

UNIT 5 OTHER FORMS OF RENEWABLE ENERGY

Structure

- 5.1 Introduction
 - Objectives
- 5.2 Geothermal Energy
 - 5.2.1 Use of Geothermal Energy
 - 5.2.2 Geothermal Power Plants and Environment
- 5.3 Ocean and Tidal Energy
 - 5.3.1 Ocean Thermal Energy
 - 5.3.2 Tidal Energy
 - 5.3.3 Advantages and Disadvantages of Tidal Energy
- 5.4 Hydrogen and Fuel Cells
 - 5.4.1 Hydrogen as Fuel
 - 5.4.2 Hydrogen as Energy Carrier
 - 5.4.3 Hydrogen Fuel Cells Produce Electricity
 - 5.4.4 Hydrogen Use in Vehicles
 - 5.4.5 Fuel Cells
 - 5.4.6 Fuel Cell Components
 - 5.4.7 Advantages of Fuel Cells
- 5.5 Biofuels
 - 5.5.1 1st-Generation Biofuels
 - 5.5.2 2nd-Generation Biofuels
- 5.6 Hydropower
 - 5.6.1 Hydropower and Environmental Impacts
- 5.7 Animal Energy
- 5.8 Let Us Sum Up
- 5.9 Key Words
- 5.10 Answers to SAQs

5.1 INTRODUCTION

You have already studied important sources of renewable energy like solar thermal energy, biogas, biomass, solar PV, wind energy, etc. There are other renewable energy sources which are not so popular but are now gaining importance. The other sources of renewable energy are mainly geothermal, ocean, hydrogen and fuel cells. These have immense potential, although tapping this potential for power generation and other applications calls for development of suitable technologies. You will learn these renewable energy sources in this unit. We begin our discussion with geothermal energy.

Objectives

After studying this unit, you will be able to learn other forms of renewable energies. More precisely, you will be able to

- understand hydel power,
- understand geothermal power,
- understand ocean and tidal energy,
- understand fuel cell, and
- understand hydrogen energy.

5.2 GEOTHERMAL ENERGY

There are two large sources of energy. One is sun which is above the earth and other is geothermal energy beneath the earth. The word geothermal comes from the Greek words *geo* (earth) and *therme* (heat). Therefore, geothermal energy is heat from within the Earth. We can recover this heat as steam or hot water and use it for various applications like power generation and direct heat applications. Geothermal energy is a renewable energy source because the heat is continuously produced inside the Earth. Today we have recognized that this resource has potential for much broader application. In India, Northwest Himalayas and the west 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.

You might have heard the names like volcanoes and fumaroles (holes where volcanic gases are released), hot springs and geysers. These are the visible forms of geothermal energy. However, the geothermal energy inside the earth may be utilized to heat buildings and to produce electricity by digging deep wells and pumping the heated underground water or steam to the surface.

Geothermal energies are of two types; the high grade and low the grade geothermal energies. The high-grade geothermal energy is the heat due to the earth's pressure that turns water into steam. The low-grade geothermal energy is the heat within the earth's crust. This heat is actually stored solar energy.

5.2.1 Use of Geothermal Energy

You may be familiar with some uses of geothermal energy like bathing and cooking in hot springs. The main areas where geothermal energy is being used are :

- **Direct use as heating systems** : Geothermal energy is used to heat water from springs or reservoirs near the surface.
- **Electricity generation by power plants** : This application requires water or steam at very high temperature.
- **Geothermal heat pumps** : The geothermal energy is used where stable ground or water temperatures near the Earth's surface are available to control temperatures in a buildings above ground. A heat pump is a mechanical device used for heating and cooling purposes. The heat pump operates on the principle that heat can be extracted from a warmer temperature to a cooler temperature. A geothermal heat pump uses the earth to warm us in the winter and cool us in the summer. You may be familiar with one of the most widely used heat

pump in your home. It is your refrigerator. It extracts the heat from the items put inside the refrigerator and throws it outside which you can feel if you put your hand behind it. The geothermal heat pumps are energy efficient, environmentally clean, and cost effective systems for temperature control.

5.2.2 Geothermal Power Plants and Environment

Since geothermal power plants do not burn fossil fuels to generate electricity, harmful emission levels are negligible. The geothermal power plants release less than 1% of the CO₂ emissions as compared to a fossil fuel plant. Another interesting fact is that geothermal plants emit about 97% less acid rain-causing sulphur compounds than are emitted by fossil fuel plants. After the steam and water from a geothermal reservoir have been used, they are injected back into the Earth.

