SOLUTION FOR RENEWABLE ENERGY SOURCES – 8TH SEMESTER EEE

INTERNAL TEST -2

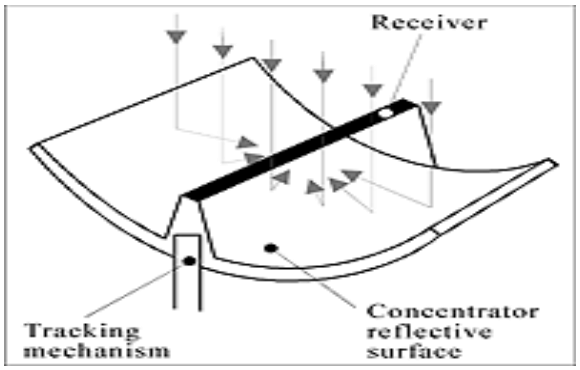
Answer any Five FULL Questions

1. There are four basic types of concentrating collectors:

- Parabolic trough system
- Parabolic dish
- Central tower collector
- Stationary concentrating collectors

Parabolic Trough System

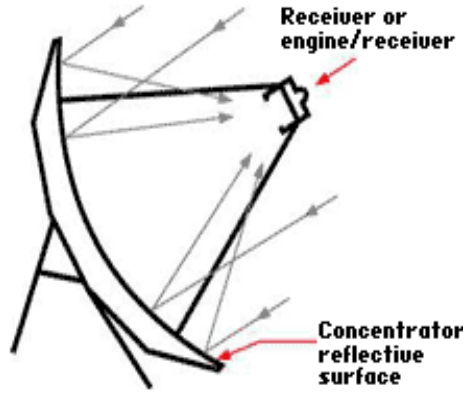
Parabolic troughs are devices that are shaped like the letter "U". The troughs concentrate sunlight onto a receiver tube that is positioned along the focal line of the trough. Sometimes a transparent glass tube envelops the receiver tube to reduce heat loss . Temperatures at the receiver can reach *400 °C* and produce steam for generating electricity. In California, multi-megawatt power plants were built using parabolic troughs combined with gas turbines.



Parabolic Dish Systems

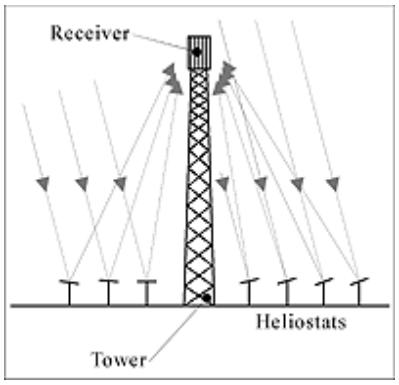
A parabolic dish collector is similar in appearance to a large satellite dish, but has mirror-like reflectors and an absorber at the focal point. It uses a dual axis sun tracker. A parabolic dish system uses a computer to track the sun and concentrate the sun's rays onto a receiver located at the focal point in front of the dish. In some systems, a heat engine, such as a Stirling engine, is linked to the receiver to generate

electricity. Parabolic dish systems can reach 1000 °C at the receiver, and achieve the highest efficiencies for converting solar energy to electricity in the small-power capacity range.



Central Tower Collector System

A heliostat uses a field of dual axis sun trackers that direct solar energy to a large absorber located on a tower. To date the only application for the heliostat collector is power generation in a system called the power tower. A power tower has a field of large mirrors that follow the sun's path across the sky. The mirrors concentrate sunlight onto a receiver on top of a high tower. A computer keeps the mirrors aligned so the reflected rays of the sun are always aimed at the receiver, where temperatures well above 1000°C can be reached. High-pressure steam is generated to produce electricity.



