

## **Bio fuels**

### **Introduction**

The capacity to do work is referred to as energy. Energy may be considered as a form of matter which is inter-convertible. The modern man is mostly dependent on three sources for his energy needs—coal, natural gas and oils, collectively referred to as fossil fuels or fossil energy sources.

The fear of depletion of global fossil fuels has forced man to look for suitable alternative energy sources such as solar, hydro, tidal and wind power, and more recently nuclear energy. In addition to these, advances in biotechnology have helped to fruitfully utilize the energy from biological systems.

### **Biomass:**

Biomass is the total cellular and organic mass, produced by the living organisms. It is the primary product of photosynthesis and is a good source of energy i.e. bioenergy. Broadly speaking, biomass represents all forms of matter derived from biological activities. These include plants and agricultural products, microorganisms, animal wastes and manure.

The term biomass is also used to collectively describe the waste materials produced in food and agricultural industries. Besides being a good source of energy, biomass is important for the production of several commercially important products. Thus, biomass is appropriately regarded as a renewable source of energy which can be

directly converted to energy or energy carrier compounds by various means.

In most developed countries, biomass is utilized for the production of industrial and commercial products (ethanol, oils, methane, and single – cell protein). In contrast, in the developing countries (India, Latin America, Africa), a major part of the biomass is directly used as a source of energy (as firewood).

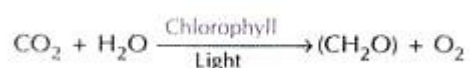
### **Fossil fuels-derivatives of biomass:**

The modern society is dependent of on the non-renewable sources of energy namely oil, gas and coal. These fossil fuels are actually derivatives of ancient biomass. It took millions of years for the fossil fuels to be deposited beneath the earth and oceans.

However, in just within a century of exploration, the major fuel reserves (particularly gas and oil) are depleted, and at the present rate, they are not likely to last long. As such, there exists an energy crisis throughout the world. Consequently, researchers continue their search for alternate and renewable sources of energy.

### **Photosynthesis-the ultimate source of energy:**

Photosynthetic organisms are the ultimate sources for trapping the solar energy. In the presence of photosynthetic pigment chlorophyll, carbon dioxide is converted into complex carbohydrates with the evolution of oxygen.



In the reactions that follow later, solar energy is trapped into molecules such as fat and proteins, besides other complex carbohydrates (cellulose, hemicellulose, and lignin). Photosynthetic organisms are the true solar energy converters.

The biomass produced by photosynthesis can be appropriately utilized for the production of fuels (alcohol, methane) and various other commercial products.

