Model Question Paper-1 with effect from 2021(CBCS Scheme)

USN | | | | | | | | | | |

Sixth Semester B.E. Degree Examination Subject Title: Renewable Energy Power Plants

TIME: 03 Hours SET -1 **Max. Marks: 100**

Note: Answer any **FIVE** full questions, choosing at least **ONE** question from each **MODULE**.

		Module -1 Download	Bloom's Taxonomy Level	COs	Marks
Q.01	a	Explain different types of renewable energy and Discuss India's production and reserves of commercial energy sources. Renewable energy sources are derived from natural resources that are continuously replenished. The main types of renewable energy include: 1. Solar Energy : This is harnessed from sunlight and is one of the most abundant energy sources available. The Earth intercepts about 1.8 × 10^11 megawatts (MW) of solar power, which is thousands of times greater than the current global energy consumption. Solar energy can be utilized through direct methods like thermal and photovoltaic systems, or indirectly through methods such as water power and biomass. 2. Wind Energy : Generated from the movement of air, wind energy is captured using turbines. It is a significant contributor to renewable energy production, especially in regions with consistent wind patterns. 3. Hydropower : This is produced from flowing water, typically from rivers or dams. It relies on the natural water cycle and is considered sustainable as long as water resources are managed responsibly. 4. Biomass : This includes organic materials such as wood, agricultural waste, and even cow dung. Biomass can be used directly for heating or converted into biofuels.	L2	CO1	10

		5. Geothermal Energy : This is derived from the heat stored beneath the Earth's surface. It can be harnessed for electricity generation or direct heating applications. 6. Tidal Energy : Generated from the gravitational effects of celestial bodies, tidal energy harnesses the movement of tides to produce electricity. Now, regarding India's production and reserves of commercial energy sources, the country heavily relies on fossil fuels, which account for about 93% of its commercial energy requirements. Here's a breakdown of the key sources: - Coal : India produced approximately 310 million tons (Mt) of coal in the year 2000, contributing around 56.16% to the total energy production. Coal is formed from the decomposition of vegetable matter over thousands of years and is a significant energy source. - Oil : With a production of about 103.44 Mt, oil contributed 29.75% to the energy mix. The country has seen fluctuations in oil production, with increasing imports to meet demand. - Natural Gas : The production of natural gas has been steadily increasing, with a notable rise from 0.516 billion cubic meters in 1969 to 27.860 billion cubic meters in 2000, contributing 7.47% to the total energy production. - Water Power : Contributing about 5.25% to the total energy production, hydropower is a renewable source that utilizes the natural flow of water. - Nuclear Power : Although it contributes only about 1.37% to the total energy production, nuclear power is a non-renewable source generated from nuclear reactions, primarily using uranium. Overall, while India has substantial reserves of coal and is increasing its natural gas production, the country faces challenges in diversifying its energy sources and increasing the share of renewables in its energy mix. The reliance on fossil fuels poses sustainability concerns, especially with the anticipated decline in oil production in the coming decades.			
	b	Explain extra-Terrestrial radiation and Solar constant. With neat sketch describe construction and working principle of Pyranometer (Pyrometer)	L2	CO1	10

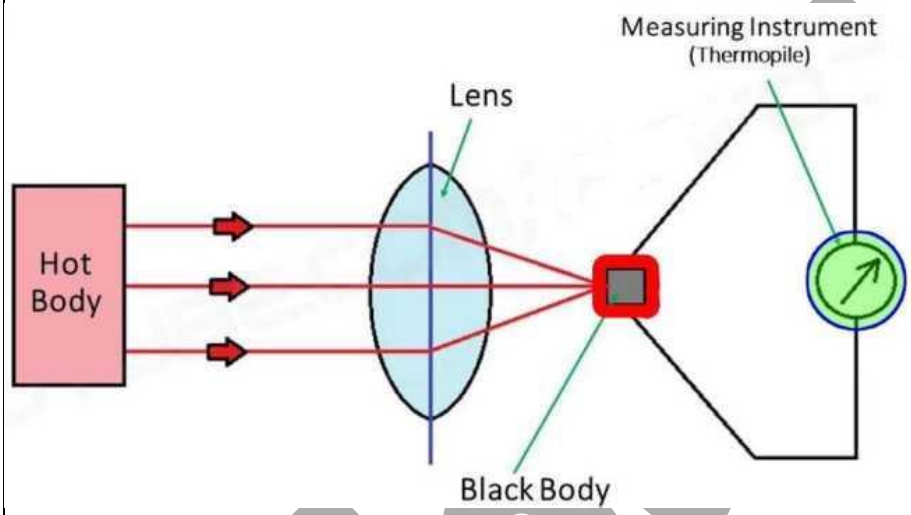
Extra-terrestrial radiation refers to the solar radiation that is received outside the Earth's atmosphere. This radiation is measured at the mean distance between the Earth and the Sun, which is approximately 1 astronomical unit (AU). The average value of this extra-terrestrial irradiance is about 1367 W/m², although it can vary by ±3% due to the elliptical orbit of the Earth around the Sun. This radiation spans a spectrum from approximately 0.1 to 4.0 micrometers, with about 44% of the solar radiation emitted by the Sun falling within the visible light range (0.40 to 0.71 micrometers).

The Solar Constant is a measure of the flux density of solar radiation received at the top of the Earth's atmosphere, perpendicular to the Sun's rays. It quantifies the amount of solar energy received per unit area and is crucial for understanding solar energy potential. The standard value of the Solar Constant was initially set at 1353 W/m² in 1971, but later measurements have revised it to approximately 1367 W/m².

Pyranometer: Construction and Working Principle

A pyrometer is an instrument used for measuring high temperatures, typically in industrial and scientific applications where direct contact with the object is impractical or impossible.:

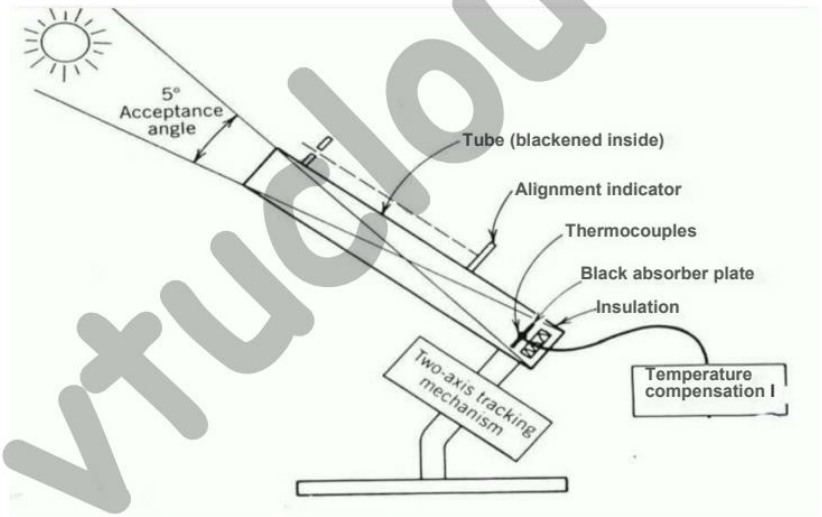
1. Function: Pyrometers measure the temperature of an object by detecting the amount of thermal radiation emitted by the object.
2. Types:
• Optical Pyrometers: Measure temperature based on the color or brightness of the thermal radiation emitted by the object. They compare the brightness of the object's thermal radiation to a calibrated filament or reference source.
• Infrared Pyrometers: Measure temperature based on the intensity of infrared radiation emitted by the obj e ct . They detect the infrared radiation using sensors sensitive to specific wavelengths.
3. Working Principle:
• Optical pyrometers utilize the principle that as an object gets hotter, it emits more visible light. The instrument compares the brightness of the object's emitted light with a known source, allowing it to determine the temperature.
• Infrared pyrometers detect the thermal radiation emitted by the obj ect . They typically use a lens to focus the infrared radiation onto a detector, which converts the radiation into an

