Manonmaniam Sundaranar University,

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Tirunelveli - 627 012 Tamil Nadu, India

OPEN AND DISTANCE LEARNING(ODL) PROGRAMMES

(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023–2024)

III YEAR

B.Sc. Physics

Course Material

NMC - JNPH61 – APPLIED PHYSICS

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Prepared

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UNIT:1

Conventional Energy Sources

1.1 Introduction to Energy

Energy is one of the fundamental requirements for the development of modern civilization. Industrial growth, transportation, agriculture, communication, and domestic activities depend heavily on the availability of energy resources. The rapid increase in population and industrialization has led to a continuous rise in global energy demand.

The energy resources used by mankind can be broadly classified into conventional and non-conventional sources. Conventional energy sources such as coal, petroleum, and natural gas have been extensively used since the Industrial Revolution. Although these sources provide large amounts of energy, their reserves are limited and their utilization results in environmental pollution. Therefore, there is a growing need to develop renewable and sustainable energy systems.

1.2 Conventional Energy Sources

Conventional energy sources are those energy resources that have been traditionally used for large-scale energy production over many decades. These sources possess high energy density and established technologies for extraction, transportation, and utilization.

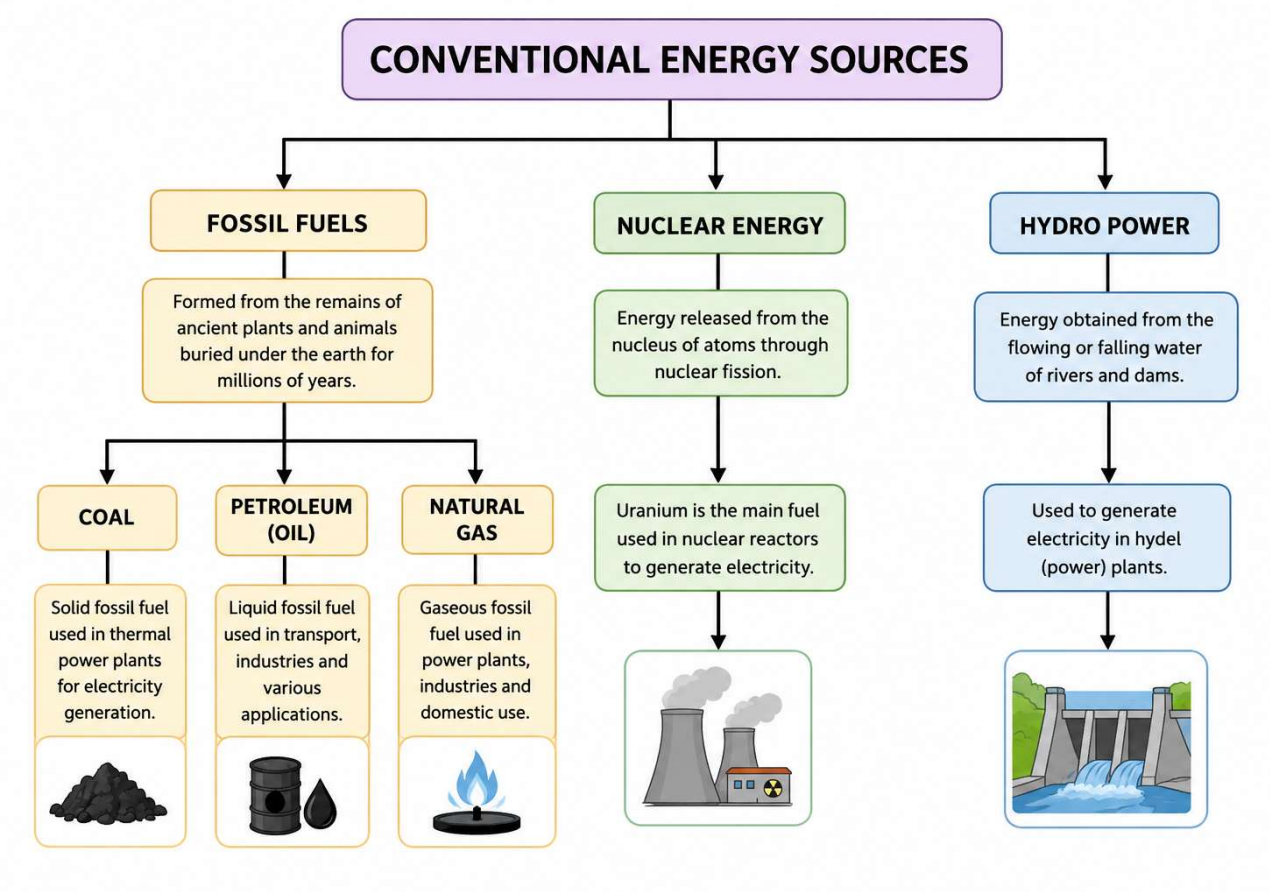

Figure 1.1 Conventional Energy Sources

The major conventional energy sources are:

Coal

Coal is a combustible sedimentary rock formed from ancient plant remains subjected to heat and pressure over millions of years. It remains one of the most important fuels for electricity generation.

Advantages

- Abundant availability
- Relatively low cost
- Mature technology

Disadvantages

- High carbon dioxide emissions
- Air pollution
- Environmental degradation due to mining

Petroleum

Petroleum is a naturally occurring liquid fossil fuel composed mainly of hydrocarbons. It is refined to produce petrol, diesel, kerosene, and lubricants.

Applications

- Transportation
- Power generation
- Petrochemical industry

Natural Gas

Natural gas consists mainly of methane and is considered the cleanest fossil fuel.

Advantages

- Higher efficiency
- Lower carbon emissions
- Easy transportation through pipelines

1.3 World Reserves of Conventional Energy Sources

The world's energy consumption is still dominated by fossil fuels. According to international energy statistics:

- Coal contributes significantly to electricity generation.
- Petroleum remains the primary fuel for transportation.
- Natural gas is increasingly used due to its lower environmental impact.
- Uranium serves as the fuel for nuclear power plants.

The Middle East possesses nearly half of the world's proven petroleum reserves, while countries such as China, India, USA, Australia, and Russia possess large coal reserves.

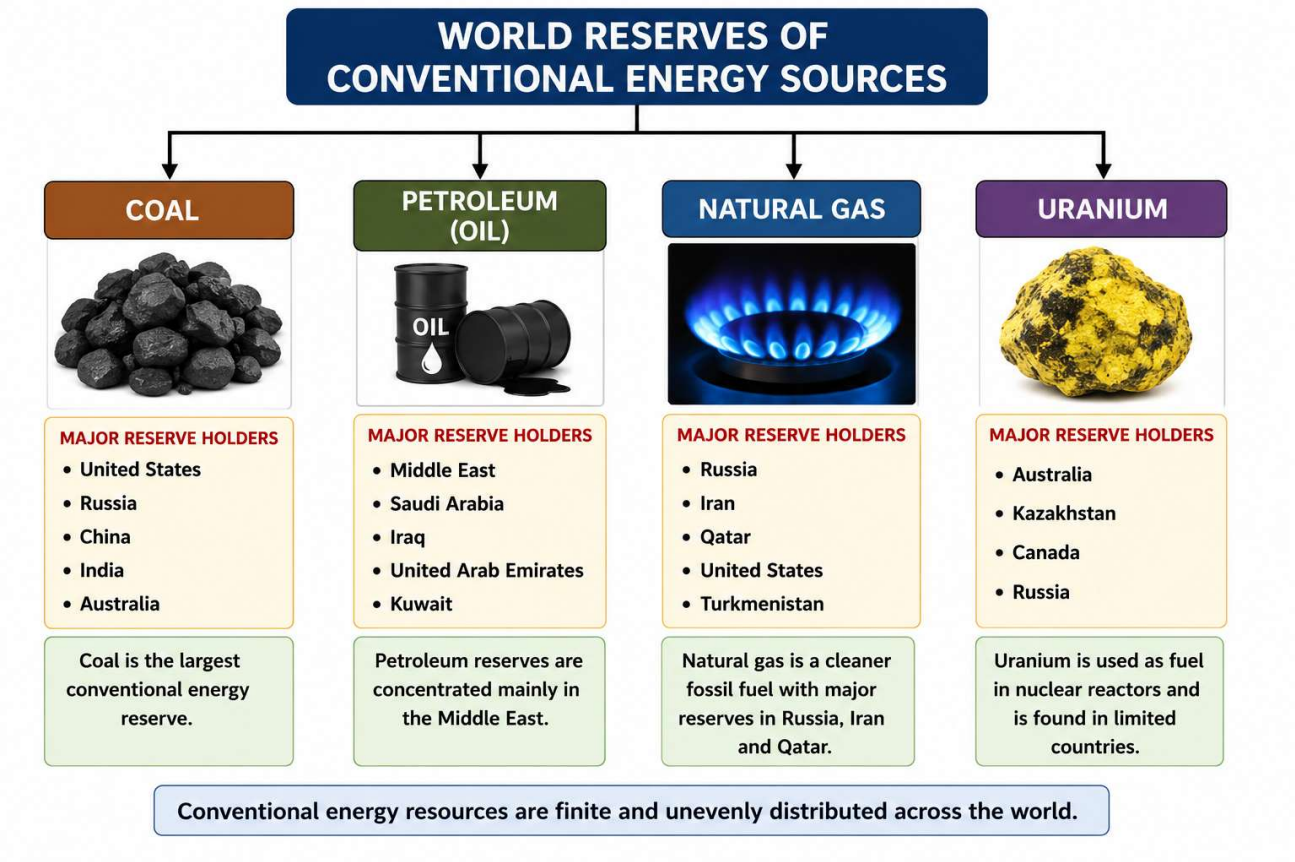

Figure 1.2 World Reserves of Conventional Energy Sources

1.4 Various Forms of Energy

Energy exists in different forms and can be converted from one form to another. The law of conservation of energy states that energy can neither be created nor destroyed, but only transformed from one form into another.

1.4.1 Mechanical Energy

Mechanical energy is the energy possessed by an object due to its motion or position. It is the sum of kinetic energy and potential energy.

Examples

- Moving vehicles
- Rotating turbines
- Water stored in dams
- Falling objects

1.4.2 Thermal Energy (Heat Energy)

Thermal energy is the energy associated with the random motion of atoms and molecules. It is transferred from a hotter body to a colder body as heat.

Examples

- Burning coal
- Steam in boilers
- Hot water
- The Sun's heat

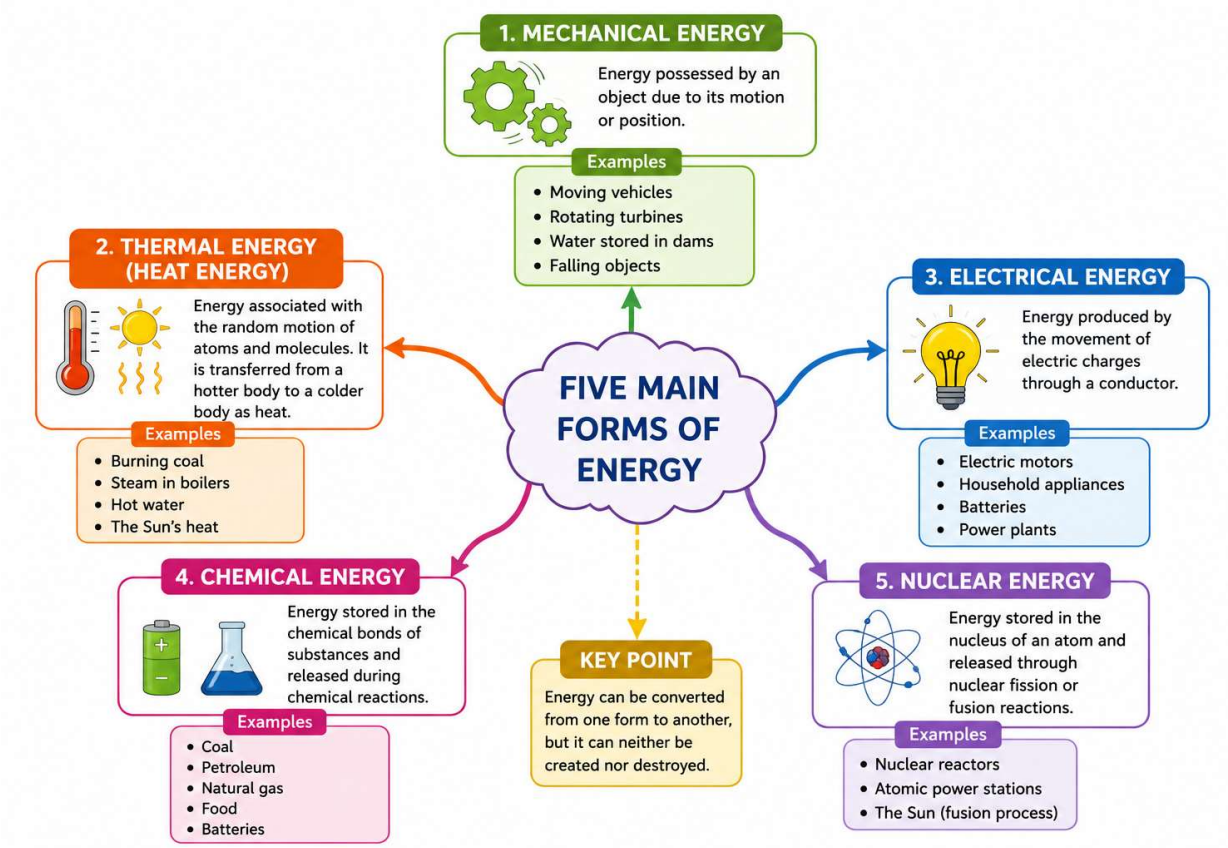

Figure 1.3 A Mind map Mains Forms of Energy

1.4.3 Electrical Energy

Electrical energy is the energy produced by the movement of electric charges through a conductor.

