SPACE – HEATING (OR SOLAR HEATING OF BUILDING)

Many different concepts have been proposed for using solar energy in space heating of buildings. There are two primary categories into which virtually all solar heating systems may be divided. The first is passive systems, in which solar radiation is collected by some element of the structure itself, or admitted directly into building through large, south facing windows. The second is the active system which generally consists of

(a) separate solar collectors, which may heat either water or air,

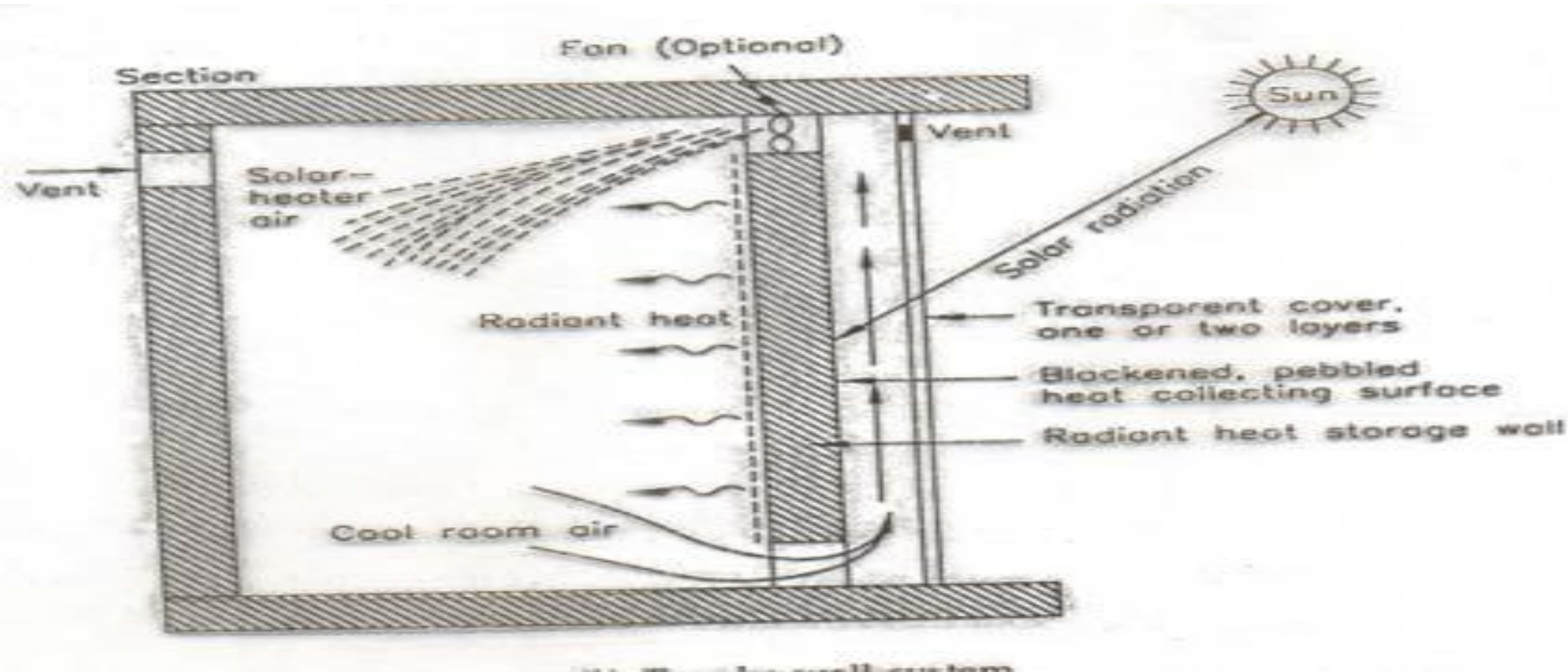
(b) storage devices which can accumulate the collected energy for use at nights and during inclement days, and,

(c) a back up system to provide heat for protected periods of bad weather.

