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RENEWABLE SOURCES OF ENERGY-II

In the previous lesson you studied about some of the important non-conventional or renewable sources of energy such as solar energy, wind energy and hydel power, tidal and hydrogen etc. but now gaining momentum as alternative resources such as biomass, geothermal and hydrogen as a source of vast energy resources. These energy sources are renewable because they are regenerated within a reasonable time period. Moreover these energy resources can be used with minimal environmental degradation and offer us a chance to develop a truly sustainable energy policy. Its for these reasons there is growing interest in renewable energy resources. This lesson deals with these renewable energy resources.

OBJECTIVES

After completing this lesson, you will be able to:

- *define biomass and explain its uses including biogas;*
- *describe the concept of bio fuels (ethanol, biodiesal/ petro crops) and list their uses;*
- *describe geothermal energy;*
- *explain hydrogen energy and its uses;*
- *explain fuel cell technology;*
- *describe the limitations of the alternative sources of energy and*
- *state the thrust areas of renewable energy programmes in India.*

30.1 BIOMASS

Energy from biomass is the oldest fuel used by human's .Our ancestors burned wood to keep the cave warm. Biomass is a renewable energy resource derived from plants and animal waste. The energy from biomass (biomass conversion) is released on burning or

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breaking the chemical bonds of organic molecules formed during photosynthesis. Thus biomass represents an indirect form of solar energy. Biomass fuels can be used directly or they can be transformed into more convenient form and then used.

More than one million people in the world still use wood as primary source of energy for cooking.

30.1.1 Sources of biomass

It is derived from numerous sources, including the by-products from the timber industry, agricultural crops and their by products, raw material from the forest, major parts of household waste and wood.

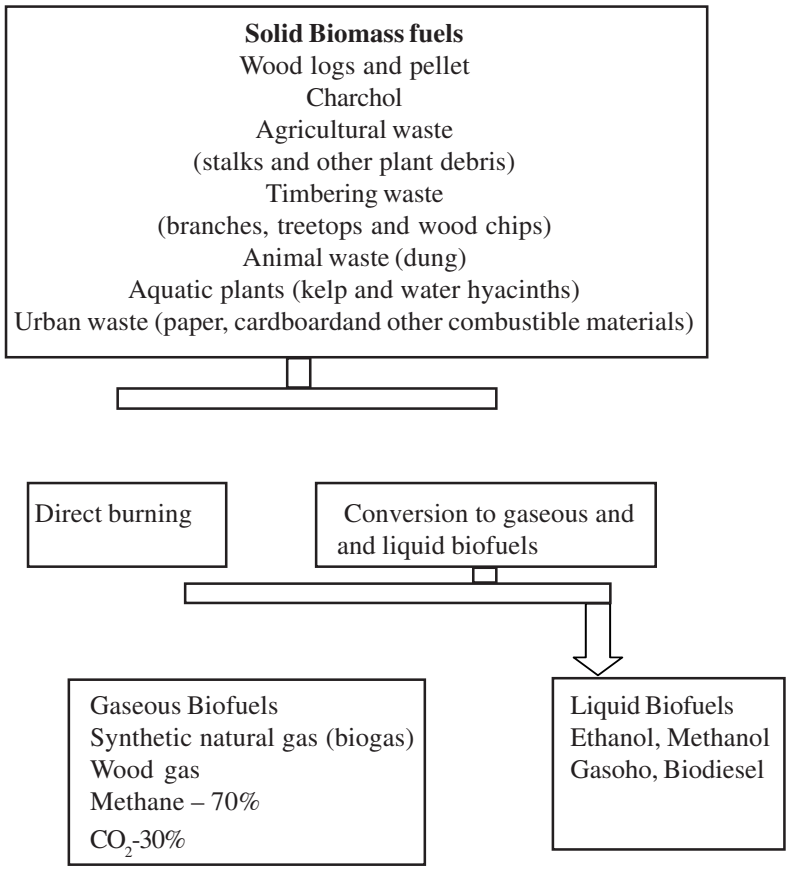

***Fig. 30.1**: Principal types of biomass*

- biomass can be burnt directly as a source for cooking, heating, lighting, generating steam, for industrial use for producing electricity.
- can be used to generate gaseous fuels (gasification).
- can be converted into alcohol (liquid biofuels) by distillation.

