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The future Clean Energy Harvesting by Wind Power Generation

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***Abstract*—** The electricity generation today is the major issue toward development of human mankind. The current electricity generation depends almost completely on the fissile fuels like coal, petroleum products etc. we are using it in very large scale resulting in pollution and high cost of electricity. The non-conventional methods like solar & wind is being developed on the scale where its use is affordable and pollution free, without any side effects. In this paper we have discussed the basics of wind power generation and the technologies involved in the process. The overall energy harvesting by wind power plants and transmitting it into usable form can solve the electricity problems, In country like India where electricity demand is estimated to increase at least 30% in next 5 to 10 years. This process involves the complex engineering and out of which some of the basics aspects like capacity , stricter of turbines, Synchronous generators are discussed briefly along with the basic components of the Wind Power Generation.

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I. INTRODUCTION

The energy that can be directly extracted from the wind and utilized to drive the generator of very large capacity through which electricity can be produced can be termed as wind power generation. The rate of generation of power through wind is directly proportional to the cube of the wind speed, so an understanding of the characteristics of the wind (velocity, direction, and variation) is critical to all aspects of wind energy generation. The wind speed is not constant at all parts of the earth, hence wind farms cannot be installed anywhere. The geographical locations and wind patterns according to satellite imaging can be studied to decide the perfect location for installing wind farms.

Wind energy has come a long way in the last two decades. At a given site, a single modern wind turbine annually produces 180 times more electricity and at less than half the cost per kilowatt hour (kWh) than its equivalent of 20 years ago. Today, Europe leads the world in terms of manufacturing and development of wind farms. In 1994, there were 1,683 megawatts (MW) of wind energy installed across the EU. By the end of 2005, installed capacity had increased 24 times and some 40 Gigawatts (GW) of cumulative installed capacity were providing about 2.8% of European electricity consumption. Still, the potential of wind energy is far greater[4].

. The most striking characteristic of the wind is its stochastic nature or randomness. The wind is highly variable, geographically and climatically. The wind currents change as per the seasons mostly summer and winter. The unpredictable nature of the wind makes it difficult to predict the extractable wind energy available through the year irrespective of the seasons. Moreover this variability exists over a very wide range of scales, both in space and time. Also within any climatic region, there is a great deal of variation on a smaller scale, which is dictated by several factors such as ratio of land and water, presence of mountains etc. its observed the t he useful wind is available mostly in hilly areas on the top of hills. The low level land or plain areas do not witness strong winds due to urbanizations and human interventions. Even more locally, wind velocities are altered by obstacles such as trees or buildings. For any location there is variation of wind pattern, wind speed may vary from year to year; also wind distribution will change from decade to decade [1].

These long-term variations of the wind are very un predictive in nature, this may also lead to economic and low life along with decreased generation of power from wind. But wind distribution is more predictable over shorter time spans like a year.The associated power generation systems must be prepared for these variations.

A. Betz Limit

Betz limit is the theoretical limit assigned to efficiency of a wind turbine. It states that no turbine can convert more than 59.3 % of wind kinetic energy into shaft mechanical energy. Thus the value of Cp is limited to Betz limit. For a well designed turbine the efficiency lies in the range of 35-45 %.

B. Capacity Factor

Capacity factor is a term used to denote the utilization rate of a wind turbine or any power generating source for that matter. It is the ratio between powers produced to the power that could have been produced if the generation source operated at 100% efficiency.

CAPICITY FACTOR =
Actual amount of power produced over time / Power that would have been produced if turbine operated at maximum output 100% of the time.

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The capacity factor of turbines is typically low around 40 %.

The grater designing considerations for the wind turbines it encompasses the design aspects of wind turbines. Due to randomness in wind turbines, there exist two options of lower generator rating with higher capacity ratio or higher generator rating with lower capacity ratio. Generally the last option is preferred because of higher electricity produced per rupee invested.

The position of wind turbines according to their location also classifies as onshore wind farms and off shore wind farms. Wind Energy systems are then also classified into the following categories

- Wind Electric Systems connected to the Grid(without need for storage)
- Standalone Electric Systems(with energy storage)
- Wind Mechanical energy systems(without energy storage)
- Hybrid Energy Systems that is wind diesel, solar electric, battery hybrid etc.

