

LECTURE NOTES  
ON  
ENERGY RESOURCES  
**ENVIRONMENT & ECOLOGY**

B.Tech 2<sup>nd</sup> year

By

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# Contents

1. Introduction
2. Types of energy resources
  - i) Conventional energy resources
  - ii) Non-conventional energy resources
3. Alternative source of energy
  - i) Hydroelectricity
  - ii) Solar energy
  - iii) Geothermal energy
  - iv) Biomass
  - v) Biogas
  - vi) Hydrogen gas
4. Nuclear energy
5. Fossil fuel

# MAP OF INDIA

## SHOWING INSTALLED GENERATING CAPACITY STATEWISE/MODEWISE

Including allocated shares in Joint and Central Sector  
(As on 31.03.2018, Figures in MW)

[Map not be scale]

All India Capacity : 3,44,002.39 MW

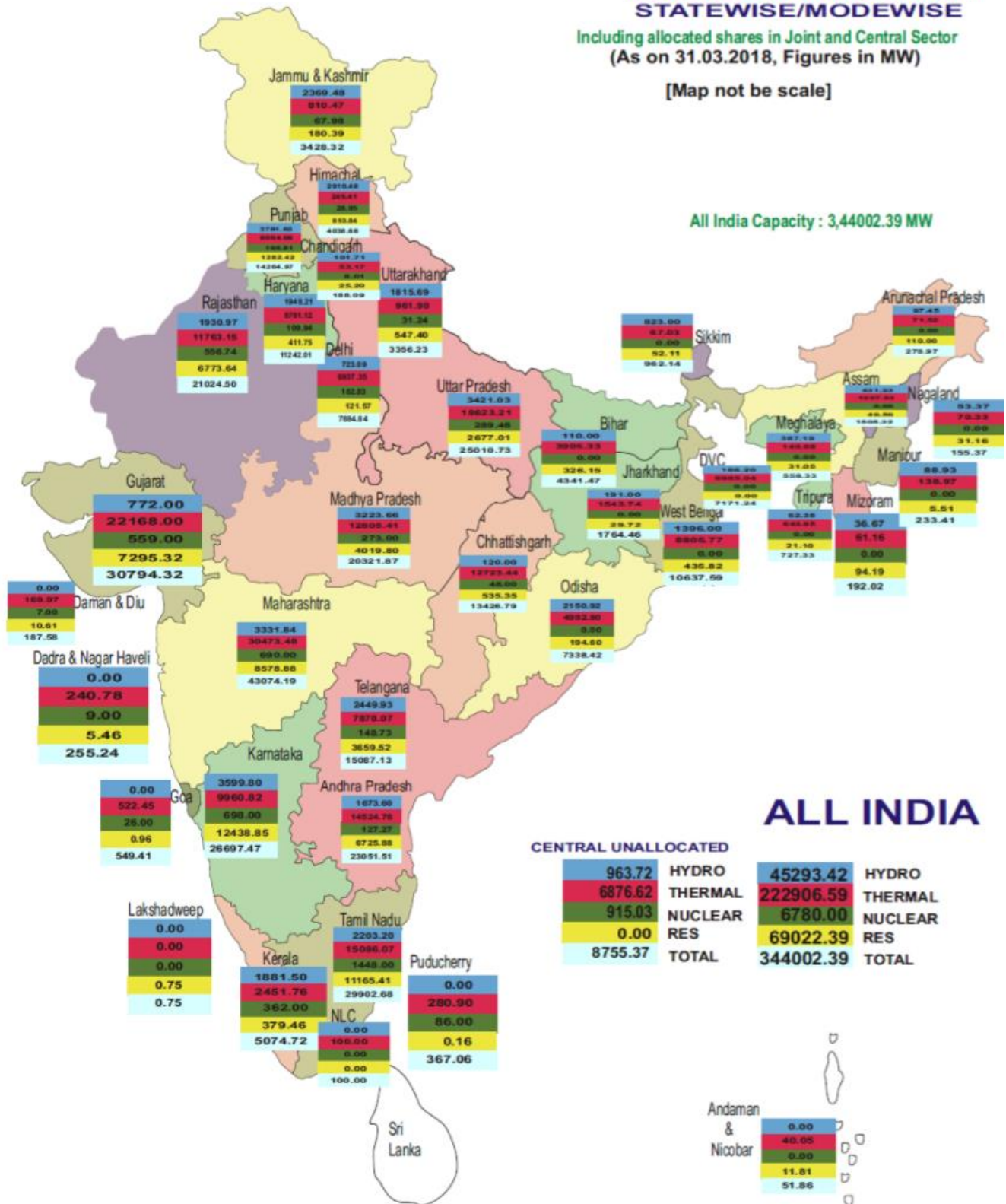


Figure source: Central Electricity Authority of India

## INTRODUCTION

Energy can be defined as the capacity produce an effect to do some work. Energy is one of the most important building blocks for human life on earth and economic development of the country. The demand for energy resources are increasing day by day in the development of industries, transportation and agricultural activities.

## TYPES OF ENERGY RESOURCES

On the basis of sources energy are classified into categories, renewable energy resources and non renewable energy resources.

### i) **Renewable energy resources:**

These energy resources are also known as non conventional energy resource, which can be regenerated continuously. It can be used again and again in an endless manner because these resources are available in large amount. For example, solar energy, wind energy, bio-fuels, hydro energy, geothermal energy, wave & tidal energy.