Methane and biogas can be produced from urban wastes in landfills and sewage at waste water treatment plants. In some facilities, manure from livestock and other organic waste

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is converted by microorganisms in specially designed digestion chamber to form methane (CH_4), which is burned to produce electricity, used in fuel cell, or used as fuel for vehicles. Molasses obtained from sugarcane is fermented to produce ethanol, that can be used in automobiles.

Half a kilo of dry plant tissue can produce as much as 1890 K Cal of heat which is equivalent to the heat available from a quarter of kilogram of coal.

30.1.2 Uses of biomass

- Traditional use of biomass is more than its use in modern application. In the developed world biomass is once again becoming important for applications such as combined heat and power generation.
- In addition, biomass energy is gaining significance as a source of clean heat for domestic heating and community heating applications. In fact. in countries like Finland, USA and Sweden use of biomass energy is increasing biomass fuels used in India account for about one third of the total fuel used in the country, and it amount to 90% of the rural households.
- Instead of burning loose biomass directly, it is more practical to compress it into briquettes (compressing them into blocks of a chosen shape) improve its utility and convenience of use. Such biomass in the biomass briquettes can be used as fuel in place of coal in traditional chulhas and furnaces or in a gasifier. A gasifier converts solid fuels into a more convenient-to-use gaseous fuel called producer gas.

Form of Energy: Chemical energy

This energy is being used for: Cooking, mechanical, applications/pumping, power generation, transportation

Some of the gadgets and other devices: Biogas plant/gasifier/burner, gasifier engine pump sets, sterling engine pump sets, producer gas/ biogas based engine generator sets, ethanol/methanol

30.1.3 Advantages of biomass energy

Burning of biomass does not increase atmospheric carbon dioxide because to begin with biomass was formed by atmospheric carbon dioxide and the same amount of carbon dioxide is released on burning. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.

Biomass is renewable and free from net CO_2 (carbon dioxide) emissions and is abundantly available on the earth in the form of firewood, agricultural residues, cattle dung,city garbage etc. Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development.

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30.1.4 Bagasse as biofuel

Indian sugar mills are rapidly turning to **bagasse**, the leftover of cane after it is crushed and its juice extracted, to generate electricity. This is mainly being done to clean up the environment, cut down power costs and earn additional revenue. According to current estimates, about 3500 MW of power can be generated from bagasse in the existing 430 sugar mills in the country. Around 270 MW of power has already been commissioned and more is under construction.

Biogas plant

The biogas plant consists of two components: a digester (or fermentation tank) and a gas holder. The digester is a cube-shaped or cylindrical waterproof container with an inlet into which the fermentable mixture is introduced in the form of liquid slurry. The gas holder is normally an airproof steel container that, by floating like a ball on the fermentation mix, cuts off air to the digester (anaerobiosis) and collects the gas generated. In one of the most widely used designs, the gas holder is equipped with a gas outlet, while the digester is provided with an overflow pipe to lead the sludge out into a drainage pit.

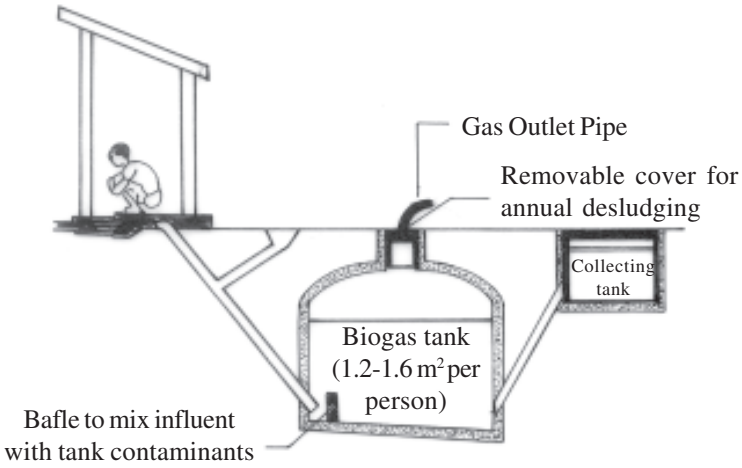

Fig. 30.2: *Biogas Plant*

Any biodegradable (that which can be decomposed by bacteria) substance can be fermented anaerobically (in absence of oxygen) by methane-producing (methanogenic) bacteria. Cowdung or faeces are collected and put in a biogas digester or fermenter (a large vessel in which fermentation can take place). A series of chemical reactions occur in the presence of methanogenic bacteria (CH_4 generating bacteria) leading to the production of CH_4 and CO_2.

