27

333en27B

IMPORTANCE OF ENERGY IN SOCIETY

Energy is the capacity to do work and power is the rate of energy delivery. Energy is essential for most activities of modern society. Its use or consumption is generally taken as an index of standard of living. We use energy in the form of fire wood, fossil fuels and electricity to make life comfortable and convenient.

At home we use electricity for our lights and fans, air-conditioner, water heater and room heaters, oven, microwave, washing machine and drier etc. We use petrol, diesel, CNG for our cars, buses, autos etc. Large amount of energy is consumed in agriculture and industry. In offices we use energy to run air conditioners, fans, lights, computers, copying machines etc.

We use fossil fuel to run buses, trucks, trains, aeroplanes, ships etc and thus transportation uses a large percentage of all the energy used. In this lesson, we learn about the role of energy in society.

OBJECTIVES

After completing this lesson, you will be able to:

- *explain the concept of energy;*
- *explain the importance of energy for human society;*
- *explain the 1st and 2nd law of thermodynamics;*
- *list various sources of energy.*

27.1 WHAT IS ENERGY?

"The ability to do work"

Energy from the sun gives us light during the day. It dries our clothes when they are hanging outside on a clothesline. It helps plants and crops to grow. Energy stored in plants is eaten

Notes

by animals (herbivores), giving them energy. Predator animals eat their prey, which gives the predator animal energy. When we eat food, our bodies transform the energy stored in food into energy to do work. When we talk, run or walk, think or read we "burn" food energy in our bodies. But where does energy come from?

27.2 LAWS GOVERNING ENERGY

The **First law of thermodynamics** deals with conservation of energy. It states that energy cannot be created or destroyed but can only change from one form to another. For example, the energy of the sunlight is absorbed by the green plants it in the process of photosynthesis and store the solar energy as chemical energy in form of food or biomass.

The **Second law of thermodynamics** states that in every energy transformation, some energy is always lost in the form of heat which is unavailable to do further useful work. In other words no energy transformation is hundred percent efficient i.e., at each energy transformation some energy is lost as waste heat and dissipated into the environment.

Heat is familiar to everyone because we all know how it feels in hot summer and cold winter days. The degree of hotness of a body can be measured with a thermometer, which contains a fluid that expands as the temperature rises. Heat is one of the many forms that energy can take and heat is one form of energy into which all the other forms of energy can be fully converted. It is for this reason that a measure of heat, the *Calorie (Cal) or Joule* is used to express the amounts of energy.

A gram Calorie (c): It is the amount of heat required to raise the temperature of one gram of water through one degree centigrade (from 14.5°C to 15.5°C) *and is the unit in which energy value of food or any other organic matter is expressed, although it is now being replaced by joules.*

Joule (J): A practical unit of work. It is the derived SI unit of energy/work, being the work done when a force of one *Newton* displaces the point by one metre.

Energy in the form of heat is hard to harness because the molecular motions are chaotic. Heat is a degraded energy and cannot do any work if every thing is at the same temperature. If there are differences in temperature, the chaotic motions can tend to spread from points of concentration (high temperature) to points of lesser concentration (low temperature).

INTEXT QUESTIONS 27.1

1. How would you define energy?

_____

2. What is a gram calorie?

_____

3. What is the SI unit of energy?

_____

4. State the First and the Second law of thermodynamics.

_____

27.3 SOURCES OF ENERGY

Energy being so essential for our lives, it is important for us to know about the various sources of energy. Energy sources are broadly divided into two categories, namely, renewable (an energy source that we can use over and over again) and non renewable sources (when the energy source cannot be reused).

27.3.1 Renewable sources

Renewable energy is the term used to describe energy that comes from sources whose supplies are regenerative and virtually inexhaustible. Renewable energy sources can be replenished in a short period of time. Some of the important renewable sources of energy are described below:

(i) **Solar energy**

The most common energy received on our planet (Earth) is the direct sun light. Solar energy is inexhaustible and it comes to earth in the form of visible light and infrared radiation. We have always used the energy of the sun as far back as humans have existed on this planet. People worship sun as "Sun God" because it is sun energy which runs the earth. Every day we use the energy of the sun in many different ways. Without sunlight life would not exist on our planet. Plants use sunlight to make food. Animals eat plants as food. Decaying plants, hundreds of millions of years ago produced fossil fuels - coal, oil and natural gas, thus what we use today is actually sunlight stored millions and millions of years ago. As consumption is increasing it is getting depleted fast. Although the amount of solar energy reaching the earth's surface is immense, but it is not easy to store and transport.

