

SOLAR ENERGY

1. State the advantages and disadvantages of flat plate collectors over concentrated collectors.

Advantages of Flat plate collector:

- a. *Of using both beam and diffuse solar radiations*
- b. *They do not require orientation towards the sun*
- c. *They require little maintenance.*
- d. *Mechanically simpler than the concentrating reflectors, absorbing surfaces and orientation devices of focusing collectors.*

Disadvantages of Flat plate collector:

- e. *Limited to low temperature applications such as household water heating.*

2. What are the main components of a flat plate collector? Explain the function of each part.

Basic Components of Flat plate collectors:

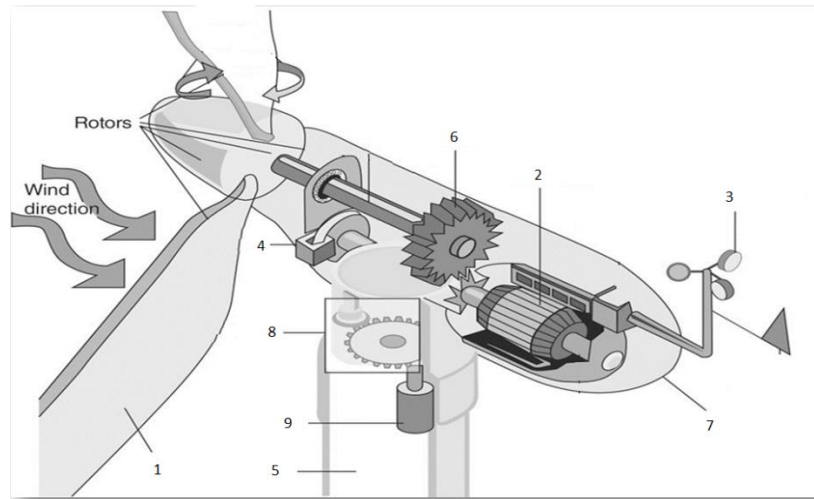
- a. *A transparent cover which may be one or more sheets of glass or radiation transmitting plastic film or sheets.*
- b. *Tubes, fins, passages or channels are integrate with the collector absorber plate or connected to it, which carry the water, air or other fluids*
- c. *The absorber plate, normally metallic or with a black surface although a wide variety of other materials can be used with air heaters.*
- d. *Insulation, which should be provided at the back and sides to minimize the heat losses. (fiberglass or foam)*
- e. *The casing or container which enclose the other components and protects them from the weather.*

3. Why we need concentrating collectors. Explain the advantages and disadvantages with respect to flat plate collector:

- a. *Focusing Collector is a device to collect solar energy with high intensity of solar radiation on the energy absorbing surface. Optical system in the form of reflectors or refractors are used.*
- b. *A focusing collector is a special form of flat plate collector modified by introducing a reflecting surface between the solar radiators and absorber.*
- c. *Radiation increases from low value of 1.5-2 to high values of the order of 10,000.*
- d. *Radiation falling on a relatively large area, is focused on to a receiver (or absorber) of considerably smaller area.*
- e. *Fluid can be heated to temperature of 5000C or more.*

WIND ENERGY

4. Compare maximum possible efficiency of hydroelectric and wind energy systems. What is the main reason of these upper limits?
5. Describe the physics of blade in wind turbine system. Show the applied forces on the blade and describe how the blade geometry effect energy absorption.
6. What are the functions of gearbox and generator in a wind energy conversion system?
7. Write the names of components numbered in the figure.



8. Most of the industrial scale wind turbines has 3 blade design. Why engineers prefer three blade designs?
9. With a suitable block diagram, explain the functions of different components of horizontal axis wind energy conversion systems.
 - a. **Blades:** These are aerodynamically designed structures such that when wind flows over them they are lifted as in airplane wings. The blades are also slightly turned for greater aerodynamic efficiency.
 - b. **Brake:** This is either a mechanical, electrical or hydraulic brake used for stopping the turbine in high wind conditions.
 - c. **Controller:** This is the most important part of the turbine as it controls everything from power output to pitch angle. The controller senses wind speed, wind direction, shaft speed and torque at one or more
 - d. **Gear box:** This steps-up or steps down the speed of turbine and with suitable coupling transmits rotating mechanical energy at a suitable speed to the generator. Typically a gear box system steps up rotation speed from 50 to 60 rpm to 1200 to 1500 rpm.
 - e. **Generator:** This can be a synchronous or asynchronous Ac machine producing power at 50Hz.
 - f. **High-speed shaft:** Its function is to drive the generator.
 - g. **Low-speed shaft:** The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.
10. Explain the working of a wind energy conversion system for Generation of electricity.