Methanogenesis is a microbial process, involving many complex, and differently interacting species, but most notably, the methane-producing bacteria. The biogas process is shown below in figure 30.3, and consists of three stages; hydrolysis, acidification and methane formation.

Fig. 30.3: The process of methanogenesis (After GTZ, 1999).

30.1.5 Potential of biogas in India

In India, the dissemination of large–scale biogas plants has began in the mid-seventies and the process has become consolidated with the establishment of the National Project on
2 million biogas
oil-based plants
in a saving of 3
quivalent to 0.7

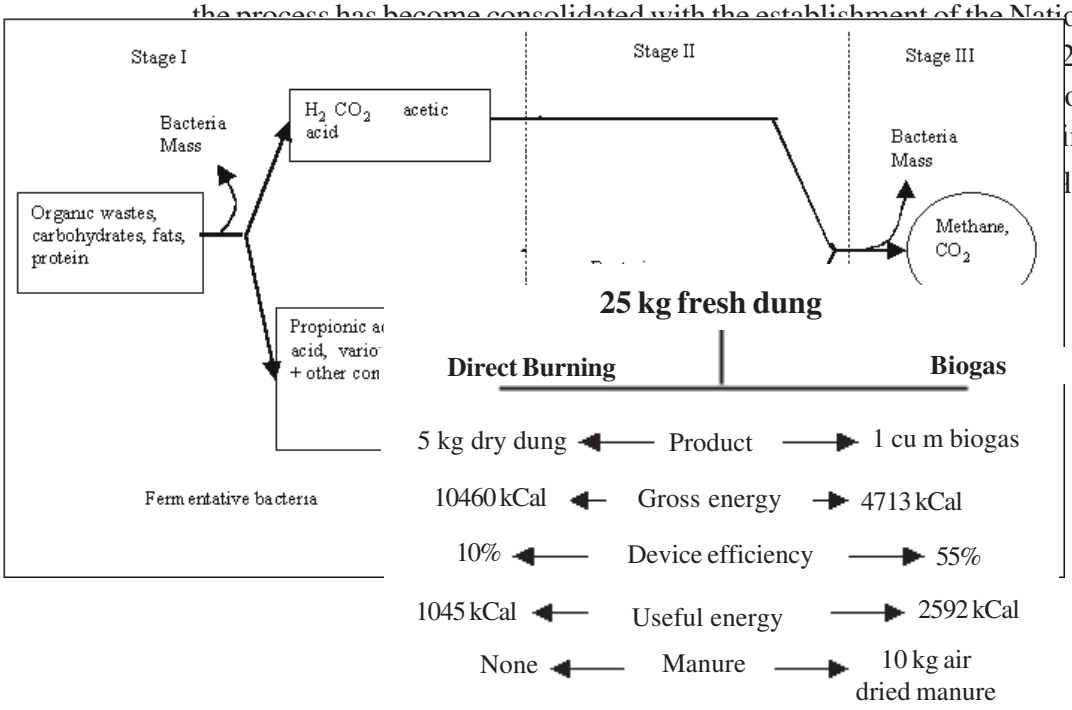

Fig. 30.4: Energy from fresh dung

However, in terms of total dung that is available in the country, the potential is much more. The bovine population in India is 260 millions. As an adult, bovine produces an average of

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10 kg of dung per day. If it is assumed that 75% of the dung is collected, nearly 2 millions tonnes of dung would be available everyday. This dung can feed as many as 40 millions biogas plants which can be considered the ultimate potential for biogas technology.

But even this high potential of biogas is based on animal dung only. However, all organic matter can technically be used to generate methane; if the scientific experiments that are going on in the country to develop alternative feedstocks (such as water hyacinth, kitchen waste, and poultry waste) become successful, potential for biogas generation could be virtually unlimited. It can be mentioned in this context that human waste is an excellent source of biogas which would enhance the potential; substantially. With such high potential, which can be routed to hitherto unemphasized applications of shaft power and electricity generation, biogas can make a significant contribution to the development of small industries and agriculture, and thus to the overall advancement of the rural areas.

