future.

Unit -4

POWER FROM RENEWABLE ENERGY

Introduction :-

84,000 MW hydroelectric power is at 60% load factor. In adding up, 6,780 MW in terms of installed capacity from small, mini and micro Hydel Schemes have been evaluated. Also, 56 sits for pumped storage schemes with the total installed capacity of 94,000 MW have been identified. Hydroelectric energy is mainly used in the form of renewable energy. India stands in 5th place for hydro-electric potential in the world on global scenario.

HYDROELECTRIC ENERGY RESOURCES :-

The present installed capacity as on September 30, 2013 was around 39,788.40 MW which means 17.39 % of total electricity generation in India. The public sector has a predominant share of 97% in this sector. National Hydroelectric power corporation (NHPC), Northeast Electric power company (NEEPCO), Satluj Jal vidyut Nigam (SJVNL), THDC, NTPC-Hydro are few public sector. National Hydroelectric power companies developing hydro projects in India.

The purposes of developing hydro projects are mentioned below ·

(i) To meet the power needs during peak and off-peak requirements.

(ii) To run of the river

(iii) To obtain a clean process of power generation

(iv) To avoid suffering from the limitation of Inflation on account of fuel consumption in the long run.

In north India, Bhakra Beas Management Board (BBMB) has an installed capacity of 2.9 GW and it generates 12,000-14,000 million units per year. BBMB is a major source of peaking power and black start to the northern grid in India.

Hydro power :-

The turbine converts the hydraulic energy into mechanical energy. This mechanical energy is converted into electrical energy. So, the conversion of energy from hydraulic form into electric form, is called hydroelectric power.

Advantages of Hydro power :-

(i) The electricity can be produced at constant rate from hydro power.

(ii) If the electricity does not require, the sluice gates can be shut and stopped electricity generation.

(iii) The lakes water can be used for irrigation purposes.

(iv) The energy from stored water in the lake can be stored and it can be released to produce electricity.

Disadvantages of Hydro power :-

(i) Constructing the standard dams is highly expensive

(ii) The flooding area needs to be large to meet

(iii) It has the restriction to operate the dam for many decades by natural calamity; cost involved in building dams to become profitable due high

(iv) People living in villages and towns near dams should be moved during flood period. so, the power generation will be affected.

(v) Although modern planning and design of dams is good, it may lead to deaths and flooding.

HYDEL POWER PLANTS :-

Water is the cheapest source of power. A hydro electric power plant is aimed at harnessing energy from water flowing under pressure. In hydroelectric power plants, the energy of water is utilized to drive the hydro turbine or waterpower is only important next to the thermal power. Hydroelectric power was initiated in India in 1897 near Darjeeling.

Hydrology is the study of science concentrating the properties of the earth's water and the movement of earth with respect to land.

A hydrograph is a graph plotted for the rate of flow versus time past a specific point in a river, or other channel or conduit carrying flow.

Classification of Hydro-Electric power plants

(i) Classification according to the availability of head;-

1. Low head power plant :-

The operating head of water is less than 10m of power plant known as low head power plant - Kaplan turbine is used as a prime mover in this type of power plant.

2. Medium head power plant :-

The operating heat of water ranges from 10m to 50 m, then the power plant is known as medium head power plant - francis turbine is

3. High head power plant :-

If the operating head of water exceeds 50m the plant is known as "high head power plant". Pelton turbine is used as a prime mover in this type of power plant.

(ii) Classification according to the nature of load :-

1. Base load plant :-

This type of power plant is designed to take the load on the base portion of the load curve. The load on the plant is more or less constant throughout the operation period. Large scale hydro plants are used for this purpose.

2. Peak load plant :-

This type of powerplant is designed to take the load on the peak load of the load curve. The load on the plant is more or less constant throughout the opearation period. Small scale and Micro-hydro plants are used for this purpose.

(iii) classification according to the quantity of water available :-

1. Run-off river plant without pondage :-

This type of power plant has no storage pond. This type of power plant uses the water as it comes. This type of plant has no control over the river flow.

2. Run-off river plant with pondage :-

This type of power plant has a storage pond. This type of plant stores water during off peak hours and it is used during peak

fluctuating load on 24 hours.

