UNIT 01 : SOLAR THERMAL SYSTEMS

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What is Renewable Energy?

Renewable energy uses energy sources that are continually replenished by nature—the sun, the wind, water, the Earth's heat, and plants.

Renewable energy technologies turn these fuels into usable forms of energy—most often electricity, but also heat, chemicals, or mechanical power.

Energy Sources:

Any physical activity in this world, whether carried out by human beings or by nature, is cause due to flow of energy in one form or the other. The word 'energy' itself is derived from the Greek word 'en-ergon', which means 'in-work' or 'work content'. The work output depends on the energy input.

Energy can be classified into several types based on the following criteria:

- Primary and Secondary energy
- Commercial and Non commercial energy
- Renewable and Non-Renewable energy
- Conventional and Non-conventional energy

1. Primary and Secondary Energy:

Primary energy sources are those that are either found or stored in nature. Common primary energy sources are coal, oil, natural gas, and biomass (such as wood). Other primary energy sources available include nuclear energy from radioactive substances, thermal energy stored in earth's interior, and potential energy due to earth's gravity.

Primary energy sources are costly converted in industrial utilities into secondary energy sources; for example coal, oil or gas converted into steam and electricity. Primary energy can also be used directly. Some energy sources have non energy uses, for example coal or natural gas can be used as a feedstock in fertilizer plants.

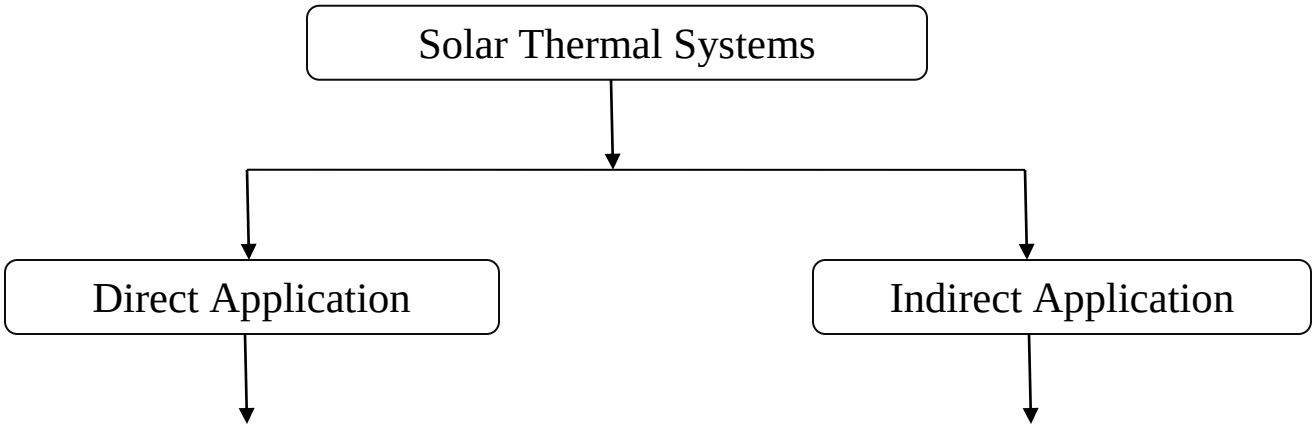
2. Renewable and Non-Renewable Energy:

Renewable energy is energy produced from sources that do not deplete or can be replenished within a human's life time. The most common examples include wind, solar, geothermal, biomass, and hydropower. This is in contrast to non-renewable sources such as fossil fuels.

Most renewable energy is derived directly or indirectly from the sun. Sunlight can be captured directly using solar technologies. The sun's heat drives winds, whose energy is captured with turbines. Plants also rely on the sun to grow and their stored energy can be utilized for bio-energy.

Non-renewable energy resources, like coal, nuclear, oil, and natural gas, are available in limited supplies. This is usually due to the long time it takes for them to be replenished. Renewable resources are replenished naturally and over relatively short periods of time.

#Classification of Solar Thermal Systems:



1. Flat plate collectors
2. Solar Concentrating Collectors
3. Solar Water Heating
4. Heating & cooling of residential buildings
5. Solar Cookers
6. Solar Distillation
7. Solar Drying of Agricultural products
8. Solar Green Houses
9. Solar Systems for Power generation
10. Solar Photo-Voltaic cell panel power plant
11. Solar Furnaces