SAQ 1

Define geothermal energy.

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SAQ 2

What is geothermal heat pump?

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5.3 OCEAN AND TIDAL ENERGY

Ocean thermal and tidal energies are two main ocean renewable energies. The other ocean renewable energies are wave energy, ocean current energy, offshore wind and ocean thermal gradient energy.

The vast potential of energy of the seas and oceans which cover about three fourth of our planet, can make a significant contribution to meet our energy needs. Ocean energy can be used to generate electricity in an environment-friendly manner.

Waves are caused by the wind blowing over the surface of the ocean. There is tremendous energy in the ocean waves. The wave energy converters are used to extract the power of ocean waves and convert it into electricity. Typically, these systems use either a water column or some type of surface to capture the wave power.

5.3.1 Ocean Thermal Energy

Ocean thermal energy conversion (OTEC) systems exploit temperature differences between warmer, surface layers and colder, deep layers of the ocean. All OTEC designs require a large-diameter intake pipe to pump cold water to the surface. They employ a variety of heat-exchange cycles to drive a turbine and generate electricity.

5.3.2 Tidal Energy

Tides are caused by the gravitational pull of the moon and sun, and the rotation of the Earth. Thus, tidal energy is the utilization of the moon and sun's gravitational forces – as tides are formed by the gravitational pull of the moon and sun on the oceans of the rotating earth. Near shore, water levels can vary up to 40 feet due to tides. A flood tide is one that is coming in or rising and an ebb tide is one that is going out. Thus, tidal energy takes advantage of the daily ebb and flow of tides and of localized examples of water in motion. The gravitational pull of the moon drives tidal flows. Tidal energy is one of the oldest forms of energy used as evidence of tide mills from before 1100AD has been found along the coast of France, Spain and the UK.

The process of generating electricity from the tidal energy may be understood by the following steps :

- When the tide comes in, water flows through a sluice into a storage pond
- When the tides go back out, the water flows back into the sea by passing through a turbine generating electricity.

5.3.3 Advantages and Disadvantages of Tidal Energy

Advantages

The important advantages of tidal energy are :

- Tidal energy does not require any fuel.
- The economic life of a tidal plant is about 75 to 100 years as compared to about 35 years of a conventional fossil fuel plant.
- Tidal energy is clean and renewable.
- Tidal energy is non-polluting. A tidal barrage can prevent approximately one million tons of CO₂ per TWH generated.

Disadvantages

The important disadvantages are :

- Tidal energy affects the ecosystem.
- Tidal energy leads to damages like reduced flushing and erosion which ultimately affects the vegetation of the area and disrupt the balance.
- The alteration of tidal currents also affects the habitat of the seabirds and the fish.

SAQ 3

What is ocean renewable energy?

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SAQ 4

What is ocean thermal energy conversion systems?

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5.4 HYDROGEN AND FUEL CELLS

In the case of Hydrogen energy, electricity is produced through an electro-chemical reaction between hydrogen and oxygen. Hydrogen gas is the primary fuel for fuel cells also. Hydrogen can be produced from the electrolysis of water using solar energy. It can also be extracted from sewage gas, natural gas, naphtha or biogas. Fuel cells can be very widely used for a wide range of applications once they become commercially viable.

5.4.1 Hydrogen as Fuel

You may be aware that hydrogen (H_2) as a gas is not found by itself on Earth. This is because Hydrogen gas is so much lighter than air that it rises fast and is quickly ejected from the atmosphere. Hydrogen is found only in compound form with other elements. You are familiar with one such compound which is water (H_2O) and is the result of Hydrogen combining with oxygen. Hydrogen when combined with carbon forms different compounds like methane (CH_4), coal, and petroleum. Hydrogen is also available in biomass.

Point to Remember :

1. Hydrogen has the highest energy content of any common fuel by weight (about three times more than gasoline)
2. Hydrogen has the lowest energy content by volume (about four times less than gasoline).

5.4.2 Hydrogen as Energy Carrier

You have seen that electricity is the most well-known energy carrier. Like electricity, hydrogen is an energy carrier and must be produced from another substance. Hydrogen is not currently widely used, but it has tremendous potential as an energy carrier in the future. Hydrogen can be separated from water, biomass, or natural gas molecules. One of the widely known methods for producing hydrogen is electrolysis. Electrolysis is a process that splits hydrogen from water. It results in no emissions, but it is an expensive process at present.

5.4.3 Hydrogen Fuel Cells Produce Electricity

Hydrogen fuel cells (batteries) are being used as a source of electricity. They are very efficient, but expensive to build. Small fuel cells can power electric cars while large fuel cells can provide electricity in remote areas where there is no power.

