JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Year & Sem	-	IV Year & VII Semester
Subject	-	Power Generation Sources [7EE6-60.2]
Unit/Topic	-	IV / Wind Energy (Part -2)
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VISSION AND MISSION OF INSTITUTE

Vision:

To become a renowned center of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

Mission:

M1: Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.

M2: Identify, based on informed perception of Indian, regional and global needs, areas of focus and provide platform to gain knowledge and solutions.

M3: Offer opportunities for interaction between academia and industry.

M4: Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

VISSION AND MISSION OF DEPARTMENT

Vision:

The Mechanical Engineering Department strives to be recognized globally for excellent technical knowledge and to produce quality human resource, which can manage the advance technologies and contribute to society through entrepreneurship and leadership.

Mission:

M1: To impart highest quality technical knowledge to the learners to make them globally competitive mechanical engineers.

M2: To provide the learners ethical guidelines along with excellent academic environment for a long productive career.

M3: To promote industry-institute linkage.

Wind Generation

History of Wind-Mills:

- The wind is a by-product of solar energy. Approximately 2% of the sun's energy reaching the earth is converted into wind energy.
- The surface of the earth heats and cools unevenly, creating atmospheric pressure zones that make air flow from high- to low-pressure areas.
- The wind has played an important role in the history of human civilization .
- The first known use of wind dates back 5,000 years to Egypt, where boats used sails to travel from shore to shore.

Wind Generation-1

- The first true windmill, a machine with vanes attached to an axis to produce circular motion, may have been built as early as 2000 B.C.
- In ancient Babylon. By the 10th century A.D., windmills with wind-catching surfaces having 16 feet length and 30 feet height were grinding grain in the areas in eastern Iran and Afghanistan.
- The earliest written references to working wind machines in western world date from the 12th century.
- These too were used for milling grain. It was not until a few hundred years later that windmills were modified to pump water and reclaim much of Holland from the sea.

Wind Generation-2

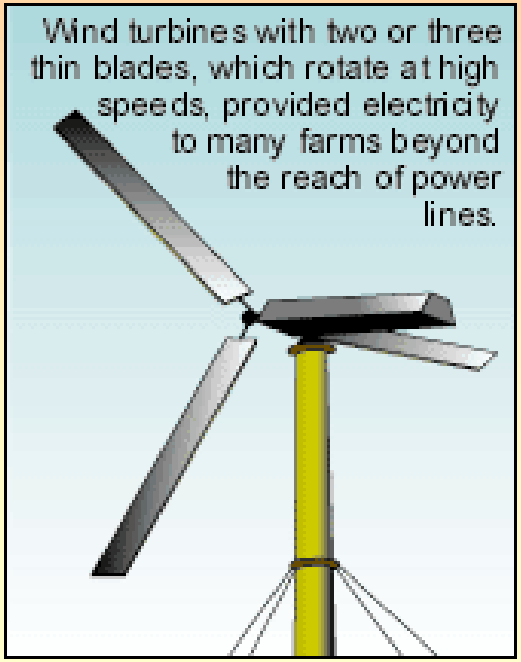
- The multi-vane "farm windmill" of the American Midwest and West was invented in the United States during the latter half of the l9th century.
- In 1889 there were 77 windmill factories in the United States, and by the turn of the century, windmills had become a major American export.
- Until the diesel engine came along, many transcontinental rail routes in the U.S. depended on large multi-vane windmills to pump water for steam locomotives.
- Farm windmills are still being produced and used, though in reduced numbers.
- They are best suited for pumping ground water in small quantities to livestock water tanks.

Wind Generation-3

- In the 1930s and 1940s, hundreds of thousands of electricity producing wind turbines were built in the U.S.
- They had two or three thin blades which rotated at high speeds to drive electrical generators.
- These wind turbines provided electricity to farms beyond the reach of power lines and were typically used to charge storage batteries, operate radio receivers and power a light bulb.
- By the early 1950s, however, the extension of the central power grid to nearly every American household, via the Rural Electrification Administration, eliminated the market for these machines. Wind turbine development lay nearly dormant for the next 20 years.