5. Storage type plants :-

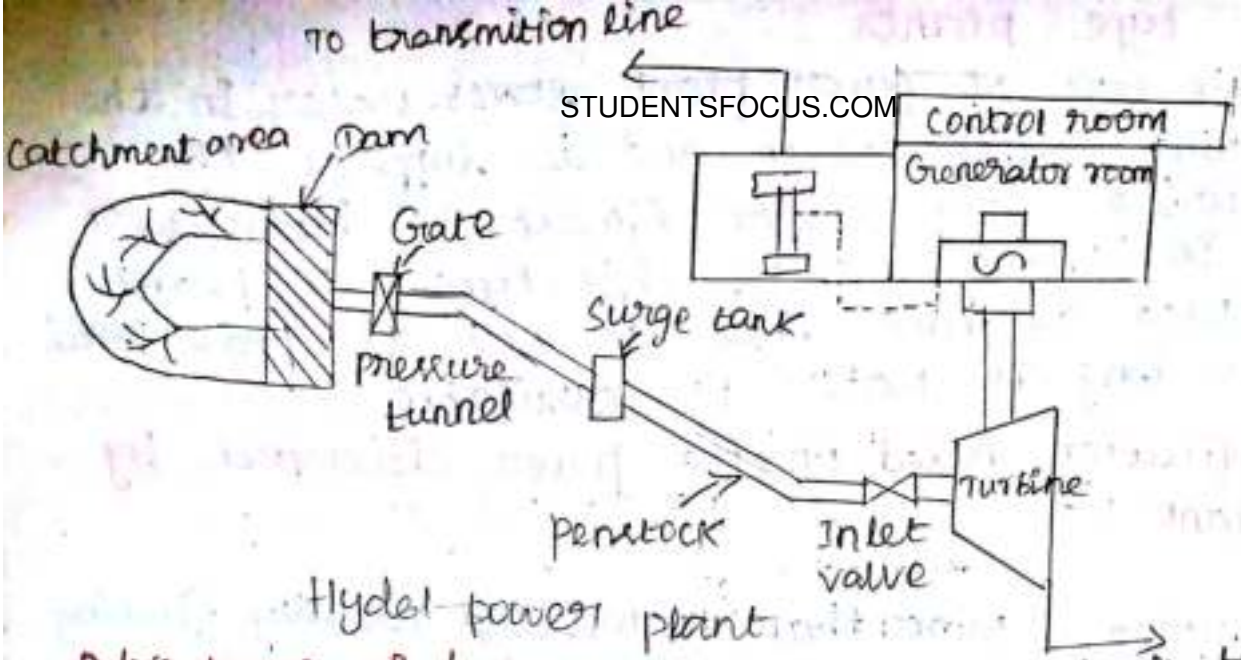
This type of power plant stores water in the dam during rainy season and it supplies the same during dry season. Almost all hydropower plants in India are of this type. This plant can be used as base load as well as peak load plant as long as water is available.

(iv) Classification based on the power developed by the plant :-

Large-hydro	More than 100 MW and usually feeding into a large electricity grid.
Medium-hydro	15-100 MW - usually feeding a grid
Small-hydro	1-15 MW - usually feeding into a grid
Mini-hydro	Above 100 KW but below 1 MW - either stand alone schemes or more often feeding into the grid.
Micro-hydro	from 5 KW up to 100 KW, usually provided power for a small community or rural industry in remote areas away from the grid.
pico-hydro	from a few hundred Watts up to 5 KW

Working principle of Hydel power plant or low head Hydel power plant :-

In hydroelectric power plants, the potential energy of water is converted into kinetic energy. The potential energy of water is used to run the water turbine to which the electric generator is coupled. The mechanical energy available at the shaft of the turbine is converted into electrical energy through a generator or alternator. The water is first passed through the penstock to the turbine from the dam.



Hydel power plant

Advantages of hydroelectric power plant :-

1. Water is the cheapest source of energy. The fuels needed for the thermal, diesel and nuclear plants are exhaustive and expensive.
2. Water is the renewable source of energy. It is neither consumed nor converted into something else
3. The fuel cost is totally absent.
4. There is no problem of handling the fuel and ash. No nuisances of smoke, exhaust gases and soot is and no health hazards are due to air pollution.
5. The running cost of hydropower installation is low when compared to thermal or nuclear power stations
6. The efficiency does not change with age
7. Maintenance cost is low.