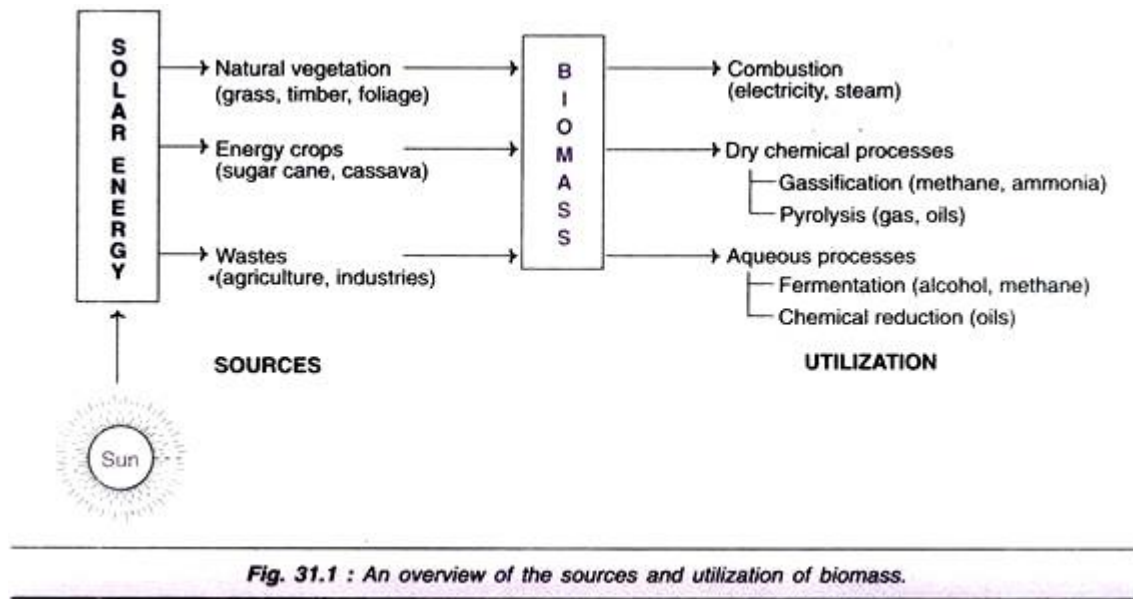
### **Chemical nature of biomass:**

The plant biomass is mainly composed of cellulose, hemicellulose, lignin, starch, proteins, water soluble (sugars, amino acids) and fat soluble (oils, pigments) compounds. In fact, majority of these constituents are present in the plant cell walls.

There is a wide variation in the chemical composition of the biomass, depending on the source. For instance, the biomass obtained from sugar cane and beet sugar is rich in sugars while the biomass of potato and tapioca is rich in starch. On the other hand, cotton has high content of cellulose. The chemical nature of biomass derived from industrial and municipal wastes is highly variable which mostly depends on the sources that contribute to the biomass.

### **Sources and Utilization of Biomass:**

The major sources of biomass are natural vegetation, energy crops, and agricultural, industrial and urban organic wastes (Fig. 31.1). Their production in turn is dependent on the solar energy.



The natural vegetation (growing natural forests and aquatic weeds) significantly contributes to biomass. Wood-rich plants are grown in many countries (particularly developing countries) to generate fire for cooking and other purposes. In recent years, well planned and organized plantations are carried out in some countries to produce biomass to meet energy demands. For instance, sugar cane and cassava plantations in Brazil and Australia are used for ethanol production. Plants rich in lignocellulose are grown in America and Sweden which are useful for the production of liquid fuels (ethanol, methanol).

Agricultural, industrial and municipal wastes were earlier considered as useless and discarded. But in the recent past, many countries have developed methods for converting these wastes into biofuels and commercially important products. The successfully used agricultural wastes include straw, bagasse, bran, cotton wastes. Among the industrial wastes, molasses, whey, distillery wastes and sewage are

the important ones. The biomass is utilized for the production of biofuels and various other compounds. The technique mainly depends on the chemical nature and moisture content of biomass.

### **Combustion:**

Low moisture containing biomass (wood, straw, bran) can be directly burnt by a process referred to as combustion to generate electricity.

### **Dry chemical processes:**

The biomass with little moisture content can be subjected to various dry chemical processes-pyrolysis, gasification to produce methanol, oil and ammonia biomass.

### **Aqueous processes:**

The biomass with high water content is used in aqueous processes such as fermentation to produce ethanol, oils and methane.

### **Production of Alcohol from Biomass:**

Alcohol, chemically ethanol ( $C_2H_5OH$ ) has been produced by fermentation for thousands of years. Although the developed countries these days prefer to manufacture ethanol by chemical means, the developing countries continue to produce it by microbial fermentation. Alcohol is the liquid fuel which is mostly produced from the biomass. The raw materials (biomass) used for alcohol production include starchy materials (wheat, rice, maize, potato) and cellulosic materials (wood, agricultural wastes).

### **Energy-Rich Crops:**

Some of the plants are very efficient in converting CO<sub>2</sub> into biomass and such plants are collectively referred to as energy-rich crops.

### **Sugar and starch crops:**

Certain plants like sugar cane, sugar beet, cereals and tuber crops produce high quantities of starch and fermentation sugars. These crops supply energy-rich foods and feeds. Such plants are useful for production of biofuels, particularly ethanol often referred to as bioethanol.

### **Wood-rich plants:**

Some plants grow very fast and they serve as good suppliers of wood. E.g. Eucalyptus, Butea, Melia, Casurina. These plants are important sources of firewood. It is estimated that approximately 50% of the total wood harvested annually is utilized for the purpose of firewood. Wood is also useful for the supply of pulp for paper manufacture.

### **Petroleum plants:**

There are certain plants which can accumulate high molecular weight hydrocarbons. They are referred to as petro-crops or gasoline plantations. The products of these hydrocarbon-rich plants can serve as good substitutes of conventional petroleum and petroleum products.