Stationary Concentrator Collectors

Stationary concentrating collectors use compound parabolic reflectors and flat reflectors for directing solar energy to an accompanying absorber or aperture through a wide acceptance angle. This class of collector includes parabolic trough flat plate collectors, flat plate collectors with parabolic boosting

reflectors, and solar cooker. Development of the first two collectors has been done in Sweden. Solar cookers are used throughout the world, especially in the developing countries.

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2. A greenhouse(also called a glasshouse) is a structure with walls and roof made chiefly of transparent material, such as glass in which plants requiring regulated climatic conditions are grown. These structures range in size from small sheds to industrial sized buildings. A green house is an enclosure where proper environment is provided for growth and production of crops, vegetables and flower plants under adverse climatic conditions.

   Types of Green House

   Winter GreenHouse

- ✓ A south facing wall and roof is provided with double glazing.
- ✓ A north facing roof is made of insulating material with reflecting inner lining to reflect solar radiation on the plant canopy.
- ✓ The frame of the entire green house is made up of wood.
- ✓ The east and west facing walls are provided with a single layer of rigid transparent fibre glass sheets.
- ✓ In some designs pipes are buried in the soil under the plants to store surplus thermal energy during day time.
- ✓ Air from the growing area is blown out through these pipes at the time of surplus heat to store the excess heat in the ground.
- ✓ At night, the heat is recovered by reversing the direction of air flow through these pipes.

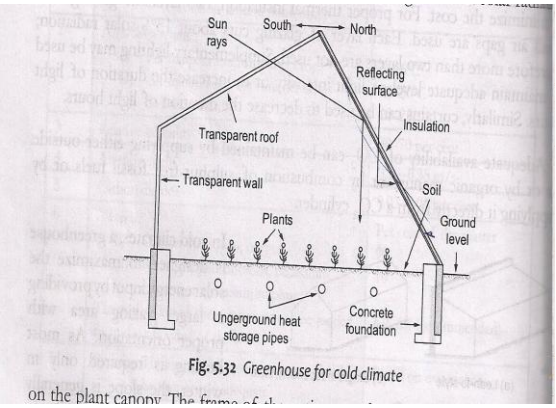

Fig. 5.32 Greenhouse for cold climate

on the plant canopy. The frame of

Summer Greenhouse

- ➢ In a summer green house, the most important requirements are maintaining moderate temperature by reducing cooling loads and also to provide adequate solar radiation.

- A south facing wall is provided with double glazing, covered with white thick movable insulating blocks.
- These blocks can be selectively moved to admit only absolutely essential solar radiation whenever needed.
- Sunlight is allowed to enter only in the morning and evening hours.
- Solar radiation can also be admitted through east and west transparent walls of the greenhouse whenever required by removing plywood sheets covering these walls.
- The north facing wall is made of insulating material like plywood with reflective lining on the inner side to reflect solar radiation on the plant canopy.
- A part of the greenhouse is also sunken in the ground to take advantage of the low and constant ground temperature.
- Windows on the north and south walls are used for cooling through a natural convection process when the outside temperature is not very high.
- When the outside temperature becomes very high, south wall windows are closed and evaporative cooling is used by drawing the outside air through wet pads using a powerful blower.

