Model Question Paper-2 with effect from 2022-23 (CBCS Scheme)

USN

Sixth Semester B.E. Degree Examination
Renewable Energy Power Plants

TIME: 03 Hours **Max.Marks:100**

These Answers Are from NOTES

		Module-1 Download	M	L	C
Q.01	a	Explain briefly different renewable and non-renewable energy sources. Renewable and Non-Renewable Energy Sources Renewable Energy Sources - Renewable energy is derived from natural resources that are continuously renewed, such as sunlight, wind, rain, tides, and geothermal heat. - Examples of renewable energy sources include solar energy, wind power, hydroelectric power, tidal energy, and geothermal energy. - It is considered sustainable and environmentally friendly. - Renewable energy resources are available free of cost to users. - Solar energy, for instance, is abundant and has the potential to meet current and future global energy needs indefinitely. - Advantages of renewable energy include being environmentally clean, free, and available in adequate quantities worldwide. - Disadvantages include the variability in energy availability due to weather conditions and the need for efficient storage solutions which can add to costs. Non-Renewable Energy Sources - Non-renewable energy resources are derived from natural sources that are finite and cannot be regenerated within a human timeframe. - Examples of non-renewable energy sources include fossil fuels like coal, oil, and natural gas, as well as nuclear fuels like uranium. - Nuclear energy, derived from the fission of uranium or plutonium isotopes, is not renewable due to the finite nature of these isotopes. - Non-renewable energy sources are commercial energy available at a price. - Non-renewable energy sources produce significant environmental impacts, including pollution and greenhouse gas emissions.	10	L2	CO1
	b	Justify the statement “Indian economy is depends on energy”. Justifying the Statement "Indian Economy Depends on Energy" Role of Energy in the Indian Economy - Energy plays a crucial role in powering various sectors of the Indian economy, including manufacturing, transportation, agriculture, and infrastructure development. - Fossil fuels, such as coal, oil, and natural gas, are major contributors to meeting India's energy demands. - In the year 2000, fossil fuels dominated the energy production in India, with coal	10	L2	CO1

contributing 56%, and oil and natural gas together contributing 37% to the total energy production.
- The Indian economy heavily relies on energy sources like coal, oil, natural gas, water power, and nuclear power to meet its energy requirements.

Energy Sources and Contributions to the Indian Economy
- Coal: A significant energy source in India, contributing to 56% of the total energy production in 2000.
- Oil: Played a substantial role, contributing 29.75% to the energy production in India in the year 2000.
- Natural Gas: Contributed 7.47% to the energy production in India in 2000.
- Water Power (Hydroelectric Power): Provided 5.25% of the total energy production in India in 2000.
- Nuclear Power: Accounted for 1.37% of the energy production in India in 2000.
- The installed capacity for various energy sources, such as wind power, small hydro-power, biomass, and nuclear power, has been increasing over the years, indicating their importance in sustaining the Indian economy.

Significance of Energy Sources in Industrial and Economic Processes
- Fossil fuels, besides serving as energy sources, are essential raw materials for manufacturing organic chemicals, emphasizing their dual role in energy production and industrial processes.
- As fossil fuel resources decline, there may be an increased need to utilize them exclusively for producing organic chemicals, highlighting the interconnectedness of energy sources with industrial activities in the Indian economy.

Energy Dependency and Economic Implications
- The heavy reliance on fossil fuels for energy production in India implies that any fluctuations or scarcity in these resources can directly impact the functioning of various industries and economic sectors.
- With the Indian economy's significant dependence on energy sources like coal, oil, and natural gas, ensuring stable and sustainable energy supply becomes essential for maintaining economic growth and development.

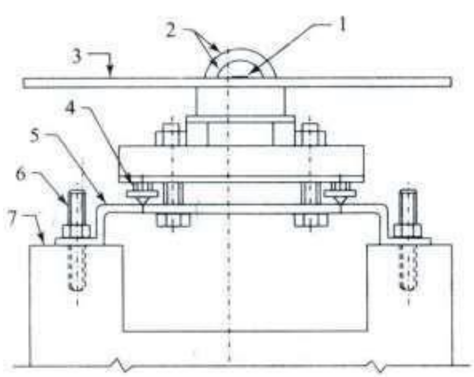
OR

Q.02 **a** Illustrate the radiation data collection with suitable graphs. **10** **L2** **CO1**

Radiation Data Collection Illustrated with Suitable Graphs

Pyranometer and Pyrheliometer

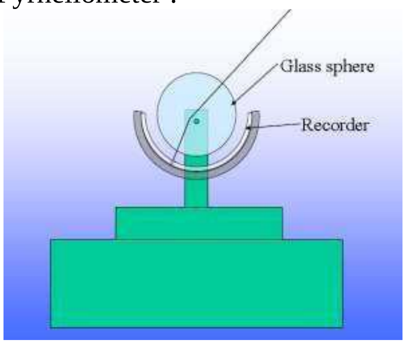
- Pyranometer :



Measures global or diffuse radiation on a horizontal surface over a hemispherical field of view.
- Pyranometer Setup : Consists of a black surface that heats up when exposed

to solar radiation. It generates an emf measuring global radiation.
- Diffuse Radiation Measurement : Achieved by mounting the pyranometer in a semi-circular shading ring to measure diffuse radiation received from the sky.

- Pyrheliometer :



Measures beam radiation falling on a surface normal to the sun's rays. It receives beam radiation and a small amount of diffuse radiation within its acceptance angle.
- Instrument Configuration : Black absorber plate with hot junctions of a thermopile attached to it, located at the base of a collimating tube aligned with the sun's rays.

Solar Energy
- Vast Renewable Energy Source : Solar energy is abundant, intercepting a significant amount of power from the sun.
- Solar Energy Interception : Earth intercepts about 1.8 × 10^11 megawatts of solar energy, significantly surpassing current consumption rates from all commercial energy sources.

Energy Alternatives
- Solar Option : Noted as a renewable energy source with immense potential. - Nuclear Option : Includes alternatives like the breeder reactor and nuclear fusion for energy production.

Solar Radiation Measurement
- Instruments Used : Pyranometer and pyrheliometer are utilized for measuring solar radiation.
- Measurement Methods : Pyranometer measures global or diffuse radiation, while pyrheliometer measures beam radiation falling normal to the sun's rays.

Radiation Scattering
- Scattered Radiation : Occurs due to interaction with gaseous molecules and particulate matter in the atmosphere, with redistribution in various directions.

Solar Energy Utilization
- Direct Methods : Include thermal and photovoltaic methods for harnessing solar energy.
- Indirect Methods : Encompass water power, wind, biomass, wave energy, ocean temperature differences, and marine currents as alternative energy sources .

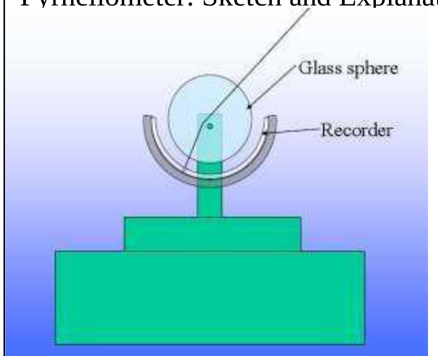
Radioactive Waste
- Careful Disposal : Radioactive waste generated from certain energy alternatives requires meticulous disposal and management protocols.

Solar Energy Potential
- Vast Potential : Solar energy offers a vast and untapped resource for sustainable energy production.

Nuclear Energy Options
- Breeder Reactor and Fusion : Two alternatives under the nuclear option for energy production.

b Sketch and explain the Pyrheliometer.	10	L2	CO1

Pyrheliometer: Sketch and Explanation



Explanation of Pyrheliometer

A Pyrheliometer is an instrument designed to measure beam radiation falling on a surface normal to the sun's rays. In contrast to a pyranometer, the black absorber plate with hot junctions of a thermopile attached to it is located at the base of a collimating tube. The tube is aligned with the direction of the sun's rays using a two-axis tracking mechanism and alignment indicator. This setup ensures that the black plate receives only beam radiation and a small amount of diffuse radiation that falls within the acceptance angle of the instrument.

Sketch of a Pyrheliometer

The sketch of a Pyrheliometer would show the collimating tube aligned with the direction of the sun's rays. At the base of the tube, there would be a black absorber plate with thermopile hot junctions attached to it. The two-axis tracking mechanism and alignment indicator would also be visible to illustrate how the instrument is oriented towards the sun to measure beam radiation accurately.

