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# Wind Power Technology: An Overview

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ABSTRACT

The shortage of energy resources is experienced globally, due to exponential increase in the rate of energy consumption. Wind power is being adopted the world over as the most efficient power generation source that does not cause greenhouse emissions. With the raising concerns on climate change, countries are under pressure to turn renewable energy sources and reduce $CO_2$ emissions. This paper gives the brief review of wind power technology and its potential in India.

## 1. Introduction

Wind energy is highly preferred alternative as compared to conventional sources of power[1]. India plays a leading role in the global wind energy market, but it is still not use its full wind potential, which is far from the exhausted condition. An urgent need is felt to explore more sustainable energy system. The use of renewable energy (RE) sources is one of the best available options[2]. As a result of these actions, India is in leading position and as one of the 'emerging economies' in broad sense at present. Wind has served the mankind as a source of power for ages. Before the development of the steam engine, conventionally wind power was primarily used for applications like sailing ships etc.[3].

Wind energy is one of the clean and renewable energy sources which hold out the promise of meeting a significant portion of energy demand in the direct grid-connected modes, stand-alone and remote 'niche' applications (e.g.,water pumping, desalination, and tele-communications), in developing countries like India. The last decade has seen the Indian wind turbine industry growing very rapidly out pacing many other countries, which has resulted in India emerging as one of the leading countries in this sector. However, the irony is that technical education system of the country could not keep pace with these developments, whereby a lack of courses and programs exclusively devoted to wind energy technology is being felt. Wind turbines do not need any type of fuel, so there are no environmental risks or degradation from the exploration, extraction, transport, shipment, processing or disposal of fuel of all the renewable, wind energy dominates as an immediate viable, cost effective option which promotes energy conservation and avoids equivalent utilization of fossil fuels and avoid million ton of Green house gas emission causing ozone depletion and other environmental impacts like global warming[4]**.** Amongst RE sources, Wind energy proved more successful energy option next to hydro and about 215 GW has been installed worldwide. Earth's commercially viable wind power potential is estimated 72 TW which is five times more than world's total energy demand. With such a huge potential, only very few countries are really using wind power. USA, some of the European countries and Asian countries China and India are using wind energy at a large scale. Wind energy has been least used in African continent, where only very few countries like Egypt, Morocco, Tunisia, South Africa etc. uses Wind energy for power generation**.**

## 2. Discussion

When wind blowing at sufficient speed hits the blades of a turbine, it forces the blades to rotate. This is turn rotates the shaft on which the blades are fixed (mounted). This rotary motion of shaft can be used directly for mechanical application or can be converted to electrical energy by coupling it to a generator. The two main applications of wind energy are electricity generation and water lifting.

### I. Grid connected wind electric generators

The Grid-connected Wind Electric Generators (GCWEG) has been installed on the largest scale and most of these systems are Horizontal Axis Wind Turbines (HAWTs). The major component of HAWTs are tower, engine be of turbine containing rotor shaft, gear-box, hydraulic brake mechanism, generators, yaw mechanism, other controls and accessories and the foundation. The engine bed is mounted on top of the tower such that it can be stated about the tower axis. The GCWEGs are produced in a wide range of ratings and sizes varying from 50 to 6000 kW. However, the largest number of machines installed so far lies in the 100 to 300 kW range. It is felt that in the very new future

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most of the commercially available GCWEGs will be in the range of 0.5-1 MW.

**II. Hybrid wind electric generators**

For supplying electricity to villages not connected with grid, hybrid wind electric system can be used. Hybrid wind electric systems are operated with a diesel engine backup or can be a combination of wind, solar and diesel engine. The components/ sub-systems of the turbine in hybrid systems are similar to those of grid-connected wind turbines described earlier. However, there are major differences in controls, wind-fuel inter phase, storage, and power regulation. Storage is needed to limit the start and stop cycles of the fuel engine and to ensure the reliability of supply. Autonomous systems in the strict sense are seldom used as some storage backup is always there. Hybrid systems are being used for rural electrification in countries like Australia, the technology has good potential for rural electrification in coastal India.

