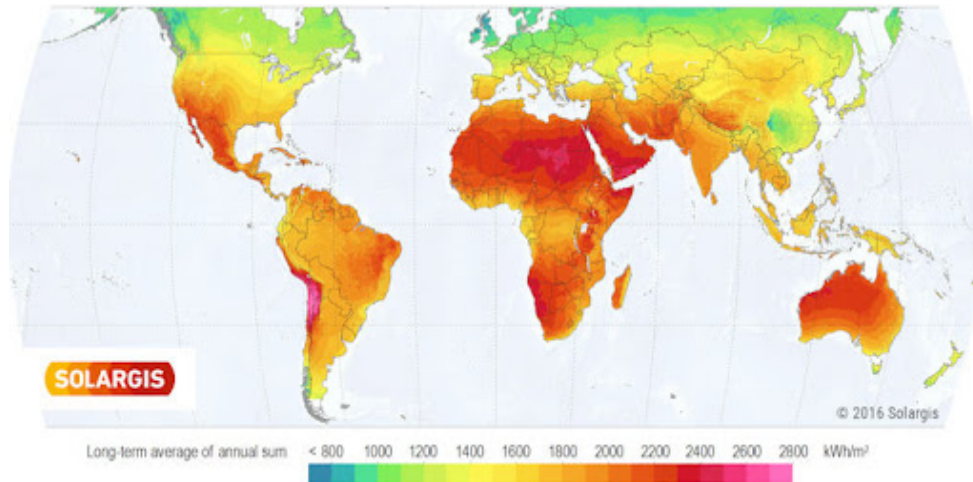


Unit: 3

Solar Thermal systems



- **Subject:** Renewable Energy Sources
- **Faculty:** Rahul G. Suryavansh
- **College:** KLS-GIT, belagavi.

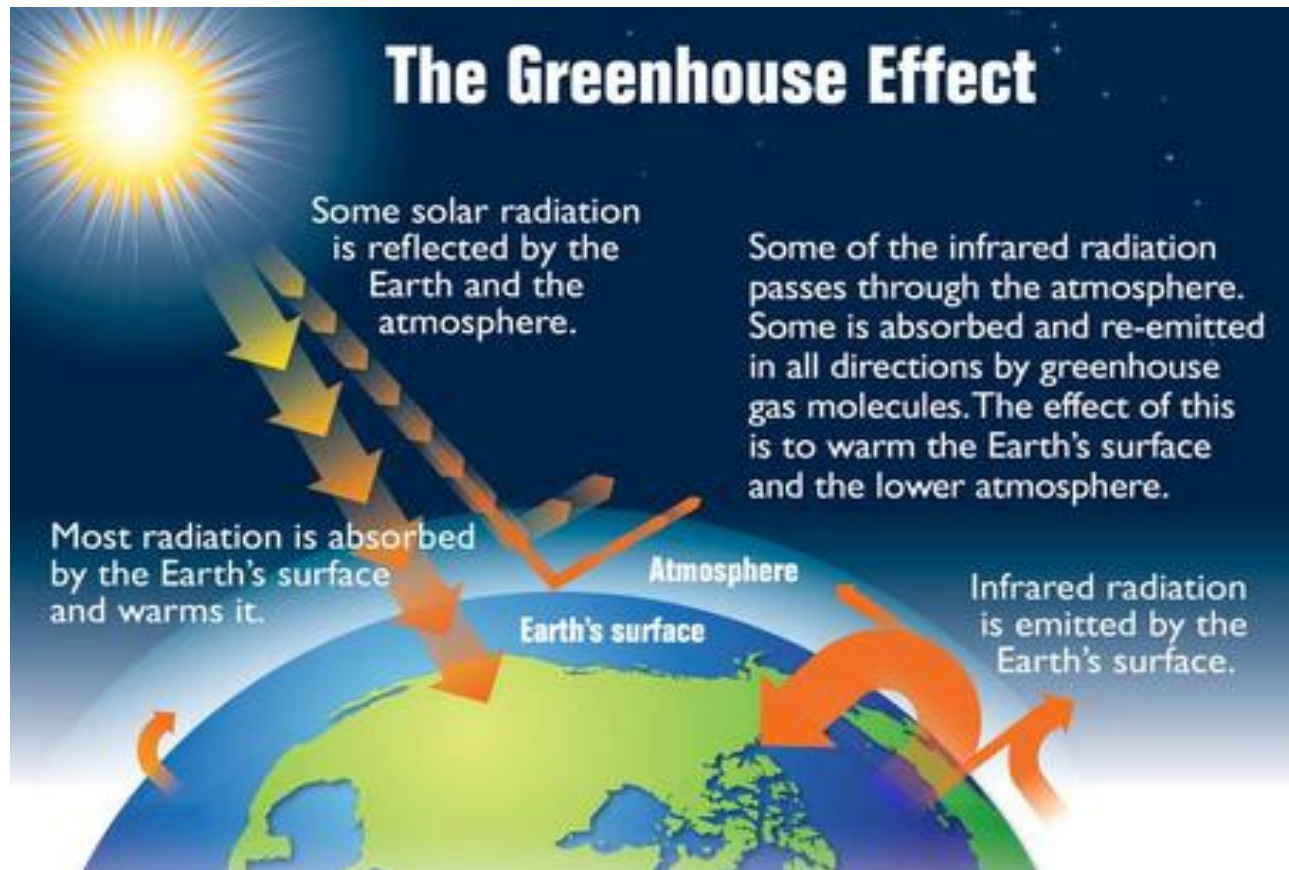


Content:

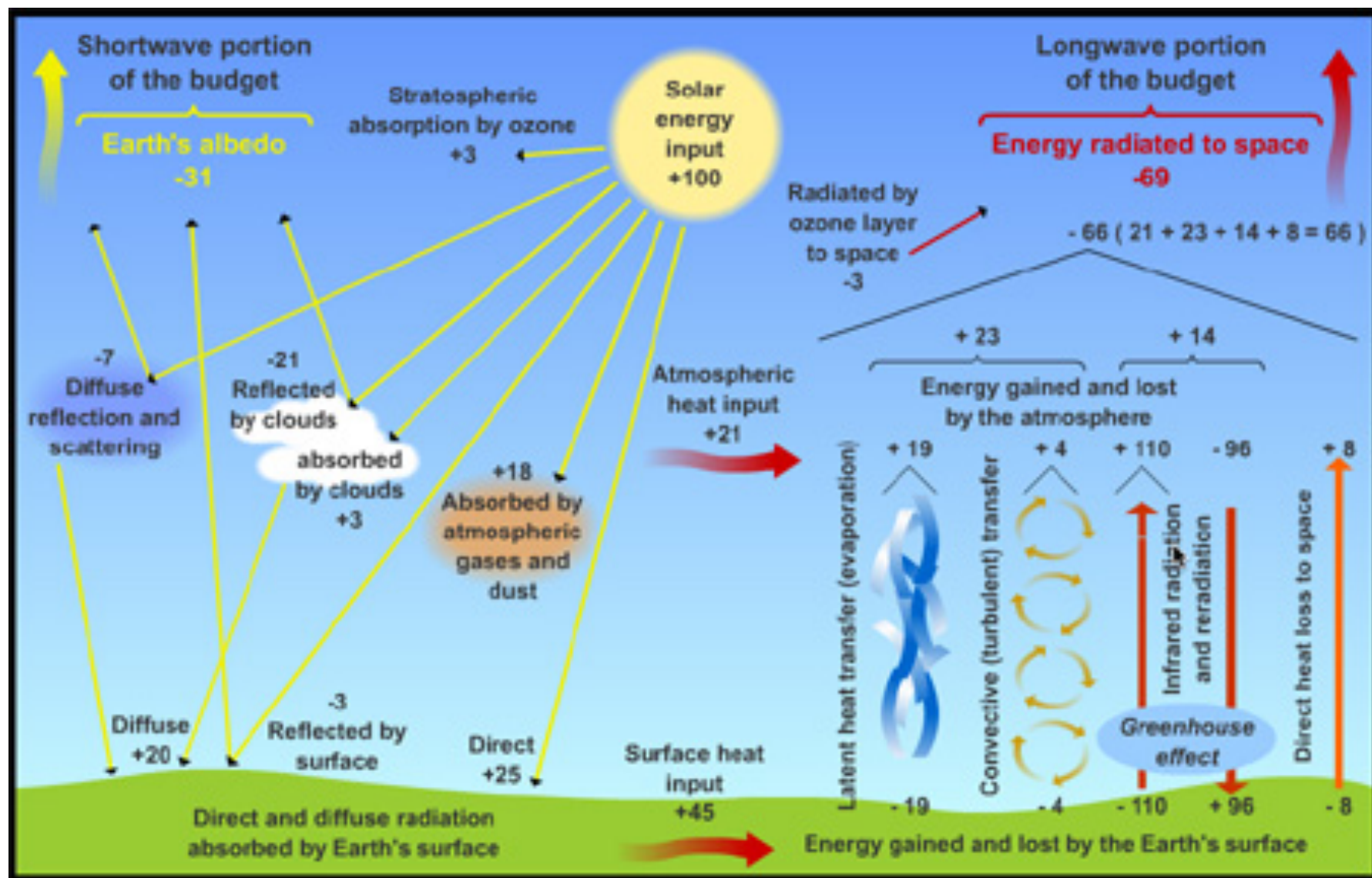
- Principle of conversion of solar radiation into heat,
- solar water heaters (Flat Plate Collectors),
- solar cookers
 - Box type,
 - concentrating dish type.
- solar driers
- solar still,
- solar furnaces,
- solar green houses.