Solar energy can be harnessed in a variety of ways to heat homes, heat water, grow plants and produce electricity. Solar power includes active, passive, and photovoltaic technologies and practices. Active and passive solar technologies use the sun's energy for cooking, space heating, and water heating. Photovoltaic (solar cells), convert solar energy directly into electricity. The simplest solar cells are used to energise watches and calculators and the like, while more complex systems of large panels of solar cells can light houses, provide power to space crafts and satellites. Currently, there is a renewed interest in developing innovative ways to use solar energy for reducing our dependence on fossil fuels.

Notes

(ii) **Biomass**

Biomass energy or bioenergy is the energy from organic matter such as fire wood, twigs, dead plant parts, cattle dung, livestock manure and dead animal matter. Plant leaves convert sunlight into chemical energy, which is stored in the plants.

Animals that eat the plants store chemical energy in their bodies; some of it also remains in manure and other wastes. Biomass fuels are renewable because the raw materials can be produced simply by growing more crops or collecting more organic waste. The use of renewable energy is not new, traditionally wood has been as the main source of energy for thousands of years, ever since people started burning wood to cook food or to keep warm. Even today fire wood and crop residues form the largest biomass energy source and is used by rural communities and forest dwellers.

But many other sources of biomass can now be used, including plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Biogas can be produced from cattle dung, human faeces and other organic waste by a process called "anaerobic digestion" in a biogas plant. It contains about 55 to 75% methane, which is inflammable and can be used for cooking, lighting, heating or for producing electricity. Even the methane gas which is given off during composting of organic waste or from landfills can be used as a biomass energy source

Biogas is a clean, non-polluting and low - cost fuel. The digested left over material which comes out of the biogas plant in the form of slurry is a valuable by-product, which can be used as organic manure in agricultural fields. Biomass fuels are obtained from agricultural wastes (crops), alcohol fuels, animal waste and municipal solid waste. Now, the biomass which would normally present a disposal problem is converted into electricity (e.g., manufacturing wastes, rice hulls, and black liquor from paper production).But many other sources of biomass can now be used, including plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes.

Today, new ways of using biomass are still being discovered. One way is to produce ethanol, a liquid alcohol fuel from biomass. Unlike other renewable energy sources, biomass can be converted directly into liquid fuels (biofuels) for our transportation needs (cars, trucks, buses, airplanes, and trains). The two most common types of biofuels are ethanol and biodiesel.

Ethanol is made by fermenting any biomass rich in carbohydrates (starches, sugars, or celluloses) through a process similar to brewing beer. Ethanol is mostly used as a fuel additive to cut down a vehicle's carbon monoxide and other smog-causing emissions. Ethanol can be used in special types of cars that are made for using alcohol fuel instead of gasoline. The alcohol can also be combined with gasoline. Plants grown for making alcohol or diesel are known as energy crops, such as fast-growing trees and grasses.

Notes

(iii) **Bio-diesel**

Bio-diesel is obtained by trans-etherification of vegetable oils. Oil rich seeds of the wild plants rich in non-edible oils are the potential source of bio-diesel. Seeds of Pongamia, Jatropha, Neem are favorites for producing bio-diesel.

The use of biomass energy has the potential to greatly reduce greenhouse gas emissions. Biomass generates about the same amount of carbon dioxide as fossil fuels, but the green plants remove carbon dioxide from the atmosphere as they grow and develop. The net emission of carbon dioxide will be zero as long as plants continue to be replenished for biomass energy purposes. Consumer demand for clean renewable energy have stimulated growth in green power—solar, wind, geothermal steam, biomass, and hydroelectric sources of power.

