Sources of energy - Thermal power generation

Objectives: At the end of this lesson you shall be able to
- **explain conventional and energy source**
- **state the various source of energy**
- **explain the working principle of thermal power station.**

Introduction of power generation

Energy is the basic necessity for the economic development of a country and it exists in different forms in nature. But the most important form is the electrical energy . The modern society is fully depend on the electrical energy and it has close relationship with standard of living. The per capita consumption of energy is the measure of standard of living of people.

Sources of electrical energy

Since electrical energy is produced from energy available in various forms in nature, it is desirable to look into the various sources of energy. The natural sources of energy which are used to generate the electricity are :

i Sun

ii Wind

iii Water

iv Fuels

v Nuclear energy

vi Tidal

Types of electrical power generation

Basically power generation are of two types

a Conventional power generation

Power generations by using non- renewable sources of energy through various methods such as hydro, thermal and nuclear etc is called conventional power generation. It contributes to the major power requirement.

b Non conventional power generation

Power generation by using renewable energy sources such as wind, Tide and sun etc, is called non-conventional power generation. They are small scale power generation used for specific purpose.

Generating stations

Bulk electric power is produced by special plants known as generating station or power plants. A generating station employs a prime mover coupled with an alternator or generator for the production of electric power. The generated power is further transmitted and distributed to the customers.

Depending upon the form of energy converted into electrical energy the generating station are classified into,

1 Steam power stations /Thermal power stations

2 Hydro - electric power stations

3 Diesel power stations

4 Nuclear power stations

5 Gas - turbine power stations

1 Thermal /steam power station

A generating station which converts the heat energy of coal combustion into electrical energy is known as a steam power station.

The scheme of generation can be divided into two phases (i) Formation of steam in the boiler house (ii) Generation of electrical power in the generator room.

In the boiler the fuel is burnt and the water is converted into high pressure steam which is further super heated in a super - heater. The super - heated steam is passed in to the turbine to rotate the turbine blades, thus it converts the heat energy into electrical energy.

The turbine is the generation room acts as a prime mover of the alternator which generates electric energy. The alternator is connected through the circuit breaker to the bus bars.

This type of power station is suitable where coal and water are available in abundance and a large amount of electric power is to be generated.

Choice of site for steam power stations

In order to achieve overall economy, the following points should be considered while selecting a site for a steam power station.

i **Supply of fuel :** The steam power station should be located near the coal mines so that transportation costs of fuel is minimum.

ii **Availability of water :** As huge amount of water is required for the condenser, therefore, such a plant should be located at the bank of a river or near a canal to ensure the continuous supply of water.

iii **Transportation facilities :** A modern steam power station often requires the transportation of materials and machinery. Therefore, adequate transportation facilities must exist. i.e., the plant should be well connected to other parts of the country by rail, road etc.

iv **Cost and type of land :** The steam power station should be located at a place where land is cheap and further extension, if necessary is possible.

v **Nearness to load centers:** In order to reduce the transmission cost, the plant should be located near the center of the load.

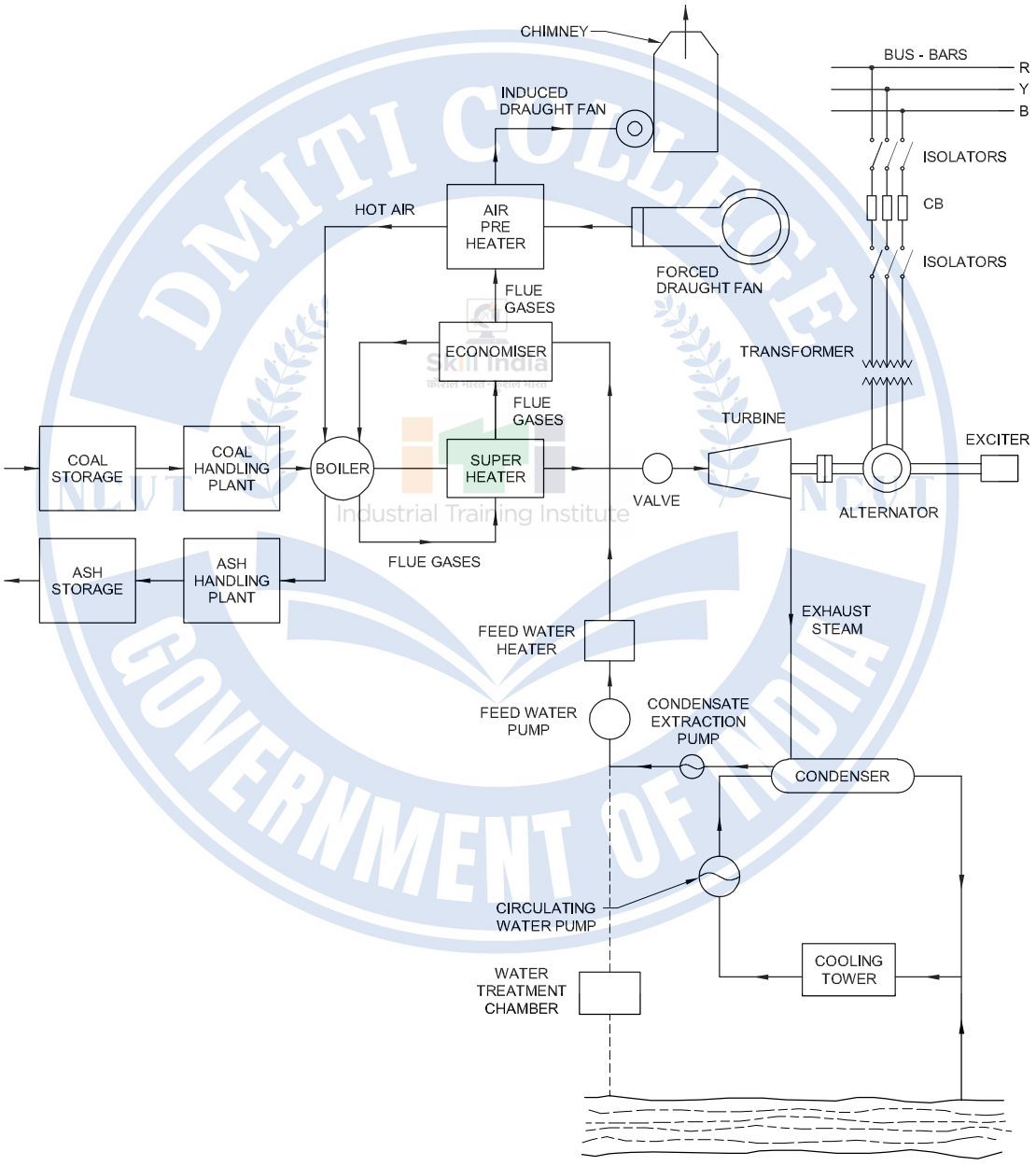
vi **Distance from populated area :** As huge amount of coal is burnt in a steam power station, therefore, smoke and fumes pollute the surrounding areas. This necessitates that the plant should be located at a considerable distance from the populated areas.

Schematic arrangement of steam power station

Although steam power station simply involves the conversion of heat of coal combustion into electrical energy, yet it embraces many arrangements for proper working and efficiency. The schematic arrangement of a modern steam power station is in Fig.1. The whole arrangement can be divided into the following stages for the sake of simplicity.

1 Coal and ash handling arrangement
2 Steam generating plant
3 Steam turbine
4 Alternator
5 Feed water
6 Cooling arrangement

Fig 1



SCHEMATIC ARRANGEMENT OF STEAM POWER STATION

Constituents in steam power station : A modern steam power station is highly complex and has numerous equipment and auxiliaries. However, the most important constituents of a steam power station are :

1 Steam generating equipment
2 Condenser
3 Prime mover

4 Water treatment plant

5 Electrical equipment

1 Steam generating equipment

This is an important part of steam power station. It is concerned with the generation of superheated steam and includes such items as boiler, boiler furnace, super heater, economizer, air pre-heater and other heat reclaiming devices.

i **Boiler :** A boiler is closed vessel in which water is converted into steam by utilizing the heat of coal combustion. Steam boilers are broadly classified into the following two types.

ii **Boiler furnace :** A boiler furnace is a chamber in which fuel is burnt to liberate the heat energy. In addition, it provides support and enclosure for the combustion equipment i.e burners. The boiler furnace walls are made of refractory materials such as fire clay, silica, kaolin etc. These materials have the property to resist change of shape, weight or physical properties at high temperatures.

iii **Super heater :** A super heater is a device which super heats the steam (i.e) it further raises the temperature of steam. This increases the overall efficiency of the plant.

iv **Economiser :** It is a device which heats the feed water on its way to boiler by deriving heat from the flue gases. This results in raising boiler efficiency, saving in fuel and reduces stresses in the boiler due to high temperature of feed water.

v **Air Pre-heater :** Super heaters and economizers generally cannot fully extract the heat from flue gases. Therefore, pre - heaters are employed which recover some of the heat in the escaping gases. The function of an air pre-heater is to extract heat from the flue gases and give it to the air being supplied to furnace for coal combustion.