□ Principle of conversion of solar radiation into heat,

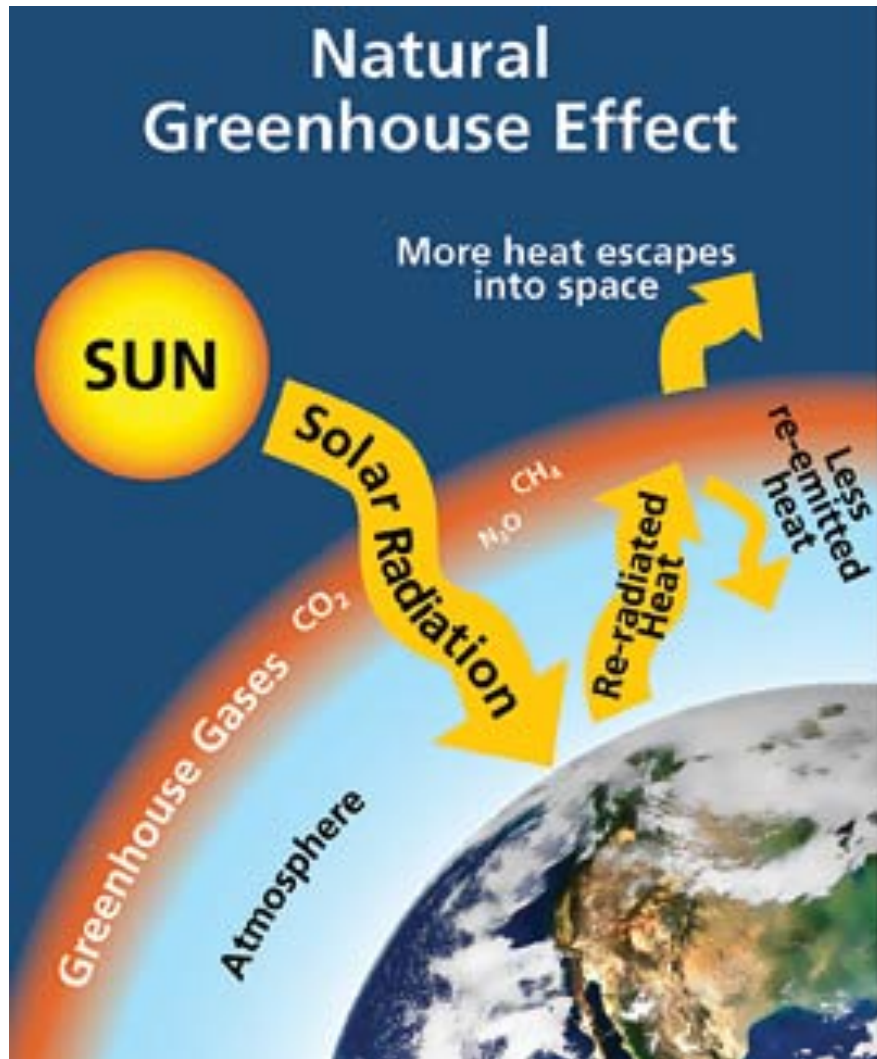
- The basic process used for heat conversion is green house effect.
- Most of the radiation received from sun comes in the form of short wave radiation.



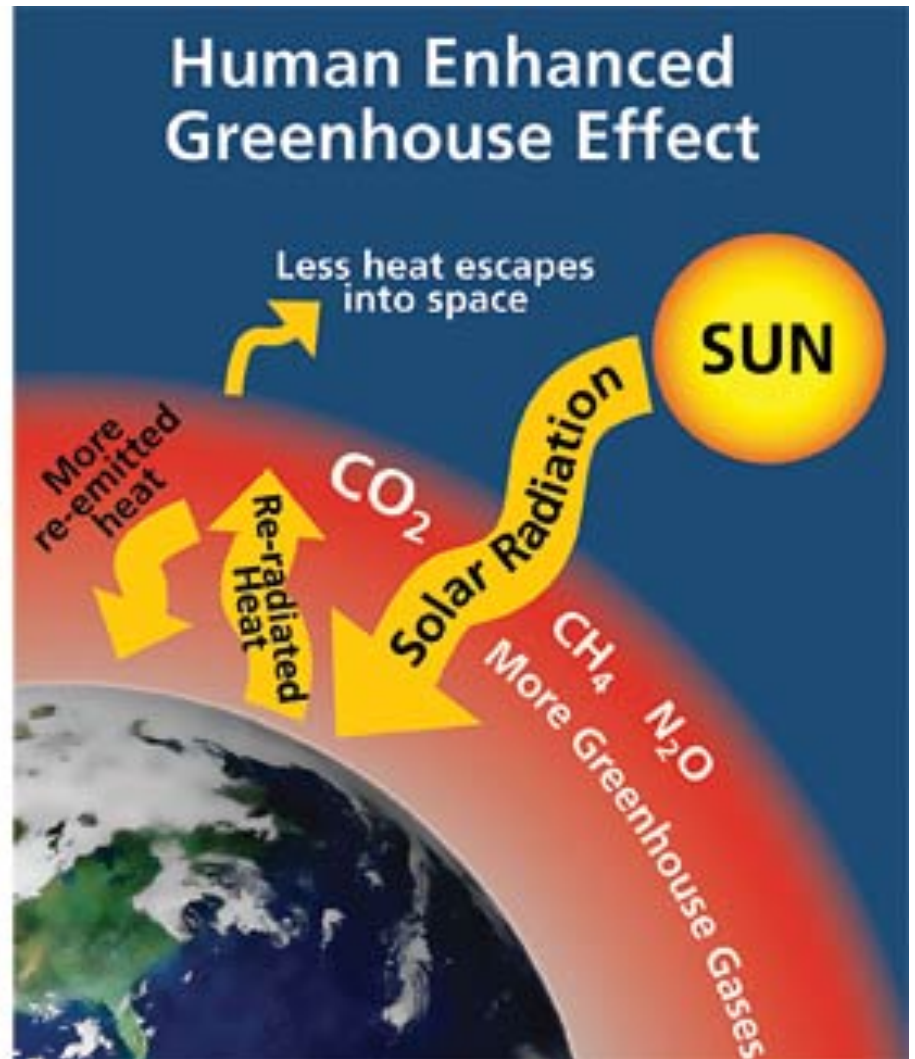
*Conduction,
Convection
Radiation, helps to
keep the
surrounding warm*