### ii) **Non renewable resources:**

These energy resources are also known as conventional (traditional) energy resources. It cannot be replenished when these sources are exhausted because these resources are present in limited amount and take a long period of time to re-synthesize. For example, nuclear energy, coal, petroleum, natural gas etc.

## ALTERNATIVE SOURCE OF ENERGY

### HYDROELECTRICITY OR HYDRO ENERGY

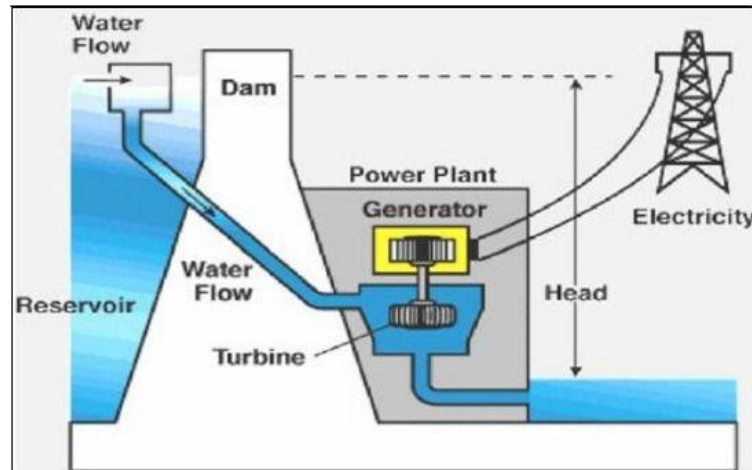
It is a form of renewable energy resources. Electricity produced from water is usually referred as hydro electricity. In this process dams are constructed for storage of water and then water led down through tunnel to lower level which rotates the turbine to produce mechanical energy. The produced mechanical energy can be converted into electrical energy with the help of generator and again transformed in alternating current through transformer. Once the electricity is produced it can be delivered to homes, industries etc. The output of energy produce by dams is totally depends on the volume of water released or discharge speed and vertical distance from where water fall or vertical distance of water head.

### **Advantage of hydroelectricity**

- i) It is renewable source of energy.
- ii) Once the dams are constructed, electricity can be produced to many years or decades.
- iii) Hydroelectricity is non polluting sources of energy.
- iv) Dams used in production of hydroelectricity, is also used in irrigation purposes.