Disadvantages of hydroelectric power plant :-

1. Hydropower projects are capital-intensive with a low rate of return.
2. power generation is dependent on the quantity of water available which may vary season-to-season and year-to-year.
3. Initial cost of the plant is high
4. The hydel power plants are often far away from the load center and they require long transmission lines to deliver power.

large hydro-plants destroy the energy of the
by way of deforestation, destroying vegetarian
uprooting people.

Turbines :-

Hydraulic turbines are the machines which convert
flowing energy of water into mechanical energy.
mechanical energy developed by a turbine
used to run an electric generator which is
directly coupled to the shaft of the turbine. Thus
mechanical energy is converted into electrical
energy.

Hydraulic turbines may be classified according
several considerations as follows.

) According to the action of the water flowing :-
a. Impulse turbine e.g :- pelton wheel
b. Reaction turbine e.g :- francis turbine, kaplan-
turbine

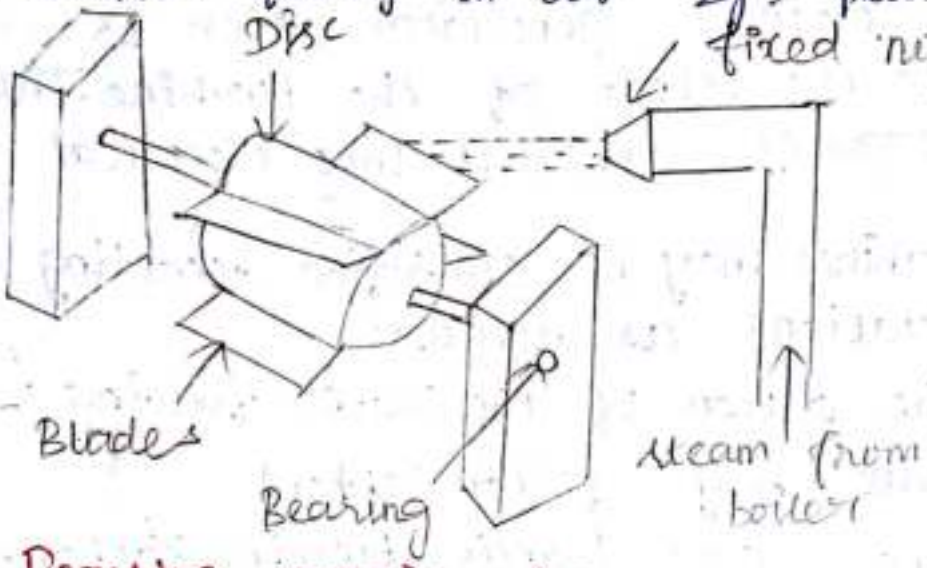
) According to the main direction of flow of
water :-
a. Tangential flow turbine e.g :- pelton wheel
b. Radial flow turbine e.g :- Old francis turbine
c. Axial flow turbine e.g :- Kaplan turbine
d. Mixed flow turbine e.g :- Modern francis
turbine

) According to the head and quantity of water require
. High head turbine
(above 250m) e.g - pelton wheel
. Medium head turbine (60m to 250m) e.g :- Modern
francis turbine
. Low head turbine (Less than 60m) e.g kaplan turbine

) According to the specific speed
a. low specific speed (10 to 35) e.g :- pelton wheel
b. Medium specific speed (60 to 400) e.g francis turbine
c. High specific speed (300 to 1000) e.g :- kaplan turbi