The rubber plant (Hevea rubber), grown in South-East Asia is the principal source of rubber. Rubber is collected in the form of latex

from the stems of trees. This plant meets about one third of the total world's demand of rubber.

However, the rubber produced from petroleum is preferred for use in automobiles and planes, due to low-cost and high elasticity. Besides Hevea rubber, there are some other plants for the production of natural rubber e.g. *Parthenium agrentatum* (guayule) *Taraxacum koksaghyz* (Russian dandelion) grown in Mexico and some parts of USA.

*Euphorbia lathyrus* and *E. terucalli* contain high contents of terpenoids (complex hydrocarbons) that can be directly converted to gasoline/petrol. It is estimated that *E. terucelli* can yield about 5-10 barrels of oil/acre/year.

Aak plant (*Calotropis procera*) secretes latex which is very rich in hydrocarbons. These hydrocarbons, and the yield are comparable to *Euphorbia lathyrus*, and they also serve as good substitutes of petroleum.

For obvious reasons, the cultivation of petroleum plants is encouraged throughout the world.

Besides its utility for the generation biofuels (alcohol, methane), biomass is also used for the production of butanol, acetone, single-cell protein and many other products. However, being a renewable source of energy, biomass will have immense value in future. This is particularly true as the world's non-renewable fuels (gas and oil) get depleted.

There is a growing realization on the fuel value of biomass. In the coming years, biomass production and utilization strategies will be fully exploited. In addition, further improvements in the biotechnological processes for better management and utilization of industrial, agricultural and domestic wastes will also solve the problem of world energy crisis.



## **Renewable Resources and Non-Renewable Resources**

Everything which surrounds us is collectively called as the environment. Environment forms a life supporting system for us.

In other words, we can say that the basic needs of human life are fulfilled by the materials available in the nature. These materials are air, water, soil, minerals, coal, petroleum, animals and plants.

These stocks of nature, which are useful to mankind, are called natural resources. Human beings use various natural resources for their requirements

Various modes of human advancements such as growing population, agriculture, industrialization and urbanization have put pressure on the mankind to over exploit the natural resources.

The resources that are available in the environment and develop independent of human interference are called natural resources. Natural resources can be used directly by humans or it can be processed and used.

## Earth's Natural Resources



According to the renewability of the resources there are two types of natural resources.