Wind Generation-3

- A typical modern windmill looks as shown in the following figure.
- The wind-mill contains three blades about a horizontal axis installed on a tower.
- A turbine connected to a generator is fixed about the horizontal axis.



Wind Generation-4

- Like the weather in general, the wind can be unpredictable. It varies from place to place, and from moment to moment.
- Because it is invisible, it is not easily measured without special instruments.
- Wind velocity is affected by the trees, buildings, hills and valleys around us.
- Wind is a diffuse energy source that cannot be contained or stored for use elsewhere or at another time.

Classification of Wind-mills

- Wind turbines are classified into two general types: Horizontal axis and Vertical axis.
- A horizontal axis machine has its blades rotating on an axis parallel to the ground as shown in the above figure.
- A vertical axis machine has its blades rotating on an axis perpendicular to the ground.
- There are a number of available designs for both and each type has certain advantages and disadvantages.
- However, compared with the horizontal axis type, very few vertical axis machines are available commercially.

Classification of Wind-mills-1

Horizontal Axis:

- This is the most common wind turbine design.
- In addition to being parallel to the ground, the axis of blade rotation is parallel to the wind flow.
- Some machines are designed to operate in an upwind mode, with the blades upwind of the tower.
- In this case, a tail vane is usually used to keep the blades facing into the wind.
- Other designs operate in a downwind mode so that the wind passes the tower before striking the blades.
- Some very large wind turbines use a motor-driven mechanism that turns the machine in response to a wind direction sensor mounted on the tower.
- Commonly found horizontal axis wind mills are aero-turbine mill with 35% efficiency and farm mills with 15% efficiency.

Classification of Wind-mills-3

Vertical Axis:

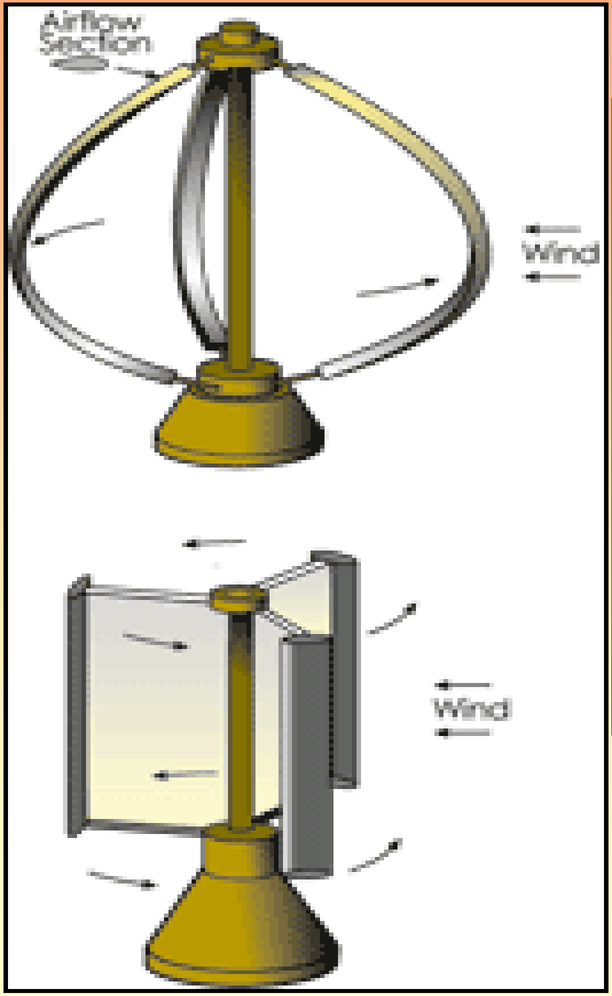
- Although vertical axis wind turbines have existed for centuries, they are not as common as their horizontal counterparts.
- The main reason for this is that they do not take advantage of the higher wind speeds at higher elevations above the ground as well as horizontal axis turbines.
- The basic vertical axis designs are the Darrieus, which has curved blades and efficiency of 35%, the Giromill, which has straight blades, and efficiency of 35%, and the Savonius, which uses scoops to catch the wind and the efficiency of 30%.
- A vertical axis machine need not be oriented with respect to wind direction.

