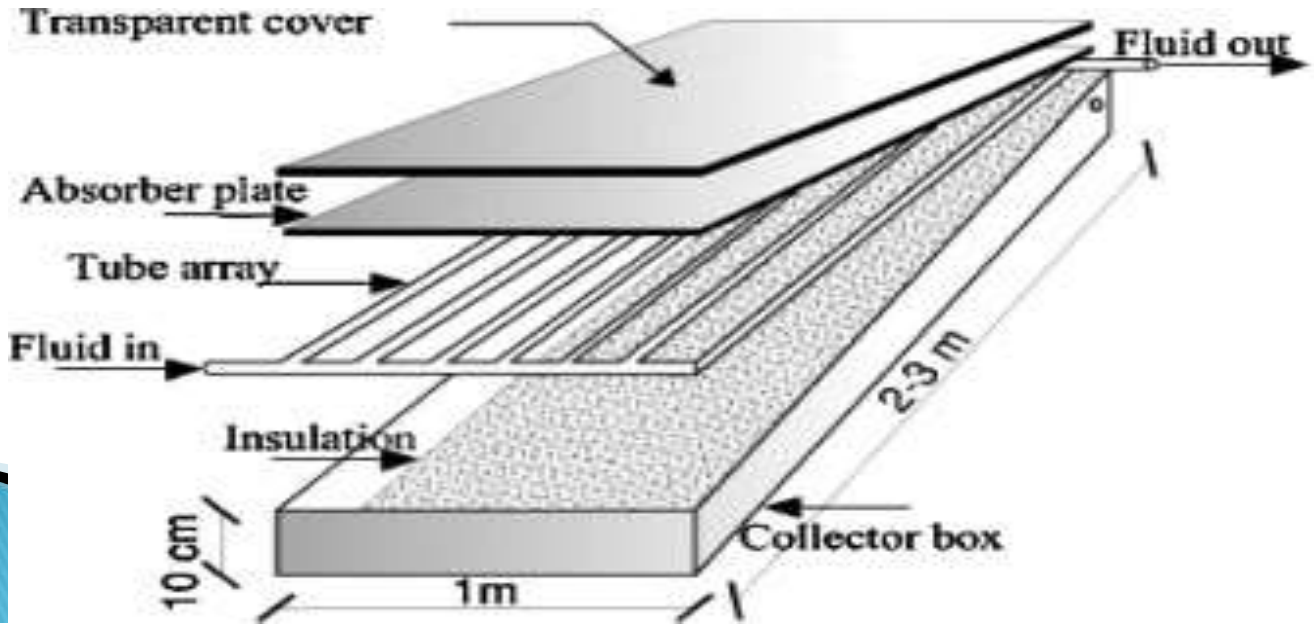
SOLAR COLLECTORS

- A **solar collector** is a device that collects and/or concentrates solar radiation from the Sun.
- **Solar collectors** transform solar radiation into heat and transfer that heat to a medium (water, solar fluid, or air).
- These devices are primarily used for active solar heating and allow for the heating of water

- Two type
  1. Non concentrating or flat plate collector
  2. Concentrating solar collector

FLAT PLATE COLLECTOR

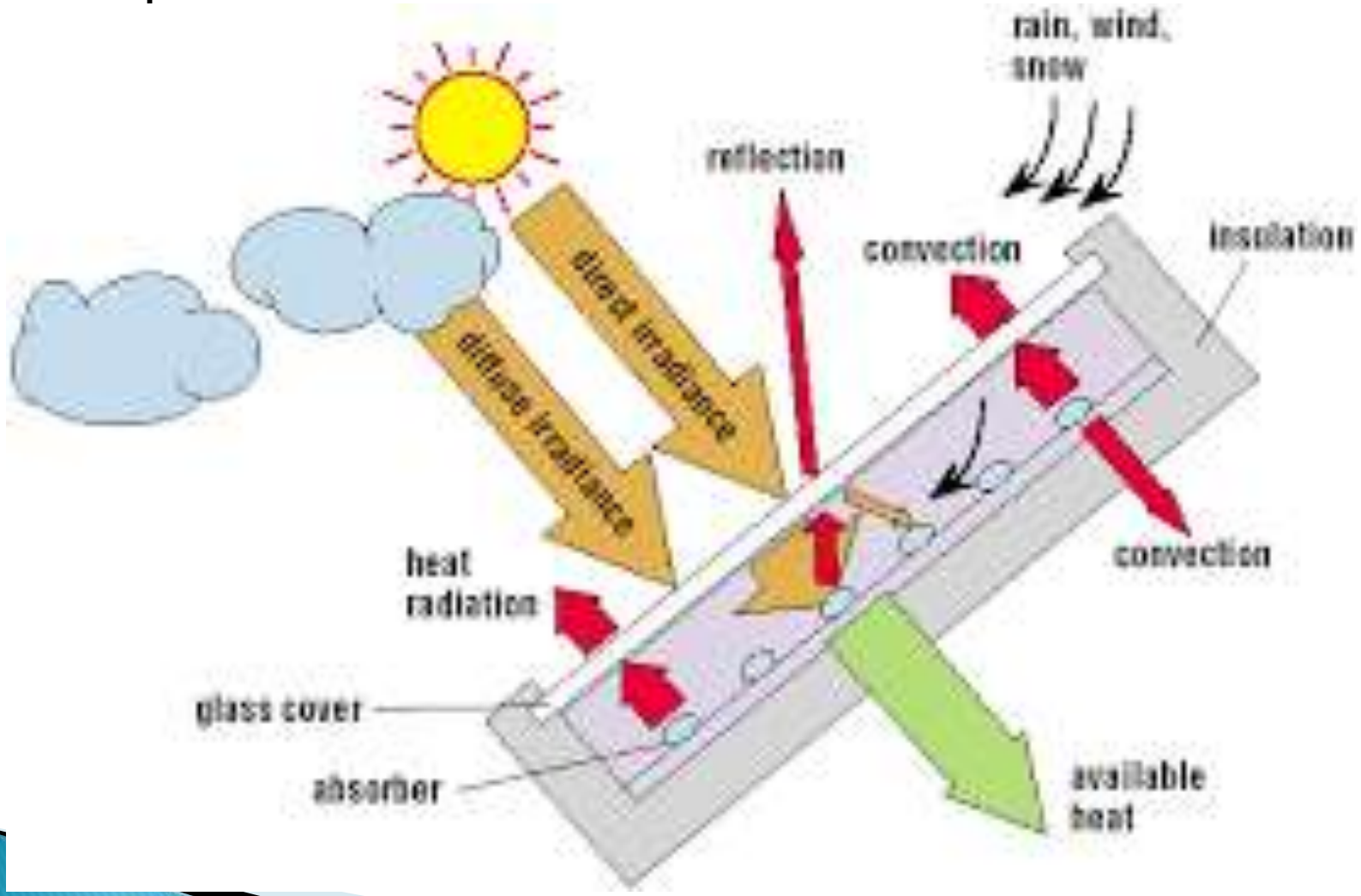
- Used to collect heat for space heating, domestic hot water or cooling with absorption chiller
- temperature below 90 degree Celsius
- collect both direct and diffuse radiation
- A flat-plate collector consists of **an absorber, a transparent cover, a frame, and insulation**.



