2.3 Components of Wind Power Plants:

Wind energy systems include the following major components

- the rotor and its blades
- the hub assembly
- the main shaft
- the gear box system
- main frame
- transmission
- yaw mechanism
- over speed protection
- electric generator
- Nacelle
- yaw drive
- power conditioning equipment
- Tower

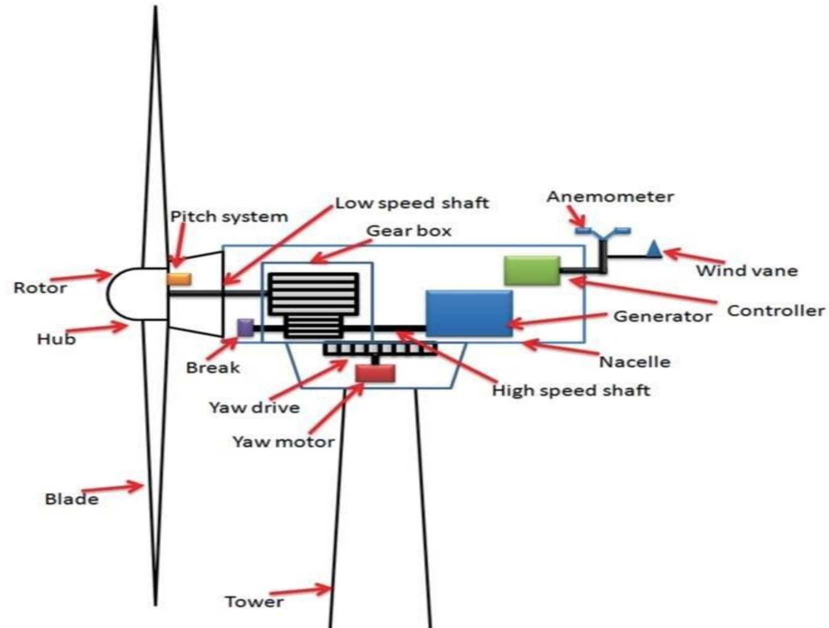

Figure: 2.3.1

[Source: "Solar Photovoltaics: Fundamentals,Technologies andApplications" by ChetanSingh Solanki, Page: 152]

