SOURCES OF ENERGY

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INTRODUCTION

If energy can neither be created nor destroyed, we should have no worries! We should be able to perform endless activities without thinking about energy resources then why we speak to save energy ?

Its because energy from the usable form, is dissipated to the surroundings in less usable forms. Hence, any source of energy we use, to do work, is consumed and cannot be used again.

GOOD SOURCES OF ENERGY

A good source of energy would be one

- Which would do a large amount of work per unit volume or mass,
- Be easily accessible,
- Be easy to store and transport, and
- Economical.

RENEWABLE AND NON- RENEWABLE RESOURCES

Natural resources can be classified into the renewable resources and non-renewable resources.

The resources which have the capacity or ability to reproduce or renew quickly are called **renewable resources**. They include solar and wind energy, water, soil, forests, etc. Some of the renewable resources can be destroyed due to careless use.

The **non-renewable** resources are limited in reserves and it may take thousands of years to renew them. For example, coal or petroleum if taken out completely, may take millions of years to produce them.

CONVENTIONAL SOURCES OF ENERGY

(A) Fossil Fuels :

Millions of years ago, the remains of plants and animals were buried under the earth by the forces of nature. The large amount of heat and pressure inside the earth converted these remains in fossil fuels, such as coal, petroleum and natural gas. These are the main sources of conventional energy.

The reserves of the fossil fuels are finite and limited. Their consumption is rapidly increasing in the modern world than their rate of formation. Thus one day or the other, the fossil fuels are likely to be exhausted.

They cannot be replenished like commodities derived from plant and animal kingdoms. Thus, we must develop alternative sources of power

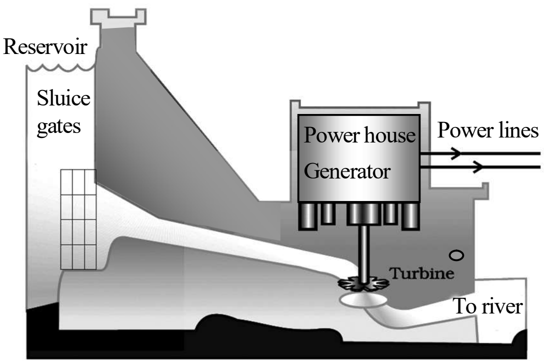
(B) Thermal power plant :

Large amount of fossil fuels are burnt every day in power stations to heat up water to produce steam which further runs the turbine to generate electricity.

The transmission of electricity is more efficient than transporting coal or petroleum over the same distance. Therefore, many thermal power plants are set up near coal or oil fields. Here fuel is burnt to produce heat energy which is converted into electrical energy.

(C) **Hydro power plants :**

Hydro power plants convert the potential energy of falling water into electricity. Since there are very few water-falls which could be used as a source of potential energy, hydro power plants are associated with dams.



In order to produce hydel electricity, high-rise dams are constructed on the river to obstruct the flow of water and thereby collect water in larger reservoirs. The water level rises and in this process the kinetic energy of flowing water gets transformed into potential energy. The water from the high level in the dam is carried through pipes, to the turbine, at the bottom of the dam .

Since the water in the reservoir would be refilled each time it rains (hydro power is a renewable source of energy) we would not have to worry about hydro electricity sources getting used up the way fossil fuels would get finished one day.

Limitation : constructions of big dams have certain problems associated with it. The dams can be constructed only in a limited number of places, preferably in hilly terrains. Large areas of agricultural land and human habitation are to be sacrificed as they get submerged.

Large eco-systems are destroyed when submerged under the water in dams.

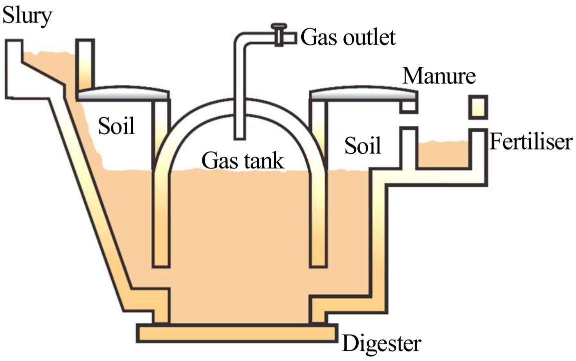
The vegetation which is submerged rots under anaerobic conditions and gives rise to large amounts of methane which is also a green-house gas. It creates the problem of satisfactory rehabilitation of displaced people. Opposition to the construction of Tehri Dam on the river Ganga and Sardar Sarovar project on the river Narmada are due to such problems.