Differences from Pyranometer
- Pyrheliometer measures beam radiation specifically, while a pyranometer measures either global or diffuse radiation.
- The black absorber plate of the pyrheliometer is located at the base of a collimating tube, whereas in a pyranometer, the black surface is exposed to solar radiation directly.
- Pyrheliometer requires precise alignment with the sun's rays using a tracking mechanism, unlike a pyranometer which measures radiation falling on a horizontal surface over a hemispherical field of view.

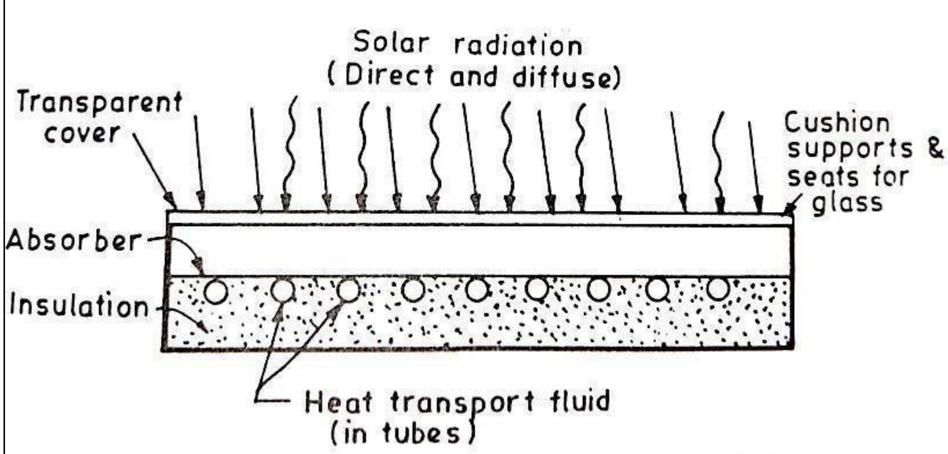
Importance of Pyrheliometer
- Provides accurate measurements of beam radiation, which is crucial for various solar energy applications.
- Helps in studying the intensity of direct solar radiation and its variations based on the sun's position.

Applications
- Used in solar energy research, meteorology, and climatology to measure direct solar radiation.
- Vital for monitoring solar energy availability and optimizing solar energy systems' performance.

Advantages
- Offers precise measurements of beam radiation due to its design focused on normal incidence of solar rays.
- Enables detailed analysis of direct solar radiation for scientific and practical purposes.

Limitations
- Requires consistent and accurate alignment with the sun for reliable measurements.
- May not capture diffuse radiation effectively, as its primary focus is on beam radiation.

Module-2 Download					
Q.03	a	Define the following: (i) Solar altitude (ii) Declination angle (iii) Zenith angle (iv) Hour angle (v) Surface azimuth angle Solar Altitude Solar altitude angle (α) is the angle between the Sun's rays and the projection of the Sun's rays on the horizontal plane. Declination Angle Declination (δ) is the angle between a line extending from the center of the Sun and the center of the Earth and its projection on the Earth's equatorial plane. It varies between 23.5o on June 22 to -23.5o on December 22, with a value of zero on the equinoxes of March 21 and September 22. Zenith Angle Zenith angle (θz) is the complementary angle of the Sun's altitude angle. It is the vertical angle between the Sun's rays and a line perpendicular to the horizontal plane through the point, calculated as θz = π/2 - α. Hour Angle Hour angle (ω) is the angle through which the Earth must turn to bring the meridian of the point directly in line with the Sun's rays. Hour angle is equal to 15o per hour. Surface Azimuth Angle Surface azimuth angle (γ) is the solar angle in degrees along the horizon east or west of north. It is the horizontal angle measured from north to the horizontal projection of the Sun's rays. Additional Definitions - Meridian: The imaginary line passing through a point or place on Earth and the north and south poles of the Earth. - Slope (β): The angle between the collector surfaces with the horizontal plane. - Surface Incident Angle (θ): The angle between an incident beam radiation falling on the collector and the normal to the plane surface. Formulas and Equations - Declination (δ) calculation: δ = 23.45 sin{(360/365) * (284 + n)} - Local Solar Time calculation: Local Solar Time = Standard time ± 4(Standard time Longitude - Longitude of the location) + (Equation of time correction) Example Calculation - Calculate the angle made by beam radiation with the normal to a flat plate collector on December 1 at 9.00 A.M for a location at 28°05'N latitude, with the collector tilted at an angle of latitude plus 10° pointing due south.	10	L1	CO2
	b	Analyze with a sketch, the working of flat plat collector. Working of Flat Plate Collector	6	L3	CO2

		 Fig. 3.3.1. Selection through typical flat-plate collector. Overview of Flat Plate Collector A flat plate collector (FPC) is a type of solar collector designed to harness solar energy for heat absorption. It consists of an absorber plate coated with selective coatings to maximize radiation absorption and minimize emission. The absorber plate is typically made of materials like aluminum or copper and is black to enhance absorption properties. Components and Functionality - Absorber Plate: Positioned above insulators to prevent conductive heat transfer, the absorber plate absorbs solar radiation and heats up. - Absorber Tubes: Located underneath the plate, these tubes circulate a heat-absorbing medium (e.g., water) to collect heat energy. - Insulation: Materials like mineral wool, glass wool, or thermocol are used as insulators to reduce heat loss. - Glass Covers: Placed above the absorber plate to create a greenhouse effect, enhancing heat retention. Working Mechanism 1. Solar Energy Absorption: Solar radiation is absorbed by the black-coated absorber plate. 2. Heat Absorption: The absorber plate transfers heat to the circulating medium in the absorber tubes. 3. Heat Transfer: The medium absorbs heat, raising its temperature and converting solar energy into heat energy. 4. Greenhouse Effect: Glass covers trap heat, enhancing the collection efficiency by maintaining a warmer environment.			
	c	Explain the thermal energy storage systems Thermal Energy Storage Systems Absorption Cooling System	**4**	**L2**	**CO2**

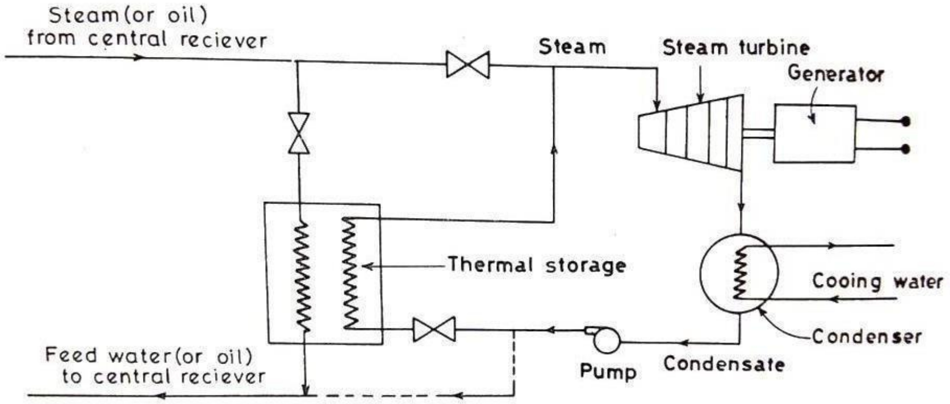
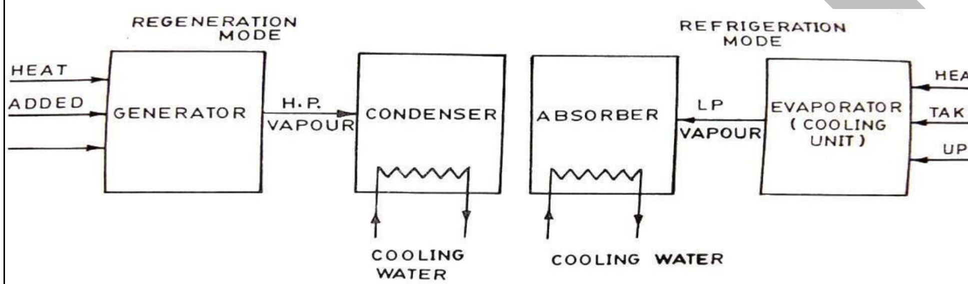
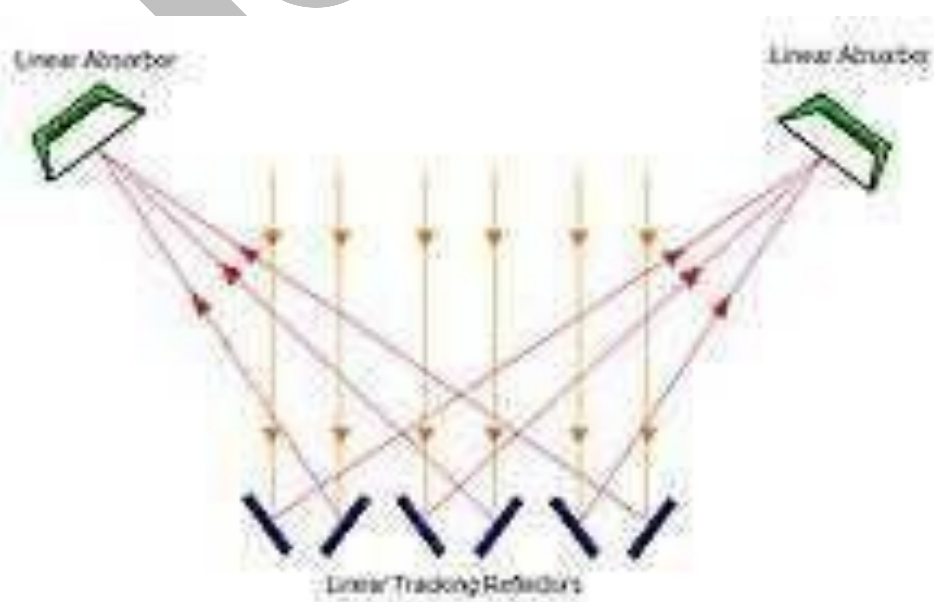