2 Condensers

A condenser is a device which condenses the steam and the exhaust of turbine. It serves two important functions. Firstly, it creates a very low pressure at the exhaust of turbine, thus permitting expansion of the steam in the prime mover to a very low pressure. This helps in Converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler.

3 Prime movers

The prime mover converts steam energy into mechanical energy. There are two types of steam prime mover viz., steam engines and steam turbines. A steam turbine has several advantages over a steam engine as a prime mover viz., high efficiency, simple construction, higher speed, less floor area requirement and low maintenance cost. Therefore, all modern steam power stations employ steam turbines as prime movers.

Steam turbines are generally classified into two types according to the action of steam on moving blades viz.

a Impulse turbines

b Reaction turbines

4 Water treatment plant

Boilers require clean and soft water for longer life and better efficiency. However, the source of boiler feed water is generally a river or lake which may contain suspended and dissolved impurities, dissolved gases etc. Therefore, it is very important that water is first purified and softened by chemical treatment and then delivered to the boiler

Hydel power plants

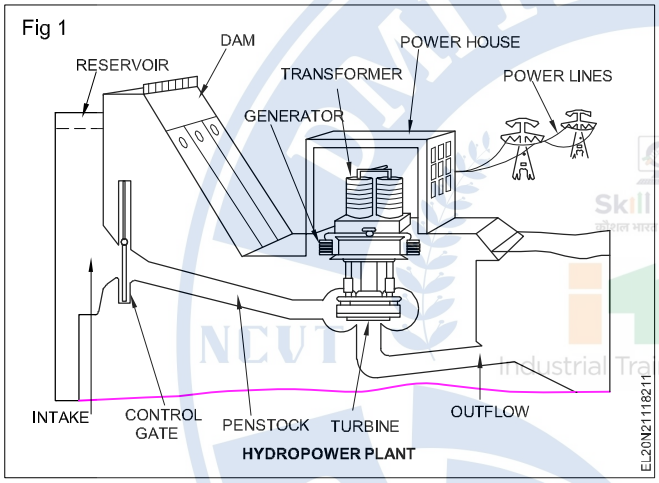
Objectives: At the end of this lesson you shall be able to
- **state the types of hydro- electric power station**
- **state the advantage & disadvantage of hydro electric power station over thermal power station**
- **list out the reason for selecting the site of a hydro electric power station**
- **explain the schematic arrangement of hydro electric power station**
- **state the turbines used in hydro electric power station with suitable reasons**
- **state the classification of hydro electric power station.**

Hydro - electric power stations

A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as "Hydro-electric power station".

A basic model of a H.E.P generation is illustrated in Fig 1 is known as hydro - electric power station.

Fig 1



Hydro - electric power stations are generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy (i.e product of head and flow of water) into mechanical energy at the turbine shaft.

The turbine drives the alternator which converts mechanical energy into electrical energy. Hydro electric power stations are becoming very popular because the reserves of fuels (i.e coal and oil) are depleting day by day.

Advantages

i It requires no fuel as water is used for the generation of electrical energy

ii It is quite neat and clean as no smoke or ash is produced

iii It requires very small running charges because water is the source of energy which is available free cost.

iv It is comparatively simple in construction and requires less maintenance.

Disadvantages

i It involves high capital cost due to construction of dam

ii There is uncertainly about the availability of huge amount of water due to dependence on weather conditions.

iii Skilled and experienced hands are required to build the plant

iv It requires high cost of transmission lines as the plant is located in hilly areas which are away from the consumers.

Choice of site for hydro - electric power stations

The following points should be taken into account while selecting the site for a hydro - electric power station

i **Availability of water :** Since the primary requirement of a hydro - electric power stations is the availability of huge quantity of water, such plants should be built at a place (e.g. river, canal) where adequate water is available at the good head.

ii **Storage of water :** There are wide variations in water supply from a river or canal during the year. This makes it necessary to store water by constructing a dam in order to ensure the generation of power throughout the year.

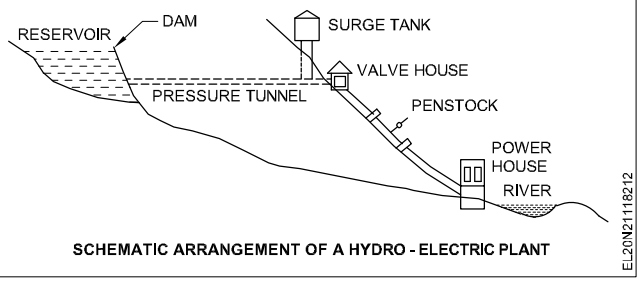
iii **Cost and type of land :** The land for the construction of the plant should be available at a reasonable price. Further, the bearing capacity of the ground should be adequate to withstands the weight of heavy equipment to be installed.

vi **Transportation facilities :** The site selected for hydro - electric plant should be accessible by rail and road so that necessary equipment and machinery could be easily transported

Schematic arrangement of hydro - electric power station (Fig 2)

The schematic arrangement of a modern hydro - electric plant is shown in Fig. 2. The dam is constructed across a river or lake and water from the catchment area collects at the back of the dam to form a reservoir. A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the Penstock.

Fig 2



SCHEMATIC ARRANGEMENT OF A HYDRO - ELECTRIC PLANT

The valve house contains main sluice valves and automatic isolating valves. The former controls the water flow to the power house and the latter cuts of supply of water flow to the power house when the penstock bursts. From the valve house, water is taken to water turbine through a huge steel pipe known as penstock . The water turbine converts hydraulic energy into mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy.

Constituents of Hydro - Electric Plant

The constituents of hydro - electric plant are (1) hydraulic structures (2) water turbines and (3) electrical equipment.

1 Hydraulic Structures

Hydraulic structures in a hydro electric power station include dam, spillways, headworks, surge tank, penstock and accessory works.

i **Dam :** A dam is a higher barrier which stores water and creates water head. Dams are built of concrete or stone masonry, earth or rock fill.

ii **Spillways :** There are times when the river flow exceeds the storage capacity of the reservoir. Such a situation arises during heavy rainfall in the catchment area. In order to discharge the surplus water from the storage reservoir into the river on the down - stream side of the dam, spillways are used.

iii **Headworks :** The headworks consists of the diversion structures at the head of an intake. They generally include booms and racks for diverting floating debris, sluices for by - passing the debris and sediments and valves for controlling the flow of water to the turbine. The flow of water into and through head works should be as smooth as possible to avoid the head loss and cavitation. For this purpose, it is necessary to avoid sharp corners and abrupt contractions or enlargements.

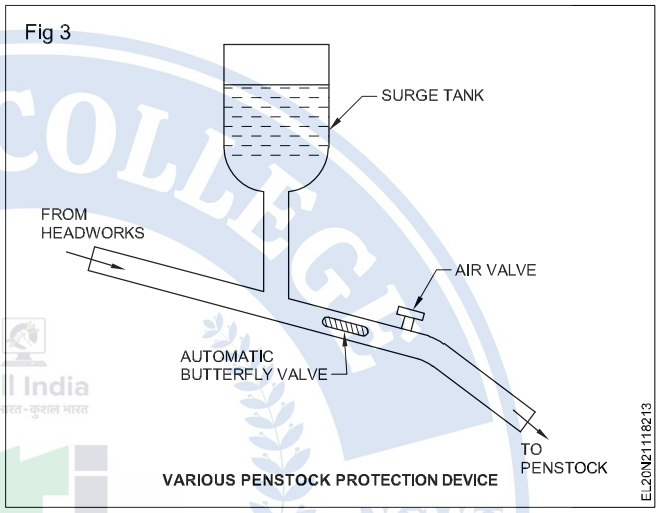
iv **Surge tank :** Open conduits which leading the water to the turbine require no protection. However, when closed conduits are used, protection becomes necessary to limit the abnormal pressure in the conduit. For this reason, closed conduits are always provided with a surge tank. a surge tank is a small reservoir or tank (open at the top) in which water level rises or fails to reduce the pressures swings in the conduit.

v **Pen stock :** Penstocks are open or closed conduits which carry water to the turbines. They are generally made of reinforced concrete or steel. The thickness of the Penstock increases with the head or working pressure

Various devices such as automatic butterfly valve, air valve and surge tank are provided for the protection of penstocks. Automatic butterfly valve shuts off water flow through the penstocks promptly of its ruptures. Air valve maintains the air pressure inside the penstock equal to outside atmospheric pressure.