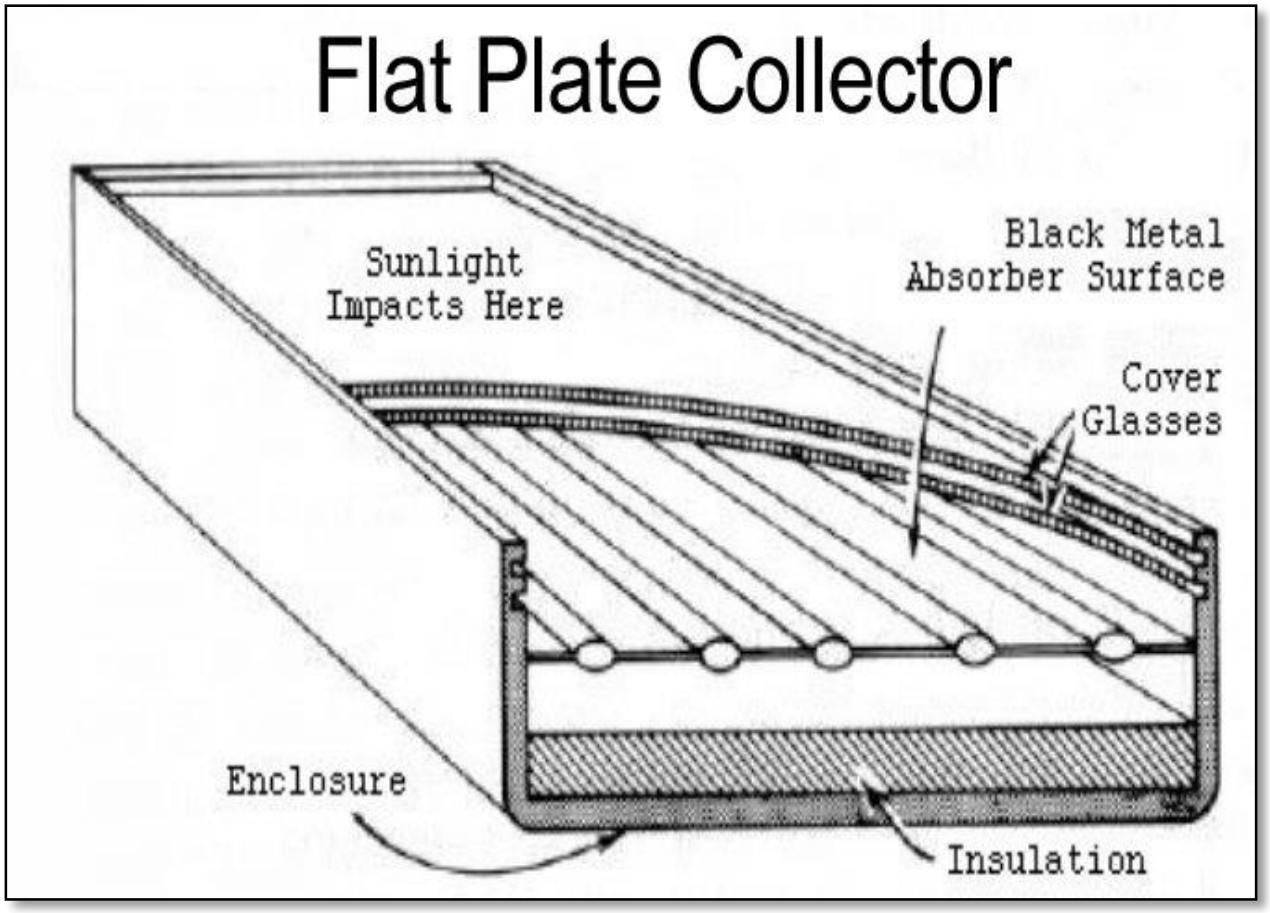
1. Wind Energy
2. Tidal Energy
3. Wave Energy
4. Geothermal Energy
5. Ocean Thermal Energy
6. Bio-mass & Bio-Gas
7. Hydrogen Energy
8. Fuel Cells

#Concentrated SolarPower Systems:

- ✓ A solar collector is a device that collects and/or concentrates solar radiation from the Sun. These devices are primarily used for active solar heating and allow for the heating of water for personal use.
- ✓ These collectors are generally mounted on the roof and must be very sturdy as they are exposed to a variety of different weather conditions.
- ✓ The use of these solar collectors provides an alternative for traditional domestic water heating using a water heater, potentially reducing energy costs over time.
- ✓ As well as in domestic settings, a large number of these collectors can be combined in an array and used to generate electricity in solar thermal power plants.

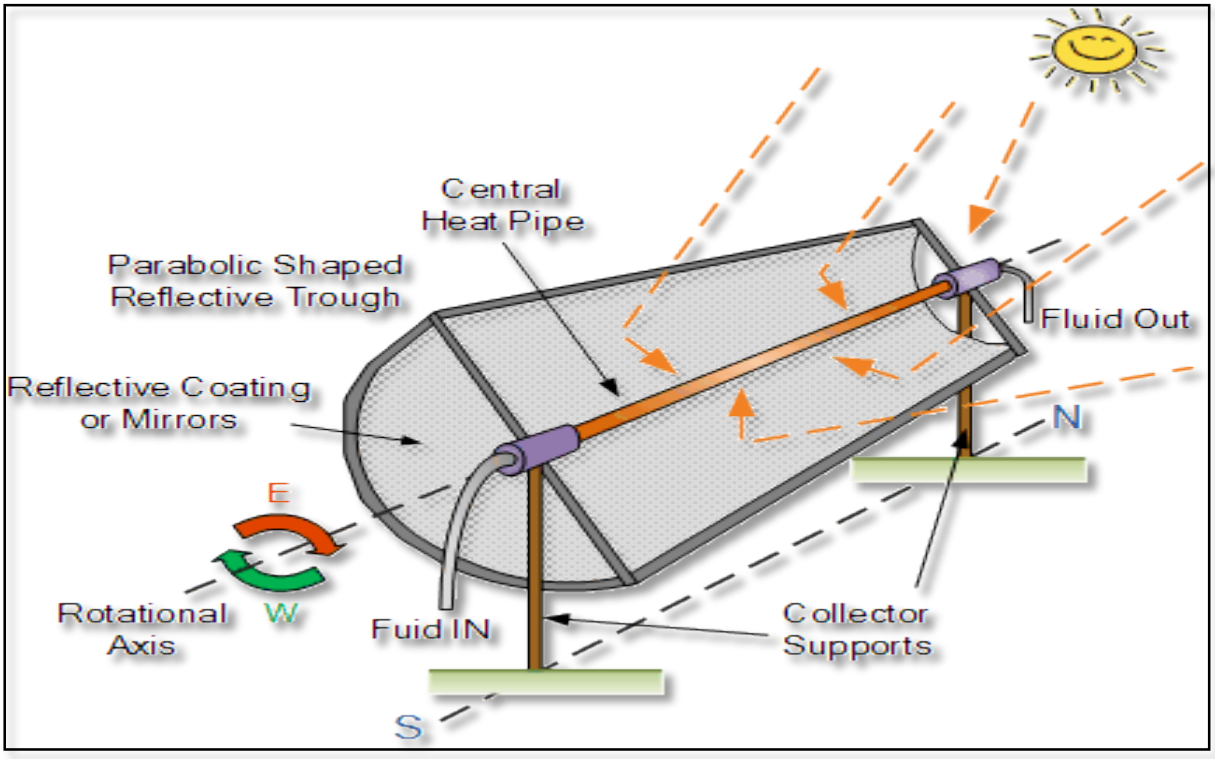
01.Flat Plate Collectors:

- These collectors are used for low temperature applications in the range from ambient temperature upto 100^0c.
- If the working fluid absorbing heat is liquid , such collectors are also called as liquid flat plate collectors.
- Flat plate collectors are used for low temperature applications like solar water heating , space heating & cooling , drying , low temperature power generation etc.

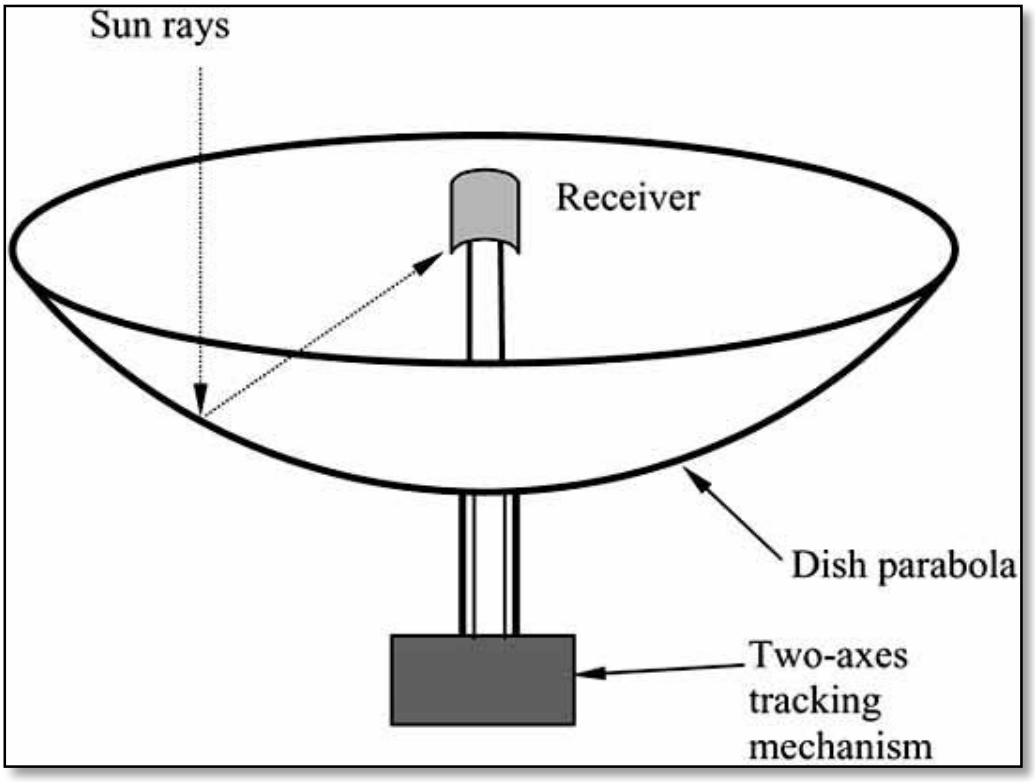


02. Parabolic Collector:

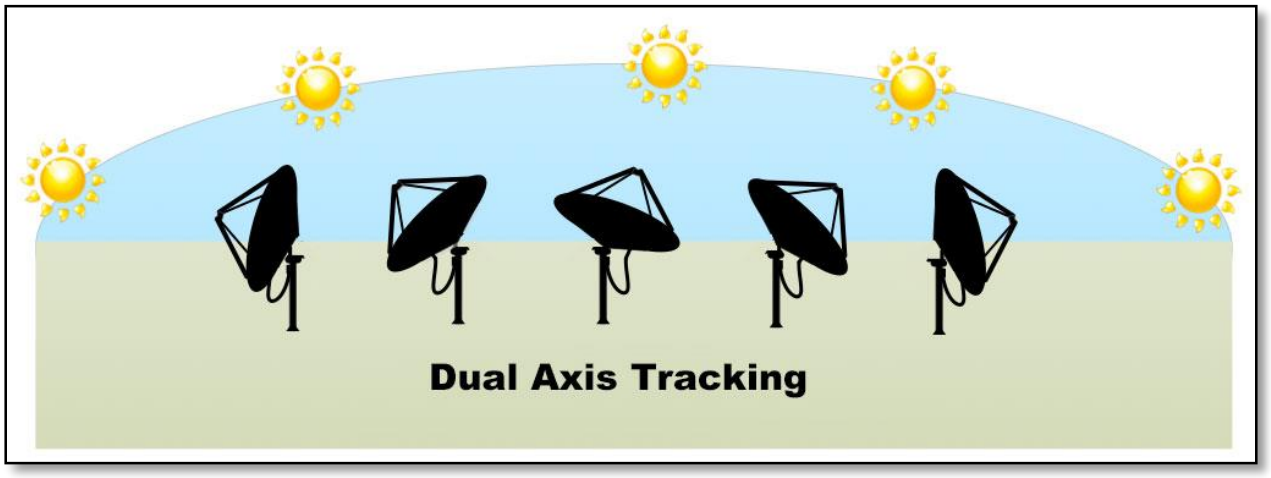
- This type is line focusing type collector. The cross-section area of such collector is in parabolic shape.
- In this type of collectors , the solar radiations falling on the area of the parabolic reflector are concentrated at the focus of parabola.
- Mostly cylindrical parabolic concentrators are used in which the absorber is placed along the focus axis.
- In this collector pipe is used as an absorber with a selective coating.
- Parabolic reflectors are usually made of highly polished or silvered glass or of a film of aluminised plastic on a firm base.



