of this arrangement, the wind turbines in this hybrid configuration not only reduce the amount of fuel used to generate electricity in the village, they also reduce the amount of fuel used for heating at a local school, he pointed out.

For details please log onto
http://www.awea.org/smallwind/success_stories/success_stories_024.html

d) TRAVERSE CITY WIND POWER

Traverse City Light and Power owns the turbines which spin as the wind blows through their blades, converting wind energy into electricity for the city people. People agreed to pay a little more on their electric bills, about $7.58 each month, for electricity generated by this wind turbine just outside their town. It was put into operation in June 1996, and stands 160 feet tall! Each of the three blades is 72 feet long. It generates enough electricity for 200 homes. Each home that uses the wind turbine's electricity prevents the burning of 6,000 pounds of coal that would otherwise have been used to generate their electricity. This prevents the release of 10,000 pounds of carbon dioxide (a greenhouse gas), 60 pounds of sulfur dioxide, and 40 pounds of nitrogen oxides (both cause acid rain).

For details please log onto
http://www.urbanoptions.org/RenewableEnergy/WindElectricityForACity.htm

e) UCS WIND ENERGY PROJECT

UCS (Union of Concerned Scientists) helped to launch a first-of-its-kind wind power project in Minnesota. As a result, over 76,000 customers of a rural electricity cooperative will have the opportunity to choose electricity generated by wind power that is not contributing to global warming or air pollution. The story of how this project unfolded demonstrates that achieving a clean, renewable future is not easy -- but it can be done.

This project was a prime example of a collaborative effort.

For details please log onto
http://www.ucsusa.org/clean_energy/clean_energy_policies/cooperative-wind-a-minnesota-success-story.html

f) DOE/NREL INNER MONGOLIA HOUSEHOLD PV/WIND HYBRID SYSTEMS PILOT PROJECT

The objective of the Inner Mongolia Pilot Project was to disseminate wind-solar hybrid systems to a rural and remote population in order to demonstrate their performance advantages over wind-only systems or diesel-powered gen-sets, and thus leverage future installations of such systems in the province. Over 400 single-household wind-solar hybrid systems were installed in six counties of Inner Mongolia between 1996 and 2001. Since that time, as many as 8,000 additional single-household hybrid systems have been installed as a result of the Pilot Project, which served to demonstrate that hybrid systems are indeed practically and technically well suited to meet the needs of the population. However, demonstrating that the renewable energy based hybrid power system is technically feasible is only part of the value of a pilot project. Understanding how the technology fits in with the socioeconomic context of a rural community is critical to ensuring the sustainability of rural energy projects. Toward this end, the underlying objective of the pilot project was to raise the quality of life of the project population.

For details please log onto
http://www.nrel.gov/docs/fy05osti/37678.pdf

g) ADVANCED HIGH-PENETRATION WIND-DIESEL POWER SYSTEM

Denham is an isolated community of about 800 people, with the next major town some 350 kilometres away. Western Power selected Denham as the site for Australia's first large variable speed wind turbine because its isolation meant that it relied on diesel fuel for its electricity, incurring high generation costs and a reliance on fossil fuel that produces greenhouse gas. The fact that the area has strong, consistent winds made it the perfect choice for wind energy, a clean and sustainable local energy resource in an environmentally significant area. Western Power and Powercorp, aided by a $1 million Renewable Energy Showcase grant, are developing an innovative system that will supply nearly half the town's electricity from wind energy. This is a remarkable breakthrough, with worldwide potential.

For details please log onto
http://www.greenhouse.gov.au/renewable/recp/wind/pubs/wind1.pdf

h) EXMOUTH ADVANCED MINI WIND FARM PROJECT

A $225,000 grant from the Renewable Energy Commercialisation Program is enhancing the prospects for remote and cyclone-exposed areas of Australia to offset some of their reliance on diesel energy with renewable wind power. Western Power Corporation and Westwind Turbines of Perth, both with years of wind-generation experience, have combined to develop the Exmouth advanced mini wind farm project, using a wind turbine of Australian design and construction. The support from the grant is enabling the consortium not only to install the three unique 25kW wind turbines that offer a number of advantages for use in high-wind areas, but also to closely monitor their performance over the project's duration.