When water run out of a penstock faster than it enters, a vacuum is created which may cause the penstocks to collapse. Under such situations, air valve opens and admits air in the penstock to maintain inside air pressure equal to the outside air pressure. A typical penstock protective device is in Fig 3.

Fig 3



VARIOUS PENSTOCK PROTECTION DEVICE

vi **Tail race** : The tail race is the channel which carries water (known as tail water) away from the power house after it has passed through the turbine.

vii **Draft tube :** In the case of a reaction turbine there is a pressure difference existing between water in the turbine and atmosphere. Therefore this type turbine must be completely enclosed. Accordingly it is necessary to connect the turbine outlet by means of a pipe or a passage of gradually increasing cross sectional area up to tail - race level.

A draft tube has two important purposes to serve.

1 It permits a negative or suction head to be established at the runner exit thus making it possible to install the turbine above the tail race level without loss of head.

2 It converts a large proportion of the velocity energy rejected from the runner into useful pressure head i.e it acts as a recuperator of pressure energy.

2 Water turbine

Water turbines are used to convert the energy of falling water into mechanical energy. The principal types of water turbines are :

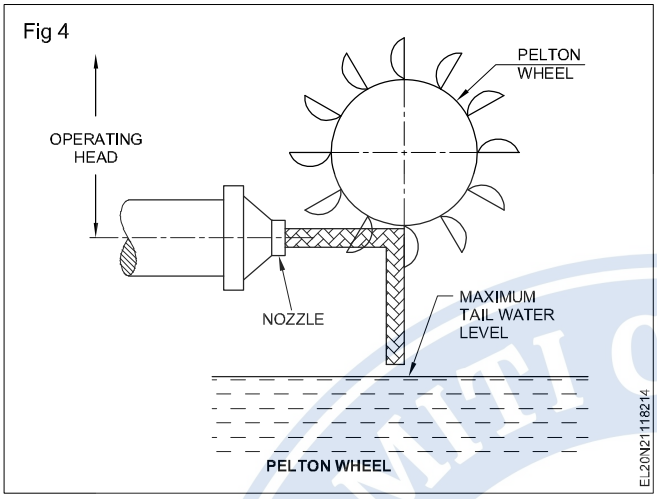
i Impulse turbines

ii Reaction turbines

i **Impulse turbines :** Such turbines are used for high heads. In an impulse turbines, the entire pressure of

water is converted into kinetic energy in a nozzle and the velocity of the jet drives the wheel i.e, pelton wheel as in Fig 4. It consists of a wheel fitted with elliptical buckets along it periphery. The force of water jet striking the bucket on the wheel drives the turbine. The quantity of water jet falling on the turbine is controlled by means of needle or spear (not shown in the figure) placed in the tip of the nozzle.

Fig 4



The movement of the needle is controlled by the governor. If the load on the turbine decreases the governor pushes the needle into the nozzle, there reducing the quantity of water striking the bucket. Reverse action takes place if the load on the turbine increases.

ii Reaction turbines : Reaction turbines are used for low and medium heads. In a reaction turbine water enters the runner partly with pressure energy and partly with velocity head. The important types of reaction turbine are.

a Francis turbines

b Kaplan turbines

A fancies turbine is used for low to medium heads. It consists of an outer ring of stationary guide blades for to the turbine casing and an inner ring of rotating blade forming the runner.

3 Electrical equipment

The electrical equipment of a hydro - electric power includes alternators, transformers, circuit breaker and switching and protective devices.

Types of hydro - electric plants

There are three different methods of classifying the electric plants. The classification may be based on,

a Quantity of water available

b Available head

c Nature of load

Classification of Hydro - electric plants according to quantity of water available

According to this classification, the plants may be divided into.

i Run - off river plants without pondage

ii Run - off river plants with pondage

iii Reservoir plants

i Run off river plants without pondage

As the name indicates this type of plant does not store water. The plant uses water as it comes. The plant can use water only as and when available.

ii Run- off river plants with pondage

Usefulness of a run - off river plant is increased by pondage. Pondage permits storage of water during the off - peak periods and use of this water during the peak periods.

iii Reservoir plants

Water is stored behind the dam and is available to the plant with control as required. Such a plant has better capacity and can be used efficiently throughout the year.

Classification of hydro - electric plants according to available head

Hydro - electric plants may be classified into high - head, medium - head and low head plants. A plant may be classified as high - head if operating on a head above 300 meters. Low - head plants work under heads below 30 metres. Medium - head plants are those lying between the above two classes.

Classification of Hydro- electric plants according to nature of load

Hydro - electric plants may be classified in to base load peak load and pumped storage plants for peak load.

Visiting to transmission and distribution sub station

Objectives: At the end of this lesson you shall be able to
- **state the initial preparatory work before commencing the visit**
- **explain the individual trainees main areas and its importance for preparation**
- **list out the supporting materials to carry for visit**
- **prepare a list of do's and dont's during visit.**

Introduction : A industrial visit is a very important step to tap actual working environments. During practical exercises practicing in the lab or workshop never provides actual working condition because it is a part of structure training planned to complete within a stipulated time and a assessment at later stage.

To understand the whole process from the concerned technician or operator, you must have a sound knowledge of that particular abject or process. You should prepare well to meet the challenge whenever you go industrial visit in a factory or sub station.

Preparation areas and its importance : If the process is complicated or multi level procedure involved; in that case trainees should be made small batches to interact or involve the whole process. In such cases each batch should be formed in advance and decided the section or part to be interacted. Finally all the batches together to make the end result.

When you visit a sub station collect the following:

1 Installed capacity of the sub station.
2 Maximum load demand**.**
3 Load factor .
4 Total number of transformers installed and its working conditions.
5 Location Map of the sub station and its surroundings.
6 Gather maximum information regarding transmission and distribution techniques other than guided or studied.
7 Maximum hazardous Area - PPE facility Emergency root in case of emergency.

Do's & Dont's

Do's

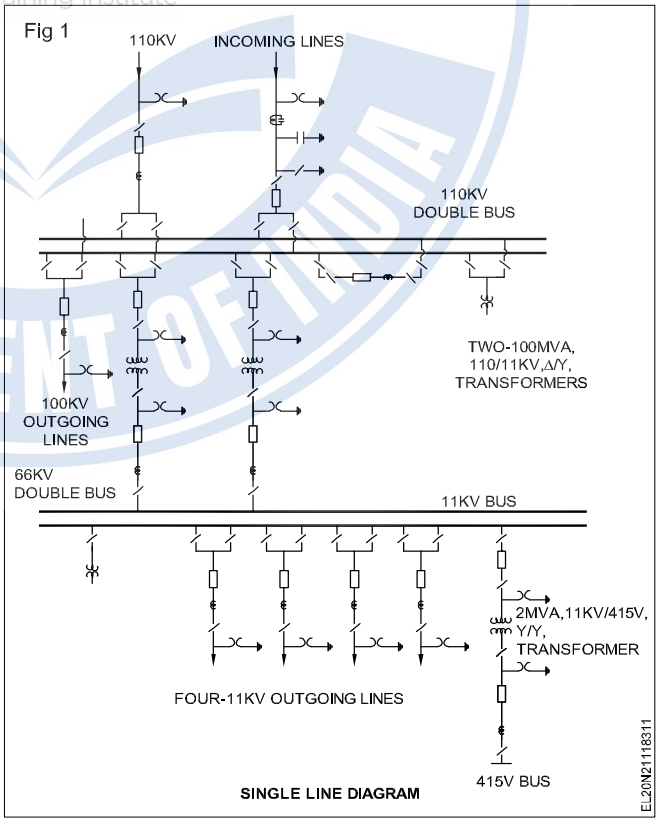
1 Wear uniform with name badge.
2 Ensure the protective gadgets are available otherwise carry them.
3 Follow the safety norms imposed in the particular areas, listen the instruction carefully.
4 Carry materials to record your findings and assessments to make then and their.
5 Follow strict discipline and punctuality .
6 Obey all the instructions and rules.
7 Walk in the prescribed areas only.