Examples

- Electric motors, Household appliances, Batteries, Power plants.

1.4.4 Chemical Energy

Chemical energy is the energy stored in the chemical bonds of substances and released during chemical reactions.

Examples

- Coal, Petroleum, Natural gas, Food, Batteries.

1.4.5 Nuclear Energy

Nuclear energy is the energy stored in the nucleus of an atom and released through nuclear fission or fusion reactions.

Examples

- Nuclear reactors, Atomic power stations, The Sun (fusion process).

Comparison Table

Form of Energy	Source	Example
Mechanical Energy	Motion or position of objects	Turbine, moving car
Thermal Energy	Heat	Steam, burning fuel
Electrical Energy	Flow of charges	Generator, motor
Chemical Energy	Chemical bonds	Coal, oil, battery
Nuclear Energy	Atomic nucleus	Nuclear reactor, Sun

1.6 Renewable and Conventional Energy Systems

Energy systems can be broadly classified into **Conventional Energy Systems** and **Renewable Energy Systems** based on the source of energy used for power generation.

1.6.1 Conventional Energy Systems

Conventional energy systems use traditional energy sources such as **coal, petroleum, natural gas, and nuclear fuels**. These sources have been widely used for electricity generation, transportation, and industrial applications for many decades.

Characteristics

- High energy density
- Reliable power generation
- Well-established technology
- Limited reserves (exhaustible)
- Cause environmental pollution

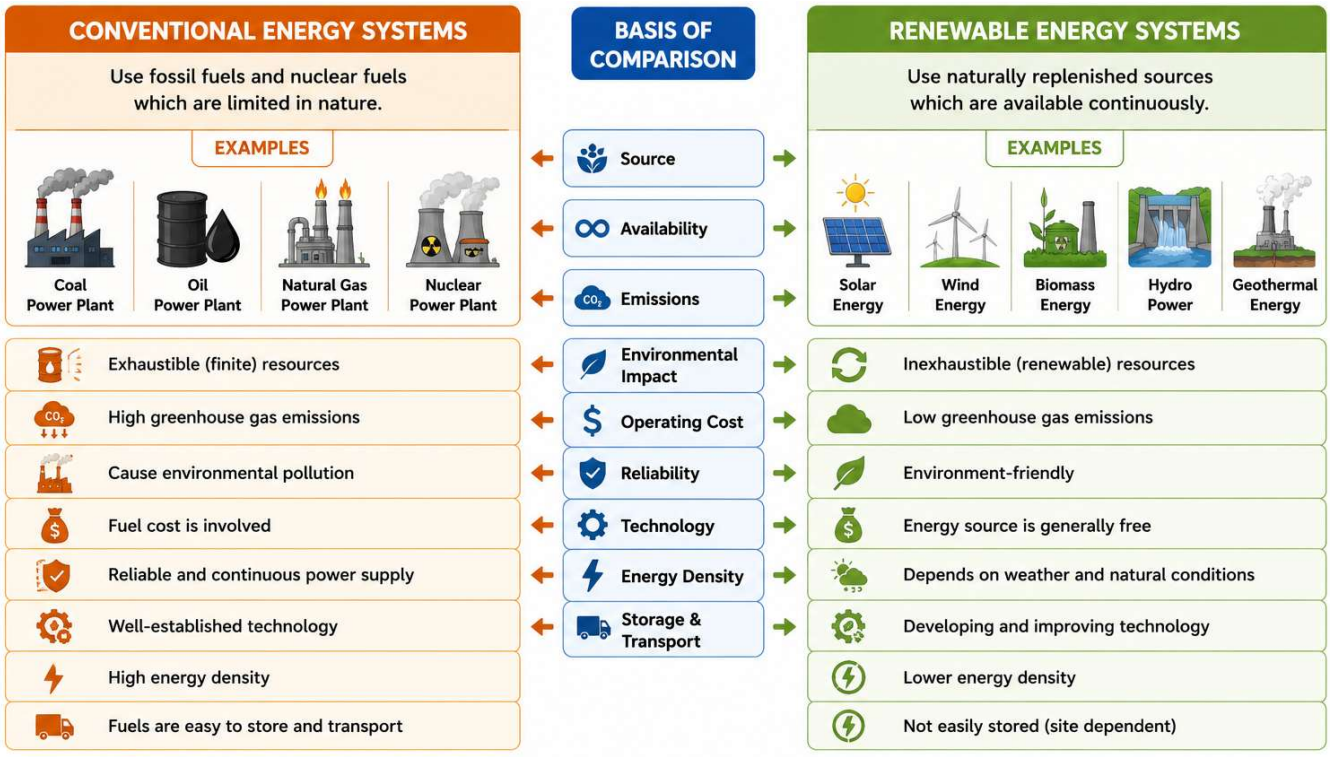

Figure 1.4 Comparison of Conventional Energy Systems and Renewable Energy Systems

Examples

- Coal-fired power plants
- Oil-fired power plants
- Natural gas power plants
- Nuclear power plants

1.6.2 Renewable Energy Systems

Renewable energy systems use naturally replenished energy sources that are continuously available in nature. These sources are considered sustainable and environmentally friendly.

Characteristics

- Inexhaustible resources
- Low environmental impact
- Sustainable energy production
- Low greenhouse gas emissions
- Depend on weather and geographical conditions

Comparison Between Renewable and Conventional Energy Systems

Conventional Energy Systems	Renewable Energy Systems
Use fossil fuels and nuclear fuels	Use naturally replenished sources
Exhaustible resources	Inexhaustible resources
High carbon emissions	Low carbon emissions
Cause environmental pollution	Environment-friendly
Fuel cost is involved	Energy source is generally free
High operating pollution	Minimal pollution
Reliable continuous supply	Depends on natural conditions
Suitable for large-scale power generation	Suitable for both small and large-scale applications
Examples: Coal, Oil, Gas, Nuclear	Examples: Solar, Wind, Biomass, Geothermal

Examples

- Solar energy systems
- Wind energy systems
- Biomass energy systems
- Geothermal energy systems
- Hydroelectric power plants

Advantages of Conventional Energy Systems

- Continuous power generation
- Mature technology
- High energy output
- Easy storage and transportation of fuels

1.7 Key Terms

Term	Meaning
Energy	Capacity to do work.
Conventional Energy Source	Traditional energy source such as coal, petroleum, and natural gas.
Renewable Energy	Energy obtained from naturally replenished resources.
Coal	Solid fossil fuel formed from ancient plant remains.
Petroleum	Liquid fossil fuel used mainly as transportation fuel.
Natural Gas	Gaseous fossil fuel consisting mainly of methane.
Mechanical Energy	Energy due to motion or position of an object.
Thermal Energy	Energy associated with heat.
Electrical Energy	Energy produced by the movement of electric charges.
Fossil Fuel	Fuel formed from ancient plants and animals over millions of years.

1.8 Unit Summary

- Conventional energy sources include **coal, petroleum, and natural gas**, which are widely used for power generation and transportation.
- The world's major reserves of conventional energy resources are distributed across countries such as China, India, USA, Russia, and the Middle East.
- Energy exists in different forms such as **mechanical, thermal, electrical, chemical, and nuclear energy**.
- Conventional energy systems provide reliable and large-scale energy but are based on finite resources.
- Renewable energy sources such as **solar, wind, and biomass** are naturally replenished and environmentally friendly.
- Conventional energy sources contribute significantly to environmental pollution and greenhouse gas emissions.
- The growing depletion of fossil fuels highlights the need for energy conservation and the adoption of sustainable energy technologies.

1.9 Objective Questions

1. Which of the following is a conventional energy source?

A) Solar Energy
B) Wind Energy
C) Coal
D) Tidal Energy

2. Petroleum is a _____ fossil fuel.

A) Solid
B) Liquid
C) Gas
D) Semi-solid

3. Natural gas mainly consists of:

A) Oxygen
B) Nitrogen

C) Methane
D) Hydrogen

4. Energy associated with heat is called:

A) Mechanical Energy
B) Thermal Energy
C) Electrical Energy
D) Nuclear Energy

5. Which of the following is a renewable energy source?

A) Coal
B) Petroleum
C) Natural Gas
D) Solar Energy

6. Conventional energy sources are generally:

A) Renewable
B) Inexhaustible
C) Exhaustible
D) Unlimited

7. Electrical energy is produced by the movement of:

A) Molecules
B) Atoms
C) Electric Charges
D) Neutrons

Answers

1. **C) Coal**
2. **B) Liquid**
3. **C) Methane**
4. **B) Thermal Energy**
5. **D) Solar Energy**
6. **C) Exhaustible**
7. **C) Electric Charges**

1.10 Review Questions

Short Answer Questions

1. What are conventional energy sources?
2. Mention the major conventional energy resources.
3. What is renewable energy?
4. Explain the various forms of energy.
5. Differentiate between renewable and conventional energy sources.
6. What are the advantages of conventional energy sources?
7. What are the environmental impacts of conventional energy sources?

Long Answer Questions

1. Explain conventional energy sources and discuss their importance.
2. Describe the world's reserves of conventional energy sources.
3. Explain the various forms of energy with suitable examples.
4. Compare renewable and conventional energy systems.
5. Discuss the advantages and disadvantages of conventional energy sources.

UNIT:2

Fossil Fuels

2.1 Introduction

Fossil fuels are naturally occurring energy resources formed from the remains of ancient plants and animals that lived millions of years ago. Over geological time, these organic materials were subjected to high temperature and pressure beneath the Earth's surface, resulting in the formation of **coal, petroleum (oil), and natural gas**.

Fossil fuels are the primary source of energy for electricity generation, transportation, industries, and domestic applications. Even today, they contribute a major share of the world's energy consumption.

2.2 Classification of Fossil Fuels

Fossil fuels are naturally occurring energy resources formed from the buried remains of ancient plants and animals over millions of years. Based on their physical state, fossil fuels are classified into three major categories: **coal, petroleum (crude oil), and natural gas**.

