

# **SIR CHHOTU RAM INSTITUTE OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF MECHANICAL ENGINEERING**

**RENEWABLE ENERGY RESOURCES (BT-806)**

**NOTES ON SOLAR ENERGY**

# SOLAR ENERGY

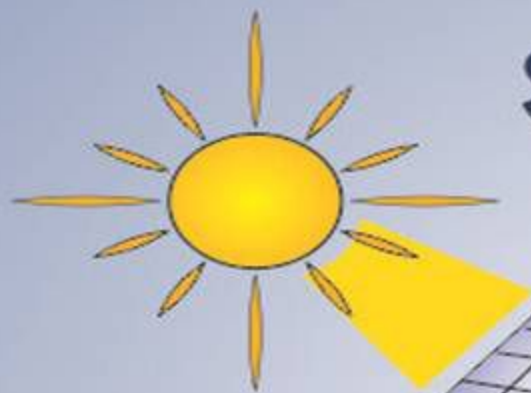
- ❖ Solar energy is the radiant energy produced by the Sun. It is both light and heat.
- ❖ The Earth receives 174 peta watts (PW) (1 peta watt =  $1.0 \times 10^{15}$  ) watts of solar radiation at the upper atmosphere.
- ❖ Solar power is energy from the sun.  
"Solar" is the Latin word for "sun" and it's a powerful source of energy.



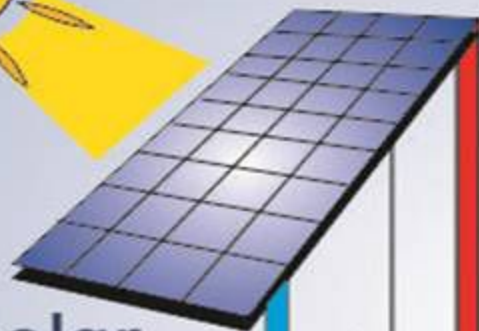
## **SOLAR WATER HEATING**

A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the heat to the riser pipes underneath the absorber panel. The water passing through the risers get heated up and is delivered to the storage tank. There-circulation of the same water through absorber panel in the collector raises the temperature to 80 C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar hot water system.