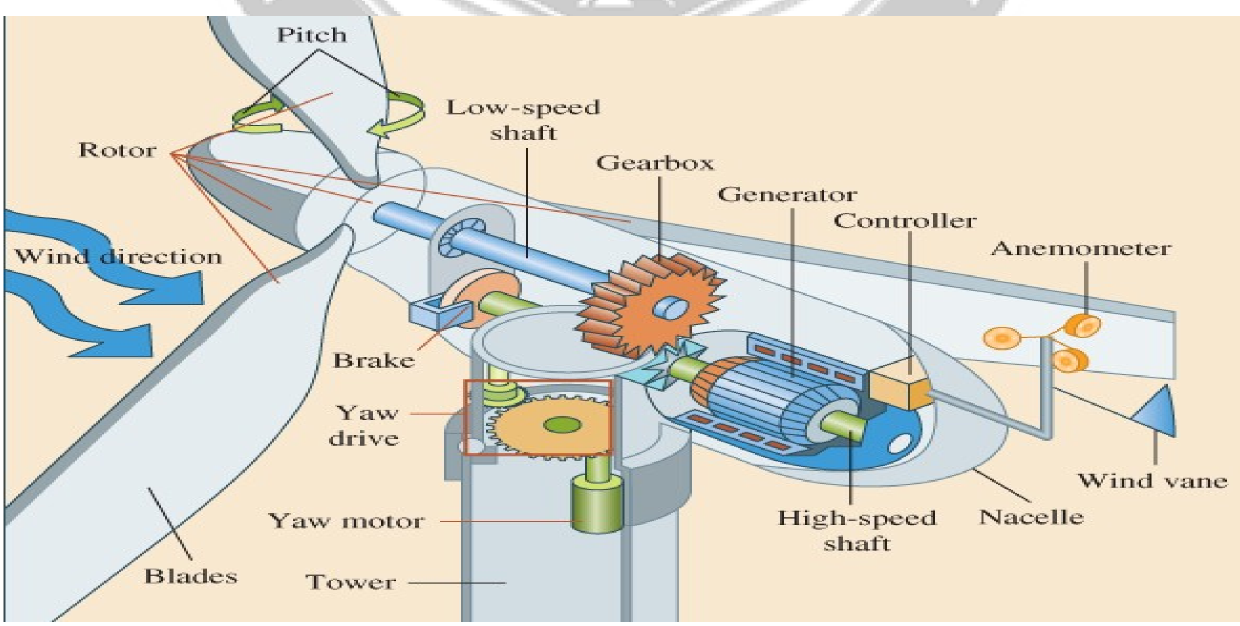

Figure: 2.3.2

[Source: "Solar Photovoltaics: Fundamentals,Technologies andApplications" by ChetanSingh Solanki, Page:154]

- Early wind machines ranged in their rated powers from 50 to 100 kW, with rotor diameters from 15 to 20 meters. Commercial wind turbines now have ratings over 1 MW and machines for the land based and offshore applications have rated power outputs reaching 5 and even 7-10 MW of rated power for off-shore wind applications.
- Larger sizes are mandated by two reasons. They are cheaper and they deliver more energy. Their energy yield is improved partly because the rotor is located higher from the ground and so intercepts higher velocity winds, and partly because they are more efficient. The productivity of the 600 kW machines is around 50 percent higher than that of the 55 kW machines. Reliability has improved steadily with wind turbine manufacturers guaranteeing availabilities of 95 percent.
- Wind energy systems include the following major components: the rotor and its blades, the hub assembly, the main shaft, the gear box system, main frame, transmission, yaw mechanism, overspeed protection, electric generator, nacelle, yaw drive, power conditioning equipment, and tower
- The nacelle is the housing that protects the main frame and the components attached to it. This enclosure is particularly important for wind electric systems, but does not exist in water pumping machines.

HUB ASSEMBLY AND MAIN SHAFT

- The blades are attached by a hub assembly to a main shaft. The main shaft rotates in bearings supported in the main frame. If the blades are designed for pitch control, the hub can be fairly intricate. With fixed pitch, attachment is relatively simple.

- The main frame of the wind machine serves as the point of attachment for various components, such as the main shaft, transmission, generator, and nacelle. It usually contains a yaw bearing assembly.

TRANSMISSION MECHANISM:

A transmission assembly consisting of a gear box or chain drive is required to properly match the rotational speed to the desired speed of the electric generator, or air compressor because the rotational speed of the rotor does not match that of the pump or electric generator to which it is to be connected.

YAW MECHANISM:

- Horizontal axis machines must be oriented to face the wind by a process called yawing. Upwind machines with blades upwind of the tower incorporate instead a tail vane, small yaw rotors or fantails, or a servo mechanism to ensure that the machine always faces upwind.
- Downwind machines with blades downwind of the tower have the blades tilted slightly downwind or coned so that they simultaneously act as a tail; this angle ensures proper orientation.
- Vertical axis machines are affected by the wind from all directions and thus do not need yaw control.

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ELECTRIC GENERATOR:

- Variable speed machines are common and most generate power using an AC/DC/AC system. Variable speed brings several advantages. It means that the rotor turns more slowly in low wind, which keeps the noise level down. It reduces the loadings on the rotor and the power conversion system is usually able to deliver current at any specified power factor.
- Some manufacturers build direct drive machines, without a gearbox. These are usually of the variable speed type, with power conditioning equipment.

- The electric generator in a wind machine is attached to the main support frame and coupled to the high speed end of the transmission shaft. Alternating current generators often run at 1,800 rpm in the USA or 1,500 rpm in much of the world to maintain system frequencies of 60 Hz and 50 Hz, respectively. The most popular types are:
- For small independent wind systems, Direct Current (DC) generator alternators with built-in rectifier diodes are often used to change AC to DC.
- For larger independent systems, or those that are run in conjunction with a small diesel electric grid, synchronous generators are common. These machines produce Alternating Current (AC) and must be able to be regulated precisely, to ensure proper frequency control and matching.
- Wind machines connected to a utility grid may have induction generators. These induction machines produce AC current, but are electrically much simpler to connect to a grid than a synchronous generator. They normally require a utility connection to maintain the proper frequency and cannot operate independently without special equipment.