(iv) **Hydropower**

Flowing water creates energy that can be captured and turned into electricity. This is called **hydroelectric power or hydropower.** Hydro-energy from water is also a renewable energy source. Hydroelectric energy or hydropower is energy which is produced by the action of falling water turning a waterwheel, propeller or turbine. Almost all hydroelectric energy is used to produce electricity, although early pioneers built waterwheels to grind grain and operate other machinery.

The most common type of hydroelectric power plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water stored at a higher elevation is a source of potential- energy. It is converted to kinetic-energy in the turbines and then to electrical-energy. Generally more than 90% of the potential energy of the water can be converted into electrical energy.

Another type of hydroelectric power plant is called a pumped storage plant that can even store power. The power is sent from a power grid into the electric generators. The generators then spin the turbines backward, which causes the turbines to pump water from a river or lower reservoir to an upper reservoir where the power is stored. To use the power, the water is released from the upper reservoir back down into the river or lower reservoir. This spins the turbines forward, activating the generators to produce electricity.

Small hydroelectric plants or micro-hydroelectric power system doesn't necessarily require a large dam but just use a small canal to channel the river water through a turbine which can produce enough electricity for a home, farm, or a small village.

(v) **Wind energy**

The kinetic energy of the wind can be changed into other forms of energy, either mechanical energy or electrical energy. When a boat lifts a sail, it is using wind energy to push it

Notes

through the water. This is one form of energy. Farmers have been using wind energy for many years to pump water from wells using windmills. In Holland, windmills have been used for centuries to pump water from low-lying areas and grind grains. Today, the wind is also used to make electricity.

Wind energy is a clean renewable energy source produced by the daily cooling and heating patterns on the surface of the earth. Wind energy can be harnessed to produce electricity, pump water, grind grain and move sailing vessels. Wind generators consist of a steel tower, propeller blades to capture the wind and a generator. Individual wind generators are commonly built near homes or farms but may be arranged in clusters or wind farms. Wind can be used to do work. Blowing wind spins the blades on a wind turbine just like a large toy pinwheel. This device is called a wind turbine and not a windmill. A windmill grinds or mills grain, or is used to pump water.

The blades of the turbine are attached to a hub that is mounted on a turning shaft. The shaft goes through a gear transmission box where the turning speed is increased. The transmission box is attached to a high speed shaft which turns a generator that makes electricity. Wind turbines, like windmills, are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more aboveground, they can take advantage of the faster and less turbulent wind. Turbines catch the wind's energy with their propeller-like blades. Usually, two or three blades are mounted on a shaft to form a *rotor.* We have many windy areas in the country, especially the coastal regions of India.

(vi) **Wave energy**

Oceans and sea waves are caused indirectly by solar energy. Wave energy is derived from wind energy, which is driven in turn from solar energy. Wave energy may be converted to mechanical energy and then to electricity.

(vii) **Ocean thermal energy conversion**

Conversion of solar energy stored as heat in the ocean into electrical energy by making use of the temperature difference between the warm surface water and the colder deep water.

(viii) **Geothermal energy**

Geothermal energy refers to energy contained in underground rock and fluids. Thermal or heat energy deep within the earth may heat water or form steam. Geothermal energy is used to power steam turbines and generate electricity, although it can be used to heat homes and other buildings. This heat is a result of the increase in temperature of the earth with increasing depth below the surface. It is the energy which comes from inside the earth i.e. the energy contained in underground rock and fluids. Geothermal energy is responsible for heating of water of hot water springs.

Notes

(ix) **Fuel cell technology**

Fuel cells are devices that directly convert hydrogen into electricity. Hydrogen is a colourless, odourless gas found on earth only in combination with other elements such as oxygen, carbon and nitrogen. To use hydrogen, it must be separated from these other elements.

Hydrogen as a fuel is high in energy and a very promising clean fuel. A fuel cell converts hydrogen (produced and stored) and oxygen from the air into electricity. A machine that burns pure hydrogen produces energy and pure water without causing any pollution. Fuel cells are a promising technology for use as a source of heat and electricity in buildings, and as an electrical power source for vehicles.