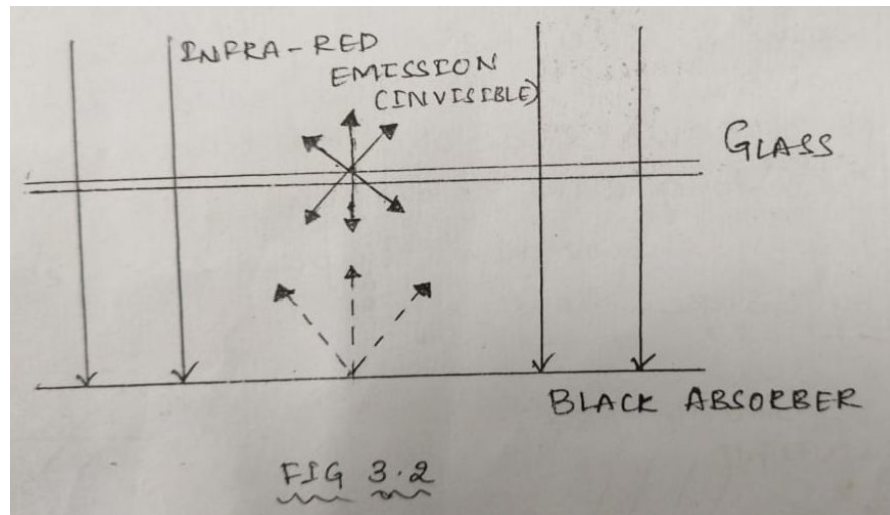
Natural Greenhouse Effect



Human Enhanced Greenhouse Effect

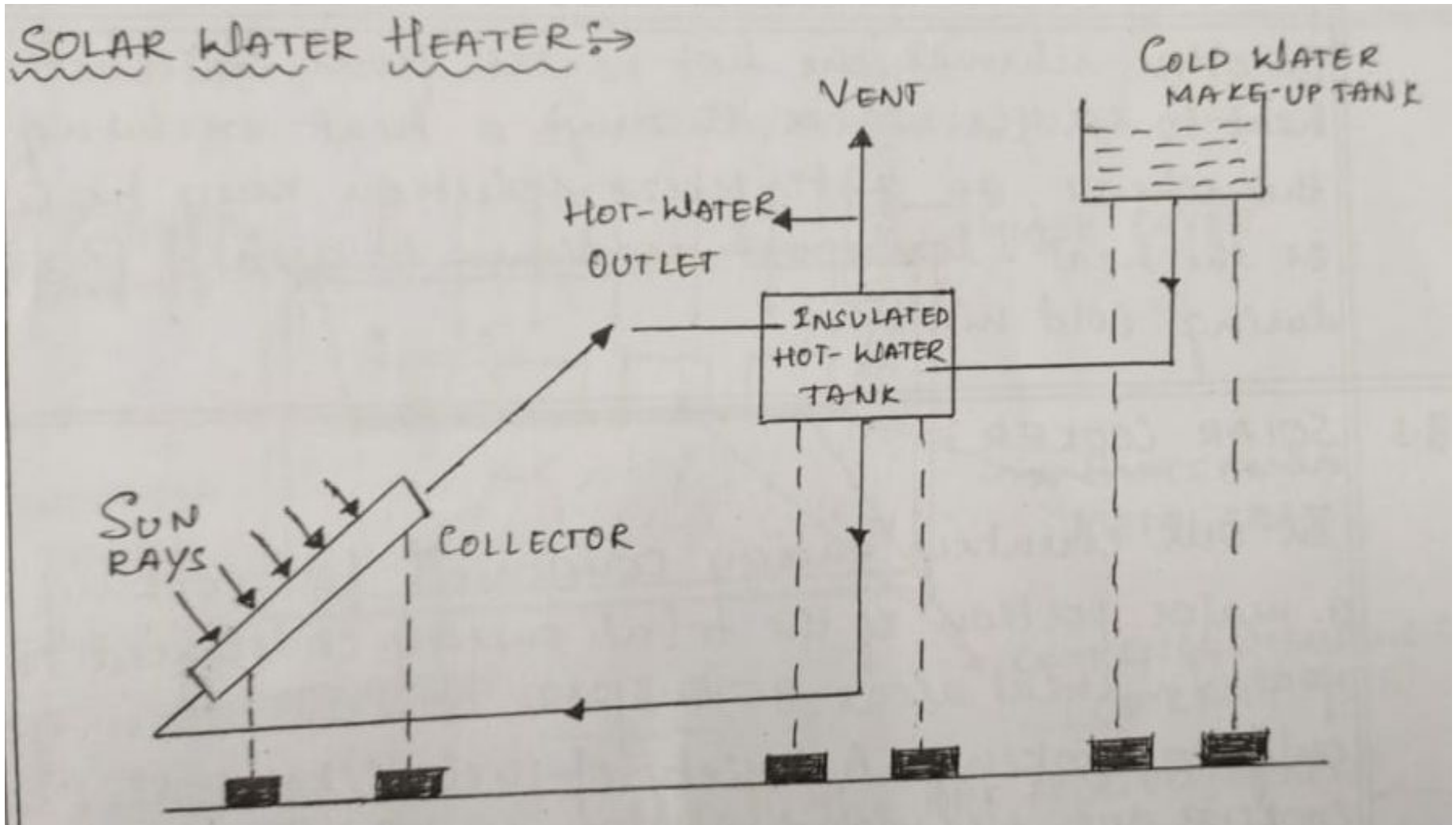


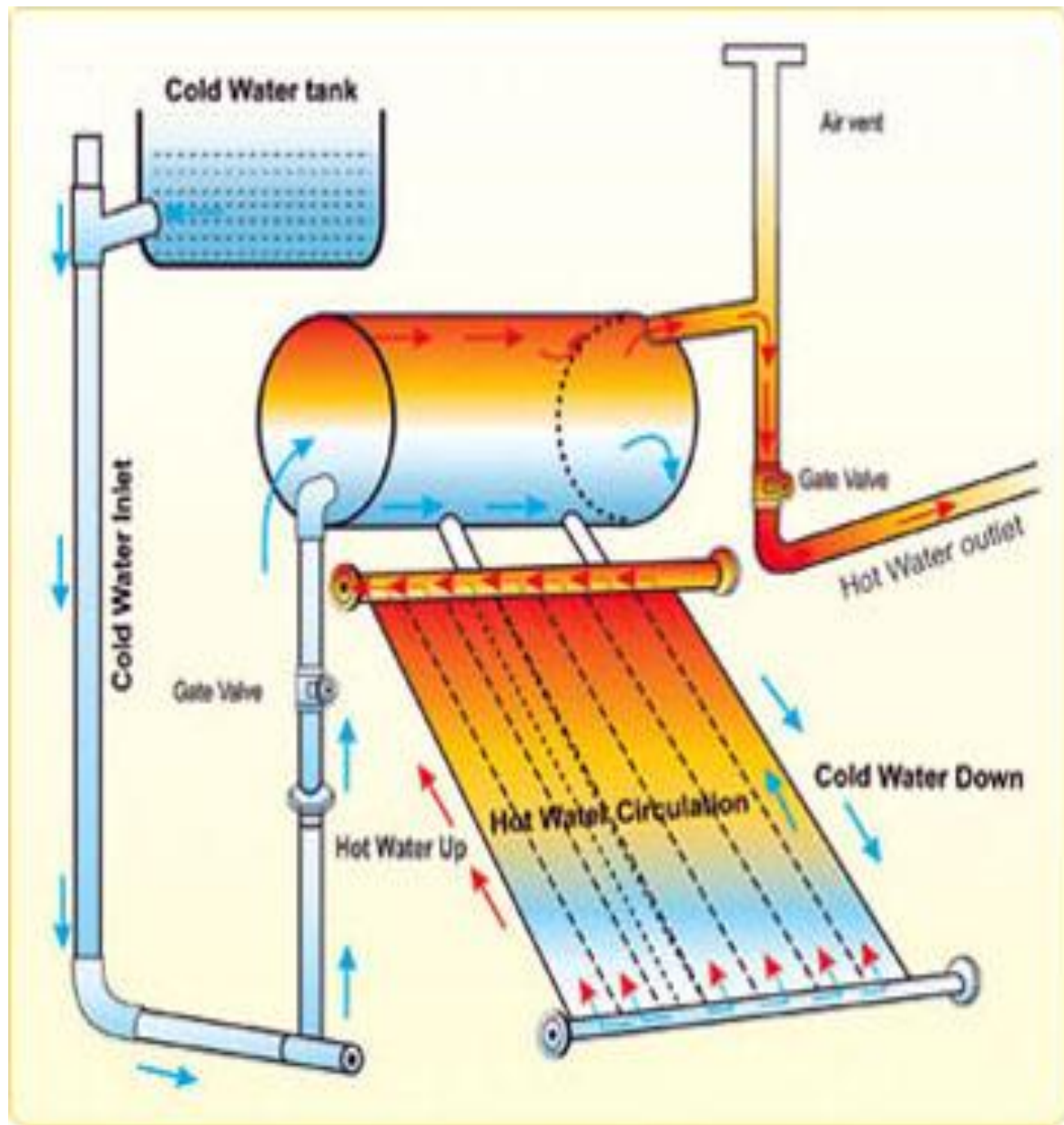
- Heat trapping using Glass and black body absorber:
 - Glass easily transmits short wavelength radiation.
 - But is a poor transmitter of long wavelength radiation.
 - Once the sun energy passes the glass body and is absorbed by any material, the heat produced inside will not be easily radiated outside.
 - Thus glass is used as a heat trap for designing green house.