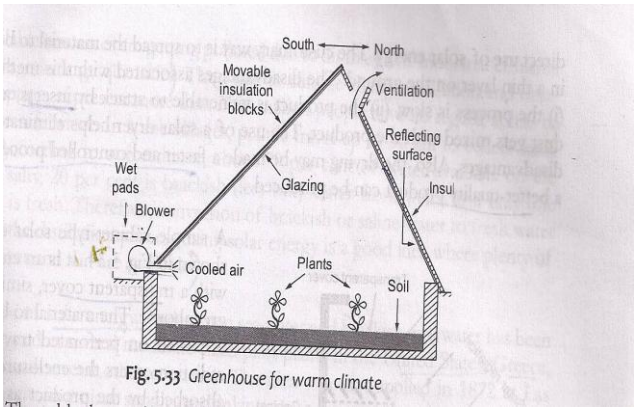

Fig. 5.33 Greenhouse for warm climate

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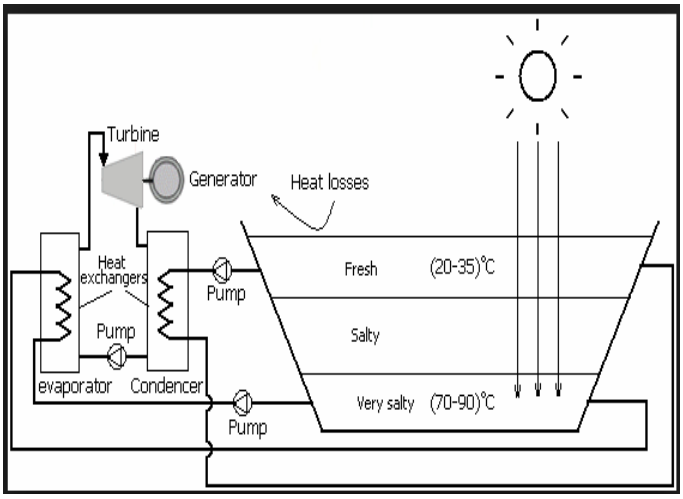
3. Working of a Solar Pond Electric Power Plant

A Solar Pond is a body of water that collects and stores thermal energy. A Solar Pond can be used for various applications such as process heating, desalination, refrigeration, drying and solar power generation.

Working Principle of Solar Pond

- It is well-known that, when water or air is heated they become lighter and rise upward.

- Similarly, in an ordinary pond, the sun's rays heat the water and the heated water from within the pond rises and reaches the top but loses the heat into the atmosphere.
- The net result is that the pond water remains at the atmospheric temperature.
- The solar pond restricts this tendency by dissolving salt in the bottom layer of the pond making it too heavy to rise.
- The solar pond possesses a thermal storage capacity spanning the seasons.
- The surface area of the pond affects the amount of solar energy it can collect.
- The bottom of the pond is generally lined with a durable plastic liner made from material such as *black polythene* and *hypalon reinforced with nylon mesh.*
- This dark surface at the bottom of the pond increases the absorption of solar radiation.
- Salts like *magnesium chloride*, *sodium chloride* or *sodium nitrate* are dissolved in the water, the concentration being densest at the bottom (20% to 30%) and gradually decreasing to almost zero at the top.
- Typically, a salt gradient solar pond consists of *three zones*



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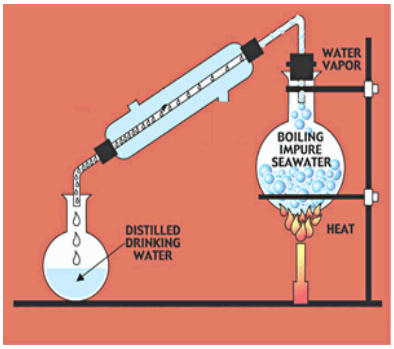
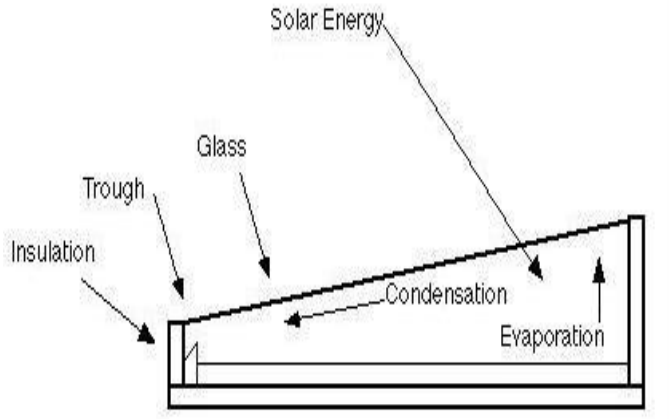
4. Working of a Solar Still