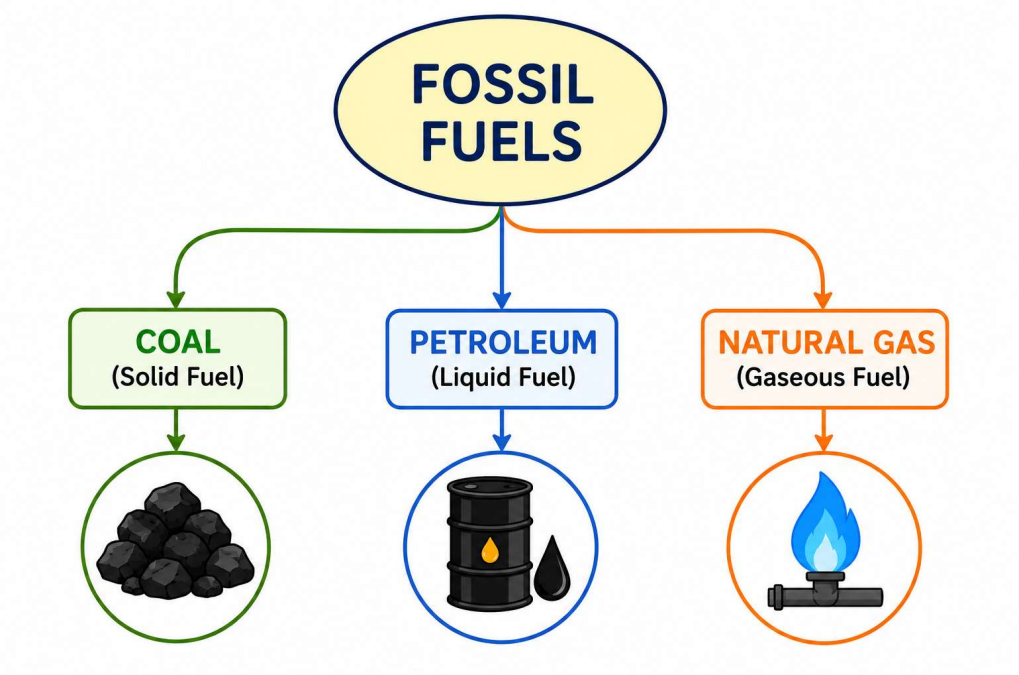

Figure 2.1 Classification of Fossil Fuels

- **Coal**: Coal is a solid fossil fuel formed mainly from the remains of ancient vegetation subjected to heat and pressure beneath the Earth's surface. It is rich in carbon and is one of the most widely used fuels for electricity generation and industrial applications. Coal occurs in different forms such as peat, lignite, bituminous coal, and anthracite, which differ in carbon content and calorific value. It is extensively used in thermal power plants, steel industries, and cement manufacturing.
- **Petroleum (Crude Oil):** Petroleum is a liquid fossil fuel formed from the remains of marine plants and animals buried under layers of sedimentary rock. It is a complex mixture of hydrocarbons and serves as an important source of energy and raw material

for petrochemical industries. Crude oil is refined to produce petrol, diesel, kerosene, liquefied petroleum gas (LPG), lubricating oils, and several other products. Petroleum is widely used in transportation, industries, and power generation.

- **Natural Gas:** Natural gas is a gaseous fossil fuel consisting mainly of methane along with small quantities of ethane, propane, and butane. It is formed by the decomposition of organic matter under high temperature and pressure and is often found associated with petroleum deposits. Natural gas has a high calorific value and burns more cleanly than coal and petroleum, making it the cleanest fossil fuel. It is widely used for domestic cooking, electricity generation, industrial heating, and fertilizer production.

  Thus, coal, petroleum, and natural gas are the three major fossil fuels that provide a significant portion of the world's energy requirements and play a crucial role in economic and industrial development.

2.3 Availability of Fossil Fuels

The term **availability of fossil fuels** refers to the occurrence, distribution, and reserves of coal, petroleum, and natural gas in different parts of the world. Fossil fuels are finite resources and their availability depends on geological conditions and past biological activity.

- **Coal**

  Coal is the most abundant fossil fuel and is widely distributed across the world. Large coal reserves are found in countries such as **China, India, United States, Australia, and Russia**. Due to its abundant reserves and relatively low cost, coal continues to be a major source of electricity generation.

- **Petroleum (Crude Oil)**

  Petroleum reserves are unevenly distributed around the world. The largest reserves are concentrated in the **Middle East**, particularly in **Saudi Arabia, Iraq, Iran, Kuwait, and the United Arab Emirates**. Significant reserves are also found in Russia, the United States, and Venezuela. Petroleum remains the primary fuel for transportation and industrial applications.

- **Natural Gas**

  Natural gas reserves are found both independently and along with petroleum deposits. Major reserves occur in **Russia, Iran, Qatar, the United States, and Turkmenistan**. Due to its cleaner combustion and high efficiency, natural gas consumption has increased significantly in recent years.

Table

Fossil Fuel	Major Reserve Countries
Coal	China, India, USA, Australia, Russia
Petroleum	Saudi Arabia, Iraq, Iran, Kuwait, UAE
Natural Gas	Russia, Iran, Qatar, USA, Turkmenistan

2.4 Statistical Details of Fossil Fuels

Statistical details provide information about the contribution of different fossil fuels to the world's energy consumption and their available reserves. Fossil fuels continue to dominate the global energy sector despite the growing use of renewable energy sources.

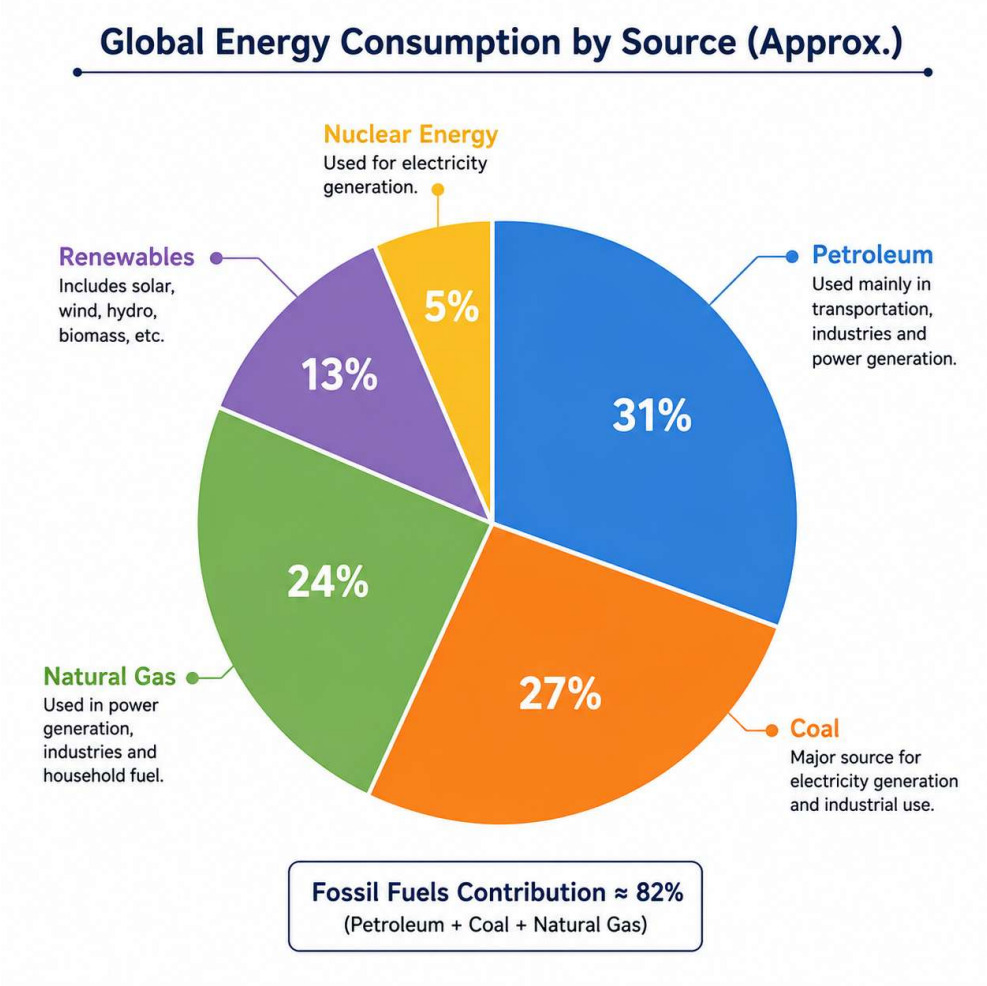

Figure 2.2 A Pie-Chart Showing the distribution of Fossil Fuels Contribution

Coal

Coal is one of the most abundant fossil fuels and accounts for a significant share of global electricity generation. It contributes approximately **25–30% of the world's primary energy consumption**. Major reserves are located in the United States, Russia, Australia, China, and India.

Petroleum (Crude Oil)

Petroleum is the most widely used fossil fuel, particularly in the transportation sector. It contributes nearly **30–35% of global energy consumption**. The largest proven oil reserves are

concentrated in the Middle East, especially in Saudi Arabia, Iraq, Iran, Kuwait, and the United Arab Emirates.

Natural Gas

Natural gas is the fastest-growing fossil fuel due to its cleaner combustion and higher efficiency. It contributes approximately **20–25% of global energy consumption**. Major reserves are found in Russia, Iran, Qatar, the United States, and Turkmenistan.

2.4.1 Global Energy Consumption (Approximate)

Energy Source	Share of World Energy Consumption
Petroleum	31%
Coal	27%
Natural Gas	24%
Renewables	13%
Nuclear Energy	5%

2.5 Applications of Fossil Fuels

Fossil fuels such as **coal, petroleum, and natural gas** play a vital role in modern society by providing energy for electricity generation, transportation, industries, and domestic activities. Their high energy content and easy availability make them the most widely used energy resources in the world.

1. Electricity Generation

Coal, petroleum, and natural gas are extensively used in thermal power plants to generate electricity. The heat produced by burning these fuels converts water into steam, which drives turbines connected to generators.

2. Transportation

Petroleum products such as petrol, diesel, and aviation fuel are the primary energy sources for cars, buses, trucks, ships, and aircraft. They provide the energy required for transportation of people and goods.

3. Industrial Applications

Fossil fuels are widely used in industries as sources of heat and power. Coal is used in steel and cement manufacturing, while petroleum and natural gas are used in chemical, fertilizer, and petrochemical industries.

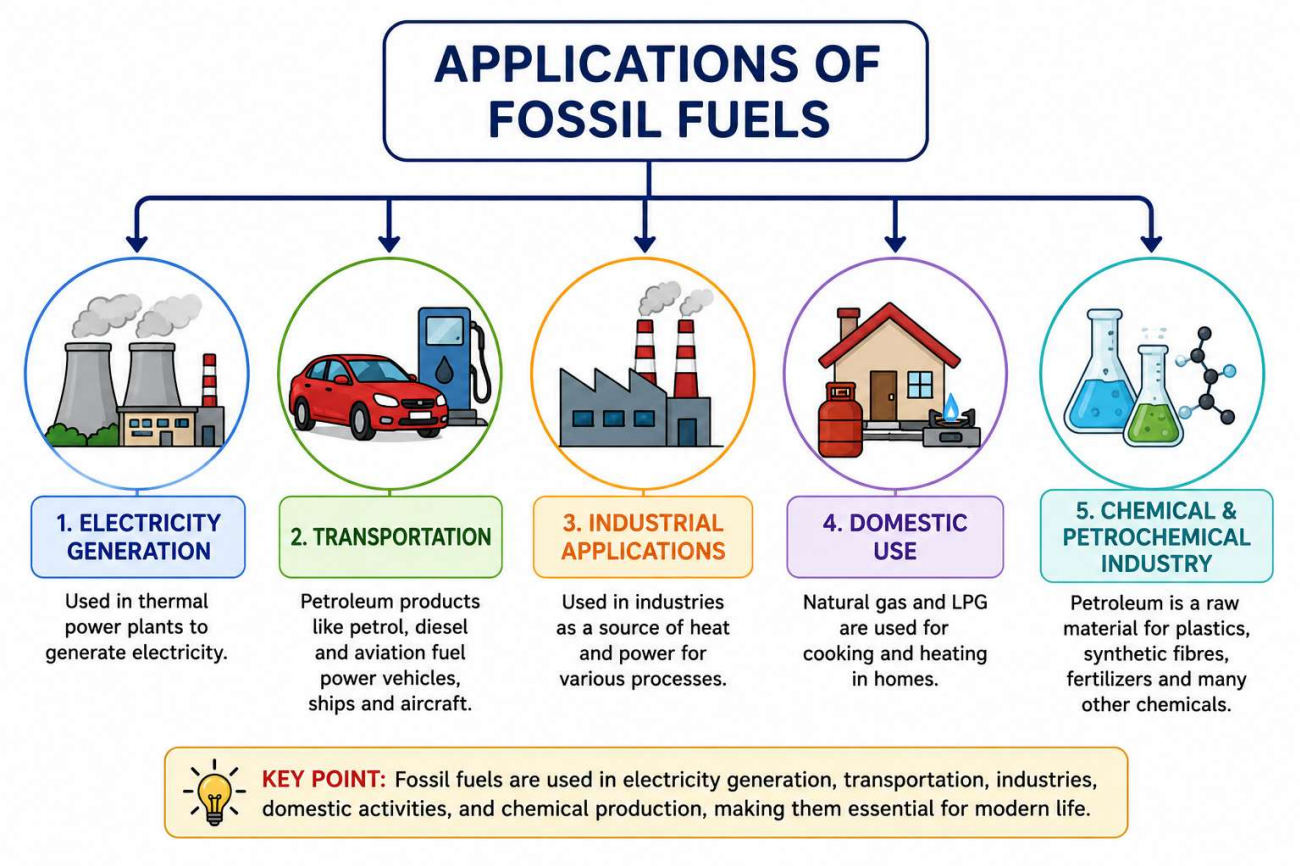

Figure 2.3 Application of Fossil Fuels in various areas

4. Domestic Applications

Natural gas and LPG are commonly used for cooking and heating in homes. Kerosene is also used in some regions for cooking and lighting purposes.