		electrical signal. The temperature is then calculated based on the intensity of the infrared radiation. 4. Applications: • Industrial: Used in steel manufacturing, metalworking, ceramics, and glass industries to monitor and control temperatures during processing. • Scientific: Used in laboratories for high-temperature research, combustion studies, and materials testing. • Medical: Used in medical diagnostics to measure body temperature at a distance.  the pyranometer effectively measures solar radiation by converting temperature differences caused by absorbed solar energy into an electrical signal, allowing for accurate quantification of solar energy available for various applications.			
		OR			
Q.02	a	How renewable energy is different from Conventional one? Discus Indian and global energy scenario. Renewable energy differs from conventional energy primarily in its sources and sustainability. Renewable energy is derived from natural resources that are continuously replenished, such as sunlight, wind, rain, tides, and geothermal heat. In contrast, conventional energy typically refers to non-renewable sources like fossil fuels (coal, oil, and natural gas) and nuclear energy, which are finite and can deplete over time. In the global energy scenario, fossil fuels dominate the energy mix, meeting a significant portion of energy demands. For instance, coal, oil, and natural gas together account for about 93% of India's commercial energy requirements, with coal alone contributing 56% and oil and	L2	CO1	10

		natural gas making up 37%. This heavy reliance on fossil fuels raises concerns about sustainability, especially as oil production is expected to decline and reserves are projected to deplete by the century's end. On the other hand, renewable energy sources, particularly solar energy, are gaining attention due to their potential to meet all current and future global energy needs indefinitely. Solar energy is abundant and environmentally clean, making it one of the most promising unconventional energy sources. However, challenges remain, such as the relatively low amount of sunlight available per square meter for efficient technology use, which necessitates large solar panels and higher costs. Additionally, the economic feasibility of solar energy systems is a significant hurdle, requiring more affordable methods of collection and storage to mitigate substantial initial investment costs. Globally, the shift towards renewable energy is becoming increasingly urgent as countries seek to reduce their carbon footprints and transition to more sustainable energy systems. In India, while the contribution of renewable sources like wind and water power is growing, it still lags behind fossil fuels, which dominate the energy landscape. The Indian government is actively promoting renewable energy initiatives to enhance energy security and sustainability, aiming to increase the share of renewables in the energy mix.			
	b	Describe spectral distribution of extra-terrestrial radiation. With neat sketch describe construction and working principle of Pyrheliometer. The spectral distribution of extra-terrestrial radiation refers to the range of wavelengths of solar radiation that reaches the outer edge of Earth's atmosphere. This radiation spans a spectrum from approximately 0.1 to 4.0 micrometers (μm). The sun emits energy across this spectrum, with about 7% of its emission in the ultraviolet (UV) range (0.1 to 0.4 μm), approximately 44% in the visible light range (0.4 to 0.71 μm), and about 48% in the infrared range (0.71 to 4.0 μm). On average, the extraterrestrial irradiance is about 1367 W/m², although this value can vary by ±3% as the Earth orbits the sun. Now, let's discuss the Pyrheliometer, which is an instrument specifically designed to measure beam radiation from the sun.	L2	CO1	10

Construction of Pyrheliometer:

1. Collimating Tube : The Pyrheliometer features a collimating tube that aligns with the direction of the sun's rays. This tube helps to ensure that only direct sunlight is measured.
2. Black Absorber Plate : At the base of the tube, there is a black absorber plate equipped with hot junctions of a thermopile. This plate absorbs the solar radiation.
3. Two-Axis Tracking Mechanism : This mechanism allows the Pyrheliometer to track the sun's movement across the sky, ensuring that it remains aligned with the sun throughout the day.
4. Alignment Indicator : This feature helps in accurately positioning the instrument towards the sun.



Working Principle of Pyrheliometer:

- When sunlight strikes the black absorber plate, it heats up due to the absorption of solar radiation.
- The temperature of the plate increases until the rate of heat gain from solar radiation equals the rate of heat loss through convection, conduction, and radiation.
- The thermopile generates an electromotive force (emf) as a result of the temperature difference between the hot junctions (on the black plate) and the cold junctions (located under a guard plate).
- This emf, typically ranging from 0 to 10 mV, can be measured and recorded, providing a quantifiable measure of the beam radiation received from the sun.

Module -2

Download

Q. 03	a	Define the following terms (i) latitude angle (ii) declination angle (iii) hour angle. Explain with a neat sketch Evacuated tubular collector.	L2	CO2	10

Sure! Let's break down the definitions of the terms you asked about:

(i) Latitude Angle (φ)

The latitude angle is the angle between a point on the Earth's surface and the equatorial plane. It is measured in degrees north or south of the equator. For example, a latitude of 30°N means the point is 30 degrees north of the equator. Latitude plays a crucial role in solar energy applications as it affects the angle at which sunlight strikes the Earth.

(ii) Declination Angle (δ)

The declination angle is the angle between a line extending from the center of the Sun to the center of the Earth and the projection of this line onto the Earth's equatorial plane. It varies throughout the year due to the tilt of the Earth's axis, ranging from +23.5° at the summer solstice (around June 21) to -23.5° at the winter solstice (around December 21). On the equinoxes (around March 21 and September 23), the declination angle is 0°.

(iii) Hour Angle (ω)

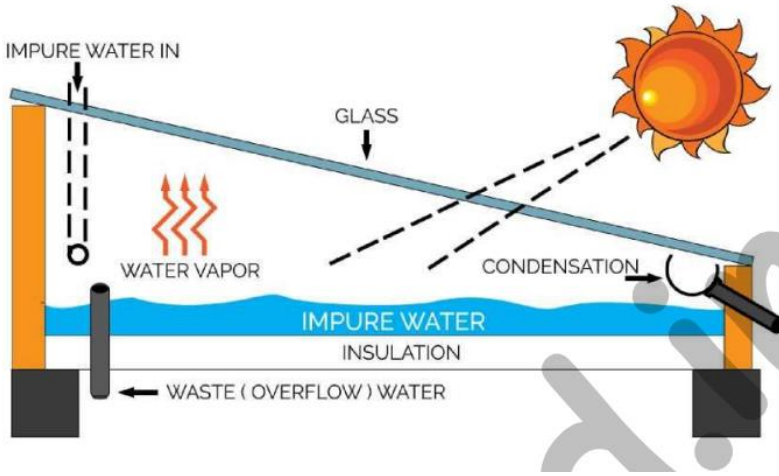
The hour angle is the angle through which the Earth must rotate to bring the meridian of a specific location directly in line with the Sun's rays. It is measured in degrees, with 15° corresponding to one hour of time. At solar noon, the hour angle is 0°, and it increases by 15° for each hour before or after noon.