Large amounts of hydrogen are available in combined form in water. But free hydrogen is not available in nature. Hydrogen can be made from hydrocarbons by applying heat, a process known as "reforming" hydrogen. This process makes hydrogen from natural gas. An electrical current can also be used to separate water into its components i.e. oxygen and hydrogen in a process called electrolysis. Some algae and bacteria, using sunlight as their energy source, give off hydrogen under certain conditions. Large amount of energy is needed to produce hydrogen from water, so it will not come into its own as a clean alternative until renewable energy is widely available for the process.

In the future, hydrogen could substitute electricity as an important energy carrier. An energy carrier stores, moves and delivers energy in a usable form to consumers. Renewable energy sources, like the sun, can not produce energy all the time. The sun does not always shine. But hydrogen can store this energy until it is needed and can be transported to wherever it is required.

Hydrogen has been used in NASA's space program as fuel since the 1970s to propel rockets and now the space shuttle into orbit and in fuel cells that provide heat, electricity and drinking water for astronauts. In the future, hydrogen may be used as a fuel for motor vehicles and aircrafts, and provide power for our homes and offices.

27.3.2 Non-renewable energy

Non-renewable energy resources have limited amount of stocks available. The regeneration rate of non renewable energy resources is negligible when compared with the rate of consumption. That is, non-renewable energy that we are using up cannot be recreated in a short period of time or at least, in our lifetime. Fossil fuels are important energy resource. Fossil fuels (coal, lignite, peat) are found under the ground and below the sea floor (petroleum etc.) in liquid and gaseous form. Fossil fuels are the remains of ancient plant and animal life found on earth. Fossil fuel energy is released in the form of heat.

Notes

(i) **Oil (Petroleum)**

Oil is a liquid fossil fuel that is found under the ground and below the sea floor. Fossil fuels were formed before and during the time of the dinosaurs when plants and animals died. Their decomposed remains gradually changed over the years to form coal, oil and natural gas.

Oil and natural gas is formed by complex decay processes from microscopic life forms called phytoplankton (tiny plants called algae) which floated in the world's oceans million years ago. Just like today's phytoplankton, they harnessed and stored the solar energy through the process of photosynthesis. Zooplanktons are tiny animals which eat phytoplankton but themselves are the main food for the fish and some whales.

When these myriads of tiny floating plants died, they sank to the sea floor and got buried and slowly hardened into rocks. Heat from the earth's interior and the weight of the overlying rocks gradually changed the energy containing substances in the buried phytoplankton into liquid hydrocarbon and gases. Hydrocarbons are simple molecules made up of carbon and hydrogen atoms joined together in chains or in rings. These molecules, being light and mobile, migrated upwards through the rock but eventually became trapped beneath impermeable rock structures in the earth's crust.

Petroleum is one of our most vital resources. During the past thirty years consumption of petroleum has grown more steeply than other energy sources. Petroleum provides about 40% of the commercial energy used in the world. Think of the various ways, petroleum is used like cars, planes, tractors, shipping, electricity, cooking, agriculture, industries etc. These are only a few of the seemingly endless list of uses we have for petroleum. Fossil fuels took millions of years to form. We are using up the fuels formed more than 65 million years ago. They can not be renewed; they can not be made again. We can save fossil fuels by conserving them and finding ways to harness energy from seemingly "endless sources," like the sun and the wind. Oil is obtained by drilling deep wells into the ground and then pumping it out. Oil can be converted into gasoline. Both oil and gasoline are burned in automobiles and in aeroplanes. We depend on oil for 90% of our transport, and for food, pharmaceuticals, chemicals etc. Our modern way of life is totally dependent on oil and gas. But oil industry experts estimate that current reserves will only last for about 40 years.

(ii) **Natural gas**

Natural gas is also fossil fuel that is a mixture of gases found under the ground. Natural Gas is collected and transported almost the same way as oil. Natural gas burns in home furnaces and cooking ranges. It is now being used in cars and buses for transportation.

(iii) **Coal**

Coal is the most common solid fossil fuel which was used as a primary source of energy in homes and industry. It is found under the ground in solid form and have to be mined and transported for use. Our country has large coal reserves.