- **A transparent cover** which may be one or more sheets of glass or radiation transmitting plastic film or sheet
- Usually an iron-poor solar safety glass is used as a transparent cover, as it transmits a great amount of the short-wave light spectrum.
- the transparent cover prevents wind and breezes from carrying the collected heat away (convection)
- Together with the frame, the cover protects the absorber from adverse weather conditions. Typical frame materials include aluminium and galvanized steel; sometimes fibreglass-reinforced plastic is used.

- **Tubes, films, passages or channels** are integral with the collector absorber plate or connected to it, which carry the water, air or other fluid
- **The absorber plate,** normally metallic or with a black surface, although a wide variety of other material can be used with the air heaters
- **Insulation** which should be provided at the back and sides to minimize heat loss. glass,fibers,styro-foam are used for this purpose.
- The insulation on the back of the absorber and on the side walls lessens the heat loss through conduction.

- **The container** which enclose the other components and protect from the weather.



WORKING PRINCIPLE OF FLAT PLATE COLLECTORS

- In **FLAT PLATE COLLECTORS** Sunlight passes through the glazing and strikes the absorber **plate**, which heats up, changing solar energy into heat energy. ... Absorber **plates** are commonly painted with "selective coatings," which absorb and retain heat better than ordinary black paint.

Flat plate solar collectors divided in to two

- **1. Liquid heating collectors**
  2. Air or gas heating collectors

Liquid flat plate collector

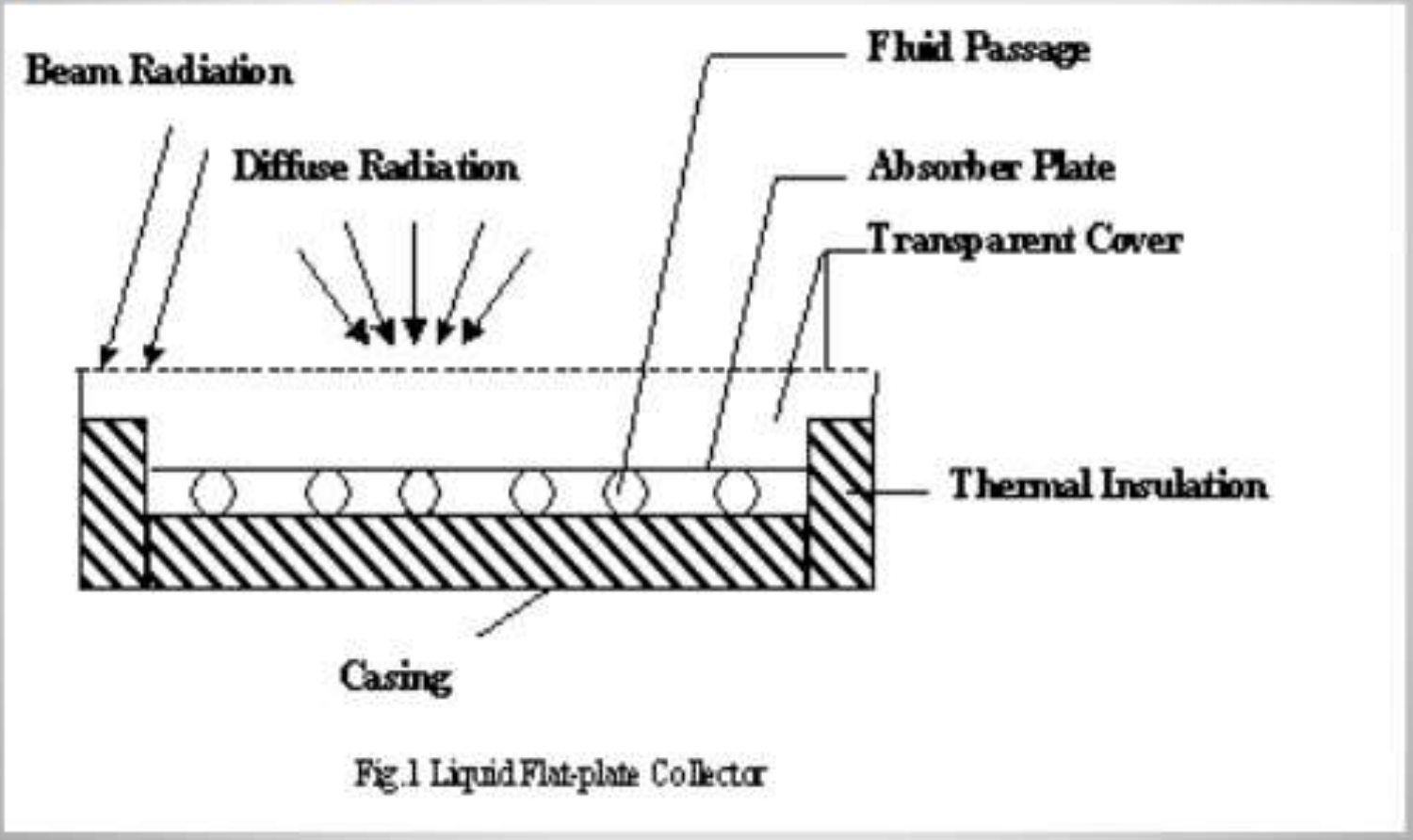
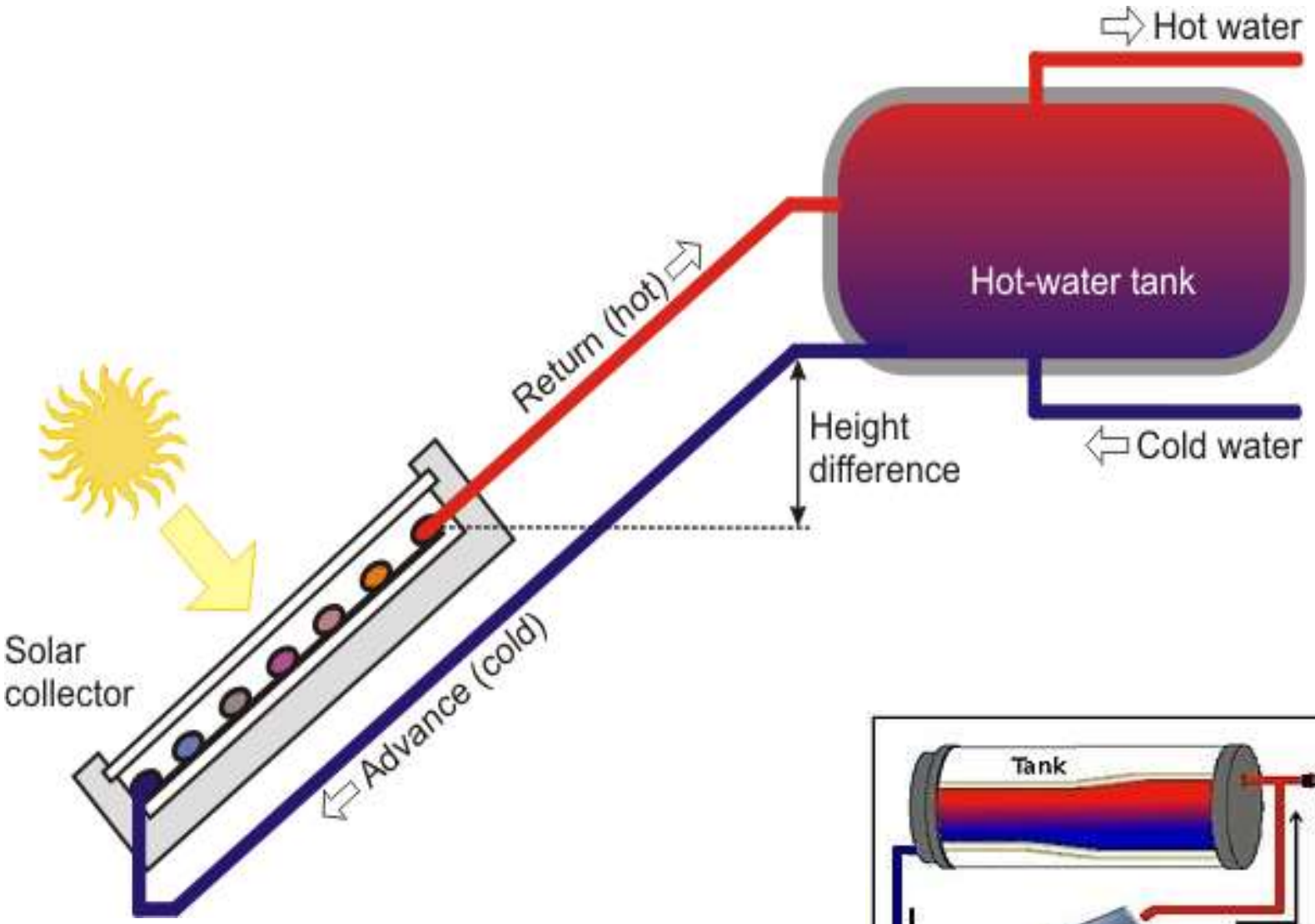
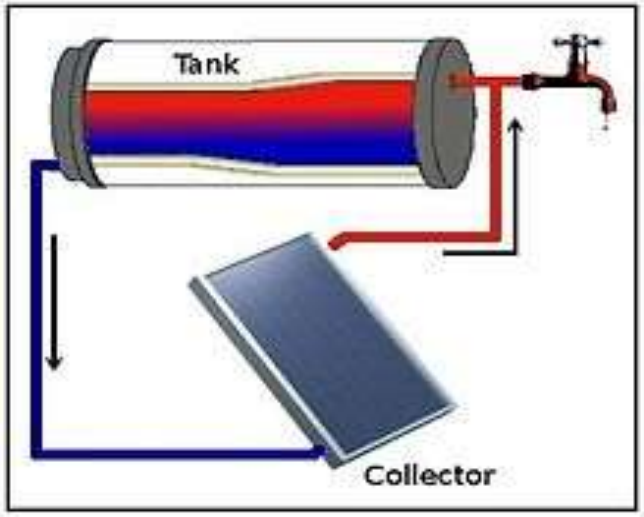
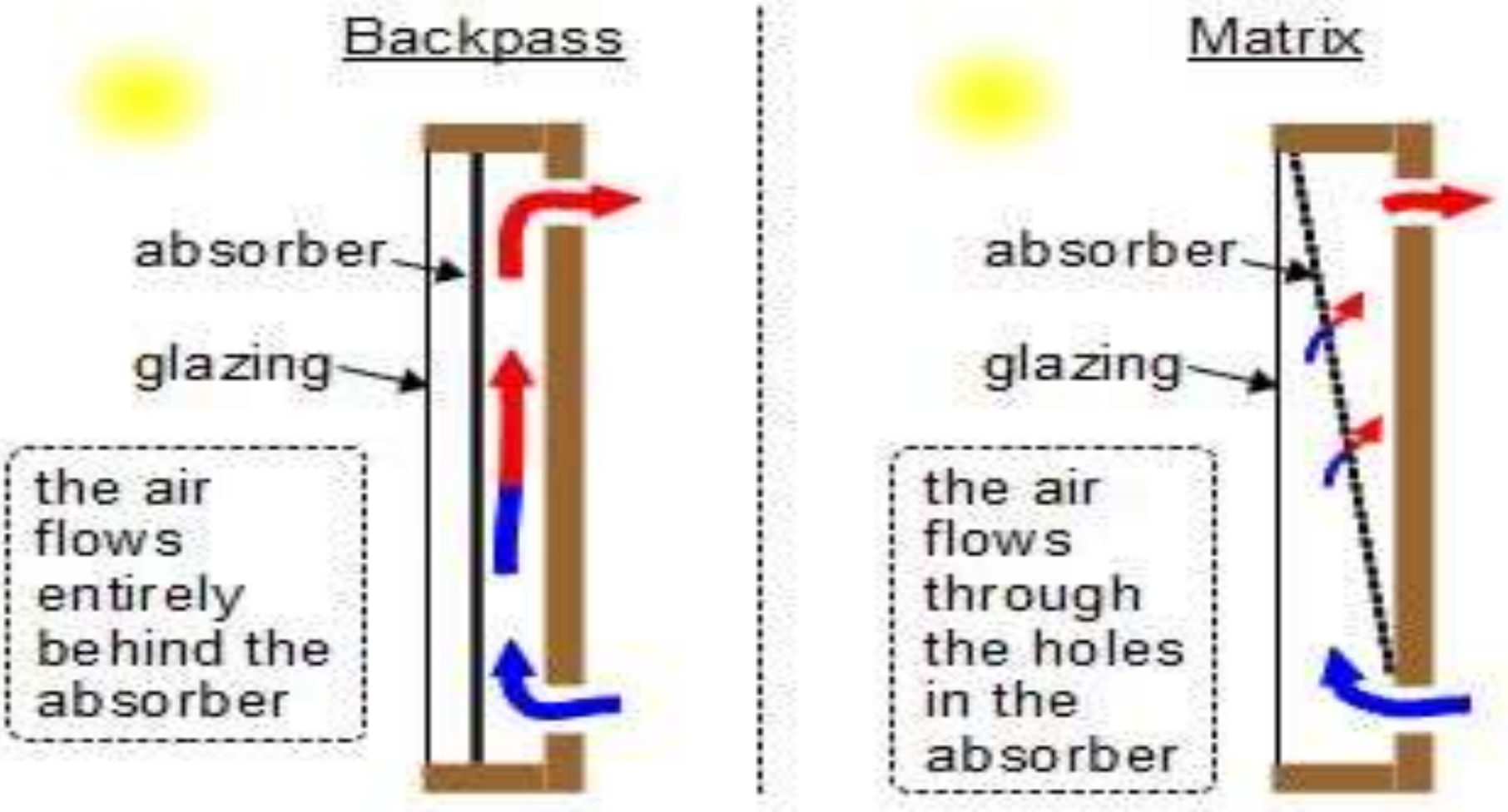


