Module:3 Renewable Energy Resources

SOLAR ENERGY

1. Basics of Solar Energy

The amount of sunlight that strikes the earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year. Solar technologies convert sunlight into electrical energy either through photovoltaic (PV) panels or through mirrors that concentrate solar radiation. This energy can be used to generate electricity or be stored in batteries or thermal storage.

Photovoltaics Basics

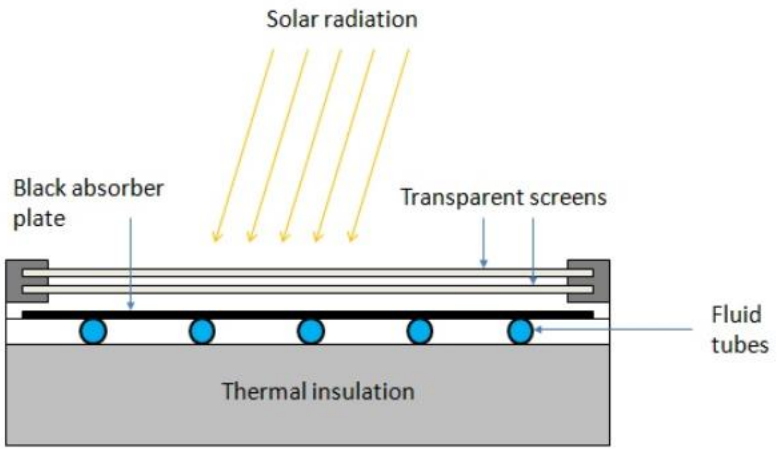
When the sun shines onto a solar panel, energy from the sunlight is absorbed by the PV cells in the panel. This energy creates electrical charges causing electricity to flow.

Concentrating Solar-Thermal Power Basics

Concentrating solar-thermal power (CSP) systems use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat, which can then be used to produce electricity or stored for later use. It is used primarily in very large power plants.

2. Flat Plate Collector

The flat-plate solar collectors are probably the most fundamental and most studied technology for solar-powered domestic hot water systems. The Sun heats a dark flat surface, which collect as much energy as possible, and then the energy is transferred to water, air, or other fluid for further use. The heat collected is then used for heating water for bathing, washing etc.



The main components of a typical flat-plate solar collector are:

- Black surface (Aluminium /Copper) - absorbent of the incident solar energy
- Glazing cover - a transparent layer that transmits radiation to the absorber, but prevents radiative and convective heat loss from the surface
- Tubes containing heating fluid to transfer the heat from the collector
- Support structure to protect the components and hold them in place
- Insulation covering sides and bottom of the collector to reduce heat losses