Horizontal-axis wind turbines (HAWT) get their name from the fact that their axis of rotation is horizontal. They have the main rotor shaft and electrical generator at the top of a tower, and are pointed into the wind. The variability of wind distribution and speed brings up the requirement of a gear system connected to the rotor and the generator. The gear system enables a constant speed of rotation to the generator thus enabling constant frequency generation. Turbine blades are made stiff in order to prevent the blades from being pushed into the tower by high winds. Down wind machines have also been built, as they no longer require a yaw mechanism to keep them facing the wind, and also because in high winds the blades can turn out of the wind thereby increasing drag and coming to a stop. Most of the HAWTs are upwind as downwind systems cause regular turbulence which may lead to fatigue.
11. Describe the Weibul distribution. Why we need this probabilistic mathematical function for wind power calculations?
12. Suppose two wind turbines are built: A at a hub height of 10 m and B at a hub height of 100 m at a location having an open flat terrain with no obstacles such as trees. What is the power ratio for turbines A and B assuming both have the same power coefficient C_P ? Assume that the wind obeys Hellmann function with $\alpha=0.14$.

13. Calculate the power per square meter in a wind if the wind is flowing with a speed of 3m/s and 10 m/s.
14. Calculate the required blade length for a 5 MW wind turbine if the average wind speed is 8 m/s for the region and power coefficient (C_p) of the wind turbine is 0.40.
15. Calculate the rotational speed of a cup anemometer with respect to the wind speed. Assume that $C_d= 1.3$ if the cup's concave side is facing the wind and $C_d= 0.34$, for convex side is facing the wind.

HYDROELECTICITY

16. Describe the types of turbines in hydroelectric power plants. Which types are suitable for which type of flow regimes?
17. Explain the types of hydroelectric power plants.
18. There is a pool on top of 8 floor building. Every floor and the pool has a height of 3 meters. The building base area is 100m^2 .
 - a. What is the potential energy of the water with respect to the ground if the pool is full of with water?
 - b. If we use a turbine to convert the energy to the electricity, what is the price of the generated electricity if we sell it directly to the grid? Assume that the price is equivalent to the current household electricity price.
19. A dam is constructed in front of Firat river. As a result of dam construction, a head of 170 meter is available for the energy generation. Assume that the river has a flow rate of $360\text{m}^3/\text{s}$. Calculate the power generation potential of the dam by assuming reasonable efficiency values for the penstock, turbine and electrical generator.

TIDAL ENERGY/ OCEAN/WAVE

20. Describe the types of tidal energy generation systems.
21. What is the minimum head requirement to build an efficient tidal power plant?
22. Discuss the technical differences of tidal turbines and the wind turbines.
23. Explain the types of OTEC systems.

Cold seawater is an integral part of each of the three types of OTEC systems: closed-cycle, open-cycle, and hybrid. To operate, the cold seawater must be brought to the surface. The primary approaches are active pumping and desalination. Desalinating seawater near the sea floor lowers its density, which causes it to rise to the surface.