For details please log onto
http://www.greenhouse.gov.au/renewable/recp/wind/pubs/wind2.pdf

Chapter-9

Wind Power Directory

IMPORTANT GLOBAL ORGANIZATIONS (WORLD)

ASSOCIATION/ORGANIZATIONS

Australian Wind Energy Association
PO Box 4499, Melbourne
Victoria Australia 3001
Tel: 61 3 8605 4832
Fax: 61 3 8605 4839
Web Site: http://www.auswea.com.au

British Wind Energy Association
1 Aztec Row, Berners Road
London, United Kingdom N1 OPW
Tel: 20 7689 1960
Fax: 20 7689 1969
Web Site: http://www.bwea.com

Canadian Wind Energy Association (CanWEA)
130 Slater Street, suite 750
Ottawa, Ontario Canada K1P 6E2
Tel: 613-598-4658 or toll free 800-922-6932
Fax: 613-594-8705
Web Site: http://www.canwea.ca

European Wind Energy Association (EWEA)
63-65 Rue d'Arlon, Brussels
Belgium B-1040
Tel: 32 2 546 1940
Fax: 32 2 546 1944
Web Site: http://www.ewea.org

German Wind Energy Association (BWE)
Herrenteichsstrasse 1, Osnabrueck
Germany D-49074
Tel: 49 541 35060 0
Fax: 49 541 35060 20
Web Site: http://www.wind-energie.de

Irish Wind Energy Association Ltd
Arigna, Carrick-on-Shannon
County Roscommon, Ireland
Tel: 353 (0) 71 9646072
Fax: 353 (0) 71 9646080
Web Site: http://www.iwea.com

South African Wind Energy Association
P.O. Box 837, Sunvalley
Cape Town, Republic of South Africa 7975
Tel: 27 21 789 2009
Fax: 27 021 790 0063
Web Site: http://sawea.www.icon.co.za

Wind on the Wires
1619 Dayton Avenue, Saint Paul
Minnesota, USA 55104
Web Site: http://www.windonthewires.org

World Wind Energy Association WWEA e.V.
Charles-de-Gaulle-Str. 5
53113 Bonn, Germany
Tel: 49 228 369 40 80
Fax: 49 228 369 40 84
Web Site: http://www.wwindea.org

American Wind Energy Association

122 C Street NW 4th Floor
Washington, Washington DC 20001
Tel: 202 383-2500
Web Site: http://www.awea.org

Austrian Wind Energy Association
Mariahilfer Str. 89/22, Wien
Austria A-1060
Tel: 43 1 5817060
Fax: 43 1 5817061
Web Site: http://www.atmedia.net/IGW

Danish Wind Industry Association
Vester Voldgade 106
Copenhagen V, Denmark DK-1552
Tel: 45 3373 0330
Web Site: http://www.windpower.org

European Forum for Renewable Energy Sources (EUFORES)
Rue d'Arlon 63-65, Brussels
Belgium B-1040
Tel: 32 546 1948
Fax: 32 546 1934
Web Site: http://www.eufores.org

Finnish Wind Power Association
P.O. Box 846
Helsinki, Finland 00101
Web Site:
http://www.tuulivoimayhdistys.fi

Illinois Renewable Energy Association
1230 E. Honey Creek Rd.
Oregon, Illinois 61061
Tel: 815 732 7332
Web Site: http://www.illinoisrenew.org

New Zealand Wind Energy Association
131 Lambton Quay
PO Box 553
Wellington, New Zealand
Tel: 64 4 499 5048
E-mail: info@windenergy.org.nz
Web site: http://www.windenergy.org.nz/