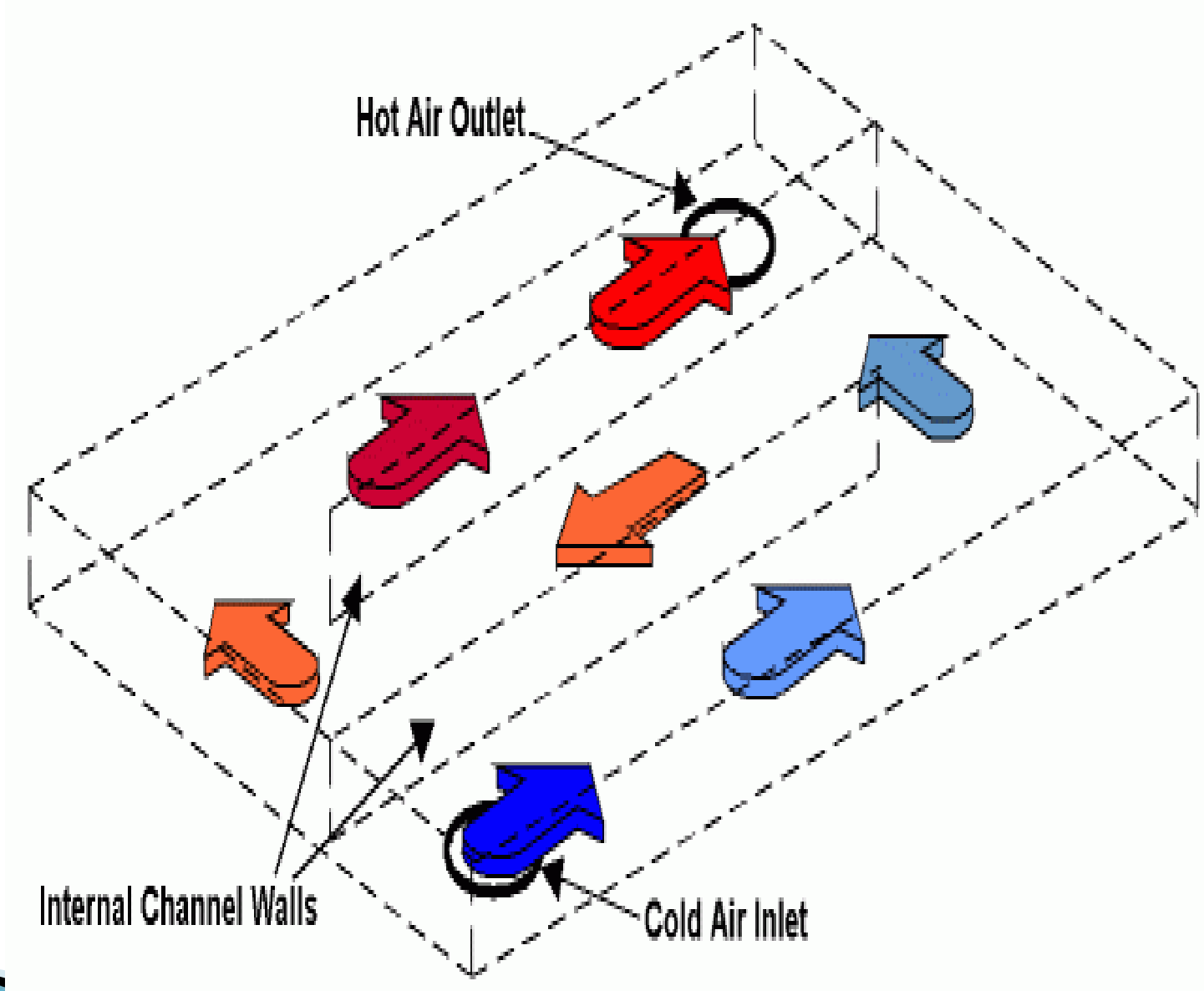
Fig.1 Liquid Flat-plate Collector


Hot water
Hot-water tank
Return (hot)
Height
difference
Cold water
Solar
collector
Advance (cold)


Tank
Collector

Air heating collector




Hot Air Outlet
Internal Channel Walls
Cold Air Inlet

CONCENTRATING SOLAR COLLECTOR

CONCENTRATING COLLECTOR

- A solar collector that uses ***reflective surfaces*** to concentrate sunlight onto a small area, where it is absorbed and converted to heat or, in the case of ***solar photovoltaic (PV) devices,*** into electricity.

- Concentrators can increase the power flux of sunlight hundreds of times.

- The principal types of concentrating collectors include: **compound parabolic, parabolic trough, fixed reflector moving receiver, fixed receiver moving reflector, Fresnel lens, and central receiver.**

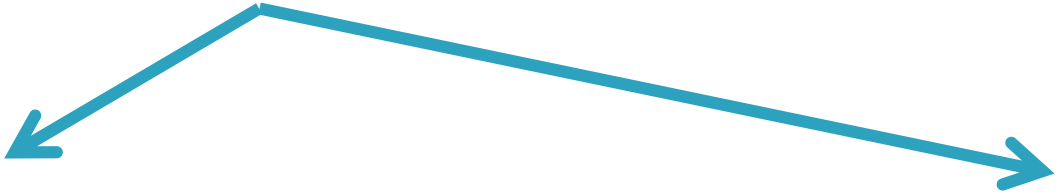
- A PV concentrating module uses ***optical elements*** (Fresnel lens) to increase the amount of sunlight incident onto a PV cell.

- Concentrating PV modules/arrays track the sun and use concentrating devices to reflect direct sunlight onto the solar cell to produce electricity directly.

- Concentrating solar collectors in ***Concentrated Solar Power (CSP)*** facilities concentrate sunlight onto a receiver where it heats a heat transfer fluid that subsequently exchanges its absorbed heat to water to produce steam to power a steam turbine-generator (STG) to produce electricity

Concentrating collectors

focusing type **Non focusing type**



Line focusing **point focusing**

1.Parabolic trough collector

2.Mirror strip reflector

3.Fresnal lens collector

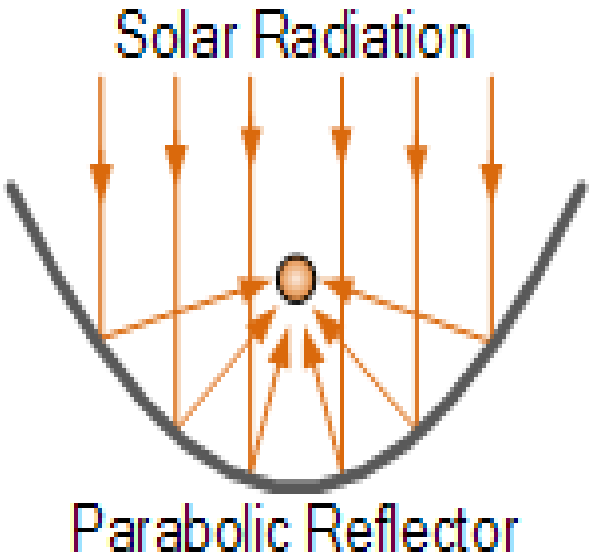
4.Flat plate collector with adjustable mirrors