II. WIND TURBINES

Modern wind turbine generators are highly sophisticated machines, taking full advantage of state-of-the-art technology, led by improvements in aerodynamic and structural design, materials technology and mechanical, electrical and control engineering and capable of producing several megawatts of electricity. Large wind farms or wind power stations have become a common sight in many western countries. To a lesser degree, there has been a parallel development in small-scale wind generators for supplying electricity for battery charging, for stand-alone applications and for connection to small grids. Table 1 shows the classification system for wind turbines.

TABLE I. ROTOR DIAMETER & THEIR POWER RATING

Sr.no	Scale	Rotor Diameter	Power Rating
1	Micro	Less than 3m	50W to 2 KW
2	Small	3m to 12m	2 KW to 40 KW
3	Medium	12m to 45m	40KW to 999KW
4	Large	46m and larger	More than 1.0MW

Wind turbines can be separated into two types based by the axis in which the turbine rotates as Horizontal Axis Wind Turbines (HAWT) and Vertical Axis Wind Turbines (VAWT).

A. *Horizontal Axis Wind Turbines (HAWT)*

Horizontal-axis wind turbines (HAWT) get their name from the fact that their axis of rotation is horizontal. They have the main rotor shaft and electrical generator at the top of a tower, and are pointed into the wind. The variability of wind distribution and speed brings up the requirement of a gear system connected to the rotor and the generator. The gear system enables a constant speed of rotation to the generator thus enabling constant frequency generation. Turbine blades are made stiff in order to prevent the blades from being pushed into the tower by high winds. Downwind machines have also been built, as they no longer require a yaw mechanism to keep them facing the wind, and also because in high winds the blades can turn out of the wind thereby increasing drag and coming to a stop. Most of the HAWTs' are upwind as downwind systems cause regular turbulence which may lead to fatigue.

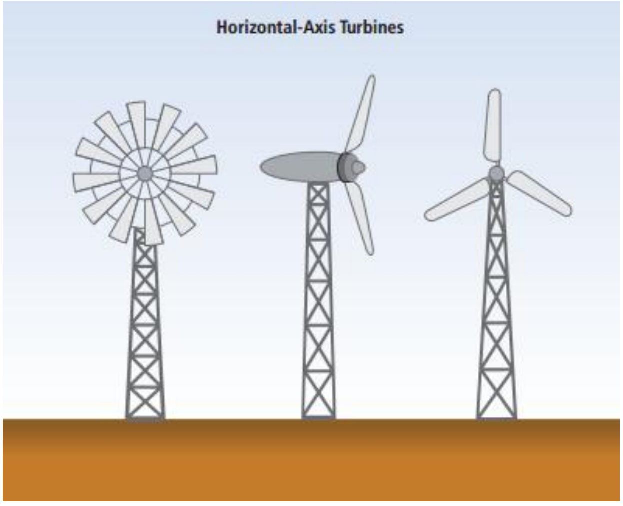


Figure 1 Horizontal Axis Turbines

B. *Vertical Axis Wind Turbines (VAWT)*

Vertical-axis wind turbines (or VAWTs) have the main rotor shaft arranged vertically as the plane of rotation is vertical. Blades are also vertical in this arrangement. The biggest advantage of VAWTs is they don't require a yaw control mechanism to be pointed into the wind. Thus these are useful in sites where wind direction is random or there is presence of large obstacles like trees, houses etc. Also VAWTs' don't require a tower structure and can be placed nearby a ground enabling access to electrical components. Some drawbacks are the low efficiency of wind production and the fact that large drag is created for rotating the blades in a vertical axis.