Biogas in Rashtrapati Bhavan

GOING Green starts from the top, and in the capital the President's Estate is taking the lead. Besides lighting an entire auditorium wing with solar power, the Rashtrapati Bhavan is using cow dung-fuelled biogas in its kitchen for the President's bodyguards.

30.1.6 Petro crops (Plants)

Petroleum and wood are chief energy resources from time immemorial, but they have been overused and not being replenished fast enough. This is cause for concern. There is a need for alternative energy providing sources that can be regenerated. Recent researches suggest that hydrocarbon producing plants can become alternative energy sources, which can be inexhaustible and ideal for liquid fuel. These plants called petroplants/petrocrops can be grown on land which are unfit for agriculture and not covered with forests.

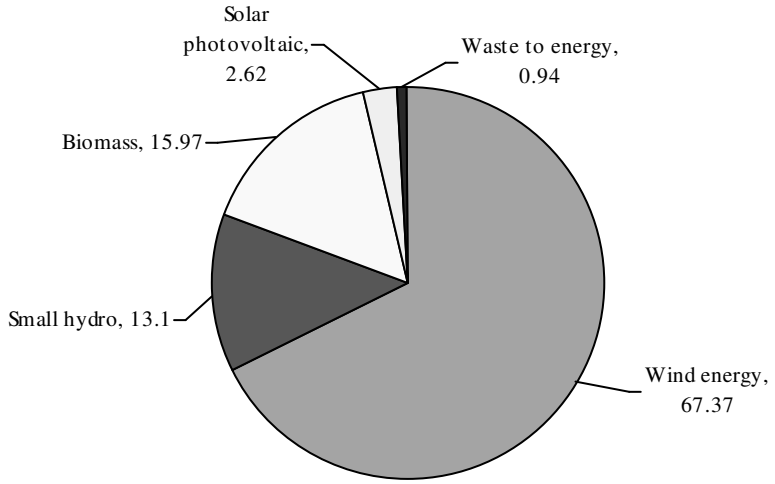

Fig. 30.5: *Use of non-conventional energy source in India.*

The most critical step in bioenergy production is the selection of plant species that produce substances from which useful products can be extracted in an economically viable way. Many such promising species belong to the families Asclepiadaceae, Asteraceae, Anacardiaceae Euphorbiaceae, Convolvulaceae, Caprifoliaceae, Lamiaceae, and Moraceae. *Jatropa curcas* is an important petro plant (Fig. 30.6)

Fig. 30.6: *Jatropha curcas*

This biocrude can be obtained by tapping the latex, followed by coagulation, or by extraction of the dry biomass using a suitable solvent in cases where latex tapping is not possible. Biocrude is a complex mixture of liquids, terpenoids, triglycerides, phytosterols waxes, and other modified isoprenoid compounds. It can be catalytically upgraded for use as liquid fuels. Hydro cracking of biocrude can convert it into several useful products like gasoline (automobile fuel), gas oil and kerosene. Some potential Petro-crop species are:

PLANT SPECIES	*FAMILY*
Calotropis procera	Asclepiadaceae
Calotropis gigantea	Asclepiadaceae
Cryptostegia grandiflora	Asclepiadaceae
Asclepias curassavica	Asclepiadaceae
Euphorbia antisyphilitica	Euphorbiaceae
Euphorbia caducifolia	Euphorbiaceae
Pedilanthus tithymaloides	Euphorbiaceae
Jatropa curcas	Euphorbiaceae
Pittosporum resiniferum	Pittosporaceae
Copaifera longsdorfii	Fabaceae
Parthenium argentatum	Asteraceae
Simmondsia chinensis	Simmondsiaceae

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INTEXT QUESTIONS 30.1

1. Define biomass and list various sources of biomass.

   _____

2. What is biomass conversion?

   _____

3. Why is biomass considered as an indirect form of solar energy?

   _____

4. Give two advantages of using biomass fuel.

   _____

5. What are petro crops? List any two such plants.

   _____

30.2 GEOTHERMAL ENERGY

We live between two great sources of energy, the hot rocks beneath the surface of the earth and the sun in the sky. Our ancestors knew the value of geothermal energy; they bathed and cooked in hot springs. Today we have recognized that this resource has potential for much broader application. Geothermal energy is natural heat from the interior of the earth that can be used to generate electricity as well as to heat up buildings.

