

# Introduction to Wind Power Generation System

Kaustav Mallick

Department of Electrical Engineering,  
Institute  
Hooghly, India

Anjana Sengupta

Department of Electrical Engineering Technique Polytechnic  
Technique Polytechnic Institute  
Hooghly, India

**Abstract** - Nowadays wind kinetic energy is a promising source of renewable energy in many parts of the world. Most of the countries in the world wants to exploit wind energy in maximum possible way to meet their energy demands. Wind energy is a green energy source and does not cause pollution. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth.. Small wind turbines needs to be affordable, reliable and almost maintenance free for the average person to consider installing one .This paper deals with the principle of energy conversion , favorable conditions for site selection of wind generation, various wind generation schemes as well as different wind power generation schemes. Not only that this paper also emphasizes about different advantages and challenges for development of wind power generation.

**Key words**- Principle of Conversion, Wind Power Energy, Schemes, Site Selection.

## I.INTRODUCTION

Wind energy is developing to be one of the fastest growing power generation sectors in the whole world. This trend is expected to continue globally to meet a growing electrical energy demand in an environmentally responsible manner. The kinetic energy in the wind shows as a potential source of renewable energy in many parts of the world. The energy obtained from wind turbines is highly reliant on the average wind speed of a particular area. Some of the most suitable regions for wind power generation are located near coasts, inland areas with open terrain or on the edge of bodies of water. Some mountainous areas also have good Factors effecting wind energy converter are

- The wind speed
- Cross-section of the wind swept by rotor

Theoretically it is possible to obtain 100% efficiency by halting and preventing the passage of air through the rotor. However, a rotor can decelerate the air column upto one third of its free velocity. A 100% efficient wind generator can transform maximum up to 60% of the available energy in wind into mechanical energy. In addition to this, losses occurring in the generator or pump decrease the overall efficiency of power generation to 35%.

## III. PRINCIPLE OF ENERGY CONVERSION:

Wind mills or turbines works on the principle of transforming wind kinetic energy in to mechanical energy.

Power available from wind turbine=  $\frac{1}{2} \rho A V^3$

Where,  $\rho$  – air density = 1.225 Kg. / m<sup>3</sup> at sea level.  
(Changes by 10-15% due to Temperature and pressure variations)

potential. In spite of these geographical limitations for wind energy project siting, there is sufficient terrain in most areas of the world to provide a significant portion of the local electricity needs with wind energy projects. As the number of wind power plants (WPPs) increases and the level of access become high in some areas, there is an increase in interest on the part of power system planners in methodologies and techniques that can be used to adequately represent WPPs in interconnected power system studies in more effective and efficient way.

## II. WIND POWER ENERGY:

Wind is an atmospheric phenomenon which occurs due to the heat of the sun. The sun radiates on the Earth a power of 1.74 x 10<sup>17</sup> Watts approximately. Only 2% of it is transformed into wind energy. The Earth releases the heat received from the Sun, but this is hardly homogeneous. In Areas where less heat is released, the pressure of atmospheric gases increases, while in those Areas where more heat is released, the air becomes hot and the air pressure decreases. As a Consequence, high-pressure areas and low-pressure areas are formed, which are also influenced by the Earth's rotation. When different masses of air get in contact, the area with a higher pressure tends to transfer air towards the area with lower pressure. Therefore wind is rapid air transfer between different pressure areas. The greater is the pressure difference, the faster will be the air displacement and the stronger will be the wind which facilitates wind power generation.

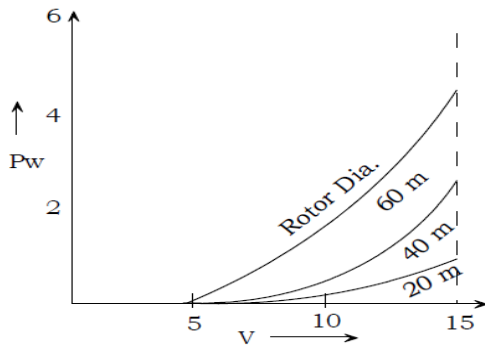
- Conversion efficiently of rotor
- Generator
- Transmissionsystem

A – Area swept by windmill rotor =  $\pi D^2$  sq-m. (D – Diameter)

V – Wind speed m/sec.

Air density linearly affects the power output at a given speed and air density is a function of altitude, temperature and barometric pressure. Variation in temperature and pressure affect air density up to 10 % in either direction. Warm climate reduces air density.

Maximum power also depends on diameter of rotor. The combined effects of wind speed and rotor diameter can be observed by the following graph:



This graph indicates that wind machines should have large rotors and should be located in areas of high wind speeds. Practically, wind turbines are able to convert only a fraction of available wind power into useful power. As the free wind stream passes through the rotor, it transfers some of its energy to the rotor and its speed decreases to a minimum in the rotor wake. After some distance from the rotor wind stream regains its speed from the surrounding air.