Independent Energy Producers Association
1112 I Street, Suite 380
Sacramento, California 95814
Tel: 916 448 9499
Fax: 916 448 0182
Web Site: http://www.iepa.com

Kern Wind Energy Association
P.O. Box 41616, Bakersfield
California 93384
Tel: 661 831 1038
Web Site: http://www.kwea.org

Utility Wind Interest Group (UWIG)
P.O. Box 2671, Springfield
Virginia 22152
Tel: 703 644 5492
Fax: 703 644 1961
Web Site: http://www.uwig.org

National Renewable Energy Laboratory (NREL)
1617 Cole Blvd., Golden
Colorado 80401
Tel: 303 275 3000
Web Site: http://www.nrel.gov

Deutsches Windenergie-Institut GmbH (DEWI - German Wind Energy Institute)
Eberstr. 96, Wilhelmshaven, Germany D-26382
Tel: 49 (0) 4421 4808 0
Fax: 49 (0) 4421 4808 43
Web Site: http://www.dewi.de

Global Wind Energy Council
Renewable Energy House
Rue d’Arlon 63-65
1040 Brussels
Belgium
Tel: 32 2 400 1028
Fax: 32 2 546 1944
Web site: http://www.gwec.net
COMPANIES

ENERCON SCADA
Dreekamp 5, 26605 Aurich, Germany
Tel: 0049 / 49 41 927-0
Fax: 0049 / 49 41 927-109
Web Site: http://www.enercon.de

Vestas Wind Systems A/S
Alsvej 21
DK - 8900 Randers
Tel.: +45 97 30 00 00
Fax: +45 97 30 00 01

INDIA

Government Organizations

NODAL MINISTRY

Ministry of Non-conventional Energy Sources
Wind Energy Division, Power Group
Block No. 14, C G O Complex
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New Delhi – 110 003
Tel: 011-24360707, Fax 011-24367413/24361298
E-mail: mnes@hub.nic.in, secy@mnes.hub.nic.in
Website: http//www.mnes.nic.in

CENTRAL GOVERNENT AGENCIES

Indian Renewable Energy Development Agency (IREDA)
1st floor, Core-4A, East Court
India Habitat Centre Complex
Lodi Road
New Delhi – 110 003
Tel: 011-24682214-21
Fax: 011-24682202, 24682204, 24682207
E-mail: mdireda@rediffmail.com
Web site: www.iredaltd.com

Rural Electrification Corporation Ltd
Core 4, Scope Complex,
7 Lodi Road
New Delhi 110003
Tel: 011-24365161
Fax: 011-24360644
E-mail: reccorp@recl.nic.in, recitd@nda.vsnl.net.in
Website: www.recindia.nic.in

The National Small Industries Corporation Ltd
NSIC Bhawan
Okhla Industrial Estate
New Delhi - 110 020
Tel: 011-2683 7071, 2692 0907, 2692 6275
Fax: 011-2692 0907
E-mail: nsicttc@vsnl.com
Website: www.nsicindia.org, www.techshowindia.com

Centre for Wind Energy Technology (C-WET)
Velachery – Tambaram High Road
Pallikaranai
Chennai 601 302
Tamil Nadu
Tel: +91-44-22463982-84
Fax: + 91-44-22463980
E-mail: info@cwet.res.in
Web Site: www.cwet.tn.nic.in

Wind Turbine Test Station (WITS)
TNEB (110 kVSS Windfarm Complex)
Ayyanarathu P O
Kayathar – Devarkulam Road
Tuticorin Dist. (T N)
Tel: +91-4632-261751/261931
Fax: +91-04632-261751

Sardar Swaran Singh National Institute of Renewable Energy
Adhikhui Village
Near Jallandhar
Jallandhar- Kapurthala Road
Punjab

STATE NODAL AGENCIES

Department of Non-conventional Energy Sources
Prothrapur
Port Blair – 744 101
A & N Islands
Tel: 03192-232404, 232685
Fax: 03192-233365