Black body has the highest absorption rate and highest emission coefficient for all wavelength

Solar water heaters (flat plate collectors),





- The system **works** on a principle called “**THERMOSYPHON**” (Natural circulation). Due to the density difference between the cold & hot **Water**, the lighter hot **water** flows up into the **tank** and the heavier cold **water** enters the collector
- The fig shows a passive (natural circulation) type of FPC solar water heater.
- If the collector is placed above the hot water tank, then a forced circulation is done using pumps, such type of system is called active system.
- An additional electric coil can be placed inside the tank to be used during non sunny days. (India has 300 sunny days)
- Price ranges from 10,000/- to 12,000/- for a 100LPD system.
- Life span of 10 to 15 years.
- Payback period:3 years

☐ Solar still:

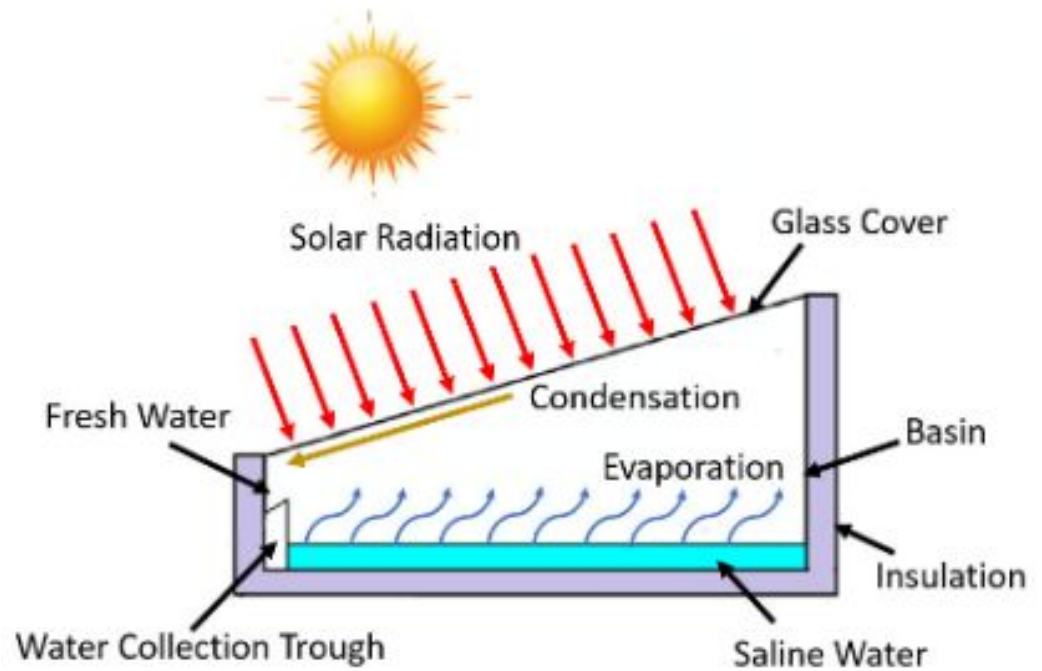
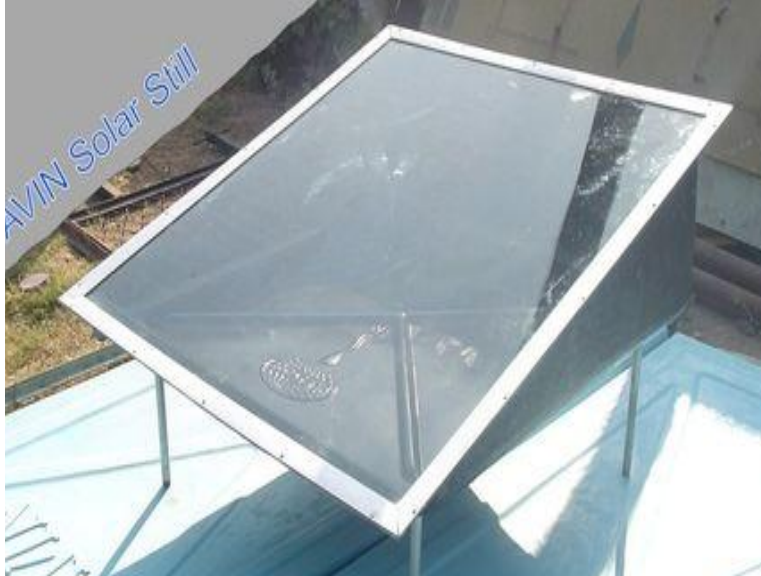
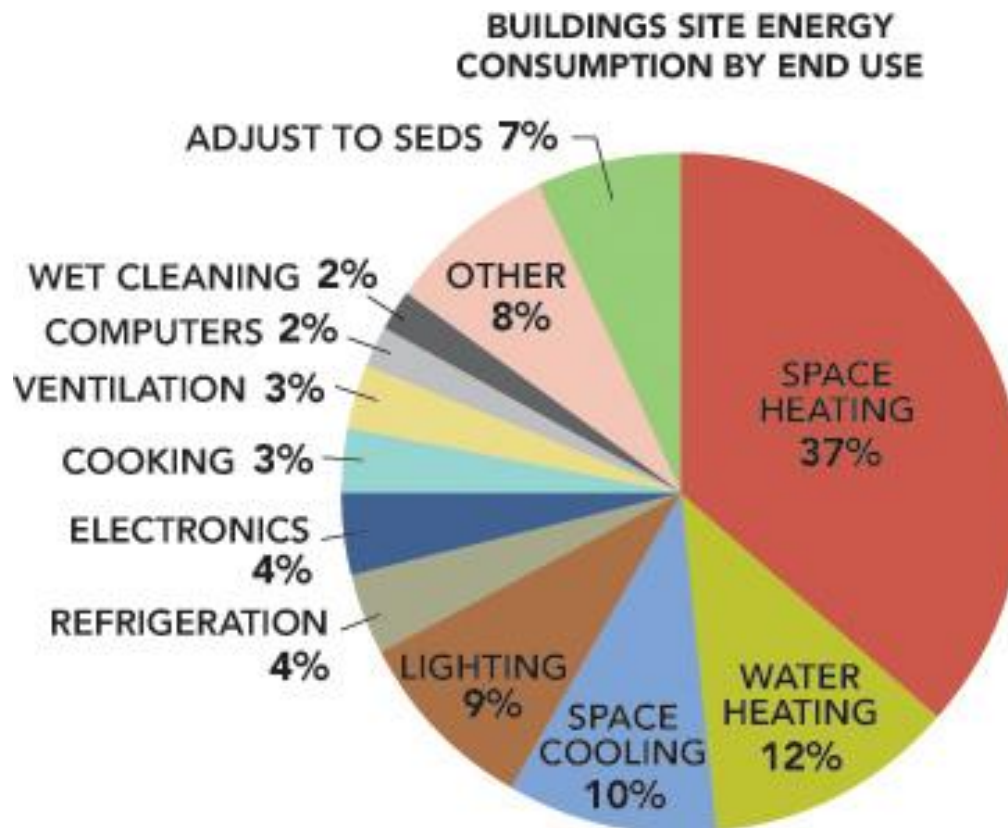


Figure 3. Heat transfer process in a solar still.