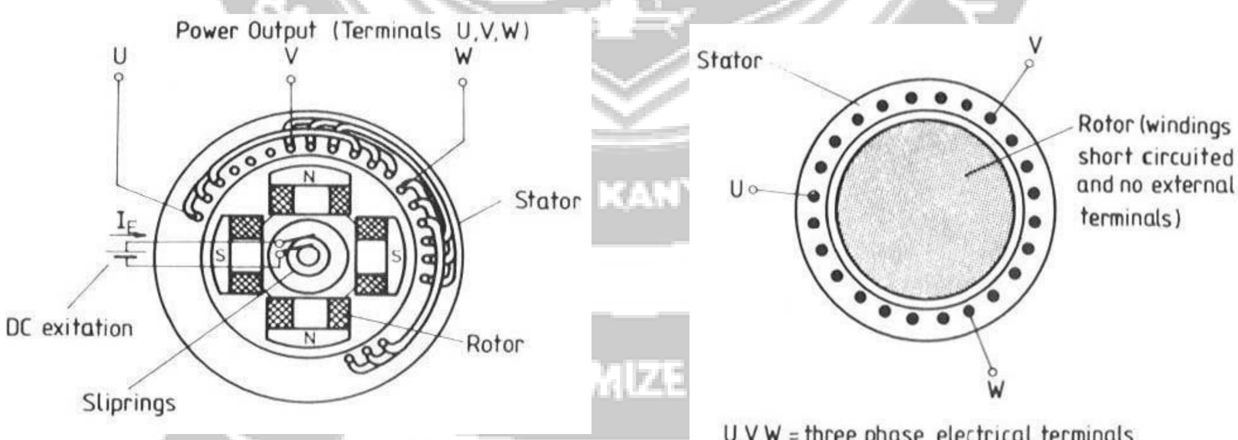

Figure 2.3.3 Wiring of three phase synchronous generator & Induction three-phase asynchronous generator

[Source: "Solar Photovoltaics: Fundamentals,Technologies andApplications" by ChetanSingh Solanki, Page: 142]

ELECTRIC POWER CONDITIONING EQUIPMENT, INVERTER:

- The need for electrical equipment in addition to the generator will depend primarily on the type of generator. For small DC systems, at least a voltage regulator is needed. Battery storage is often used to provide energy in times of low winds.

- An inverter to convert DC to AC is used if some of the load requires alternating current.

- Because the mains grid operates on AC current, it is important that the current fed into the mains grid is properly synchronized. This is a key role of the inverter system.

- The inverter system is also designed to cut the power to the mains grid in the event that the mains grid connection is lost. This is a safety feature for the electrical utility workers.

- For grid connected systems, a control panel is needed that will typically include circuit breakers, voltage relays, and reverse power relays. Synchronous machines require special synchronizing equipment and frequency relays.

STRUCTURAL TOWER

- A structural tower is needed to get the wind machine up into the air, away from the slower and more turbulent winds near the ground. A wind machine should be at least 10 m higher than any obstructions in the surroundings such as trees.
- Small wind machines towers are typically of truss design or of poles supported by guy wires. Guy wires are cables attached to the tower and anchored in the ground so that the tower will not move or shake from the force of the wind.

- Large wind machines towers are usually made of steel and the great majority is of the tubular or conical type. Some towers have been built out of reinforced concrete sections. Lattice or truss towers, common in the early days are now rare, except for very small machines in the range 100 kW and below. Guyed pole towers are used for small wind machines.

- Towers must be designed to resist the full thrust produced by an operating windmill or a stationary wind machine in a storm. Special concern must be given to the possibility of destructive vibrations caused by a natural frequency mismatch between the wind machine and tower.