Impulse Turbine :-

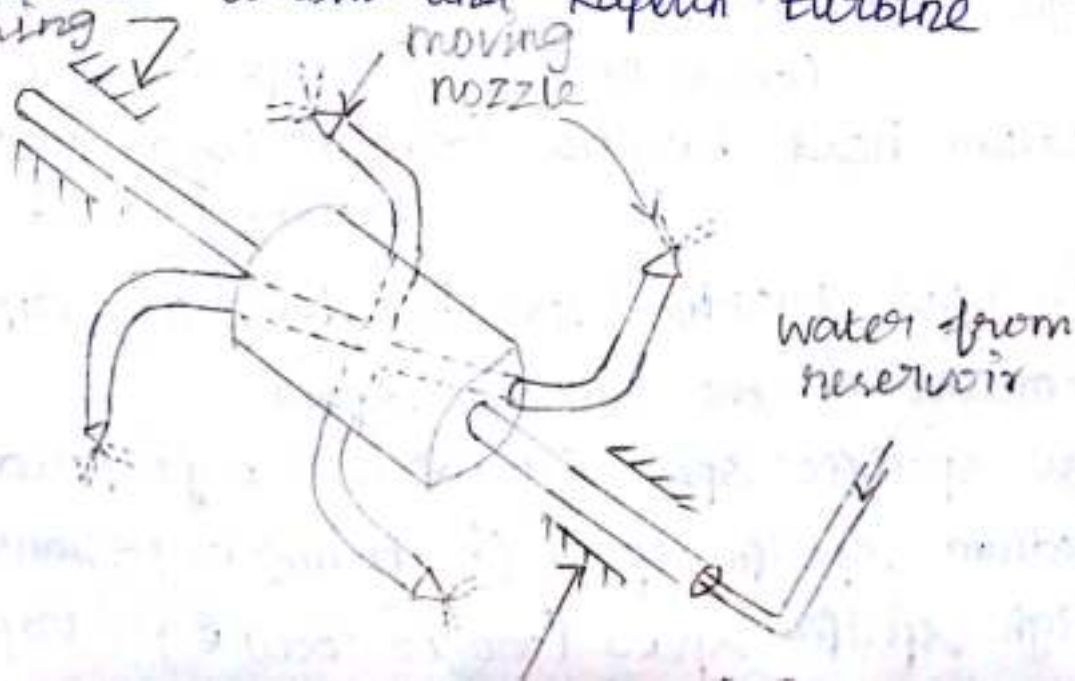
In an impulse turbine the energy available by water is converted into kinetic energy by passing it through a nozzle. The high velocity jet coming out of the nozzle impinges on a series of buckets fixed around the rim of a wheel. Thus, the runner revolves freely in air Eg :- pelton wheel.



Reaction Turbine :-

In a reaction turbine, the runner utilizes both potential and kinetic energies. Here, only a portion of potential energy is transformed into kinetic energy before the fluid enters the turbine runner. As the water flows through the runner, the remaining part of potential energy is converted into kinetic energy.

Eg :- francies turbine and kaplan turbine



Tangential flow turbine :-

In tangential flow turbines, water flows along the tangent to the path of the runner. Eg :- Pelton wheel.

Radial flow Turbine :-

In radial flow turbines, water flows in the radial direction and mainly in the plane normal to the axis of rotation as it passes through the runner. It may be either inward radial flow type or outward radial flow type.

Axial flow Turbine :-

In an axial flow turbine, water flows parallel to the axis of the turbine shaft. Eg :- Kaplan turbine and propeller turbine.

Mixed flow Turbine :-

In mixed flow turbines, the water enters the blades radially and it comes out axially or parallel to the turbine shaft. Eg :- Modern francis turbine

Wind Energy conversion :-

Principle of wind Energy conversion :-

The wind energy can be extracted from lift force alone or drag force alone or combination of lift and drag forces. It is known that the lift force acts perpendicular to the air flow direction and drag force acts parallel to the wind direction. The lift is produced by the change in velocity of air stream which speeds up the air flow thereby creating a pressure drop. So, the pressure drop forces the lift surface from high pressure side to low pressure side called an airfoil. If the air pressure increases on the low pressure side, enormous turbulence is produced which reduces the lift force and it leads to increase the drag significantly called stalling.

The basic features which characterize lift and drag are as follows :-

(1) Drag is in the direction of airflow

(2) Lift is perpendicular to the direction of airflow

(iii) Generation of lift [illegible] amount of drag to be developed with a good aerofoil.

(iv) The lift produced can be thirty times greater than the drag.

(v) Lift devices are generally more efficient than drag devices.

TIDAL ENERGY :-

The periodic rise and fall of the water level of sea which are carried by the action of sun and moon on water of the earth is called "Tide". The difference in potential energy during high-tide and during low-tide is called Tidal Energy

The main feature of the tidal cycle is the difference in water surface elevations at high tide and low tide. If this differential head could be utilized in operating a hydraulic turbine, the tidal energy could be converted into electrical energy by means of an attached generator.

Tidal energy can furnish a significant portion of all such energies which are renewable in nature. Tidal energy is a form of hydro energy recurring with every tide.

Spring Tides :-

If the tide's range is maximum, this is called the spring tide. Around new and full moon days when the sun, Moon and Earth form a line. The tidal force due to the sun reinforces the Moon.