Fig. 5.5.6. Electric power generation using thermal storage.



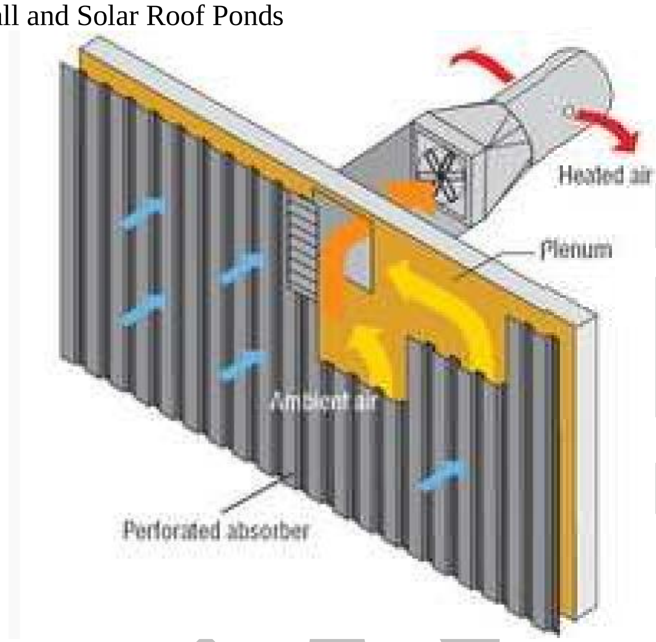
- It operates intermittently with two vessels functioning in alternative modes.
- In one mode, vessels act as the generator and condenser of an absorption system.
- Heat is supplied to the generator by various sources like oil, gas, steam, or solar energy.
- The system switches between the generator-condenser mode and the absorber-evaporator mode.
- This technique can be used for refrigeration and food preservation in areas with limited electricity access.

Solar Tower Power Generation



- Utilizes heliostats to concentrate sunlight on a tower-mounted receiver.
- The concentrated sunlight heats molten salt to high temperatures, which is then stored in a thermal storage tank.
- The stored heat is used to generate steam that drives a turbine for electricity production.
- This method allows for efficient conversion of solar energy to electricity and cost-effective storage for later use.
- Offers advantages over parabolic trough design in terms of higher temperature operation and minimal ground area requirements.

Trombe Wall and Solar Roof Ponds



- Trombe wall utilizes sunlight to heat a thermal mass and warm air for circulation.
- Solar roof ponds control heat exchange between interior and exterior environments using a water bladder with insulating cover.
- The bladder is uncovered during the day for heating and covered at night for cooling.
- These systems provide efficient heating and cooling solutions for buildings.

Solar Photovoltaic Systems

Advantages
- Converts solar energy directly into electrical energy without mechanical linkages.
- Reliable, durable, quiet, and maintenance-free with an expected lifespan of over 20 years.
- Suitable for various environments, respond instantly to solar radiation, and can be located at the point of use without extensive distribution networks.

Disadvantages
- High initial costs of solar cells compared to conventional power sources.
- Low efficiency due to the need for large solar cell modules to generate sufficient power.
- Intermittent nature of solar energy requires additional electrical energy storage, increasing system costs.

OR

Q.04	a	With a neat sketch, enumerate the concept behind the solar pond and solar chimney.	10	L2	CO2

Solar Pond and Solar Chimney Concepts

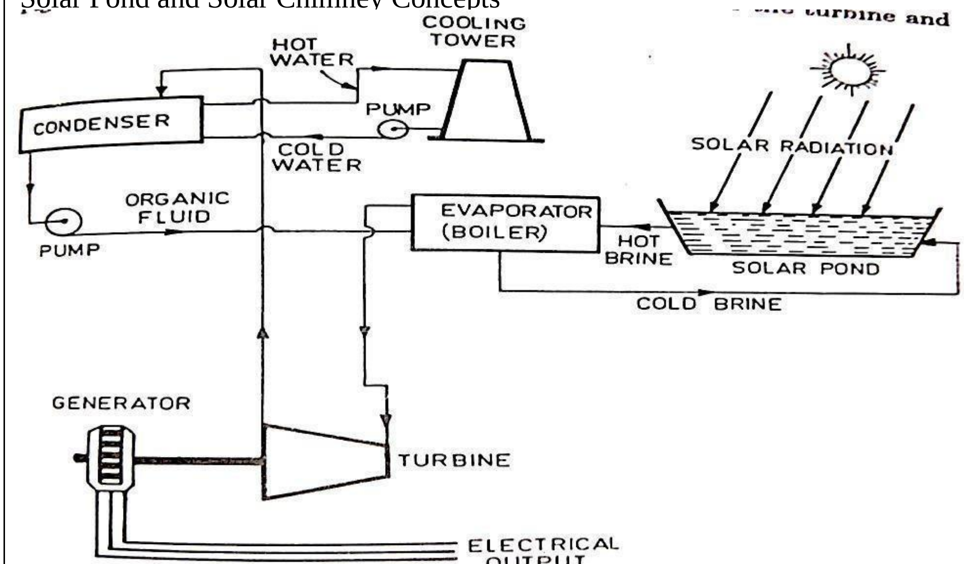


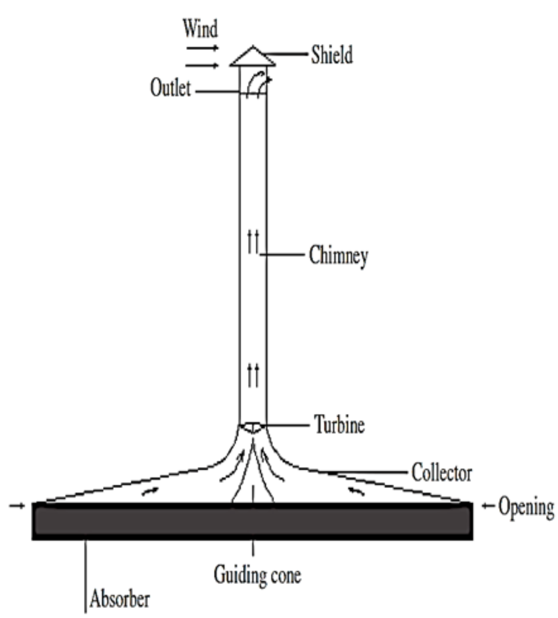
Fig. 4.3.3. Solar pond electric power plant with cooling tower.