5. Chemical and Petrochemical Industries

Petroleum serves as a raw material for the production of plastics, synthetic fibres, detergents, paints, pharmaceuticals, fertilizers, and many other chemical products.

6. Metallurgical Industries

Coal, particularly coke derived from coal, is used in blast furnaces for the extraction and processing of metals such as iron and steel.

7. Agriculture

Natural gas is an important raw material for the manufacture of ammonia and fertilizers. Fossil fuels also power agricultural machinery such as tractors, pumps, and harvesters.

2.6 Merits of Fossil Fuels

1. High Energy Density

Fossil fuels produce a large amount of energy from a small quantity of fuel.

2. Reliable Energy Source

They can provide continuous and stable power generation regardless of weather conditions.

3. Easy Storage and Transportation

Coal, oil, and natural gas can be stored and transported conveniently through trucks, ships, pipelines, and railways.

4. Well-Developed Technology

The technology for extraction, processing, and utilization of fossil fuels is highly advanced and widely available.

5. Supports Industrial Growth

Fossil fuels are essential for power plants, industries, transportation, and economic development.

2.7 Demerits of Fossil Fuels

1. Non-Renewable Resource

Fossil fuels are finite resources and cannot be replenished within a human timescale.

2. Environmental Pollution

Burning fossil fuels releases harmful pollutants into the atmosphere.

3. Global Warming

They emit large quantities of carbon dioxide (CO_2), a major greenhouse gas responsible for climate change.

4. Acid Rain

Sulphur dioxide (SO_2) and nitrogen oxides (NO_x) released during combustion can cause acid rain.

5. Health Hazards

Air pollution from fossil fuels can lead to respiratory and cardiovascular diseases.

6. Environmental Damage

Mining, drilling, and transportation of fossil fuels can damage ecosystems and natural habitats.

Merits	Demerits
High energy output	Non-renewable
Reliable power supply	Air pollution
Easy storage and transport	Global warming
Mature technology	Acid rain
Supports industries	Health hazards
Economically important	Environmental degradation

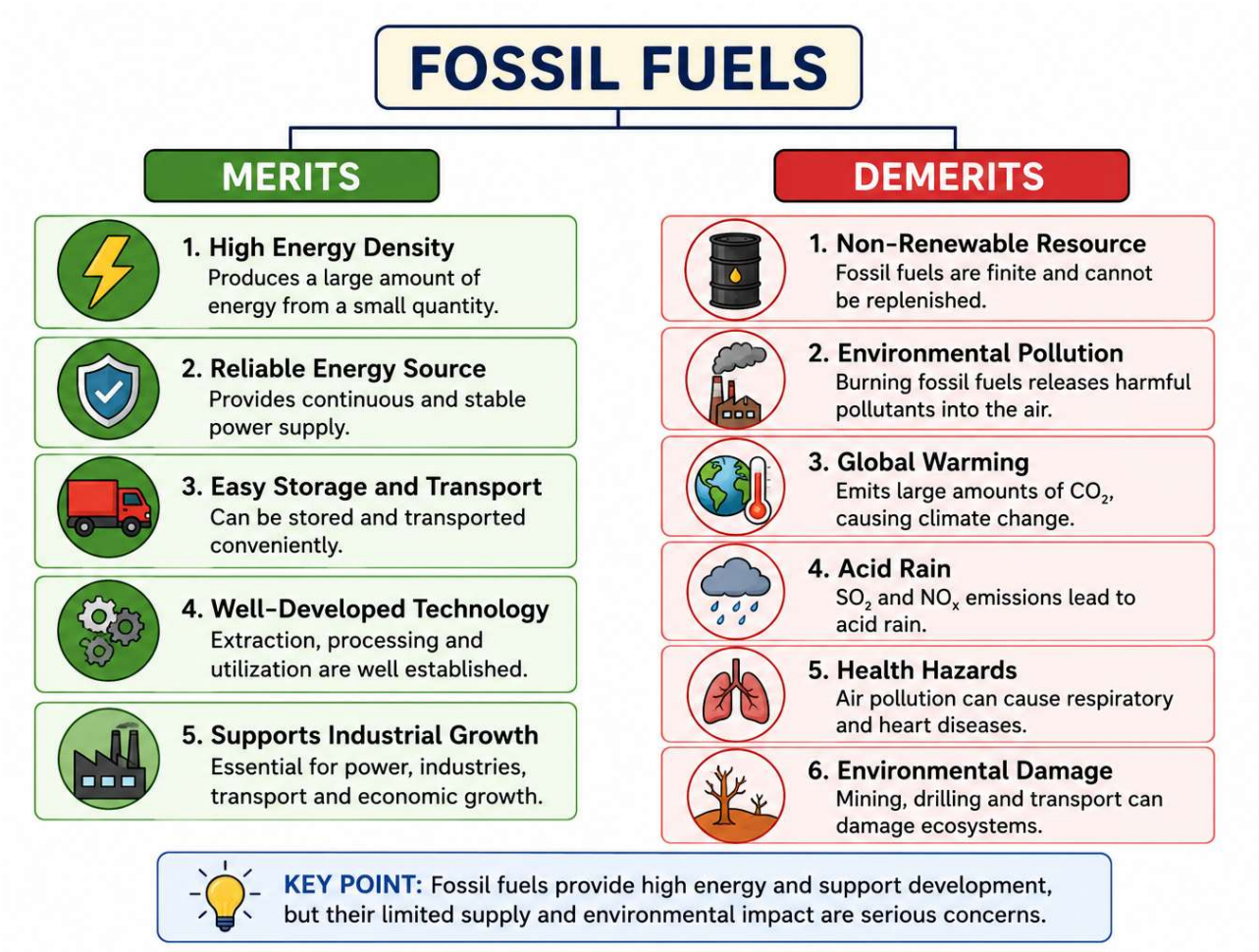

Figure 2.4 Merits and Demerits of Fossil Fuel

2.8 Key Terms

Term	Meaning
Fossil Fuel	Fuel formed from the remains of ancient plants and animals.
Coal	Solid fossil fuel rich in carbon.
Petroleum	Liquid fossil fuel composed mainly of hydrocarbons.
Natural Gas	Gaseous fossil fuel consisting mainly of methane.
Hydrocarbon	Compound containing hydrogen and carbon atoms.
Methane	Main constituent of natural gas.
Calorific Value	Amount of heat produced by complete combustion of a fuel.
Producer Gas	Combustible gas obtained from gasification processes.
Carbon Emission	Release of carbon dioxide during fuel combustion.
Greenhouse Effect	Warming of the Earth due to heat-trapping gases.

2.11 Unit Summary

- Fossil fuels are energy resources formed from the remains of ancient plants and animals over millions of years.
- The three major fossil fuels are **coal, petroleum, and natural gas**.
- Coal is a solid fuel widely used in thermal power plants and industries.
- Petroleum is a liquid fuel used mainly in transportation and petrochemical industries.
- Natural gas is the cleanest fossil fuel and is widely used for cooking, heating, and power generation.
- Fossil fuels provide a major share of the world's energy requirements but are non-renewable resources.
- The use of fossil fuels leads to environmental issues such as pollution, greenhouse gas emissions, and global warming.

2.12 Objective Questions

1. Which of the following is a solid fossil fuel?

A) Petroleum
B) Natural Gas
C) Coal
D) LPG

2. Petroleum is mainly composed of:

A) Metals
B) Hydrocarbons
C) Water
D) Oxygen

3. The major constituent of natural gas is:

A) Nitrogen
B) Oxygen
C) Methane
D) Hydrogen

4. Which fossil fuel is considered the cleanest?

A) Coal
B) Petroleum
C) Natural Gas
D) Coke

5. Coal is mainly used in:

A) Thermal Power Plants
B) Solar Cells
C) Wind Turbines
D) Fuel Cells

6. Which fossil fuel is widely used in transportation?

A) Coal
B) Petroleum
C) Biomass
D) Wood

7. Fossil fuels are:

A) Renewable Resources
B) Inexhaustible Resources
C) Non-Renewable Resources
D) Artificial Resources

Answers

1. C) Coal
2. B) Hydrocarbons
3. C) Methane
4. C) Natural Gas

5. A) Thermal Power Plants
6. B) Petroleum
7. C) Non-Renewable Resources

2.12 Review Questions

Short Answer Questions

1. What are fossil fuels?
2. Explain the classification of fossil fuels.
3. Write a short note on coal.
4. What are the major products obtained from petroleum?
5. Why is natural gas considered a clean fuel?
6. Mention the applications of fossil fuels.
7. What are the merits and demerits of fossil fuels?

Long Answer Questions

1. Explain the formation, availability, applications, merits, and demerits of coal.
2. Discuss the origin, availability, applications, merits, and demerits of petroleum.
3. Explain the composition, availability, applications, merits, and demerits of natural gas.
4. Compare coal, petroleum, and natural gas with respect to their properties and uses.
5. Discuss the environmental impacts of fossil fuels and the need for alternative energy sources.

UNIT:3

Biomass Energy

3.1 Introduction to Biomass Energy

Biomass energy is a form of renewable energy obtained from organic materials derived from plants, animals, and agricultural wastes. These organic materials store solar energy through the process of photosynthesis. Biomass can be converted into useful forms of energy such as heat, electricity, biogas, and biofuels.

Biomass is one of the oldest sources of energy used by humans and continues to play an important role in meeting energy demands, especially in rural areas.

3.2 Classification of Biomass

Biomass can be classified into **Primary Biomass, Secondary Biomass, and Tertiary Biomass** based on its origin and source.

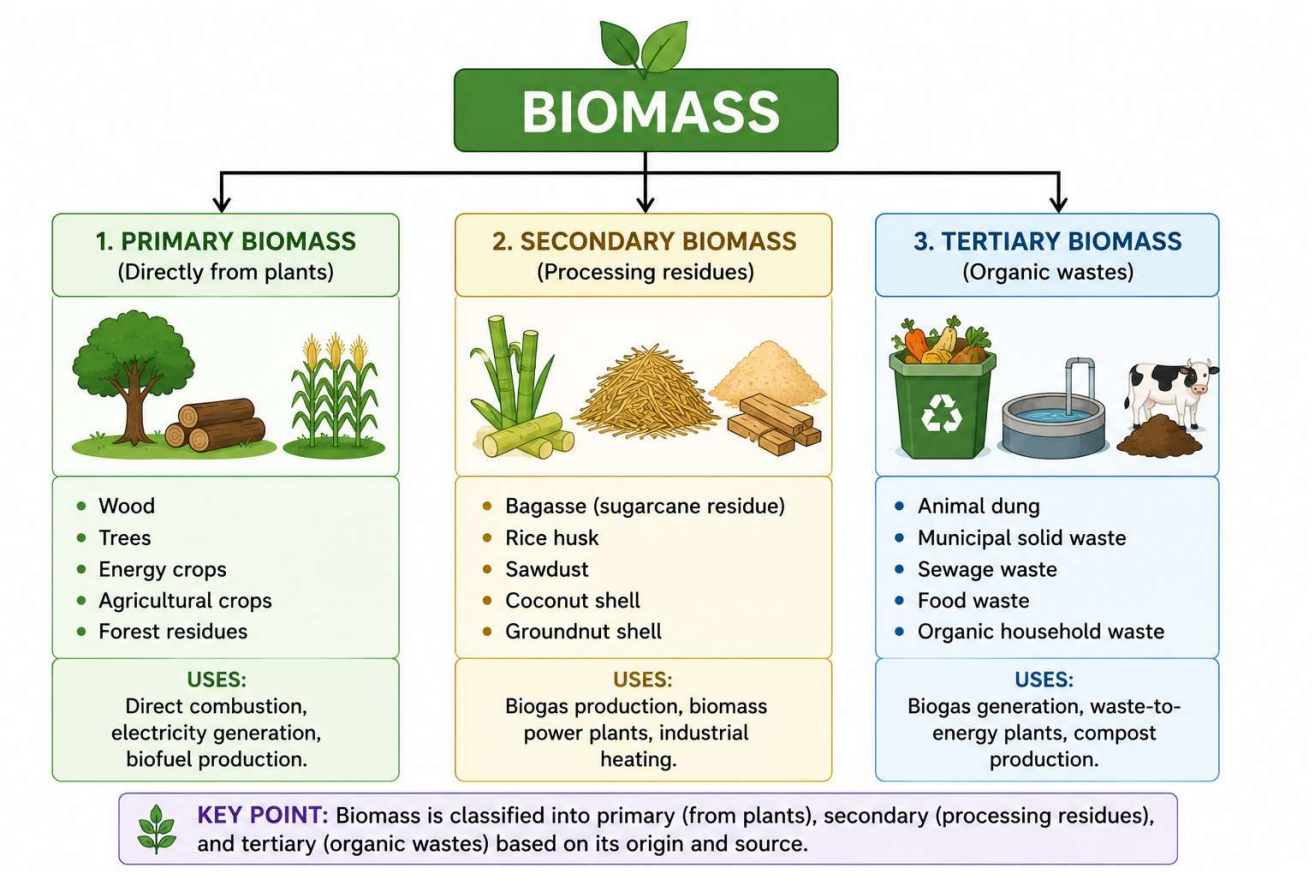

Figure 2.1 Classification of Biomass

3.2.1 Primary Biomass

Primary biomass refers to biomass obtained directly from plants and natural vegetation. It is produced through photosynthesis and is available without significant processing.