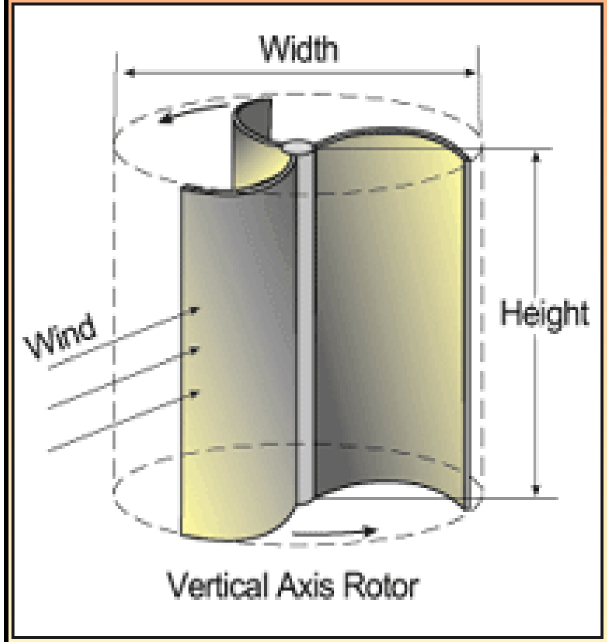
Classification of Wind-mills-4

- Because the shaft is vertical, the transmission and generator can be mounted at ground level allowing easier servicing and a lighter weight, lower cost tower.
- Although vertical axis wind turbines have these advantages, their designs are not as efficient at collecting energy from the wind as are the horizontal machine designs.
- There is one more type of wind-mill called Cyclo-gyro wind-mill with very high efficiency of about 60%. However, it is not very stable and is very sensitive to wind direction. It is also very complex to build.