3. Solar Pond

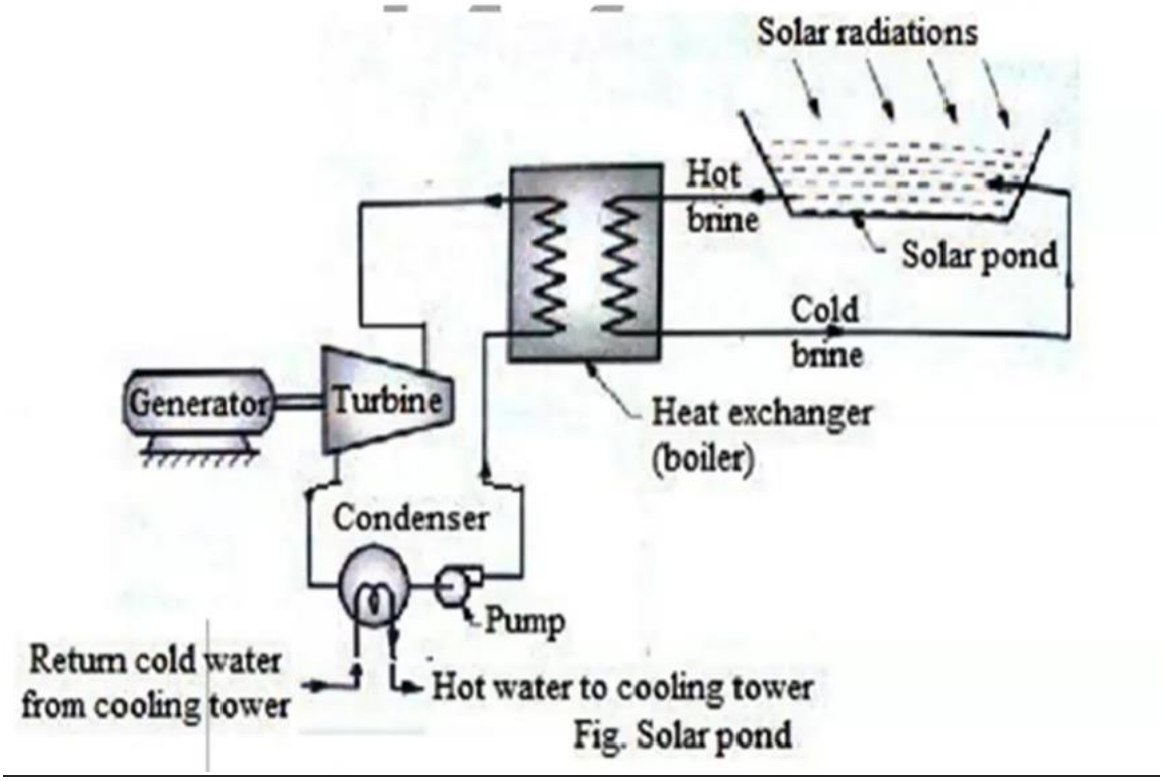


Fig. Solar pond

Solar pond is a human-made body of salt water that collects and stores solar energy, thereby providing a sustainable source of heat and power.

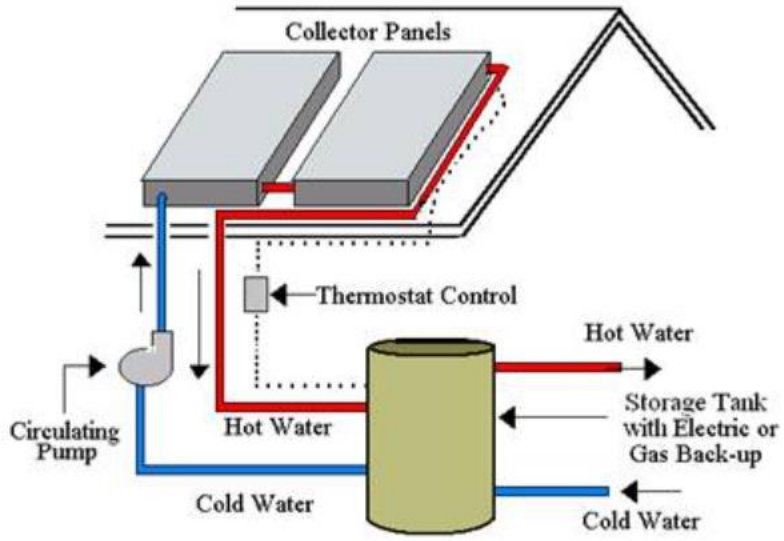
In freshwater ponds, the Sun heats the water, and the hot water rises. The water cools through evaporation as the heat is released to the atmosphere, keeping the pond water at atmospheric temperature. Solar pond technology, on the other hand, attempts to prevent the loss of heat from water through the use of salt, the concentration of which increases with depth.

The more common non-convecting solar pond reduces heat loss by preventing convection (the transfer of heat from one place to another by the movement of fluids) with the addition of a concentration of 20–30 percent salt to the bottom level (lower convective zone) of the pond.

When saturated with high amounts of salt in the form of concentrated brine, the temperature of the bottom level rises to about 100 °C (212 °F) as heat from the Sun is trapped. The middle level (non-convective zone) receives a lower amount of salt than the bottom level. Because it is lighter than the bottom level but heavier than the top level, the water in the middle level is unable to rise or sink. The middle level, therefore, halts convection currents and acts as an insulator, trapping sunlight in the bottom level. In the top level (upper convective zone), where there is little salt, the water remains cold. Fresh water is added to that level, and saline water is drained. Finally, heat from the bottom level is transferred to pipes circulating through the pond to extract thermal energy.

Heat generated by solar ponds has many applications and can cut down on the use of fossil fuels. The heat extracted from the pond enables the production of chemicals, food, textiles, and other industrial products. Heat from the pond can also be used to warm greenhouses, swimming pools, and livestock buildings. The heat can be converted to electricity also.

4. Solar Water Heater



Solar water heating system is a device that uses solar energy to heat water for domestic, commercial, and industrial needs.