Examples

- Wood

- Trees
- Energy crops
- Agricultural crops
- Forest residues

Uses

- Direct combustion
- Electricity generation
- Biofuel production

3.2.2 Secondary Biomass

Secondary biomass consists of residues and by-products generated during the processing of primary biomass.

Examples

- Rice husk
- Bagasse (sugarcane residue)
- Sawdust
- Coconut shell
- Groundnut shell

Uses

- Biogas production
- Biomass power plants
- Industrial heating

3.2.3 Tertiary Biomass

Tertiary biomass includes waste materials generated after the consumption and use of biomass products by humans and animals.

Examples

- Animal dung
- Municipal solid waste
- Sewage waste
- Food waste
- Organic household waste

Uses

- Biogas generation
- Waste-to-energy plants
- Compost production

3.3 Biomass Conversion Process

The **biomass conversion process** refers to the methods by which biomass materials are transformed into useful forms of energy such as **heat, electricity, biogas, biofuels, and producer gas**. Since raw biomass cannot always be used directly and efficiently, it is converted into more useful energy products through biological, thermal, and chemical processes.

Principle

Biomass contains stored solar energy in the form of chemical energy. Through various conversion processes, this chemical energy is converted into usable forms of energy.

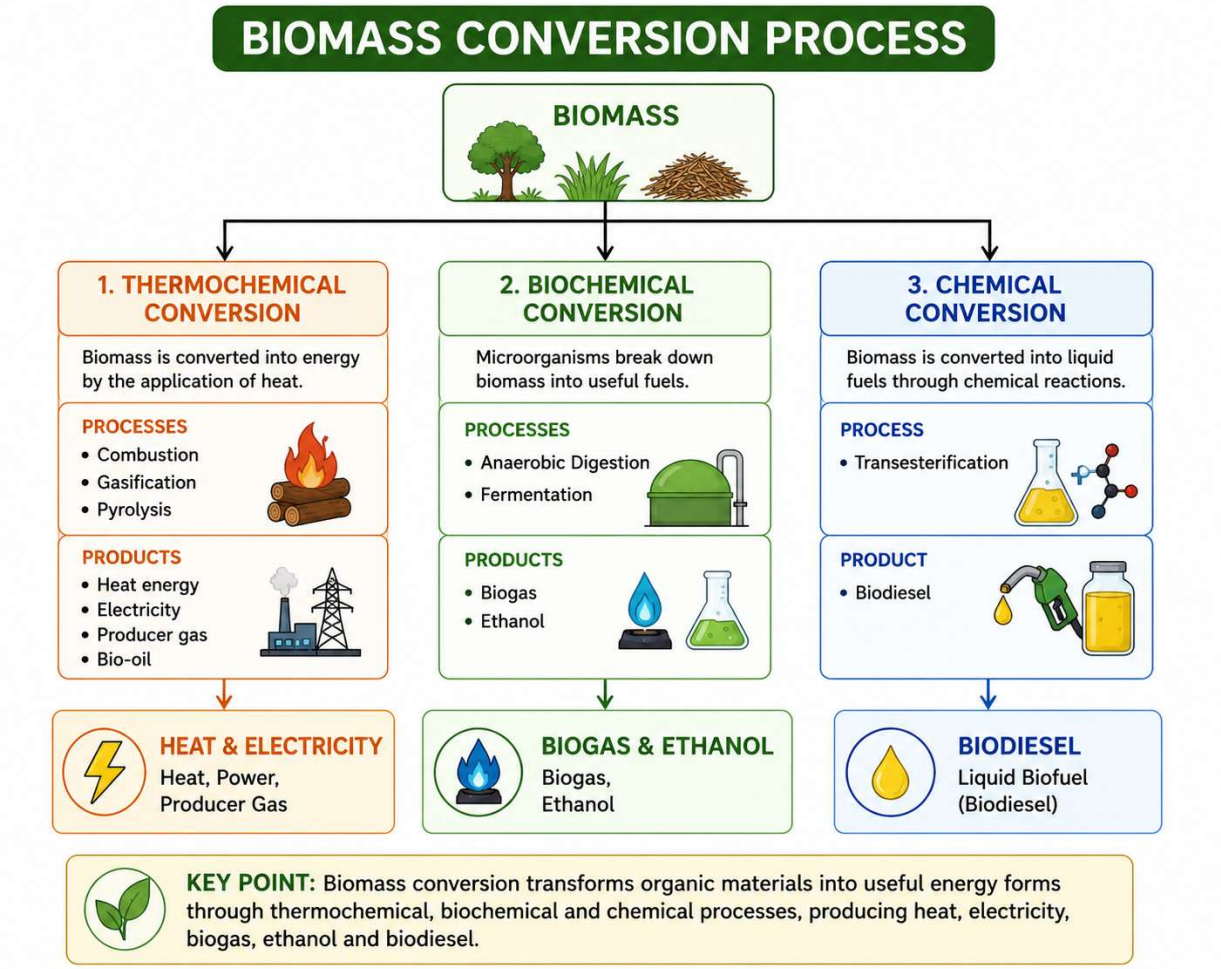

Figure 3.2 Biomass Conversion Process

3.4 Types of Biomass Conversion Processes

3.4.1 Thermochemical Conversion

In this method, biomass is converted into energy by the application of heat.

Processes

- Combustion
- Gasification
- Pyrolysis

Products

- Heat energy
- Electricity
- Producer gas
- Bio-oil

3.4.2 Biochemical Conversion

In this method, microorganisms break down biomass into useful fuels.

Processes

- Anaerobic digestion
- Fermentation

Products

- Biogas
- Ethanol

3.4.3 Chemical Conversion

Biomass is converted into liquid fuels through chemical reactions.

Process

- Transesterification

Product

- Biodiesel

Importance of Biomass Conversion

- Produces renewable energy.
- Converts agricultural and organic wastes into useful products.

- Reduces environmental pollution.
- Decreases dependence on fossil fuels.
- Supports sustainable energy development.

3.5 Biogas Plants

A **biogas plant** is a system used to convert organic wastes such as cattle dung, agricultural residues, sewage, and kitchen waste into **biogas** through the process of **anaerobic digestion** (decomposition in the absence of oxygen). The gas produced mainly consists of **methane (CH_4)** and **carbon dioxide (CO_2)** and can be used as a fuel for cooking, lighting, and electricity generation.

Principle

When organic matter is decomposed by anaerobic bacteria in an oxygen-free environment, biogas is produced. The methane present in biogas is responsible for its fuel value.

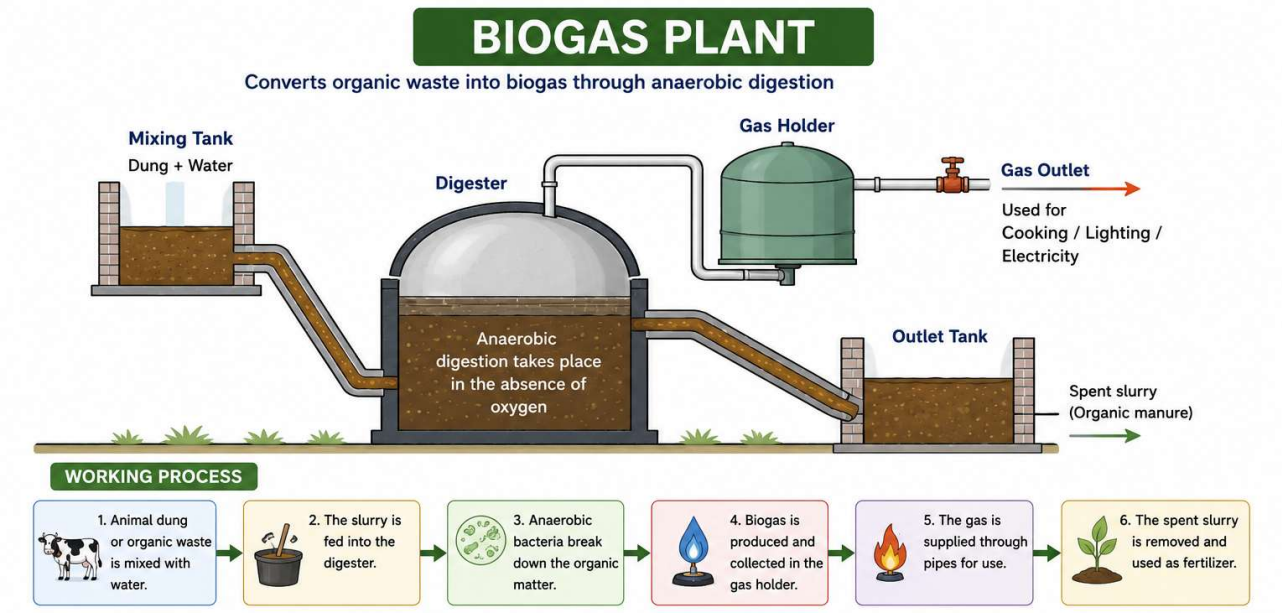

Figure 3.3 Processes in a Bio-Gas plant

3.5.1 Main Components of a Biogas Plant

1. Mixing Tank

Organic waste and water are mixed to form a slurry.

2. Digester

An airtight chamber where anaerobic digestion takes place and biogas is generated.

3. Gas Holder

Stores the biogas produced inside the digester.

4. Outlet Tank

The digested slurry flows out and can be used as organic manure.

3.5.2 Working of a Biogas Plant

1. Animal dung or organic waste is mixed with water in the mixing tank.
2. The slurry is fed into the digester.
3. Anaerobic bacteria decompose the organic matter.
4. Biogas is produced and collected in the gas holder.
5. The gas is supplied through pipelines for use.
6. The spent slurry is removed through the outlet and used as fertilizer.

3.5.3 Composition of Biogas

Component	Percentage
Methane (CH_4)	55–70%
Carbon Dioxide (CO_2)	30–45%
Hydrogen Sulphide (H_2S)	Small amount
Water Vapour	Trace amount

Advantages of Biogas Plants

- Renewable source of energy.
- Utilizes agricultural and animal waste.
- Reduces environmental pollution.
- Produces valuable organic manure.
- Suitable for rural areas.

Disadvantages of Biogas Plants

- Requires regular supply of biomass.
- Initial installation cost is high.
- Gas production depends on temperature.
- Needs proper maintenance.

3.6 Wood Gasification

Wood gasification is a thermochemical process in which wood or biomass is converted into a combustible gas called **producer gas (wood gas)** by heating it at high temperatures with a limited supply of air or oxygen.

The process converts solid biomass into gaseous fuel, which can be used for cooking, heating, electricity generation, and operating internal combustion engines.

Principle

When wood is heated in a gasifier under controlled oxygen conditions, it does not burn completely. Instead, it undergoes partial oxidation and produces a mixture of combustible gases.

Main Components of Producer Gas

- Carbon Monoxide (CO)
- Hydrogen (H_2)
- Methane (CH_4)
- Carbon Dioxide (CO_2)
- Nitrogen (N_2)

Working of Wood Gasification

1. Wood or biomass is fed into the gasifier.
2. A limited amount of air is supplied.
3. Biomass undergoes drying and pyrolysis.
4. Partial combustion occurs at high temperature.
5. Producer gas is generated.
6. The gas is cleaned and used as fuel.

