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Unit-II

NON-RENEWABLE ENERGY RESOURCES

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Fossil Fuels and Nuclear Energy

- Fossil fuels and nuclear energy are pivotal in powering modern civilization. While they provide the bulk of global energy, their environmental and resource limitations necessitate careful management and exploration of alternatives.

- 1. Fossil Fuels: The Three Kings - Coal, Oil, and Natural Gas
- *Formation*
- **Coal:**
  - Formed from plant material in swampy areas over millions of years.
  - High pressure and temperature turned peat into lignite, bituminous coal, and eventually anthracite.
- **Oil (Petroleum):**
  - Derived from microscopic marine organisms deposited in sediments.
  - Heat and pressure over millions of years converted organic material into liquid hydrocarbons.
- **Natural Gas:**
  - Often found alongside oil deposits.
  - Formed by similar processes as oil but at higher temperatures.
- *Calorific Value*
- **Coal:** 25-35 MJ/kg (varies with type; anthracite is highest).
- **Oil:** 42-46 MJ/kg (high energy density).
- **Natural Gas:** 50-55 MJ/kg (highest among the three).

- *Advantages and Limitations*
- **Advantages:**
- **High Energy Content:**
  - Dense energy sources, making them efficient for power generation and transport.
- **Infrastructure:**
  - Well-established extraction, refining, and distribution networks.
- **Economic Driver:**
  - Vital for industrial growth and employment generation.
- **Limitations:**
- **Non-Renewable:**
  - Finite reserves, with depletion risks.
- **Environmental Impact:**
  - Release of greenhouse gases (CO_2, CH_4) and pollutants like SO_2 and NO_x.
- **Extraction Challenges:**
  - Mining and drilling cause land degradation and ecological damage.
- **Geopolitical Issues:**
  - Unequal distribution of reserves leads to conflicts and dependency.

- 2. Greenhouse Gases and Global Warming
- **Greenhouse Gases (GHGs):**
  - CO_2, CH_4 (methane), N_2O (nitrous oxide), and fluorinated gases trap heat in Earth's atmosphere.
- **Role of Fossil Fuels:**
  - Combustion of coal, oil, and natural gas is the largest contributor to anthropogenic CO_2 emissions.
- **Global Warming:**
  - Enhanced greenhouse effect leads to rising global temperatures, melting ice caps, rising sea levels, and extreme weather events.
- **Mitigation Strategies:**
  - Transition to renewable energy.
  - Carbon capture and storage (CCS).
  - Energy efficiency improvements and reforestation.

- 3. Nuclear Energy
- *Availability*
- Nuclear energy is derived from fission, where heavy nuclei (like uranium-235 or plutonium-239) split to release energy.
- **Uranium Reserves:**
  - Found globally, with major reserves in Kazakhstan, Canada, and Australia.
- **Thorium:**
  - A potential alternative, with abundant reserves in India.
- *Advantages of Nuclear Energy*
- **High Energy Density:**
  - 1 kg of uranium can produce as much energy as 25,000 kg of coal.
- **Low Greenhouse Gas Emissions:**
  - Nearly zero emissions during power generation.
- **Reliability:**
  - Provides a stable and continuous energy supply.
- **Space Efficiency:**
  - Nuclear plants require less land compared to renewables like solar or wind farms.

- *Limitations of Nuclear Energy*
- **Radioactive Waste:**
  - Long-lived waste requires secure storage and management.
- **High Costs:**
  - Expensive to build, operate, and decommission plants.
- **Safety Concerns:**
  - Risks of catastrophic accidents (e.g., Chernobyl, Fukushima).
- **Resource Limitations:**
  - Uranium reserves are finite, and extraction has environmental impacts.

Comparison of Fossil Fuels and Nuclear Energy

Feature	Fossil Fuels	Nuclear Energy
Energy Density	Moderate to high	Extremely high
Environmental Impact	High (GHG emissions)	Low (but hazardous waste)
Resource Longevity	Limited	Relatively long (with thorium use)
Cost	Low initial, high operational	High initial, moderate operational
Safety	Risks from pollution and accidents	High risks, but low probability

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