 - a. *Closed-cycle systems use fluid with a low boiling point, such as ammonia, to power a turbine to generate electricity. Warm surface seawater is pumped through a heat exchanger to vaporize the fluid. The expanding vapor turns the turbo-generator. Cold water, pumped through a second heat exchanger, condenses the vapor into a liquid, which is then recycled through the system.*
 - b. *Open-cycle OTEC uses warm surface water directly to make electricity. Placing warm seawater in a low-pressure container causes it to boil. In some schemes, the expanding steam drives a low-pressure turbine attached to an electrical generator. The steam, which has left its salt and other contaminants in the low-pressure container, is pure fresh water. It is condensed into a liquid by exposure to cold temperatures from deep-ocean water. This method produces desalinated freshwater, suitable for drinking water or irrigation.*
24. In the black sea average wave height is 1 meter and wave duration is 18 hours per/day. If the wave energy conversion device has a 20% efficiency, and an average home spends 10 kWh energy per day, how many kilometers of the shore should be covered with wave energy device to generate all the energy of Rize which has approximately 100.000 houses?
25. Describe the wave energy. What kind of devices can be used to use it.

Wave power is the transport of energy by ocean surface waves, and the capture of that energy to do useful work for example, electricity generation, water desalination, or the pumping of water (into reservoirs). Machinery able to exploit wave power is generally known as a wave energy converter (WEC). Wave power is distinct from the diurnal flux of tidal power and the steady gyre of ocean currents.

Oscillating water column devices:...

Wave activated bodies:...

Overtopping devices:...

GEOTHERMAL ENERGY

26. What are the direct and indirect use of geothermal energy?

27. Explain the nature of geothermal energy?

Geothermal energy has its origin in the molten core of the earth, where temperatures are about 4000°C (7200°F) nature's own boiler. This thermal energy is produced primarily by the decay of radioactive materials within the interior, leading some people to refer to geothermal energy as a form of "fossil nuclear energy." The interior of the earth is thought to consist of a central molten core surrounded by a region of semifluid material called the mantle.

28. Describe the internal structure of the earth? Explain briefly.

Core: The core extends out to half the Earth's radius (6400 km) and is made mostly of iron (80%) and nickel (20%), whose inner half (by radius) is solid and whose outer half is liquid. This iron and nickel core is the source of the Earth's magnetic field, which is believed to be created by electric currents in the core.

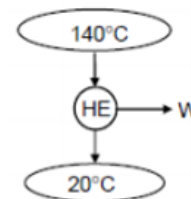
Mantle: The mantle makes up most of the rest (83%) of the Earth's volume and made mostly of rocky material, whose inner part is semi-rigid and whose outer and cooler part is plastic and, therefore, can flow (think lava).

Crust: The crust is the outermost thin layer (1% of the Earth's volume), whose average thickness is 15 km. The crustal thickness ranges from a high of 90 km under continental mountains to as little as 5 km under some parts of the oceans. On a scale where the Earth is the size of a soccer ball, the crust would be a mere 0.25 mm thick.

29. Explain in the main types of geothermal power plants.

- a. **Flash Steam Plants:** In the flash type of power plant, high-pressure water comes up from the production well and vaporizes (flashes) when its pressure is reduced to produce a flow of steam that drives a turbine, which then generates electricity. These types are the most common due to the lack of naturally occurring high-quality steam. In this method, water must be over 180°C, and under its own pressure it flows upwards through the well
- b. **Dry Steam Plants:** The dry steam type (not depicted) is similar to the flash type, but without the first step, since the dry steam directly coming up from the production well directly drives the turbine. This type of plant is rare because it is generally used in very high-gradient locations where steam spontaneously rises out of the production well.
- c. **Binary Cycle Plants:** Binary cycle power plants involve one additional step in the process. For these plants, high-temperature fluid coming up from a production well passes through a heat exchanger in which the secondary loop contains a low-boiling point liquid such as butane or pentane, which can vaporize at a lower temperature than water. This added step allows such plants to generate electricity at much lower temperatures than the other types.

30. An innovative way of power generation involves the utilization of geothermal energy. The energy of hot water that exists naturally underground as the heat source. If a supply of hot water at 140°C is discovered at a location where the environmental temperature is 20°C, determine the maximum thermal efficiency a geothermal power plant built at that location can have.



$$\eta_{th,max} = \eta_{th,C} = 1 - \frac{T_L}{T_H} = 1 - \frac{20 + 273K}{140 + 273K} = \% 29.1$$

Notes:

*Also check the worksheet for the midterm.

*Final exam will cover all the subjects including solar energy and fundamental energy concepts that we discussed through the semester.