The core of the earth is very hot and it is possible to make use of this geothermal energy. These are areas where there are volcanoes, hot springs, and geysers, and methane under the water in the oceans and seas. In some countries, such as in the USA water is pumped from underground hot water deposits and used for heating of houses. The utilization of geothermal energy for the production of electricity dates back to the early part of the twentieth century. For 50 years the generation of electricity from geothermal energy was confined to Italy and interest in this technology was slow to spread elsewhere. In 1943 geothermal hot water was used for the first time in Iceland. At present in 21 countries the internal heat of earth is used to produce electricity. However, at the global level, geothermal energy supplies less than 0.15% of the total energy supply

Form of Energy: Thermal energy

This energy is being used for: Heating/power generation

Some of the gadgets and other devices: Heat exchanger, steam turbines

Fig. 30.7: Geothermal energy

Geothermal resource falls into three major categories:

i) Geopressurized zones, ii) hot-rock zones and iii) Hydrothermal convection zones. Of these three only the first is currently being exploited on a commercial basis:

30.2.1 Geothermal energy in India

In India, Northwestern Himalayas and the western coast are considered geothermal areas. The Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy. Satellites like the IRS-1 have played an important role, through infrared photographs of the ground, in locating geothermal areas. The Puga valley in the Ladakh region has the most promising geothermal field. An experimental 1-kW generator is already in operation in this area. It is being used mainly for poultry farming, mushroom cultivation, and pashmina-wool processing, all of which need higher temperature.

Geothermal manifestations are wide spread in India in the form of 340 hot spring sites.

30.2.2 Environmental impact of geothermal energy

Geothermal energy can pose several environmental problems which includes on-site noise, emissions of gas and disturbance at drilling sites, disposal sites, roads and pipelines and power plants during its development.

The steam contains hydrogen sulphide gas, which has the odour of rotten eggs, and cause air pollution. The minerals in the steam are also toxic to fish and they are corrosive to pipes, and equipment, requiring constant maintenance.

30.3 HYDROGEN ENERGY

Many scientists believe that the fuel for the future is hydrogen gas. When hydrogen gas burns in the air or in fuel cells, it combines with oxygen gas to produce non-polluting water

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vapour and fuel cells directly convert hydrogen into electricity. Widespread use of hydrogen as fuel would greatly reduce the problem of air pollution and danger of global warming because there will not be any CO_2 emission.

Hydrogen may be a clean source of energy but getting large amount of pure hydrogen for commercial purposes is a problem because hydrogen is present in combination with other elements such as oxygen, carbon and nitrogen thus hydrogen has to be produced from either water or organic compounds like methane etc. requiring large amounts of energy that is hydrogen as a fuel has to be produced using energy present. This is a very costly proposition.

Producing hydrogen from algae in large scale cultures will be a good idea. You have studied about the process of photosynthesis where green (plant) cells break down water molecule in the presence of sunlight to produce oxygen gas and hydrogen thus produced go to reduce CO_2 to carbohydrate. Hydrogen produced via photosynthesis. CO_2 will not emit. Carbon dioxide in future it may be possible to control photosynthesis so that green algae are able to produce hydrogen through the process of photosynthesis.

Hydrogen is a pollution free, cost effective manner and if technologies such as fuel cells can be made cost effective, then hydrogen has the potential to provide clean, alternative energy for diverse uses, including lighting, power, heating, cooling, transportation and many more.

30.4 FUEL CELL TECHNOLOGY

Fuel cells are highly efficient power-generating systems that produce electricity by combining fuel (hydrogen) and oxygen in an electrochemical reaction or fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity (DC) and heat, thus doing away with combustion.