Non-conventional Energy Development Corpn. of Andhra Pradesh (NEDCAP)
5-8-207/2, Pisgah Complex
Nampally
Hyderabad 500 001
Andhra Pradesh
Tel: 040-232-2391/3692/3376
Fax: 040-23201666
E-mail: nedcap@ap.nic.in

Arunachal Pradesh Energy Development Agency
P B No. 141
Land Survey Hostel Bldg. (1st Floor)
Itanagar – 791 111
Arunachal Pradesh
Tel: 0360-2211160
Fax: 0360-2214426

Assam Energy Development Agency
Co-operative City Bank Building
U N b Road, Silpukhuri
Guwahati – 781 003
Assam
Tel: 0361-2664415, 2662232
Fax: 0361-2668475
E-mail: aeda@india.com
Web site: www.assamrenewable.org

Bihar Renewable Energy Development Agency
Sone Bhawan, 1st Floor
Birchand Patel Path
Patna 800 001
Bihar
Tel: 0612-2233572
Fax: 0612-2228734
E-mail: dir_bredo@sancharnet.in

Department of Science & Technology
Chandigarh Administration
Additional Town Hall Building
Sector – 17 C
Chandigarh – 160 001
Tel: 172-2745502
Fax: 172-2726698

Chattisgarh Renewable Energy Development Agency
MIG 1/20-A, Sector – 1, Shankar Nagar
Raipur 492 007
Chhattisgarh
Tel: 0771-5066770, 2426445, 2422448
Fax: 0771-5066771
E-mail: credacg@rediffmail.com
Web site: www.credacg.com

Energy Development Agency
Development and Planning
Administration of Dadra & Nagar Haveli
Silvassa.
Dadra & Nagar Haveli
Tel: 0260-642070

Delhi Energy Development Agency
37, Tughlakabad Institutional Area
Near Batra Hospital
New Delhi – 110 067
Tel: 011-26855025
Fax: 011-26082465

Goa Energy Development Agency
C/o Department of Science
DST&E Building, 1st Floor, Saligo Plateau
Opp. Seminary, Saligao, Bardez
Goa – 403511
Tel: 271194

Gujarat Energy Development Agency (GEDA)
Suraj Plaza, Part II

Sayaji Ganj
Vadpdara – 390 005
Gujarat
Tel: 0265-2362058, 2361409
Fax: 0265-2363120
E-mail: info@geda.org.in,
Web site: www.geda.org.in

Haryana State Energy Development Agency (HAREDA)
(Dept of Non-conventional Energy Sources)
SCO, No 48, Sector 26
Chandigarh – 160 019
Haryana
Tel: 0172-2778911, 2778917, 2778928
Fax: 0172-2778928
E-mail: hareda@chd.nic.in

H P Govt Energy Development Agency (HIMURJA)
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SDA Block No 8-A
Kasumpti
Shimla 171 009
Himachal Pradesh
Tel: 0177-2621430
Fax: 0177-2621783

J & K Energy Development Agency
Dhar Villa, Rajbagh
Srinagar – 190 008
Jammu & Kashmir
Tel: 191-546495, 2552725
Fax: 191-2546495

Energy Department
Government of Jharkhand
HEC Proj. Bldg
Dhruva, Ranchi 834 001
Jharkhand
Tel: 0651-2403240
Fax: 0651-2403255

Jharkhand Renewable Energy Development Agency
Plot No. 328/B, Road No. 4
Ashok Nagar
Ranchi 834 002
Jharkhand
Tel: 0651-2246970
Fax: 0651-2247049

Karnataka Renewable Energy Development Ltd (KREDL)
No 19, Major Gen. Logandan INA Cross
Queen's Road
Bangalore 560 052
Karnataka
Tel: 080-2282221
Fax: 080-2257399
E-mail: kredl@blr.vsnl.net.in, agmpayannavar@yahoo.co.in
Web site: www.kar.nic.in/kredl