Heat is transferred from the collectors or from the storage means by conventional equipment, such as fan coil units, when hot or cold water is provided; fan, ducts, and air outlets, when the heat transfer medium is air; and radiant means when heating is the only task which must be accomplished.

❑ Passive systems

Passive heating systems operate without pumps, blowers, or other mechanical devices; the air is circulated past a solar heated surface (or surface) and through the building by convection (i.e., less dense, cooler air tends to rise while more dense, cooler air moves downward). These systems are more practical in locations where there is ample winter sunshine and an unobstructed southern exposure is possible. The building to be heated is an essential part of the system design. A passive method is one in which thermal energy flows through a living space by natural means without the help of a mechanical device like a pump or a blower. A diagram of such a system designed by Professor Trombe.



- The south facing wall of the house is double glazed. Behind it is a thick, "Black"' concrete wall, which absorbs the sun's radiation and serves as a thermal storage. Vents (A and B) which can be kept open or closed are provided near the top and bottom of the storage wall.

- During the day, both vents A and B are kept open. The air between the inner glazing and the wall gets heated and flows into the living space through the top vent. Simultaneously, the cooler air from the room is pulled out of the living space through the bottom vent. Thus, a natural circulation path is set up. Some energy transfer to the living space also takes place by radiation from the inner surface of the storage wall. During the night, both vents are closed and energy transfer takes place only by radiation. The 'Trombe' wall design can also provide summer ventilation by using vents C and D near the top of the glazing and on the north-facing wall. On a hot summer day, vents B, C and D would be kept open, while vent A would be kept closed. The heated air between the glazing and the wall would then flow out through vent C drawing air from the living space to replace it. This in turn would cause air to be pulled in from outside through the vent D. The vent D should be located such that the air pulled in through it comes from a shaded and cool area. It should be noted that the overhang on the roof prevents direct radiation from falling on the glazing during summer