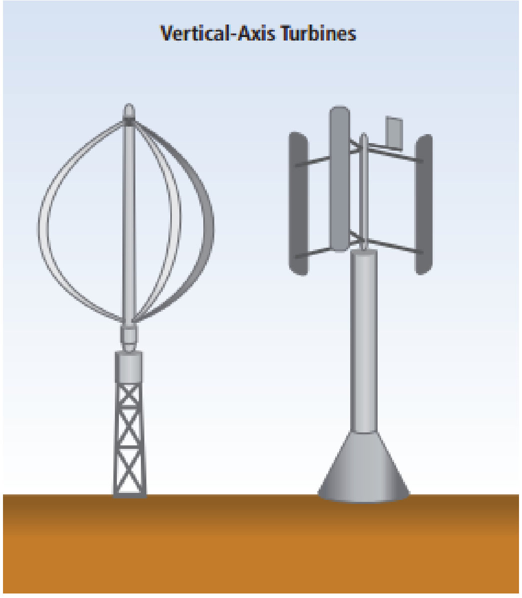


Figure 2 Vertical Axis Turbines

C. *Internal Structure of Wind Turbine*

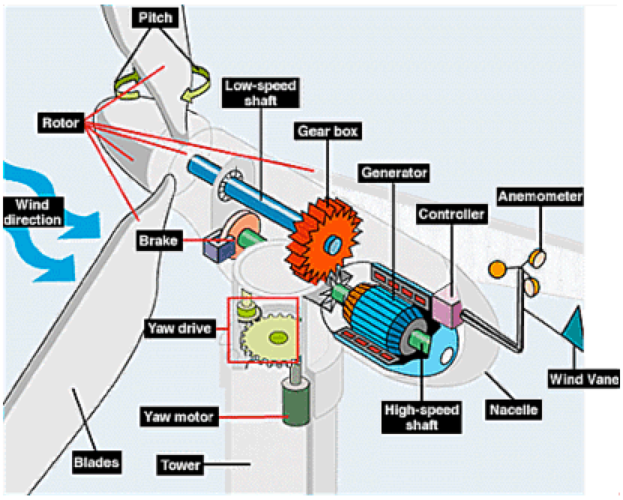


Figure 3 Internal Structure of Wind Turbine

1. Anemometer
   This device is used for measurement of speed. The wind speed is also fed to the controller as it is one of the variables for controlling pitch angle and yaw

2. Blades
   These are aerodynamically designed structures such that when wind flows over them they are lifted as in airplane wings. The blades are also slightly turned for greater aerodynamic efficiency.

3. Brake
   This is either a mechanical, electrical or hydraulic brake used for stopping the turbine in high wind conditions.

4. Controller
   This is the most important part of the turbine as it controls everything from power output to pitch angle. The controller senses wind speed, wind direction, shaft speed and torque at one or more points. Also the temp of generator and power output produced is sensed.

5. Gear box
   This steps-up or steps down the speed of turbine and with suitable coupling transmits rotating mechanical energy at a suitable speed to the generator. Typically a gear box system steps up rotation speed from 50 to 60 rpm to 1200 to 1500 rpm

6. Generator:
   This can be a synchronous or asynchronous Ac machine producing power at 50Hz

7. High-speed shaft
   Its function is to drive the generator.

8. Low-speed shaft
   The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

9. Nacelle
   The nacelle is the housing structure for high speed shaft, low speed shaft, gear box, generator, converter equipment etc. It is located atop the tower structure mostly in the shadow of the blades.

10. Pitch
    This is basically the angle the blades make with the wind. Changing the pitch angle changes weather the blades turn in or turn out of the wind stream.

11. Rotor:
    The hub and the blades together compose the rotor.

12. Tower:
    Towers are basically made up of tubular steel or steel lattice. Taller the towers greater is the amount of power generated as the wind speed generally goes on increasing with height.

13. Wind direction
    Generally erratic in nature, hence the rotor is made to face into the wind by means of control systems.

14. Wind vane
    Basically the job of a wind sensor, measuring the wind speed and communicating the same to the yaw drive, so as to turn the turbine into the wind flow direction.