# Solar Water Heating System



Solar collector



Controller



Pump



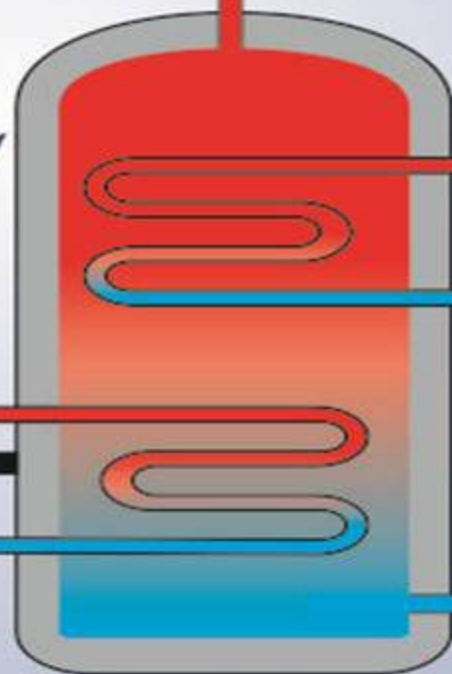
To taps



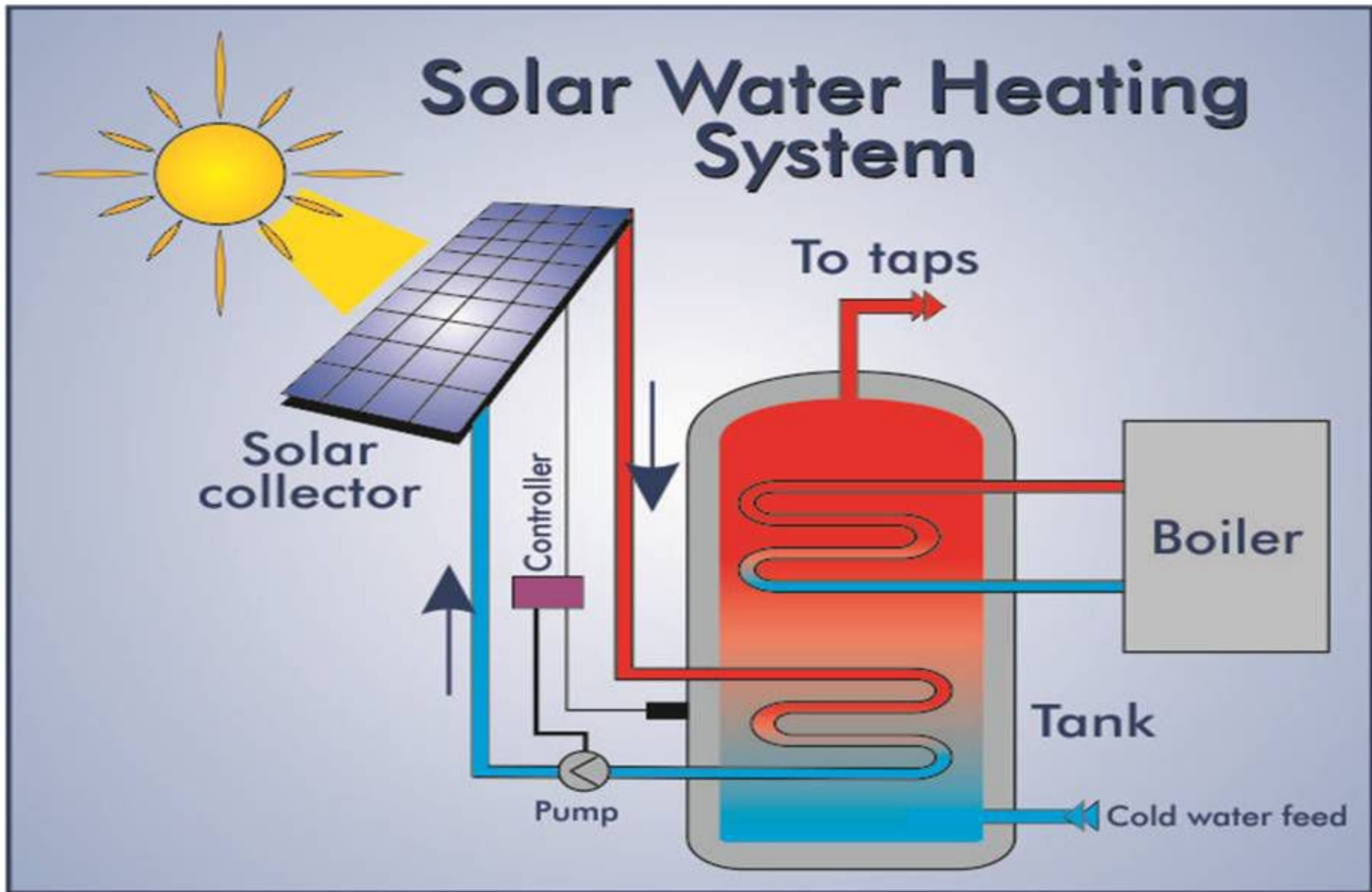
Boiler



Tank



Cold water feed



## TYPES OF SOLAR COLLECTORS

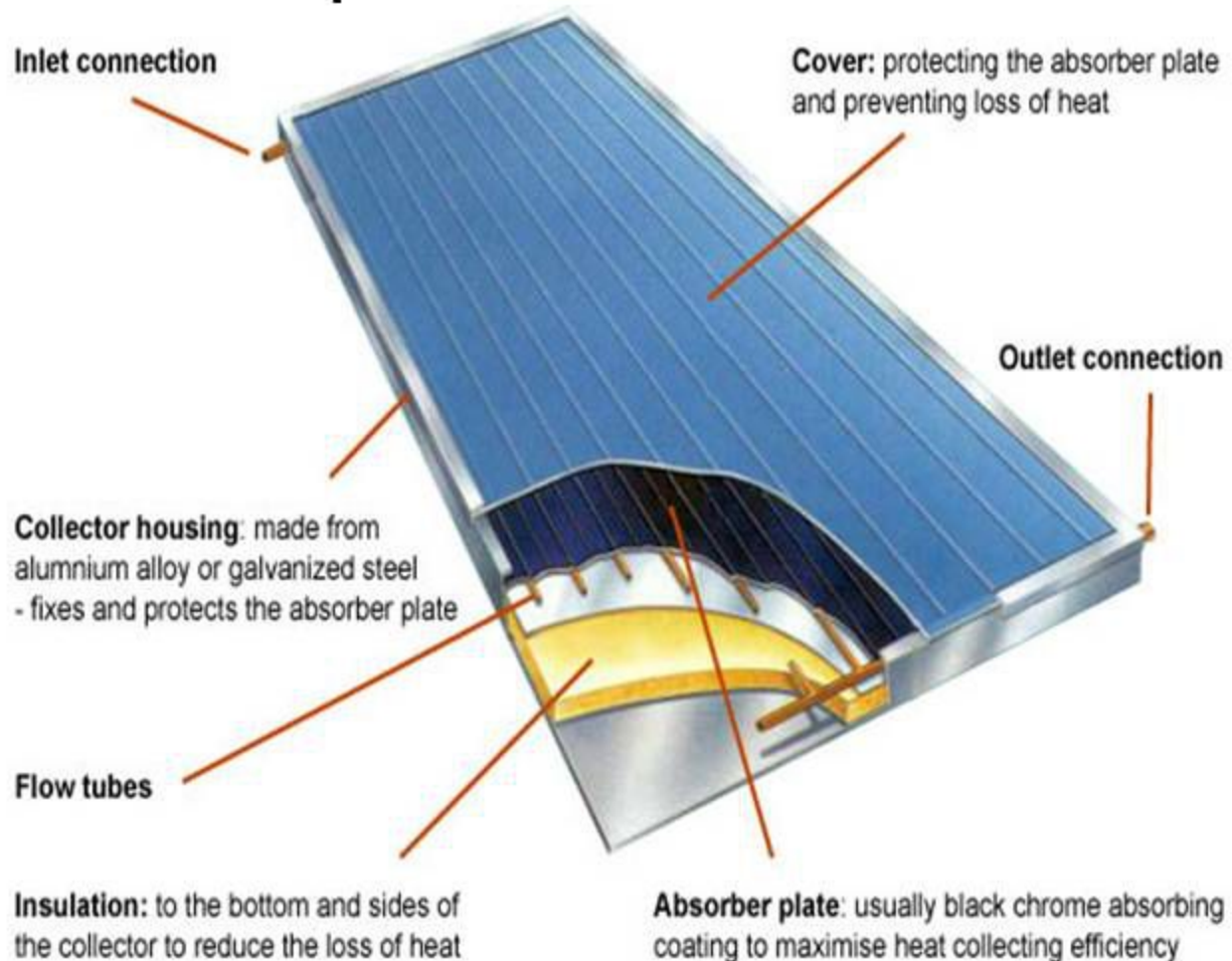
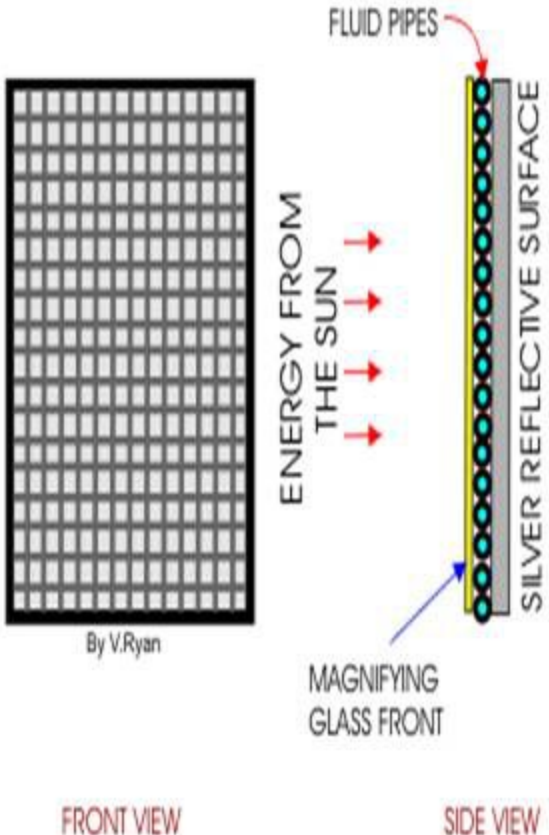
- ❖ Solar collectors are heat exchangers that use solar radiation to heat a working fluid, usually liquid or air. They can be classified in three groups:
  - ❖ Flat – Plate Collectors
  - ❖ Evacuated Tube Collectors
  - ❖ Concentrating Collectors



## FLAT – PLATE COLLECTOR

- ❖ The solar radiation is absorbed by Flat Plate Collectors which consist of an insulated outer metallic box covered on the top with glass sheet. Inside there are blackened metallic absorber (selectively coated) sheets with built in channels or riser tubes to carry water. The absorber absorbs the solar radiation and transfers the heat to the flowing water.

- A flat plate collector is basically a black surface that is placed at a convenient path of the sun.