5.compound parabolic concentrator

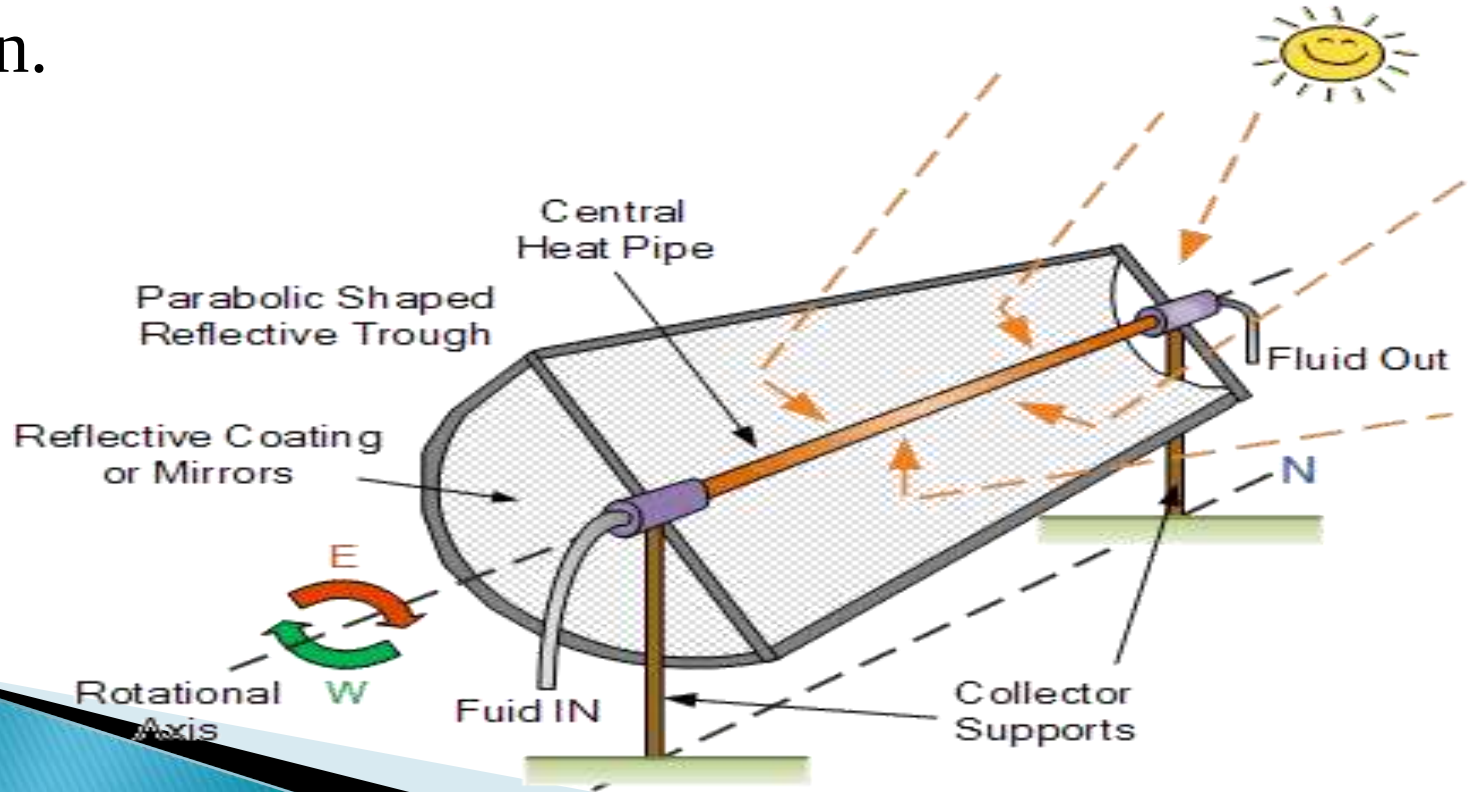
PARABOLIC TROUGH COLLECTOR

- The parabolic trough reflector is a solar thermal energy collector designed to capture **the sun's direct solar radiation** over a large surface area and focus, or more generally "concentrate it" onto a small focal point area increasing the solar energy received by more than a factor of two which means more overall heat per square meter of trough.
- Concentrating solar collectors for residential applications are usually a "U-shaped" parabolic trough that concentrates the sun's energy on an absorber heat tube called a receiver that is positioned along the focal point axis of the reflective trough.

- **Parabolic Trough Reflectors** or **PTR**, are made by simply bending a sheet of reflective or highly polished material into a parabolic shape called a parabola. Since solar light waves essentially travel parallel to each other, this type of solar collector can be pointed directly into the sun and still achieve a total focal output from all parts of the trough shaped reflector as shown.
- parabolic trough reflectors use only direct solar radiation to heat the receiver tube as diffused solar radiation cannot be focused onto the absorber making them less effective when the skies are cloudy or the sun is out of alignment.



- most concentrating collectors require some form of mechanical equipment that constantly orients the collectors towards the sun keeping the heat pipe absorber at the correct focal point. This is achieved by using a Tracking Solar Concentrator that aligns the trough with the sun throughout the day, maximising the solar heat gain.

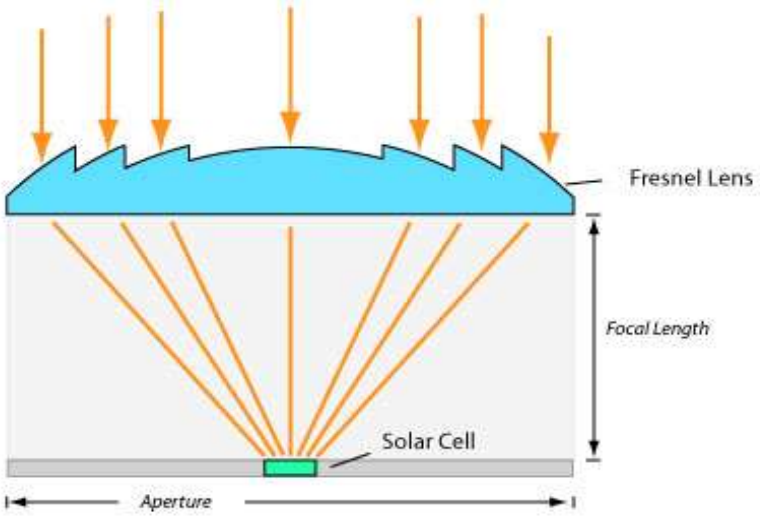


MIRROR STRIP REFLECTOR

- A number of plain or slightly curved(concave),mirror strips are mounted on a flat base
- The angles of the individual mirrors are such that they reflect solar radiation from a specific direction to the same focal line.

FRESNEL LENS COLLECTOR

- It utilizes the focusing effect of a Fresnel lens
- To be fully effective the Fresnel lens must be continuously aligned with the sun in two direction, both along and perpendicular to its length
- This is achieved by orienting the troughs in the north south direction.
- The solar radiation is focused in to the absorber from the top



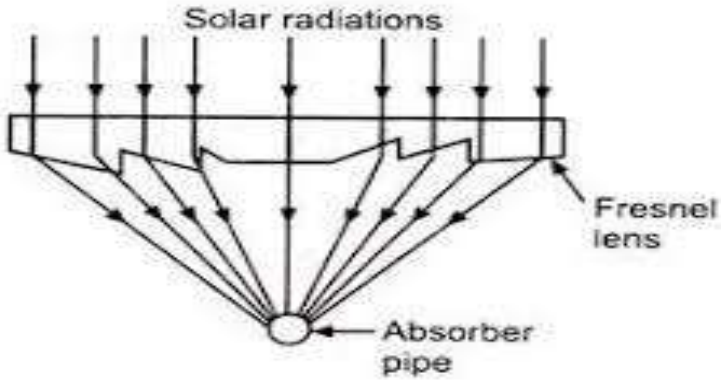


Fig. 3.7. Fresnel lens collector.