15. Yaw drive
    This drive controls the orientation of the blades towards the wind. In case the turbine is out of the wind, then the yaw drive rotates the turbine in the wind direction

16. Yaw motor
    Powers the yaw drive

III. Generators

A generator is an electrical machine which helps in generating electricity by using the mechanical energy of a prime mover. Wind or Aero-generators are basically wind turbine-generator sets, i.e. a propeller or rotor attached to a turbine which in turn is coupled with an electric generator. The generator is further connected to appropriate electronic devices that help in its connection and synchronization to the electrical grid. Basically there are two types of generators Synchronous generators and Asynchronous generators.

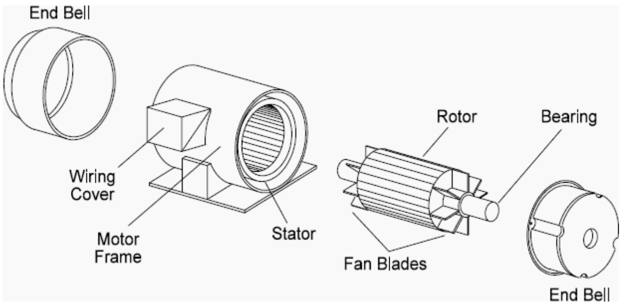
A. *Synchronous Generators*

Synchronous generators are doubly fed machines which generate electricity by the principle of electromagnetic induction. The rotor is rotated by a prime mover. The result is a current, which flows in the stationary set of rotor conductors. Now this produces a magnetic field which in turn induces a current in the stator conductors. This is the current which we use finally as the output. This rotating magnetic field induces an Alternating voltage, by the principle of electromagnetic induction, in the stator windings. Generally there are three sets of conductors distributed in phase sequence, so that the current produced is a three phase current. The rotor magnetic field is generally produced by means of induction, where we use either permanent magnets (in very small machines) or electromagnets in larger machines. Also the rotor winding is sometimes energized with direct current through slip rings and brushes. Sometimes even a stationary field winding, with moving poles in the rotor may be the source of the rotor magnetic field. Now this very setup is been used in automotive alternators, where by varying the current in the field winding we can change and control the alternator voltage generated. This process is known as excitation control. Basically the problem which plagues the electromagnets is the magnetization losses in the core, this is absent in the permanent magnet machines. This acts as an added advantage, but there is a size restriction owing to the cost of the material of the core[5]

B. *Asynchronous generators*

Asynchronous generators or Induction generators are singly excited a.c. machine. Its stator winding is directly connected to the ac source whereas its rotor winding receives its energy from stator by means of induction. Balanced currents produce constant amplitude rotating mmf wave. The stator produced mmf and rotor produced mmf wave, both rotate in the air gap in the same direction at synchronous speed. These two mmf s combine to give the resultant air-gap flux density wave of constant amplitude and rotating at synchronous speed. This flux induces currents in the rotor and an electromagnetic torque is produced which rotates the rotor. Asynchronous generators are mostly used as wind turbines as they can be operated at variable speed unlike synchronous generator. Two kinds of asynchronous generators are used namely

a) Squirrel cage induction generator (SCIG)
b) Doubly fed induction generator (DFIG)



C. *Squirrel cage induction generator*

A squirrel cage rotor is so named due to the shape which represents a cage like structure; it basically is the rotating part of the generator. Being cylindrical in nature, it's mounted on the shaft. The internal construction relates to the cage structure and contains longitudinal conductive bars (made of aluminum or copper) set into channel like constructs and connected together at both ends by shorting rings forming a proper cage-like shape. The core of the rotor is built of a stack of iron laminations, so as to decrease the eddy current losses.

The current flowing in the field windings in the stator results in the setting up of a rotating magnetic field around the rotor. This magnetic field cuts across the shorted rotor conductors resulting in electromagnetic induction which induces a voltage and in turn a current in the rotor windings. The magnitude of both the induced entities depends directly on the relative speed of the rotor with respect to the stator; this quality is basically called the slip of the motor. Slip basically signifies the difference between the speeds of the rotor and synchronous stator field speed. The rotor is carried around with the magnetic field but at a slightly slower rate of rotation.