### **Disadvantage of hydroelectricity**

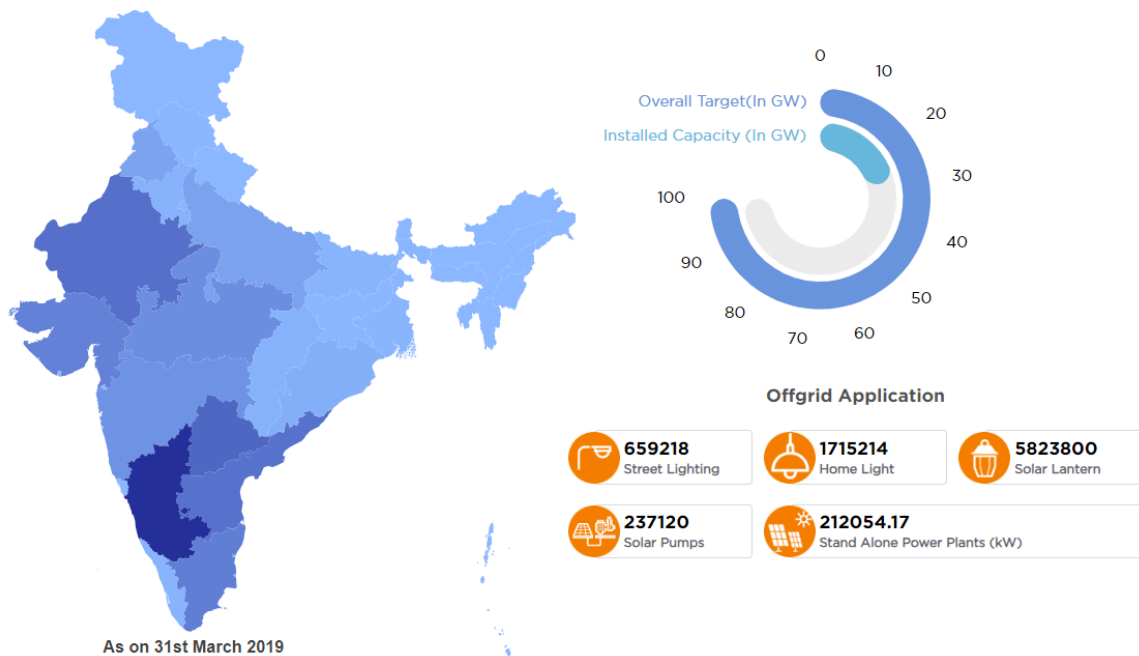
- i) Loss of biodiversity.
- ii) Construction of dams is expensive.
- iii) During drought condition electricity cannot be produce by hydroelectricity plant.



Generation of hydro electricity

## **SOLAR ENERGY**

It is also a renewable energy resource. In this case we get electricity directly from the sun light, contains radiation like ultraviolet, visible and infrared etc. The earth surface gets maximum energy when radiations strike at  $90^\circ$  (vertical). India received 4–8 kWh of solar radiation per square meter per day which is equal to 5000 trillion kWh per year. In order to give a boost to the solar energy sector, India saw the advent of Jawaharlal Nehru National Solar Mission (launched in 11 January, 2010). The mission was specifically aimed at developing comprehensive policies and strategies of technology diffusion that would catapult and establish India as a global leader in the arena of solar energy. This ambitious solar mission aims to install 100 GW grid-connected solar power plants by the year 2022.