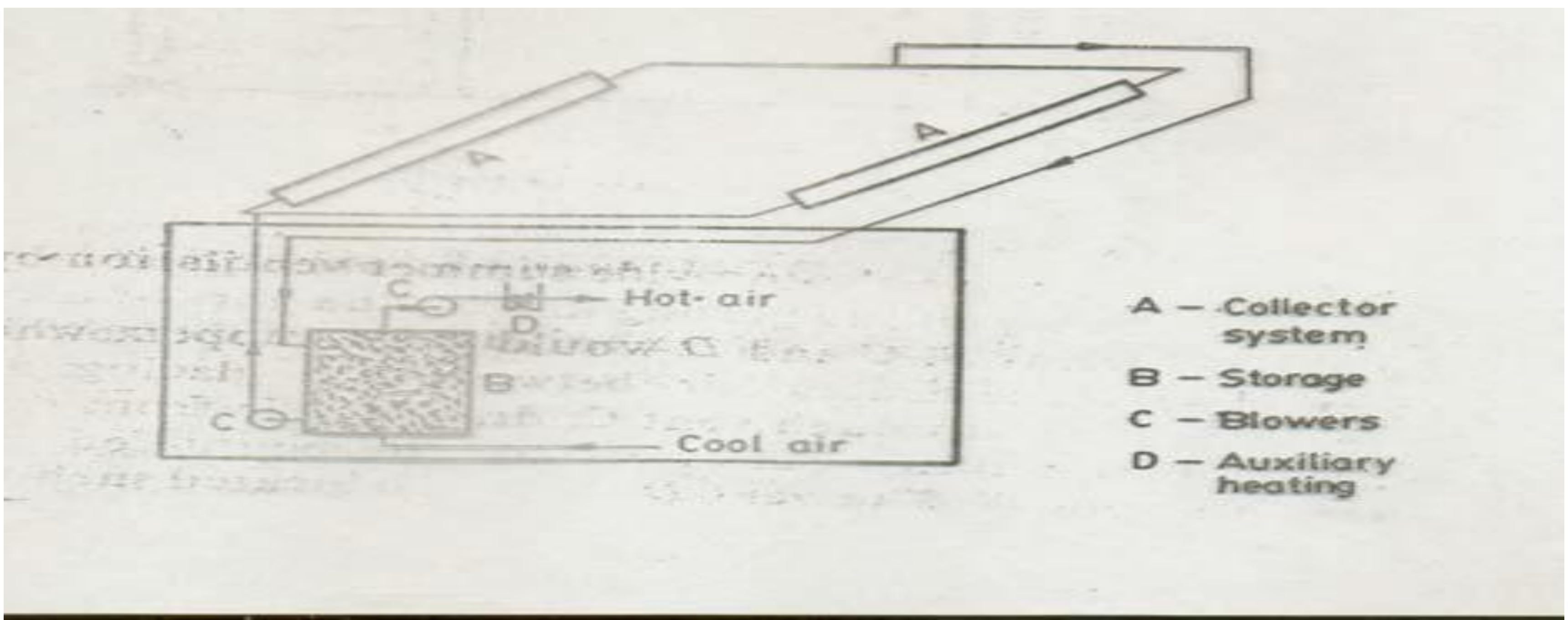
❑ Active systems

Active systems, on the other hand, can be adapted to almost any location and type of building; however they are more expensive than passive systems to construct and operate. An advantage of active solar systems is that the building air temperature can be controlled in the same way as with the conventional heating, but in most passive systems substantial temperature variations may occur in the course of the day.

In principle, it should be possible to provide all the heating (and cooling) needs of a building by solar energy. However, to do this, the heating system would have to be designed for minimum sunshine conditions and hence would be over- designed for the majority of the situations. In most cases, solar-energy systems provide roughly 50 to 75 per cent of the annual heating requirements. The remainder is supplied by an auxiliary-heating systems using gas, oil, or electricity.

❑ Active Heating

In active heating systems, fans and pumps are used to circulate the air and often a separate heat absorbing fluid. A space-heating system is illustrated. Water is heated in the solar collectors (A) and Stored in the tank (B). Energy is transferred to the air circulating in the house by means of the water-to-air heat exchanger (E). Two pumps (C) provide forced circulation between the collectors and the tank, and between the tank and the heat exchanger. Provision is also made for adding auxiliary heat.



An alternative approach to space heating is to heat air directly in the collectors. The heat is then stored in a tank packed with rock, gravel or pebbles. Space heating is of particular relevance in colder countries where significant amounts of energy are required for this purpose. In India, it is of importance mainly in the northern regions in winter. In contrast to the above methods, which are often called active methods, space heating giving a fair degree of comfort can also be done by adopting passive methods.

- **Solar Cooker**

Though there are many types of solar cookers, all of them have a concentrator or lenses to increase the available solar energy and insulation to reduce heat loss. There is an oven type cavity to place food into the box for cooking. Solar cookers are commonly able to reach cooking temperatures of 90-1500C and some can even reach 2300C. With these temperatures, it is possible to cook virtually any food as long as it is sunny outside.

The first solar cooker was developed in the year 1945 by Mr. M.K. Ghosh of Jamshedpur. He developed a box type solar cooker with a reflecting mirror and a copper coil inside, on which the food materials used to be placed in pots. Basically there are three designs of solar cookers:

(i) Flat plate box type solar cooker with or without reflector
(ii) Multi reflector type solar oven
(iii) Parabolic disc concentrator type solar cooker.

Flat plate box type design is the simplest of all the designs. Maximum no load temperature with a single reflector reaches upto 1600C. In multi reflector oven four square of triangular or rectangular reflectors are mounted on the oven body. They all reflect the solar radiations into the cooking zone in which cooking utensils are placed. Temperature obtained is of the order of 2000C. The maximum temperature can reach upto 2500C, if the compound cone reflector system is used. With parabolic disc concentrator type solar cooker, temperatures of the order of 4500C can be obtained in which solar radiations are concentrated on to a focal point.