**Natural resources can be classified into two categories:**

1. Renewable resources.
2. Non-renewable resources.

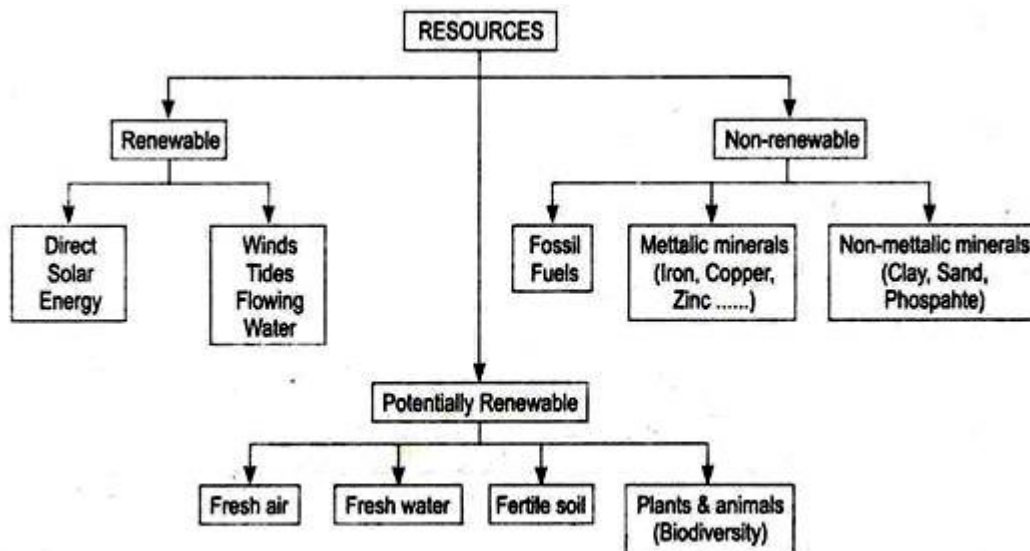
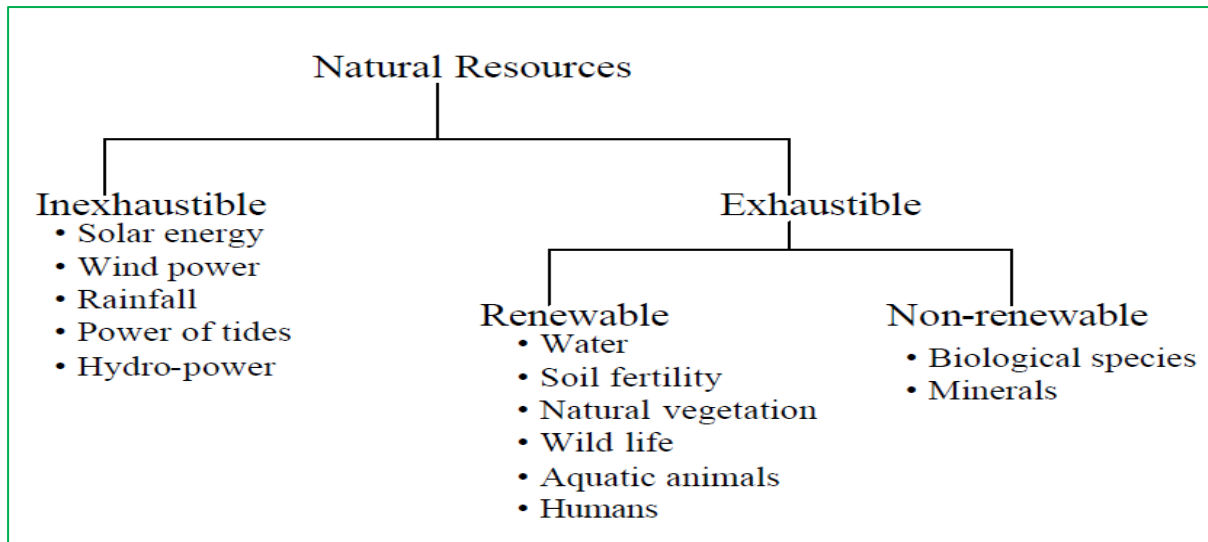


Fig. 6.1: Major types of natural resources



### 1. Renewable resources:

The resources that are responsible for the production of renewable energy are called renewable resources. They can be replenished at the same rate at which they are used. These resources are present in unlimited quantity in the nature and having the capacity to get replaced by quick recycling through natural cycles. Oxygen, in air is renewable resource because it is replaced by the plants by the process of photosynthesis. Some of the other renewable resources are solar radiation, water, wind, geo thermal and atomic power. However, these resources can be exhausted if used too rapidly by improper management and they do not get enough time for renewal.

The resources that are essentially inexhaustible in considered as renewable resources.

On the contrary a **potentially renewable resource** can be renewed fairly rapidly (few hours to several decades) through natural processes. Examples of such resources include forest, grassland, animal, fresh water, fresh air and fertile soil. But the resource renovation rate must be faster than resource exploitation.

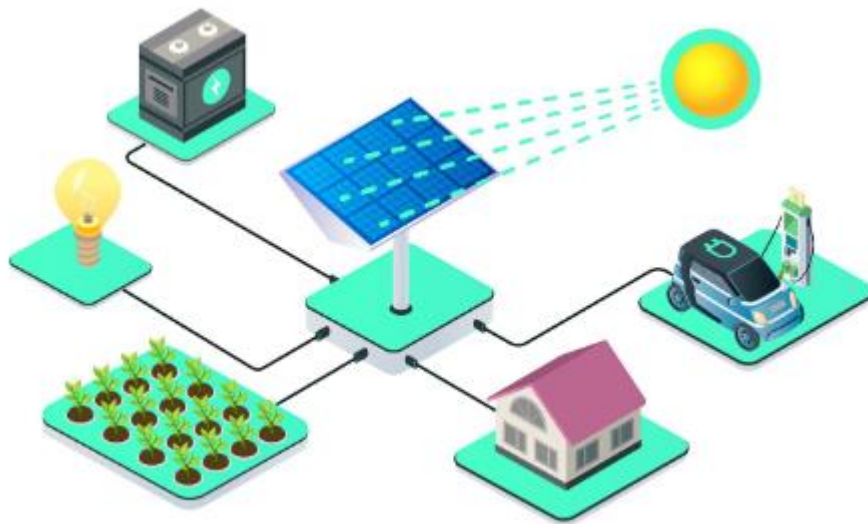
The highest rate at which a potentially renewable resource can be used indefinitely without reducing its available supply is called its sustainable yield. Several types of environmental degradation can change potentially renewable resources into non-renewable or unusable resources.