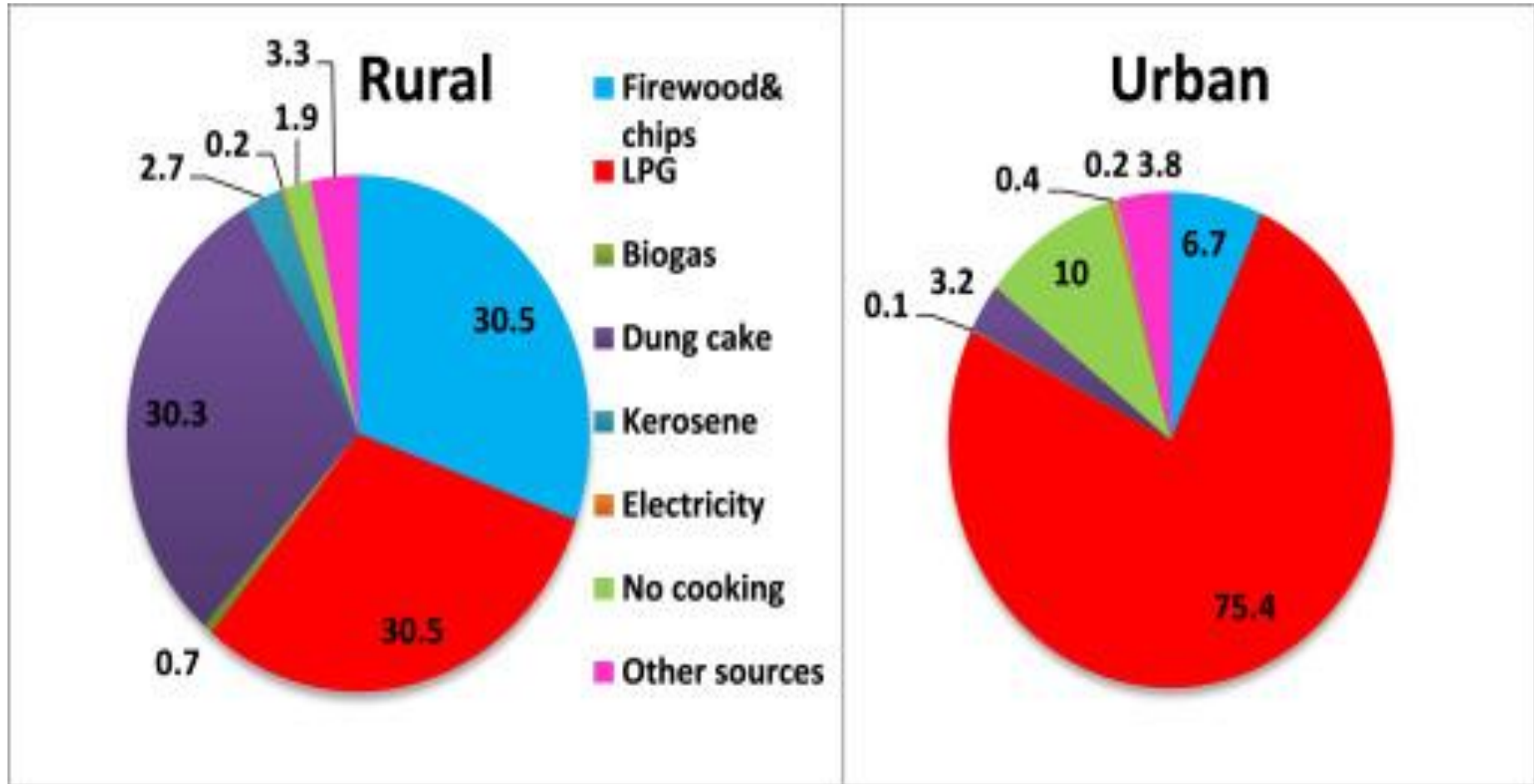
- Basin type solar still.
- Depth of water around 5 to 10 cm.
- Inside it's a black body.
- Saline water evaporates and condenses on the top glass and then slides down where it gets collected.
- Efficiency of 45% to 50%.
- In Indian climate its rate is around, 5.3 ltr/m² per day during summers and 0.9 lter/m²/day during winters.

Solar cookers

- Major portion of energy consumption is for cooking



Fuels used in rural and urban regions:



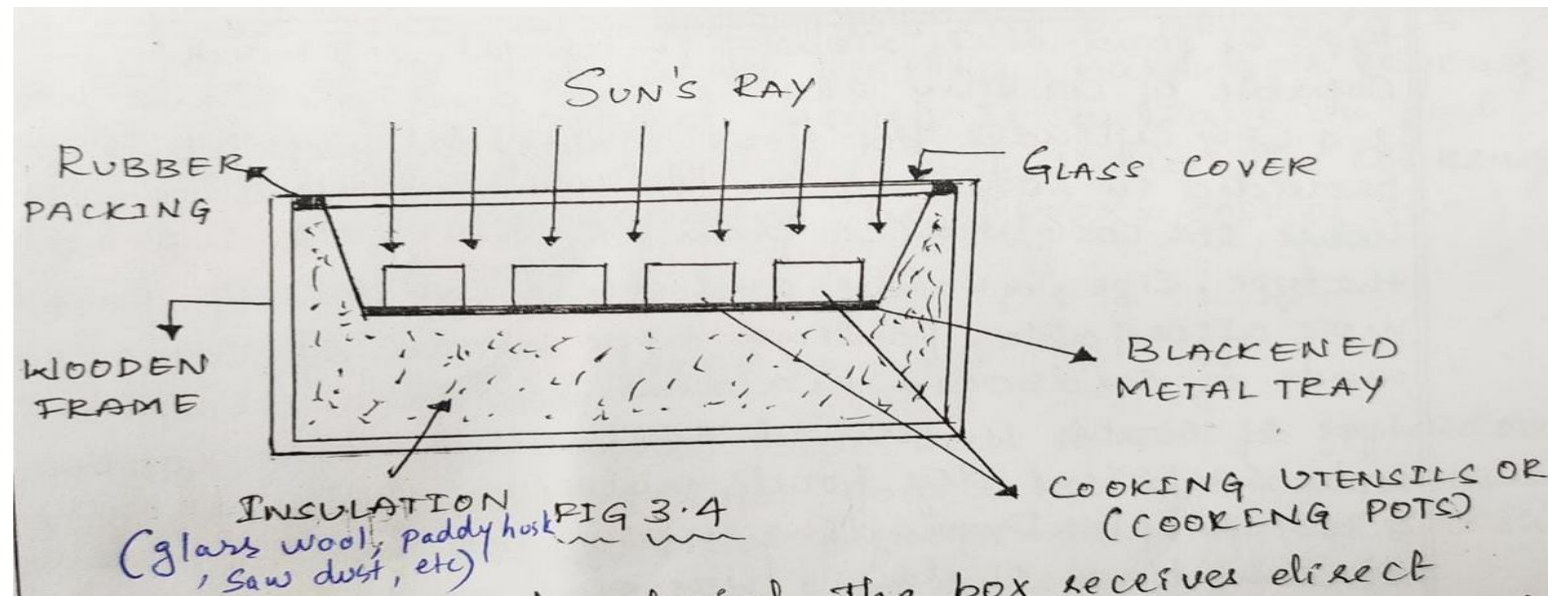
Considering the drawbacks of conventional cooking we need to move towards cleaner and cheaper source of cooking, i.e. **solar cooking**

Types of solar cookers:

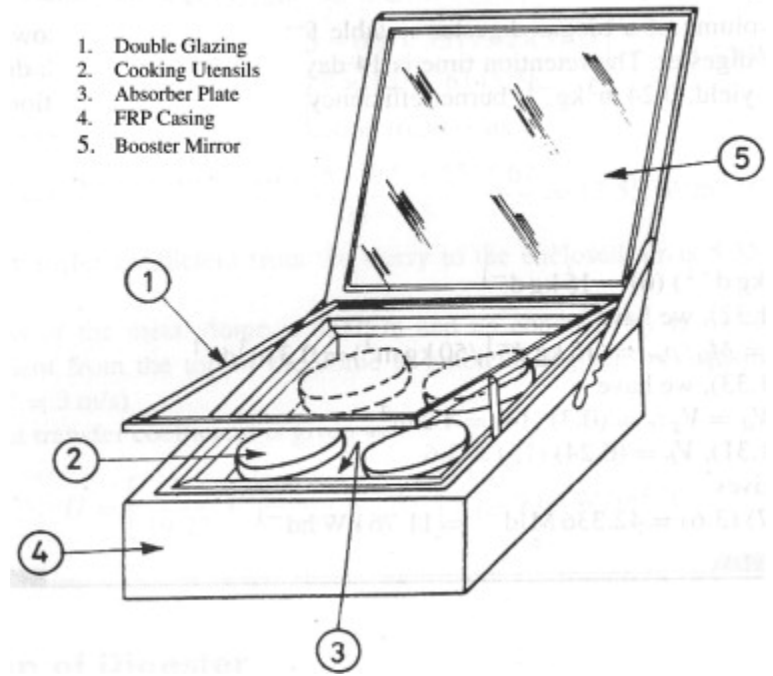
1. Box type of solar cooker
2. Dish type of solar cooker.

1945- **Indian** pioneer Sri M. K. Ghosh designed the **first solar box cooker** to be commercially produced

1. Box type of solar cooker :

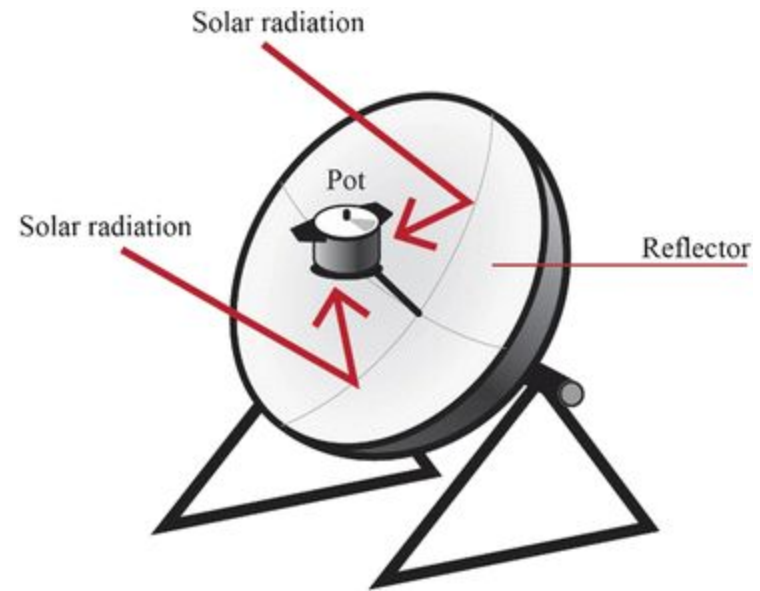


- Typical size of 4 vessel box is 60 cm * 60 cm * 20 cm
- Vessels are placed over the black aluminum metal tray to trap the heat.
- Top of the box is covered with dual glass layer to trap the heat.
- The external box is made of wood and is filled with the insulating material.
- Temperature can reach upto 140 to 150 degrees Celsius.
- Suitable for a family of 4 to 6 members.
- Requires cooking time of around 2 to 4 hrs depending upon the climate.
- An electric coil is provided for usage during dull climatic conditions.
- Cost □ 1800/- to 3000/- Rs.
- Can save upto 4 LPG cylinders per year.



2. Dish type of solar cooker

- Parabolic dish type of reflector is used to concentrate the solar radiation on a cylindrical brass vessel containing food materials.
- Vessel is usually blackened for better absorption of radiation.
- The reflector is periodically adjusted to track the sun.
- Temperature of around 450 degree C can be obtained.
- Cooking for 10 to 15 people can be performed.
- Time required is around 20- 30 min.
- Cost □ 8500/-



□ Advantages and disadvantages of solar cookers:

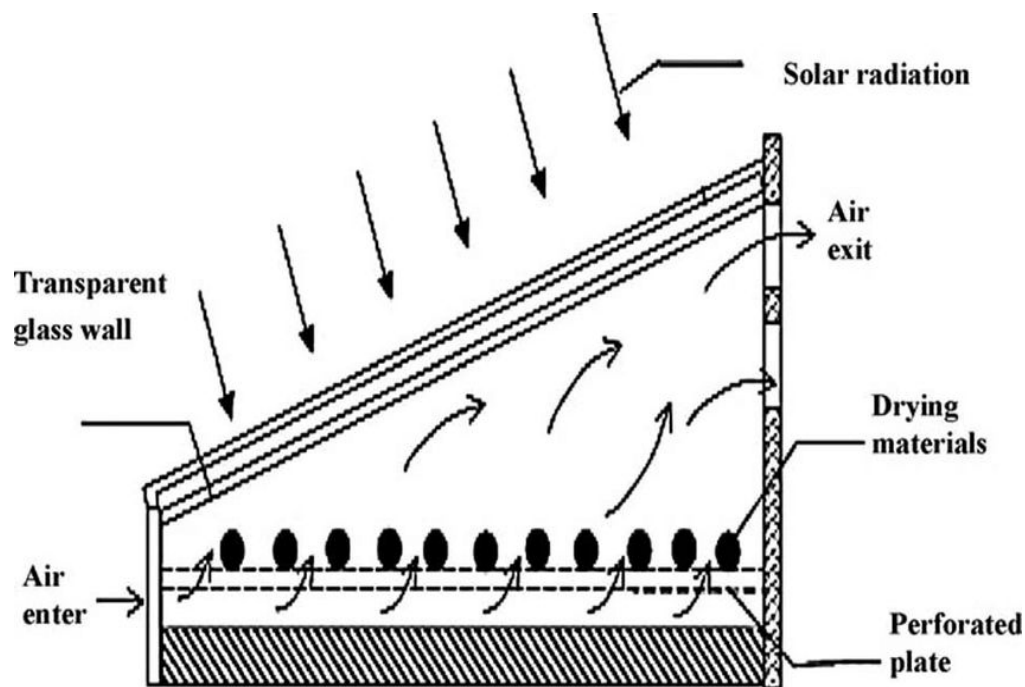
ADVANTAGES ⇒

- 1) No attention is needed during cooking as in other devices
- 2) No fuel is required.
- 3) Negligible maintenance cost.
- 4) No pollution.
- 5) Vitamins of food are not destroyed & food cooked is nutritive & delicious with natural taste.
- 6) No problem of charring of food & no over flowing.

DISADVANTAGES ⇒

- 1) It is too expensive for individual family ownership.
- 2) It requires comparatively more time.
- 3) It is to be used outdoors.
- 4) Cannot be used during nights and cloudy days.
- 5) Chapatties are not cooked (Box type & paraboloidal disc type) because high temperature for baking is required.