D. *Doubly fed induction generator*

DFIG is Double Fed Induction Generator, a generating principle widely used in wind turbines. It is based on an induction generator with a multiphase wound rotor and a multiphase slip ring assembly with different brushes for access to the varied rotor windings. For wind power applications, this type of machine has distinct advantage over the conventional type of machines.

- The rotor circuit is basically controlled by a power electronics converter. Now this makes it possible for the induction generator to act both as a source and sink for reactive power. This allows for power system stability and allows the machine to support the grid during severe voltage disturbances also it allows for reactive power compensation of the system.
- The control of the rotor voltages and currents enables the induction machine to remain synchronized with the grid while the wind turbine speed varies. This allows for the proper usage of the wind stream, since a variable speed drive can derive greater power from the wind stream, as compared to a fixed sped drive
- Another factor which reduces the cost of the converter, apart from the initial investment is that only fraction of the Mechanical power, typically 25-30 %, is fed to the grid through the converter, the rest is fed to grid directly from the stator. This in turn enhances the efficiency of the DFIG.[5]

IV. General Controllers in Wind Turbine

The wind turbine control system consists of a of sensors, actuators, and a system consisting of hardware and software which processes the input signals from the sensors and generates output signals for the actuators. The controllers can be divided according to the functionality and device they control. These are broadly listed below:

1) Supervisory control
2) Pitch control
3) Stall control
4) Generator output and input control
5) Yaw control
6) Closed loop control of the system
7) The safety system control

V. Electricity Generation

The electricity generated from the generator can be in different forms depending upon the types of generator and the electrical equipments connected across the output. The output can be AC, DC, Variable voltage, and Variable frequency.

India's Wind Power Generation

From the perspective of the wind power generation, India has huge amount of locations available where wind farms can be established. The current wind power generation in India state wise is listed below.

TABLE II. WIND POWER GENERATION IN INDIA

State	Capacity as on 31/3/2014 (MW)
Andhra Pradesh	753
Gujarat	3414
Karnataka	2409
Kerala	55
Madhya Pradesh	439.00
Maharashtra	2976
Others	4.30
Rajasthan	2820
Tamilnadu	7253
Total	**21264 MW**

VI. CONCLUSION

If the energy crises scenario from future point of view is devastating, then clean energy from Wind can provide an huge amount of support for completing the overall power demand. Even though the production of wind power is problematic, it is not a factor to consider due to large energy crisis. The wind potential in India is about 20,000 MW. But we presently achieved is just a fraction of total potential. If we utilize the potential up to some more extent the energy crisis will be reduced. Still research is going on to design efficient wind turbines.

VII. REFERENCE

[1] G.D Rai “Non Conventional Energy Sources” Khanna Publishers

[2] S Rao, Dr. B.B Parulekar “Energy Technology” Khanna Publishers Fourth Edition, 2005.

[3] Papers by Antonio E. Haniotis Et Al, and Hassan H El-Tannaly Et Al

[4] S.N Bhadra, D. Kastha and S. Banerjee “Wind Electrical Systems”. Oxford University Press.

[5] Licun Wang, Jing Wei, Xudong Wang and Xianming Zhang “The Development and Prospect of Offshore Wind Power Technology in the World” World Non-Grid-Connected Wind Power and Energy Conference 2009. WNWEC 2009.

[6] A report prepared by BVG associates for BWEA “UK Offshore Wind: Moving up a Gear” Winter 2007.

[7] Kondapani, P.; Sakri S.G. “Preliminary Study to Access the Wind Energy Potential in Gulbarga, Karnataka State” TENCON 2008- 2008 IEEE Region 10 Conference.

[8] David Milborrow “Assimilating Wind” IEEE Review, Jan 2002.

[9] BWEA Briefing Sheet Offshore Wind.

[10] Mohammad A Al-Fawzan “Methods for Estimating the Parameters of Weibull Distribution” Oct 2000.

[11] Wide Energy The Facts: A Guide to the Technology, Economics and Future of Wind Power, European Wind Energy Association (EWEA) Earthscan Publications Ltd. (April 2009).

[12] http://www.wolframalpha.com

[13] Wind Resource Assessment Unit, Centre for Wind Energy technology Chennai Sept 2005.