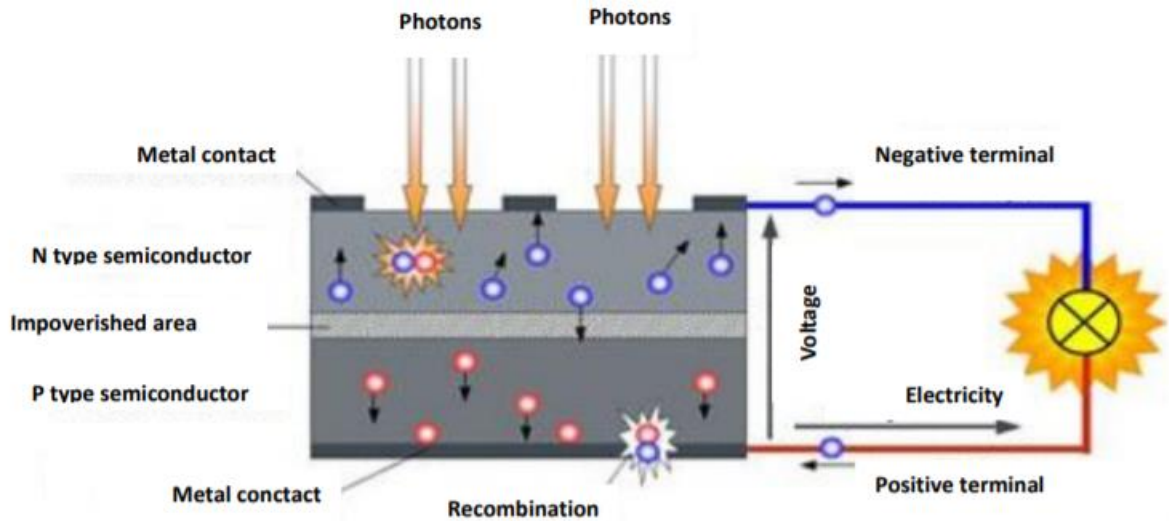


Solar energy situation in India (March 2019)

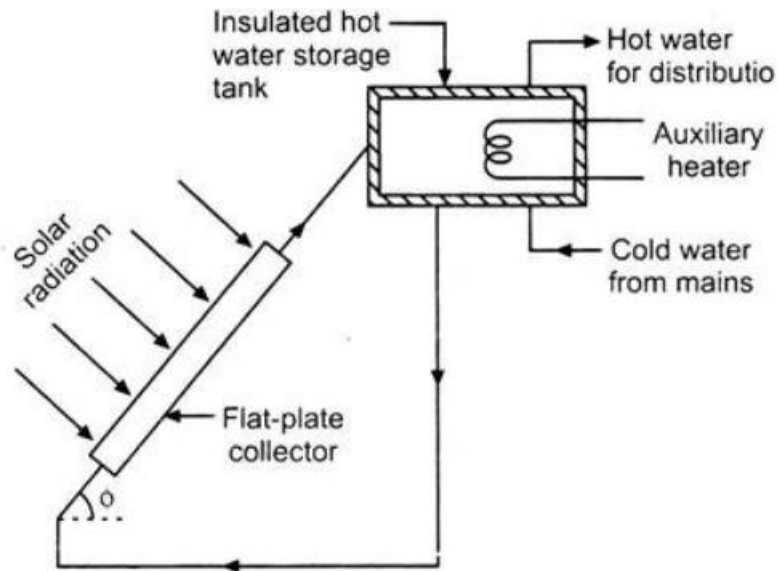
Figure source: Ministry of new and renewable energy of India

## Method of harvesting solar energy

1. **Photovoltaic (PV) cell:** Photovoltaic cell is a device which directly converts sun light (photons) into electricity. The term photovoltaic is composed by two words, photo means light and voltaic means electric. Photovoltaic cell formed by the semiconductor material like silicon. Silicon is an element that naturally releases electrons when exposed to sun light and increase the conductivity. The conductivity can also be increased by introducing impurities into their crystal structure. It is based on *p-n junction* diode. As we know that if we introduce impurity like phosphorus atom with five valence electron act as n- type donor (excess of electrons) and impurity like boron with three electron act as p-type donor (excess of holes). Diffusion of electron occurs from the area of high electron concentration into a region of low electron concentration. When electron diffused across the p-n junction, they combine with holes on p-type. Due to diffusion electricity produce.



2. **Solar water heater:** Solar water heater consist collectors (flat-plate), insulated storage tank, interconnecting pipelines. The flat-plate collectors (absorb solar radiation) are place over the roof of building or home to capture the sun light. Small tube runs along the collector and carries water. When sun light incident on the collector, then water absorbs heat from the collector. Warm water stored into the insulated storage tank.



### **Advantage of solar energy**

- i) It is renewable source of energy.
- ii) Low cost of maintenance.
- iii) Solar energy is non polluting sources of energy.