**III. Mechanical output wind machines**

The mechanical output wind machines are mostly used for pumping water. Direct shaft power has also been tried in other applications like grinding. The use of windmills for grinding grains, which has been one of the applications of traditional windmills, has declined now.

**Wind pump technology**: At present, nearly all mechanical output windmills are used for pumping water and the system is known as a wind pump. The most widely used windmills are those that the horizontal axis rotors with multiple blades. The rotary motion of the rotor shaft is converted to either vertical reciprocating motion by various mechanisms with or without speed reduction (by gears). Some machines also use bevel gears. The vertically reciprocating pump is connected to a reciprocating pump which demands high initial torque whereas the vertically rotating pump rod is connected to either a centrifugal pump or a rotary vane pump.

**Major sub-systems of a wind pump**

**Rotor**: The rotor of a windmill consists of a varied number of blades (4-24) mounted on one or two rings (depending upon the diameter) and spokes which are bolted to the rotor hub. Specifications of a typical 3m gear-driver wind pump and their pumping Capacities given in **Table 1** and **Table 2** The blades are made of either aluminum, M.S. sheet, G.I. Sheet or FRP and are fixed aerodynamically to the rotor. The rings, spokes and blade supports are fabricated of steel angle irons or flats. The rotor, however, can also be of other types like vertical axis Savories, with sailcloth blades, etc.

**Head structure**: The head structure of a windmill is usually fabricated of angle irons / pipes or is cast in a foundry. The rotor, tail wing, and the power transmission components are mounted on the head structure.

**Turn-table**: The turn-table made of steel is fixed to the tower and the windmill head structure is mounted on it. The turn-table transmits the load of the rotor, head structure, tail wing, etc. to the tower and at the same time enables the head structure to rotate about the tower axis.

**Tower**: The tower is made of M.S. angles and flats or G.I. pipes and is usually in two or three sections. It holds the head mechanism at a height that varies from 6 to 15 m. Towers are usually three-or four legged lattice structures.

**Pump**: The most widely used wind pumps operated a single acting reciprocating pump. The reciprocating piston pump consists basically of a cylinder made of brass/ bronze with or without cast iron covering, a piston and two non-return valves. The upper valve is mainly situated in the piston; the lower valve is called the foot valve. The operation is that the upper valve closes with the upward movement of the piston when the foot valve opens so that the water above the piston is lifted while suction takes place below it.

**Control and safety mechanism**: Windmills are designed/ fabricated to operate within a particular range of wind speeds. The control mechanism operates within this range. It controls the rotor speeds and the safety mechanism operates after the operating range when it stops the operation of the system. Auto furling, side vane and ratchet mechanism, brake drums, etc. are examples of control and safety mechanisms.

**Table 1**. Specifications of a typical 3m gear-driver wind pump

| Rotor diameter | 3m |
|---|---|
| Tower height | 10 |
| Number of blades | 18 |
| Cut in wind speed | 6km/hr |
| Rated wind speed | 13km/hr |
| Cut out wind speed | 35 |
| Designed maximum wind speed | 80 |
| Gear ratio | 3.29 |
| No. of gears | 2 |
| Stroke per minute | 26 |
| Stroke length | 7.25/ 9.25 inch |
| Space required | 3m× 3m |

**Table 2.** Pumping Capacities

| Diameter of cylinder (inches) | Pumping capacity of 3m rotor(l/hr) | Pumping elevation for 3m rotor (feet) |
|---|---|---|
| 1.75 | 750 | 280 |
| 2 | 950 | 260 |
| 2.5 | 1625 | 140 |
| 3 | 2350 | 100 |

The cost of a typical wind pumping machine is around Rs 65,000 only.