Dont's

1 Avoid wearing loose clothes and ornaments.
2 Not to carry any bag or attachments.
3 Do not cross-over any prohibited areas .
4 Do not operate, touch or play with any part or machine you pass over.
5 Do not sit or learn over any machine or place you come across.
6 Do not shout or make any unusual noises when the visit is in progress or inside the factory.
7 Do not involve any kind of horse play at the time of visiting various sections, areas.
8 Do not avoid or neglect any instruction passed on you at any time.

Fig 1 shows a typical single line layout diagram of a transmission and distribution substation.

Fig 1



Electrical substations

Objectives: At the end of this lesson you shall be able to
- **state the functions and purpose of electrical substations**
- **classify the different types of substation**
- **list out the equipment and components used in substation.**

Substations

Electric power is produced at the power generating stations, which are generally located far away from the load centers. Between the power generating station and consumers a number of transformations and switching stations are required. These are generally known as substations.

Substations are important part of power system and form a link between generating stations, transmission systems and distribution systems. It is an assembly of electrical components such as bus-bars, switch gear apparatus, power transformers etc.

Function

Their main functions are to receive power transmitted at high voltage from the generating stations and reduce voltage for switching operations of transmission lines. Substations are provided with safety devices to disconnect equipment or circuit at the time of faults.

Classification of substation

The substations may be classified in according to service requirements and constructional features. According to service requirements they are classified in to transformer substations, switching substations and converting substations.

1 **Transformer substations :** Majority of the substations in the power system are in this type. They are used to transform the power from one voltage level to another voltage level. Transformer is the main component in such substations. Transformer substations are further classified into step-up substations, primary grid substations, secondary substations and distribution substations.

   a **Step - up substations :** These substations are usually located at the generating stations. Generating voltage of the order of 11KV needs to be stepped up to a primary transmission voltage level of the order of 220KV or 400KV.

   b **Primary grid substations :** These substations are located at the end of primary transmission lines and the primary voltage is stepped down to suitable secondary voltages of the order of 66KV or 33KV.

   c **Secondary substations :** The voltage is further stepped down to 11KV. Large consumers are supplied with power at 11KV.

   d **Distribution substations :** These substations are located near the consumer localities to supply power at 415V three phase or 240V single phase to the consumers.

The parts, equipment and components installed in substation (Fig 1)

Each substation has the following parts and equipment.

Fig 1

1 **Outdoor switchyard**
- Incoming lines
- Outgoing lines
- Busbar
- Transformers
- Bus post insulator & string insulators
- Substation equipment such as circuit-breakers, isolators, earthing switches, surge arresters, CTs, PTs neutral grounding equipment
- Station earthing system comprising ground mat, risers, auxiliary mat, earthing strips, earthing spikes & earth electrodes.
- Overhead earthwise shielding against lightning strokes.
- Galvanized steel structures for lower equipment supports.
- PLCC equipment including line trap, tuning unit, coupling capacitor, etc.
- Power cables
- Control cables for protection and control
- Road, cable trenches
- Station illumination system

2 **6.6/11/22/33/66/132 KV switch gear LV**
- Indoor switch gear

3 **Switchgear and control panel building**
- Low voltage AC switchgear
- Control panels, protection panels

4 Battery room and DC distribution system

- DC battery system and charging equipment
- DC distribution system

5 Mechanical, electrical and other auxiliaries

- Fire fighting system
- D.G (Diesel Generator) set
- Oil purification system

Transmission substation

The three phase power leaves the generator and enters a transmission substation at the power plant. This sub station uses large transformers to convert or "step up" the generators voltage to extremely high voltages for long distance transmission on transmission grid. Typical voltages for long distance transmission are in the range of 220 KV to 400 KV. The higher the voltage the less energy is lost due to resistance.

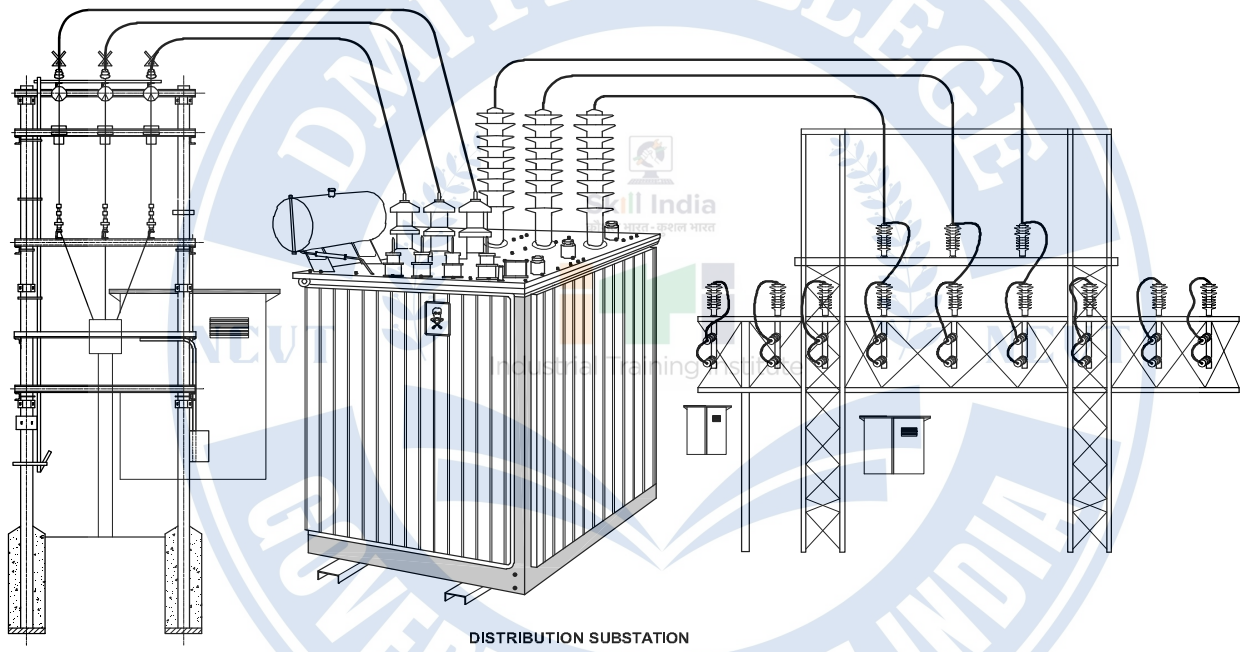
A typical maximum transmission distance is about 400 kilometres. High voltage transmission lines are quite obvious when you see them. They are huge steel towers string out in a line that stretches towards the horizon.

All high voltage towers have three wires for three phases. Many towers also have extra lines running along the top of the towers. These are ground wires and there are primarily in an attempt to attract lighting.

Distribution Substation (Fig 2)

Distribution substation typically operates at 11000 - 440V voltage levels, and deliver electric energy directly to industrial and residential consumers. Distribution feeders transport power from the distribution substations to the end consumers' premises. These feeders serve a large number of premises and usually contain many branches.

Fig 2



DISTRIBUTION SUBSTATION

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Distribution substation and its main components

At the consumers' premises, distribution transformers transform the distribution voltage to the service level voltage directly used in households and industrial plants, usually from 440 to 230 V.

Distribution substation is generally comprised of the following major components: (Fig 3)

1 Supply Line
2 Transformers
3 Busbars
4 Switchgear
5 Outcoming feeders
6 Switching apparatus
   a Switches
   b Fuses
   c Circuit breakers
7 Surge voltage protection
8 Grounding

1 Supply Line : Distribution substation is connected to a sub-transmission system via at least one supply line, which is often called a primary feeder. However, it is typical for a distribution substation to be supplied by two or more supply lines to increase reliability of the power supply in case one supply line is disconnected.

A supply line can be an overhead line or an underground feeder, depending on the location of the substation, with underground cable lines mostly in urban areas and overhead lines in rural areas and suburbs.

2 **Transformers :** Transformers "step down" supply line voltage to distribution level voltage. Distribution substation usually employs three-phase transformers.

3 **Busbars :** Busbars (also called buses) can be found throughout the entire power system, from generation to industrial plants to electrical distribution boards. Busbars are used to carry large current and to distribute current to multiple circuits within switchgear or equipment

4 **Switchgear :** Switchgear is a general term covering primary switching and interrupting devices together with its control and regulating equipment. Power switchgear includes breakers, disconnect switches, main bus conductors, interconnecting wiring, support structures with insulators, enclosures, and secondary devices for monitoring and control.

5 **Switching Apparatus :** Switching apparatus is needed to connect or disconnect elements of the power system to or from other elements of the system. Switching apparatus includes switches, fuses, circuit breakers, and service protectors.