Neap Tides :-

When the Moon is at first quarter or third quarter, the sun and Moon are separated by 90°. When viewed from the Earth and the solar gravitational force partially cancels the Moon's. At these points in the lunar cycle, the tide's [illegible] minimum called neap tide.

Schemes and Configurations :-

There is much interest in the use of tidal energy especially the development of large scale tidal power schemes. The power is obtained through the flow of water when filling and emptying partially closed sea basins. A proposed scheme exists for the Bristol Channel (UK). As the tide runs into the 'low' basin, it drives turbines and as the tide retreats, again turbines are turned to produce large amounts of electricity. Unfortunately this scheme has been shelved due to cost and possible damage to the local ecology.

Tidal energy could satisfy as much as 5% of UK's electricity needs but depending on how it is implemented, such a scheme could also cause severe damage to wildlife in the area including birds, shore-life, and fish and plants that thrive in the delicate ecosystem.

Martin Harper, head of sustainable development at RSPB said, "The government does not need to rush to judgment on it. If they do, there is a serious risk they will pick the wrong project. As this review shows that it could mean unnecessary damage to the environment, an oversized bill for the taxpayer and all for less electricity than is possible"

Impact of Tidal Energy on the Environment :-

(i) Tidal energy is a renewable source of electricity which does not cause the emission of gases responsible for global warming or acid rain associated with fossil fuel generated electricity.

(ii) The use of tidal energy could also decrease the need for nuclear power with its associated radiation risks.

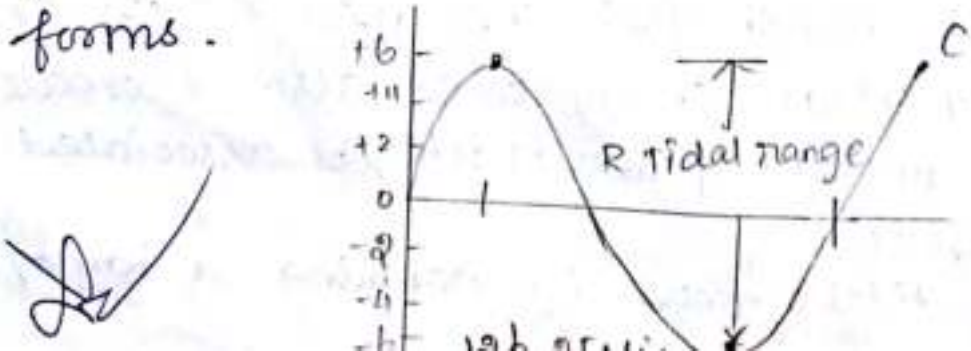
(iii) Changing tidal flows by damming a bay or

estuary could result the negative impacts on aquatic and marine ecosystems as well as navigation and recreation.

Principle of Tidal power :-

Mainly, tides are produced by gravitational attraction of the Moon and sun on the water of solid earth. Nearly, 70% of the tide produces force due to Moon and remaining 30% by the sun. So, the Moon is the main factor to form tides in the sea. During the tide formation, the surface water is pulled away from earth towards Moon but at the same time, the solid earth is pulled away from the water on the opposite side. Therefore, high tides form in these two areas and low tides are formed at intermediate points. Due to the rotation of earth, the position of the solid area changes relative to Moon there by forming tides, Thus, a periodic succession of high and low tides is formed.

Two high tides and two low tides occur in a lunar day of 24 hours and 50 minutes. The lunar day is the apparent day of moon revolution about the earth. The time delay between successive tides is 6 hours. High tide occurs at a point directly under the Moon. Therefore, high tides are produced during full Moon and no Moon day of the month. These tides are called as semi-diurnal tides. So, the rise and fall of sea water is in sinusoidal wave forms.



$C_xH_yO_z + \left(x - \frac{y}{4} - \frac{z}{2}\right) H_2O \rightarrow \left(\frac{x}{2} - \frac{y}{8} + \frac{z}{4}\right) CO_2 + \left(\frac{x}{2} + \frac{y}{8} - \frac{z}{4}\right) C_4$

for cellulose, the equation becomes

$(C_6H_{10}O_5)n + nH_2O \rightarrow 3nCO_2 + 3nCH_4$

In general 95% of the mass of the material is water. The reactions are slightly exothermic with typical heats of reaction being about 1.5 MJ/kg of digestible materials equal to 250 kJ/mole of C_6H_{10}. If the input material is dried and burnt, the heat of combustion is about 16 MJ/kg only 10% of the potential heat of combustion required for the digestion process. It produces 90% conversion efficiency. Digestion at higher temperature proceeds more rapidly than lower temperature with doubling gas yield rate at about every 5°c increase.