Classification of Wind-mills-5

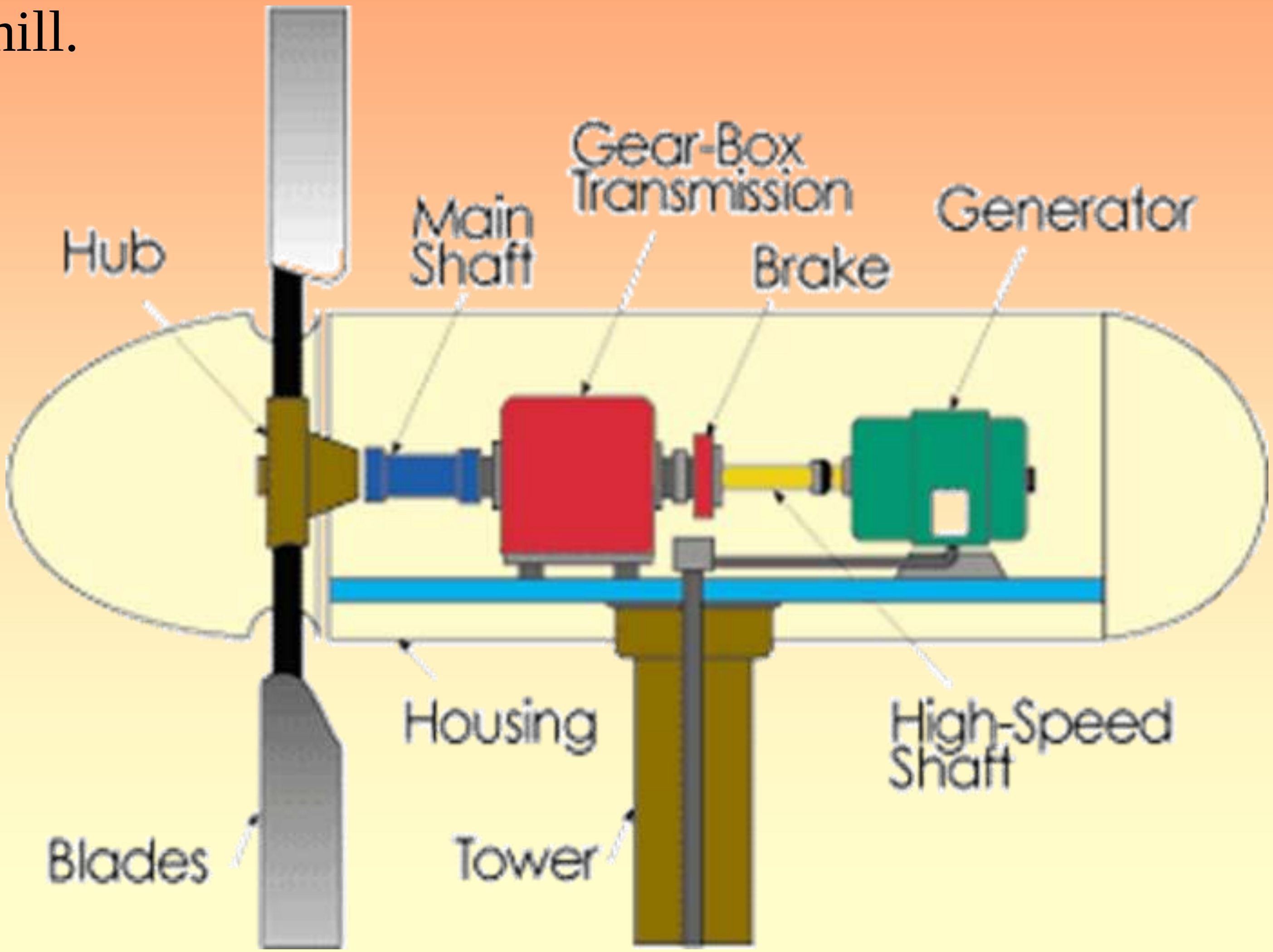
- The following figures show all the above mentioned mills.





Main Components of a wind-mill

- Following figure shows typical components of a horizontal axis wind mill.



Main Components of a wind-mill-1

Rotor:

- The portion of the wind turbine that collects energy from the wind is called the rotor.
- The rotor usually consists of two or more wooden, fiberglass or metal blades which rotate about an axis (horizontal or vertical) at a rate determined by the wind speed and the shape of the blades.
- The blades are attached to the hub, which in turn is attached to the main shaft.

Drag Design:

- Blade designs operate on either the principle of drag or lift.
- For the drag design, the wind literally pushes the blades out of the way.
- Drag powered wind turbines are characterized by slower rotational speeds and high torque capabilities.