Karnataka Power Corporation Ltd
Government of Karnataka
Shakti Bhavan
82, Race Course Road,
Bangalore-560 001
Karnataka
Tel:080-22256568,22269930-37.
Fax:22252144.
E-mail: ccm@karnatakapower.com
Website: www.karnatakapower.com

Agency for Non-Conventional Energy & Rural Technology
Pottam po no 1094
Kesavadasapuram
Thiruvananthapuram 695004
Kerala
Tel: (471) 449854, 440124, 441803, 440122
Fax: (471)449854
E-mail: anert@vsnl.com
Web site: http://education.vsnl.com/anert/

Kerala State Electricity Board (KSEB)
Vidyut Bhavanam
Pattom
Thiruvananthapuram – 695004

Kerala
Tel: 471- 2440121, 2440122
Fax: 471-2449854

Energy Management Centre
P.O. Thycaud
Opp. Police Grounds
Trivandrum 695014
Kerala
Tel: 471-2323363, 2321820
Fax: 471-2323342
E-mail: emck@vsnl.com

Department of Electricity
Lakshadweep Administration
Union Territory of Lakshadweep
Department of Electricity
Kavaratti – 673 555
Lakshadweep
Tel: 04896-262127
Fax: 04896-262936, 262140

Madhya Pradesh Urja Vikas Nigam Ltd (MPUVN)
B-Block, Urja Bhawan
Link Road No. 2
Shivaji Nagar
Bhopal 462 016
Madhya Pradesh
Tel: 0755-2553595, 2556245
Fax: 0755-2553122, 25535584
E-mail: mpuvn@sancharnet.in,
Web site: www.mprenewable.com,

Maharashtra Energy Development Agency (MEDA)
MHADA Commercial Compled
S No 191-A, Phase I, Opp. Tridal Nagar
Yerawada
Pune 411 006
Maharashtra
Tel: 020-26683633, 26683634, 26682774
Fax: 020-26683631
E-mail: mda@vsnl.com,
pg1@mahaurja.com
Web site: www.mahaurja.com

Manipur Renewable Energy Development Agency
Govt of Manipur
Governor Road
Imphal 795 001
Manipur
Tel: 385-441086
Fax: 385-224930

Meghalaya Non-conventional & Rural Energy Development Agency
Lower Lachaumiere
Opp. P & T Dispensary
Shillong 739 001
Meghalaya
Telefax: 364-537343

Zoram Energy Development Agency (ZEDA)
Govt of Mizoram
H/No.A/4, Muol Veng
Chaltlang
Aizawl, Mizoram – 796007
Tel: 0389-2350664; 2350665
Fax: 323185

Nagaland Renewable Energy Development Agency
C/o Directorate of Rural Development
NRSE Cell Rural Development
Department
Nagaland Secretariat
Nagaland Secretariat
Kohima 797 001
Nagaland
Telefax 0370-241408

Orissa Renewable Energy Development Agency (OREDA)
S-3/59, Mancheshwar Ind. Estate
Bhubaneswar – 751 010
Orissa
Tel: 0674-2580660, 2580558
Fax: 0674-2580368

District Rural Development Agency
PHB Building, 2nd Floor,
Anna Nagar, Nellithore,
Pondicherry – 605 005
Tel: 413-203601, 255944
Fax: 413-333601

Punjab Energy Development Agency (PEDA)
SCO 54-56, Sector 17-C
Chandigarh – 160 036
Punjab
Tel: 0172-2702062, 2702366
Fax: 0172-2701863
E-mail: peda@glide.net.in

Rajasthan Renewable Energy Corpn Ltd (RRECL)
E-166, Yudhishthir Marg, 'C'Scheme
Jaipur 302 001
Rajasthan
Tel: 0141-2384055, 2229055, 2383450, 2228198
Fax: 0141-2381528, 2226028
E-mail: gsomani@datainfosys.net, gopalsomani@yahoo.com
Web site: www.rrecl.com