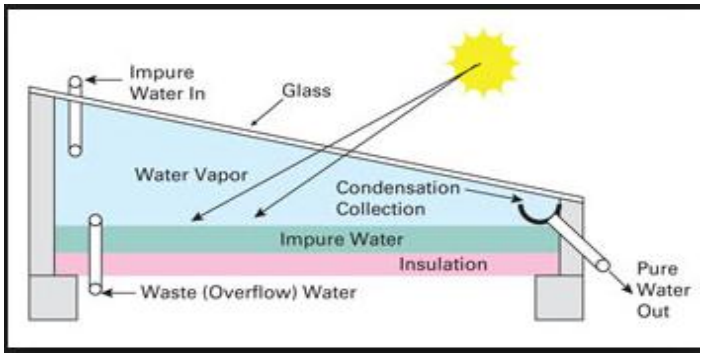
Process that removes impurities & contaminants

- Heat water to point of vaporization
- Water vapor condenses on cooler surfaces
- Condensate runs off into collection bin





- Solar still is called as “still” as they distill or purify the contaminated water.
- It works on the same principle as rain water: evaporation and condensation.
- The water from the ocean evaporates, only to cool, condense and return to earth as rain.
- When the water evaporates it removes only pure water and leaves all the contaminants behind.
- Solar stills mimic this natural process.



- The raw water supply is distributed through the jet tube and wicks in the soakage shield.
- In the distillation reservoir the raw water is led through a soakage filter and is heated up to 100˚C.

- About 50-70% is evaporated and will be condensed again. 30-50% remain as sewage water.
- The condensation is pure water. All the harmful agents and minerals stay in the unevaporized water and will be flushed out of the collector along with the sewage water.
- The condensate runs into the collecting channel. It drips from a trickling filter into the lower condensate channel.
- The product is now pure water which can be used for drinking and other industrial purposes.
- The sewage water can be used for plant irrigation with higher tolerance for salt.

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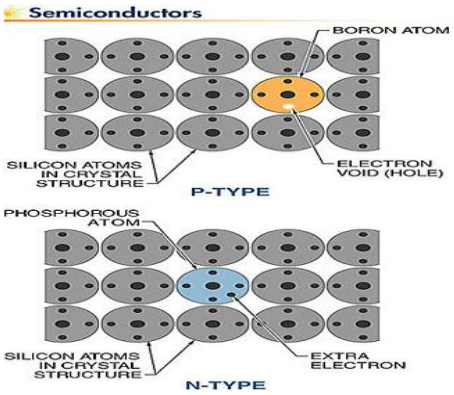
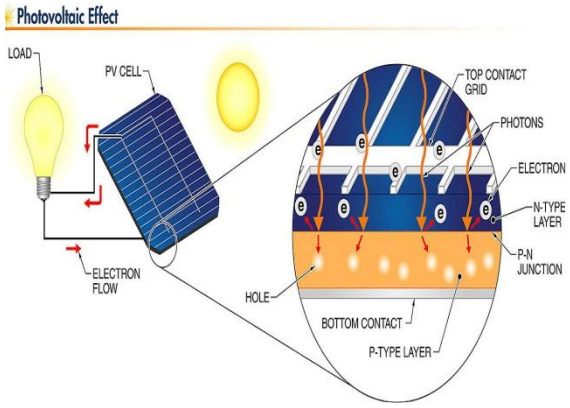
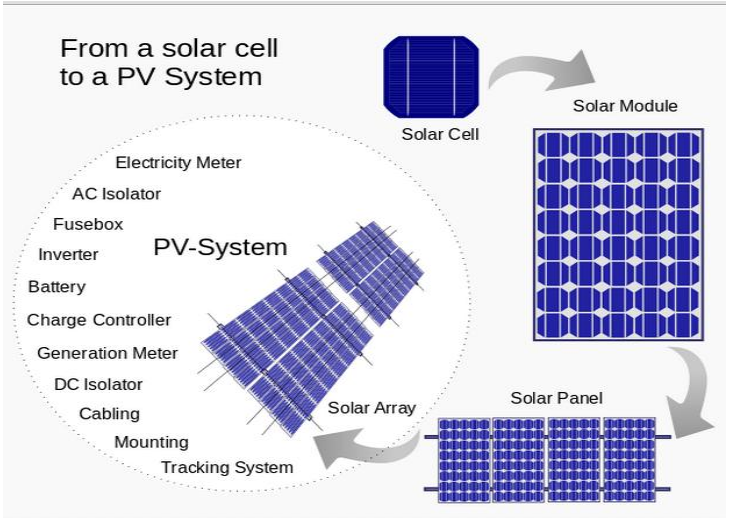
5. The basic building blocks for PV systems include cells, modules, and arrays. Semiconductor materials with special electrical properties can be made by adding small amounts of other elements to silicon crystals. The photovoltaic effect produces free electrons that must travel through conductors in order to recombine with electron voids, or "holes."