Notes

Coal is mostly carbon but contains small amounts of sulphur. It is formed from plants, mostly trees which grew millions of years ago in low lying swampy areas. When these trees died, they sank to the bottom of the swamps. In the swamps they did not rot fully as there was no air. Partially decayed plant matter in swamps and bogs is called peat which has low heat content. These peats get covered by sand and mud as water subsides. More material is deposited on them for years and the plant matter gets converted into coal under pressure and heat. That is plant material get metamorphosed into coal in millions of years. This is the most plentiful fossil fuel but it is very polluting.

27.3.3 Nuclear energy

Nuclear energy is liberated from a nuclear reaction, fission or fusion, or by radioactive decay. In a conventional nuclear reactor, isotopes of uranium and plutonium undergo controlled nuclear fission. The resulting heat produces steam, that in turn, spins turbines to generate electricity. Large fuel supply, low immediate environmental impact, low emission of CO_2, low chances of accidents because of multiple safety systems make this energy a much wanted resource. Unlike other energy resources, nuclear energy produces highly radioactive materials that must be kept safely for thousands of years until their radioactivity falls to safe levels.

Also, when the useful life (40-60 years) of a nuclear reactor comes to an end, it cannot be shut down and abandoned like a coal burning plant. It contains large qualities of radioactive materials that must be kept out of the environment for many thousand of years. The safety features make nuclear power plants very expensive to build and maintain.

However, management of the nuclear waste disposal, its vulnerability to terrorist attacks and misuse of the technology for making nuclear weapons make it a difficult choice and it remains world's slowest growing energy source.

INTEXT QUESTIONS 27.2

1. Define the terms renewable energy sources and non-renewable energy sources.

   _____

2. What are the various ways can solar energy be used?

   _____

3. List the various sources of renewable and non-renewable energy sources.

   _____

4. Why is hydrogen known as a clean energy source?

   _____

5. How is coal formed in nature?

_____

Notes

27.4 WORRYING SIGNS

A couple of centuries ago virtually everyone would have depended on the fuel they could find within a short distance from home. Now, the fuels required for heat and light travel vast distances to reach us, sometimes crossing not only continents but political and cultural watersheds on the way. These distances create a whole host of challenges from oil-related political instability to the environmental risks of long-distance pipelines. Also we can not use fossil fuels forever as they are a non-renewable and finite resource.

The International Energy Agency says the world will need almost 60% more energy in 2030 than in 2002, and fossil fuels will still meet most of its needs.

Not everyone depends on the fossil fuels. Nearly a third of today's world population (6.1bn people) has no electricity or other modern energy supplies, and another third have only limited access.

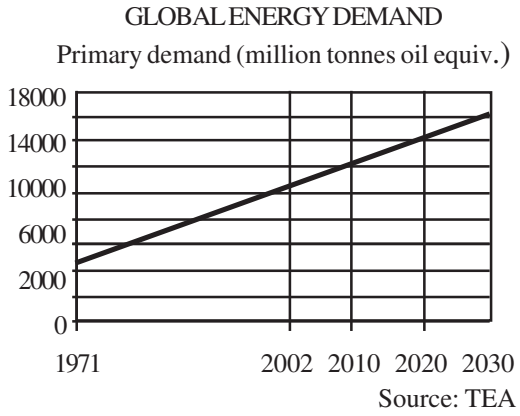


Fig. 27.1: *Facts and figures on soaring global energy demand*

However, we can also get energy to do several jobs at once, as combined heat and power plants do. And we can use less of it by becoming energy-efficient.

Cheap, available energy is essential for ending poverty: ending poverty is key to easing the pressures on the planet from the abjectly poor who have no choice but to eat the seed corn Our energy use is unsustainable, but we already know what a benign alternative would look like.

But large amounts of energy are needed to produce hydrogen from water, so it will not come into its own as a clean alternative until renewable energy is widely available for the process.