#### IV. WIND GENERATING SYSTEM:

Wind generating system consists of different

- Wind turbine: transforms wind energy into mechanical energy . it can be classified as a) horizontal axis wind turbine b) Vertical axis wind turbine.
- Gear system and coupling: It increases the speed and transfers it to generator rotor.
- Generators: Generators convert mechanical energy to electrical energy. For Small rating systems P.M.type d.c. generators are used. For Medium rating systems P.M.type d.c. generators ,Induction generators ,Synchronous Generators are used while for Large rating systems Induction generators (3-phase ) and Synchronous Generators (3 phase) are used.
- Controller(C)-Senses wind direction, wind speed generator output , temperature and provides appropriate control signals to get desired output.
- Yaw motor gear-The area of the wind stream swept by the wind turbine is maximum when blades face into the wind. Alignment of the blade angle with respect to the wind wind energy is donewith the help of yaw control that rotates wind turbine about the vertical axis direction to get maximum wind energy. In smaller wind turbines, yaw action is controlled by tail vane. In larger turbines, it is operated by servomechanism.
- Towers: There are different types of towers such as Guyed lattice towers, Guyed tilt-up towers, Self-supporting towers.

Different Schemes for wind power generation:

CSCFS (Constant Speed Constant Frequency Scheme):-

Constant speed drives are used for large generators that provide for the generated power to the grid. Generally synchronous generators or induction generators are used for power generation.

DSCFS (Dual Speed Constant Frequency Scheme):-

Generally a dual speed wind turbine is coupled to double winding. Induction generator that is specially fabricated with 2 stator windings wound with different number of poles of the machine ( $P1 > P2$ ). When wind speed is low, winding

with P1 poles is connected .As a result power is generated with grid frequency. Similarly, when wind speed is high, winding with P2 poles gets connected and feed the power to grid at the same frequency.

VSCFS (Variable speed constant frequency scheme):-

DC output which is obtained due to rectification of output of three phase alternator by bridge rectifier is transmitted through DC transmission lines and then inverted back to AC using synchronous inverters and fed to grid system.

Variable speed constant frequency with double output (VSCF with DO):-

Slip ring induction generators are generally used instead of squirrel cage induction motor to increase the power generating capacity of the system. Then rectifier is used to convert Rotor power output at slip frequency to line frequency power. Output power is obtained both from stator and rotor. Rotor output power increases with increase in slip and speeds. Therefore, operating speed varies from  $N_s$  to  $2 N_s$ .

(VSVF) Variable speed variable frequency schemes :-

squirrel cage Induction Generator generates power at variable frequency which depends upon the wind speed,. Such generators are excited by Capacitor-bank. The magnitude and frequency of the generated emf depends upon various factors like wind turbine speed, excitation capacitance and load impedance.

#### V. ENERGY STORAGE:

Output of the wind turbine is largely dependent on wind speed. When the power generated is greater than the demand then the excess energy can be stored in various ways.

Excess energy can be stored in storage batteries in the form of chemical energy. It can also be stored in water power storage in the form of mechanical energy or in form compressed air.

#### VI. SITES FOR WIND POWER GENERATION:

- A high average wind speed is preferred..
- Good grid connection is required.
- Good site access is desired.
- No special environmental or landscape designations is required.

#### VII. ADVANTAGES OF WIND POWER GENERATION:

- Wind power is cost-effective. Land-based utility-scale wind is one of the lowest-priced energy sources available today.
- It's a clean fuel source. Wind energy doesn't pollute the air like power plants which depends on combustion of fossil fuels, such as coal or natural gas, which causes air pollution affects human health. Wind turbines don't produce atmospheric emissions that cause acid rain, smog, or greenhouse gases.
- wind supply is abundant and inexhaustible.
- It's sustainable. Winds are caused by the heating of the atmosphere by the sun, the rotation of the Earth, and the Earth's surface irregularities. The energy produced can be harnessed to send power across the grid.

#### VIII. CHALLENGES OF WIND POWER GENERATION:

- Wind power still needs to compete with conventional generation sources regarding economic perspective. Depending on how energetic a wind site is, the wind farm might not be cost effective.
- Good wind sites are often located in remote locations, far from cities where the electricity is needed. Transmission lines must be constructed to bring the electricity from the wind power generation site to the city which may also increase the cost.
- Wind resource development might not be the most profitable use of the land. Land suitable for wind-turbine installation must compete with alternative uses for the land, which might have high value valued than electricity generation
- 

#### IX. CONCLUSION:

The one of the most important benefits of using wind power over other resources is mainly in its minimum operational cost. Depending on field of applications, various schemes are now being adopted to get optimum output. Different storage facilities makes it versatile source of energy. Nowadays turbines are totally controlled by computers that are totally safe. So Wind power has become one of the most important renewable energy sources in the world.

#### X. REFERENCE:

- [1] Mrs. N.V. Vader, Mrs. V.A. Joshi, "Wind power generation technology"
- [2] Navin Prasad , Janakiram, Prabu ,Sivasubramaniam , "Design and Development of horizontal small wind turbine blade for low wind speeds" International Journal of Engineering Science & Advanced Technology. Volume-4, Issue-1, 075-084
- [3] Mr. Josua Kirsch, Design of a small wind turbine for electric power generations (1-5kw)
- [4] Mayer C, Bechly ME, Hampsey M, Wood DH. The starting behaviour of a small horizontal-axis wind turbine. Renewable Energy 2001;22:411-7.