Applications

- Electricity generation
- Industrial heating
- Cooking fuel
- Small power plants
- Engine operation in rural areas

3.7 Advantages of Biomass Energy

1. Renewable Source of Energy: Biomass is continuously replenished through plant growth and agricultural activities.

2. Environment-Friendly: Biomass produces lower net carbon emissions because plants absorb carbon dioxide during photosynthesis.

3. Waste Utilization: Agricultural residues, animal waste, and municipal organic waste can be converted into useful energy.

4. Reduces Dependence on Fossil Fuels: Biomass can partially replace coal, petroleum, and natural gas.

5. Multiple Energy Products: Biomass can be converted into biogas, bioethanol, biodiesel, electricity, and heat.

6. Produces Organic Manure: The residue from biogas plants can be used as a valuable organic fertilizer.

3.8 Disadvantages of Biomass Energy

1. Low Energy Density: Biomass contains less energy per unit mass compared to fossil fuels.

2. Large Land Requirement: Large areas are needed for growing energy crops.

3. Seasonal Availability: Biomass supply may vary with seasons and agricultural production.

4. Lower Conversion Efficiency: Biomass energy systems are generally less efficient than conventional energy systems.

5. Initial Investment Cost: Biogas plants and biomass power plants require significant initial investment.

6. Air Pollution: Direct burning of biomass can produce smoke and particulate matter.

Advantages	Disadvantages
Renewable energy source	Low energy density
Utilizes waste materials	Large land requirement
Reduces fossil fuel use	Seasonal availability
Environment-friendly	Storage and transport issues
Rural employment	Air pollution during combustion
Produces biofuels and biogas	Lower efficiency
Organic manure production	High initial cost

3.9 Key Terms

Term	Meaning
Biomass	Organic material derived from plants and animals used as an energy source.
Biomass Energy	Renewable energy obtained from biomass materials.
Primary Biomass	Biomass obtained directly from plants and vegetation.
Secondary Biomass	Biomass residues generated during processing of primary biomass.
Tertiary Biomass	Organic wastes produced after consumption and use.
Biogas	Fuel gas produced by anaerobic decomposition of organic matter.
Anaerobic Digestion	Decomposition of organic matter in the absence of oxygen.
Gasification	Conversion of biomass into combustible gas using limited oxygen.
Producer Gas	Combustible gas obtained from biomass gasification.
Wood Gasification	Process of converting wood into producer gas for energy applications.

3.10 Unit Summary

- Biomass energy is a renewable energy source obtained from plant materials, animal wastes, and organic residues.
- Biomass is classified into **primary, secondary, and tertiary biomass** based on its origin.
- Biomass can be converted into useful energy through thermochemical, biochemical, and chemical conversion processes.
- Biogas is produced by the anaerobic digestion of organic wastes and can be used for cooking and electricity generation.
- A biogas plant converts organic waste into methane-rich biogas and organic manure.
- Wood gasification converts wood and biomass into producer gas using limited oxygen conditions.
- Biomass energy helps in waste utilization, rural development, and reduction of dependence on fossil fuels.

3.11 Objective Questions

1. Biomass energy is obtained from:

A) Nuclear materials
B) Organic matter
C) Rocks
D) Minerals

2. Biomass obtained directly from plants is called:

A) Secondary Biomass
B) Tertiary Biomass
C) Primary Biomass
D) Municipal Biomass

3. Biogas mainly contains:

A) Oxygen
B) Nitrogen
C) Methane
D) Hydrogen

4. Anaerobic digestion takes place in the:

A) Presence of oxygen
B) Absence of oxygen
C) Vacuum condition
D) High-pressure chamber

5. Producer gas is obtained through:

A) Fermentation
B) Distillation
C) Gasification
D) Condensation

6. Which of the following is a tertiary biomass source?

A) Wood
B) Rice Husk
C) Animal Dung
D) Sugarcane

7. Wood gasification converts wood into:

A) Biodiesel
B) Ethanol

C) Producer Gas
D) LPG

Answers

1. B) Organic matter
2. C) Primary Biomass
3. C) Methane
4. B) Absence of oxygen
5. C) Gasification
6. C) Animal Dung
7. C) Producer Gas

3.12 Review Questions

Short Answer Questions

1. What is biomass energy?
2. Classify biomass with suitable examples.
3. Explain the biomass conversion process.
4. What is biogas?
5. Describe the working of a biogas plant.
6. What is wood gasification?
7. Write the advantages and disadvantages of biomass energy.

Long Answer Questions

1. Explain biomass energy and discuss its sources and importance.
2. Describe the classification of biomass with suitable examples.
3. Explain the various biomass conversion processes.
4. Discuss the construction and working of a biogas plant.
5. Explain the principle, working, applications, advantages, and disadvantages of wood gasification.

UNIT:4

Renewable Energy Sources

4.1 Introduction

Renewable energy sources are energy resources that are naturally replenished and can be used continuously without depletion. These sources are derived from natural processes such as sunlight, wind, water flow, biomass growth, and geothermal heat. Unlike fossil fuels, renewable energy sources are environmentally friendly and sustainable.

The increasing demand for energy, depletion of fossil fuel reserves, and environmental concerns have led to the growing importance of renewable energy technologies worldwide.

4.2 Solar Energy

Solar energy is the energy obtained from the Sun in the form of electromagnetic radiation. The Sun is the ultimate source of energy for life on Earth and provides an enormous amount of clean and renewable energy every day. Solar energy can be converted into thermal energy and electrical energy using various technologies such as solar collectors and solar cells.

Solar energy is one of the most promising renewable energy sources because it is abundant, non-polluting, and available in most parts of the world.

Principle of Solar Energy

The Sun continuously emits radiant energy due to nuclear fusion reactions occurring in its core. This energy reaches the Earth in the form of solar radiation and can be utilized for heating and electricity generation.

4.3 Importance of Solar Energy

Solar energy plays a vital role in meeting future energy demands and reducing dependence on fossil fuels.

1. Renewable and Inexhaustible

Solar energy is continuously available as long as the Sun exists.

2. Environment-Friendly

It does not produce harmful pollutants or greenhouse gases during operation.

3. Reduces Dependence on Fossil Fuels

Solar energy helps conserve coal, petroleum, and natural gas resources.

4. Energy Security

It reduces reliance on imported fuels and enhances national energy security.

5. Suitable for Remote Areas

Solar systems can provide electricity in rural and isolated regions where grid supply is unavailable.

4.4 Storage of Solar Energy

Since solar energy is available only during daytime, energy storage systems are necessary to ensure a continuous supply.

1. Thermal Energy Storage

Solar heat is stored in materials such as water, rocks, or molten salts and used later when sunlight is unavailable.

Examples

- Solar water heaters
- Solar thermal power plants

2. Electrical Energy Storage

Solar electricity generated by photovoltaic cells can be stored in batteries.

Examples

- Lead-acid batteries
- Lithium-ion batteries

3. Chemical Energy Storage

Solar energy can be converted into chemical fuels such as hydrogen through electrolysis.

Example

- Solar hydrogen production

4.5 Applications of Solar Energy

Solar energy is used in a wide variety of domestic, agricultural, industrial, and commercial applications.

1. Solar Water Heaters

Used to heat water for domestic and industrial purposes.

2. Solar Cookers

Use solar heat for cooking food without conventional fuels.

3. Solar Dryers

Used for drying agricultural products, fruits, vegetables, and fish.

4. Solar Cells (Photovoltaic Systems)

Convert sunlight directly into electricity.

Applications

- Street lighting
- Calculators
- Satellites
- Rooftop power systems

5. Solar Thermal Power Plants

Generate electricity using solar heat.

Solar energy is used in a wide variety of domestic, agricultural, industrial, and commercial applications.

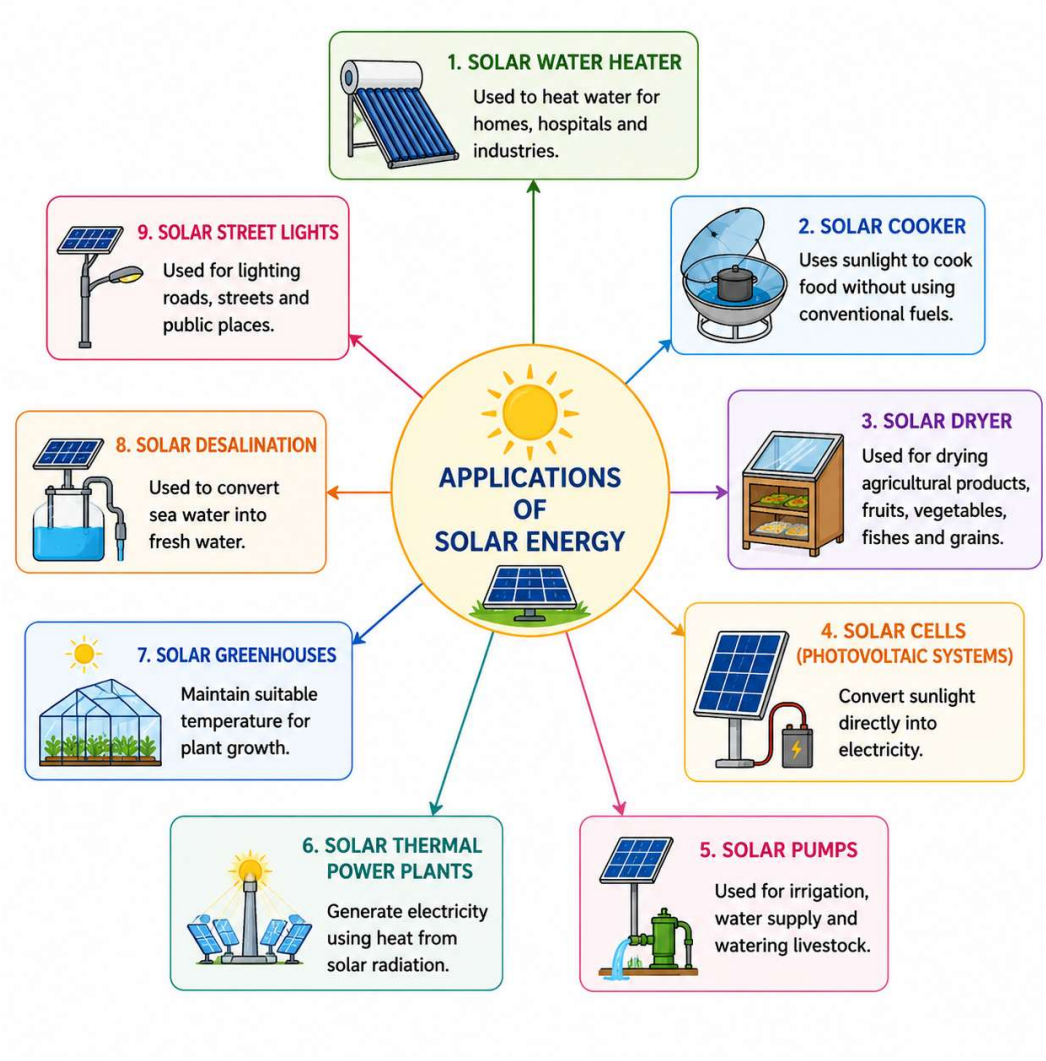

Figure 4.1 Applications of Solar Energy

4.6 Solar Pond

A **solar pond** is a large body of salt water designed to collect and store solar energy. It acts as both a **solar collector** and a **thermal energy storage system**. The presence of a salt concentration gradient prevents convection currents, allowing heat to accumulate at the bottom of the pond.

Solar ponds are used to store solar heat and provide thermal energy for industrial processes, heating applications, and electricity generation.

Principle

Normally, when water at the bottom becomes hot, it rises due to convection. In a solar pond, the lower layer contains a high concentration of salt, making it denser than the upper layers. This prevents the hot water from rising and traps the heat at the bottom.

Structure of a Solar Pond

1. Upper Convective Zone (UCZ)

- Low salt concentration
- Near ambient temperature

2. Non-Convective Zone (NCZ)

- Salt concentration increases with depth
- Prevents convection currents

3. Lower Convective Zone (LCZ)

- Highest salt concentration
- Stores solar heat
- Temperature may reach 70–90°C

Working

1. Sunlight penetrates through the pond.
2. Heat is absorbed at the bottom layer.
3. Salt gradient prevents convection.
4. Heat remains trapped in the lower layer.
5. Stored thermal energy is extracted through heat exchangers.