## EVACUATED TUBE COLLECTORS

- Evacuated Tube Collector is made of double layer borosilicate glass tubes evacuated for providing insulation. The outer wall of the inner tube is coated with selective absorbing material. This helps absorption of solar radiation and transfers the heat to the water which flows through the inner tube.



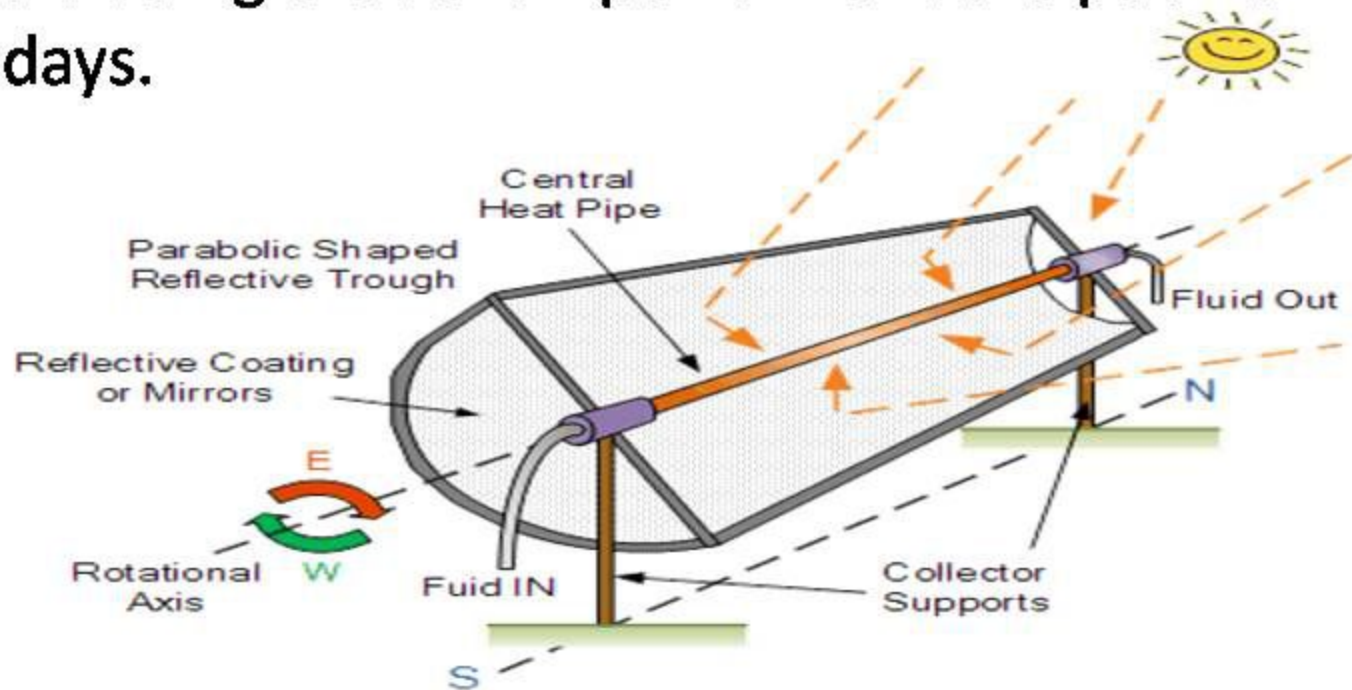
Evacuated tube collectors are made up of rows of parallel, transparent glass tubes. Each tube consists of a glass outer tube and an inner tube or absorber, covered with a coating that absorbs solar energy but inhibits heat loss.



## CONCENTRATING COLLECTORS

- ❖ Concentrating collectors use mirrored surfaces to concentrate the sun's energy on an absorber called a receiver. Concentrating collectors also achieve high temperatures, but unlike evacuated-tube collectors, they can do so only when direct sunlight is available. The mirrored surface focuses sunlight collected over a large area onto a smaller absorber area to achieve high temperatures. Some designs concentrate solar energy onto a focal point, while others concentrate the sun's rays along a thin line called the focal line.