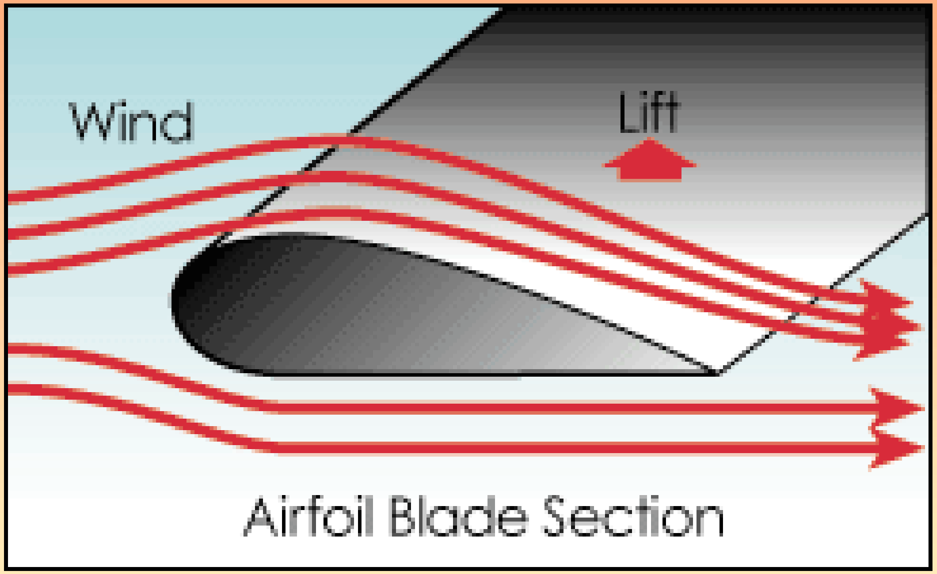
Main Components of a wind-mill-2

Lift Design:

- The lift blade design employs the same principle that enables airplanes, kites and birds to fly.
- The blade is essentially an airfoil, or wing.
- When air flows past the blade, a wind speed and pressure differential is created between the upper and lower blade surfaces.
- The pressure at the lower surface is greater and thus acts to "lift" the blade.
- When blades are attached to a central axis, like a wind turbine rotor, the lift is translated into rotational motion.
- Lift-powered wind turbines have much higher rotational speeds than drag types and therefore well suited for electricity generation.

Main Components of a wind-mill-3

- Following figure gives an idea about the drag and lift principle.



- **Tip Speed Ratio:**
- The tip-speed is the ratio of the rotational speed of the blade to the wind speed.
- The larger this ratio, the faster the rotation of the wind turbine rotor at a given wind speed.

Main Components of a wind-mill-4

- Electricity generation requires high rotational speeds.
- Lift-type wind turbines have maximum tip-speed ratios of around 10, while drag-type ratios are approximately 1.
- Given the high rotational speed requirements of electrical generators, it is clear that the lift-type wind turbine is most practical for this application.
- The number of blades that make up a rotor and the total area they cover affect wind turbine performance.
- For a lift-type rotor to function effectively, the wind must flow smoothly over the blades.
- To avoid turbulence, spacing between blades should be great enough so that one blade will not encounter the disturbed, weaker air flow caused by the blade which passed before it.
- It is because of this requirement that most wind turbines have only two or three blades on their rotors.

Main Components of a wind-mill-5

Generator:

- The generator is what converts the turning motion of a wind turbine's blades into electricity.
- Inside this component, coils of wire are rotated in a magnetic field to produce electricity.
- Different generator designs produce either alternating current (AC) or direct current (DC), and they are available in a large range of output power ratings.
- The generator's rating, or size, is dependent on the length of the wind turbine's blades because more energy is captured by longer blades.
- It is important to select the right type of generator to match intended use.

Main Components of a wind-mill-6

- Most home and office appliances operate on 240 volt, 50 cycles AC.
- Some appliances can operate on either AC or DC, such as light bulbs and resistance heaters, and many others can be adapted to run on DC.
- Storage systems using batteries store DC and usually are configured at voltages of between 12 volts and 120 volts.
- Generators that produce AC are generally equipped with features to produce the correct voltage of 240 V and constant frequency 50 cycles of electricity, even when the wind speed is fluctuating.
- DC generators are normally used in battery charging applications and for operating DC appliances and machinery.
- They also can be used to produce AC electricity with the use of an inverter, which converts DC to AC.