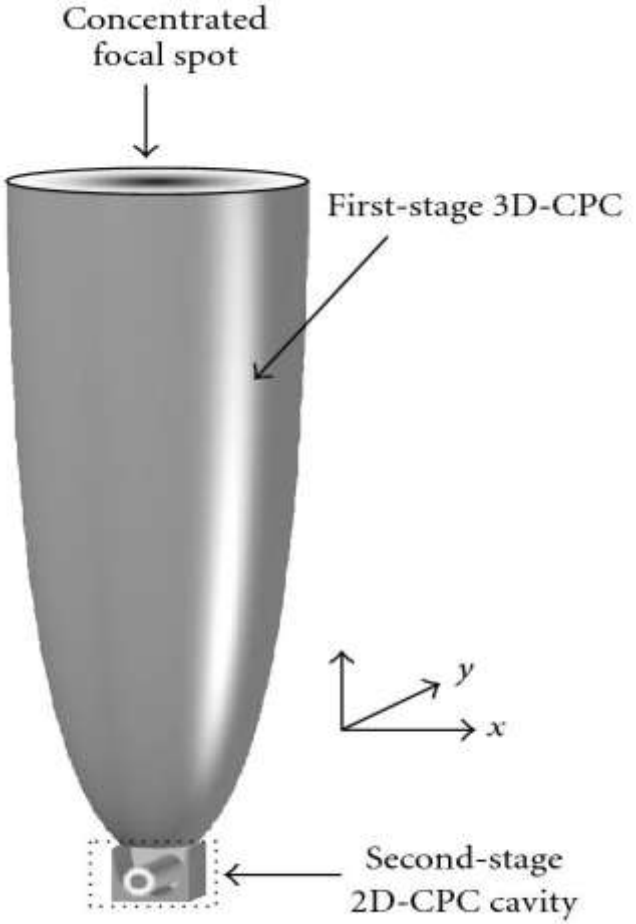
- The rounded triangular trough serves only as a container and plays no role in concentrating the solar energy
- *Receiver pipe*: the receiver pipe of a parabolic line focusing collector has the same general characteristic as a flat plate collector