### **Types of renewable resources**

- Solar energy
- Wind
- Geothermal
- Hydropower
- Bioenergy

### **Solar energy**

The energy obtained from the sun is called solar energy. This can be captured to generate heat or electricity. This is done with the help of solar panels or mirrors. Solar panels are composed of solar cells and they can convert sunlight directly into electricity. This heat absorption panel is used by the solar thermal collectors for generating electricity. Solar panels can be fixed in houses or in public places. Solar cookers, solar energy driven street lights are some examples of the uses of solar energy in daily life.



## **Wind**

Wind energy is the energy obtained from wind. It is used to generate electricity through wind turbines. It has only a smaller impact on the environment. Windmills have blades that can convert the energy carried by wind into rotational energy in the turbines of the AC generator which can further be converted into electrical energy.

The wind turns the blades of windmills. The turning blades of windmills produce kinetic energy, kinetic energy is used for various purposes. Today, there are several wind farms having hundred of windmills, have been set up in our country to produce electricity.

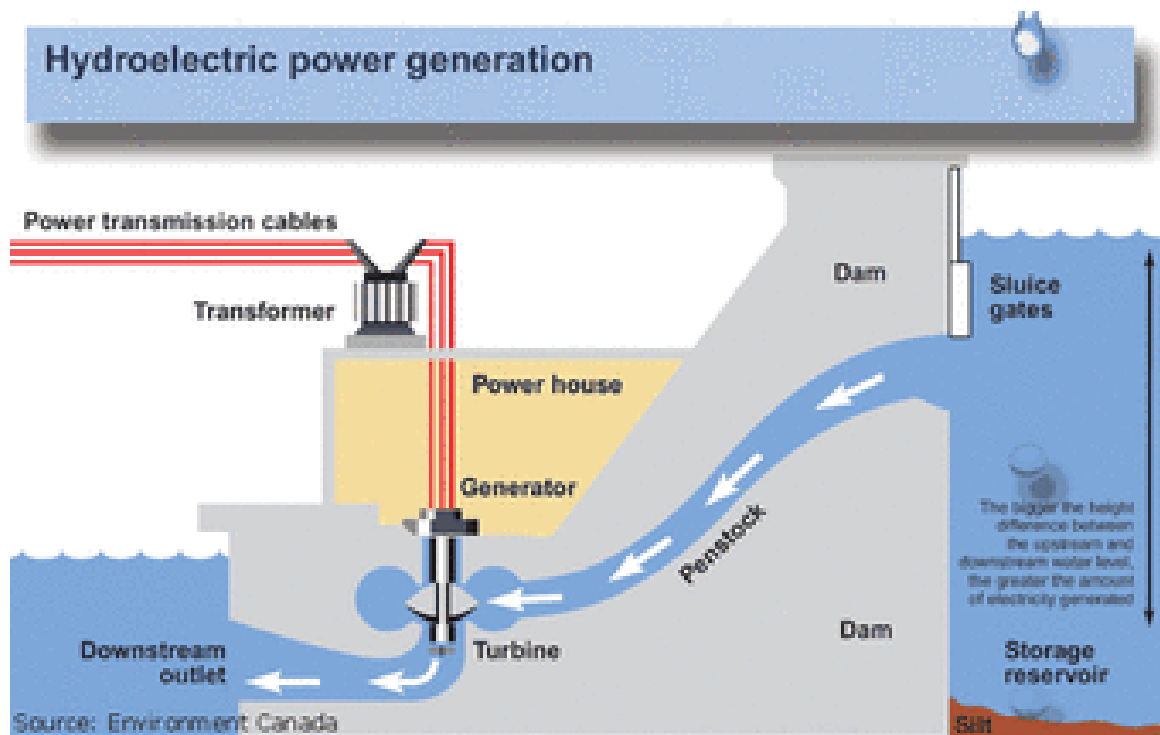
## **Geothermal**

The energy obtained from the thermal energy which is stored inside the earth is called geothermal energy. This energy originated by the formation of planet Earth and radioactive decay of materials. Electricity is generated from geothermal energy. This resource is more than adequate to supply the needs of humans.