1. psicrophilic (20°C)
2. Mesophilic (35°C)
3. Thermophilic (55°C)

The biochemical processes occur in three stages and each is facilitated by distinct sets of anaerobic bacteria.

Insoluble biodegradable materials :-

It occurs in about a day at 25°c in an active digester.

Acid forming bacteria produce mainly acetic and propionic acid :-

This is about one day at 25°c

Methane forming bacteria :-

Bacteria needs 14 days at 25°c to complete the digestion to 70% CH_4, 30% CO_2 with less amount of H_2 and H_2S.

fuel cell :-

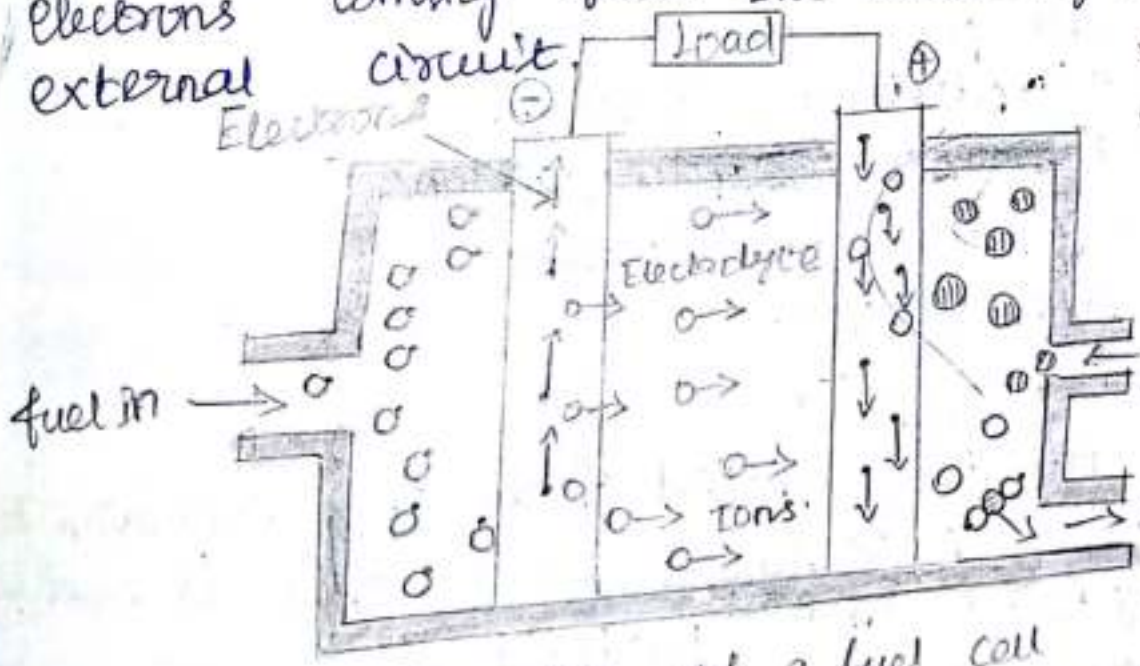
fuel cell technology is over 150 years old. The first fuel cell was demonstrated by sir William Grove in 1839. Grove used porous

electrolyte bath. William White Jaques later substituted phosphoric acid for the electrolyte bath and was the person who coined the term "fuel cell". A significant fuel cell research was done in Germany during 1920's. which laid the ground work for subsequent development of Carbonate cycle and solid oxide fuel cells. In 1960s, NASA

Working Principle of a fuel cell :-

A fuel cell is an electrochemical device in which the chemical energy of a conventional fuel is directly converted and efficiently into low voltage DC electrical energy. One of the main advantages of such a device is that the carnot limitation on efficiency does not apply because the conversion can be carried out isothermally. A fuel cell is frequently described as a primary battery in which the fuel and oxidizer are stored in the battery and fed to it as needed.

Therefore, it releases electrons to the external circuit. The oxidized fuel diffuses through the cathode and it is reduced by electrons coming from the anode by the way of external circuit.