03. Parabolic Dish Collector:



- A parabolic dish collector is a concentrating solar collector that is similar in appearance to a large satellite dish, but has mirror-like reflectors and an absorber at the focal point.
- A parabolic dish solar power plant is based on a single parabolic reflector, similar in shape to a satellite antenna. This reflector focuses light to a point where a heat engine is placed. The heat engine uses the concentrated solar heat to produce electricity.



- The 9 meter hybrid parabolic solar concentrator (solar dish) continuously tracks the sun throughout the day using a dual axis tracker enabling the system to harvest maximum solar energy from early sunrise to late sunset.
- Most solar concentrator tracking technologies use an actuator for vertical tracking. The 9 meter solar concentrator uses a slew drive instead of an actuator for rock-solid reliability and more accurate control of the movement. Regardless of the season or latitude, the solar concentrator maintains a 0.1 degree sunlock accuracy.
- As the solar concentrators follows the sun, the sun's solar energy shines onto the collector, which has a highly reflective surface, and reflects the concentrated solar power onto a receiver at a magnification of 1000 X.

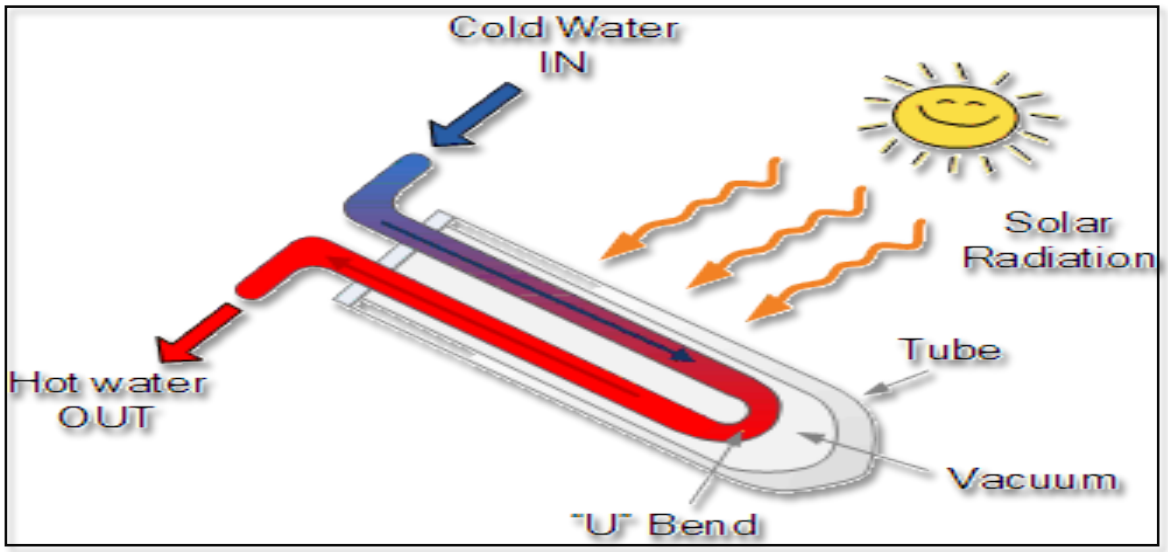
04. Solar Tower:

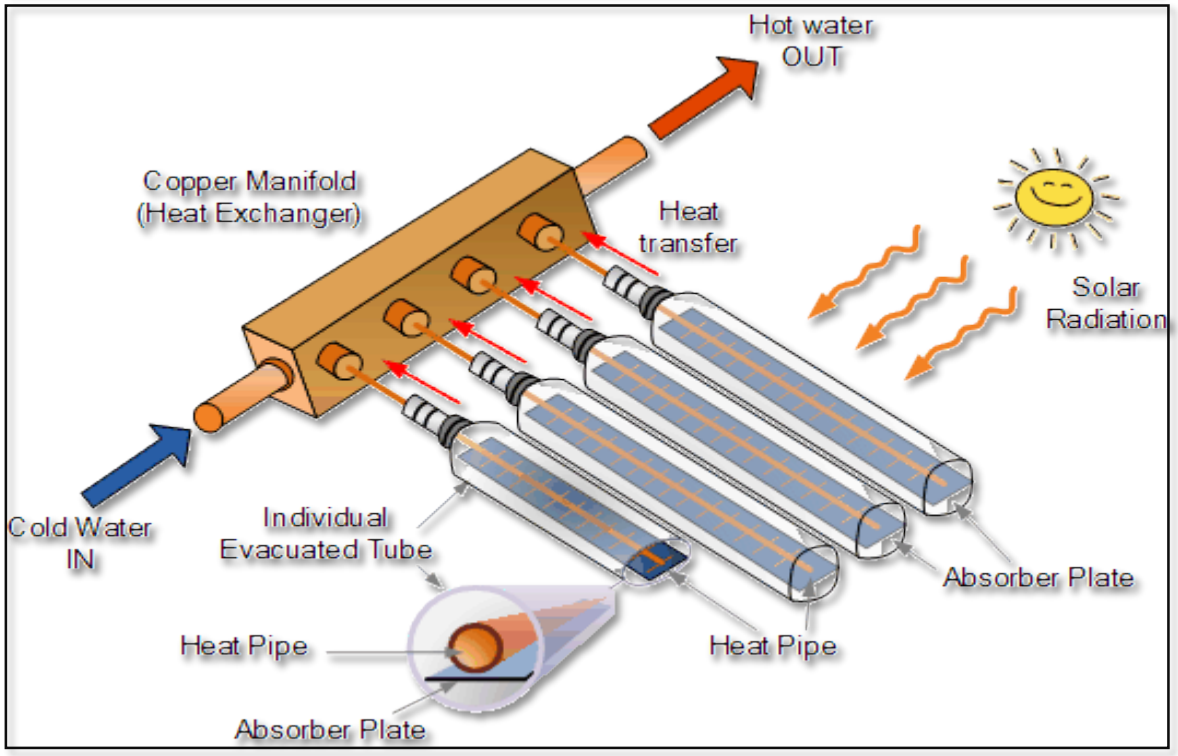
- A solar power tower is a system that converts energy from the Sun - in the form of sunlight - into electricity that can be used by people by using a large scale solar setup.
- The setup includes an array of large, sun-tracking mirrors known as heliostats that focus sunlight on a receiver at the top of a tower. In