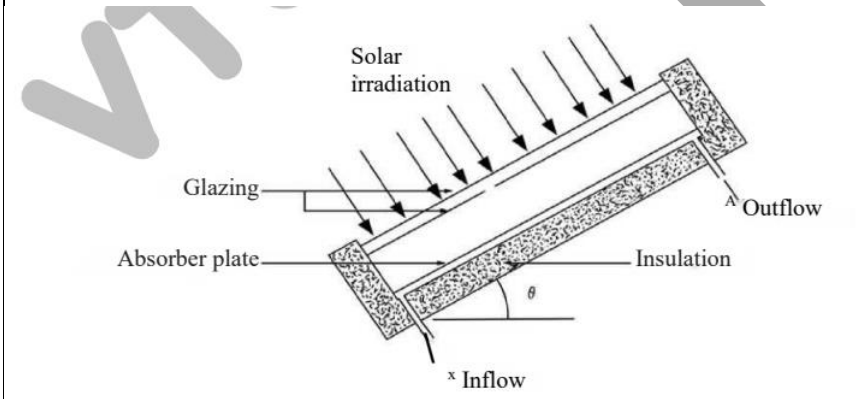
Evacuated Tubular Collector

An evacuated tubular collector is a type of solar collector that consists of a series of glass tubes, each containing a heat-absorbing element. The space between the inner and outer tubes is evacuated (i.e., a vacuum is created), which minimizes heat loss due to convection and conduction.

Sketch Explanation:

1. Outer Glass Tube : Protects the inner components and provides structural integrity.
2. Inner Absorber Tube : This is coated with a selective material that absorbs solar radiation efficiently.
3. Vacuum Layer : The space between the inner and outer tubes is evacuated to reduce heat loss.
4. Heat Transfer Fluid : A fluid (like water or antifreeze)

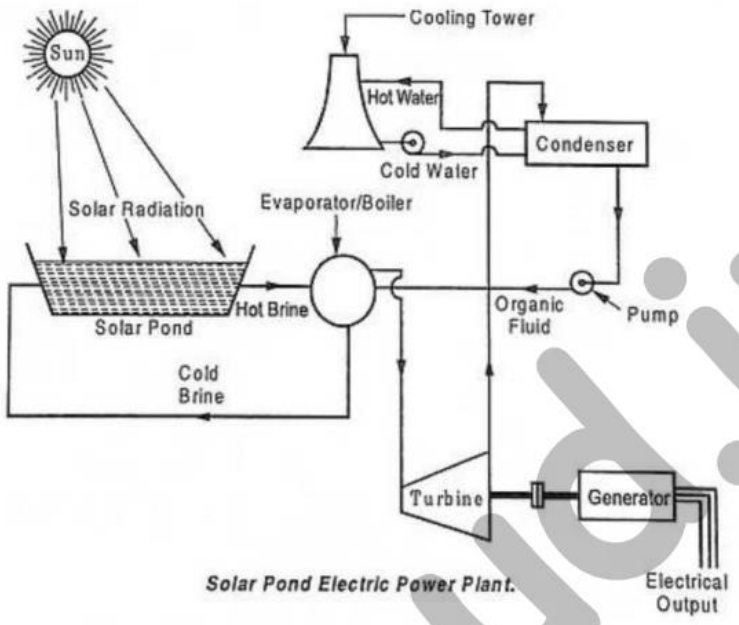
		circulates through the absorber tube, absorbing heat from the solar radiation. The design of evacuated tubular collectors allows them to perform well even in low-light conditions and during colder weather, making them suitable for various applications, including domestic hot water heating and space heating.			
	b	Describe with a neat sketch solar distillation system. With a neat sketch solar flat plate collector Solar Distillation System A solar distillation system is designed to convert saline or brackish water into potable water using solar energy. The basic components of a simple basin-type solar still include: 1. Basin : A shallow blackened basin filled with saline or brackish water, typically with a depth of about 5-10 cm. The blackened surface absorbs solar radiation effectively. 2. Transparent Cover : A sloped transparent roof that allows sunlight to enter while trapping heat. The slope helps in collecting the condensed water. 3. Condensate Channel : A channel at the lower edge of the cover where the condensed water collects and can be drained for use.  Solar Flat Plate Collector	L2	CO2	10

		Introduction: Solar flat plate collectors are one of the most common types of solar thermal collectors used to capture solar energy for heating applications. They are widely used in residential and commercial buildings for water heating, space heating, and other low to medium temperature applications. 1. Absorber Plate : A flat, dark-colored surface that absorbs solar radiation and converts it into heat. 2. Glass Cover : A transparent cover that reduces heat loss by creating a greenhouse effect. 3. Insulation : Material at the back and sides to minimize heat loss. 4. Fluid Channels : Tubes or channels through which a heat transfer fluid (usually water) circulates to absorb the heat from the absorber plate.  			
		OR			
Q.04	a	Discus apparent motion of the sun with neat sketch. Determine the local apparent time (LAT) corresponding to 1430 hours(IST) at Mumbai (19º 07' N, 72º 51' E) on July 1. In India, standard time correction on July 1 is equal to -3.5.	L2	CO2	10
	b	Describe with a neat sketch working of solar pond. With a neat sketch explain solar air collector Solar Pond A solar pond is a unique system designed to collect and store solar energy. It consists of a shallow body of water, typically 1 to 2 meters deep, with a large surface area. The pond is filled with water that contains dissolved salts, which help create a stable density gradient. This gradient allows the pond to trap heat effectively. Working Principle: 1. Solar Absorption : When sunlight hits the surface of the pond, part of the solar radiation is absorbed by the water. The dissolved salts increase the water's density at the bottom,	L2	CO2	10

allowing it to retain heat.

2. Heat Storage : The heat absorbed by the water is stored throughout the depth of the pond. The upper layers of water remain cooler, while the lower layers become significantly warmer.

3. Heat Extraction : The stored heat can be extracted for various applications, such as heating buildings or generating steam for electricity.



Solar Pond Electric Power Plant.