Schematic of a fuel cell

The fuel cell is a device which keeps the fuel from mixing with the oxidizer

molecules in permitting the transfer of electron by a metallic path contain a load of the available fuels. Hydrogen has so far given the most promising results; although cells consuming coal oil or natural gas would be economically much more useful for large scale applications.

Some of the possible reactions are.

Hydrogen / oxygen	1.23 V	$2H_2 + O_2 \Rightarrow 2H_2O$
Hydrazine	1.56 V	$N_2H_4 + O \Rightarrow 2H_2O + N_2$
Carbon (Coal)	1.02 V	$C + O_2 \Rightarrow CO_2$
Methane	1.05 V	$CH_4 + 2O_2 \Rightarrow CO_2 + 2H_2O$

A fuel cell power system has many components but its heart is the fuel cell stack which is made of many thin, flat cells layered together. Each cell produces electricity and the output of all cells is combined to get more power.

Major sections of fuel cell power plants :-

The fuel cell power plant consists of six major sections which are as follows.

(i) fuel processing section
(ii) fuel cell power pack
(iii) power conditioning section
(iv) switchgear and supply section
(v) control subsystem section
(vi) Heating section.

fuel processing section :-

The fuel is supplied from this section to fuel cell power pack. The supplied fuel is received processed, filtered and purified.

fuel cell power pack section :-

The processed fuel is sent to the fuel cell power pack along with air or oxidant which is

DC power in this section and it is sent to power conditioner.

power Conditioning section :-

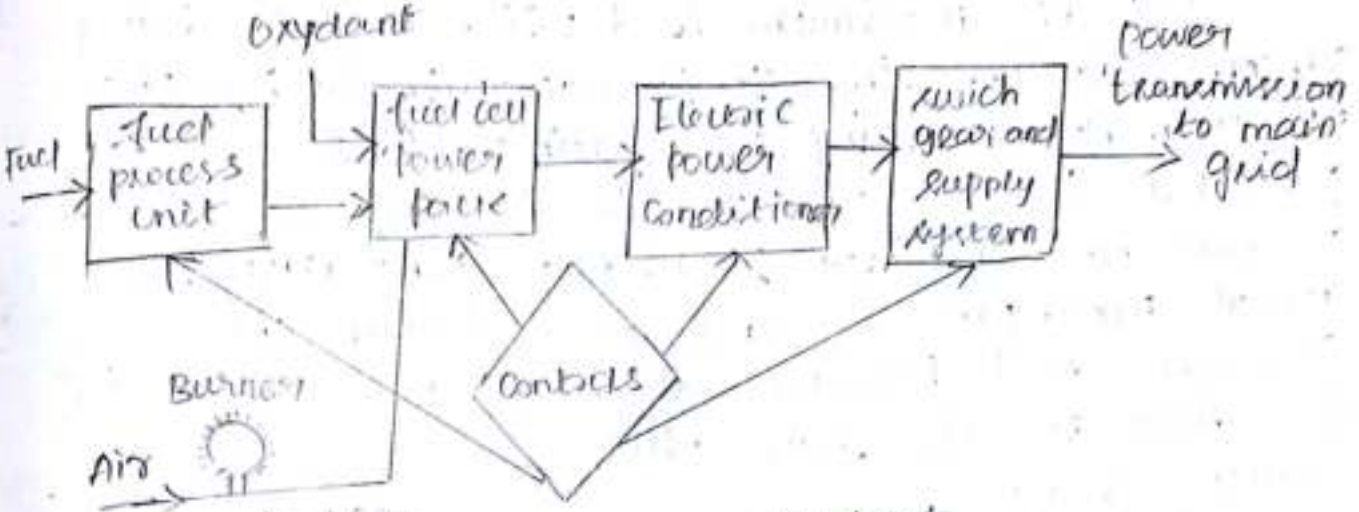
DC power coming out of fuel cell power pack is converted into 3 phase or single phase regulated AC power.

switchgear and supply section :-

This section delivers AC power to the connected load.

Control subsystem section :-

This section controls the voltage, current, power, rate of power, fuel input and temperature.



fuel : Cell power plant

Heating section :-

The working temperature of electrolyte is maintained within the permissible limit in this section by installing a heating subsystem.

Unit-5

ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS

Introduction :-

Economics of power plant