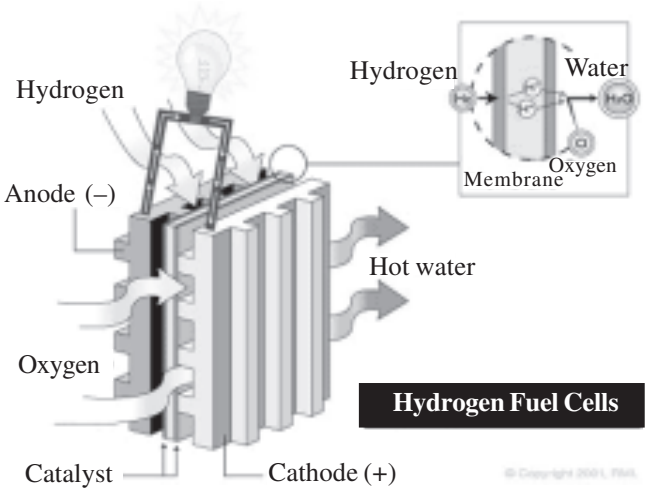
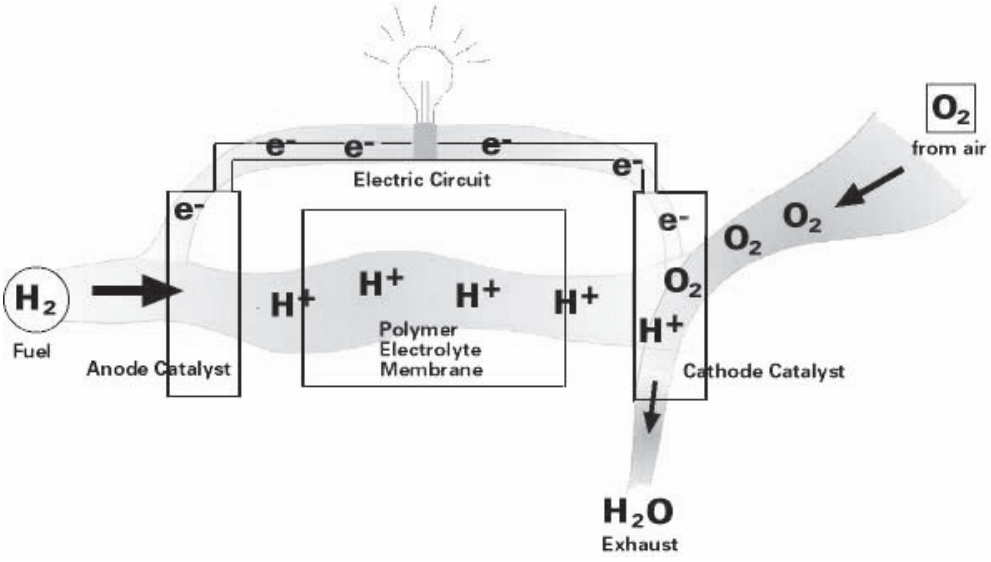


Fig. 30.8: *Structure and function of fuel cell*

Hydrogen and phosphoric acid are the most common type of fuel cells, although fuel cells that run on methanol, ethanol, and natural gas are also available. The most suitable fuel for such cells is hydrogen or a mixture of compounds containing hydrogen. A fuel cell consists of an electrolyte sandwiched between two electrodes. Oxygen passes over one electrode and hydrogen over the other, and they react electrochemically to generate electricity, water, and heat. Traditional methods generating electricity require combustion of fuel and the resultant heat is used to produce steam to run turbines which generate electricity. This method involves loss of heat and thus not very efficient. In chemical fuel cells on the other hand, chemical energy is converted directly into electricity, thus are more efficient and do not produce harmful gases.

Basic components of a hydrogen-burning fuel cell are shown in fig 30.9. Both oxygen and hydrogen are added to the fuel cell in an electrolyte solution. The reactants remain separated from one another and, upon ionization, migrate through the electrolyte solution from one electrode to another. The flow of electrons from the negative to the positive electrode is diverted along its path into an electrical motor, supplying current to keep the motor running. In order to maintain this reaction, hydrogen and oxygen are added as needed. Waste products are only oxygen and water when hydrogen is used in a fuel cell. Using natural gas methane (CH_4) in fuel cells produces some pollutants, but the amount is only about 1% of what would be produced by burning fossil fuels in an internal combustion engine or a conventional power plant



30.9: *Working of a hydrogen fuel cell (Source: Fuel cell 2000and US department of energy)*

Additionally, the efficiency of a fuel cell is largely independent of its size and energy output. For these reasons, fuel cells are well-suited for automobiles, homes, and large-scale power plants. They can also be used to store energy to be used as needed. Fuel cells are in use

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particularly in Canada's Ballad's Power Systems in Canada and Germany's Dailmer-Benz in Germany are world leaders in the application of fuel cell technology for meeting transportation needs. Such buses are already in operation in Vancouver in Canada and in Illinois in USA. Though rapid progress has been made; high initial cost is still the biggest hurdle in the widespread commercialization of fuel cells.