## Disadvantage of solar energy

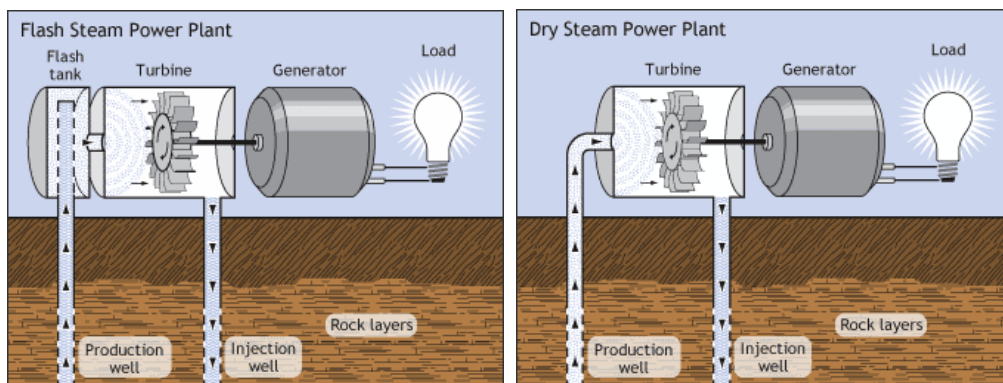
- i) Installation cost is high.
- ii) Lots of space is needed to install the solar panels.
- iii) During cloudy days and winter season energy production is lower down.

## GEOTHERMAL ENERGY

The term geothermal comes from Greek word *Geo* means Earth and *Thermos* means Heat. Energy which obtained from the earth's core is known as geothermal energy. In earth's core geothermal energy continuously produce due to collision of tectonic plates and due to decay of radioactive materials. In this process two tunnels are drilled inside the earth. One tunnel used to inject water into the earth. When water injected into the earth, where water come in contact with hot rocks and produced steam. The generated steam comes out from the second tunnel where it rotates turbine to produce mechanical energy. The produced mechanical energy can be converted into electrical energy with the help of generator.

### Types of Geothermal power plant

- a) **Flash steam power plant:** It take high-pressure hot water (around 180°C) from deep inside the earth and convert it to steam to drive generator turbines. When the steam condenses to water then it again injected back into the ground. Most geothermal power plants are flash steam plants.



- b) **Dry steam power plant:** In this case underground steam is used to rotate turbine which derive generator to produce electricity.



### **Advantage of geothermal energy**

- i) It is also a renewable source of energy.
- ii) Unlike solar cell, it works all day and night.
- iii) Low cost of maintenance.
- iv) Geothermal energy is advantageous over fossil fuel.

### **Disadvantage of geothermal energy**

- i) Underground hot water is necessary for geothermal energy.
- ii) Installation cost is high.
- iii) Production efficiency is lower.

## **BIOMASS**

Biomass is a renewable energy resource, also known as 'carbon neutral' (because biomass formed by sunlight, water, carbon dioxide, so biomass does not increase carbon dioxide on the earth) or 'phytomass'. It is formed by the excreta or waste materials of living organism (like sewage, cow dung etc.) and dead plants & tress (firewood, wood shavings, fruit stone etc.). In biomass, the energy from the sunlight is stored in the form of cellulose, sugar, starch, lignin etc. The chemical energy released from these molecule when they undergoes digestion or combustion because chemical bonds between carbon, hydrogen and oxygen are broken.

### **Energy generation from biomass**

- a) **Combustion** or burning is most common method to obtain energy directly from biomass.
- b) **Fermentation**: in this process, biomass (carbohydrate) is converted into alcohol in presence of bacteria or yeast.
- c) **Biomass gasification**: In this process, biomass is converted into combustible fuel like producer gas ( $\text{CO} + \text{H}_2$ ) and small amount of methane through incomplete combustion.

### **Advantage of biomass energy**

- i) It is also a renewable source of energy.
- ii) Burning of alcohol or producer gas produce less amount of pollutant gases.
- iii) Biomass present in large amount.
- iv) Help to reduce waste.

## Disadvantage of biomass energy

- i) Direct combustion of biomass generates pollutant gases like fossil fuel.
- ii) Cause deforestation.
- iii) Not efficient like fossil fuel.

## BIOGAS

It is formed by the bacterial degradation of biomass under anaerobic condition (airtight digesters). Biogas mainly contains methane (50-70%), carbon dioxide and trace amount of water, sulfur and hydrogen sulphide.