The temperature inside the earth is still very high, steam from deep underground is now being used to provide heat and energy. The scientists in England and the USA are drilling holes deep underground, and pump cold water down the holes, when it gets to the bottom of natural heat of the earth turn into steam. The steam that comes up turns turbines of generators and electricity is produced

## **Hydropower**

The energy which is generated from the kinetic energy of flowing water is called hydropower or water power. The falling of water or fast running water is used to generate electricity or to power machines. Here the gravitational potential or kinetic energy of water is converted into electrical energy by turbines and generators. The energy generated is called hydroelectric power. Energy can be generated from ocean tides and it is known as tidal energy and wave energy is generated from the waves of the ocean surface. Dams are built to generate power by altering the natural flow of rivers or other water bodies. Bhakra dam is one of the best hydel power project in India. Hydro power is clean, non polluting source of energy. It can be transmitted to long distances through wires and cables



## Ocean/tidal energy

Tidal power generation depends on the harnessing of rise and fall of sea level due to tidal action. Important application of tidal power is in electricity generation. In India prospective sites for the exploitation of tidal energy are Gulf of Kutch, Cambay, Sunderbans

## OTEC: Ocean Thermal Energy Conversion

The temperature differences existing between warm surface sea water (28-30°C) and the cold deep sea water (5-7°C) which is available at a depth of about 800m to 1000m in tropical water can be utilised. The power is continuous, renewable and pollution free. A floating OTEC plant can generate power even at mid sea and can be used to

provide for operations like off-shore mining and processing of manganese nodules

## **Bioenergy**

The waste of animals and plants are used for making bioenergy. Chemical energy is present in the biomass of animals and plants. When it is burnt then it can produce bioenergy. The heat generated is used to produce electricity and also to run generators. The combustion of wood and animal waste is considered a traditional use of bioenergy. Biogas produced through anaerobic digestion of residues and bio-refineries is an example of modern bioenergy technology.

## **Advantages of renewable resources**

- The energy obtained from renewable resources is inexhaustible.
- The renewable resources do not emit any greenhouse gases while generating energy, hence there is less pollution.
- The renewable resources can be easily regenerated.
- These are unlimited resources.
- Very less carbon dioxide is emitted from renewable resources.
- Renewable resources are easily available and obtained from the same nation. Hence no need to get it from other countries.
- It has a very low maintenance cost.

## **Disadvantages of renewable resources**

- Due to feasibility constraints the renewable energy plant is difficult to set up.
- Solar energy can be used only during day time and not at night.



- Weather conditions can affect the availability of renewable resources.
- Renewable energy has less efficiency.
- The initial cost is very high for renewable energy.
- A lot of space is required for the harnessing of renewable energy.
- Recycling of renewable energy devices is needed.

### **Non-renewable resources** or exhaustible resources

The stock of these resources are limited in nature. These resources once used cannot be replaced within a reasonable time. The natural resources that are formed over a long period of time in the environment and are impossible to renew easily are called non-renewable resources. These resources can be depleted more quickly than they can be regenerated. The most common non-renewable resource is minerals. Oils and natural gases are obtained from fossil fuels which is also a non-renewable resource and the time period which they take to generate is over millions of years. Hence, once we mine these resources and use them, then they cannot be replenished. Some other examples of non-renewable resources are coal, compressed natural gas or CNG, uranium, gold, other rare earth elements etc.

Most of the non-renewable resources are present in limited quantities, since they take a long time to form. Non-renewable resources are depleted mainly by the use of humans, but they can also be depleted naturally. One of the examples for this is the natural decay of radioactive elements such as uranium.

These exhaustible resources include energy resources (Coal, Oil, Natural gas, Uranium), metallic mineral resources (iron, copper, aluminium) and non-metallic mineral resources (salt, clay, sand and phosphate). Some of these resources may be recycled and – viz., metallic resources while others cannot be recycled viz., energy resources. (Coal, Oil and Natural gases)

### **Types of non-renewable resources**

Non renewable energy resources can be classified broadly into two types. These are as follows:

- Fossil fuels
- Nuclear energy

#### **Fossil fuels**

The fuels formed as a result of the continuous heating and compressing of organic matter under the earth's surface are called fossil fuels. The fossil remains of animals and plants are the major organic matters that make the fossil fuel. The fuel can be mined or drilled in the form of solid, liquid or gas. These fuels give energy on burning. Hence, these fuels are called fossil fuels. All fossil fuels are obtained from organic matter. The amount of heat liberated on burning determines the quality of fuel.