Sikkim Renewable Energy Development Agency
Tashiling Secretariat Annex – II
Gangtok 737 101
Sikkim
Tel: 03592-227891
Fax: 03592-227210
E-mail: slg_Sredo@sancharnet.in

Tamil Nadu Energy Development Agency (TEDA)
EVK Sampath Maaligai, V Floor
College Road
Chennai 600 006
Tamil Nadu
Tel: 044-28224830, 28236592
Fax: 044-28222971
E-mail: teda@md4.vsnl.net.in

Tamil Nadu Electricity Board (TNEB)
5th Floor, (East) NPKRR Maaligai
800, Anna Salai
Chennai 600 002
Tamil Nadu
Tel: 044-28520167
Fax: 044-28521944
E-mail: cences@tnebnet.org
Web site: www.tneb.org

Wind Energy Development Cell (WEDC)
TNEB, Maharaja Nagar
Tirunelveli – 11
Tamil Nadu
Tel: 0462-2530622
Fax: 0462-2534101

Tripura Energy Development Agency
Vigyan Bhawan
2nd Floor
Pandit Nehru Complex
Agartala – 799 006
Tripura
Tel: 0381-225421, 230018
Fax: 0381-225900

Uttaranchal Renewable Energy Development Agency
Energy Park Campus, Industrial Area
Patel Nagar, Near Mahantji's Hospital
Dehradun
Uttaranchal
Tel: 0135-2521386, 87
Fax: 0135-2521553
Mobile: 09837071245
E-mail: ureda@rediffmail.com

Non-Conventional Energy Dev Agency (NEDA)
Vibhuti Khand
Gomati Nagar
Lucknow 226 010
Uttar Pradesh
Tel: 0522-2392942-3, 2392872-4
Fax: 0522-2393952, 2392072

West Bengal Renewable Energy Development Agency (WBREDA)
Bikalpa Shakti Bhawan
Plot No. J-1/10, EP&GP Block
Salt Lake Electronics Complex
Sector-v, Kolkata 700 091
West Bengal
Tel: 033-23575038, 23575348
Fax: 033-23575037, 23575347
E-mail: wbreda@cal.vsnl.net.in

Other Indian Organizations/Associations

ASSOCIATIONS/ORGANIZATIONS

Indian Wind Energy Association
Phd House
4Th Floor, Siri Fort Road
New Delhi, India 110 016
Tel: 91 11 26523452
Web Site: http://www.inwea.org

Indian Wind Turbine Manufacturers Association
Mahaveer Apartments
4A/S-11 East Coast Road
Tiruvanmiyur, Chennai 600 041
Tel: 91 44 24410333
Fax: 91 44 24402537
Mobile: 98400 56641
Email: secretaryy@indianwindpower.com

TERI
Darbari Seth Block
India Habitat Centre Complex
Lodhi Road
New Delhi – 110 003
Tel : 91 11 24682100/2111
Fax: 91 11 24682144/45

COMPANIES

Suzlon Energy Limited
5th Floor, Godrej Millennium
9, Koregaon Park Road, Pune- 411 001
Phone: 91 20 5602 2000
Fax: 91 20 2620 2100
Email: pune@suzlon.com

Vestas-RRB India Limited
189, Sukhdev Vihar
New Delhi - 110025
Tel: 91 11 26327711/22
Fax: 91 11 26327733
Email:pawanshakthi@vestasrrb.com

Enercon (India) Limited
Kolsite House, Plot No. 31, Shah Industrial Estate,
Veera Desai Road, Andheri (W), Mumbai - 400 053, India.
Tel: 91 22 5692 4848
Fax: 91 22 2673 0085
Email: mktg@enerconindia.net

Chalukyanath Wind Power Pvt. Ltd.
Patan, Dist. Satara, Patan
Maharashtra 415 206
Tel: 91 2372 283237

