UNIT-III WIND ENERGY

INTRODUCTION

- Wind is essentially air in motion, which carries with it kinetic energy.
- The amount of energy contained in the wind at any given instant is proportional to the windspeed at thatinstant.
- Wind results primarilyby unequal heating of the earth's surface bythe sun.
- About 2% of the total solar flux that reaches the earth's surface is transformed into windenergy.
- Solarenergymeetsclouds, uneven surfaces, and mountainswhile reachingthe earth.
- This unequal heating causes temperature, density, and pressure differences on the earth'ssurface that are responsible for local wind formation.
- Duringdaytime, the airoverthe land massheatsupfasterthanthe airovertheoceans. Hotair expandsand riseswhilecoolairfromoceansrushestofillthespace, creatinglocalwinds.
- Atnighttheprocessisreversed astheaircoolmorerapidlyoverlandthanwateroveroff-shore land, causingbreeze.
- Onaglobalscale, the primaryforceforglobalwindsisdevelopedduetodifferentialheatingof the earth at equatorial and Polar Regions.

POWER IN WIND

- Wind possesses energy by virtue of its motion. Any device capable of slowing down the mass ofmoving air like a sail or propeller can extract part of the energy of the energy and convert it intouseful work.
- Three factor determine the output from a wind energyconverter:
  - The wind speed
  - The cross-section of wind sweptby rotor
  - Theoverallconversionefficiencyoftherotor, transmissionsystemandgeneratororpump.
- Wind mill/turbine converts the kinetic energyof the wind into mechanical energy.
- The total power of the wind stream is equal to the time rate of kinetic energy.

$$K.E = 1/2 mV^2$$

- The amount of air passing in unit time through an area A with velocity V

$$m = AV \; m^3/s$$

∴ Mass flow rate of air m =p A • V Where, p is the density of air.

$$K.E = 1/2(\rho AV)V^2$$

BASIC COMPONENTS OF A WIND ENERGY CONVERSION SYSTEM (WECS)

The main components of a wind energy conversion system (WECS) in the form of block diagram. A wind energy conversion system converts wind energy into some form of electrical energy. In particular, medium and large scale WECS are designed to operate in parallel with a utility AC grid. This is known as a grid-connected system. A small system, isolated from the id, feeding onlyto a local load is known as autonomous or isolated power system.

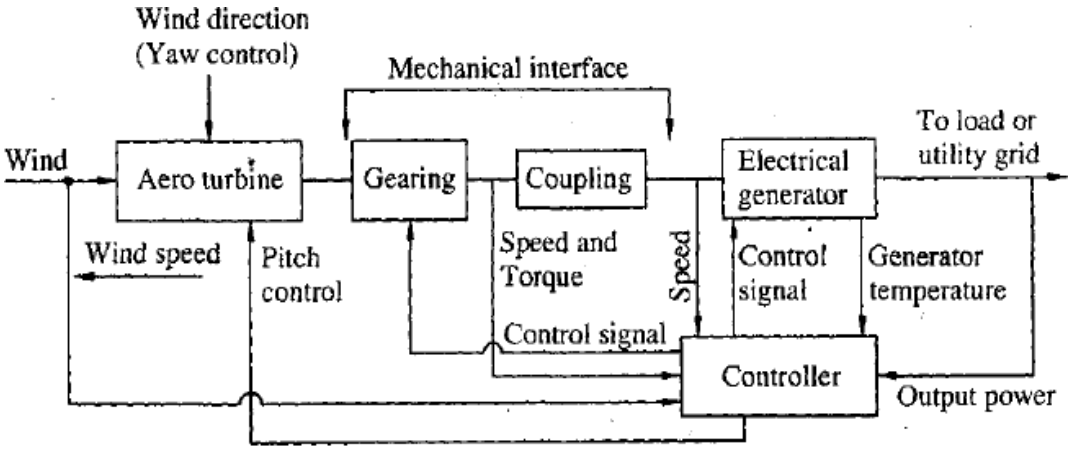

Fig 3.1 Wind Energy Conversion System (WECS)

Types of Wind Energy:

1. **According to orientation of the axis of rotor**

- Horizontal axis: When the axis of rotation is parallel to the air stream (i.e. horizontal), theturbine is said to be a Horizontal Axis Wind Turbine(HAWT).
- Vertical axis: When the axis of rotation is perpendicular to the air stream (i.e. vertical), theturbine is said to be a Vertical Axis Wind Turbine (VAWT)

2. **According to useful electrical power output**

- Small output: up to 2 kW
- Medium output: 2 to 100 kW output
- Large output: More than 100 kW output

3. According to type of rotor

- Propeller type: It is horizontal axis high speed rotor.
- Multiple blade type: It is horizontal axis low speed rotor.
- Savoniustype: It is vertical axisrotor.
- Darrieus type: It is vertical axis rotor.