this receiver, a fluid is heated and used to generate steam. This steam then powers a conventional turbine generator to generate electricity.

- Potential downsides of using towers such as this is that they involve large facilities that require large amounts of initial investment. As well, the large field of mirrors and tower that can range from 50 to more than 100 meters can be seen as an eyesore and can impact that local landscape.

❖ Evacuated Tube Solar Thermal System:

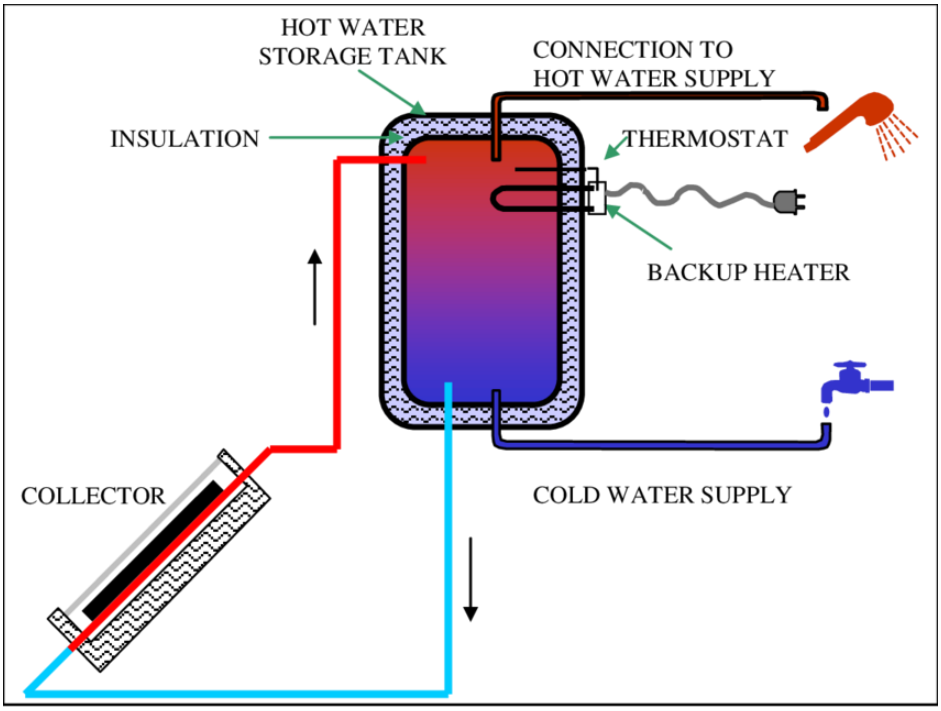




The **Evacuated tube collector** consists of a number of rows of parallel transparent glass tubes connected to a header pipe and which are used in place of the blackened heat absorbing plate we saw in the previous flat plate collector.