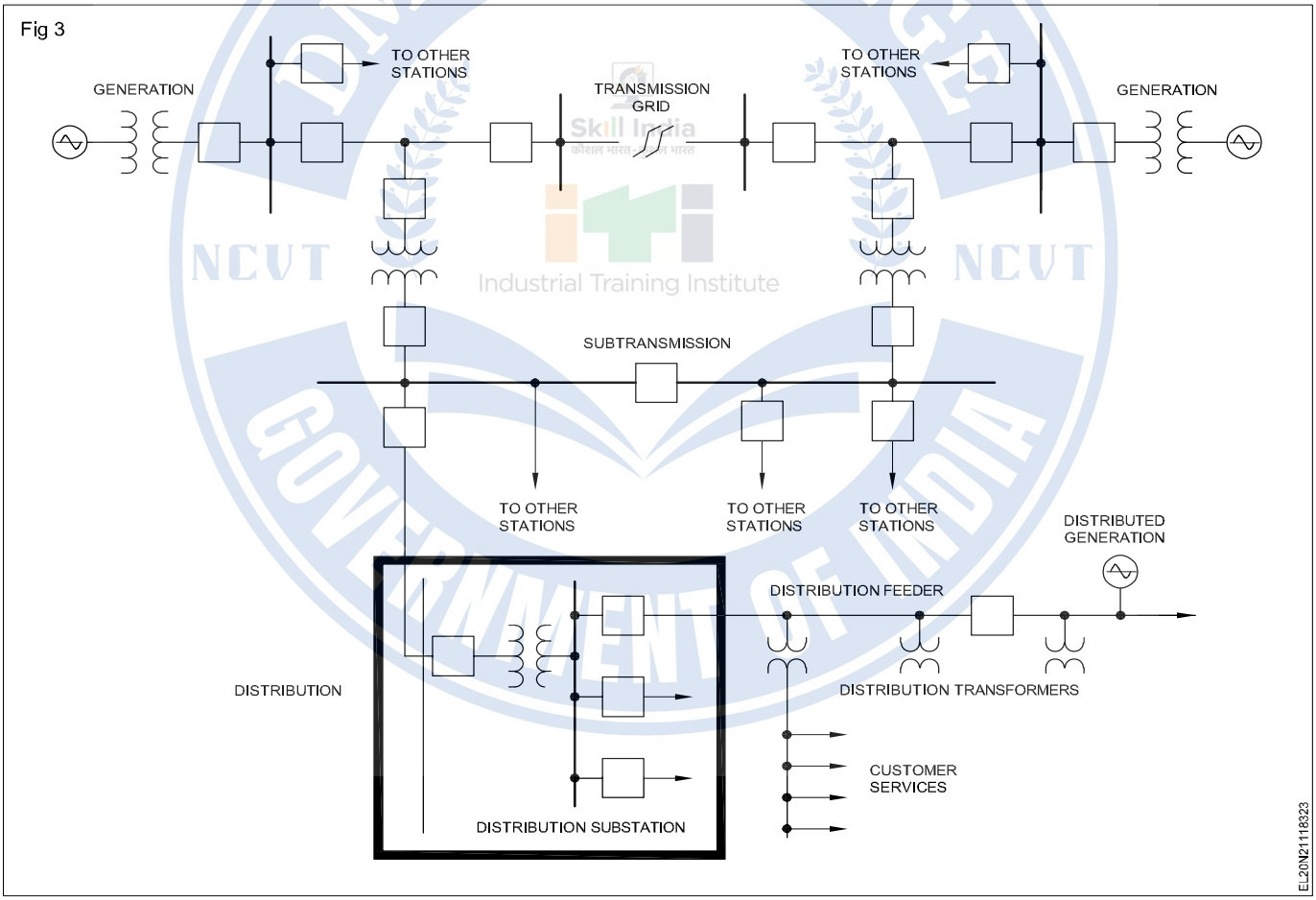
6 **Surge Voltage Protection :** Transient over voltages are due to natural and inherent characteristics of power systems. Over voltages may be caused by lightning or by a sudden change of system conditions (such as switching operations, faults, load rejection, etc.), or both. Generally, the overvoltage types can be classified as lightning generated and as switching generated.

7 **Grounding :** Grounding is divided into two categories: power system grounding and equipment grounding. electrical system grounding means that at some location in the system there are intentional electric connections between the electric system phase conductors and ground (earth).

Power system grounding

System grounding is needed to control overvoltages and to provide a path for ground-current flow in order to facilitate sensitive ground-fault protection based on detection of ground-current flow.

Fig 3



Circuit diagram of sub station and its components

Objectives: At the end of this lesson you shall be able to
- **explain the circuit diagram of a sub station**
- **explain components of sub station.**

Substation

The electrical substation can be defined as a network of electrical components comprising of power transformers, busbars, auxiliaries, and switchgear etc. The components are interconnected such that creating a sequence of a circuit capable to be switched OFF while running on normal operation through manual commands while in emergency situations it can be switched OFF automatically. The emergency situations may be an earthquake, floods, or short circuit etc.

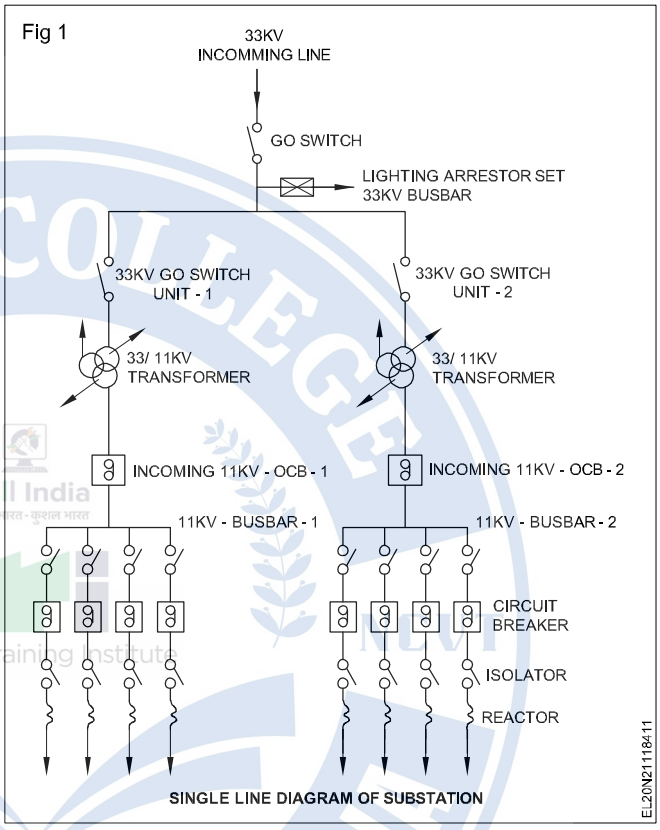
The electrical substation does not have a single circuit but is composed of numerous outgoing and incoming circuits which are connected to a busbar i.e. common entity among circuits. The substation receives electrical energy directly from generating stations through incoming power supply lines while it delivers electricity to the consumers through outgoing transmission lines. A substation which is near to the electrical power generation is also known as grid substation.

Major Tasks of Substations

There are numerous tasks associated with power substations in the distribution and transmission system. Some of the major tasks that substations perform are as follows.

- It serves as protection hub of the transmission system.
- It maintains the frequency of system confined in targeted limits and has to deal with load shedding.
- It controls the exchange of electrical energy amid consumers and generating stations.
- It is ensuring transient stability along with steady-state stability of the system.
- It delivers sufficient line capacity hence securing supply.
- It helps in reducing the flow of reactive power, hence gaining voltage control.
- Through line carrier, it performs data transmission to ensure monitoring of network, protection, and control.
- It helps in fault analysis and pinning cause for a failure, hence improving the performance of the electrical network.
- It ensures reliable supply through feeding network at numerous points.
- It assists in determining energy transfer with help of transmission lines.

Single Line Diagram of an Electrical Substation (Fig 1)



The single line diagram of the 33kv substation is depicted in the figure below. The connection of the substation is divided as

- Incoming or power feeder connection (33kv Incoming Line)
- Power transformer connection via Lighting Arrestor & Busbar
- Voltage transformer connection for control and metering.
- Outgoing feeder for feeding the other subsequent substations or switchgear.
- Circuit Breaker & Isolator between the incoming and the outgoing lines.

On the incoming 33kv incoming feeder line side, the transformer is connected to the bus bar and the lightning or surge arresters are connected as a phase to the ground as the initial connection equipment. A circuit breaker is connected between the 11kv bus-bar and each incoming and outgoing circuit with the support of the isolator being provided on each side of the circuit breaker.