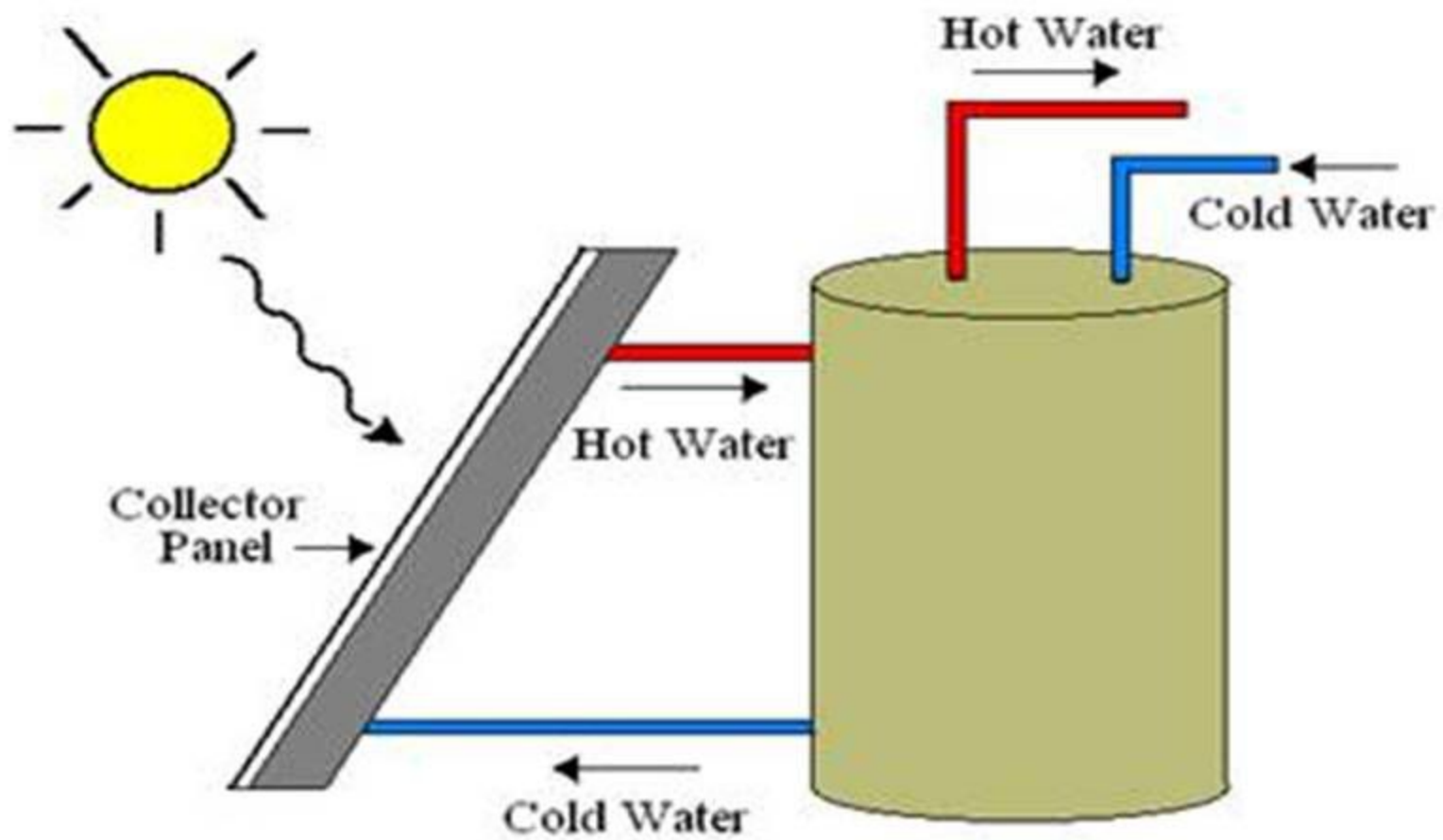
- ❖ The receiver is located at the focal point or along the focal line. A heat-transfer fluid flows through the receiver and absorbs heat. These collectors reach much higher temperatures than flat-plate collectors. However, concentrators can only focus direct solar radiation, with the result being that their performance is poor on hazy or cloudy days.





## **PASSIVE WATER HEATING SYSTEM**

- ❖ A passive solar heating system uses natural convection to circulate through a solar collector to a storage tank or to the point of use. They have no electric components, which makes them more reliable, easier to maintain and longer lasting than active systems. Although passive systems are generally less efficient than active systems, the passive approach is simple and economical. There are two types of passive water heaters.



Passive Solar Water Heating



## ACTIVE SOLAR WATER HEATING

- ❖ An active system uses an electric pump to circulate water or the working fluid through the system. Active systems are usually more expensive than passive systems, they cannot be used during a power cut. To avoid this, active systems are combined with a small solar-electric panel to power the pump. The amount of hot water a solar water produces depends on the type and size of the system, the amount of the heat available at the site, proper installation, tilt angle and orientation of the collectors.