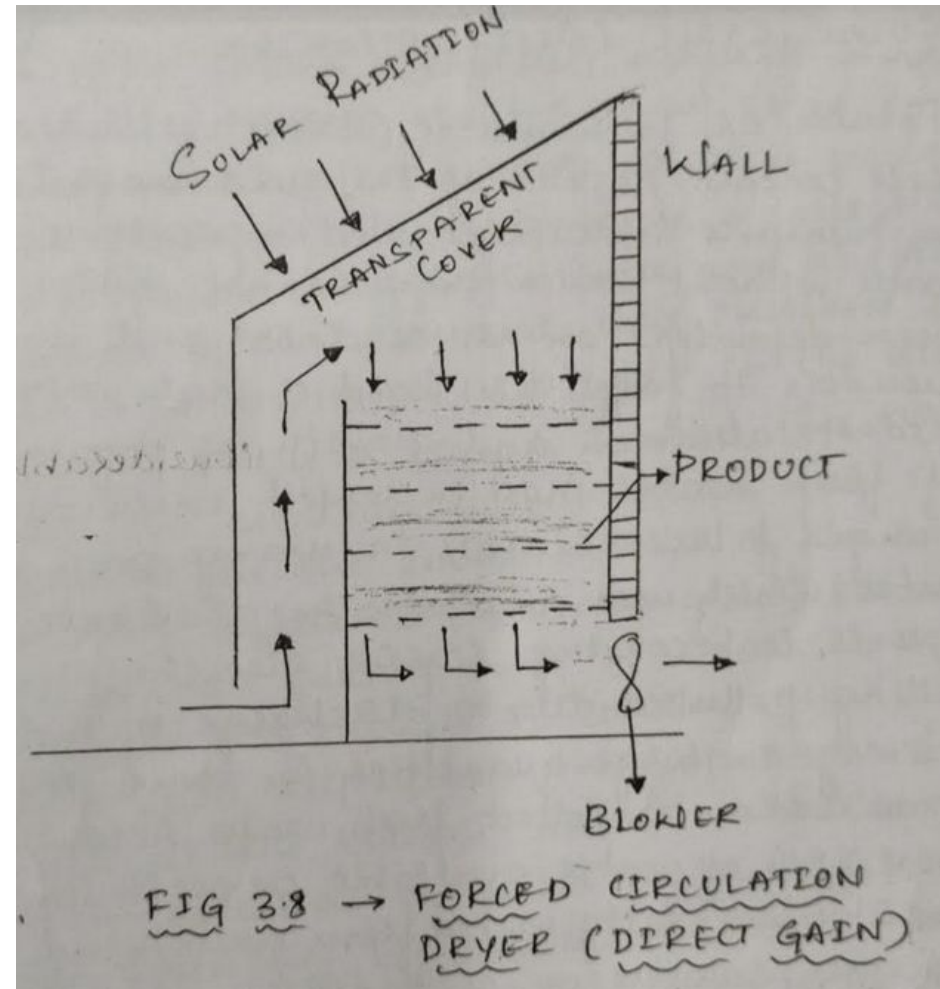
☐ Solar driers



- **Cabinet type natural air circulated** solar dryer used for small scale drying.
- Inside temperature can reach upto 50 to 80 degree Celsius.
- Natural circulation of air is provided from the bottom via perforated trays. (Passive heating)
- Drying time ☐ 2 to 4 days.
- Items dried ☐ Dates, apricots, chillies, grapes, etc.

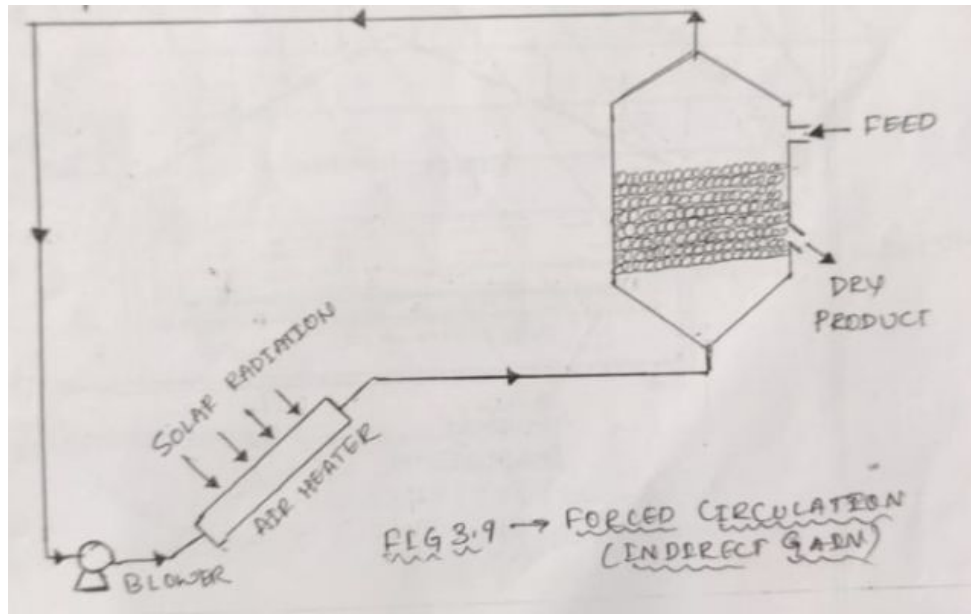
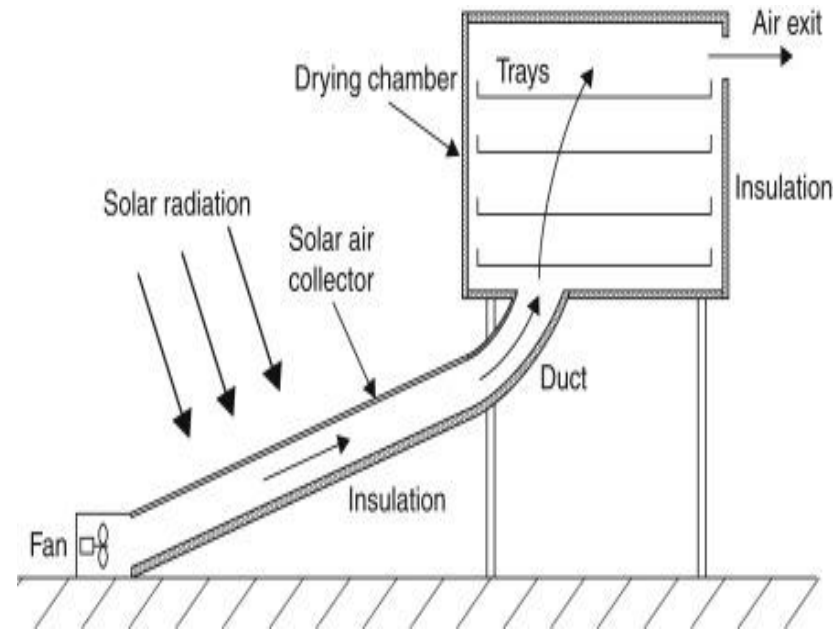
Forced Circulation solar dryer (Direct gain)