5.4.4 Hydrogen Use in Vehicles

Hydrogen has an excellent potential as fuel for vehicles. Hydrogen may be stored as gas or liquid on board and converted in to electricity. The vehicles may also burn the hydrogen directly with no pollution.

5.4.5 Fuel Cells

Fuel cells are based on the electrochemical reaction between hydrogen and oxygen to produce electricity, water vapor, and heat. The byproducts of the reaction can be re-utilized by the fuel cell system. Fuel cells are efficient, environmentally friendly and reliable for power production. The use of fuel cells has been demonstrated for stationary/portable power generation and other applications.

Fuel cells are different from electrochemical cell batteries in that they consume reactant from an external source, which must be replenished. By contrast batteries store electrical energy chemically and hence represent a closed system.

Many combinations of fuel and oxidant are possible. A hydrogen cell uses hydrogen as fuel and oxygen (usually from air) as oxidant. Other fuels include hydrocarbons and alcohols. Other oxidants include chlorine and chlorine dioxide. Fuel cells are simple, low-cost device and can produce an average of 10 watts of power.

A battery chemically stores and releases electricity while a fuel cell produces energy by reacting a fuel with air. A battery may run out of power if not recharged. A fuel cell, however, will continue to function and produce power as long as the fuel and oxygen are supplied to it.

5.4.6 Fuel Cell Components

There are three main components of a fuel cell system. These are :

- (1) hydrogen source
- (2) fuel cell stacks
- (3) power inverter

The hydrogen can be produced through electrolysis of water by using renewable energy sources like solar panels or wind generators. The fuel cell stack converts the hydrogen and oxygen into electricity, water vapor and heat. An inverter converts the DC electricity from the fuel cell into AC electricity that most equipment requires.

5.4.7 Advantages of Fuel Cells

Fuel cells have a number of advantages over other technologies for power generation. Some of the important advantages are :

- use less fuel as compared to other competing technologies.
- emit no pollution when used.
- quiet operation without noise pollution.

SAQ 5

Explain the process of producing electricity by Fuel Cells.

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SAQ 6

Write down the main components of Fuel Cells.

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SAQ 7

Fuel cells are renewable sources of energy. Do you agree?

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5.5 BIOFUELS

Biofuels are liquid or gaseous fuels. They are manufactured from biomass, such as agricultural crops and the biodegradable parts of waste. Biofuels can replace fossil fuels, such as petrol or diesel, either totally or partially. The biofuels have been used in combustion engines way back over 100 years ago.

There are many types of biofuels. The well known biofuels are biodiesel, bioethanol and biogas. Ethanol is generally produced from sugar cane or grain. In Brazil, ethanol is manufactured from sugar cane and is available at almost all filling stations, either in pure form or blended with conventional petrol. Ethanol is an alcohol that can be blended (up to 5%) with petrol, without any engine modifications required. Biofuels are classified as 1st-generation and 2nd generation biofuels.

5.5.1 1st-Generation Biofuels

The biofuels are defined based on the biomass from which these are produced. The biofuels produced from sugar, starch or oil-based crops or residues are known as 1st-generation biofuels. The examples include biodiesel from rapeseed oil or sunflower oil, and alcohol from sugar beets or corn. Majority of 1st-generation biofuels achieve CO₂ emission reductions of around 30-50% compared to fossil fuels.

5.5.2 2nd-Generation Biofuels

The biofuels produced from the woody parts of plants or trees are known as 2nd-generation biofuels. These biofuels can achieve CO₂ emissions reductions of around 90%.

Biofuels are attractive alternatives to petrol and diesel for use in automobiles. The Government of India has now permitted the use of 5% ethanol blended petrol. Ethanol produced from molasses/cane juice, when used as fuel will reduce the dependence on crude oil and help in reducing pollution.

Most of the fossil fuels which are used are biological in nature. Biofuel does not add to the carbon dioxide in the atmosphere. These are plant forms that, typically, remove carbon dioxide from the atmosphere, and give up the same amount when burnt. This is why the biofuels are considered to be "CO₂ neutral". The type of biofuel used will depend on a number of factors, like available feedstock and the energy that can be used locally.

5.6 HYDROPOWER

Hydropower is one of the oldest sources of energy. It was used thousands of years ago to turn a paddle wheel for purposes such as grinding grain.