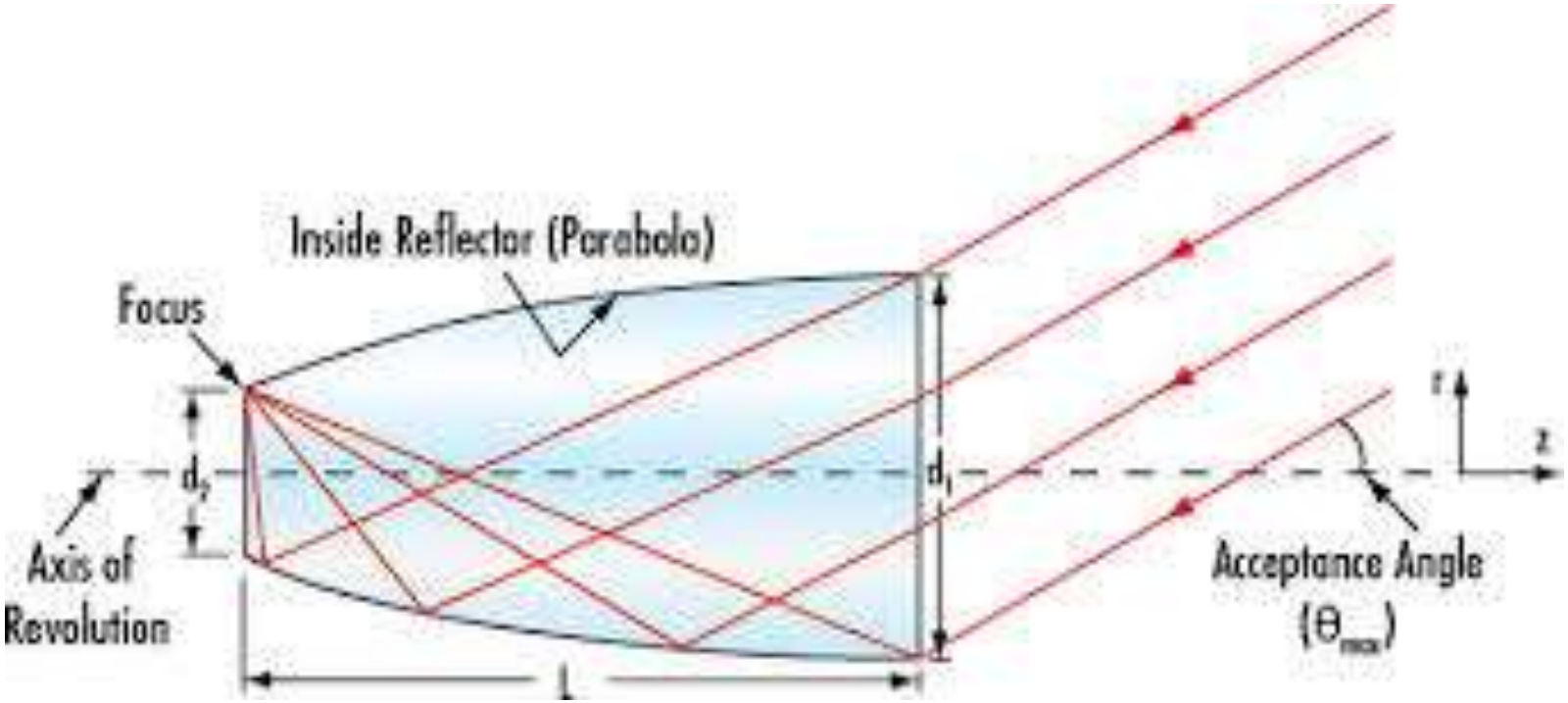
Linear Fresnel Lens Collector

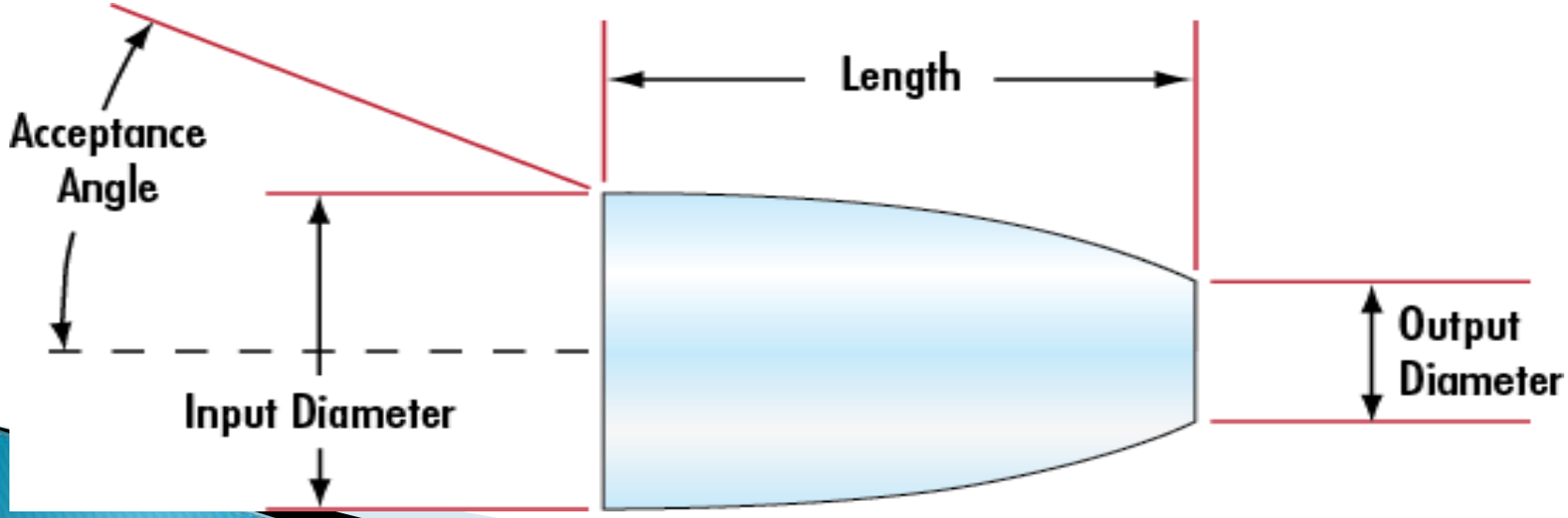
COMPOUND PARABOLIC CONCENTRATORS

Compound Parabolic Concentrators (CPCs) are designed to efficiently collect and concentrate distant light sources, with some acceptance angle

Compound Parabolic Concentrators are critical components in solar energy collection, wireless communication, biomedical and defence research, or for any applications requiring condensing of a divergent light source.




Inside Reflector (Parabola)
Focus
Axis of Revolution
Acceptance Angle
(θmax)
L


Acceptance Angle
Length
Input Diameter
Output Diameter

Flat plate collector with adjustable mirrors

- Flat mirrors are frequently used to increase the heat output from flat-plate collectors.
- They are generally oriented in an east-west direction and are mounted below and/or above the collector panels.
- The annual performance of a mirror-boosted system can be improved by allowing periodic adjustments of the mirrors alone or of the panel-mirror units.

- In order to Seasonal adjustments of the mirrors suffice to maintain acceptable values of the concentration and there is relatively little advantage in providing for collector panel adjustments..
- A double-mirror system (adjustable trough) provides higher concentrations than a single-mirror system for equal mirror area. Adjustable trough configurations with zero acceptance angle provide higher annual average concentration ratios than those with non-zero acceptance angles.

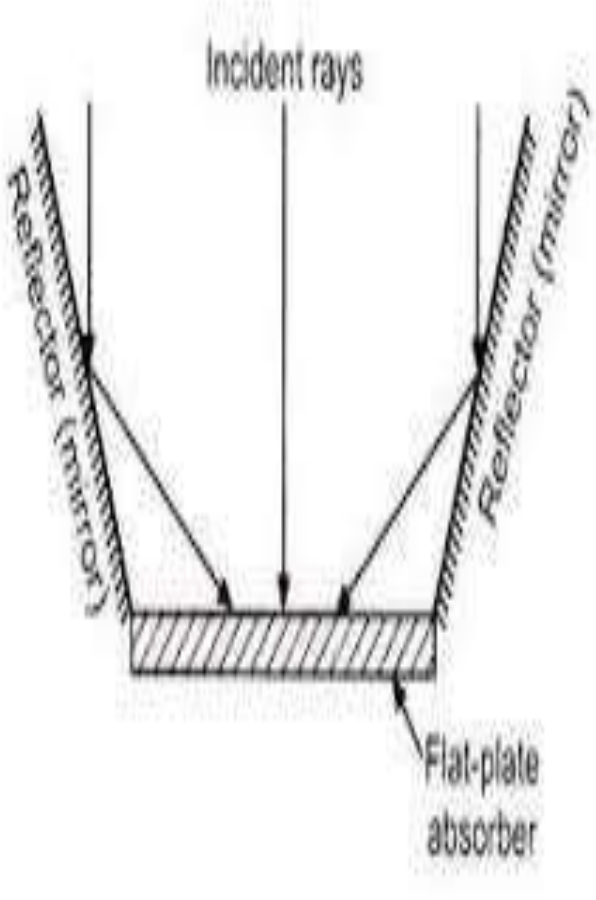


Fig. 3.8. Flat-plate collector absorber with adjustable mirrors.

What are the advantages & disadvantages of concentrating collectors over flat plate collectors?

ADVANTAGES

- 1.Reflecting surfaces require less material in concentrating collectors than in flat plate collectors.
- 2.Absorber area is smaller in concentrating collectors. So insulation intensity is greater in concentrating collectors than flat plate collectors.
- 3.Small area of absorber/unit is there in concentrating collectors than in flat plate collectors.

- 4.Little or no antifreeze is required in concentrating collectors to protect absorber in a concentrator system.
- 5.Because temperature attainable with concentrator collector is high, amount of heat stored is larger in concentrator collector.
- 6.Concentrating collector is used for power generation while flat plate collector is not used for power generation.
- 7.In solar heating & cooling, application high temperature of working fluid is attainable.

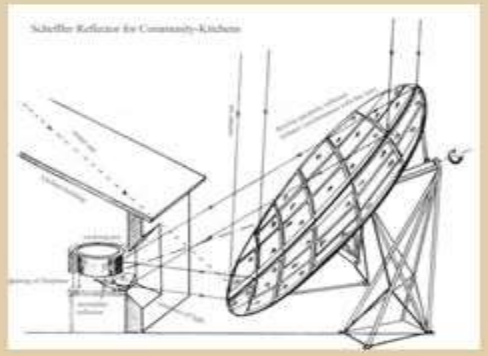
DISADVANTAGES

- 1.Non uniform flux on absorber is there in concentrating collectors than in flat plate collectors. While in flat plate collectors uniform flux is there.
- 2.Additional optical losses occur in concentrating collectors than in flat plate collectors.
- 3.High initial cost is there for concentrating collectors. Flat plate collectors are cheaper.
- 4.Additional requirement for maintenance is required in concentrating collectors than in flat plate collectors. While in flat plate collectors, not much maintenance is required.

- 5.Only beam component is collected in concentrating. While in flat plate collectors , both diffused & beam radiations are collected in concentrating collectors.

- 6.It is necessary to have an absorber to track sun image in concentrating collectors.