❖ There are five major components in active solar water heating systems:

1. Solar Collector
2. Circulation system to circulate the working fluid between the collectors to a storage tank.
3. Storage Tank
4. Backup Heating System
5. Control system to regulate the overall system operation.

# **SOLAR ENERGY CONVERSION SYSTEM**

- ❖ Solar energy can be converted to electricity by two methods. They are
  1. Solar thermal conversion
  2. Photovoltaic conversion

# SOLAR THERMAL CONVERSION

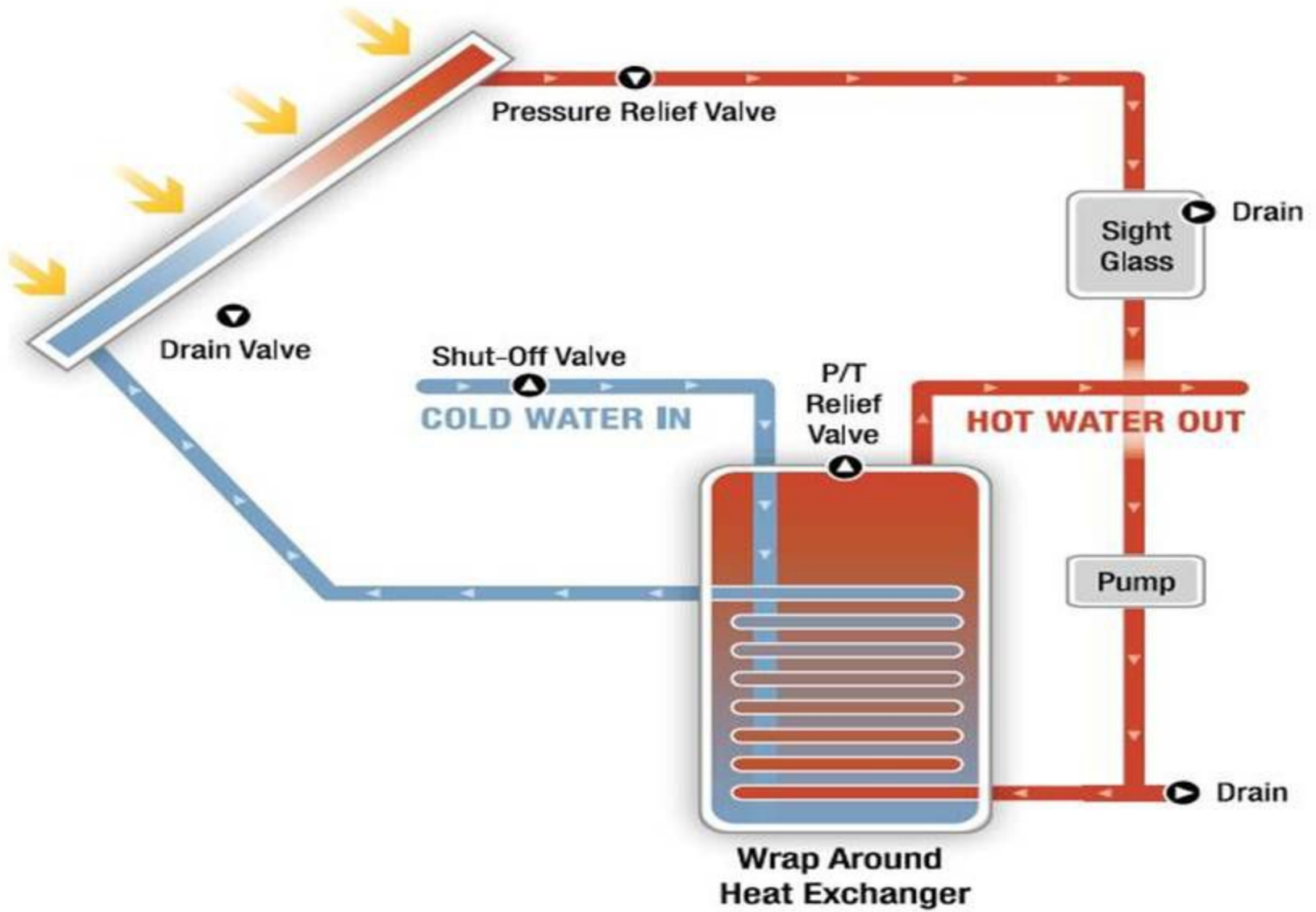
❖ Solar thermal conversion system is divided into two types