**Indian capacity of installation**

Wind Power, Installed Capacity (in MW) at a glance (As on 31.03.1996) (Table 3)

**Table 3:**Wind Power, Installed Capacity (in MW)

| State | Demonstration projects | Private sector projects | Total |
|---|---|---|---|
| Tamil Nadu | 19.355 | 537.035 | 556.390 |
| Gujarat | 16.345 | 99.328 | 115.673 |
| Andhra Pradesh | 3.050 | 41.850 | 44.900 |
| Karnataka | 2.575 | | 2.575 |
| Kerala | 2.025 | | 2.025 |
| Maharashtra | 2.600 | | 2.600 |
| Madhya Pradesh | 0.590 | 6.300 | 6.890 |
| Orissa | 1.100 | | 1.100 |
| Others | 0.465 | | 0.465 |
| Total | 48.105 | 684.513 | 732.618 |

The official installation figures show that amongst the states, Tamil Nadu ranks the highest both in terms of installed capacity and in terms of energy generation from wind, with shares of 41.8% and 53.4% respectively. Other states like Gujarat, Maharashtra and Rajasthan have seen significant growth in wind capacity over the last four to five years, also due to a stable policy and regulatory regime. **Table 4** provides an overview of the share of different states in installed capacity (MW) and cumulative energy generation (in Million Units) (India Wind energy outlook 2011)

**Table 4:** State wise generation & installed capacity

| State | Cumulative generation(MU) | Cumulative installed capacity(MW) |
|---|---|---|
| Andhra Pradesh | 1,415 | 138.4 |
| Gujrat | 8,016 | 1,934.6 |
| Karnatka | 9,991 | 1,517.2 |
| Madhya Pradesh | 554 | 230.8 |
| Maharashtra | 11,790 | 2,108.1 |
| Rajasthan | 3,938 | 1,095.6 |
| Tamil Nadu | 41,100 | 5,0731 |
| Kerala | 110 | 28 |
| Total | 7,6950 | 12,125.8 |

### Assessment of wind potential

Power that can be harnessed from wind energy generators is proportional to the cube of the wind speed and is given by the formula.Victor K. Mallet, 2001[5]

$P = C_P \times 1/2\ \rho\ AV^3$

Where, P = Power in Watts

$\rho$ = density of air in kg / $m^3$

$C_P$= Coefficient of performance of turbine

V = Wind speed in m/s

A = Area through which the wind blows, in $m^3$

This if the wind speed doubles, the power available (water pumping capacity) increases eight folds. However, for a preliminary assessment during the session of a site should be made on the following benchmark in wind speeds:

For Wind pumps it is sufficient that the place receives gentle breeze throughout the day, i.e., about 3-4 metres per second wind speeds should suffice.

For Wind electricity generators, much higher wind speeds are required. A site is considered suitable if the annual wind speed is in the range of about 6 m/s. This means that in the windy months from June to September, the wind speeds should be in the order of about 11-12 m/s and this could be even higher, say up to 25 m/s.

### Economics of wind energy

The cost of a typical wind farm would be about Rs 4-4.5 crores per MW (installed), depending on the site. The plant & machinery cost is approximately 80% of the capital cost. MNES provide 100% depreciation in the first year on P&M cost. The cost of generation from a small wind farm at a good site, varies in the range of Rs 2.25 to Rs 3.00 / k Wh.

## 3. Conclusion

In this paper a study on the wind power technology and its potential in India has been carried. Following are the salient points of the study.

1. Wind electric system studied
2. State wise comparison has been made for wind power development level.
3. Indian capacity of Installation has been studied. From which we studied that Tamil Nadu ranks the highest both in terms of installed capacity and in terms of energy generation from wind.
4. Assessment of wind potential. For Wind pumps it is sufficient that the place receives gentle breeze throughout the day, i.e., about 3-4 meters per second wind speeds should suffice. For Wind electricity generators, much higher wind speeds are required.
5. Economics of wind energy studied.

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### References

1. R. K. Pachauri, and Y.Chauhan , *International journal of renewable energy research*, **2012**, 2( 4) , 773-780.
2. S. I. Mustpa, L. Yow, and A. Hashim, *IEEE International Conference on Proceedings of the Energy and Sustainable Development: Issues and Strategies (ESD)* , **2010**, 1-6.
3. Bhadra S. N., K. D. "Wind Electrical Systems", Oxford University Press, India, **2010**.
4. S. Ratnakumaran, S. Ramaswamy and V. K. Agrawal, *Journal of engineering, science and management education,* **2011**, 4, 217-222.
5. V. K. Mallet, The Use of Wind Energy in India - Lessons learned, Term Paper, Sustainable Energy, Spring, **2001**, 10. 391J.