Solar Pond Concept

A solar pond is a large-scale solar energy collector that utilizes the natural process of salinity stratification to collect and store solar energy. It consists of three layers: the top convective zone, the non-convective zone, and the storage zone. Here are the key points regarding the solar pond concept:

- Solar ponds can store thermal energy for extended periods, providing a consistent heat source.
- The bottom layer of the solar pond, known as the storage zone, contains a highly concentrated salt solution that stores and retains heat.
- The non-convective zone acts as an insulating layer, preventing heat loss from the storage zone.
- The top convective zone absorbs solar radiation and heats the water, which then circulates down to the storage zone.
- Solar ponds are used for various applications, including power generation, space heating, and desalination processes.

Solar Chimney Concept



A solar chimney, also known as a solar updraft tower, is a renewable energy structure that generates electricity using solar radiation and temperature differentials. Here are the key aspects of the solar chimney concept:

- A solar chimney consists of a tall, hollow tower with a large canopy collector at the base to absorb solar radiation.
- The solar radiation heats the air under the canopy, causing it to rise up the tower due to the temperature differential.
- As the hot air moves up the chimney, it drives turbines located at the base, generating electricity.
- Solar chimneys are designed to operate based on the principle of natural convection, utilizing the rising hot air to produce energy.
- These structures are environmentally friendly and can provide sustainable power generation in sunny regions.

Advantages and Disadvantages of Solar Energy Systems

Solar energy systems, including solar ponds and solar chimneys, offer both advantages and disadvantages. Here are some points highlighted from the document:

Advantages:

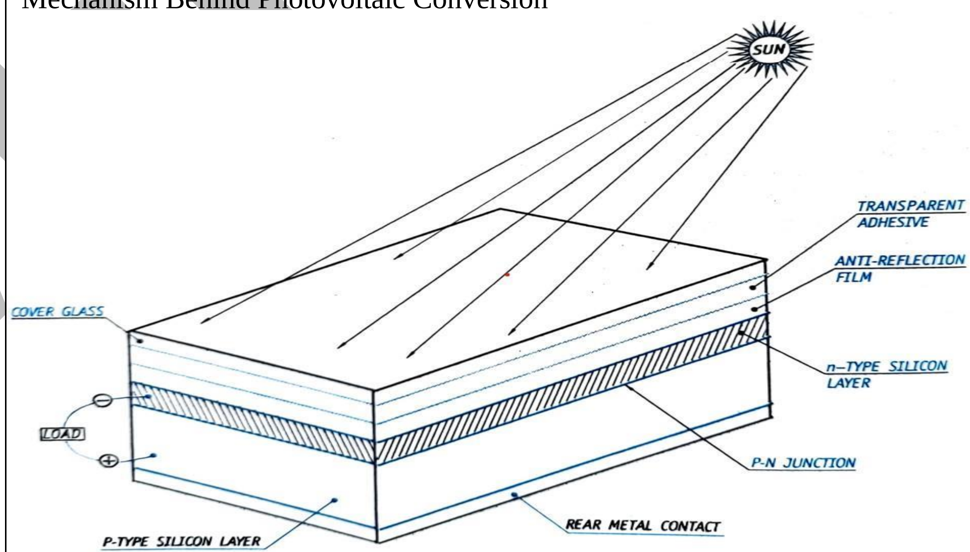
1. Solar energy systems convert solar energy directly into electrical energy without mechanical links.
2. They are reliable, durable, maintenance-free, and have a long lifespan.
3. Solar systems are quiet, respond quickly to solar radiation, and can be located at the point of use.
4. Solar PV systems are suitable for various applications, including space satellites, remote communication, lighting, and water pumping.

Disadvantages:

1. The costs of solar cells are currently high compared to conventional power sources.
2. Solar cell efficiency is relatively low, requiring a larger area for power generation.
3. Electrical energy storage is needed for intermittent solar energy, increasing system costs.

	b	Sketch and explain the mechanism behind photovoltaic conversion.	**10**	**L2**	**CO2**

Mechanism Behind Photovoltaic Conversion



Solar Cell

Photovoltaic Conversion Process

- Principle : Photovoltaic conversion involves the direct conversion of solar energy into electrical energy through the photovoltaic effect.
- Solar Cell : The basic conversion device used is a solar photovoltaic cell, also known as a solar cell.
- Operation : When photons from the sun are absorbed by a semiconductor material like silicon, they create free electrons with higher energies.
- Electric Field : An electric field is required to induce these high-energy electrons to flow out of the semiconductor, generating an electric current.

Solar Cell Functionality

- Semiconductor Materials : Semiconductors like silicon, germanium, cadmium sulphide, and gallium arsenide are commonly used due to their high power generation capability.
- Efficiency : Commercial solar cells can have efficiencies in the range of 10- 20 % and produce electrical energy of 1-2 kWh per sq. m per day in ordinary sunshine.
- Characteristics : Typically, a solar cell produces a potential difference of about 0.5 V and a current density of about 200 A per sq. m of cell area in full solar radiation.

Advantages and Disadvantages of Solar PV Systems

Advantages

1. Direct conversion of solar energy into electrical energy without a thermal-mechanical link.
2. Reliable, modular, durable, and maintenance-free systems.
3. Quiet operation, compatible with various environments, and long lifespan of over 20 years.
4. Can be located at the place of use, reducing the need for extensive distribution networks.

Disadvantages

1. High initial costs of solar cells compared to conventional power sources.
2. Low efficiency due to the requirement of large areas of solar cell modules.
3. Intermittent solar energy necessitates electrical energy storage solutions.

Applications of Photovoltaic Systems

- Major Uses : Solar PV systems are commonly used in space satellites, remote communication stations, marine warning lights, lighting, water pumping, and medical refrigeration in remote areas.
- Recent Applications : Solar-powered vehicles and battery charging are emerging applications of solar PV power.

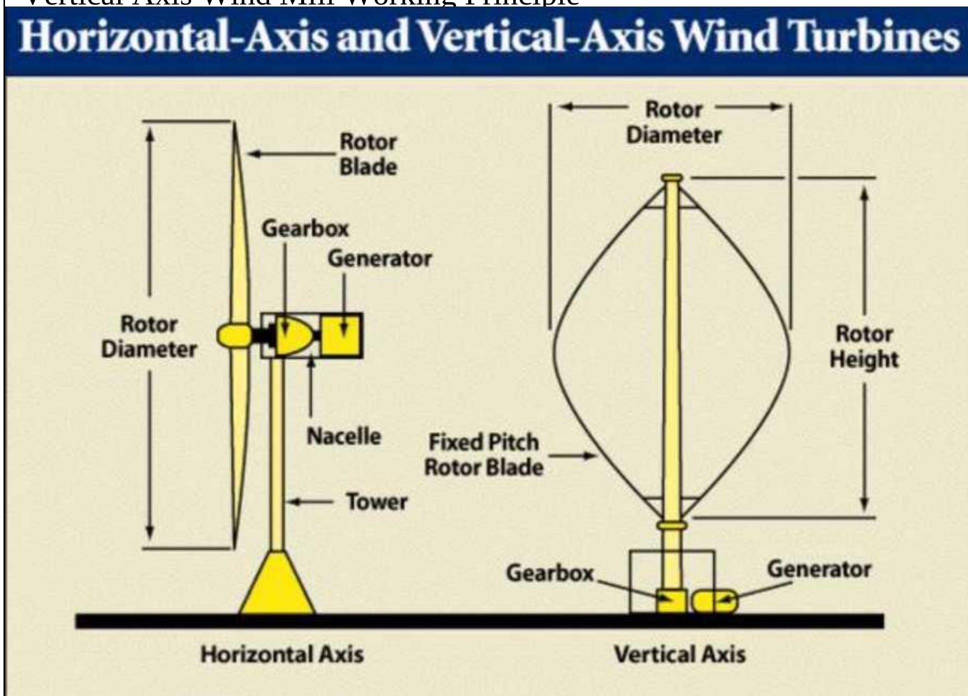
Types of Solar PV Systems

1. Stand-alone PV Systems (Off-grid)
   - Not connected to utility power lines, self-sufficient with solar panels, batteries, and charge controllers.
2. Grid-connected PV Systems (On-grid)
   - Connected to utility power lines, feed excess power back to the grid.
3. Hybrid Systems
   - Combination of stand-alone and grid-connected systems, offering flexibility and stability.