The advantages of solar cooker

- There is no problem of charring of food and no over flowing.
- Orientation or sun tracking is not needed.
- No attention needed during cooking as in other devices.
- No, fuel, maintenance or recurring cost.
- Simple to use and easy to manufacture.
- No pollution of utensils, house or atmosphere.
- Vitamins in the food are not destroyed and food cooked is nutritive and delicious with natural taste.
- One can relay on cooker's efficiency for longer period.

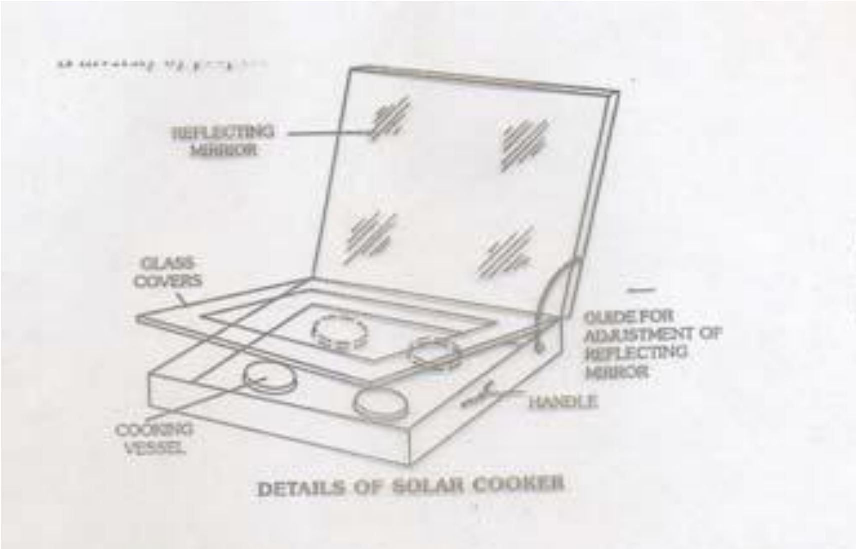
Disadvantages of solar cooker

- Traditional cooking habit.
- No cooking after sunshine hours.
- Focusing on sun needed.
- No temperature control.
- Cost is high.
- Some food items cannot be prepared.
- Takes long time to prepare.
- Initial cost is more.

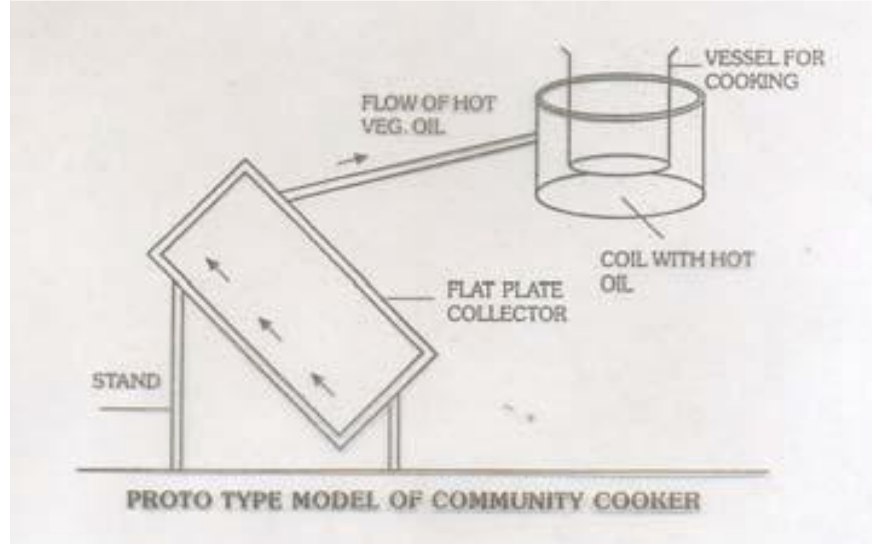
❑ Types of Cooker: The different types of solar cookers are:

(a) Box type:

Shows the box type cooker. The salient feature of the solar cooker is that there is no flow phenomenon in the devices. It operates under stagnant condition or equilibrium condition. Therefore, the governing parameters of the cooker are different from many other devices. The solar cooker is made up of inner and outer metal or wooden boxed with double glass sheets on it. Absorber tray is painted black with suitable black paint like boiler interior paint. The paint should be dull in colour so that it can withstand the max temperature attained inside the cooker as well as water vapor coming out of the cooking utensils. The top cover contains two plain glasses each 3mm thick fixed in the wooden frame with about 20mm distance between



Box Type cooker



Community type cooker

them. The entire top cover can be made tight with padlock hasp. Neoprene rubber sealing is provided around the contact surfaces of the glass cover and cooker box. A small vent for vapour escape is provided in the sealing. A mechanism is provided to adjust the reflector at different angles with the box cooker box. A 150 to 250C rise in temperature is achieved inside the cooker when reflector is adjusted to reflect the sun rays into the box. Overall dimensions of a typical model are 60x60x20cm height. This type of cooker is termed as family solar cooker as it cooks sufficient dry food materials for a family of 5 to 7 people.

The temperature inside the solar cooker with a single reflector is maintained from 70 to 1100C above the ambient temperature. This temperature is enough to cook food slowly, steadily and surely with delicious taste and preservation of nutrients. Maximum air temperature obtained inside the cooker box (without load) is 1400C in winter and 1600C in summer. Depending upon the factors, such as, season and time of the day, type of the food and depth of the food layer, time of cooking with this cooker ranges from 1 hour to 4 hours. Meat should be allowed to stay for 3-4 hours. Vegetables take from ½ to 2 ½ hours. All types of Dals can be cooked well between 1 ½ to 2 hours. Rice is cooked between 30 minutes and 2 hours. The best time of the day for cooking is between 11 a.m. and 2 p.m.

(b) **Focusing Type of Indirect Type**: Shows the focusing type cooker in the shape of parabolaid. The glass surface or aluminum foil is used as a reflector coating from inside. The cooking pot is placed at the focus of parabolaid, where reflected rays get focused to heat the pot. The temperature of the pot achieved is more than 2000C. The system is adjustable to track the sun.

(c) **Collector Type (community Cooker)**: These cookers are used to cook the food during day and night by utilizing the collector and storage as the excess thermal energy in day and utilized it at night. The shows the schematic of such device and it can be operated in three modes i.e., day cooking, day non cooking period and night cooking by opening and closing the different passes through the control valve.