Parts of the Solar Water Heating System

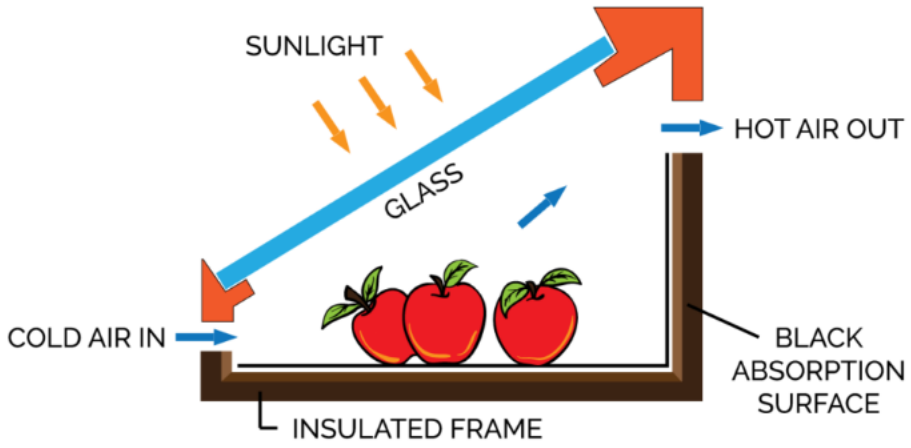
- A solar water heating system consists of a flat plate solar collector, a storage tank kept at a height behind the collector, and connecting pipes.
- The collector usually comprises copper tubes welded to copper sheets (both coated with a highly absorbing black coating) with a toughened glass sheet on top and insulating material at the back. The entire assembly is placed in a flat box.

Working of a solar water heater

- The system is generally installed on the roof or open ground, with the collector facing the sun and connected to a continuous water supply.
- Water flows through the tubes, absorbs solar heat and becomes hot.
- The heated water is stored in a tank for further use.
- The water stored in the tank remains hot overnight as the storage tank is insulated and heat losses are small.

5. Solar Dryer

Solar dryers are devices that use solar energy to dry substances, especially food. Solar dryers use the heat from sun to remove the moisture content of food substances.



The black surface heats incoming air rather than directly heating the substance to be dried. This heated air is then passed over the substance to be dried and exits upwards often through a chimney, taking moisture released from the substance with it.

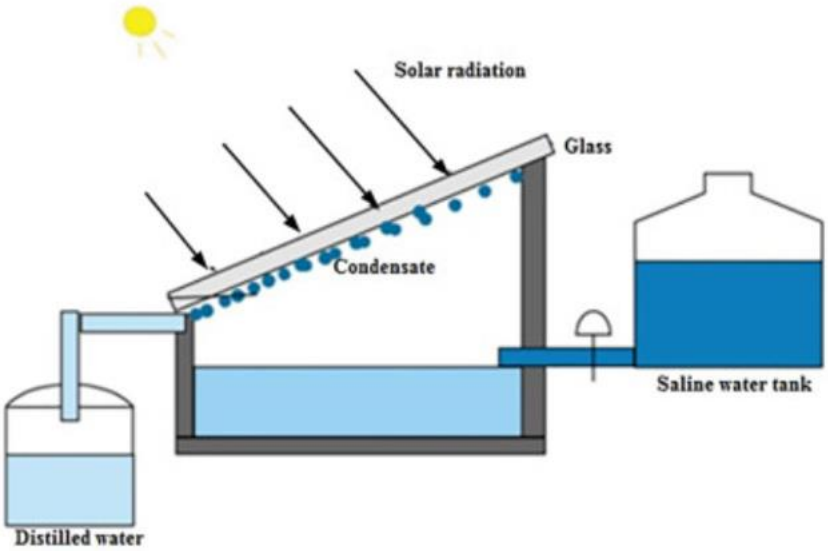
Solar drying is mostly carried out between 50-70 degree Celsius. Solar dryers not only make the drying faster, it also prevents dust, pathogens, bird droppings, and interference of external agents that affect the quality of the food. Food items such as fruits, vegetables, spices and other items once dried in solar can be stored for longer period of time.

5. Solar Still

A **solar still** is an arrangement to separate pure water from sea water by evaporation using solar energy.

This technology is based on the simple evaporation-condensation principle by the virtue of which the sun evaporates the sea-water and then condenses it to culminate into pure water. Saline water is fed into the tank which is exposed to the sun. The black bottom of the tank absorbs solar energy and gets heated. The heat evaporates the tank water which condenses on the glass sheet

and finally converts into drops of pure drinking water. This purified water collects in the channel running through a tap. Hence, you get clean hygienic drinking water by simply turning on the tap and storing this water for further usage. The average output of the still is 2 to 3 litres of drinking water per day per square metre of the area.



BIOMASS

Biomass is renewable organic material that comes from plants and animals. Biomass is an important fuel in many countries, for cooking, heating and power generation.