Module-3 Download					
Q.05	a	Interpret the properties, availability and problems associated with wind Energy Properties, Availability, and Problems Associated with Wind Energy Properties of Wind Relevant to Wind Energy 1. Wind Speed : Wind speed is crucial for determining energy generation potential, with small increases leading to significant energy production boosts. 2. Wind Direction : Influences turbine orientation to capture maximum wind energy. 3. Wind Turbulence : Irregular fluctuations in wind speed and direction can reduce turbine efficiency and lifespan. 4. Wind Density : Air density affects energy extraction, with denser air containing more energy influenced by temperature, pressure, and altitude. 5. Wind Power Density : Amount of power per unit area of wind, aiding in assessing energy yield. 6. Wind Shear : Change in wind speed and direction with height above the ground, impacting turbine performance. 7. Seasonal and Daily Variability : Wind patterns vary with seasons and times of day, affecting energy production predictions. 8. Local Effects : Geographical features like hills and bodies of water influence wind patterns, enhancing or reducing wind energy potential. Availability of Wind Energy - Wind energy is dependent on wind speeds, which can vary over time and location. - Wind power generation is more suited for urban environments with variable wind directions. - Accurate wind resource assessment is crucial for successful wind farm deployment. Problems Associated with Wind Energy 1. Intermittency and Variability : Wind power availability is not constant, impacting grid stability and reliability. 2. Energy Storage : Efficient storage solutions are necessary due to wind power intermittency. 3. Land Use and Environmental Impact : Wind farms require significant land, impacting wildlife habitats and ecosystems. 4. Noise and Aesthetic Concerns : Noise and visual impact from wind turbines can be undesirable. 5. Impact on Wildlife : Wind turbines pose risks to birds and bats, requiring mitigation strategies. 6. Grid Integration : Challenges in integrating wind power into existing grids due to its variable nature. 7. High Initial Costs : Capital investment for wind turbine installation is high, requiring long-term financial commitment. 8. Maintenance and Operational Costs : Regular maintenance and repairs can be costly, affecting efficiency and reliability. 9. Wind Resource Assessment : Accurate assessment is crucial to avoid	10	L3	CO3

		underperformance and financial losses. 10. Technological Limitations : Efficiency of wind turbines is limited by factors like the Betz limit.			
	b	Sketch and explain the working principal of a vertical axis wind mill.	10	L2	CO3

Vertical Axis Wind Mill Working Principle



Explanation of Vertical Axis Wind Turbines (VAWTs)
- Rotor Axis: Vertical axis, allowing the turbine to capture wind from any direction.
- Blades: Blades are arranged around a central vertical shaft, with common designs like Darrieus and Savonius types.
- Operation: VAWTs do not need to be oriented into the wind, simplifying their operation and installation.

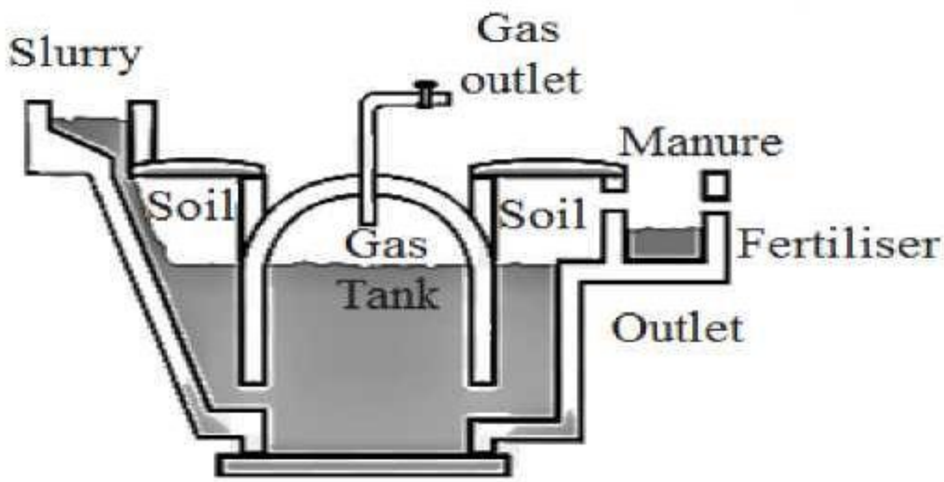
Advantages of Vertical Axis Wind Turbines
- Wind Direction: Capable of capturing wind from any direction, reducing the need for orientation mechanisms.
- Simple Design: Fewer moving parts compared to HAWTs, potentially lowering initial costs and maintenance requirements.
- Urban Suitability: More suited for urban environments where wind direction can be variable.

Disadvantages of Vertical Axis Wind Turbines
- Complexity: The design can be complex and may require advanced materials and engineering.
- Low Wind Speeds: Less effective in low wind speeds and may experience performance issues in turbulent conditions.

Working Principle Summary
- Vertical axis wind turbines have a vertical rotor axis that allows them to capture wind from any direction without requiring complex alignment mechanisms.

		- The design simplicity and ability to operate efficiently in various wind conditions make VAWTs suitable for urban environments and areas with turbulent wind conditions. - However, VAWTs may face challenges with low wind speeds and could require advanced engineering due to their complex design.			
		OR			
Q.06	a	Discuss biogas production from organic wastes by anaerobic fermentation with a neat sketch.	10	L2	CO3

Biogas Production from Organic Wastes by Anaerobic Fermentation



Biogas production from organic wastes through anaerobic fermentation is a sustainable process that involves the breakdown of organic matter in the absence of oxygen. This process results in the generation of biogas primarily composed of methane (CH4) and carbon dioxide (CO2). The key steps involved in anaerobic digestion include hydrolysis, acidogenesis, acetogenesis, and methanogenesis, each facilitated by specific groups of microorganisms. Various types of anaerobic digesters exist, such as batch digesters, continuous stirred tank reactors (CSTR), plug flow digesters, and composting digesters, each with distinct advantages and disadvantages.

Process Overview

- Anaerobic Digestion : Biological process breaking down organic matter without oxygen, yielding biogas and digestate in a digester.
- Steps :
  1. Hydrolysis : Complex organic materials broken down into simpler compounds by hydrolytic bacteria.
  2. Acidogenesis : Conversion of simpler compounds into volatile fatty acids and alcohols by acidogenic bacteria.
  3. Acetogenesis : Further conversion of VFAs and alcohols into acetic acid.
  4. Methanogenesis : Conversion of acetic acid, hydrogen, and CO2 into methane by methanogenic archaea.

Types of Anaerobic Digesters

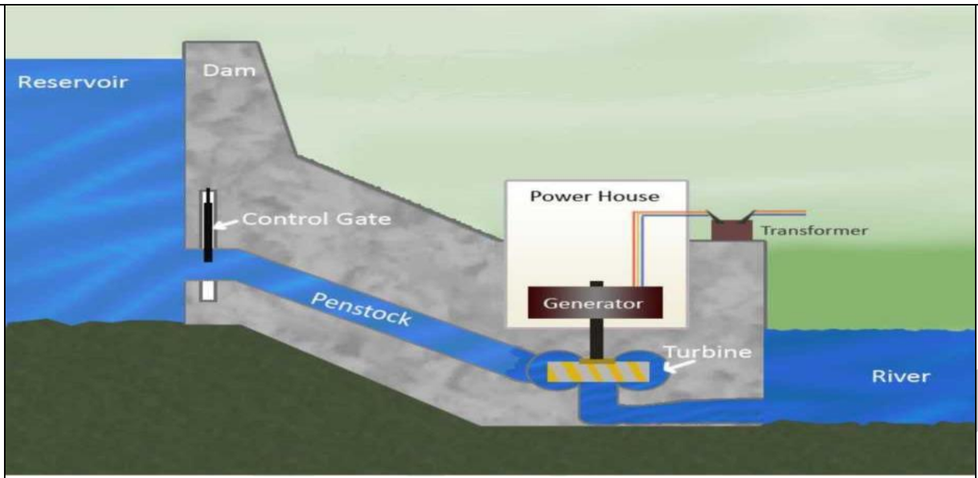
- Batch Digesters :
  - *Operation*: Organic waste added at once, processed until complete.
  - *Advantages*: Simplicity, lower cost.
  - *Disadvantages*: Less continuous biogas production, need for emptying.