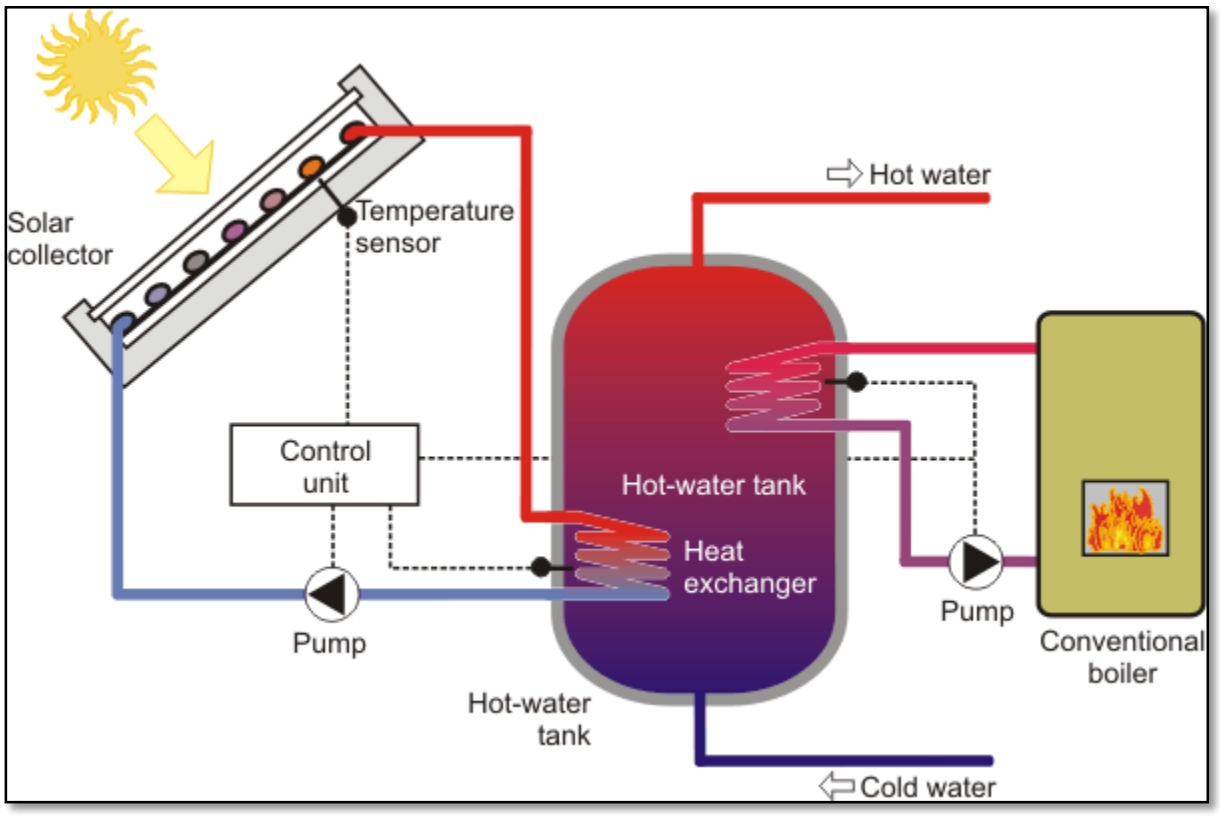
- These glass tubes are cylindrical in shape. Therefore, the angle of the sunlight is always perpendicular to the heat absorbing tubes which enables these collectors to perform well even when sunlight is low such as when it is early in the morning or late in the afternoon, or when shaded by clouds.
- Evacuated tube collectors are particularly useful in areas with cold, cloudy wintry weathers.
- Inside the each glass tube, a flat or curved aluminium or copper fin is attached to a metal heat pipe running through the inner tube. The fin is covered with a selective coating that transfers heat to the fluid that is circulating through the pipe.
- This sealed copper heat pipe transfers the solar heat via convection of its internal heat transfer fluid to a “hot bulb” that indirectly heats a copper manifold within the header tank. These copper pipes are all connected to a common manifold which is then connected to a storage tank, thus heating the hot water during the day. The hot water can then be used at night or the next day due to the insulating properties of the tank.

Domestic-Water Heating Systems-



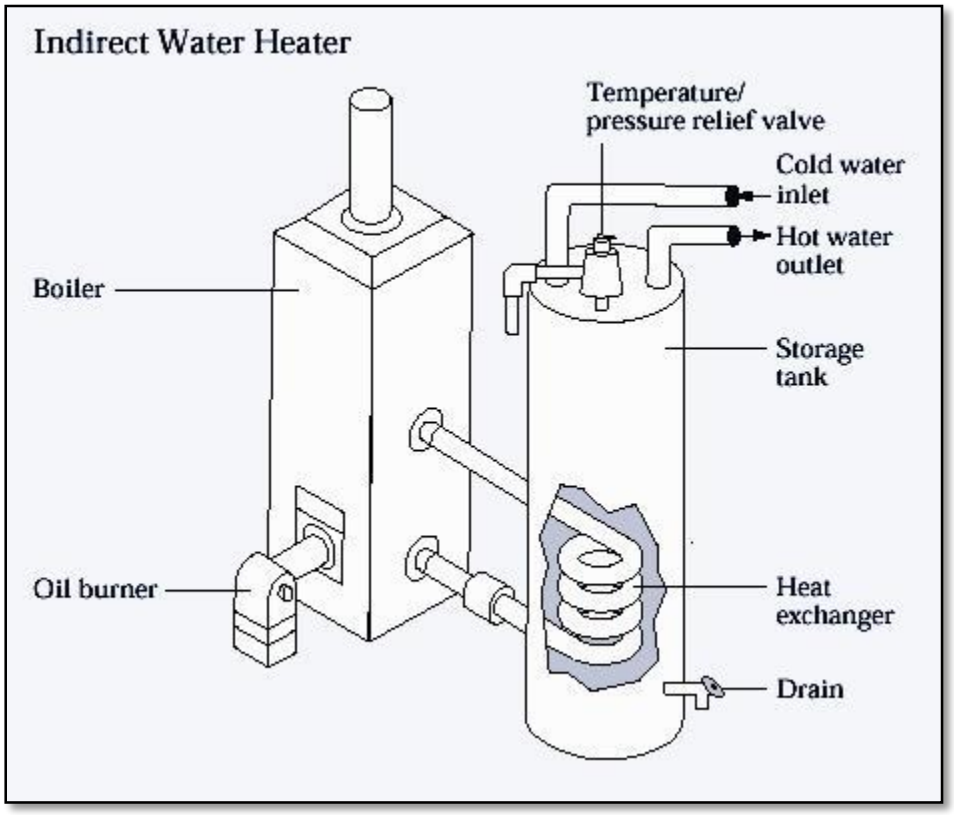
- Solar water heating (SWH) is the conversion of sunlight into heat for water heating using a solar thermal collector. A variety of configurations is available at varying cost to provide solutions in different climates and latitudes. Solar water heating are widely used for residential and some industrial applications.
- A sun-facing collector heats a working fluid that passes into a storage system for later use. SWH are active (pumped) and passive (convection-driven). They use water only, or both water and a working fluid. They are heated directly or via light-concentrating mirrors. They operate independently or as hybrids with electric or gas heaters. In large-scale installations, mirrors may concentrate sunlight into a smaller collector.