- Large scale drying.
- Ex: Timber drying

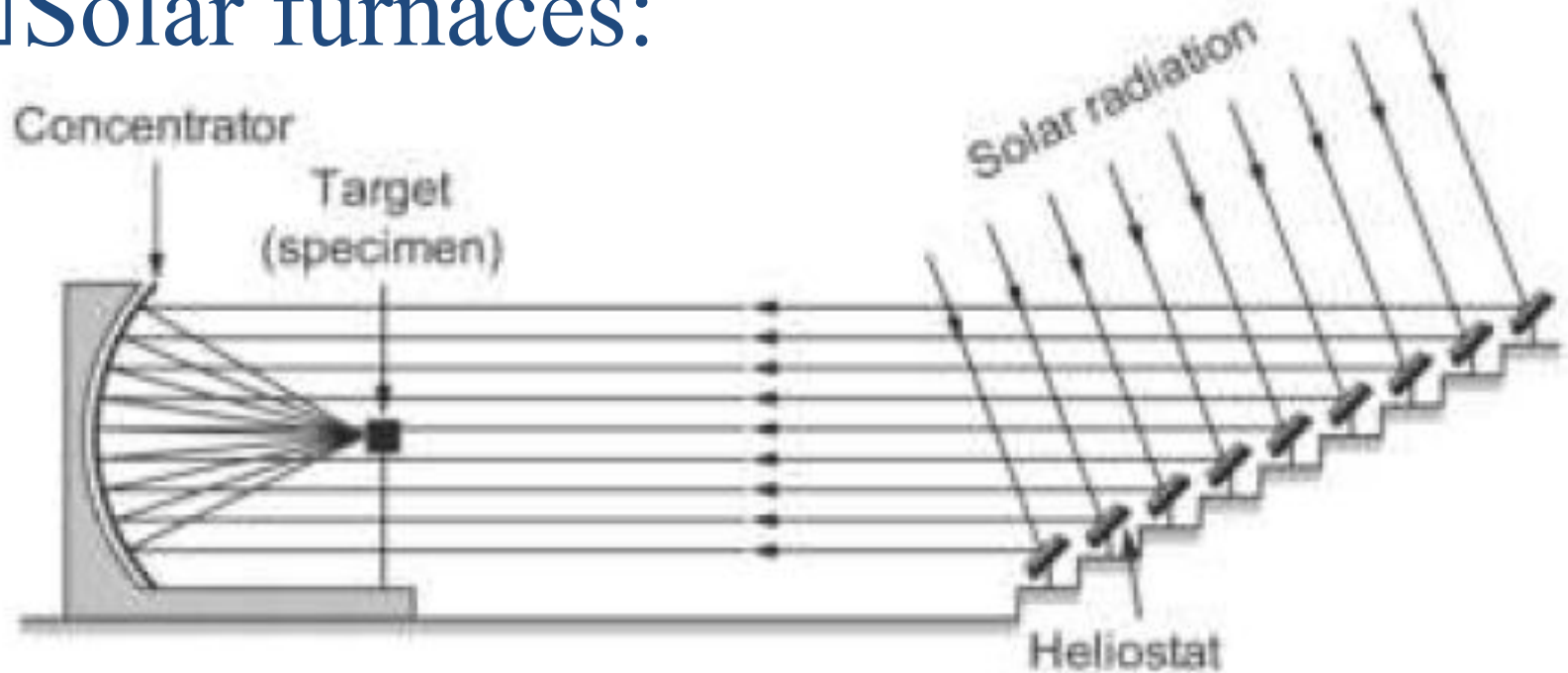


Forced Circulation (Indirect gain):

- When sunlight falling on the product is not sufficient or temperature control is needed then indirect gain method of solar drying is used.
- Used for drying of grains, tea leaves, tobacco etc.



□ Solar furnaces:



- Solar furnace is a device to get high temperature by concentrating solar radiation on a particular specimen.
- 2 main components are,
 - Concentrator
 - Heliostats (Single or multiple)
- Heliostat with horizontal optical axis is shown. It can be used in vertical axis also.
- A drive controlled heliostats track the sun and reflect the sunlight on a single large parabolic concentrator which further focuses it on to a small area.
- Temperature as high as 3500 degree Celsius can be achieved.

Odeillo solar furnace

- Location: France
- Capacity: 1000 kW
- Temperature: 3500 degree C



- It is 54 metres (177 ft) high and 48 metres (157 ft) wide,
- No. of heliostat: 63.
- Size: 7.5m * 6m (45 sq. mtr)

□ Solar Green House:

- Used to grow flowers and vegetables under controlled conditions.
- Winter green house □ Provides hot temperatures
- Summer Green house □ Provides lower temperatures
- For better growth of plants they require, moderate temp, light, adiquite CO₂, O₂, minerals, air movement.
- Out of the above mentioned, Light, Temp and air movement can be supplied by green house.
- If natural modes are used to control, store and distribute the energy then it's a **passive green house**
- If auxiliary modes are used then it's a **active green house.**

Table 5.3 Desirable environmental conditions for growth of a plant

S.N.	Parameter	Optimum required level
1	<i>Light intensity</i> (about 100,000–150,000 lumen/m ² available around noon time)	25,000–50,000 lumen/m ²
2	<i>Night temperature:</i> (i) Air temperature for winter crops (ii) Air temperature for summer crops (iii) Soil temperature	5–15°C 20–30°C 20–25°C
3	Relative humidity	30–70 per cent
4	Air movement	0.10–0.35 m/s
5	Carbon dioxide	0.03–0.04 per cent
6	<i>Nutrients</i> (i) Carbon, hydrogen, oxygen (ii) Nitrogen, phosphorous, potassium, calcium, magnesium, sulphur The availability of these nutrients can be judged from the pH value of the soil.	Per cent of dry matter 90 10 6.2–6.8 (recommended)
7	<i>Watering</i> Timing, quantity and frequency should be proper and adequate	Based on experience

- For Light □ Glass or plastic sheet is provided at top facing the sun.
- For Thermal Insulation □ 2 layers of glazing with small air gaps is used.(each layers cuts 13 to 15% of radiation so more that 2 layers not preferred)
- Supplementary lighting is used if necessary.

Winter Green house:

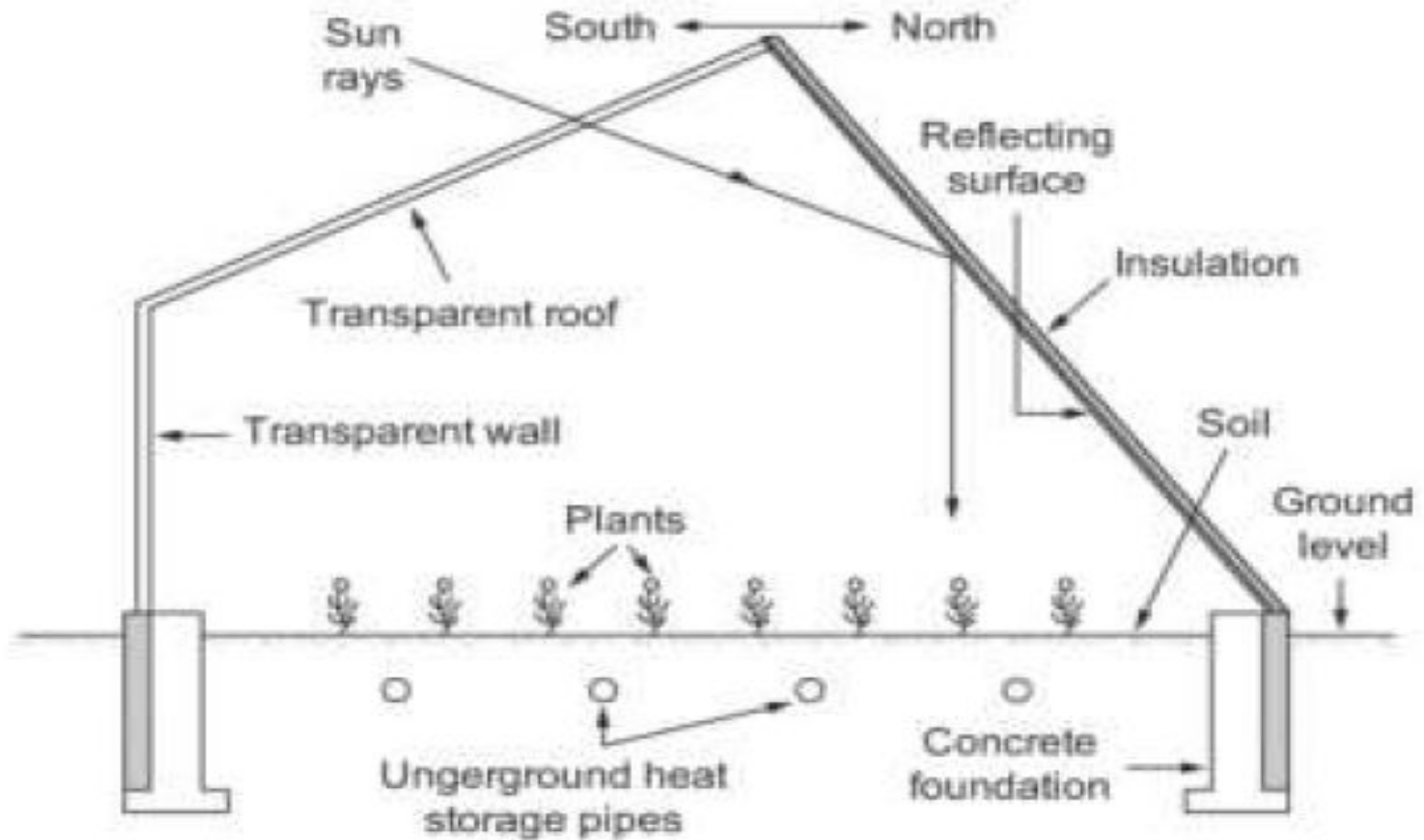


Fig. 5.32 Greenhouse for cold climate