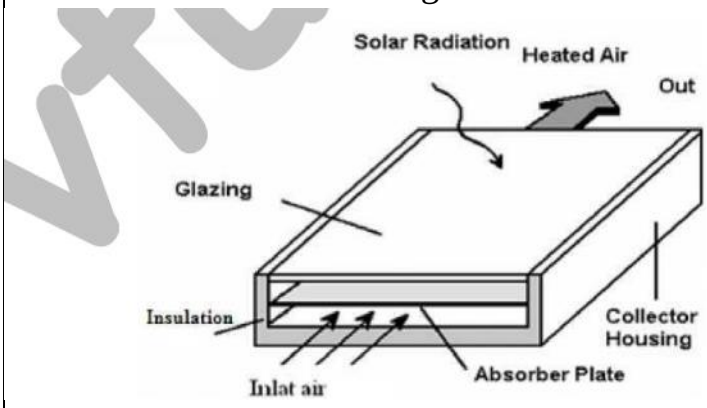
Solar Air Collector

A solar air collector is a device that captures solar energy to heat air, which can then be used for space heating or ventilation in buildings.

Working Principle:

1. Air Flow : Ambient air is drawn into the collector through an inlet. The collector typically has a transparent cover that allows sunlight to penetrate.

2. Heating Process : Inside the collector, the air passes over a dark absorber surface that absorbs solar radiation and converts it into heat. The heated air then rises due to convection.

		3. Heat Distribution : The warm air is either directed into the building's ventilation system or stored in a thermal mass for later use. Dampers can be adjusted to control the flow of heated air between the storage and distribution systems.  Both systems utilize solar energy effectively, with the solar pond focusing on heat storage and the solar air collector on direct heating of air for immediate use.			
		Module -3 **Download**			
Q. 05	a	Discus the causes and properties of wind. What are the major problems associated with wind machines. Wind is a fascinating and complex natural phenomenon that plays a crucial role in harnessing renewable energy through wind machines, particularly wind turbines. Let's delve into the causes and properties of wind, as well as the major problems associated with wind machines. Causes of Wind Wind is primarily caused by the uneven heating of the Earth's surface by the sun. This heating creates differences in air pressure, leading to air movement from areas of high pressure to areas of low pressure. Several factors contribute to this process: 1. Temperature Differences : The sun heats different surfaces (land, water, vegetation) at varying rates, causing localized temperature variations. 2. Pressure Systems : High-pressure systems are associated with cooler, denser air, while low-pressure systems are linked to warmer, less dense air. The movement of air from high to low pressure generates wind. 3. Earth's Rotation : The Coriolis effect, caused by the Earth's rotation, influences wind direction, causing it to	L2	CO3	10

curve rather than move in a straight line.

Properties of Wind

Understanding the properties of wind is essential for optimizing wind energy generation. Here are some key properties:

1. Wind Speed : This is a critical factor in determining the potential energy that can be generated. The kinetic energy of the wind increases with the cube of the wind speed, meaning even small increases can lead to significant energy production.
2. Wind Direction : The orientation of wind turbines must align with the prevailing wind direction to maximize energy capture.
3. Wind Turbulence : Irregular fluctuations in wind speed and direction can reduce turbine efficiency and lifespan due to increased wear and tear.
4. Wind Density : The density of air affects the energy that can be extracted; denser air contains more mass, translating to more energy.
5. Wind Shear : This refers to changes in wind speed and direction with height, impacting turbine performance since wind speeds are generally higher at greater heights.

Major Problems Associated with Wind Machines

While wind power is a promising renewable energy source, several challenges must be addressed:

1. Intermittency and Variability : Wind power generation is dependent on wind speeds, which can fluctuate significantly. This intermittency can affect grid stability and reliability, necessitating energy storage solutions or backup generation.

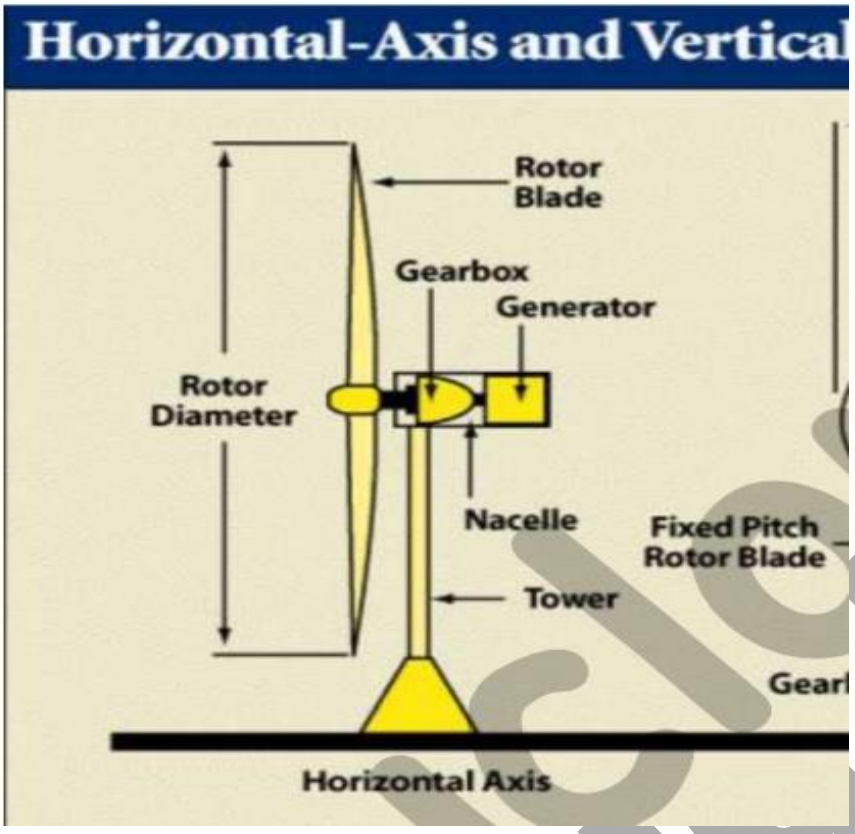
2. Energy Storage : Due to the variable nature of wind, efficient energy storage systems are required to store excess energy generated during high wind periods and release it during low wind periods. Current storage technologies, like batteries, can be expensive and may not scale adequately for large wind power integration.

3. Land Use and Environmental Impact : Wind farms require substantial land, which can disrupt local ecosystems and wildlife habitats. The construction of large wind farms may affect land availability for agriculture and recreational activities.