(D) Bio-mass :

Plant and animal products are said to be bio-mass. These fuels, however, do not produce much heat on burning and a lot of smoke is given out when they are burnt. Therefore, technological inputs to improve the efficiency of these fuels are necessary.

When wood is burnt in a limited supply of oxygen, water and volatile materials present in it get removed and **charcoal** is left behind as the residue. Charcoal burns without flames, is comparatively smokeless and has a higher heat generation efficiency.

Similarly, cow-dung, various plant materials like the residue after harvesting the crops, vegetable waste and sewage are decomposed in the absence of oxygen to give **bio-gas**. Since the starting material is mainly cow-dung, it is popularly known as '*gobar-gas*'

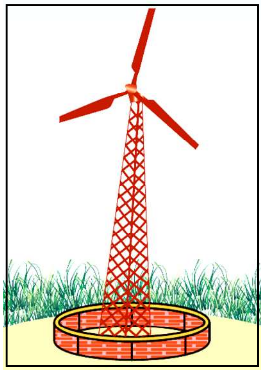


Bio-gas plant

Structure :
The plant has a dome-like structure built with bricks. A slurry of cow-dung and water is made in the mixing tank from where it is fed into the digester.
The digester is a sealed chamber in which there is no oxygen. Anaerobic micro-organisms that do not require oxygen decompose or break down complex compounds of the cow-dung slurry.
It takes a few days for the decomposition process to be complete and generate gases like methane, carbon dioxide, hydrogen and hydrogen sulphide.

The bio-gas is stored in the gas tank above the digester from which they are drawn through pipes for use. Bio-gas is an excellent fuel as it contains up to 75% methane. It burns without smoke, leaves no residue like ash in wood, charcoal and coal burning. Its heating capacity is high. Bio-gas is also used for lighting. The slurry left behind is removed periodically and used as excellent manure, rich in nitrogen and phosphorous.

(E) Wind energy :
Heating of the landmass and water bodies by solar radiation generates air movement and causes winds to blow. This kinetic energy of the wind can be used to do work. This energy was harnessed by windmills in the past to do mechanical work.
For example, in a water-lifting pump, the rotatory motion of windmill is utilised to lift water from a well. Today, wind energy is also used to generate electricity.
To generate electricity, the rotatory motion of the windmill is used to turn the turbine of the electric generator. The output of a single windmill is quite small and cannot be used for commercial purposes. Therefore, a number of windmills are erected over a large area, which is known as wind energy farm.



Advantage :
Wind energy is an environment-friendly and efficient source of renewable energy. It requires no recurring expenses for the production of electricity.

limitations : Wind energy farms can be established only at those places where wind blows for the greater part of a year. The wind speed should also be higher than 15 km/h to maintain the required speed of the turbine. Furthermore, there should be some back-up facilities (like storage cells) to take care of the energy needs during a period when there is no wind.

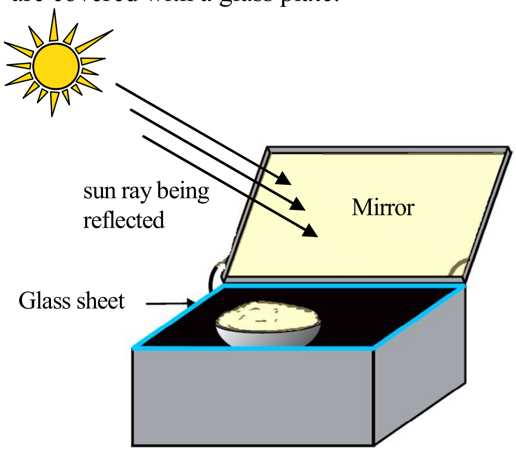
Establishment of wind energy farms requires large area of land. For a 1 MW generator, the farm needs about 2 hectares of land. The initial cost of establishment of the farm is quite high. Moreover, since the tower and blades are exposed to the vagaries of nature like rain, Sun, storm and cyclone, they need a high level of maintenance.