Forced-Circulation Systems



- In contrast to thermo systems, an electrical pump can be used to move water through the solar cycle of a system by forced circulation. Collector and storage tank can then be installed independently, and no height difference between tank and collector is necessary. Figure shows a system using forced circulation with a conventional boiler for back-up heating. Two temperature sensors monitor the temperatures in the solar collector and the storage tank. If the collector temperature is above the tank temperature by a certain amount, the control starts the pump, which moves the heat transfer fluid in the solar cycle; 'switch-on' temperature differences are normally between 5°C and 10°C.

* Commercial Heating System:



Depending on the type of commercial establishment the water heater is being installed in. A hotel or hospital may use large amounts of hot water where a office building may not. In any case, savings from high efficiency hot water heaters can be substantial.

High efficiency water heaters use 10% to 50% less energy than standard models. When combined with complementary products like insulation blankets and timers, advanced systems can save significantly on utility costs. Energy savings from high efficiency water heaters depend on several factors such as heater location, family size, use behavior, heating fuel used, climate zone, and the size and placement of water pipes.

What is a Solar Dryer:

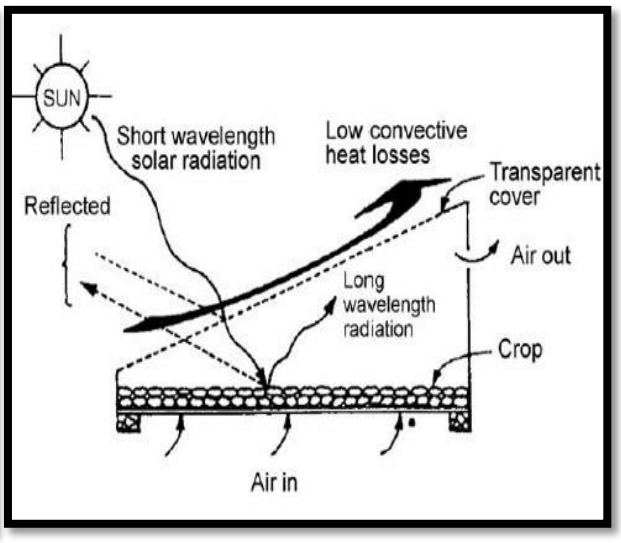
- A **Solar Dryer** is another application of solar energy, used immensely in the food and agriculture industry. Though sun is still used as the direct source for drying food items and clothes in certain parts of the world.
- An indirect source of solar power can also be used for the same purpose in the form of a solar dryer. The main disadvantage of drying directly under the sun is contamination – dirt, animals, insects etc. Also there is a fear of sudden change in weather conditions like wind or rain.
- Solar Dryer can be classified as:

  i) Direct Gain Type

  ii) Indirect Gain Type

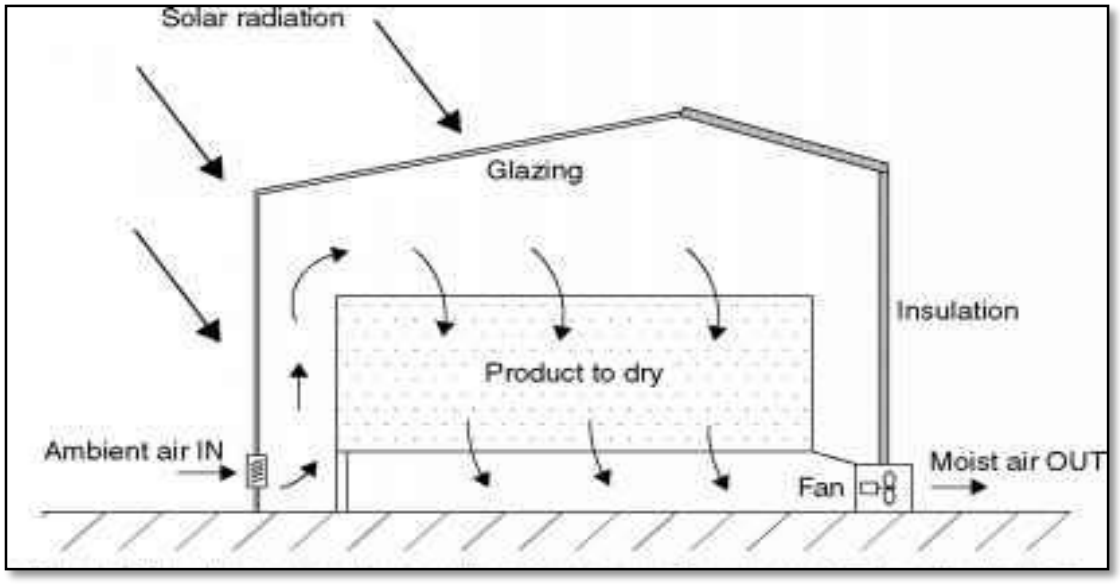
i) Direct Gain Type:

* These type of solar dryers do not require any external power source for running a fan or blower.
* They are suitable for drying the foods on small scale e.g. conservation of grapes into resins, drying of chilies, apricot, dates.
* The cabinet solar dryer is shown in fig. which is natural convection type.
* It has an enclosed cabinet having transparent glass covers at top & insulation is provided at the bottom. The perforated tray is provided for keeping the food.
* The inner surface of cabinet is coated with black colour and door is provided at rear of the cabinet. Ventilation holes are also provided on the upper side of the dryer for hot moist air to escape by natural convection.