Biomass contains stored chemical energy from the sun. Plants produce biomass through photosynthesis. Biomass can be burned directly for heat or converted to renewable liquid and gaseous fuels through various processes.

Biomass sources for energy include:

- Wood and wood processing wastes—firewood, wood pellets, and wood chips, lumber and furniture mill sawdust and waste, and black liquor from pulp and paper mills
- Agricultural crops and waste materials—corn, soybeans, sugar cane, switchgrass, woody plants, and algae, and crop and food processing residues
- Biogenic materials in municipal solid waste—paper, cotton, and wool products, and food, yard, and wood wastes
- Animal manure and human sewage

1. Converting biomass to energy

Biomass is converted to energy through various processes, including:

- Direct combustion (burning) to produce heat
- Thermochemical conversion to produce solid, gaseous, and liquid fuels

- Chemical conversion to produce liquid fuels
- Biological conversion to produce liquid and gaseous fuels

Direct combustion: All biomass can be burned directly for heating buildings and water, for industrial process heat, and for generating electricity in steam turbines.

Thermochemical conversion of biomass includes *pyrolysis* and *gasification*.

(i) Pyrolysis involves heating organic materials to 800–900ºF (400–500 ºC) in the near complete absence of free oxygen. Biomass pyrolysis produces fuels such as charcoal, bio-oil, renewable diesel, methane, and hydrogen.

(ii) Gasification involves heating organic materials to 1,400–1700ºF (800–900ºC) with injections of controlled amounts of free oxygen and/or steam into the vessel to produce a carbon monoxide and hydrogen rich gas called synthesis gas or syngas*. Syngas can be used as a fuel for diesel engines, for heating, and for generating electricity in gas turbines.*

Chemical conversion process known as *transesterification* is used for converting vegetable oils, animal fats, and greases into fatty acid methyl esters (FAME), which are used to produce biodiesel.

Biological conversion includes fermentation to convert biomass into ethanol and anaerobic digestion to produce renewable natural gas. Ethanol is used as a vehicle fuel. Renewable natural gas—also called *biogas* or *biomethane*—is produced in anaerobic digesters at sewage treatment plants and at dairy and livestock operations. Properly treated renewable natural gas has the same uses as fossil fuel natural gas.

WIND ENERGY

Wind power or wind energy is mostly the use of wind turbines to generate electricity.

There is now 743 GW of wind power capacity worldwide, helping to avoid over 1.1 billion tonnes of CO_2 globally – equivalent to the annual carbon emissions of South America.

However, the current rate of wind power deployment will not be enough to achieve carbon neutrality by the middle of this century, and urgent action must be taken by policymakers now to scale up wind power at the necessary pace.

India has been the fourth largest wind energy generator. The country has a cumulative installed capacity of 39 GW approximately till March 2021.

1. Advantages of wind energy
• Wind is a reliable and infinite renewable energy resource
• Wind energy is cost effective
• Wind energy reduces carbon emissions when used instead of fossil fuels

• Few running costs when the turbines are up and running.
• Offshore wind farms can take advantage of offshore wind flow, without affecting the landscape view.

2. Disadvantages of wind energy
• Wind energy can be unpredictable as the amount of electricity generated is dependent on the speed and direction of the wind
• Wind farms can affect the visual appearance of the landscape
• Wind turbines can damage the habitats of birds and marine life.
• Wind farms can be expensive to construct

HYDROGEN ENERGY

Hydrogen gas is used in fuel cells to generate electricity. A fuel cell is a device that combines hydrogen with oxygen from the air in an electrochemical reaction to create electricity, which can power an electric motor and propel a vehicle. Fuel cells are twice as energy-efficient as combustion engines, and the hydrogen used to power them can come from a variety of sources, including renewable energy resources. A hydrogen fuel cell emits only heat and water, without producing any air pollutants or greenhouse gases. Hydrogen fuel cell is mainly used in,

- Automobiles
- Petroleum refining
- Semiconductor manufacturing
- Aerospace applications
- Fertilizer production
- Welding, annealing and heat-treating metals
- Pharmaceuticals

TIDAL ENERGY

Tidal energy is a form of power produced by the natural rise and fall of tides caused by the gravitational interaction between Earth, the sun, and the moon. Tidal currents with sufficient energy for harvesting occur when water passes through a constriction, causing the water to move faster. Using specially engineered generators in suitable locations, tidal energy can be converted into useful forms of power, including electricity.

The predominant application for tidal energy has been the generation of electricity. There is also potential value in tidal energy to serve the needs of other existing or emerging ocean industries (e.g., aquaculture, ocean mineral mining, oceanographic research, or military missions).