Hydropower is the renewable energy source. The original source of hydropower is the Sun. You can understand the hydropower by looking over the following observations :

- Solar energy heats water on the surface, causing it to evaporate.
- This water vapor condenses into clouds and falls back onto the surface as precipitation (rain, snow, etc.).
- The water flows through rivers back into the oceans, where it can evaporate and begin the cycle over again.
- The water at high levels is collected in dams. The amount of available energy in moving water is determined by its flow or fall. Thus when the water stored in the dam is released; it runs turbines for generating electricity. The flowing rivers on higher levels like mountains etc are also put to run turbines.

SAQ 8

Define 1st-generation and 2nd-generation biofuels.

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5.6.1 Hydropower and Environmental Impacts

Hydropower is a clean source and does not pollute the water or the air. However, hydropower facilities can have large environmental impacts by changing the environment and affecting land use, homes, and natural habitats in the dam area.

5.7 ANIMAL ENERGY

Domesticated animals are used in drawing heavy loads. Draft animals were in common use in Mesopotamia before 3000 BC for farm work and for pulling wheeled vehicles. Their use spread to the rest of the world over the following 2,500 years. While cattle, usually in teams, have been used most often as draft animals, horses and donkeys have supplemented them in many areas. Some horses such as the Belgian horse, the Clydesdale, the Suffolk, the Shire, and the Percheron have been bred to serve as draft animals; they weigh more than 725 Kg

and stand at least 16 hands high. The Asian water buffalo, however, is probably the most important draft animal in the world today. Many of the some 165 million domesticated water buffalo worldwide are used as draft animals, particularly in tropical Asia, where they assist in the production of rice. The role of draft animals in agriculture in less-developed regions of the world continues because of the advantages they offer: their feed is easily grown and commonly available; little maintenance of the animals is required; their manure is a valuable resource for the farmer; and the animal itself may become a source of food or other products at the end of its useful life.

A draught or draft animal is an animal used for its physical (i.e. muscular) power, as in transport and haulage, such as pulling carts or sleds, ploughing fields and hauling goods. Animals are also used for animal-powered transport, for movement of people and goods. People ride some animals directly as mounts, use them as pack animals to carry goods, or harness one or a team to pull vehicles. Such animals are sometimes known as beasts of burden.

Pack Animals

These often belong to the same species as mounts or harness animals, though animals such as horses, mules, donkeys, or the Arabian camel may be of specialized breeding for packing. Other species are only used to carry loads, including llamas in the Andes, and the Bactrian camel in Central Asia.

Bovines include water buffalo (as distinct from bison and the extremely dangerous African Cape buffalo both of which cannot be domesticated, oxen, bullocks, and yaks (the latter adapted to extreme conditions in the Himalayas). Other species include dogs, reindeer and goats.

Other Draught Animals

Animal power is also used to drive machines and devices, and for ploughing, especially oxen. Water buffalo in tropical or very wet subtropical, areas help in rice-growing. Elephants are still used for logging in South-east Asia.

Animal Used for different Purpose

As predatory species are naturally equipped to catch prey, this is a further use for animals and birds. This can be done either for sustenance or sport, to reduce the population of undesired animals (pests) that are considered harmful to crops, livestock or the environment.

Hounds and other dogs are used to kill and fetch prey. Certain breeds have been bred for this task. Mousers (domestic cats used for hunting small rodents and birds) are one of the oldest working animals having protected food supplies from pests since the foundation of human agriculture. Ferrets prey on creatures living in burrows, such as rabbits and hares.

Dogs, with their highly developed sense of smell, are used to catch human 'prey', such as escaped prisoners or people lost in remote areas. They are used also to find people who are trapped, such as in avalanches or collapsed buildings.

Horses are used in remote areas to help human searchers cover large areas of rugged terrain. Their natural awareness of their surroundings will often alert human handlers to the presence of anything unusual, including lost hikers, hunters or other. Like some dogs, some horses are trained to follow scent.

The best-known example is the guide dog or seeing eyes dog for blind people. Miniature horses are also occasionally used for this purpose as well.

5.8 LET US SUM UP

Geothermal energy is a renewable energy source because the heat is continuously produced inside the Earth. There are two types of geothermal energies; the high grade and low grade geothermal energies. The high-grade geothermal energy is the heat of the earth's pressure that turns water into steam. The low-grade geothermal energy is the heat within the earth's crust. This heat is actually stored solar energy.

Ocean thermal and tidal energies are referred to as ocean renewable energies. Ocean energy can be used to generate electricity in an environment friendly manner. Ocean thermal energy conversion (OTEC) systems exploit temperature differences between warmer, surface layers and colder, deep layers of the ocean.