1. Low temperature systems
2. High temperature systems

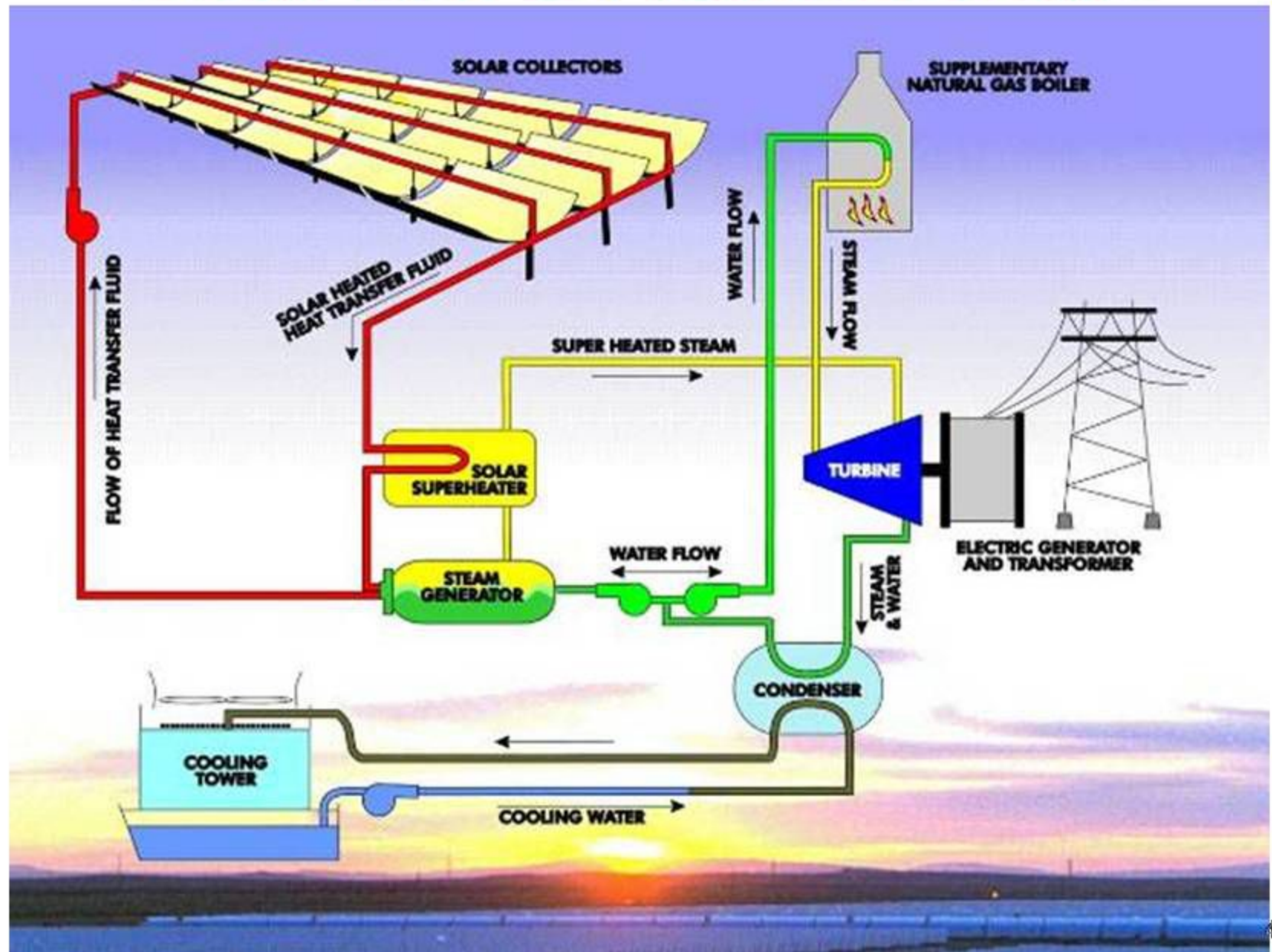
## LOW TEMPERATURE SYSTEMS

- ❖ Water is circulated through the flat plate collector by the circulation pump. The heat received by the collector is transferred to water and it is heated. This hot water enters the heat exchanger where butane is available. Butane is used because it is having a very low boiling point. At about 80 °C of water, Butane becomes a superheated vapour and enters the turbines and rotates it, the generator coupled to it converts the mechanical energy into electrical energy. The vapour after doing work enters the condenser, becomes a liquid and is circulated with the help of pump.





# HIGH TEMPERATURE SYSTEMS



❖ These systems convert the sun's heat into both electricity and hot water at the same time for many uses. They offer electrical power for both remote and utility-scale applications. Because of their economies of scale and efficiencies, they can work in many large-scale projects where other sources of energy are not yet economical. There are three types of CSP (Concentrating Solar Power) systems.

