

Conventional and Non-Conventional Energy Sources

Energy is essential for economic growth and daily life. It is categorized into Conventional and Non-Conventional energy sources based on their usage history, availability, and environmental impact.

1. Conventional Energy Sources

These are traditional energy sources that have been used for decades. They are mostly non-renewable, meaning they are found in limited quantities and take millions of years to form.

Types of Conventional Energy Sources

(i) Fossil Fuels

Fossil fuels include coal, petroleum (oil), and natural gas. They are formed from decomposed plants and animals buried under the earth's surface for millions of years.

- **Coal:** A solid fuel mainly used in power plants and industries.
- **Petroleum (Oil):** A liquid fossil fuel refined into gasoline, diesel, and jet fuel.
- **Natural Gas:** A cleaner fossil fuel used for heating, electricity, and cooking.

Advantages:

- ✓ High energy production
- ✓ Easy to store and transport

Disadvantages:

- ✗ Causes air pollution and global warming due to CO₂ emissions
 - ✗ Limited supply, leading to depletion
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(ii) Hydropower Energy

- Generated by using the flow of water in dams to produce electricity.
- Considered renewable but requires large land areas and water sources.

Advantages:

- ✓ Clean and renewable
- ✓ Can generate electricity consistently

Disadvantages:

- ✗ Construction of dams affects the environment and wildlife
 - ✗ Expensive initial investment
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(iii) Nuclear Energy

- Produced through nuclear fission, where atoms (mostly uranium) are split to release energy.
- Used in nuclear power plants to generate electricity.

Advantages:

- ✓ High energy output with low fuel consumption
- ✓ No carbon emissions

Disadvantages:

- ✗ Risk of radiation leaks and nuclear accidents (e.g., Chernobyl, Fukushima)
 - ✗ Disposal of radioactive waste is a challenge
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2. Non-Conventional Energy Sources

Also known as renewable energy sources, these are sustainable, eco-friendly, and help reduce dependence on fossil fuels.

Types of Non-Conventional Energy Sources

(i) Solar Energy

- Energy from the sun is captured using solar panels to generate electricity or heat water.

Advantages:

- ✓ Unlimited and freely available
- ✓ No pollution or greenhouse gases

Disadvantages:

- ✗ Depends on sunlight availability
 - ✗ High initial cost for installation
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(ii) Wind Energy

- Wind turbines convert wind energy into electricity.
- Used in wind farms, especially in coastal and high-altitude regions.

Advantages:

- ✓ Clean and renewable energy
- ✓ Low operational costs

Disadvantages:

- ✗ Unpredictable wind conditions affect efficiency
 - ✗ Large areas required for wind farms
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(iii) Biomass Energy

- Energy generated from organic materials like agricultural waste, wood, and animal dung.
- Used for heating and electricity generation.

Advantages:

- ✓ Reduces agricultural waste
- ✓ Provides an alternative to fossil fuels

Disadvantages:

- ✗ Produces CO₂ emissions
 - ✗ Requires a continuous supply of biomass
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(iv) Geothermal Energy

- Heat from the Earth's core is used to generate electricity and provide heating.
- Found in regions with volcanic activity or hot springs.

Advantages:

- ✓ Reliable and consistent source of energy
- ✓ Minimal environmental impact

Disadvantages:

- ✗ Only available in specific locations
 - ✗ High drilling costs
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(v) Tidal and Wave Energy

- Uses ocean tides and waves to generate electricity.
- Tidal power plants are built in coastal areas.

Advantages:

- ✓ Predictable and renewable energy source
- ✓ No air pollution

Disadvantages:

- ✗ High initial cost
- ✗ Affects marine ecosystems

Comparison Table: Conventional vs. Non-Conventional Energy

Feature	Conventional Energy	Non-Conventional Energy
Availability	Limited (Non-renewable)	Unlimited (Renewable)
Environmental Impact	High (Causes pollution)	Low (Eco-friendly)
Cost	Low initial cost, high long-term cost (due to fuel use)	High initial cost, low long-term cost
Sustainability	Unsustainable (finite supply)	Sustainable (infinite)

Conclusion

The excessive use of conventional energy sources has led to problems like climate change, pollution, and depletion of resources. Therefore, there is a global shift towards non-conventional energy sources, which are renewable, sustainable, and eco-friendly. Investing in solar, wind, hydro, and geothermal energy is essential for a cleaner and greener future.

2. Here's a more detailed explanation of the different types of renewable energy sources for a **10-mark** answer:

1. Wind Energy 🌬️

Wind energy is generated by **harnessing the kinetic energy of moving air** using wind turbines. The wind rotates the blades of a turbine, which spins a generator to produce **electricity**. Wind energy is widely used in **wind farms** on land (onshore) and at sea (offshore).

- **Advantages:** Clean, renewable, and cost-effective after installation.

- **Disadvantages:** Depends on wind speed, requires large land areas, and can impact bird migration.

◆ **Example:** The Jaisalmer Wind Park in India is one of the largest wind farms.

2. Solar Energy ☀️

Solar energy is harnessed from the **sun's radiation** and can be converted into electricity using **solar photovoltaic (PV) panels** or into heat using **solar thermal systems**.

- **Solar Photovoltaic (PV):** Converts sunlight directly into electricity using the **photovoltaic effect** in semiconductor materials.

- **Solar Thermal:** Uses mirrors to concentrate sunlight and produce heat, which generates electricity in power plants.