Electrical power generation by non conventional methods

Objectives: At the end of this lesson you shall be able to
- **state the non - conventional energy**
- **explain the methods of generation power from bio-gas and tidal**
- **list out the merits and demerits of non-conventional power generation.**

Non - conventional energy

Energy generated by using wind, tides, solar, geothermal heat and biomass including farm and animal waste is known as non-conventional energy. All these sources are renewable or inexhaustible and do not cause environmental pollution.

Merits of non - conventional over conventional sources of energy

1 Provide more energy

2 Reduce security risk associated with the use of nuclear energy.

3 Reduce pollutants

4 Less running and maintenance cost

5 Never destroyed

6 Despite the high initial investment and several limitations, use of solar energy to meet our ever increasing energy demand seems to be the only answer.

7 Green house effect and global warming is avoided

8 Less environment problems.

Demerits of non conventional over conventional sources of energy

1 Many non- conventional sources are still in their infant stages and required a lot of development efforts.

2 High initial cost

3 Less reliable and efficiency

4 Can not be used for base load demand.

Bio-gas power generation

The method of generating the electrical energy by using bio-gas is termed as bio-gas power generation.

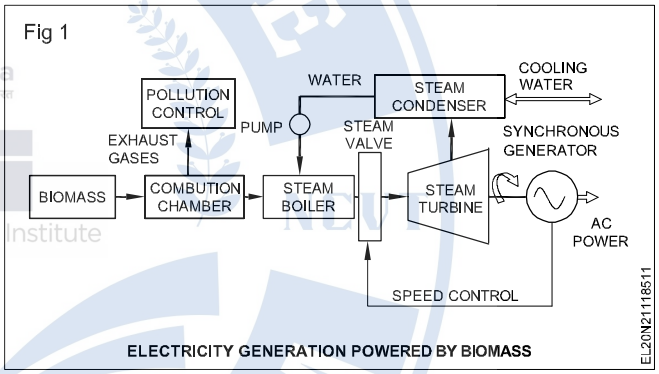
Bio-gas

Biogas is a good fuel. Bio mass like animal excreta, vegetable wastes and seeds undergo decomposition in the absence of oxygen in a biogas plant and form a mixture of gases. This mixture is the **biogas**. Its main constituent is methane. This is used as a fuel for cooking and lighting.

Electricity generating plant

Generating plant fuelled by biomass uses conventional steam turbine as used in thermal power stations with modifications to the combustion chamber and fuel handling systems to handle the bulkier fuel. The schematic arrangement is in Fig 1.

Fig 1



ELECTRICITY GENERATION POWERED BY BIOMASS

Co - generation

Because of the poor energy conversion efficiencies of biomass fuels, practical generating systems often employ a co-coal generation to achieve reasonable utilization of the generating plant.

Environmental issues

While biomass crops provide an environment friendly fuel source for generating electrical energy. The land used for disposing the slurry (waste) may be better employed for cultivation.

Tidal power generation

Objectives: At the end of this lesson you shall be able to
- **explain the features of tidal power generation**
- **state the system on which the tidal power generation works**
- **state the advantages and disadvantages of tidal power generation.**

The generation of electricity using tidal power is termed as tidal power generation. It is basically the transformation of tidal power found in tidal motion of water in seas and oceans into electrical energy.

Tidal power

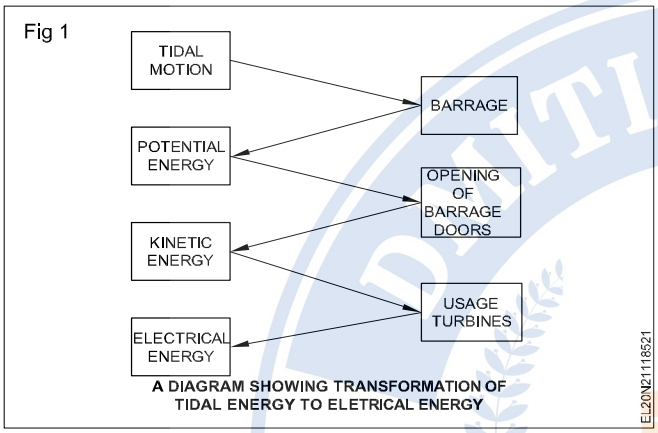
Tidal power is the power inherent in tides at sea or oceans, that is power of motion of water actuated by tides. Tides are defined as the increase and decrease in water levels

due to the motion of water from one place to the other. Thus there is a renewable source of energy in the tidal motion of water at seas and oceans. This source of energy could be used to generate other types of energy that could be useful in industrial applications.

This is done using a very basic idea involving the use of a barrage or small dam built at the entrance of a bay where tides are known to reach very high levels of variation. This barrage will trap tidal water behind it creating a difference in water level, which will in turn create potential energy.

This potential energy will then be used in creating kinetic energy as doors in the barrage are opened and the water rush from the high level to the lower level. This kinetic energy will be converted into rotational kinetic energy that will rotate turbines giving electrical energy. Fig 1 shows the process in very simple terms.

Fig 1



A DIAGRAM SHOWING TRANSFORMATION OF TIDAL ENERGY TO ELETRICAL ENERGY

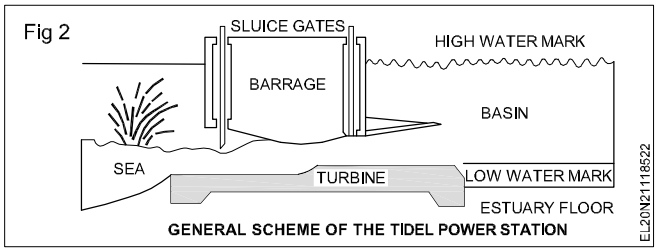
Working of tidal power generation system

In very simple terms a barrage is built at the entrance of a gulf and the water levels vary on both sides of the small dam. Passages are made inside the dam and water flows through these passage and turbines rotate due to this flow of water under head of water. Thus, electricity is created using the turbines. A general diagram of the system is in Fig 2.

The components of a tidal power station are :

1 **A barrage :** a barrage is a small wall built at the entrance of a gulf in order to trap water behind it. It will either trap it by keeping it from going into the gulf when water levels at the sea are high or it will keep water from going into the sea when water level at the sea is low.

Fig 2



GENERAL SCHEME OF THE TIDEL POWER STATION

2 **Turbines :** They are the components responsible for converting potential energy into kinetic energy. They are located in the passage ways that the water flows through when gates of barrage are opened.

3 **Sluices :** Sluice gates are the ones responsible for the flow of water through the barrage they could be seen Fig 2.

4 **Embankments :** They are caissons made out of concrete to prevent water from flowing at certain parts of the dam and to help maintenance work and electrical wiring to be connected or used to move equipment or cars over it.

Advantages of tidal power generation

There are many advantages of generating power from the tide; some of them are listed below.

- Tidal power is a renewable and sustainable energy resource.
- It reduces dependence upon fossil fuels.
- It produces no liquid or solid pollution.
- It has little visual impact.
- Tidal power exists on a world wide scale from deep ocean waters.

Disadvantages and constraint to tidal power generation

Unfortunately, there are also disadvantages and limitations to generating tidal power. Some of these are;

- At the present time both tide and wave energy are suffering from orientation problems, in the sense that neither method is strictly economical (except in few locations throughout the world) on a large scale in comparison with conventional power sources.

Power generation by solar energy

Objectives: At the end of this lesson you shall be able to
- **explain the basic principle and construction of the solar cell.**

Solar electricity

When sunlight strikes on photovoltaic (PV) solar panel, the electricity is produced. The method of generating the electrical energy from the solar panel (cells) is termed as solar energy generation.

Generation of electricity by using solar energy depends up on the photovoltaic effect in some specific materials. There are certain materials that produce electric current when these are exposed to direct sun light. This effect is seen in combination of two thin layers of semiconductor materials. One layer of this combination will have a depleted number of electrons.

When sunlight strikes on this layer, it absorbs the photons of sun light ray and consequently the electrons are excited and jump to the other layer. This phenomenon creates a charge difference between the layer and resulting to a tiny potential difference between them.

The unit of such combination of two layers of semi conductor materials, for producing electric potential difference in sunlight is called solar cell. Silicon is normally used as solar cell. For building cell, silicon material is cut into very thin wafers. Some of these wafers are doped with impurities. Then both doped and undoped wafers are sandwiched together to build solar cell. A metallic strip is attached to two extreme layers to collect current.

A desired number of solar cell are connected together in both parallel and series to form a solar module for producing desired electricity.