➢ NON CONVENTIONAL SOURCES OF ENERGY

(A) SOLAR ENERGY :
The Sun has been radiating an enormous amount of energy. Small part of solar energy reaches the outer layer of the earth's atmosphere is absorbed while passing through the atmosphere and the rest reaches the earth's surface.

(i) Solar cooker :

A black surface absorbs more heat as compared to a white or a reflecting surface under identical conditions. Solar cookers and solar water heaters use this property in their working. Some solar cookers achieve a higher temperature by using mirrors to focus the rays of the Sun. Solar cookers are covered with a glass plate.



(ii) Solar cell :

Solar cells convert solar energy into electricity. A typical cell develops a voltage of 0.5–1 V and can produce about 0.7 W of electricity when exposed to the Sun. A large number of solar cells are, combined in an arrangement called solar cell panel that can deliver enough electricity for practical use.

The principal advantages associated with solar cells are that they have no moving parts, require little maintenance and work quite satisfactorily without the use of any focussing device.

Another advantage is that they can be set up in remote and inaccessible hamlets or very sparsely inhabited areas in which laying of a power transmission line may be expensive and not commercially viable.

Silicon, which is used for making solar cells, is abundant in nature but availability of the special grade silicon for making solar cells is limited. The entire process of manufacture is still very expensive, silver used for interconnection of the cells in the panel further adds to the cost.

In spite of the high cost and low efficiency, solar cells are used for many scientific and technological applications. Artificial satellites and space probes like Mars orbiters use solar cells as the main source of energy.

(B) ENERGY FROM SEA :

(i) Tidal energy : Due to the gravitational pull of mainly the moon on the spinning earth, the level of water in the sea rises and falls.This phenomenon is called high and low tides and the difference in sea-levels gives us tidal energy. Tidal energy is harnessed by constructing a dam across a narrow opening to the sea.

A turbine fixed at the opening of the dam converts tidal energy to electricity.

(ii) Wave Energy : the kinetic energy possessed by huge waves near the seashore can be trapped in a similar manner to generate electricity.

The waves are generated by strong winds blowing across the sea. Wave energy would be a viable proposition only where waves are very strong. A wide variety of devices have been developed to trap wave energy for rotation of turbine and production of electricity.

(iii) Ocean Thermal Energy :

The water at the surface of the sea or ocean is heated by the Sun while the water in deeper sections is relatively cold. This difference in temperature is exploited to obtain energy in ocean-thermal-energy conversion plants. These plants can operate if the temperature difference between the water at the surface and water at depths up to 2 km is 293 K (20°C) or more. The warm surface-water is used to boil a volatile liquid like ammonia. The vapours of the liquid are then used to run the turbine of generator. The cold water from the depth of the ocean is pumped up and condense vapour again to liquid.

The energy potential from the sea (tidal energy, wave energy and ocean thermal energy) is quite large, but efficient commercial exploitation is difficult.

(C) GEO THERMAL ENERGY :

Due to geological changes, molten rocks formed in the deeper hot regions of earth's crust are pushed upward and trapped in certain regions called 'hot spots'. When underground water comes in contact with the hot spot, steam is generated. Sometimes hot water from that region finds outlets at the surface. Such outlets are known as hot springs.

The steam trapped in rocks is routed through a pipe to a turbine and used to generate electricity. The cost of production would not be much, but there are very few commercially viable sites where such energy can be exploited. There are number of power plants based on geothermal energy operational in New Zealand and United States of America.

(D) NUCLEAR ENERGY :

Nuclear fission :

- The process of splitting of a heavy nucleus into two lighter nuclei of comparable masses (after bombardment with a energetic particle) with liberation of energy is called nuclear fission.