Applications

- Electricity generation
- Industrial process heating

- Desalination of water
- Space heating and Agricultural drying

4.7 Solar Water Heater

A **solar water heater** is a device that uses solar energy to heat water for domestic, commercial, and industrial applications. It converts solar radiation into thermal energy and stores the heated water for later use. Solar water heaters are widely used because they reduce electricity consumption and fuel costs while providing an environmentally friendly method of water heating.

Principle

A solar water heater works on the principle of **absorption of solar radiation**. The collector absorbs sunlight and converts it into heat, which is transferred to water flowing through pipes.

Main Components

1. Solar Collector

Absorbs solar radiation and converts it into heat.

2. Storage Tank

Stores the heated water.

3. Connecting Pipes

Carry water between the collector and storage tank.

4. Insulation

Reduces heat loss from the system.

Working

1. Sunlight falls on the solar collector.
2. The collector absorbs solar energy and heats the water.
3. Hot water rises naturally to the storage tank.
4. Cold water flows into the collector for heating.
5. Heated water is supplied for domestic or industrial use.

Applications

- Domestic water heating
- Hotels and hospitals
- Swimming pools
- Industrial hot water supply

4.8 Solar Crop Dryers

A **solar crop dryer** is a device that uses solar energy to remove moisture from agricultural products such as grains, fruits, vegetables, spices, and fish. Drying helps preserve the quality of the products and increases their storage life by preventing spoilage caused by microorganisms. Solar crop dryers provide a clean and economical alternative to traditional open-sun drying methods.

Principle

A solar crop dryer works on the principle of **greenhouse heating and hot air circulation**. Solar radiation is absorbed inside the dryer, increasing the temperature of the air. The warm air passes over the crops and removes moisture through evaporation.

Main Components

1. Solar Collector

Absorbs solar radiation and heats the air.

2. Drying Chamber

Contains the agricultural products to be dried.

3. Air Inlet

Allows fresh air to enter.

4. Air Outlet

Removes moist air from the dryer.

Working

1. Sunlight falls on the solar collector.
2. Air inside the collector becomes hot.
3. Hot air flows into the drying chamber.
4. Moisture from the crops evaporates.
5. Moist air leaves through the outlet.
6. Dried products are collected for storage.

Applications

- Drying grains
- Drying fruits and vegetables
- Drying spices and meat
- Agricultural product preservation

4.9 Solar Cooker

A **solar cooker** is a device that uses solar energy to cook food without the use of conventional fuels such as firewood, coal, kerosene, or LPG. It converts sunlight into heat energy, which is utilized for cooking. Solar cookers are environmentally friendly, economical, and widely used in regions with abundant sunlight.

Principle

A solar cooker works on the principle of the **greenhouse effect** and **absorption of solar radiation**. Sunlight enters through a transparent glass cover and is absorbed by a blackened cooking vessel. The absorbed solar energy is converted into heat, which is trapped inside the cooker and used for cooking food.

Main Components

1. Reflector

Reflects additional sunlight into the cooker.

2. Glass Cover

Allows sunlight to enter and prevents heat from escaping.

3. Cooking Vessel

Usually blackened to absorb maximum heat.

4. Insulated Box

Reduces heat loss and retains thermal energy.

Working

1. Sunlight falls on the reflector and glass cover.
2. Solar radiation enters the cooker.
3. The black cooking vessel absorbs heat.
4. Temperature inside the cooker increases.
5. Food is cooked using the trapped thermal energy.

Applications

- Cooking rice
- Cooking vegetables
- Boiling water
- Baking food
- Domestic cooking in sunny regions

4.10 Solar Cell

A **solar cell** (or photovoltaic cell) is a semiconductor device that converts solar energy directly into electrical energy through the **photovoltaic effect**. Solar cells are the basic building blocks of solar panels and are widely used for generating clean and renewable electricity. Solar cells are commonly made from semiconductor materials such as **silicon (Si)**. When sunlight falls on the solar cell, electrical energy is produced without any moving parts or fuel consumption.

Principle

A solar cell works on the principle of the **photovoltaic effect**. When sunlight strikes the semiconductor material, photons transfer their energy to electrons. These electrons become free and move through an external circuit, producing an electric current.

Construction of a Solar Cell

A typical solar cell consists of:

1. P-Type Semiconductor Layer

Contains excess holes as charge carriers.

2. N-Type Semiconductor Layer

Contains excess electrons as charge carriers.

3. P-N Junction

The interface between the P-type and N-type layers where electricity is generated.

4. Metallic Contacts

Collect and transfer electric current to the external circuit.

5. Protective Glass Cover

Protects the solar cell from environmental damage.

Working

1. Sunlight falls on the solar cell.
2. Photons are absorbed by the semiconductor.
3. Electron-hole pairs are generated.
4. The electric field at the P-N junction separates the charges.
5. Electrons flow through the external circuit.
6. Electrical energy is produced.

Applications

- Solar power plants and Rooftop solar systems

- Street lighting
- Traffic signals
- Satellites and spacecraft
- Calculators and watches
- Remote communication systems

4.11 Key Terms

Term	Meaning
Solar Energy	Energy obtained from the Sun's radiation.
Renewable Energy	Energy obtained from naturally replenished sources.
Solar Radiation	Electromagnetic energy emitted by the Sun.
Solar Pond	Salt-gradient pond used to collect and store solar heat.
Solar Water Heater	Device that uses solar energy to heat water.
Solar Crop Dryer	Device that uses solar-heated air to dry agricultural products.
Solar Cooker	Device that cooks food using solar energy.
Solar Cell	Semiconductor device that converts sunlight into electricity.
Photovoltaic Effect	Conversion of solar energy directly into electrical energy.
Energy Storage	Storage of solar energy in thermal, electrical, or chemical form.

4.12 Unit Summary

- Solar energy is a clean, renewable, and abundant source of energy obtained from the Sun.
- Solar energy plays an important role in reducing dependence on fossil fuels and minimizing environmental pollution.
- Since solar energy is intermittent, it can be stored in thermal, electrical, and chemical forms for later use.
- Solar energy has a wide range of applications in domestic, agricultural, and industrial sectors.

- A solar pond acts as both a solar collector and a thermal energy storage system.
- Solar water heaters, solar crop dryers, and solar cookers utilize solar thermal energy for practical applications.
- Solar cells convert sunlight directly into electricity through the photovoltaic effect.

4.13 Objective Questions

1. Solar energy is obtained from:

A) Wind
B) Earth
C) Sun
D) Water

2. A solar pond is mainly used for:

A) Water purification
B) Thermal energy collection and storage
C) Agriculture
D) Transportation

3. A solar water heater converts solar energy into:

A) Nuclear energy
B) Thermal energy
C) Mechanical energy
D) Chemical energy

4. Solar crop dryers are used to:

A) Generate electricity
B) Pump water
C) Remove moisture from crops
D) Produce fuel

5. A solar cooker works mainly on the principle of:

A) Electromagnetic induction
B) Greenhouse effect
C) Nuclear fission
D) Gasification

6. A solar cell converts sunlight directly into:

A) Heat energy
B) Mechanical energy
C) Electrical energy
D) Chemical energy

7. The working principle of a solar cell is:

A) Photoelectric effect
B) Photovoltaic effect
C) Greenhouse effect
D) Thermionic emission

Answers

1. C) Sun
2. B) Thermal energy collection and storage
3. B) Thermal energy
4. C) Remove moisture from crops
5. B) Greenhouse effect
6. C) Electrical energy
7. B) Photovoltaic effect

4.12 Review Questions

Short Answer Questions

1. What is solar energy?
2. Explain the importance of solar energy.
3. What are the methods of solar energy storage?
4. What is a solar pond?
5. Describe the working of a solar water heater.
6. What is a solar cooker?
7. Explain the photovoltaic effect.

Long Answer Questions

1. Explain solar energy and discuss its importance.
2. Describe the various methods used for storage of solar energy.
3. Discuss the applications of solar energy with suitable examples.
4. Explain the construction and working of a solar pond.
5. Describe the principle, construction, and working of a solar cell.

UNIT:5

Geo-Thermal Energy

5.1 Introduction

Geothermal energy is the thermal energy stored within the Earth's interior. The word *geothermal* is derived from the Greek words **"Geo"** meaning Earth and **"Therme"** meaning heat. This energy originates from the natural heat of the Earth's core and is continuously produced by radioactive decay and residual heat from the Earth's formation.

Geothermal energy is a renewable and environmentally friendly source of energy that can be used for heating and electricity generation.

5.2 Geothermal Power Plant

A **geothermal power plant** is a power generation system that converts the heat energy stored inside the Earth into electrical energy. It utilizes naturally occurring hot water or steam reservoirs located beneath the Earth's surface. The steam produced from geothermal reservoirs is used to rotate a turbine, which drives a generator to produce electricity.

Geothermal power plants are considered renewable because the Earth's internal heat is continuously replenished.

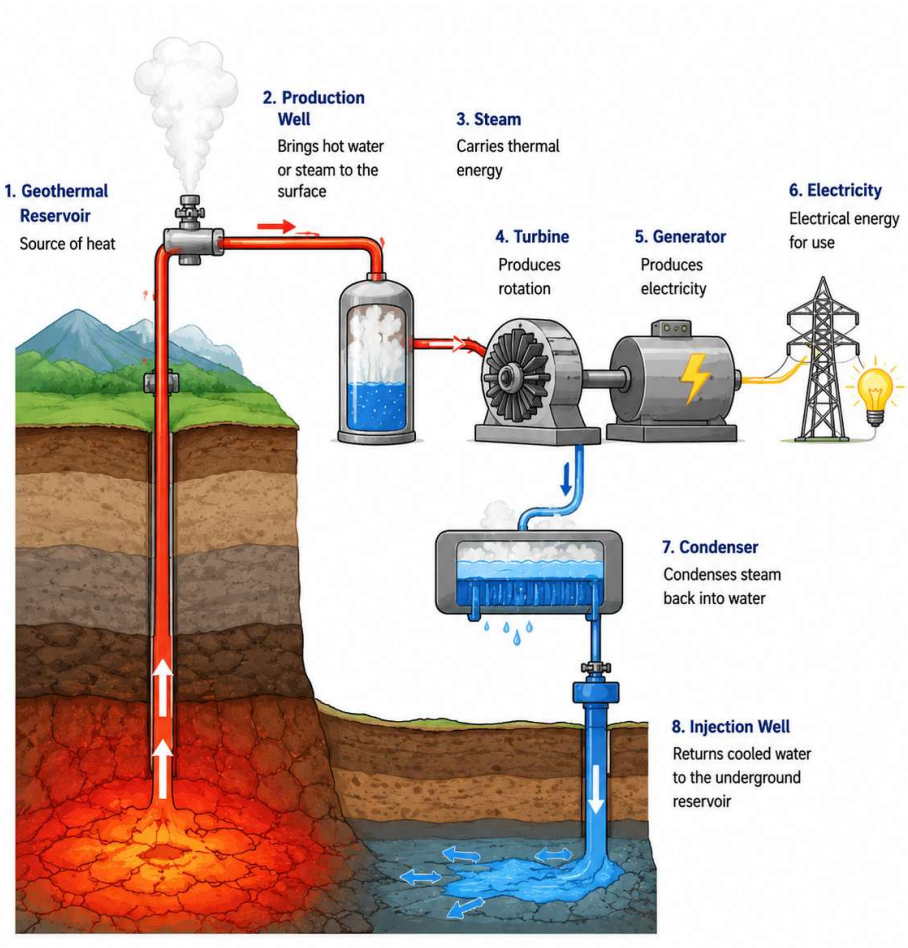

Figure 5.1 This Image represents a Model of Geothermal Power plant

Principle

A geothermal power plant works on the principle of converting the thermal energy of underground steam or hot water into mechanical energy and then into electrical energy.

Main Components

1. Geothermal Reservoir

Underground source of hot water and steam.

2. Production Well

Brings hot water or steam to the surface.

3. Turbine

Converts steam energy into mechanical rotation.

4. Generator

Converts mechanical energy into electrical energy.

5. Condenser

Condenses steam back into water.

6. Injection Well

Returns cooled water to the underground reservoir.

Working of a Geothermal Power Plant

1. Heat from the Earth's interior produces hot water and steam.
2. Steam is brought to the surface through production wells.
3. The steam drives a turbine.
4. The turbine rotates a generator.
5. Electricity is generated.
6. Steam is condensed into water.
7. The cooled water is reinjected into the Earth through injection wells.