Solar PV System Components

- Modules – solar electric collectors. 3 basic types in the marketplace: Mono crystalline, poly crystalline, thin film.
- Array – modules connected together into a system.
- Inverter – converts the DC power produced by the modules to A/C.
- Grid Tie Inverter – converts DC to AC and feeds the utility grid with the A/C power.
- Charge Controller – regulates the power going to the batteries.
- Batteries – stores DC power.



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6. Principle and Working of a Central Tower Collector System

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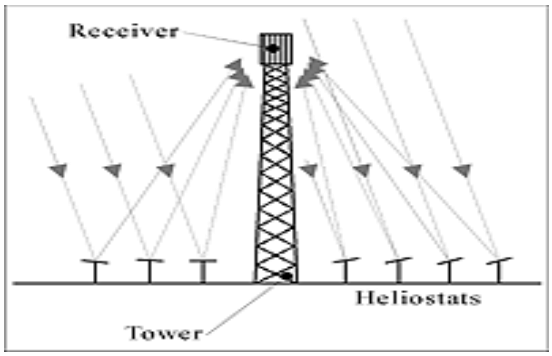
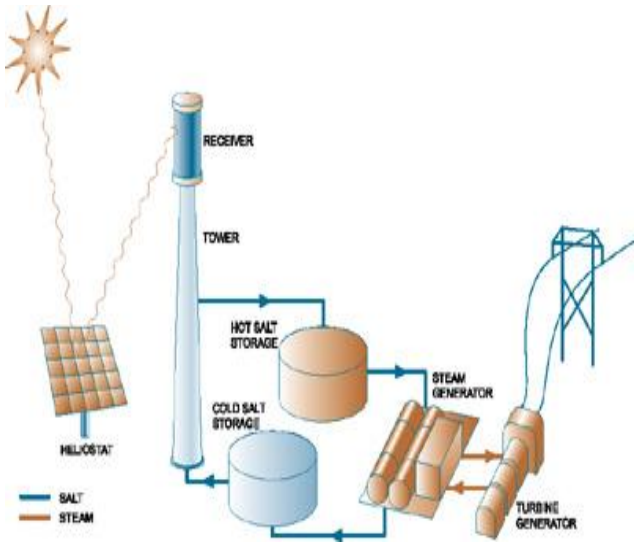


A power tower has a field of large mirrors that follow the sun's path across the sky. The mirrors concentrate sunlight onto a receiver on top of a high tower. A computer keeps the mirrors aligned so the reflected rays of the sun are always aimed at the receiver, where temperatures well *above 1000°C* can be reached. High-pressure steam is generated to produce electricity. .

- Central receivers (or power towers) use thousands of individual sun-tracking mirrors called "heliostats" to reflect solar energy onto a receiver located on top of tall tower.
- The receiver collects the sun's heat in a heat-transfer fluid (molten salt) that flows through the receiver.
- The salt's heat energy is then used to make steam to generate electricity in a conventional steam generator, located at the foot of the tower.
- In this system, molten-salt is pumped from a “cold” tank at 288 ˚C and cycled through the receiver where it is heated to 565 ˚C and returned to a “hot” tank.
- The hot salt can then be used to generate electricity when needed. Current designs allow storage ranging from 3 to 13 hours .