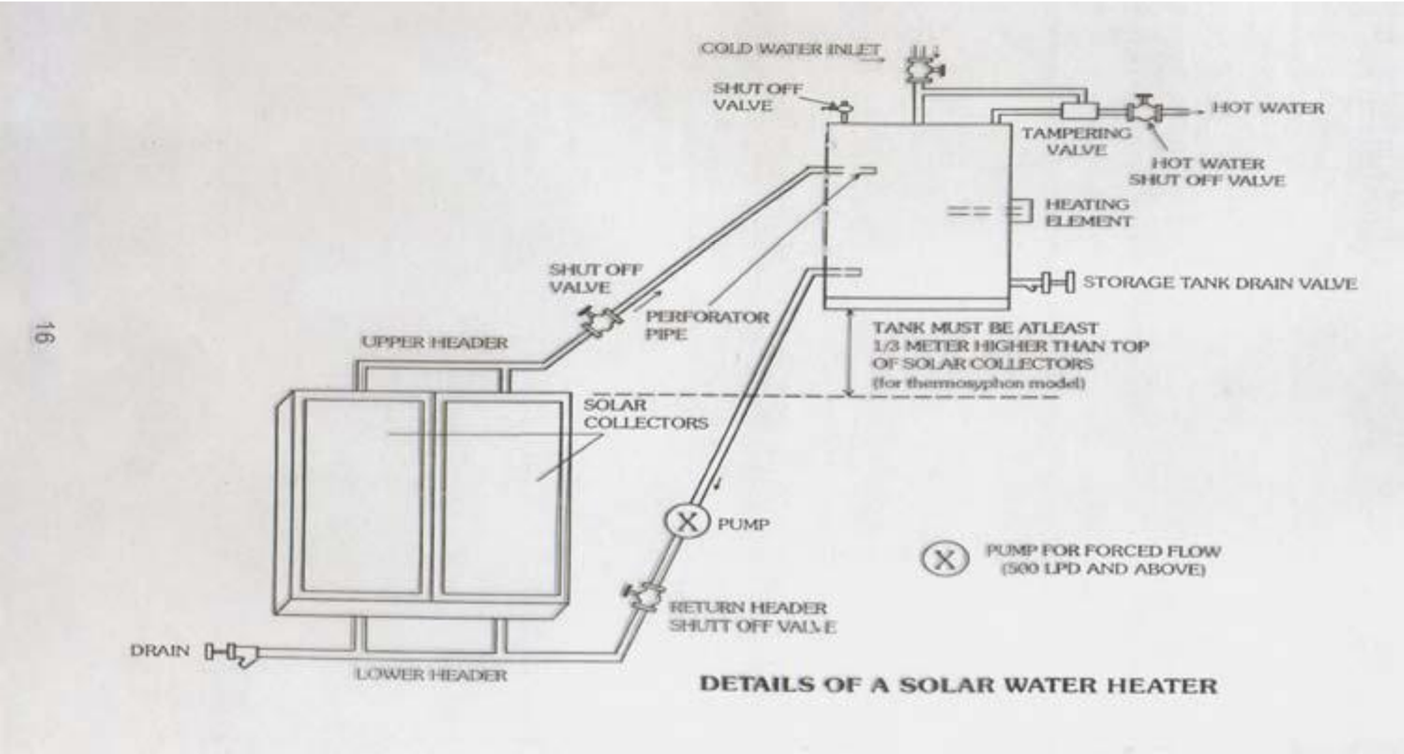
❑ Solar Energy Applications

A perfect black body (like sun) radiates its energy in the form of Electro- magnetic waves. These waves have two characteristics. When these waves fall on surfaces, they transfer the heat value to the surface wherein the transferred heat can be utilized for various purposes. Based on this principle, the present-day solar thermal devices are designed. However, there are substances on which these sun rays induce flow of electrons in a particular direction due to photo-electric effect. These substances are known as semi conductors. Based on the principles of photo-electric effect of sun rays, various photo-voltaic devices are designed to utilize solar energy for generation of electricity.

- **Solar hot water heating system:**

- **Solar Collector**: Solar Collector is a complex component of the system, where solar radiation is absorbed and transferred to the water flowing all along in fin-tubes. Hence, solar collector consists of a flat surface with high absorbivity, generally made of metal (Copper, steel, aluminum, GI sheet of 1 to 2 mm thickness). The fin-tubes are longitudinally inserted with maximum provision of contact to facilitate heat transfer. In practice, various versions are commonly used where these fin-tubes are either pressed under pressure, bonded thermally or by soldering or otherwise as suited. This absorber is also coated with black paint of high quality to improve absorption of radiation. These absorbers are covered by suitable tempered glass with a gap of maximum 3cm on to the absorber plate and are suitably fixed on all sides in a frame. This is called paneling and suitable measures are taken to ensure very minimum heat losses by padding with thermal insulators. In these flat plate collectors, no complicated tracking mechanism is required. Components are fixed permanently and hence no moving parts. These flat plate collectors can absorb both direct and diffuse radiation. These solar panels/collectors are typically of 2m2 in size. Depending on the requirement, these panels can be arranged serially to maximize the output based on end use. The maximum temperatures that can be reached by these panels are around 1000C. The panels are to be kept clean to avoid dust which in turn reduces the performance.