Hive Solution
3/34, 1st Floor, J- Extension
Laxminagar, Delhi 110092
Tel: 11-22453206/22020385

S.S.TRADING COMPANY
20, Trivelian Basin Street
Chennai 600079
Tel: 91 44 25299161
Fax: 91 44 25292221

Zenith Corporate Services (P) Limited
10-5-6/B, My Home Plaza, 2nd Floor
Masab Tank, Hyderabad 500 028, AP
Tel: 91 40 3376630/3376631/3325803
Fax: 91 40 3322517

Sun Technologies Pvt Ltd
#19, Progressive Colony, Manovikas Nagar
Bowenpally, Secunderabd
Hyderabad, Andhra Pradesh 500009

Tel: 91 40 27757769/27757116/98499 86264
Fax: 91 40 27757838
Web Site:
http://www.suntechnologiesindia.com

Digipro-Wind
620, 12 th Main, Hal II Strage
Indira Nagar, Bangalore, Karnataka 560008
Tel: 918025266706
Fax: 918025263088

Greenfield Consulting Group
#49-266/2, Padmanagar Phase I
Chintal, Hyderabad, AP 500 055
Tel: 91 40 5545 6252 / 098488 77131

Sun Technologies
401, Surabhi Sapphire
Rtc X Roads, Hyderabad, Andhra Pradesh
500020
Tel: 91 40 55825233/55825266/9849986264
Fax: 91 40 55753373

Hindustan Controls & Equipment Pvt. Ltd.
P-16 & P-16/1 Kasba Industrial Estate
Kolkata, West Bengal 700 107
Tel: 91 33 2442 0325/6/1686, 2443-1184
Fax: 91 33 2442 1167

Nagalaxmi Industries
2E-3, Dyavasandra Industrial Area
Mahadevapura P O
Bangalore, Karnataka 560048
Tel: 91 80 8510888/8511086

Natural Energy Processing Co. (NEPC)
36, Wallajah Road
Madras 600 002

PV Gear Designers
SF. No: 69/1, III Street, AKG Nagar
Varatharajapuram, Uppilipalayam – Post
Coimbatore, Tamilnadu 641 015
Tel: 91 42 22599372

Rashron Energy and Auto Ltd
603, GIDC, Makarpura
Vadodara, Gujarat 390010
Tel: 91 265 643224
Fax: 91 265 643778

Wintec Energy India Private Limited
Wintec Complex, Nilambur
Coimbatore, Tamilnadu 641 014
Tel: 91 422 5350707/2210465
Fax: 91 422 2627110
E-mail: Send Email to Wintec Energy India Private Limited

NEG-MICON India (Pvt.) Ltd.,
298, Old Mahabalipuram Road,
Sholinganallur
Chennai- 600 119.
Tel: 91 44 2450 5100.
Fax: 91 44 2450 5101.

Elecon Engineering Company Ltd.,
P.O. Box No:6 Anand Sojibra Road Vallabh Vidyanagar,
Gujarat - 388 120.
Tel: 91 2692 236469 / 236513
Fax: 91 2692 236457 / 236542

GE Wind Energy INDIA,
A-1, Golden Enclave Corporate Towers, 3rd Floor, Airport Road,
Bangalore - 560 017
Tel: 91 80 25263121
Fax.: 91 80 25263860

M/s Pioneer Asia Wind Turbines
(A division of pioneer Asia Industries Private Limited)
16 - SP, Developed Plot,
Industrial Estate, Guindy
Chennai - 600 032
Phone : 91 44 22326596
Fax: 91 44 22346626

Shriram EPC Ltd.
TTG House,
36, College Road,
Chennai - 600 008.
Tel: 91 44 26531592, 26530732
Fax: 91 44 26532780

L M GLASFIBRE (INDIA) Pvt. LTD.
Plot 61/62 Kasaba Indl Area,
Hoskote - 562 114
Tel: 91 80 7971532 / 1700 / 1701
Fax: 91 80 7971320.