		Applications and Advantages - Applications : - Electricity generation, heat production, vehicle fuel, and waste treatment. - Advantages : - Renewable energy source, effective waste management, greenhouse gas reduction, soil fertility enhancement. Factors Affecting Biogas Production - Feedstock Composition : Higher organic content increases biogas production. - Temperature : Mesophilic (30-40°C) and thermophilic (50-60°C) ranges affect digestion speed. - pH Level : Optimal range crucial for microbial activity. - Retention Time : Influences the efficiency of the digestion process. Environmental Benefits - Greenhouse Gas Reduction : Mitigates methane emissions. - Resource Recovery : Utilizes recovered heat for various applications. Summary Biogas production from organic wastes via anaerobic fermentation is a sustainable process yielding biogas primarily composed of methane and carbon dioxide. Various types of digesters and factors such as feedstock composition, temperature, pH level, and retention time influence the efficiency of the process. The environmental benefits include greenhouse gas reduction and resource recovery.			
	b	Illustrate the process of transportation of biogas and problems associated with it. Mention the application of biogas. Process of Transportation of Biogas, Problems Associated, and Applications Transportation of Biogas 1. Methods of Biogas Transportation : - Pipeline Transport : Biogas is transported through pipelines from the production site to the end-user. - Transport in Digestate Form : Biogas is captured as part of the digestate (solid and liquid by-products) when the gas is not separated out. 2. Challenges in Biogas Transportation : - Safety : Methane being highly flammable poses explosion risks if not handled correctly, requiring stringent safety measures. - Cost : High costs associated with compression, liquefaction, infrastructure, and compliance with regulations. - Efficiency : Energy losses in some transport methods like compression and liquefaction, emphasizing the need for efficient storage solutions. Problems Associated with Biogas Transportation	**10**	**L3**	**CO3**

		1. Feedstock Variability and Quality : - Inconsistent Quality : Variability in feedstock quality affects the efficiency of biogas production. Applications of Biogas 1. Electricity Generation : Biogas can be burned in engines or turbines to generate electricity. 2. Heat Production : Used for heating purposes in industrial processes or residential heating. 3. Vehicle Fuel : Processed into compressed biogas (CBG) for use in vehicles. 4. Waste Treatment : Utilizes organic waste and reduces the need for landfills. Additional Applications - Cooking Fuel : Used in household, institutional, and commercial cooking facilities. - Engine Performance with Biogas : Adjustments needed for engine efficiency due to the variable composition of biogas. - Benefits of Using Biogas in Engines : Renewable energy source, waste management, and cost savings.			

Module – 4 **Download**					
Q. 07	**a**	Write a note on flow duration curve and hydrographs. Flow Duration Curve and Hydrographs Flow Duration Curve: - A flow duration curve represents the relationship between streamflow magnitude and the percentage of time that flow is equal to or exceeded. - It is a graphical representation of flow data that helps in analyzing the distribution of streamflow over a specific period. - The curve shows how often certain flow rates are equaled or exceeded, providing insights into the variability of water availability. Hydrographs: - Hydrographs are graphical representations of streamflow over time, typically showing the discharge of a river or stream against time. - They are useful in understanding the response of a watershed to precipitation events, including the timing and magnitude of peak flows. - Hydrographs help in analyzing flood events, baseflow conditions, and overall streamflow patterns. Characteristics of Flow Duration Curve: 1. Flow Variability: Indicates the range of flows experienced in a river system. 2. Baseflow and Peak Flow: Distinguishes between periods of low flow (baseflow) and high flow (peak flow). 3. Seasonal Patterns: Reflects variations in flow rates throughout different seasons. 4. Flood Events: Highlights extreme flow conditions during flood events. 5. Water Availability Analysis : Aids in assessing water availability for various purposes like irrigation, hydropower generation, and environmental management. Types of Hydrographs: 1. Runoff River Power Plants without Pondage: - Operate without significant water storage capacity, relying on immediate runoff for power generation. 2. Runoff River Power Plants with Pondage: - Include storage capacity to regulate flow and manage fluctuating demand. 3. Reservoir Power Plants: - Utilize stored water behind a dam, ensuring consistent water availability for power generation throughout the year.	**3**	**L2**	**CO4**
	b	Discuss the advantages and disadvantages of hydroelectric power plant. Advantages and Disadvantages of Hydroelectric Power Plants Advantages: 1. Renewable Energy Source: - Hydroelectric power is sustainable and relies on the natural water cycle for energy generation. 2. Low Operating Costs: - Once constructed, hydroelectric plants have relatively low operational and maintenance costs compared to other energy sources.	**7**	**L2**	**CO4**

		3. Clean Energy: - Hydroelectric power is environmentally friendly with no direct emissions of greenhouse gases or pollutants. 4. Reliable and Efficient: - Provides a consistent power supply with high efficiency rates, converting over 90% of available energy into electricity. 5. Energy Storage and Management: - Hydroelectric plants can store energy through pumped-storage methods, helping balance supply and demand. Additional Advantages: 6. Multipurpose Use: - Dams used for hydroelectric plants can also provide benefits such as flood control, irrigation, and water supply. 7. Long Lifespan: - Hydroelectric plants generally have long operational lifespans exceeding 50 years. Disadvantages: 1. Environmental Impact: - Construction of dams and reservoirs can disrupt ecosystems, affecting fish migration, water quality, and wildlife habitats. 2. High Initial Costs: - Capital-intensive construction requirements, including dam construction, infrastructure, and land acquisition. 3. Dependence on Water Availability: - Hydroelectric power generation is reliant on water availability, susceptible to seasonal variations, droughts, and climate change. 4. Displacement of Communities: - Building reservoirs can lead to the displacement of local communities and loss of arable land and cultural sites. 5. Limited Suitable Locations: - Suitable sites for hydroelectric plants are limited to areas with sufficient water flow and specific topographical features. Additional Disadvantages: 6. Ecological Disruption: - Construction and operation of hydroelectric plants can affect local ecosystems, water quality, and wildlife habitats. 7. Land Use: - Requires substantial land for reservoirs and infrastructure, potentially leading to displacement and land-use changes.			
	c	Sketch and explain the hydroelectric power plant. Sketch and Explain the Hydroelectric Power Plant	**10**	**L2**	**CO4**



Components of a Hydroelectric Power Plant:
1. Dam and Reservoir:
- The dam is constructed on a large river in hilly areas to ensure sufficient water storage at height.
- The height of water level in the reservoir determines the potential energy stored.

2. Control Gate:
- Regulates the water flow from the reservoir to the turbine through the penstock.
- Controls the amount of water released into the penstock.

3. Penstock:
- A large steel pipe carrying water from the reservoir to the turbine.
- Converts potential energy of water into kinetic energy as it flows down due to gravity.

4. Water Turbine:
- Converts water's kinetic energy into mechanical energy.
- Coupled to an electric generator for producing electricity.
- Two main types: Impulse turbine for large heads and Reaction turbine for low and medium heads.

Types of Hydroelectric Power Plants:
1. Medium Head Hydroelectric Power Plant:
- Features a fore-bay used as a surge tank, tapped with the river to lead water to the turbine via a penstock.

2. High Head Hydroelectric Power Plant:
- Head of over 300 meters with a dam constructed to form a maximum reserve water level.
- Includes a pressure tunnel connected to the valve house, penstock, and surge tank to reduce water hammering and store extra water.

Advantages and Disadvantages of Hydroelectric Power:
- Advantages:
  - Multipurpose Use: Provides flood control, irrigation, and water supply.
  - Long Lifespan: Operational for over 50 years.

- Disadvantages:
  - Environmental Impact: Disrupts ecosystems, water quality, and wildlife habitats.
  - High Initial Costs: Requires significant upfront investment.

- Dependence on Water Availability: Relies on water availability affected by climate variations.
- Displacement of Communities: Leads to the displacement of local communities and loss of arable land.