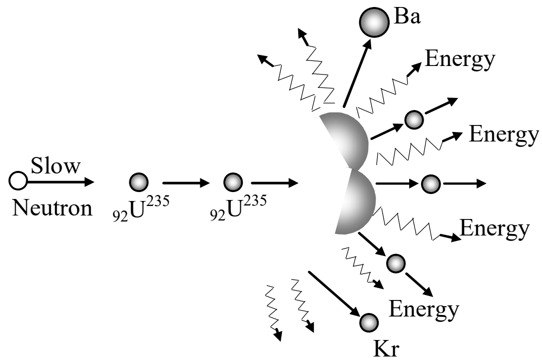
- **Fission reaction of U^{235}**

$${}_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{92}U^{236} \rightarrow$$

(unstable nucleus)

$${}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_{0}n^{1} + Q$$

- The energy released in U^{235} fission is about 200MeV or 0.8 MeV per nucleon.
- Fission of U^{235} occurs by slow neutrons only (of energy about 1eV) or even by thermal neutrons (of energy about 0.025 eV).
- The neutrons released during the fission process are called prompt neutrons.
- Most of energy released appears in the form of kinetic energy of fission fragments.



◈ Nuclear Fusion :

It has been observed that under special conditions, it is possible for the nuclei of light elements to combine and form a nucleus of a high atomic number. When two or more light nuclei moving at very high speed are fused together to form a heavy nucleus, then the process is known as nuclear fusion.

The mass of the product nucleus is smaller than the sum of the masses of the nuclei which were fused. The lost mass is converted into energy which is released in the process.

$${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{1}^{3}H + {}_{1}^{1}H + 4.0\text{ MeV}$$

Deuteron Deuteron Triton Proton Energy

The triton so formed can further fuse with a third deuteron to form an α–particle (Helium–nucleus).

$${}_{1}^{3}H + {}_{1}^{2}H \longrightarrow {}_{2}^{4}He + {}_{0}^{1}n + 17.6\text{ MeV energy}$$

◈ Difference (Table) :

S. No	NUCLEAR FISSION	NUCLEAR FUSION
1	A heavy nucleus disintegrates to give lighter nuclei with the release of energy.	Two or more light nuclei join together to form a heavy nucleus with the release of energy
2	Nuclear fission is a chain reaction-the fission of one nucleus leading to the production of neutrons, which cause more nuclei to disintegrate.	Nuclear fusion is not a chain reaction.
3	Nuclear fission requires thermal neutrons neutronswith sufficient energy to split a nucleus. But it does not require very high temp.	Nuclear fusion requires high temperatures in the range of 10^6K.
4	Fission process can be carried out in a reactor.	Fusion cannot be carried out in any container, as the temperature is very high. Scientists hope to contain matter in a magnetic field
5	Controlled nuclear fission is possible and takes place in a nuclear reactor.	Controlled nuclear fusion has so far not been achieved. Only uncontrolled fusion reactions in the thermonuclear devices such as the hydrogen bomb have been achieved.
6	Nuclear fission produces radioactive wastes, which pose the problem of waste disposal.	Nuclear fusion does not produce radioactive wastes and, therefore, does not cause pollution.

➢ ELECTRICITY FROM NUCLEAR ENERGY

◈ ELECTRICITY FROM NUCLEAR ENERGY

- **Nuclear Power Plant and it's Working :**
The heat produced in a controlled fission can be used for producing electricity. The set–up used for generating electricity from the heat released in a controlled nuclear fission is called a nuclear power plant or nuclear power station. The heat produced in a controlled nuclear fission is used for producing steam. The steam so produced runs the turbine. The rotatory motion of the turbine rotates the alternator of the generator and the electricity is produced. Thus, in a nuclear power plant the energy transforms in the following sequence :
Nuclear energy of uranium–235 nucleus → Heat energy of steam → Kinetic energy of turbine → Kinetic energy of the alternator → Electrical energy

- **Components of a Nuclear Power Plant :**
A nuclear power plant consists of the following components :
(a) Nuclear reactor : Here, a controlled nuclear fission of a fissionable fuel such as ${}^{235}_{92}U$ is carried out.
(b) Heat exchanger : The reactor is connected to heat exchanger. Here, the heat produced in the reactor is transferred to water by circulating a coolant through a coiled pipe. The water gets converted into steam. The coolant is pumped back to the reactor.
(c) Steam turbine : The steam generated in the heat exchanger is used to run the steam turbine. The spent steam is sent back as hot water to the heat exchanger.
(d) Electric generator (or dynamo) : The shaft of the steam turbine is connected to an electric generator (or dynamo). Electricity so produced is sent for transmission.