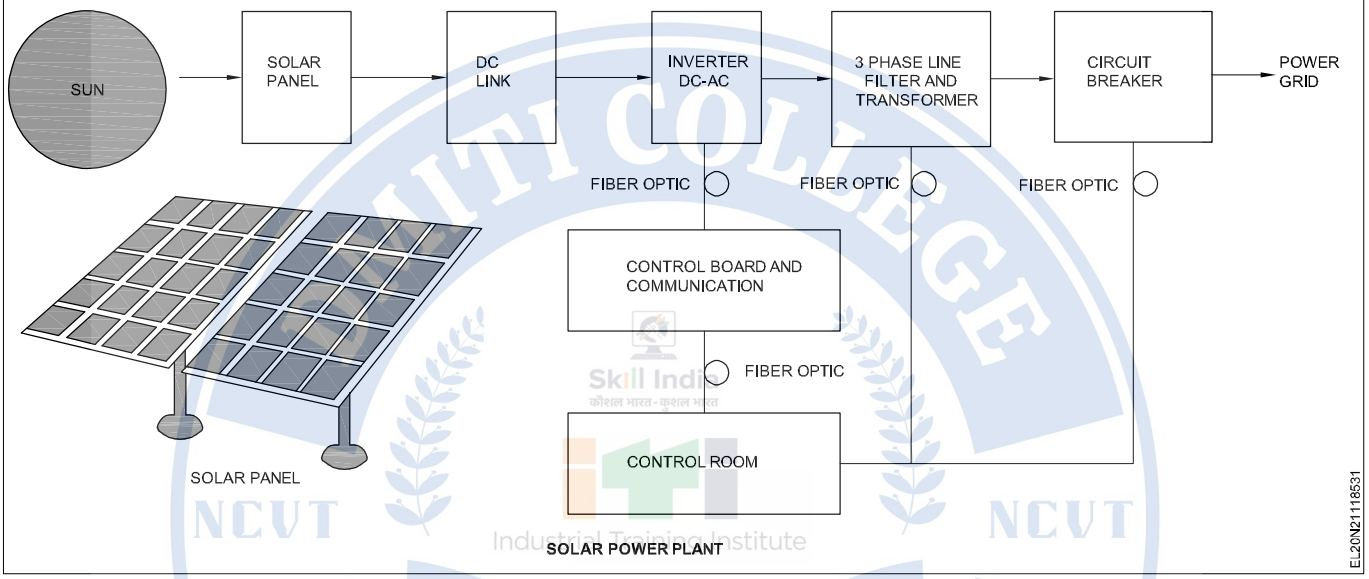
The solar cell can also work in cloudy weather as well as is moon light but the rate of production of electricity low as and it depends up on intensity of incident light ray.

Fig 1 describes the typical system of solar panels, controller, energy storage, inverter for converting DC into AC and how the system is connected to power grid.

Assembling and installation of solar panels

A solar panel is a able to function using the solar energy which is derived from the sun. The solar panel installed on the roof top absorb sun's light (photons) from the sun.

Fig 1



SOLAR POWER PLANT

Silicon and the conductors in use for solar panel converts the sunlight into direct current (DC) electricity flows into the inverter. It is an renewable energy. The process of converting sunlight to electrical energy and more efficient than other process.

Solar panel contains many different silicon cells (or) solar cells. The energy derived from the sun is connected into electricity with help of solar panels.

1 The solar panels installed on the roof top absorb sun's light from the sun.

2 The silicon and the conductor in the panel convert the sunlight into DC flows into inverter.

3 The inverter then converts DC to AC which can be used at home.

4 Excess electricity that is not used, can be feedback to the grid.

5 When the solar panels produce less power than required at home.

Process of connecting solar panel to electricity

Solar panels is used a special process of connecting photons to electrons to generate a current by making use of a special type of cell known as photovoltaic cell. These cells are commonly found on the front of calculation and small gadgets are connected together, called as solar panels (photovoltaic cells) are made up of semiconductor materials such as silicon, which absorb the light from the sun. The photons in the sunlight current the electron within the sunlight.

Basic idea of a solar module, array and balance of system (BOS)

Module

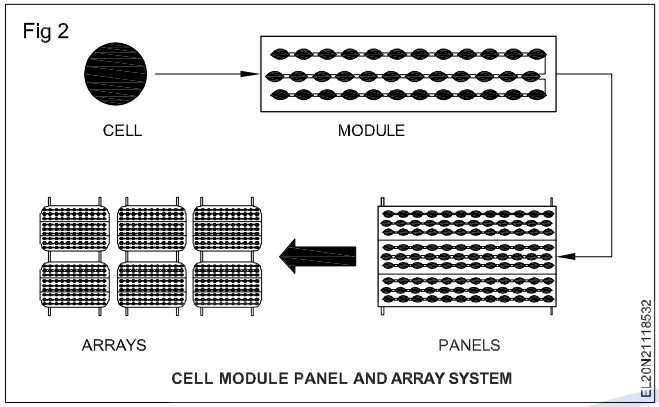
Solar cells are made in various shapes and sizes. The smallest of the cells can be seen in devices like an ordinary calculator, these type of devices are very little amount of power used in home lighting system needs more power to run on. The number of cells are put together to produce more power. The group of cells is packaged together in an enclosed space is called as a **module**.

It helps to give higher voltage, high power and protects the panel from rain, snow and wind etc. voltage and power output of module depend on the size and number of cells used. So, more number of modules are to be connected in a simple assembly of modules is known as **array.** (Fig 2)

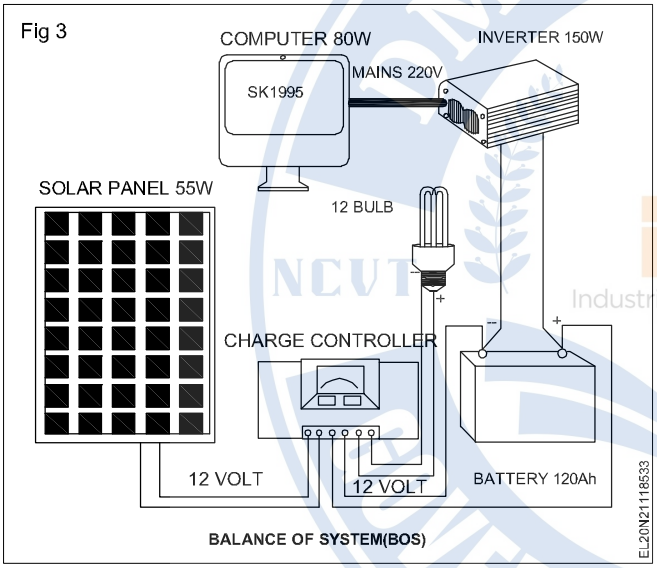
Balance of system (BOS)

The cells modules and arrays are the power producing part, a small devices like radio, needs a small amount of

power, can be directly connected to a small module. But most of the devices appliances need more power at night. The assembly of module, battery and an appliance is simple form a P.V system.



A module cannot be connected directly to a battery, so, a charge controller ON charge regulator is used in between module and battery and inverter are required to operate AC appliances. So, the whole system excepts the module is known as balance of system (BOS). (Fig 3)



The main components is BOS assembly are:

- Storage battery
- Charge controller
- Inverter
- Support structure
- Junction boxes
- Wire, cables and fuses
- Connections and switches

The functions of the above components are explained briefly below:

Storage battery

The most small systems used for lightening needs only 12V battery for longer system like refrigerator, 24V is used. If helps to keep the wire size small and system losses to a minimum. It needs to be handled carefully. If must not be over charged or fully discharged to prevent from damage.

Charge controller

If the battery is not able to control charge on its own. This work is done by a simple automatic device known as a charge controller in the following way.

- It senses the battery charge and switches 'OFF' the charging current and avoid from damage.
- It disconnects the appliances when the battery charge goes below a set limit.
- Prevents reverse current and protects from short circuit.

Inverter

A solar system produces only DC power. But home appliances need AC power. The device (example CFL) is required for this purpose to convert DC into AC is called as inverter.

Support structure

The solar module cannot be simply placed either on ground or roof. It needs to collect the sunshine at an angle. To keep the module safe from any strong winds support structure is used for solar PV system.

Junction boxes

It is meeting point for many wires. These may be from a raw of modules are from modules to a battery bank. A junction box is made of an unbreakable material (ie) polycarbonate. It makes use of copper connectors for a high current flow. It protects the system from moisture.

Wires and fuses

This solar systems carry a low voltage but high current. So, the large diameter wire is needed. Fuses keep the solar equipment safe against the short circuit.