Examples of fossil fuels are as follows:

- Crude oil
- Natural gas

- Coal

## **Crude oil**

The only liquid non-renewable resource that can be extracted from the layers of earth crust is called crude oil. It is also called petroleum oil. It can also be found in between the rocks. A vertical well into the ground and ocean floor is drilled to get the crude oil. Gasoline and diesel which powers the motor vehicles are obtained from crude oil. It is used up more quickly and very less oil fields are now available, hence scientists predict that this resource may not last beyond the middle of the 21<sup>st</sup> century.

## **Natural gas and oil**

The gaseous non-renewable resource found below the earth crust is called natural gas. It is a colourless, highly flammable gaseous hydrocarbon. It is used for electricity generation, heating, cooking and for vehicles. Natural gas is often found dissolved in oil at the high pressures existing in reservoir-associated gas (wet gas). The reservoir that contains gas and no oil – non associated gas. (dry gas)

Methane is the primary component of natural gas. It also contains other forms such as propane, ethane and butane. The odourless methane is mixed with a special additive to give an odour. This will help to find the leakage. Propane and butane are removed in the processing plants and this is used as liquefied petroleum gas or LPG. The major uses of natural gas are cooking, heating homes etc.

Sedimentary rocks containing plant and animal remains about 10 to 20 crore year old are the source of mineral oil. Regions in the world which are rich in mineral oil are USA, Mexico, Iraq, Saudi Arabia, Kuwait, Iran, Qatar, Bahrain, and UAE. India has a large proportion of tertiary rocks and alluvial deposits in extra peninsular India

## **Coal**

The compressed organic matter which contains carbon and hydrocarbon matter are called coal. Coal is a hard rock which can be burned as a solid fossil fuel. It is mostly carbon but also contains hydrogen, sulphur, oxygen and nitrogen. It is a sedimentary rock formed from peat, by the pressure of rocks laid down later on top. It is formed by taking millions of years, when the plant filled swamps that are covered by sediments. Coal, when burnt, gives off almost a third more carbon dioxide per unit of energy than oil, and 80% more than natural gas. Almost half of the carbon dioxide is because of burning coal, so it is the biggest single cause of global warming

The solid coal is dug from the soil and processed to form the energy. Anthracite, lignite, bituminous coal etc are some examples of coal. Bituminous coal is used for making steel and iron. Anthracite has the highest heating value. Heating value is the amount of heat released during combustion of a specific amount.

In developed world there is a trend to shift from coal to oil/gas. Major coal fields are Raniganj, Jharia, East Bokaro. Major states known for coal reserves are Bihar, Orissa, West Bengal, and Maharashtra.

## **Nuclear energy**

The non-renewable energy obtained from the mining and refining of uranium ore is known as nuclear energy. Uranium is a naturally occurring radioactive element below the surface of the earth. Nuclear fusion is the process by which the power is generated. This power has enough pressure to run turbines and generate nuclear power. Nuclear power is providing 13 to 14 percent of world electricity and six percent of the total energy.

### **Advantages of non-renewable resources**

- The non-renewable energy resources like diesel and oil are affordable.
- These resources are easily accessible and compatible and are abundant.
- The storage of non-renewable resources is easy.
- It can provide more energy when compared with renewable resources.
- The rate of profit generated in mining and selling of coal is more.

### **Disadvantages of non-renewable resources**

- The replacement of energy resources is not possible, once it is used up.
- It increases greenhouse gases and leads to global warming.
- The burning of fossil fuels will cause different types of pollution.
- The process of mining, searching for oil, installing oil drills etc are time consuming and need more manpower.
- The carbon monoxide emitted by fossil fuels can cause respiratory diseases in humans.
- The oil spilled by the cargo ships in the sea can affect the life of sea animals adversely.

- More space is needed for the setting up of the reservoirs for the non-renewable energy.