Environmental and Economic Considerations:

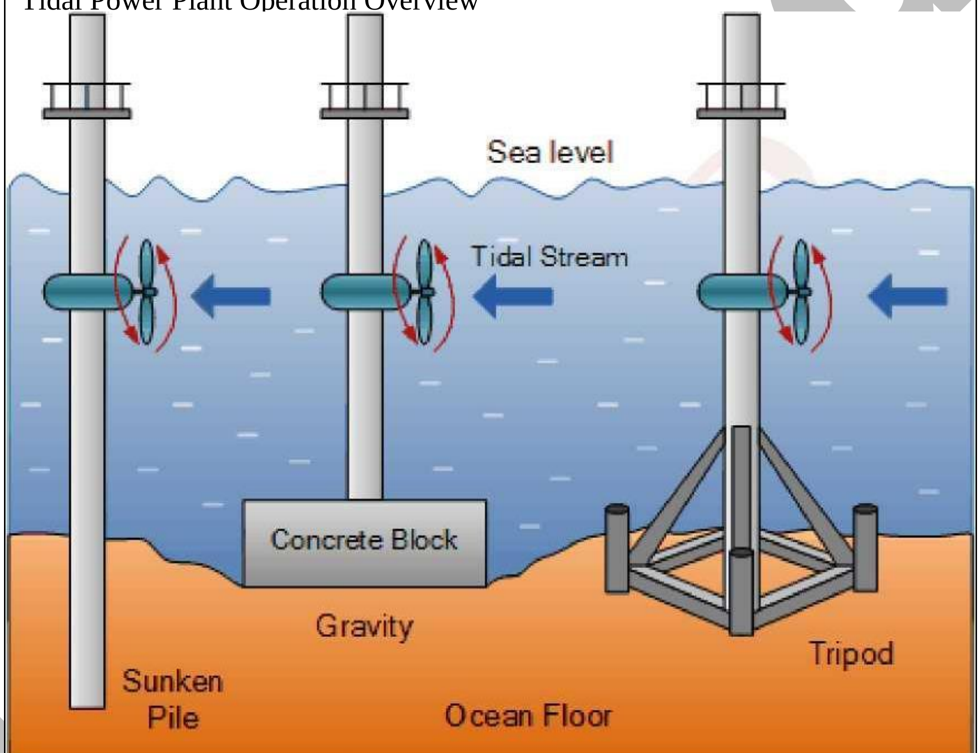
- Environmental Impact:
  - Tidal energy projects may affect marine ecosystems, sediment transport, and water quality.
  - Impact assessments are vital to mitigate negative effects.

- Economic Viability:
  - High initial costs can be offset by low operational and maintenance costs.
  - Government incentives and technological advancements can enhance economic feasibility.

OR

Q. 08	**a**	Illustrate the operation of tidal power plant with a neat sketch	**10**	**L2**	**CO4**

Tidal Power Plant Operation Overview

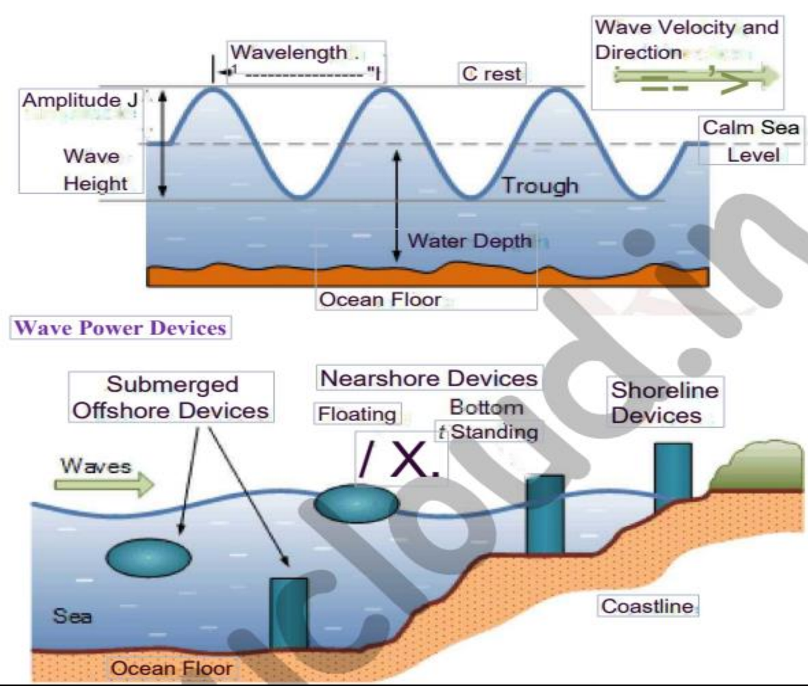


Tidal Energy Basics

- Tidal energy is derived from the gravitational interactions between the Earth, Moon, and Sun, causing the periodic rise and fall of ocean levels.
- Two primary methods to harness tidal energy are Tidal Stream Generators and Tidal Barrages.
- Tidal Stream Generators function similarly to underwater wind turbines, utilizing the flow of water to spin turbine blades and generate electricity.
- Tidal Barrages are dam-like structures built across tidal basins, allowing water to flow through gates and turbines to produce electricity.

Components of Tidal Power Plants

1. Generators :
   - Convert mechanical energy from turbine movement into electrical energy.
2. Power Electronics :

		- Manage electricity flow for stable supply to the grid. 3. Structural Components : - Foundations secure turbines to the seabed or riverbed. - Support structures like towers or monopiles aid in turbine support. Environmental and Economic Considerations - Environmental Impact : - Tidal energy projects can impact marine ecosystems, sediment transport, and water quality, necessitating environmental impact assessments. - Economic Viability : - High initial costs can be offset by low operational and maintenance costs with government incentives and technological advancements. - Energy Output : - Tidal energy offers a predictable and stable renewable energy source, reducing fossil fuel reliance and enhancing energy security. Challenges and Limitations - Tidal energy is site-specific, economically feasible in locations with tidal ranges of 5m or more. - Power generation fluctuates due to variable tidal energy availability. - Turbines must operate with fluctuating heads, and several turbines may be needed in parallel to handle large flow rates of tidal water. - Tidal plants face challenges related to marine life and ecology in their location due to potential navigation system disruptions. Advantages of Tidal Energy - Predictability and reliability due to the regular and cyclical nature of tidal patterns. - High energy density compared to other renewable sources. - Minimal greenhouse gas emissions during operation. - Long operational lifespans and low operating costs once operational.			
	b	Discuss briefly process of wave energy conversion and technologies available. Wave Energy Conversion Process and Technologies Overview 	**10**	**L2**	**CO4**

Wave Energy Conversion Process
- Description : Wave energy is harnessed by converting the kinetic energy of waves into electricity through various technologies.
- Mechanism : Different devices like oscillating water columns, point absorbers, wave attenuators, and overtopping devices capture wave energy and convert it into electrical power using turbines and generators.
- Process : Waves drive the movement of these devices, which in turn generate electricity through hydraulic pumps, air pressure, or hydraulic pressure mechanisms.

Technologies Available for Wave Energy Conversion
1. Oscillating Water Column :
   - Converts wave energy into air pressure by utilizing vertical wave motion.
   - Utilizes a partly submerged chamber fixed at the shoreline to compress and decompress air that powers a wind turbine generator.

2. Point Absorbers :
   - Floating structures that absorb wave energy from all directions.
   - Generate electricity from the bobbing or pitching motion of devices like buoys, floating bags, ducks, and articulated rafts.

3. Wave Attenuators :
   - Long, horizontal, semi-submerged snake-like devices that convert wave-induced motion into hydraulic pressure.
   - Comprised of linked cylindrical sections with flexible joints, converting motion into electricity through hydraulic turbine generators.

4. Overtopping Devices :
   - Structures with ramps positioned perpendicular to waves, capturing wave energy.
   - Waves spill over into a reservoir, and the potential energy of trapped water is released through a turbine generator to produce electricity.

Advantages of Wave Energy
- Abundant and clean energy resource generated by wind-driven waves.
- Minimal pollution compared to other green energies.
- Reduces dependency on fossil fuels.
- Consistent and predictable energy source with accurate wave forecasting capabilities.

Disadvantages of Wave Energy
- Visual impact on shorelines due to conversion devices.
- Location dependency on strong wave sites.
- Intermittent power generation during calm periods.
- Navigation hazards for offshore devices.
- High power distribution costs and upfront construction and maintenance expenses.