❖ Forced Convection Solar Dryer (Direct Gain Type) Active Type or Forced Circulation Type :

- Solar dryers are used for large scale drying of food products since the passive or natural convection types solar dryers are not found to be suitable.
- A forced convection type solar dryer which uses direct solar radiations as shown in fig.
- It has large number of perforated trays on which the products are kept for drying. The top of the dryer is covered by transparent glass and side is covered with plastic sheet on w

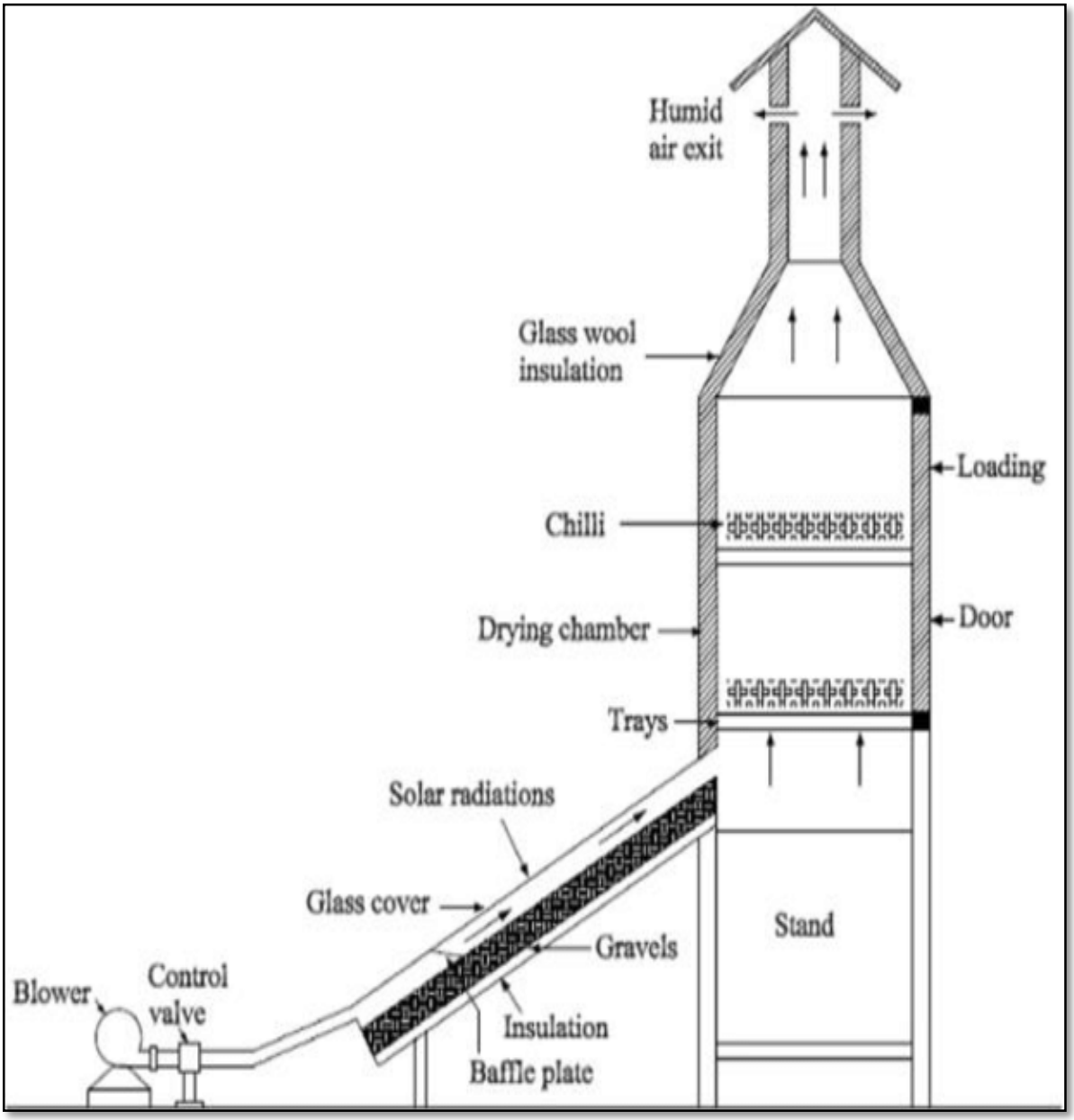


radiations fall.

- The system uses a blower to draw the hot humid air which causes the fresh air to enter due to vacuum created inside dryer.

❖ Forced Convection Solar Dryer - Indirect Gain Type :

- Such type of dryers can be used at low as well as at high temperature drying of large quantity of agricultural products like drying of food grains, tea, coffee, tobacco etc.
- In direct type of solar dryers discussed above, the temperature of the product cannot be controlled since solar radiations fall directly on the products.
- In order to control the temperature of drying , the indirect type forced solar dryers invariably use some kind of thermal storage.
- The working is similar in principal to active hot air heating system.
- It consist of an array of solar collectors in which surrounding air is forced by a blower. The heated air is supplied to the dehydrator for drying the products.
- The excess hot air is supplied to rock storage tank where the excess solar heat can be stored.
- The hot air temperature to the dehydrator can be controlled by passed fresh air with the help of dampers & temperature controllers.
- The humid hot air is exhausted to surrounding after drying the food products in the dehydrator.


Humid
air exit
Glass wool
insulation
Loading
Chilli
Drying chamber
Door
Trays
Solar radiations
Glass cover
Stand
Gravels
Blower
Control
valve
Insulation
Baffle plate