Chiranjeevi Wind Energy Ltd
23, Kamaraj Road,
Mahalingapuram,
Pollachi - 642 002.(T.N.).
Tel: 91 4259 2224438 / 2225482
Fax: 91 4259 2224437

Malaviya Energy Consultancy
B24, Ujwal Park
NIBM Road, Kondhwa
Pune - 411048, Maharashtra 411013
Tel: 91 20 26833399/9890033399

CSE Panels Private Limited
38, Ashwamegh Industrial Estate
Sarkhej Bavla Road, Village Changodar
Dist. Ahmedabad,
Gujarat 382213
Tel: 91 2717 250143
Fax: 91 2717 250678
Web Site: http://csepanels.com

Shelik Industries
2 Manikbaug, Sinhagad Road
Wadgaon Bk
Pune, Maharashtra 411051
Tel: 91 20 24352096
Fax: 91 20 24353808
Web Site: http://www.shelikind.com

CSM Group
I-18, Kirtidham,Vavol
Gandhinagar, Gujrat 382016
Tel: 91 79 23284454
Fax: 91 79 23284454

K. R. Tex
63/64, Gothan Ind. Estate
Kabirwadi, A. K. Road
Surat, Gujarat 395008
Tel: 91 261 2543814
Fax: 91 261 2564642

Karshni Intertech Pvt.Ltd
A-23, Sect 33
NOIDA, UP 201301
Tel: 91 11 24505051
Fax: 91 11 26919970

Perfect Engineers & Consultants
1-A/2, Lucky Complex
Jia Sarai, Hauz Khas
New Delhi 110016
Tel: 91 11 26534807/26861028
Fax: 91 11 26861358

Rpsoni
B-311 Shanti Bagh Apts
Hyderabad, AP 500016
Tel: 91 40 3735425

S.S.TRADING COMPANY
20, Trivelian Basin Street
Chennai 600079
Tel: 91 44 25299161
Fax: 91 44 25292221

Shree Krishna Industries
No 275, Timber Yard Layout, Mysore Road
Bangalore 560026
Tel: 91 9845022200
Fax: 91 80 26742466

Super Shapers
D-58, Developed Plots Industrial Estate
Thuvakudi, Tiruchirappalli
Tamil Nadu 620015
Tel: 91 431 2500669/2513627

Viral Controls Pvt. Ltd
B-29, G.I.D.C., Electronics Zone
Sector-25, Gandhinagar
Gujarat 382023
Tel: 91 79 3225456

Windia Power Ltd.
26, Gobind Mahal
86/#, Netaji Subhash Road
Mumbai, India 400002

Chapter-10

Reference Sources

Publications

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2. Directory: India Wind Power 2005. Bhopal, India: Consolidated Energy Consultants Ltd., vp.
3. InWind Chronicle, 2005, 2(1): 7

Web sites

4. The Irish Wind Energy Association (http://www.iwea.com/links.html)
5. World Energy Council (http://www.worldenergy.org)
6. Centre for Wind Energy Technology, Govt. of India (http://www.cwet.tn.nic.in/images/Newsletter-PDF/Issue%203.pdf)
7. Danish Wind Energy Association (www.windpower.org)
8. Ministry of Non-Conventional Energy Sources, Govt. of India (www.mnes.nic.in)
9. ENVIS Web site (www.envis.nic.in)
10. European Wind Energy Association (www.ewea.org)
11. The Energy and Resources Institute (www.teriin.org)
12. German Wind Energy Association (www.wind-energie.de/)
13. National Renewable Energy Association (http://www.nrel.gov/wind/)
14. Indian Wind Energy Association (http://www.inwea.org/)
15. Indian Wind Power.com (www.indianwindpower.com)
16. World Wind Energy Association (http://www.wwindea.org/)
17. Wind energy businesses in the world (http://energy.sourceguides.com/businesses/byP/wRP/wRP.shtml)