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7. Renewable energy is often intermittent (like wind and sun), and storage allows use at a convenient time. Compressed air, flywheels, weight-shifting (pumped water storage) are developing technologies. Batteries are traditional for small systems and electric vehicles; grid storage is a financial alternative.

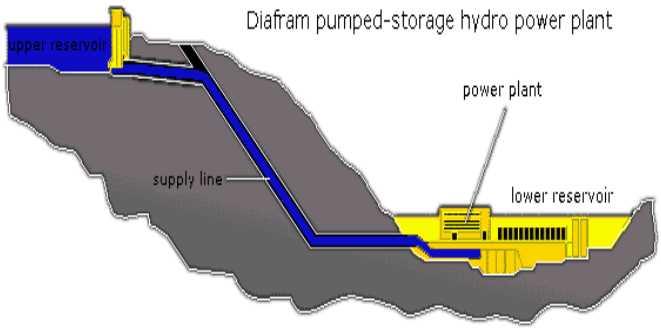
   Mechanical energy storage – Types of storage

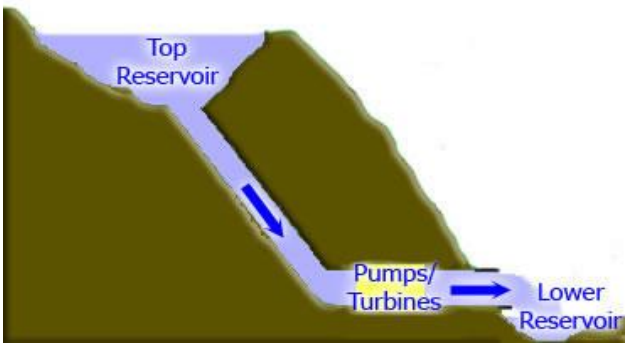
   1) Pumped storage

   2) Compressed air storage

3) Flywheel storage

Pumped Storage

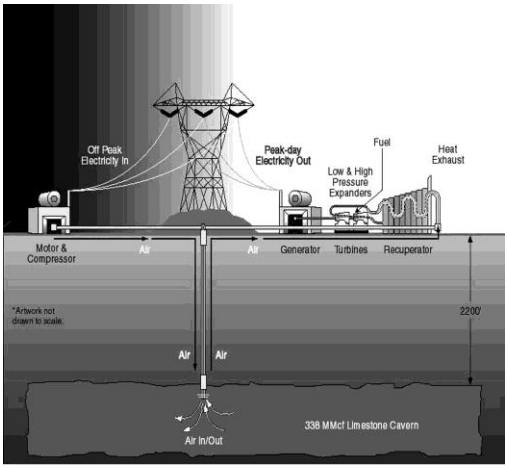




- In most pumped storage plants, the turbine generator system is irreversible.
- The overall pumped storage ,for pump water is producing 60% of electricity.

Compressed Air Storage

The world's first compressed air energy storage plant was in Germany," Lee Davis (plant manager for the Compressed Air Energy Storage (CAES) Power Plant in McIntosh, Alabama). "The Alabama CAES plant was the first in the United States when it opened in 1991.“ Compressed air reservoir probably be too large and expensive. so underground one is preferable considered.



Fly wheels and Trains

This trackside flywheel system provides stabilization of voltages on the track system by being both motor and generator. Similar types are used to stabilize renewable energy outputs. Buses have been operated that use flywheels charged by electricity at the bus stops, thus avoiding the cost of overhead trolley wires.

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8. Wind Energy Conversion System(WECS)

A wind energy conversion system converts wind energy into some form of electrical energy.