Main Components of a wind-mill-7

Transmission:

- The number of revolutions per minute (rpm) of a wind turbine rotor can range between 40 rpm and 400 rpm, depending on the model and the wind speed.
- Generators typically require rpm's of 1,200 to 1,800.
- As a result, most wind turbines require a gear-box transmission to increase the rotation of the generator to the speeds necessary for efficient electricity production.
- Some DC-type wind turbines do not use transmissions.
- Instead, they have a direct link between the rotor and generator.
- These are known as direct drive systems.
- Without a transmission, wind turbine complexity and maintenance requirements are reduced.
- But a much larger generator is required to deliver the same power output as the AC-type wind turbines.

Main Components of a wind-mill-8

Tower:

- The tower on which a wind turbine is mounted is not just a support structure.
- It also raises the wind turbine so that its blades safely clear the ground and so it can reach the stronger winds at higher elevations.
- Maximum tower height is optional in most cases, except where zoning restrictions apply.
- The decision of what height tower to use will be based on the cost of taller towers versus the value of the increase in energy production resulting from their use.
- Studies have shown that the added cost of increasing tower height is often justified by the added power generated from the stronger winds.
- Larger wind turbines are usually mounted on towers ranging from 40 to 70 meters tall.

Main Components of a wind-mill-9

- Towers for small wind systems are generally "guyed" designs.
- This means that there are guy wires anchored to the ground on three or four sides of the tower to hold it erect.
- These towers cost less than freestanding towers, but require more land area to anchor the guy wires.
- Some of these guyed towers are erected by tilting them up.
- This operation can be quickly accomplished using only a winch, with the turbine already mounted to the tower top.
- This simplifies not only installation, but maintenance as well. Towers can be constructed of a simple tube, a wooden pole or a lattice of tubes, rods, and angle iron.
- Large wind turbines may be mounted on lattice towers, tube towers or guyed tilt-up towers.

Operating Characteristics of wind mills

- All wind machines share certain operating characteristics, such as cut-in, rated and cut-out wind speeds.

Cut-in Speed:

- Cut-in speed is the minimum wind speed at which the blades will turn and generate usable power.
- This wind speed is typically between 10 and 16 kmph.

Rated Speed:

- The rated speed is the minimum wind speed at which the wind turbine will generate its designated rated power.

  For example, a "10 kilowatt" wind turbine may not generate 10 kilowatts until wind speeds reach 40 kmph.
- Rated speed for most machines is in the range of 40 to 55 kmph.

Operating Characteristics of wind mills-1

- At wind speeds between cut-in and rated, the power output from a wind turbine increases as the wind increases.
- The output of most machines levels off above the rated speed. Most manufacturers provide graphs, called "power curves," showing how their wind turbine output varies with wind speed.

Cut-out Speed:

- At very high wind speeds, typically between 72 and 128 kmph, most wind turbines cease power generation and shut down.
- The wind speed at which shut down occurs is called the cut-out speed.
- Having a cut-out speed is a safety feature which protects the wind turbine from damage.
- Shut down may occur in one of several ways. In some machines an automatic brake is activated by a wind speed sensor.

Operating Characteristics of wind mills-2

- Some machines twist or "pitch" the blades to spill the wind.
- Still others use "spoilers," drag flaps mounted on the blades or the hub which are automatically activated by high rotor rpm's, or mechanically activated by a spring loaded device which turns the machine sideways to the wind stream.
- Normal wind turbine operation usually resumes when the wind drops back to a safe level.

Betz Limit:

- It is the flow of air over the blades and through the rotor area that makes a wind turbine function.
- The wind turbine extracts energy by slowing the wind down.

Operating Characteristics of wind mills-3

- The theoretical maximum amount of energy in the wind that can be collected by a wind turbine's rotor is approximately 59%.
- This value is known as the Betz limit. If the blades were 100% efficient, a wind turbine would not work because the air, having given up all its energy, would entirely stop.
- In practice, the collection efficiency of a rotor is not as high as 59%. A more typical efficiency is 35% to 45%.
- A complete wind energy system, including rotor, transmission, generator, storage and other devices, which all have less than perfect efficiencies, will deliver between 10% and 30% of the original energy available in the wind.