Module – 5					
Download					
Q. 09	**a**	Execute a case study on OTEC power plant. Case Study on OTEC Power Plants Overview of OTEC Power Plants Ocean Thermal Energy Conversion (OTEC) is a process that generates electricity by utilizing the temperature difference between warm surface water and cold deep water in the ocean. The technology involves a Rankine cycle where warm seawater heats a working fluid, leading to evaporation, turbine operation, and electricity generation. The condensed working fluid is then recirculated to repeat the cycle. Advantages and Disadvantages Advantages 1. Renewable and Sustainable Energy Source 2. Base Load Power Generation 3. Environmental Benefits 4. Energy Independence 5. Desalination Potential Disadvantages 1. High Initial Costs 2. Technical Challenges 3. Low Efficiency 4. Environmental Impact 5. Geographic Limitations 6. Energy Transmission Issues 7. Maintenance and Durability Concerns Case Studies of OTEC Power Plants 1. Natural Energy Laboratory of Hawaii Authority (NELHA), USA - Location: Kona, Hawaii - Details: Operates a small-scale OTEC plant for electricity generation, seawater air conditioning, and desalination. - Outcomes: Demonstrated feasibility and efficiency of OTEC technology. 2. Kume Island, Japan - Location: Okinawa Prefecture, Japan - Details: Hosts a small-scale OTEC plant for electricity generation and aquaculture support. - Outcomes: Successful renewable energy production and local economic development through mariculture. 3. Martinique OTEC Plant, France - Location: Martinique, Caribbean Sea - Details: Planned 10 MW OTEC plant by DCNS for sustainable energy and reduced fossil fuel dependence. - Outcomes: Delayed implementation due to high costs and technical challenges.	**10**	**L3**	**CO5**

		4. Nauru OTEC Plant, South Pacific - Location: Nauru, Micronesia - Details: Aimed at establishing a 100 kW OTEC plant for renewable energy transition. - Outcomes: Faced funding and technical challenges, highlighting issues for small island nations. 5. Makai Ocean Engineering, USA - Location: Hawaii, USA - Details: Operates a pilot-scale OTEC plant focusing on research and development. Sources - Page 1: Overview of OTEC technology principles and advantages - Page 2: Types of OTEC systems and closed-cycle OTEC description - Page 5: Example components of an OTEC Rankine cycle - Page 9: Issues related to OTEC implementation, including infrastructural and ecological concerns - Page 10: Case studies of OTEC plants in Hawaii, Japan, France, and the South Pacific			
	b	List and explain the problems associated with geothermal system operation. Problems Associated with Geothermal System Operation Technical Challenges 1. Extreme Conditions for Drilling : Drilling into magma requires overcoming extreme heat and pressure conditions, posing significant technical difficulties. 2. Complex Engineering Requirements : Geothermal systems involve complex engineering to handle harsh environments, such as corrosion and high temperatures. 3. Inaccessibility of Magma Chambers : Accessing magma chambers for geothermal energy production can be challenging due to their extreme nature. Interconnection Challenges 1. Hybrid System Integration : Combining geothermal energy with fossil fuel-based power plants can pose challenges in terms of system integration and optimization. 2. Co-production Complexity : Co-producing natural gas or oil with geothermal fluids may introduce operational complexities and technical challenges. Environmental Concerns 1. Corrosive Environments : Geothermal systems can operate in corrosive environments, leading to maintenance challenges and material durability issues. 2. Geographic Limitations : Geothermal energy production is limited to regions with high geothermal activity, restricting widespread implementation.	**10**	**L2**	**CO5**

		3. Resource Depletion : Improper management can lead to geothermal resource depletion or decreased productivity over time. 4. Environmental Impact : Extraction of geothermal energy can result in land subsidence, induced seismicity, and the release of trace gases. Economic Factors 1. High Initial Costs : Developing geothermal power plants involves significant upfront investment for exploration, drilling, and construction 2. Operating Costs : While operating costs are generally low compared to fossil fuel plants, initial investment costs can be a barrier to entry. 3. Economic Viability : Geothermal projects' economic feasibility can vary based on factors like resource accessibility and market conditions. Efficiency and Maintenance 1. Low Efficiency : Geothermal systems may have lower thermal efficiency compared to other energy generation methods due to temperature differentials. 2. Maintenance Requirements : Geothermal systems require regular maintenance to address issues like corrosion, biofouling, and wear and tear in marine environments. Summary Geothermal system operation faces technical, environmental, and economic challenges, including extreme drilling conditions, interconnection complexities, corrosive environments, and high initial costs. Addressing these challenges is crucial for maximizing the potential of geothermal energy as a sustainable and reliable power source. SOURCES - Page 10: Geothermal system operation challenges and technical aspects. - Page 18: Overview of geothermal system interconnection challenges and economic factors. - Page 19: Environmental concerns and economic factors related to geothermal energy production.			
		OR			
Q. 10	**a**	With a neat sketch explain the geothermal system by Hot Dry Rock (HDR). Geothermal System by Hot Dry Rock (HDR) Explanation Hot Dry Rock (HDR) Resources Overview Hot Dry Rock (HDR) resources, also known as Enhanced Geothermal Systems (EGS), are found in dry rock formations with high heat content but low natural permeability. These resources require artificial stimulation, such as hydraulic fracturing, to create a reservoir of hot water or steam. 1. Characteristics : - High-temperature rock (above 150°C or 302°F) with low natural permeability. 2. Techniques : - Hydraulic Fracturing: Creating artificial fractures in the rock to enhance	**10**	**L2**	**CO5**

		fluid flow. - Hydrothermal Stimulation: Injecting water into the rock to create or enhance a geothermal reservoir. 3. Examples : - Experimental projects in the United States and Europe, such as the Enhanced Geothermal Systems (EGS) projects in the Desert Peak and Soultz-sous-Forets fields. 4. Usage : - Potential for both electricity generation and direct use applications, though commercial viability is still developing. Magma Resources Overview Magma resources involve tapping into molten rock or magma chambers directly, facing significant technical and safety challenges. 1. Characteristics : - Extremely high temperatures (above 700°C or 1292°F) and highly corrosive environments. 2. Challenges : - Drilling into magma requires overcoming extreme heat and pressure conditions, posing significant technical difficulties. Examples of Geothermal Stations 1. The Geysers, California, USA : - Type: High-temperature hydrothermal. - Capacity: Approximately 1.5 GW. - Details: One of the largest geothermal power complexes globally, operational since the 1960s. 2. Hellisheidi Geothermal Power Station, Iceland : - Type: High-temperature hydrothermal. - Capacity: Approximately 303 MW of electricity and 133 MW of thermal energy. - Details: One of the largest geothermal power plants in Iceland near Reykjavik, providing electricity and district heating. 3. Krafla Geothermal Power Station, Iceland : - Type: High-temperature hydrothermal. - Capacity: Approximately 60 MW. - Details: Located in the Krafla volcanic area, forming part of a larger geothermal development project.			
	b	Discuss the advantages, disadvantages and application of geothermal power. Advantages, Disadvantages, and Applications of Geothermal Power Advantages of Geothermal Energy: 1. Renewable and Sustainable: Geothermal energy is continuously replenished by natural processes, making it a reliable and sustainable energy source. 2. Low Greenhouse Gas Emissions : Geothermal power plants produce minimal greenhouse gases, contributing to the reduction of climate change	**10**	**L2**	**CO5**

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		3. Base Load Power: Geothermal energy provides a constant and reliable power supply, suitable for base load electricity generation. 4. Low Operating Costs: Once established, geothermal power plants have relatively low operating and maintenance costs compared to fossil fuel plants. 5. Minimal Land Footprint: Geothermal power plants require less land compared to solar or wind farms, making them suitable for locations with limited space. 6. Direct Use Applications: Geothermal energy can be directly used for various purposes like district heating, greenhouse heating, and industrial processes without conversion to electricity. Disadvantages of Geothermal Energy: 1. High Initial Costs: The development of geothermal power plants involves significant upfront investment for exploration, drilling, and plant construction. 2. Site Specific: Geothermal resources are geographically specific, limiting their applicability to regions with accessible resources. 3. Environmental and Structural Risks: Geothermal energy extraction can lead to land subsidence, induced seismicity, and the release of trace gases, requiring careful management. 4. Resource Depletion: Improper management can lead to the depletion or decreased productivity of geothermal resources over time. 5. Limited to Certain Areas: Effective geothermal energy production is often constrained to regions with high geothermal activity, such as volcanic areas or tectonic plate boundaries. Applications of Geothermal Power: - Direct Use Applications: Geothermal energy can be utilized for heating applications such as district heating, greenhouse heating, industrial processes, and more without the need for electricity conversion. - Geothermal Power Plants: Examples include The Geysers in California, Hellisheidi Geothermal Power Station in Iceland, Krafla Geothermal Power Station, Larderello Geothermal Complex in Italy, and Cerro Prieto Geothermal Power Station in Mexico.			