Horizontal Axis Wind Turbine (HAWT)

- Horizontalaxis machines have emerged as the most successful type of turbines. These are being used for commercial energy generation in many parts of theworld.Theyhave low cut-inwind speed, easyfurlingand, ingeneral, showhighpowercoefficient.
- However, their design is more complex and expensive as the generator and gear box are to be placed at the top of the tower. Also, a tail or yaw drive is to be installed to orient them in the wind direction.

Main components:

1. Turbine blades
2. Hub
3. Nacelle
4. Power transmissionsyste m
5. Generator
6. Yaw control
7. Brakes
8. Tower

Fig 3.2 Photographic view of wind mills

1. Turbine blades

- Wind turbine blades need to be light weight and possess adequate strength and hence

require to be fabricated with aircraft industrytechniques.

- The blades are made of glass fibre reinforced plastic (F.R.P.). They have an aerofoil type of crosssection to create lift as the air flows over them.
- The blades are slightlytwisted from the outer tip to the root to reduce the tendencyto stall.
- In addition to centrifugal force and fatigue due to continuous vibration, there are many extraneous forces arising from wind turbulence, gust, gravitational forces and directional changes inthe wind. All these factors have to be considered at the designing stage.
- The diameter of a typical, MW range, modern rotor maybe of the order of 100m.

SITE SELECTION CONSIDERATIONS

1. Average annual windspeed

- The power available in wind increases rapidly with wind speed. Therefore, the main consideration for locating a wind-power generation plant is the availability of adequate and uniform average wind velocity throughout the year.
- The total wind power from free wind stream increases as the cube of the wind speed. Therefore, wind velocities available should be in the range of 5 m/s to 25 m/s throughout the year.

2. Area

- As the building, forests offers the resistance to the air movement, the wind farms are located away from cities and forests. Flat open area should be selected, as the wind velocities are high inflat openarea.

3. Altitude of thesite

- Altitude of the proposed site should be considered. Higher altitude ground experience strong winds than lower altitude ground. Thus, altitude affects the electric power output of wind energy conversion system.
- Wind velocities must be measured by anemometer at several heights from the ground The velocity of wind increases with height given bythe relation:

$$V \propto H^{1/7}$$

- This relation is applicable for the heights between 50 m to 250 m.–

4. **Wind structure**

– At the proposed site, wind should blow, smooth and steady all the time, i.e. the wind velocity curve should be flat. Wind specially near the ground is turbulent and gusty, and changes rapidly in direction and in velocity.

5. **Local ecology**

– If small trees, grass or vegetations are present, all of which destructure the wind, then the height of the tower will increase, which increases the cost of thesystem.

6. **Nature of land and its cost**

– The site selected should have high load bearing capacity. It would reduce the cost of foundation. The cost of the land should be low to reduce the initialcost.

7. **Transport facilities**

– There should be transport facilities for transportation of heavy machinery, structures, materials,blades, etc to chosen site for installation.

8. **Nearness of site to load centre**

– The site should be located near the load to which the power is supplied. The location of site nearload centre reduces the cost of transmission linesand the lossesoccurring in it.

9. **Away from localities**

The selected site should be awayfrom localities so that the sound pollution caused bywindturbine does notaffect.

Advantages

1. It is renewable and not depleted with the use like fossil fuels.
2. Wind energy generation is eco-friendly and does not pollute the atmosphere, unlike in the case ofgeneration from coal, oil, etc.
3. The cost of installation of wind power plant is competitive compared to conventional power plant/Since, thereisno fuelcostand lowmaintenancecost, thecostofenergyproducedinlong run is almostfree.

Fig 3.3 Wind mill sites

4. Wind energy system does not require fuel and its transportation.
5. In large portion of the world, wind blows for 320 days in a year and this gives them anadvantage over sunlight in direct conversion programmer.

Disadvantages

1. Wind energy is available in dilute and fluctuating in nature.
2. It is necessaryto store wind energyin some other forms during periods of high windsfor uselater on duringcalm.
3. Favorable winds are available only in few geographical locations.
4. There is fluctuation in electric power depending on fluctuating wind speed.
5. The capital cost is high. At present it is about Rs. 3.5 crores/MW.
6. It causes negative impacts like noise, bird hits, land erosion, impact on wild life, etc.