Medium and large scale WECS are designed to operate in parallel with a public or local ac grid.

This is known as grid – connected system. A small system, isolated from the grid, feeding only to a local load is known as autonomous, remote, decentralized, stand alone or isolated power system.

General Block diagram of WECS

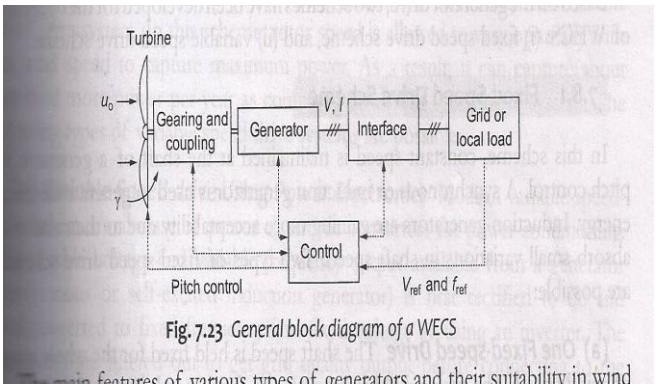

Fig. 7.23 General block diagram of a WECS

main features of various types of generators and their suitability in wind

- The turbine shaft speed is stepped up with the help of gears, with a fixed gear ratio to suit the electrical generator.
- Fine tuning of speed is incorporated by pitch control.
- This block acts as a drive for the generator.
- Use of variable gear ratio in the past was not beneficial.
- Hence DC, Synchronous or Induction generators are used for mechanical to electrical power conversion depending on the design of the system.
- The interface conditions the generated power to grid – quality power.
- It may consist of a power electronic converter, transformer and filter.

- The control unit monitors and controls the interaction among various blocks.
- It derives the reference voltage and frequency signals from the grid and receives wind speed, wind direction and wind turbine speed signals.
- The control unit processes them and accordingly controls various blocks for optimal energy balance.

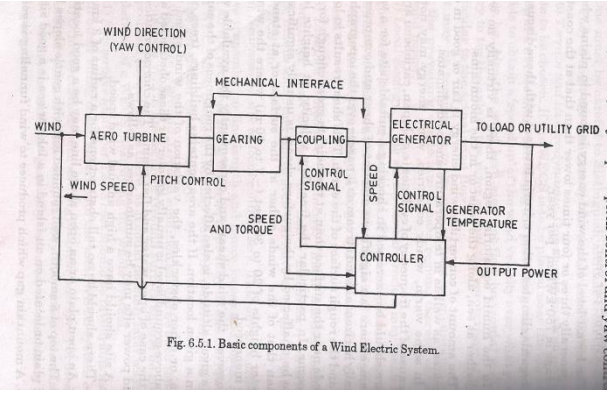

Fig. 6.5.1. Basic components of a Wind Electric System.

- Aeroturbines convert the energy in moving air to rotary mechanical energy.
- They require pitch control and yaw control(only in the case of horizontal or wind axis machines) for proper operation.
- A mechanical interface consisting of a step up gear and a suitable coupling transmits the rotary mechanical energy to an electrical generator.
- The output of this generator is connected to the load or power grid based on the application.
- Either constant or variable speed generators are used.
- Constant speed generators which are in use are Synchronous Induction motor and Permanent magnet motor types.

Yaw Control

- The rotor can be in a fixed orientation with the swept area perpendicular to the predominant wind direction.
- Such a machine is said to be yaw fixed.
- Most wind turbines are yaw active.
- In these turbines, as the wind direction changes, a motor rotates the turbine slowly about the vertical(yaw) axis so as to face the blades into the wind.
- The area of the wind stream swept by the wind rotor is then a maximum.

- In small machines, yaw action is controlled by a tail vane, similar to that in a typical pumping windmill.
- In large machines, a servomechanism operated by a wind direction sensor controls the yaw motor that keeps the turbine properly oriented.

----------(10 Marks)