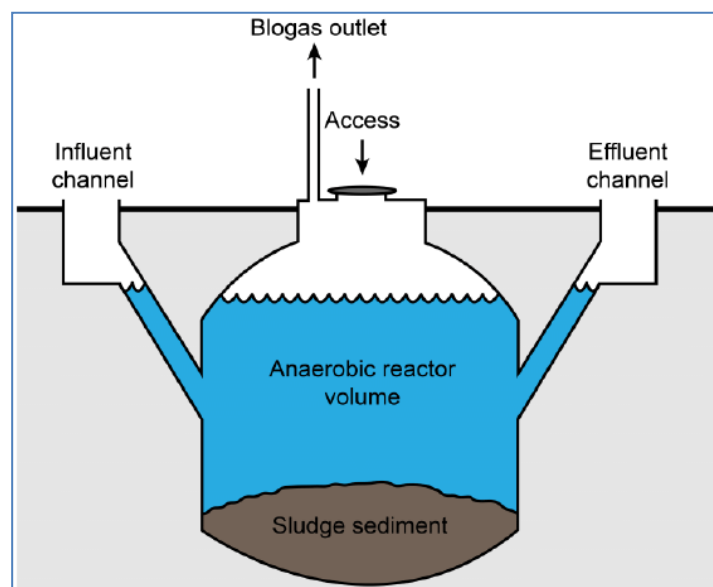
### Biogas generation

The biogas generated by anaerobic digestion of organic waste (animal waste, plant residue, crops) in biogas plant, mainly involve three steps: hydrolysis, acid formation and gas production.

**Hydrolysis:** In this step, macromolecule like fats, proteins, carbohydrates are broken down through hydrolysis into fatty acids, amino acids and sugars respectively.

**Acid formation:** in this step, fatty acids, amino acids and sugars are fermented by acid producing bacteria under anaerobic condition into acetic acid, carbon dioxide and hydrogen.

**Gas production:** In this step, methanogenic bacteria produce methane either by fermenting acetic acid to form methane and carbon dioxide or by reduction of carbon dioxide into methane.



### Advantage of biogas

- i) Produce organic waste
- ii) Burn without smoke
- iii) Renewable
- iv) Help to reduce waste.

### Disadvantage of biogas

- i) Methane is health hazardous.
- ii) Not efficient like fossil fuel.

## HYDROGEN ENERGY

Hydrogen is light in weight, most abundant chemical element (about 90% of material present on Earth contains hydrogen) of the earth, present in the form of hydrocarbon, hydrides, organic compounds, water etc. Hydrogen is a cleanest (burn without emission of carbon containing gases) and renewable source of energy.

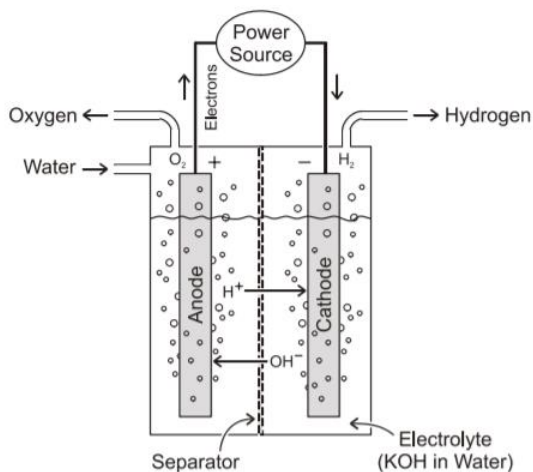
### Technology for hydrogen generation

- a) **Electrolysis of water:** Electrolysis is a process in which electricity is used to decompose water into hydrogen and oxygen. The cell is filled with pure water and two electrodes (cathode and anode) are connected with external power source. When a critical voltage is provide to electrodes then electrodes start to produce hydrogen gas at cathode and oxygen gas at anode by electrolysis:

At anode



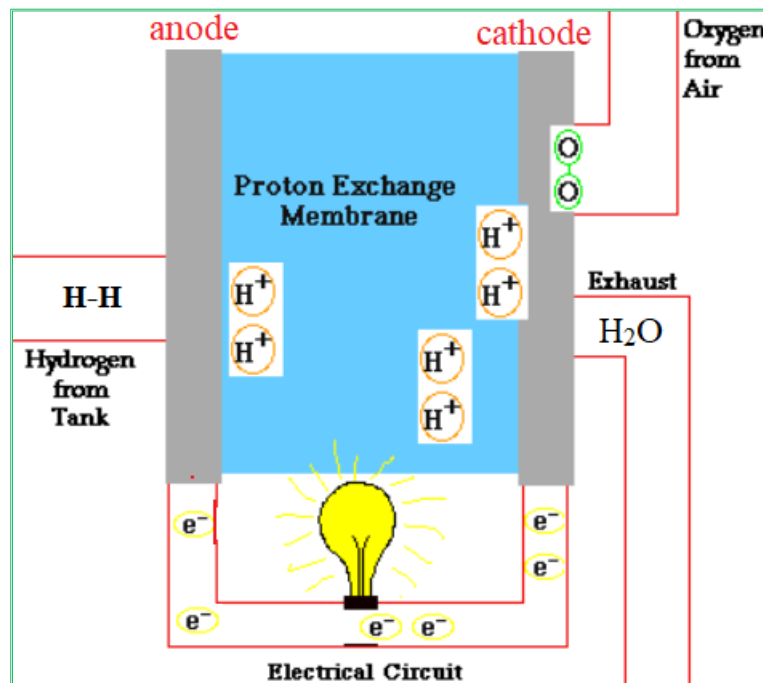
At cathode



- b) **Steam methane reforming:** In this process, methane gas is converted into hydrogen gas in presence of steam. The process comprises three steps; in first step methane is mixed with steam and fed in catalytic reactor, where methane is converted in carbon monoxide and hydrogen. In second step, produce carbon monoxide fed in CO catalytic converter, where CO converts into hydrogen and carbon dioxide in presence of steam. In last step, carbon dioxide and other impurities are removed from gas stream and only pure hydrogen gas remains left.

### Energy generation

**Fuel cell:** In fuel cell, electricity produces by combination of hydrogen with oxygen and only water and heat are generated as by product. Fuel cell consist two electrodes, one cathode and other one is anode. Hydrogen gases enter through anode side where catalyst (platinum catalyst) converts hydrogen molecules into hydrogen ions (protons) and release electrons. The electrons go through the external circuit to produce electricity and hydrogen ions migrate towards cathode side where hydrogen ions combine with oxygen in presence of electrons to produce water molecule.



### Advantage of hydrogen energy

- i) Better energy-to-weight ratio.
- ii) Produce zero harmful gas.
- iii) Renewable.
- iv) High efficiency.

### Disadvantage of hydrogen energy

- i) Expensive to extract (because hydrogen does not present in pure form).
- ii) Highly inflammable.
- iii) Hydrogen is difficult to storage and transport.

## NUCLEAR ENERGY

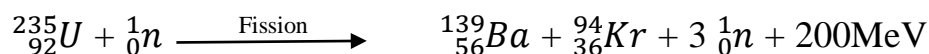
In India, the foundation of Atomic energy programme was laid down by Dr. Homi Jehangir Bhabha. He drew the road map of the nuclear power programme that has helped India in securing a place among the elite club of nations that possess advance nuclear technology.

Operating Units in India	Under construction units in India
Tarapur Atomic Power Station Units	Kakrapar Atomic Power Project Unit-3&4
Madras Atomic Power Station Units	Rajasthan Atomic Power Project Units-7&8
Rajasthan Atomic Power Station Units	Gorakhpur Haryana Anu Vidhyut Pariyojna Units-1&2
Narora Atomic Power Station Units	Kudankulam Nuclear Power Project Unit-3&4
Kakrapar Atomic Station Units	
Kaiga Generating Station Unit	
Kudankulam Nuclear Power Station Unit	

Nuclear energy is produced by the nuclear fission or nuclear fusion reaction, which start with decay of radioactive elements like uranium, thorium, radium etc.

### Nuclear Fission:

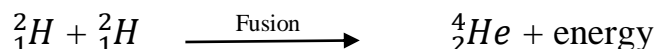
In this case nuclear energy is produced by bombardment of slow neutrons or thermal neutrons on heavy atom like Uranium. On bombardment Uranium get excited and split into two medium weight nuclei and liberate large amount of energy (more than 200 MeV of energy).



In above reaction, large amount of neutrons are release during fission reaction. These neutrons can be used in **chain reaction**.

