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Course Title :ENERGY AND ENVIRONMENT

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Unit-I

ENERGY AVAILABILITY AND USAGE

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Earth’s Energy Source and Usage

- The Earth’s energy system is a complex interplay of natural energy flows and human usage patterns. Understanding Earth's energy sources, energy balance, reserves, and usage patterns is critical for sustainable development and addressing global energy challenges.

- 1. Earth’s Energy Source
- *Natural Energy Sources:*
- **Solar Energy:**
  - The Sun is the primary source of energy for Earth, providing heat and light.
  - Drives processes like photosynthesis, weather patterns, and ocean currents.
- **Geothermal Energy:**
  - Heat from Earth’s interior generated by radioactive decay and residual heat from planetary formation.
- **Tidal Energy:**
  - Energy derived from the gravitational pull of the Moon and the Sun.
- **Wind Energy:**
  - Results from atmospheric circulation driven by solar heating and Earth's rotation.
- **Fossil Fuels:**
  - Derived from organic matter buried and transformed over millions of years, including coal, oil, and natural gas.
- **Biomass:**
  - Organic material from plants and animals, storing solar energy.
- **Nuclear Energy:**
  - Produced through nuclear fission or fusion, primarily utilizing uranium.

- 2. Earth’s Energy Balance
- *Definition:*
- The energy balance of Earth refers to the equilibrium between incoming energy from the Sun and outgoing energy radiated back into space.
- *Components of Energy Balance:*
- **Incoming Solar Radiation:**
  - Approximately 340 W/m^2 of solar energy reaches Earth’s atmosphere.
  - About 30% is reflected back into space (albedo), and 70% is absorbed by the Earth system.
- **Outgoing Radiation:**
  - Earth emits longwave infrared radiation to balance the absorbed energy.
- **Role of Greenhouse Gases:**
  - Gases like CO_2, CH_4, and water vapor trap heat, maintaining Earth's habitable temperature.
- **Disruptions to Energy Balance:**
  - Human activities, such as burning fossil fuels and deforestation, increase greenhouse gases, causing global warming.

- 3. Energy Reserves and Usage
- *Global Energy Reserves:*
- **Fossil Fuels:**
  - Coal: Largest reserves; used for electricity generation.
  - Oil: Crucial for transportation and industry.
  - Natural Gas: Cleaner-burning fossil fuel; widely used for heating and electricity.
- **Renewable Resources:**
  - Solar, wind, hydropower, and geothermal energy are abundant and sustainable.
  - Limited by technological and economic factors.
- **Nuclear Resources:**
  - Uranium and thorium reserves used for nuclear power generation.
- *Energy Usage Trends:*
- Global energy consumption is dominated by fossil fuels (~80%), but renewables are growing rapidly.
- Major consumers: Industry, transportation, residential, and commercial sectors.

- 4. Determinants of Growth in Energy Use
- **Population Growth:**
  - Increased population leads to higher demand for energy.
- **Economic Development:**
  - Industrialization and urbanization drive energy consumption.
- **Technological Advancements:**
  - Innovations in energy-intensive sectors increase usage but improve efficiency.
- **Lifestyle Changes:**
  - Higher standards of living result in greater per capita energy consumption.
- **Policy and Regulation:**
  - Subsidies, taxation, and global agreements like the Paris Accord influence energy use.

- 5. Energy Usage Pattern of the World
- *Global Overview:*
- **Developed Countries:**
  - High per capita energy consumption.
  - Dependence on a mix of fossil fuels, nuclear, and renewables.
- **Developing Countries:**
  - Rapidly increasing energy demand due to industrialization.
  - Reliance on traditional biomass and fossil fuels.
- *Energy Source Shares (2022):*
- Fossil Fuels: ~80% (coal, oil, and natural gas).
- Renewables: ~12% (solar, wind, hydro).
- Nuclear: ~8%.
- *Regional Trends:*
- **Asia-Pacific:** Fastest-growing energy consumption, led by China and India.
- **Europe:** Transitioning to renewable energy with strict emission targets.
- **North America:** High energy usage with an emphasis on shale gas and renewables.

- 6. Energy Usage Pattern of India
- *India's Energy Landscape:*
- **Primary Energy Sources:**
  - Coal: Accounts for ~55% of India's energy mix, primarily for electricity.
  - Oil and Natural Gas: Major imports to meet demand.
  - Renewables: Growing focus on solar, wind, and hydropower.
  - Biomass: Significant in rural areas for cooking and heating.
- **Sectoral Consumption:**
  - Industry: Largest consumer (~40%).
  - Residential: Significant due to rural energy needs.
  - Transportation: Growing rapidly with urbanization and vehicle use.
- *Renewable Energy in India:*
- India is one of the world's leaders in renewable energy development.
- Target: 500 GW of non-fossil fuel capacity by 2030.
- Key projects: Solar parks, wind farms, and hydropower initiatives.

- 7. Future of Energy Use
- *Global Outlook:*
- Shift towards renewable energy to combat climate change.
- Energy efficiency improvements through technology.
- Greater focus on energy storage (batteries) and hydrogen fuel.
- *India's Path Forward:*
- Electrification of transportation.
- Expansion of renewable energy capacity.
- Enhancing grid infrastructure for energy distrib

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