Tides are caused by the gravitational pull of the moon and sun, and the rotation of the Earth. Tidal energy is one of the oldest forms of energy.

The tidal energy does not require any fuel and the economic life of a tidal plant is about 75 to 100 years as compared to about 35 years of a conventional fossil fuel plant. The tidal energy is clean and renewable and tidal energy is non-polluting. A tidal barrage can prevent approximately one million tons of CO₂ per TWH generated.

Hydrogen energy is used in producing electricity through an electro-chemical reaction between hydrogen and oxygen. Hydrogen gas is the primary fuel for fuel cells also. Hydrogen has the highest energy content of any common fuel by weight but the lowest energy content by volume (about four times less than gasoline). Hydrogen fuel cells (batteries) are being used as a source of electricity. They are very efficient, but expensive to build.

Fuel cells are based on the electrochemical reaction between hydrogen and oxygen to produce electricity, water vapor, and heat. Fuel cells are efficient, environmentally friendly and reliable for power production. The use of fuel cells has been demonstrated for stationary/portable power generation and other applications.

Biofuels are liquid or gaseous fuels. They are manufactured from biomass, such as agricultural crops and the biodegradable parts of waste. The well known biofuels are biodiesel, bioethanol and biogas. Ethanol is generally produced from sugar cane or grain. The biofuels produced from sugar, starch or oil-based crops or residues are known as 1st-generation biofuels. The biofuels produced from the woody parts of plants or trees are known as 2nd-generation biofuels.

The original source of hydropower is the Sun. Hydropower is a clean source and does not pollute the water or the air. However, hydropower facilities can have large environmental impacts by changing the environment and affecting land use, homes, and natural habitats in the dam area.

5.9 KEY WORDS

Biomass

A renewable source of energy derived from organic matter like wood, agriculture waste; also include algae, sewage and other organic substances that may be used to make energy through chemical processes

Bio-fuels

Fuels made from biomass; include ethanol, biodiesel and methanol

Biogas

A combustible gas derived from decomposing biological waste; normally consists of 50 to 60 percent methane

Fuel Cell

An electrochemical device with no moving parts that converts the chemical energy of a fuel, such as hydrogen, and an oxidant, such as oxygen, directly into electricity.

Geothermal Energy

Energy from hot water or steam available deep inside the earth's crust

Geothermal heat pumps

The geothermal energy is used where stable ground or water temperatures near the Earth's surface are available to control building temperatures above ground. A heat pump is a mechanical device used for heating and cooling.

5.10 ANSWERS TO SAQs

SAQ 1

There are two types of geothermal energies :

1. High grade
2. Low grade

The high-grade geothermal energy is the heat of the earth's pressure that turns water into steam. The low-grade geothermal energy is the heat within the earth's crust. This heat is actually stored solar energy.

SAQ 2

A heat pump is a mechanical device used for heating and cooling. It operates on the principle that heat can be extracted from a warmer temperature to a cooler temperature. A geothermal heat pump uses the earth to warm us in the winter and cool us in the summer.

SAQ 3

Ocean renewable energy includes all forms of renewable energy derived from the sea. This includes tidal energy, wave energy, ocean current energy and ocean thermal gradient energy. The ocean renewable energy is also known as marine renewable energy.

SAQ 4

Ocean thermal energy conversion generates electricity from the temperature differential of cold subsurface sea water and warmer surface waters.

SAQ 5

Fuel cells produce electricity through electrochemical reaction. This combines hydrogen and oxygen to form water vapor, heat and electricity. The byproducts of the reaction can be re-utilized by the fuel cell system. The heat can be used for space heating, water vapor may be used as re-supply for additional hydrogen. The electricity is directed to an external circuit for using.

SAQ 6

There are three main components of a fuel cell system. These are :

- (1) The hydrogen source
- (2) The fuel cell stacks
- (3) A power inverter

The potential sources hydrogen are fossil fuels and electrolysis of water. The function of fuel cell stack is to convert the hydrogen and oxygen into electricity, water vapor and heat. An inverter converts the DC electricity from the fuel cell into AC electricity that most equipment requires.

SAQ 7

Fuel cells use a fuel to produce power and are not a power source on their own. If this fuel is obtained from renewable sources, then fuel cells can be treated as renewable source and become an important part of the energy chain.

SAQ 8

1st-generation biofuels : The biofuels made from sugar, starch or oil-based crops or residues are known as 1st-generation biofuels.

2nd-generation biofuels : Biofuels that are produced from the woody parts of plants or trees are known as 2nd-generation biofuels.

REFERENCES

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