- **Hot Water Storage Tank**: These tanks are generally made of stainless steel, M.S. or Copper. Stainless steel tanks are preferred to avoid corrosion. These tanks are sized based on the total output of the collector's capacity to heat water as designed. These tanks are insulated to reduce heat losses. The storage tank capacity should not be oversized than the practical limits of the performance of the collectors, since increased surface area and large storage of hot water may offset the advantages associated with a system planned properly.



- **Pumps**: Once the solar panel increases the temperature of the water flowing in the fin- tubes the same is stored in the storage tank. This is achieved by two means generally.

- **Natural or thermo-siphon circulation**: Generally in small systems (100-500 lpd) this natural circulation of hot water to the tank is achieved by positioning the storage tank above the collectors. Under these circumstances, the hot water rises to the top of the panel due to less density and slowly reaches the top of the storage tank. The high density cold water naturally enters the bottom tubes of the panel and slowly rises to the top of the panel through fin-tubes due to absorption of heat. This cycle gets repeated during the day and the storage tank finally gets to full. However, to avoid reverse flow during the night, care should be taken in positioning the storage tank and panels.

- **Forced circulation**: Here there is no need for locating the tank above collectors. As a result, the system can be scale independent to suit larger end usages. A separate pump is fitted for circulation with a controller thermostat which will judge temperature differences between tank and collectors.

- **Backup Heaters**: To tide over the long spells of monsoon and cloudy days; the storage tanks are fitted with electrical heating elements of suitable capacity. Generally in domestic systems these electrical elements are fitted to the storage tanks.

- **Heat Exchangers**: Generally the water used for domestic applications is passed through the fin-tubes along the absorbers. However, in some specific occasions, (industrial application; chemical processing etc) the material to be heated cannot be passed through the absorbers. This may be due to the chemical nature of the fluid which may interact with metallic absorbers. To avoid this kind of situation, "Heat Exchangers" are used. These heat exchangers are either single loop or double loop. Let us imagine a tank with a liquid substance to be heated which can not be heated by normal solar absorbers. In such cases the solar hot water will be passed through a tube passing through or coiled in the tank, to transfer the heat (of solar hot water) to the contents in the tank. This water (Which has lost its energy value) can be recirculated through the absorbers/solar panels, to re-transfer the heat. This process is known as closed-loop heat exchangers. These exchangers can be made of copper, Aluminium, G.I. or steel. These heat exchangers are required only for specific applications.

- **Miscellaneous Items**: These are the items which include stands on which the panels are mounted, and other various accessories to erect the system, comprising pressure gauges; valves; water flow meters and the like.

❑ Basic principles of Solar Water Heater

The basic principle employed in these systems is similar to the green house effect. In these phenomena, accumulation of energy is achieved in between absorber and a re-emitting object. For example, radiation received on earth's surface emits infra-red light back to the atmosphere. CO2 in the atmosphere can absorb a portion of this and remaining is radiated back. This brings accumulation of heat energy on the ground. Similarly the black coated absorber in the solar panel takes the heat of sunlight and its temperature is increased. As a result, this black absorber emits thermal energy in the form of infra-red radiation. The glass fitted on the absorber plate absorbs this infra-red radiation and re-emits the same in all directions. In fact, 40-50% of this falls again on the absorber. As this process goes on, the temperature of the absorber also increases. Generally these absorbers in the panels are black coated selectively and have high absorption and also high emission coefficient for all wavelengths of light. As the temperature of the absorber increases, the heat value of emission of infra-red light by glass also increases. At one point of time, equilibrium is reached when energy gain of the glass by absorbing visible light is balanced by the re-emittance of the infra-red light on to the absorber. At this stage, the absorber plate works at its peak efficiency. In fact, this is the heat energy evacuated by the running water in the fin-tubes by heat transfer. This water is stored in the storage tank.

- **Solar Panel Efficiency**: Solar energy collection efficiency of a panel is defined as a ratio of useful gain over a period of time to the total solar energy incident in the same period of time. For eg. The total solar radiation in a day received by the panel is 5 kWh and the water heating energy contributed by the panel by heat transfer stands at 2.5kWh; the efficiency of the panel is 50%.