4. Noise and Aesthetic Concerns : Wind turbines generate

		noise from blade movement and mechanical components, which can lead to opposition from local communities. Additionally, some people find the visual impact of wind farms undesirable. 5. Impact on Wildlife : Wind turbines pose risks to birds and bats, which may collide with the spinning blades, leading to fatalities and necessitating mitigation strategies to minimize these impacts. 6. Technological Limitations : The efficiency of wind turbines is constrained by factors like the Betz limit, which restricts the maximum energy that can be captured from the wind. Continuous technological advancements are needed to improve turbine efficiency and performance. while wind energy presents a sustainable solution for power generation, understanding the causes and properties of wind, along with addressing the associated challenges, is essential for optimizing its use in renewable energy systems.			
	b	Explain energy plantation. Describe the applications of biogas. Energy plantations are specialized agricultural systems where specific crops are cultivated primarily for energy production. These plantations are designed to produce biomass that can be converted into various forms of energy, including: - Biofuels : Liquid fuels such as ethanol or biodiesel derived from energy crops. - Biogas : A methane-rich gas produced through the anaerobic digestion of organic matter, which can be harnessed for various energy needs. - Solid Biomass : Direct use of plant materials for combustion or gasification to generate heat and power. The applications of biogas are diverse and impactful, including: 1. Electricity Generation : Biogas can be burned in engines or turbines to produce electricity, making it a valuable energy source for both industrial and residential use. 2. Heat Production : It can be utilized for heating applications in various industries, such as food processing, where it provides thermal energy for cooking, drying, or other processes.	L2	CO3	10

		3. Vehicle Fuel : Biogas can be processed into compressed biogas (CBG), which serves as a cleaner alternative fuel for vehicles, reducing reliance on fossil fuels. 4. Waste Treatment : The production of biogas involves the digestion of organic waste, which helps manage and reduce waste, thereby decreasing the need for landfills. 5. Industrial Applications : Biogas can provide process heat for industries like brewing and paper manufacturing, and it can also serve as a feedstock for producing chemicals and other industrial products, such as bioplastics and biofuels. 6. Fertilizer Production : The solid by-product from biogas production, known as digestate, is rich in nutrients and can be used as a natural fertilizer or soil conditioner, enhancing soil fertility and reducing the need for synthetic fertilizers. Overall, energy plantations and biogas applications contribute significantly to sustainable energy solutions, waste management, and environmental benefits.			
		OR			
Q. 06	a	With neat sketch explain components of horizontal axis wind mill. Explain elementary design principles for wind turbines. To explain the components of a horizontal axis wind turbine (HAWT) and the elementary design principles, let's break it down into two parts: the components and the design principles.	L2	CO3	10



Components of a Horizontal Axis Wind Turbine (HAWT)

1. Rotor Blades :
   - Typically, HAWTs have two or three blades that are aerodynamically designed to optimize performance and efficiency. The shape of the blades is crucial as it helps in capturing the kinetic energy from the wind effectively.

2. Rotor Hub :
   - The rotor hub connects the blades to the main shaft. It is designed to withstand the forces exerted by the blades during operation.

3. Main Shaft :
   - The main shaft transfers the mechanical energy generated by the rotor to the gearbox or generator.

4. Gearbox :
   - The gearbox increases the rotational speed of the rotor to match the generator's operating speed. Some modern turbines use direct-drive systems to eliminate the gearbox, reducing maintenance needs.

5. Generator :
   - The generator converts the mechanical energy from the rotor into electrical energy. The type and size of the

generator are selected based on the expected power output.

6. Tower :
- The turbine is mounted on a tall tower to capture higher and more consistent wind speeds found at greater heights. Towers are typically made from steel or reinforced concrete.

7. Yaw Mechanism :
- This mechanism adjusts the direction of the turbine to face the wind, maximizing energy capture. It is crucial for the turbine's efficiency.

8. Control Systems :
- These systems include pitch control, which adjusts the angle of the blades to optimize performance and control rotor speed.

Elementary Design Principles for Wind Turbines

1. Wind Turbine Blade Design:
• Aerodynamics: The blades are designed to maximize aerodynamic efficiency usually with an airfoil shape. The curvature and twist of the blades help capture wind energy effectively.
• Material: Lightweight yet strong materials like fiberglass or carbon fiber are used to withstand aerodynamic forces and reduce weight.
2. Rotor Design:
• Diameter: The diameter of the rotor (or sweep area) affects the amount of wind energy captured. A larger diameter increases the swept area and thus the potential power output.
• Number of Blades: Commonly 2-3 blades are used. More blades can capture more wind energy but may increase drag and weight.
3. Tower Design:
• Height: Taller towers capture higher and more consistent wind speeds. The height is selected based on local wind conditions and logistical considerations.
• Material: Towers are typically made from steel or reinforced concrete, designed to support the rotor and withstand environmental forces.
4. Generator and Gearbox:
• Generator: Converts mechanical energy from the rotor into electrical energy. The type and size of the generator are chosen based on the expected power output.
• Gearbox: Increases the rotational speed of the rotor to match the generator's operating speed. Some modern turbines use direct-drive systems to eliminate the gearbox.

		5. Control Systems: • Yaw Mechanism: Adjusts the direction of the turbine to face the wind. This is crucial for maximizing energy capture. • Pitch Control: Adjusts the angle of the blades to control the rotor speed and optimize performance. - HAWTs generally have a higher efficiency in converting wind energy into electricity compared to other types of turbines. This efficiency is maximized by ensuring the turbine is oriented correctly to the wind direction. a horizontal axis wind turbine consists of several key components that work together to convert wind energy into electrical energy efficiently. The design principles focus on optimizing aerodynamics, rotor and tower design, and mechanical efficiency to harness wind power effectively.			
	b	Discuss working principle of KVIC biogas digester with sketch. Discuss the problems associated with biogas generation. The KVIC (Khadi and Village Industries Commission) biogas digester is a type of floating-dome digester designed for the anaerobic digestion of organic waste, particularly in rural settings. Its working principle involves several key steps: 1. Feedstock Input : Organic waste, such as cow dung, agricultural residues, or kitchen waste, is mixed with water to create a slurry. This mixture is fed into the digester. 2. Anaerobic Digestion : Inside the digester, anaerobic bacteria break down the organic matter in the absence of oxygen. This process generates biogas, primarily composed of methane (CH4) and carbon dioxide (CO2). 3. Gas Collection : The biogas produced rises to the top of the digester and collects in a flexible, floating gas holder. As more gas is produced, the holder rises, allowing for easy measurement of gas volume. 4. Digestate Management : The remaining material, known as digestate, is periodically removed from the digester. This nutrient-rich by-product can be used as a natural fertilizer or soil conditioner. 5. Utilization of Biogas : The collected biogas can be used for various applications, including cooking, heating, or generating electricity.	L2	CO3	10

Sketch of KVIC Biogas Digester

(Imagine a simple diagram here showing the following components:
- A cylindrical digester tank with an inlet for the slurry and an outlet for digestate.
- A floating dome on top to collect biogas.
- Pipes leading from the gas holder for biogas utilization.)

Problems Associated with Biogas Generation

While biogas generation has numerous benefits, several challenges can affect its efficiency and viability:

1. Feedstock Variability : The quality and composition of feedstock can vary significantly, impacting the efficiency of biogas production. Inconsistent feedstock can lead to fluctuations in gas output.

2. Technical Complexity : Biogas plants require careful management and monitoring of various parameters, such as temperature and pH, to ensure optimal digestion conditions. This complexity can lead to operational challenges.

3. Initial Costs : The setup and operational costs for biogas plants can be high, which may deter investment, especially in rural areas.

4. Space Requirements : Larger biogas digesters require significant space for installation, which can be a limitation in densely populated areas.