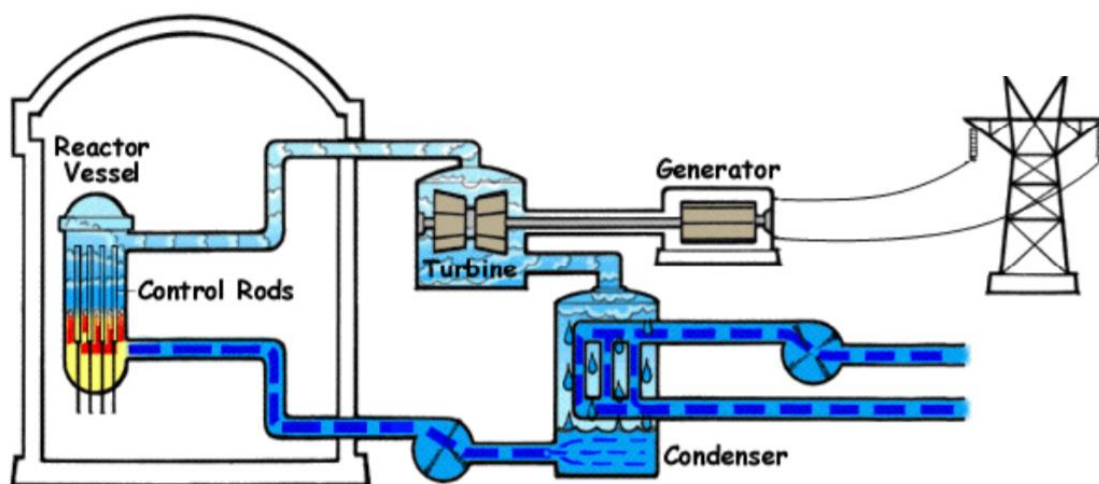
### **Nuclear Fusion:**

In this case, two lighter atoms like deuterium atom combine at extremely high temperature to form heavier nuclei helium (stable) atom and release large amount of energy.



### **Energy Generation**

During the nuclear reaction large amount of heat is generated, heat is used to create steam. Steam is used to rotate turbine to produce mechanical energy. The produced mechanical energy can be converted into electrical energy with the help of generator.



## **FOSSIL FUELS**

Fossil energy sources are non renewable energy resources, it include coal, petroleum and natural gas, formed from the remains of dead plants and animals.

**1. Coal:** it is solid, black, combustible fuel; derive from the remains of plant matter under high temperature and pressure over millions of years. On the basis of formation, coal is classified into four categories: peat, lignite, bituminous, anthracite. High rank of coal formed under extremely high temperature and pressure.

Rank:	Lignite	Subbituminous	Bituminous	Anthracite
% Carbon:	65-72	72-76	76-90	90-95
% Water:	70-30	30-10	10-5	~5
Heating value (BTU/lb):	~7000	~10,000	12,000–15,000	~15,000

From the annual report of Ministry of Coal, Government of India, the coal production in all over India during the session of 2019-2020 up to December, 2019 was 480.04 million tonnes.

**Energy generation:** Coal power plant produces electricity by burning of coal. When coal burned, large amount of heat released which is used up by water to generate high temperature and high pressure steam. Steam is used to rotate turbine which produce mechanical energy. The produced mechanical energy can be converted into electrical energy with the help of generator.

#### **Advantage of coal energy**

- i) Cheap source of energy.
- ii) Present abundantly.
- iii) It is inexpensive to convert coal into energy.

#### **Disadvantage of coal energy**

- i) Non renewable energy source.
- ii) Produce greenhouse gases.
- iii) Due to mining of coal, Natural habitats are destroyed.

**2. Natural gas:** Natural gas is a cleanest fossil fuel amongst all fossil fuel, mainly contains methane (70-90%) and some amount of ethane, propane, butane. Natural gas is used to produce electricity, in transportation, and also used as a domestic fuel. Its calorific value is about 12,500 kcal/kg.

**3. Petroleum:** it is naturally occurring mixture of paraffins, olefins, aromatic hydrocarbon with small amount of sulphur, nitrogen and oxygen. The term petroleum is derives from two Latin words *petra* means rock and *oleum* means oil. Petroleum product (gasoline, diesel, kerosene) have high calorific value, is also used as lubricating oil.