WHAT YOU HAVE LEARNT

Notes

- Energy is defined as "**ability to do work**" and power is the rate of energy delivery.
- It is required by all living organisms including humans. Nothing can move or work without the use of energy.
- The behavior and transformation of energy is strictly governed by the laws of thermodynamics.
- The **First law** of thermodynamics state that the energy can neither be created nor destroyed. This is also known as law of conservation of energy. Energy flows downhill i.e. from higher potential to lower potential.
- **The Second law** of thermodynamic states that energy transformations are never 100% efficient. i.e. at each step of energy transformation some amount of energy is lost as waste heat. The conventional unit of measuring energy is gram calorie.
- The various energy sources are broadly divided into two broad categories namely renewable and non renewable.
- Renewable energy is the term used to describe energy that comes from sources whose supplies are regenerative and virtually inexhaustible.
- The most important and inexhaustible source of energy is the sun. Solar energy is harnessed by green plants by the process of photosynthesis for making food and the biomass which is subsequently used as energy source by animals including man.
- The other renewable sources of energy include solar energy, biomass, wind energy, hydroelectric energy, geothermal energy, and wave or tidal energy.
- Non renewable energy sources have limited amount of stocks available. The regeneration rate of non renewable energy resources is negligible when compared with the rate of consumption.
- Fossil fuels are important non renewable energy source. Fossil fuels (coal, lignite, peat, gas, oil) are found under the ground and below the sea floor in liquid and gaseous form. Fossil fuels are the remains of ancient plant and animal life found on earth. Fossil fuel energy is released in the form of heat. Fossil fuel is hydrocarbons and they include coal, lignite, peat, petroleum and natural gas.
- There is growing emphasis to promote the use of renewable energy sources to reduce our dependence on fossil fuels because the latter will exhausted soon.
- Growing use of fossil fuels has increased the amount of carbon dioxide in the atmosphere leading to global warming and climate change.

Notes

- Fossil fuels are a non-renewable and finite resource and we can't use them for ever.
- Nuclear energy is liberated by a nuclear reaction (fission or fusion) or by radioactive decay. Nuclear power is generated in a specially designed nuclear power plant that converts nuclear energy into useful power such as mechanical or electrical power.
- In a nuclear electric power plant, heat produced by a reactor is generally used to make steam to drive a turbine that in turn drives as electric generator.

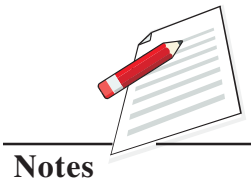
TERMINAL EXERCISE

1. What do you understand by bio-energy? Describe the various types and ways of using biomass energy.
2. Define first and second law of thermodynamics.
3. Prepare a list of renewable and non renewable energy resources.
4. What is a fuel cell? Which fuel is used to propel rockets?
5. What type of conditions necessary for biogas generation?
6. What is the average composition of biogas?
7. Why hydrogen is considered as a clean energy source?
8. What is the ultimate source of energy in coal and petroleum?
9. Describe the process of coal and petroleum formation.
10. State the reasons for increasing emphasis on developing renewable sources of energy.
11. Which type of power or energy causes no pollution?

ANSWER TO INTEXT QUESTIONS

27.1

1. Energy is the capacity to do work.
2. It is the amount of heat required to raise the temperature of one gram of water through one degree centrigrade from 14.5^0 to 15.5^0C.
3. SI unit of energy is Joule (J). It is the work done when a force of one Newton displaces the point by one metre.
4. First law: energy can neither be created nor destroyed but can only change from one form to another.



Notes

Second law states that in every transformation, some energy is always lost in the form of heat.

27.2

1. Energy that come from sources whose supplies are inexhaustible and also the energy sources are generative or can be renewed. Energy resources that have limited amount of stocks available and the energy resources cannot be recreated in a short period of time.
2. Solar energy can be used in a variety of ways like to heat up homes, heat water (as solar cooker to prepare food). And produce electricity.
3. Renewable energy sources – Solar, wind, hydropower, geothermal, ocean, thermal energy, biomass, hydrogen.

   Non-renewable energy sources – Coal, gas, oil or petroleum.

5. Hydrogen produces clean energy and pure water without causing any pollution.
6. Coal is formed from trees which grew millions of years ago in swampy areas. The trees sank to the bottom of the swamps when they died. They did not rot fully as there was no air. Many layers of sand and mud got deposited on these plant remains for without of years and the plant matter turned into coal under pressure and heat.