5. Maintenance Issues : Regular maintenance is essential to prevent equipment failure and ensure efficient operation. Poor maintenance can lead to reduced efficiency and increased operational costs.

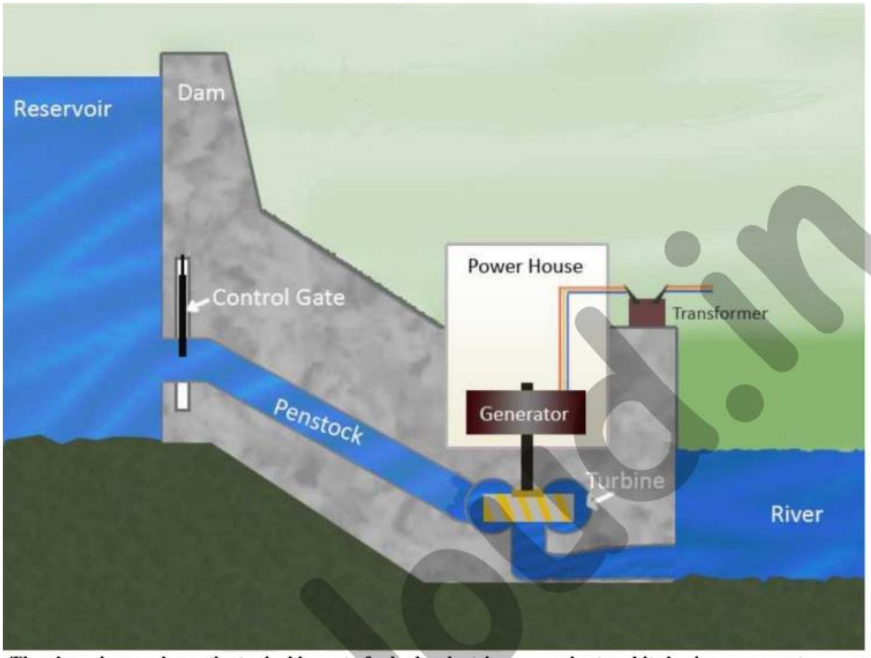
6. Safety Concerns : Methane is highly flammable, posing explosion risks if not handled correctly. Stringent safety measures are necessary to prevent leaks and ensure safe operation.

7. Digestate Management : The accumulation of digestate requires proper handling and disposal to avoid environmental pollution.

Overall, while KVIC biogas digesters offer a sustainable solution for waste management and energy production, addressing these challenges is crucial for their successful implementation and operation.

		Module -4 Download			
Q. 07	a	Discus need of hydrographs and flow duration curves with sketch. Describe general layout of hydro power plant with schematic diagram. Hydrographs and flow duration curves are essential tools in hydrology and water resource management, particularly for hydroelectric power plants. Need for Hydrographs and Flow Duration Curves: 1. Hydrographs : - A hydrograph is a graphical representation of the flow of water over time at a specific location, typically a river or stream. It helps in understanding the variability of water flow, which is crucial for planning and operating hydroelectric power plants. - Hydrographs provide insights into seasonal variations, peak flow periods, and low flow conditions, allowing engineers to design systems that can efficiently harness water energy throughout the year. 2. Flow Duration Curves (FDC) : - A flow duration curve is a plot that shows the relationship between the flow rate of a river and the percentage of time that flow is equaled or exceeded over a specified period. - FDCs are vital for assessing the reliability of water supply for power generation. They help in determining the capacity of a hydroelectric plant to meet energy demands during different flow conditions, ensuring that the plant can operate efficiently and sustainably. General Layout of a Hydroelectric Power Plant: The general layout of a hydroelectric power plant typically includes several key components, which can be illustrated in a schematic diagram. Here's a description of the layout:	L2	CO4	10

Layout and Working of Hydroelectric Power Plant



The above image shows the typical layout of a hydroelectric power plant and its basic components.

1. Dam :
   - Constructed across a river to create a reservoir. The dam raises the water level, creating potential energy.

2. Reservoir :
   - The body of water stored behind the dam. It serves as a water supply for power generation and can also provide benefits like flood control and irrigation.

3. Control Gate :
   - Located at the dam, it regulates the flow of water from the reservoir to the penstock. By adjusting the gate, operators can control the amount of water released to the turbines.

4. Penstock :
   - A large pipe that carries water from the reservoir to the turbines. The pressure of the water flowing through the penstock drives the turbines.

5. Turbine :
   - Converts the kinetic energy of flowing water into mechanical energy. The type of turbine used (Francis, Kaplan, or Pelton) depends on the height of the water head and flow conditions.

6. Generator :
   - Connected to the turbine, it converts mechanical energy into electrical energy. The generator produces electricity that is then transmitted to the power grid.

		7. Tailrace : - The channel or pipe that carries water away from the turbine after it has passed through, returning it to the river downstream..			
	b	The mean monthly discharge for 12 months at a particular site of the river is tabulated below, Discharge in million's m^3 per month. Draw: (i) Hydrograph for the given discharge and find the average monthly flow.(ii) The power available at mean flow of water if the available head is 80 m at the site and overall efficiency of the generation is 80 %. Take 30 days in a month.	L2	CO4	10

OR

Q. 08 a

The mean monthly discharge for 12 months at a particular site of a river is tabulated below:

Month	Discharge in millions m^3 per month	Month	Discharge in millions m^3 per month
January	80	J	150
F	50	A	200
M	40	S	250
A	20	O	120
M	0	N	100
J	100	D	80

Draw:

(a) Hydrograph for the given discharge and find the average monthly flow

(b) The power in MW available at mean flow of water if the available head is 100 meters at the site and overall efficiency of the generation is 80 %. Take 30 days in a month

L2 CO4 10

b

Discuss advantages and disadvantages of hydroelectric power plant. Explain working of pumped storage power plant with schematic diagram

Hydroelectric power plants offer several advantages and disadvantages, which are important to consider when evaluating their role in renewable energy generation.

Advantages of Hydroelectric Power Plants:

1. Renewable Energy Source : Hydropower is sustainable as it relies on the natural water cycle, which is continuously replenished by precipitation.
2. Low Operating Costs : Once constructed, the operational and maintenance costs are relatively low compared to other energy sources.
3. Clean Energy : Hydroelectric power produces no direct emissions of greenhouse gases or pollutants, making it an environmentally friendly option.
4. Reliable and Efficient : Hydropower plants can provide a consistent and reliable source of energy, often with high efficiency rates.
5. Multipurpose Use : Dams can also serve for flood control, irrigation, and water supply for domestic and industrial use.
6. Long Lifespan : These plants generally have long operational lifespans, often exceeding 50 years.