30.4.1 Fuel cell technology in India

Fuel cell systems are excellent options for small-scale decentralized power generation. Fuel cells can supply combined heat and power to buildings, hospitals, airports and military installations at remote locations. Fuel cells have efficiency levels up to 55% as compared to 35% of conventional power plants. The emission of green house gases is significantly low CO_2 as water vapor is being the only emission. Fuel cell systems are modular (i.e. additional capacity can be added whenever required with relative ease) and can be set up wherever power is required.

30.4.2 Fuel cell technology and environment

Fuel cells are efficient and clean energy producer. Fuel cells have been used in space flights and being introduced in electric vehicles for reducing urban air pollution. Compared to vehicles powered by the internal combustion engine, fuel cell powered vehicles have very high-energy conversion efficiency, (almost double that of currently used engines) and near-zero pollution. Fuel-cell-powered EV's (electric vehicles) score over battery operated EV's in terms of increased efficiency and easier and faster refueling.

INTEXT QUESTIONS 30.2

1. Define geothermal energy and list its uses. Give some examples from where this form of energy can be trapped.

   _____

2. Describe the disadvantage and advantage of use of geothermal energy.

   _____

3. "Hydrogen energy is called fuel for next generation", Comment on the statement.

   _____

4. Where in India is the most promising geothermal field located.

   _____

WHAT YOU HAVE LEARNT

- Biomass is one of the oldest forms of fuel used by human's .In India it is used by as primary source of fuel in rural areas. Recently, there have been efforts to produce ethanol from crops such as sugarcane. There are several environmental impacts of burning wood such as deforestation, soil erosion, water pollution and air pollution.
- The use of petro crops are still in their nascent years but lots of research has been done in this area. In coming years petro crops will become a major resource of fuel for vehicles.
- Geothermal energy is natural heat from earth's interior that is used as an energy source.
- Hydrogen gas can become an important fuel of the future especially when used in fuel cell.
- Fuel cells are electro-chemical devices that operate at a high level of efficiency with little noise or air pollution.
- Fuel cells are highly efficient power-generating systems that produce electricity by combining fuel and oxygen in an electrochemical reaction or fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity (DC) and heat, thus doing away with combustion.

TERMINAL EXERCISE

1. List the renewable sources of energy which are ideal for the coming times.
2. Describe the advantages of hydrogen as a fuel. Do you think hydrogen will become a major source of energy? Give reasons for your answer.
3. Describe fuel cell technology and its advantages.
4. Why are fuel cells more efficient in generating electricity in comparison to traditional systems?
5. Draw a schematic representation of a biogas plant and label its parts.
6. What are the limitations of (i) fuel cells (ii) geothermal energy? (any two)
7. How is the fuel obtained from petrocrops?
8. Discuss advantages and disadvantages of geothermal energy.

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ANSWER TO INTEXT QUESTIONS

30.1

1. Biomass is an accumulation of organic matter such as plant and animal materials (living or dead). It is a renewable energy source. Eg. agricultural wastes and residues.
2. Biomass conservation is the process of obtaining energy or fuel from the chemical energy stored in biomass.
3. Biomass consists of green plants which convert solar energy to chemical energy by photosynthesis, animals which feed upon plants and store chemical energy. Biomass can be burned directly as solid fuel or converted into alcohol or into biogas. So the fuel energy of biomass is actually locked up solar energy.
4. Uses of biomass energy –
   - does not add CO_2 to the atmosphere.
   - it can be used to generate electricity easily.
   - it constitutes a major form of renewable resource of energy.
5. Plants that produce hydrocarbons in substantial amount and can act as alternative energy source are called petrocrops. Examples *Jatropa curcas, Calotropis procure* (or any other).

30.2

1. It is the natural heat from the interior of the earth that is converted to heat building and generate electricity. Examples of such sites are volcanoes, hot springs, geysers and methane under the water in the process.
2. Advantages of geothermal energy- Most energy efficient, cost effective and environmentally clean.

   Disadvantages –
   - Steam contains H_2O which has the odour of rotten eggs.
   - The minerals in the steam are also toxic to fishes and also corrosive to the pipes and equipments.
3. Hydrogen is available in plenty and when it burns in presence of oxygen it produces non-polluting water vapour. it is a clean source of energy. Technology is needed to get free hydrogen as fuel and cost effective fuel cells need to be developed.
4. Puga valley in the Ladakh region.