Mounting of charge controller

- Mount the controller to the wall into screws that fit to the wall material.
- Connect the battery cable assembly with fuse supplied along with the controller.
- Connect first controller and then battery and two modules
- Connect the wires to the load and only then to controller.

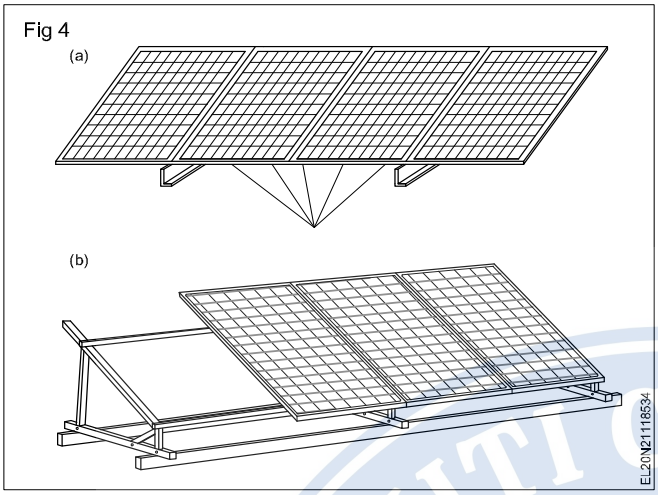
Electrical connection

- Connect the battery to the system only after getting fully charged.
- Do not switch 'ON' charged the loads for 2 - 3 days (when battery is 'ON' a full charged)
- Connect the array cable to charge controller with correct polarity.
- Keep the switch in 'OFF' position and connect the load cables and battery cables to charge controller.

- Switch 'ON' the load (ie) lamps for the normal operation.
- Test the solar panel installation for it's functioning.

(Fig 4a & b) shows the installed solar panel with mid clamp and with frame mounted installation are illustrated.

Fig 4



Functionality of solar panel

Sunlight is the basic fuel for a solar panel. Sunshine is the cause to keep the panel for normal functioning. But the environment around the modules will affect it's working.

The following few factors will affect it's normal working cause for power loss.

- Tilt angle
- Dust
- Shading
- Light intensity
- Temperature
- Charge controller
- Semiconductor energy loss
- Cabling losses
- Improper connections

Tilt angle : The solar module must be installed in the proper path of sun and it is tilted properly at an angle, equal to the latitude of the place. If any error in the tilt angle will lead to same amount of power loss.

Dust : If the modules is not cleaned properly, dust will form on the modules surface in the dry season, and it may cause for high energy loss 5-10%.

Shading

Solar module faces the sun all day. Their shade should not be present on it. In such a place only it must be put up. But due to extended free transformer, T.V antennas etc, may cause to present shades.

A solar modules are made of a string of individual solar cells and connected in series with one another. Suppose as an example one cell from 36 cells in a module is fully shaded, the power output from the module will become zero due to high resistance. But if one cell is 50% shaded then the power output is reduced to 50% only offers high resistance.

Light intensity

More power is produced from the panel in bright sunlight. For 1000W/M^2 of sunlight, the rated output power will be full. But, if it is 500W/M^2 only the rated power output will be half. The output power is directly proportional with the increasing of solar in isolation.

Temperature

The higher the temperature the output power is reduced from a module, due to power loss. It is tested at standard temperature at 25°C. During the bright sunlight, cell may reach 70°C also. If crystalline silicon decrease from 0.4 to 0.5% per°C temperature increases above 25°C. Amorphous silicon module temperature coefficient is 0.2 to 0.25 % per°C of temperature increase.

Charge controller

If the charger controller is in continuous operation and draws a small current of about 5mA to 25mA, then the power loss is around 1%.

Semiconductor energy loss

The charge controller is having the components as MOSFET and blocking diodes, which is cause for heat energy loss.

Cabling loss

The cables are also cause for power loss, It can be minimized by choosing a large diameter of wire size.

Improper connection

If the electrical connections are not made properly, it results in less power is fed to the battery. It can be reduced by keeping clean, and tight connections.

Wind power generation

Objectives: At the end of this lesson you shall be able to
- **explain the features of wind power generation**
- **state the advantages and disadvantages of wind power generation.**

The method of generating the electrical energy by using the wind is termed as wind power generation. Since the wind has velocity and kinetic energy, it can be used to produce electricity. For that, we can use windmills. The important part of a windmill is a structure with large leaves, fixed at the top of a high tower. The speed of leaves changes with the speed of the wind. If the rotation of the windmill is given to the rotor of a generator, then the electricity will be obtained from the generator. If the

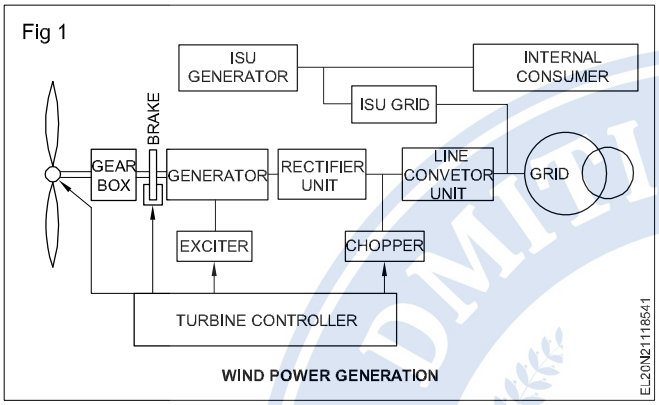
windmill is connected to a water pump, the leaves of the windmill rotate the pump and pumping out the water.

Wind power can be usefully exploited for the generation of electricity as there are large, coastal, hill and desert areas. Wind turbines comprising of machines with blade diameter of 17 m, which can generate about 100 kilowatts. A strike of blowing wind on specially designed blades of a windmill's rotor causes both to rotate. This rotation, which is the mechanical energy, when coupled to a turbine, drive the power generator.

Operation

The schematic arrangement of wind power station is given in Fig 1.

Fig 1



When the wind strikes the rotor blades, blades start rotating. Rotor is directly connected to high speed gear box. Gear box converts the rotor rotation into high speed which rotates the electrical generator. An exciter is needed to give the required excitation to the coil so that it can generate required voltage. The exciter current is controlled by a turbine controller which senses the wind speed based on that it calculate the power what we can achieve at that particular wind speed.

The output voltage of electrical generator is given to a rectifier and rectifier output is given to line converter unit to stabilise the output AC that is fed to the grid by a high voltage transformer. An extra units is used to give the power to internal auxiliaries of wind turbine (like motor, battery etc), this is called **internal supply unit**. ISU can take the power from grid as well as from wind. Chopper is used to dissipate extra energy from the Rectifier Unit (RU) for safety purpose.

Advantages

1 The wind energy is free, inexhaustible and does not need transportation.

2 Wind power plant on the other hand does not take long time to construct. Such wind mills will be highly desirable & economical to the rural areas which are far away from the existing grids.

3 There is a strong reason why wind power should be welcome by grids which have some hydroelectricity inputs in India. The water level in the hydel reservoir is at its lowest before the onset of the South West monsoon. If less water is drawn during the monsoon, a high level could be maintained for longer period. During the monsoon period wind energy can be used to feed the grid.

4 It is non polluting

5 It does not require high technology.

6 Electricity can be produced at a lower cost after installation.

Disadvantages

1 The major disadvantage associated in the wind power is that it is not constant and steady, which make the complications in designing the whole plant.

2 The rotor blades of wind turbine generators must sweep out large areas to produce worthwhile amount of power.

3 The wind is a very dangerous such storms can cause tremendous shear stresses which may spoil the whole plant within no time. To avoid this, special and costly designs and controls are always required.

4 Among all the disadvantages mentioned above, the cost factor is the major which has restricted the development of wind power on large scale for feeding to the existing grid. The estimated cost of wind electricity generation, storage & distribution system is over 1 lakh rupees which may be considered beyond the means of most Indian villages.

Modern wind machines are still wrestling with the problem of what to do when the wind is not blowing. Large turbines are connected to the utility power network some other type of generator picks up the load when there is no wind. Small turbines are often connected to diesel/electric generators or sometimes have a battery to store the extra energy they collect when the wind is blowing hard.

The wind energy is utilized by means of a wind mill or a series of wind mills. A wind mill consists of few vanes (normally 3 to 6) which rotate about their axis, when the wind blows against them. The rotational motion (i.e. mechanical energy) thus created is utilized for various applications, such as,

1 Lifting water from the well

2 Battery charging

3 Water pumping

4 Operating a simple machine

5 Wind energy is used for agricultural& rural applications such as grinding flour mills, wood cutting saw, stone crushers, mixers, water pumps and irrigation facility etc.