- **Advantages:** Abundant, non-polluting, and low maintenance.

- **Disadvantages:** Dependent on sunlight availability, requires battery storage for nighttime use.

◆ **Example:** The Bhadla Solar Park in Rajasthan, India, is one of the largest solar power plants in the world.

3. Tidal Energy 🌊

Tidal energy is produced by capturing the energy from the **rise and fall of ocean tides**, which are caused by the gravitational pull of the **moon and sun**. It is harnessed using:

- **Tidal Barrages:** Dams built across estuaries that trap water at high tide and release it at low tide to drive turbines.

- **Tidal Stream Generators:** Underwater turbines that work like wind turbines but use ocean currents instead of wind.

- **Advantages:** Predictable, renewable, and efficient.

- **Disadvantages:** High installation costs and potential environmental impact on marine ecosystems.

◆ **Example:** The Sihwa Lake Tidal Power Station in South Korea is the world's largest tidal energy plant.

4. Ocean Energy 🌊

Ocean energy includes both **wave energy** and **ocean thermal energy conversion (OTEC)**:

- **Wave Energy:** Uses the motion of ocean waves to drive turbines and generate electricity.

- **Ocean Thermal Energy Conversion (OTEC):** Uses the temperature difference between warm surface water and cold deep water to produce power.

- **Advantages:** Huge energy potential, available 24/7.

- **Disadvantages:** Expensive technology, still in early development stages.

◆ **Example:** The Pelamis Wave Energy Converter was one of the first commercial wave energy projects.

5. Biomass Energy 🌱

Biomass energy is produced by burning or decomposing **organic materials** like wood, crop residues, animal waste, and industrial byproducts. It can be used in:

- **Direct Combustion:** Burning biomass for heat or electricity.
- **Biogas Production:** Microorganisms break down organic waste to produce **methane gas**, which is used as fuel.
- **Biofuels:** Liquid fuels like **ethanol and biodiesel** are made from crops and used as alternatives to gasoline.
- **Advantages:** Renewable, reduces waste, and can be used for cooking, heating, and electricity.
- **Disadvantages:** Requires large amounts of land, may lead to deforestation if not managed properly.

◆ **Example:** The Sugarcane-based ethanol production in Brazil is a major source of biofuel.

Conclusion

All these renewable energy sources help reduce dependence on fossil fuels and contribute to a sustainable future. While each has its own advantages and challenges, **a combination of these energy sources** can provide an effective solution for global energy needs.

Would you like me to refine this answer for an exam or assignment? 🚀

3. Solar Radiation and Its Estimation

1. Introduction to Solar Radiation

Solar radiation is the energy emitted by the Sun in the form of electromagnetic waves, including visible light, infrared, and ultraviolet rays. This energy is essential for life and is widely used for solar power generation, heating, and agriculture.

2. Types of Solar Radiation

Solar radiation reaching the Earth's surface consists of three main components:

(i) Direct Radiation (Beam Radiation)

- Travels directly from the Sun to the Earth's surface without being scattered.
- Used in concentrated solar power (CSP) systems for generating electricity.

(ii) Diffuse Radiation

- Scattered by molecules, dust, and clouds in the atmosphere.
- Even on cloudy days, some amount of solar energy is available.

(iii) Global Radiation

- The total solar radiation reaching the Earth's surface.
 - It is the sum of direct and diffuse radiation and is measured using a pyranometer.
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3. Factors Affecting Solar Radiation

The amount of solar radiation received on Earth depends on:

1. **Latitude:** Higher latitudes receive less solar radiation.
 2. **Time of Day:** Maximum radiation occurs at solar noon when the Sun is at its highest point.
 3. **Season:** Summer months receive more radiation than winter due to Earth's tilt.
 4. **Altitude:** Higher altitudes receive more solar radiation as there is less atmospheric absorption.
 5. **Cloud Cover:** Reduces the amount of direct radiation and increases diffuse radiation.
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4. Estimation of Solar Radiation

To estimate solar radiation, scientists use mathematical models based on historical data.

(i) Solar Constant (S_0)

- The average solar radiation received outside Earth's atmosphere per unit area.
- Value: 1367 W/m^2 .

(ii) Extraterrestrial Radiation (H_0)

- The total solar radiation received on a horizontal surface outside the atmosphere on a given day.

(iii) Empirical Models for Estimation

One of the most commonly used equations is the Angstrom-Prescott Equation, which relates solar radiation to sunshine duration:

$$H = H_0 \left(a + b \frac{S}{S_0} \right)$$

Where:

- H = Monthly average daily solar radiation on a horizontal surface.
 - H_0 = Extraterrestrial radiation.
 - S = Actual sunshine hours per day.
 - S_0 = Maximum possible sunshine hours per day.
 - a, b = Empirical constants based on location.
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5. Measurement of Solar Radiation

Solar radiation is measured using specialized instruments:

- **Pyranometer:** Measures global solar radiation.
 - **Pyrheliometer:** Measures direct beam radiation.
 - **Sunshine Recorder:** Records the duration of sunlight in a day.
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6. Diagram of Solar Radiation Components

Here is a neat labeled diagram showing how solar radiation interacts with the Earth's atmosphere:

7. Conclusion

Understanding solar radiation and its estimation is essential for designing solar energy systems, weather forecasting, and climate studies. With advancements in technology, accurate solar radiation prediction helps optimize solar power plants and renewable energy utilization.