L2 CO4 10

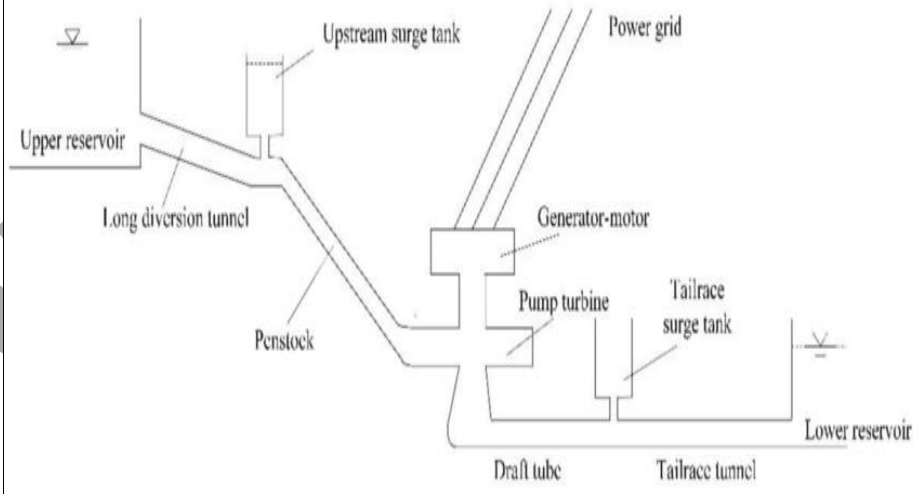
Disadvantages of Hydroelectric Power Plants:

1. Environmental Impact : The construction of dams can disrupt local ecosystems, affecting fish migration, water quality, and wildlife habitats.
2. High Initial Costs : The construction of hydroelectric plants requires significant upfront investment, including costs for dam construction and infrastructure.
3. Dependence on Water Availability : Hydropower generation is reliant on water availability, which can be affected by seasonal variations and climate change.
4. Displacement of Communities : Reservoir creation can lead to the displacement of local communities and loss of arable land.
5. Limited Suitable Locations : Suitable sites for hydroelectric plants are geographically constrained to areas with sufficient water flow and topographical features.
6. Potential for Catastrophic Failure : Although rare, dam failures can have catastrophic consequences.

Working of Pumped Storage Power Plant:

Pumped storage plants are a unique type of hydroelectric power generation facility designed to store and generate electricity to meet varying demand. Here's how they work:

1. Pumping Mode :



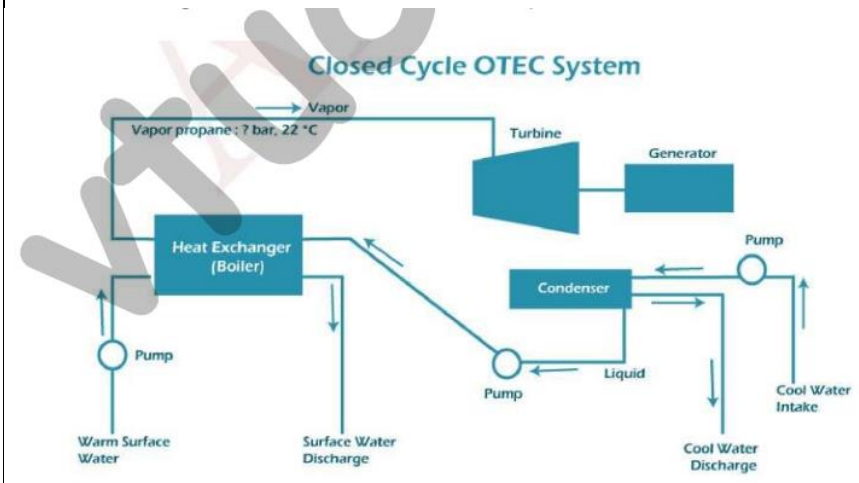
- During periods of low electricity demand, excess power (often from renewable sources like wind or solar) is used to pump water from a lower reservoir to an upper reservoir.
- This process stores energy in the form of gravitational potential energy in the water at the higher elevation.

2. Generation Mode :

		- During peak electricity demand, the stored water is released from the upper reservoir, flowing down through turbines to generate electricity. • This is unique design of peak load plants. Here two types of water pond is used, called upper head water pond and tail water pond. • Two water ponds are connected each other by a penstock. Main generating pumping plant is lower end. During the off load period, surplus energy of this plant is utilized to pumping the lower head pond water to upper head pond water. • This extra water is used to generate energy at pick load periods. By doing this arrangement, same water is used again and again. Extra water is required only to take care of evaporation and seepage. This system allows for efficient energy storage and quick response to changes in electricity demand, making pumped storage an essential component of modern energy management.			
		Module -5			
Q. 09	a	Explain the working principle of ocean thermal energy conversion (OTEC) Plant Name power plant installed in the world based on ocean thermal energy. Ocean Thermal Energy Conversion (OTEC) is an innovative process that generates electricity by utilizing the temperature difference between warm surface ocean water and cold deep ocean water. Here's how an OTEC plant works: 1. Warm Surface Water : Warm water from the ocean surface, typically between 25°C and 30°C, is pumped through a heat exchanger. In this exchanger, it heats a working fluid with a low boiling point, such as ammonia or a refrigerant. 2. Evaporation : The working fluid evaporates into gas due to the heat from the warm water. This gas expands and drives a turbine connected to a generator, producing electricity. 3. Cold Deep Water : Cold water, drawn from depths of	L2	CO4	10

around 1000 meters where the temperature is approximately 4°C to 5°C, is pumped through another heat exchanger. This cold water cools and condenses the vapor of the working fluid back into a liquid.

4. Recirculation : The condensed working fluid is recirculated back to the evaporator to repeat the cycle.



As for OTEC plants installed around the world, a notable example is the plant in Hawaii, which has a capacity of 103 kW and is one of the oldest installations, established in 1979. Other locations include Martinique and Nauru, showcasing the potential of this technology, although they face challenges such as high initial costs and environmental concerns.

OTEC not only generates energy but can also produce fresh water as a byproduct, which is particularly beneficial for arid regions. However, it is essential to consider the environmental impacts and technical complexities involved in implementing these plants.

	b	Discuss in brief geothermal energy resources. Describe a vapour dominated hydrothermal type geothermal power plant.	L2	CO4	10

Geothermal energy refers to the thermal energy stored within the Earth, which can be utilized for electricity generation and direct applications. Geothermal resources are primarily classified into three types: hydrothermal resources, geopressured resources, and hot dry rock (HDR) resources.