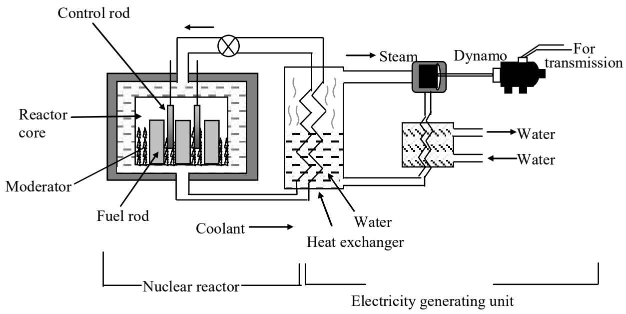


Fig : Nuclear Power Plant

Location of Power Station in India

At present about 3% of the electrical energy produced in India is obtained from nuclear power stations (also called atomic power stations).

The following atomic stations are in operation in India :

- Tarapur atomic power station (420 MW) in maharashtra.
- Rajasthan atomic power station (440 MW) at Rana Pratap Sagar near Kota in Rajasthan.
- Madras atomic power station (420 MW) at Kalpakkam in Tamil Nadu.
- Narora atomic power station (470MW) near Bulandshahar in Uttar Pradesh.

SUN"THE ULTIMATE SOURCE OF ENERGY"

The source of the large amount of solar energy is due to fusion of lighter nuclei. About 90 percent of the solar mass is composed of hydrogen and helium and rest 10 percent contains other elements. The temperature of the interior of the sun is estimated to be about 2×10^7K.

The nuclei of hydrogen fuse together in the sun's interior to produce helium and a huge amount of energy is released. It is estimated that 1g of hydrogen produces 620,000 million joules of energy.

The fusion process in the sun can be described by the equation.

$$4\,{}_1^1H \longrightarrow {}_2^4He + 2\,{}_{+1}^{\;0}e + \text{Energy}$$

DESTRUCTIVE FORM OF NUCLEAR ENERGY

(A) NUCLEAR BOMB

This produces tremendous amount of destructive energy. This energy is produced by uncontrolled nuclear fission chain reaction.

The atom bomb or nuclear bomb produces large amount of energy when two pieces of uranium (^{235}U) or Plutonium (^{239}Pu) are brought in contact so that the total mass become greater then critical mass.

During this process a very high temperature of the order of million degree kelvin is produced and also a very high pressure of the order of several million atmosphere is developed.

(B) HYDROGEN BOMB

It produces extremely high destructive energy by using nuclear fusion. The fusion reaction is performed over heavy–hydrogen nuclei at very high temperature and pressure.

To get this high temperature and pressure, nuclear fission bomb is used at the centre core of a hydrogen bomb which is formed of heavy hydrogen like lithium hydride (LiH_2).

ENVIRONMENTAL CONSEQUENCES

Exploiting any source of energy disturbs the environment in some way or the other. In any given situation, the source we would choose depends on factors such as the ease of extracting energy from that source, the economics of extracting energy from the source, the efficiency of the technology available and the environmental damage that will be caused by using that source. Research continues in these areas to produce longer lasting devices that will cause less damage throughout their life.

SAVING ENERGY RESOURCES

we cannot depend on the fossil fuels for much longer. Such sources that will get depleted some day are said to be exhaustible sources or non-renewable sources of energy. On the other hand, if we manage bio-mass by replacing the trees we cut down for fire-wood, we can be assured of a constant supply of energy at a particular rate. Such energy sources that can be regenerated are called renewable sources of energy.

Renewable energy is available in our natural environment, in the form of some continuing or repetitive currents of energy, or is stored in such large underground reservoirs that the rate of depletion of the reservoir because of extraction of usable energy is practically negligible.