1. Power towers
2. Parabolic troughs
3. Dish/Engine Systems.



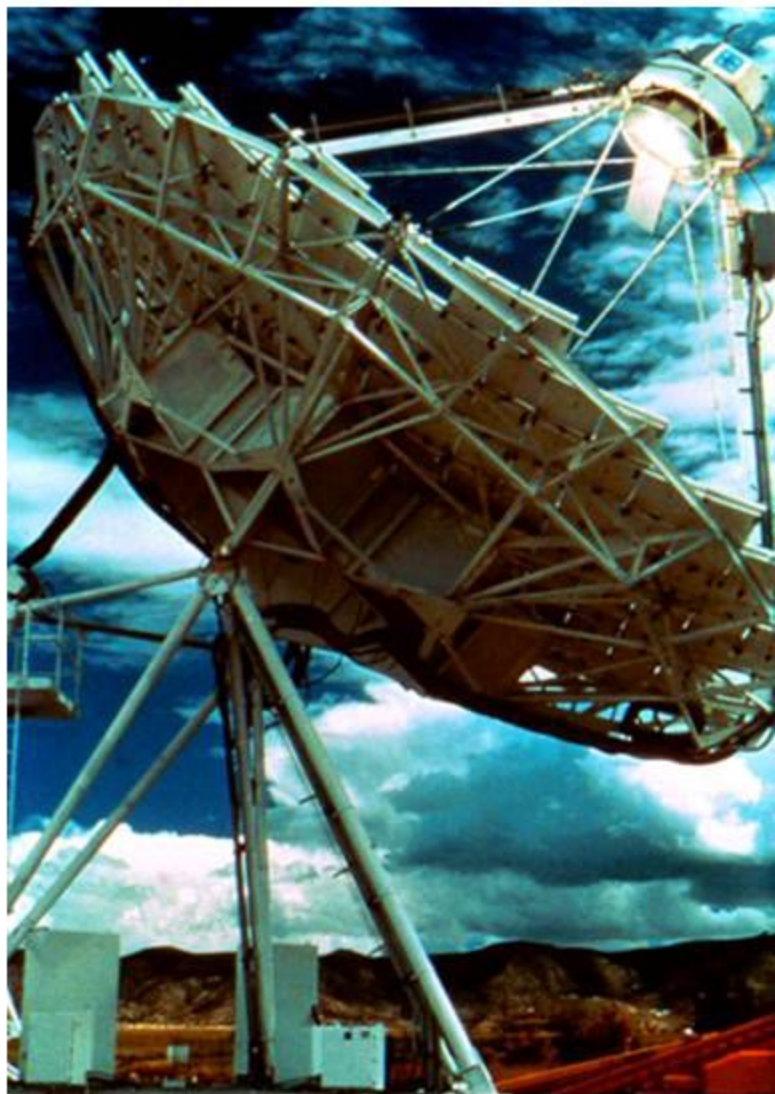
## PARABOLIC TROUGH SYSTEMS

One type of high-temperature system is the trough system, in which the troughs focus sunlight onto steel pipes or glass tubes. The heat transfer fluid in the pipes reaches more than 700 degrees F and flows through a heat exchanger, providing superheated steam for a turbine generator. Sunlight is focused on a pipe filled with oil that's runs down the axis of the trough. When the oil gets heated up, it is used to boil water in a conventional steam generator to produce electricity.



# DISH SYSTEMS

A second type of high-temperature solar thermal system is a dish system, which uses a parabolic tracking concentrator to focus the sun's rays onto a receiver mounted above the dish at its focal point. The dish-shaped surface focuses and concentrates the sun's heat onto a receiver at the focal point of the dish. The receiver absorbs the heat and transfers it to a fluid within an engine, where the heat causes the fluid to expand against a piston to produce mechanical power.





# PHOTOVOLTAIC CONVERSION

**Photovoltaic (PV)** is a method of generating electrical power by converting sunlight into direct current electricity using semiconducting materials. Photo meaning "light" and voltaic meaning "electricity"), convert sunlight directly into electricity.

Photovoltaic cells are made of special materials called semiconductors such as silicon, which is currently used most commonly. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, allowing them to flow freely. It has also been used to power small electronic devices, rural and agricultural applications. During last decade, a strong solar electric market has emerged for powering homes and buildings because of advances in solar technology.

# HOW SOLAR CELLS WORK

1. Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.
2. Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity.
3. An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