5.3 Types of Geothermal Power Plants

1. Dry Steam Power Plant

Uses natural steam directly from underground reservoirs.

2. Flash Steam Power Plant

Uses high-pressure hot water that flashes into steam when pressure is reduced.

3. Binary Cycle Power Plant

Uses geothermal water to heat a secondary fluid with a lower boiling point, which drives the turbine.

Applications

- Electricity generation
- Industrial heating
- District heating systems
- Agricultural processing

5.4 Wind Energy

Wind energy is the kinetic energy possessed by moving air. This energy is converted into mechanical energy and then into electrical energy using wind turbines. Wind energy is one of the fastest-growing renewable energy sources because it is clean, abundant, and environmentally friendly.

Wind is produced due to uneven heating of the Earth's surface by the Sun, which creates pressure differences in the atmosphere and causes air movement.

Principle

Wind possesses kinetic energy. When wind strikes the blades of a wind turbine, the blades rotate. This rotational energy drives a generator to produce electricity.

Working of Wind Energy System

1. Wind strikes the turbine blades.
2. The blades rotate.
3. The rotating shaft drives a generator.
4. The generator converts mechanical energy into electrical energy.
5. Electricity is supplied to homes and industries.

Applications of Wind Energy

- Electricity generation
- Water pumping
- Battery charging
- Agricultural applications
- Remote area power supply

Advantages

- Renewable and inexhaustible.
- No fuel cost.
- Environment-friendly.
- Low operating cost.

Disadvantages

- Depends on wind availability.
- High installation cost.
- Noise generation.
- Requires large open areas.

5.5 Wind Farms

A **wind farm** is a collection of many wind turbines installed in a suitable location to generate electricity on a large scale. The electricity produced by individual turbines is combined and supplied to the electrical grid.

Wind farms are usually established in areas with strong and consistent winds such as coastal regions, open plains, hilltops, and offshore locations.

Components of a Wind Farm

- Wind turbines
- Transmission lines
- Electrical substation
- Control system

Working of a Wind Farm

1. Wind rotates multiple turbines.
2. Each turbine generates electricity.
3. Electricity is collected through cables.
4. Power is transmitted to a substation.
5. Electricity is supplied to the grid.

5.6 Types of Wind Farms

1. Onshore Wind Farm

Located on land.

2. Offshore Wind Farm

Located in seas or oceans where wind speeds are higher.

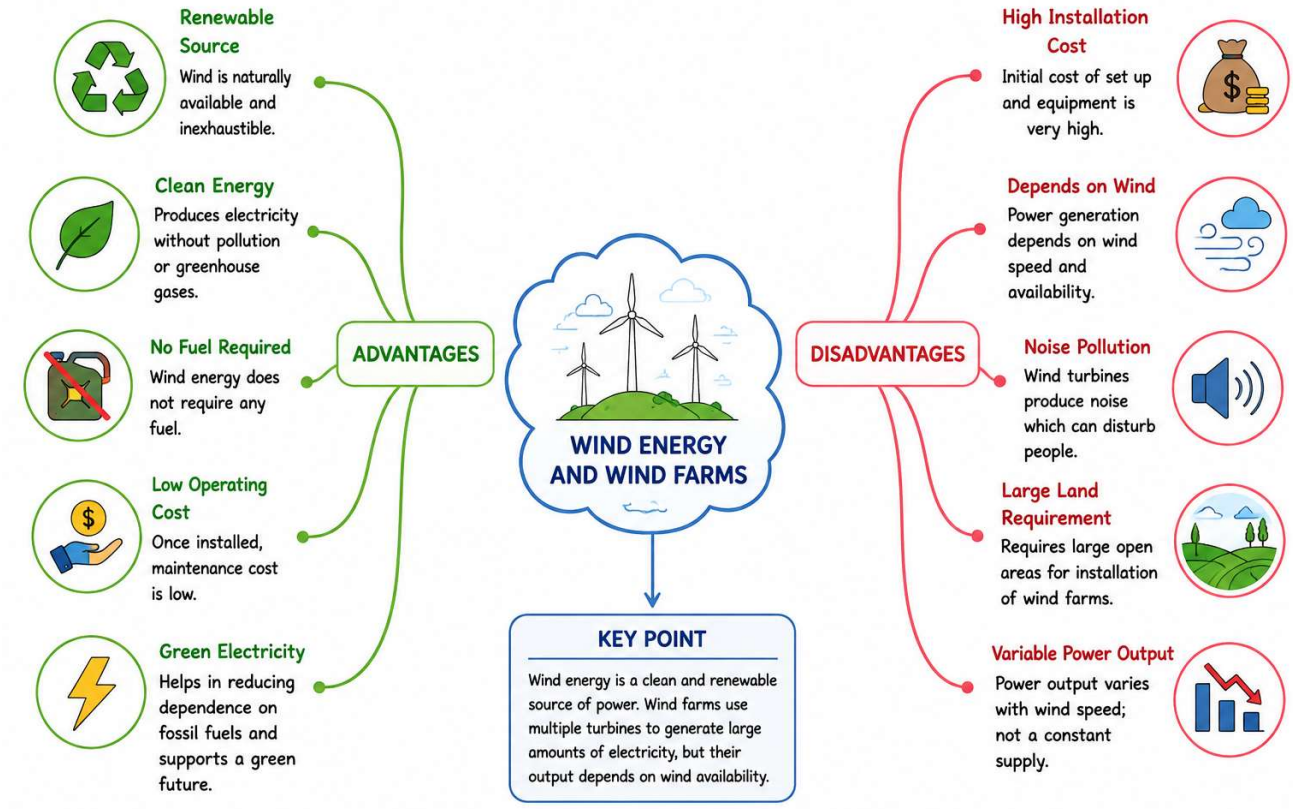

Figure 5.2 Wind Energy and Wind farms

Advantages of Wind Farms

- Large-scale electricity generation.
- No greenhouse gas emissions.
- Renewable source of energy.
- Reduces dependence on fossil fuels.

Disadvantages of Wind Farms

- High installation cost.
- Requires large land area.
- Visual and noise impact.
- Power generation varies with wind speed.

5.7 Windmills

A **windmill** is a machine that converts the kinetic energy of wind into mechanical energy. Traditionally, windmills were used for grinding grain, pumping water, and other mechanical tasks. Modern windmills are also used for generating electricity and are commonly known as wind turbines.

Windmills operate using large blades that rotate when struck by wind. The rotational motion is transmitted through a shaft to perform useful work.

Principle

A windmill works on the principle of converting the **kinetic energy of moving air** into **mechanical energy**.

Main Parts of a Windmill

1. Blades

Capture wind energy and rotate.

2. Rotor

Holds the blades and transfers rotational motion.

3. Shaft

Transmits mechanical power.

4. Tower

Supports the windmill at a suitable height.

5. Generator (Modern Windmills)

Converts mechanical energy into electrical energy.

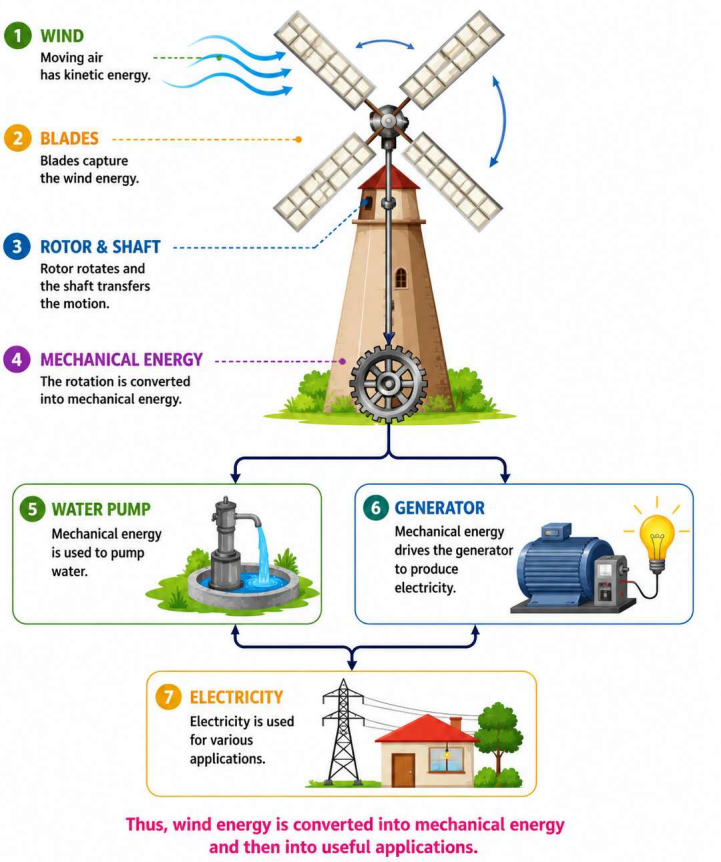

Figure 3.3 Working of a Wind Mill

Working

1. Wind strikes the blades.
2. The blades rotate.
3. The rotor and shaft rotate.
4. Mechanical energy is produced.
5. The energy is used for pumping water, grinding grain, or generating electricity.

Applications

- Water pumping
- Grain milling
- Electricity generation
- Agricultural operations and Remote area power supply

Advantages

- Renewable energy source.
- No fuel required.
- Environment-friendly.
- Low operating cost.

Disadvantages

- Depends on wind availability.
- High installation cost.
- Requires large open areas.
- Noise and visual impact.

5.8 Key Terms

Term	Meaning
Geothermal Energy	Energy obtained from the heat of the Earth's interior.
Geothermal Reservoir	Underground source of hot water and steam.
Geothermal Power Plant	Plant that converts geothermal heat into electricity.
Production Well	Well used to bring hot water or steam to the surface.
Injection Well	Well used to return cooled water back underground.
Wind Energy	Energy obtained from the kinetic energy of moving air.
Wind Turbine	Device that converts wind energy into electrical energy.
Wind Farm	Group of wind turbines installed for large-scale power generation.
Windmill	Machine that converts wind energy into mechanical energy.
Renewable Energy	Energy obtained from naturally replenished resources.

5.9 Unit Summary

- Geothermal energy is obtained from the natural heat stored inside the Earth.
- Geothermal power plants utilize underground steam or hot water to generate electricity.
- Geothermal energy is renewable, reliable, and environmentally friendly.
- Wind energy is produced by the movement of air caused by uneven heating of the Earth's surface.
- Wind turbines convert the kinetic energy of wind into electrical energy.
- Wind farms consist of multiple wind turbines working together for large-scale electricity generation.
- Windmills are used for water pumping, grain grinding, and electricity generation.

5.10 Objective Questions

1. Geothermal energy is obtained from:

A) Sunlight
B) Wind
C) Heat inside the Earth
D) Ocean waves

2. A geothermal power plant uses:

A) Solar radiation
B) Underground steam or hot water
C) Biomass
D) Tidal energy

3. Wind energy is a form of:

A) Non-renewable energy
B) Nuclear energy
C) Renewable energy
D) Chemical energy

4. A wind turbine converts:

A) Electrical energy into wind energy
B) Wind energy into electrical energy
C) Thermal energy into wind energy
D) Solar energy into heat energy

5. A wind farm consists of:

A) Solar panels
B) Geothermal wells
C) Multiple wind turbines
D) Hydroelectric generators

6. The primary function of a windmill is to convert wind energy into:

A) Nuclear energy
B) Mechanical energy
C) Chemical energy
D) Thermal energy

7. Which of the following is a renewable energy source?

A) Coal
B) Petroleum
C) Natural Gas
D) Wind Energy

Answers

1. C) Heat inside the Earth
2. B) Underground steam or hot water
3. C) Renewable energy
4. B) Wind energy into electrical energy
5. C) Multiple wind turbines
6. B) Mechanical energy
7. D) Wind Energy

5.11 Review Questions

Short Answer Questions

1. What is geothermal energy?
2. Explain the principle of a geothermal power plant.
3. What are the advantages of geothermal energy?
4. What is wind energy?
5. What is a wind farm?
6. Differentiate between a windmill and a wind turbine.
7. What are the applications of wind energy?

Long Answer Questions

1. Explain geothermal energy and discuss its advantages and disadvantages.
2. Describe the construction and working of a geothermal power plant.
3. Explain wind energy and its applications.
4. Discuss the construction and working of a wind farm.
5. Explain the principle, construction, working, advantages, and disadvantages of a windmill.

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