1. Hydrothermal Resources : These are the most commonly exploited and consist of hot water and steam in permeable

		rock formations. They are divided into: - High-Temperature Hydrothermal Resources : These have temperatures exceeding 150°C and are associated with active volcanic regions. They are primarily used for electricity generation. - Low-Temperature Hydrothermal Resources : These have temperatures below 150°C and are used for direct applications such as district heating, greenhouses, and industrial processes. 2. Geopressured Resources : These are found at great depths and under high pressure, often associated with natural gas deposits that can be co-produced with geothermal energy. 3. Hot Dry Rock (HDR) Resources : These are found in dry rock formations with high heat content but low natural permeability. They require artificial stimulation, such as hydraulic fracturing, to create a reservoir of hot water or steam. Now, regarding a vapor-dominated hydrothermal geothermal power plant, its operation is based on the use of steam extracted from a geothermal reservoir. Here's a brief explanation of its functioning: - Generation Process : In a vapor-dominated plant, steam is extracted directly from the geothermal reservoir and used to drive a steam turbine. This steam, which can reach temperatures of up to 150°C, expands in the turbine, generating electricity. - Condensation : After passing through the turbine, the steam is cooled in a condenser, where it is converted back into water. This condensate is reinjected into the geothermal reservoir to maintain pressure and sustainability of the system. - Advantages : This type of plant is efficient and can operate continuously, providing a reliable energy source with low greenhouse gas emissions. geothermal energy, especially through vapor-dominated hydrothermal plants, represents a sustainable and efficient option for electricity generation, harnessing the Earth's natural heat.			
		OR			
Q. 10	a	Describe construction and working principle of geothermal energy with schematic Diagram	L2	CO4	10

Construction and Working Principle of Geothermal Energy

Geothermal energy harnesses the heat stored within the Earth, and its construction and working principle are quite intriguing. Here's a detailed overview along with a basic schematic diagram to illustrate the process.

Construction of a Geothermal Plant

1. Drilling Well : A deep well is drilled into the ground to access hot water or steam reserves located underground. This well can be vertical or, in some cases, horizontal.

2. Piping System : Pipes are installed to facilitate the circulation of water. These pipes carry cold water down to the bottom of the well, where it is heated by contact with hot rocks.

3. Power Generation System : At the surface, there is a power plant that includes a turbine, a generator, and a condenser. The plant converts steam or hot water into electricity.

4. Reinjection System : After the steam has passed through the turbine, it is cooled and condensed back into water, which is then reinjected into the well to be heated again, thus closing the cycle.

Working Principle

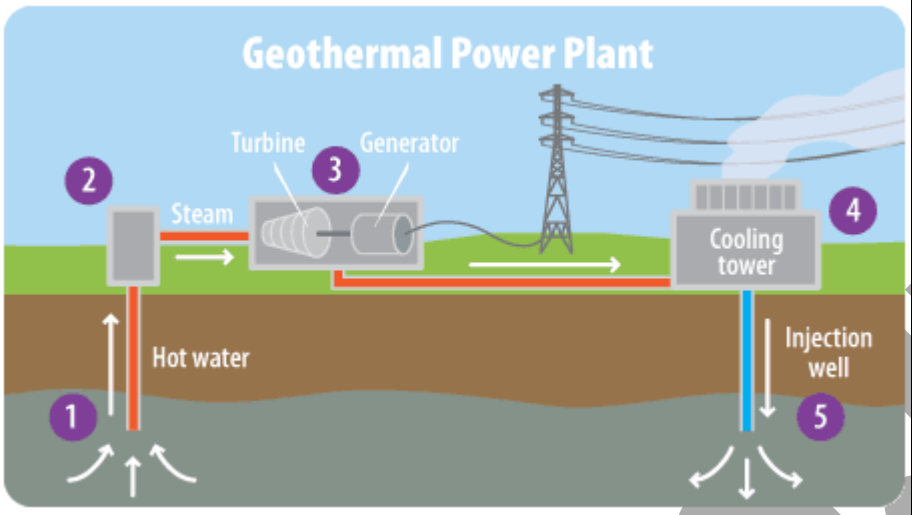
1. Heat Extraction : Cold water is injected into the well, where it is heated by contact with the hot rocks or underlying magma.

2. Steam Generation : The hot water rises to the surface, where it can be used directly for heating or to generate steam.

3. Turbine and Generator : The steam is used to turn a turbine connected to a generator, producing electricity.

4. Reinjection : The water that has passed through the turbine is cooled and reinjected into the well, completing the cycle.

Basic Schematic



Geothermal energy is a renewable and sustainable energy source that utilizes the heat from within the Earth. Its construction involves drilling wells and installing piping systems, while its operation is based on converting heat into electricity through a closed reinjection cycle. This technology is efficient and has a lower environmental impact compared to fossil fuel energy sources.

	b	Discuss advantages and disadvantages of geothermal energy. Describe a hot dry rock geothermal resource power plant	L2	CO4	10

Geothermal energy has several advantages and disadvantages that are important to consider when evaluating its viability as a renewable energy source.

Advantages of Geothermal Energy:

1. Renewable and Sustainable: Geothermal energy is derived from the Earth's internal heat, which is continuously replenished by natural processes. This makes it a sustainable and reliable energy source over the long term.

2. Low Greenhouse Gas Emissions: Geothermal power plants produce minimal greenhouse gases compared to fossil fuel-based plants, contributing to the reduction of climate change.

3. Base Load Power: Unlike solar and wind energy, which

are intermittent, geothermal energy can provide a constant and reliable supply of power, making it suitable for base load electricity generation.

4. Low Operating Costs: Once established, a geothermal power plant has relatively low operating and maintenance costs compared to fossil fuel plants, as the "fuel" (heat from the Earth) is free.

5. Minimal Land Footprint: Geothermal power plants require less space compared to large solar or wind farms, making them suitable for locations with limited available land.

6. Direct Use Applications: Geothermal energy can be used directly for heating applications, such as district heating, greenhouse heating, and industrial processes, without needing to convert it 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, which can be a barrier to entry.

2. Site Specific: Geothermal resources are geographically specific. Not all locations have accessible and economically viable geothermal resources, limiting their applicability.

3. Environmental and Structural Risks: Geothermal energy extraction can lead to land subsidence, induced seismicity (earthquakes), and the release of trace gases from geothermal reservoirs. These risks need to be carefully managed.

4. Resource Depletion: If not managed properly, geothermal resources can become depleted or experience a decrease in productivity over time. Sustainable management practices are required to prevent this.

5. Limited to Certain Areas: Effective geothermal energy production is often limited to regions with high geothermal activity, such as volcanic areas or tectonic plate boundaries.

Description of a Hot Dry Rock Geothermal Resource Power Plant:

Hot Dry Rock (HDR) geothermal resources, also known as

		Enhanced Geothermal Systems (EGS), are found in dry rock formations with high heat content but low natural permeability. To make these resources usable, several techniques are employed: 1. Characteristics: HDR resources consist of high-temperature rock (above 150°C or 302°F) with low natural permeability. 2. Techniques: - Hydraulic Fracturing: This involves creating artificial fractures in the rock to enhance fluid flow. - Hydrothermal Stimulation: Water is injected 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-Forêts fields. 4. Usage: HDR systems have potential for both electricity generation and direct use applications, although commercial viability is still developing. geothermal energy, particularly through Hot Dry Rock resources, offers significant potential as a renewable energy source, but it also faces considerable challenges that need to be addressed for effective implementation.			

Bloom's Taxonomy Level: Indicate as L1, L2, L3, L4, etc. It is also desirable to indicate the COs and POs to be attained by every bit of questions.