Solar cooker



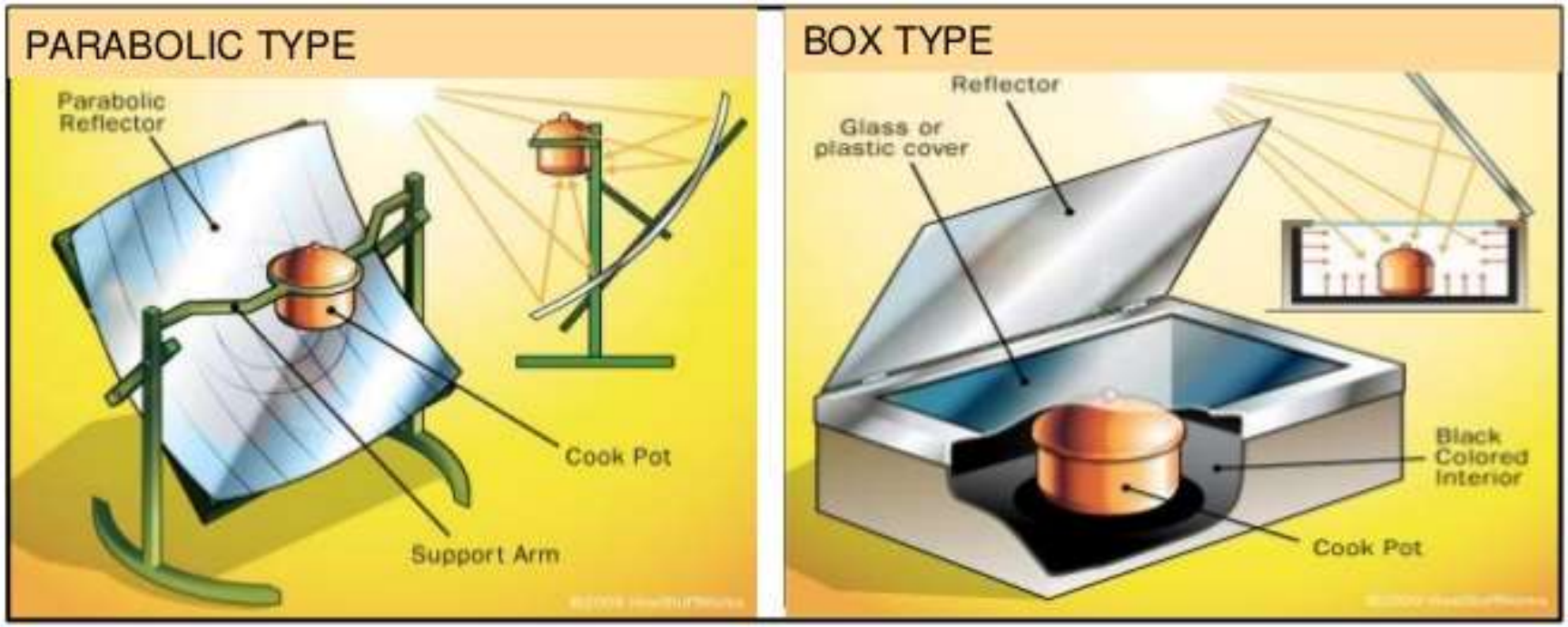
What is solar cooking?

- Principle of solar cooking: Sunlight is converted to heat energy which is retained for cooking
- Clean cooking technology
- First design of solar cooker: Nicholas de Saussure (1740-1799) built a black insulated solar cooker
- Worldwide numerous organizations working with solar cookers (SCI founded in 1987)

What is Solar Cooking ?

Solar cooking is the simplest, safest, most convenient way to cook food through solar radiations without consuming fuels or heating up the kitchen.

- **Types Of Solar Cooker :**



Solar cooker

BUILD A SOLAR COOKER

- A solar cooker uses the energy of the Sun to cook food. An essential part of a solar cooker is a reflector. This is a shiny surface that reflects and concentrates the Sun's energy. There are many possible shapes, but most use a bowl shape.

DIFFERENT TYPES OF SOLAR COOKER

- Three broad categories:
- box cookers;
- panel cookers;
- reflector cookers.

the box cooker first built by Horace de Saussure in 1767; Reach temperature 90–150 ℃

these are in use in Refugee camps around the world

focus light on a cooking container reach temperatures of 315 ℃ and above

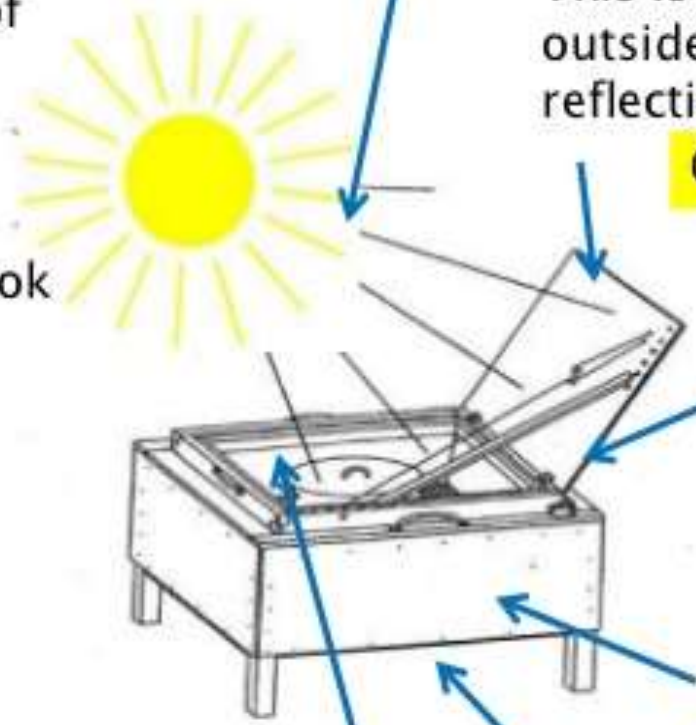
Box cooker

- Among easiest and most popular to build and use
- Lid of a cardboard box reflects light onto pots under glass
- Advantage of slow, even cooking of large quantities of food

Box Type:

This cooker can produce a temperature of 150 °C

It can also cook food using boiling water at100 °C



Its box shape is very good at **Trapping Heat**

This is the outside reflecting lid. It **Concentrates the rays.**

This is a glass lid that **Traps the Heat** and **uses the greenhouse effect**

It has a black bottom inside that **Converts light to heat energy**

It has insulated sides and bottom to **Trap Heat**

It also has reflective internal walls to **concentrate the rays**

Parabolic Cooker(curved concentrator)

- Highly focused light and high temperatures
- Cooks nearly as fast as a conventional oven
- Costly and complicated to make and use – have to turn frequently to follow the sun

Potentially hazardous-not recommended

Panel Cooker(combination cooker)

- Sunlight is reflected off of multiple panels onto a pot under a glass lid or in a bag
- Can be built quickly and at low cost
- Many different varieties

Solar Funnel Cooker

- Safe, inexpensive and easy to use
- Concentrates sunlight into a dark pot in a plastic bag
- Combines best of parabolic and box cookers
- Anyone can make one

ADVANTAGES OF SOLAR COOKERS :

- No attention is needed in cooking as in other devices.
- No fuel is required.
- Negligible maintenance cost.
- No pollution.
- Vitamins of food are not destroyed and food cooked is nutritive and delicious with natural taste.
- No problem of charring of food and no over flowing.

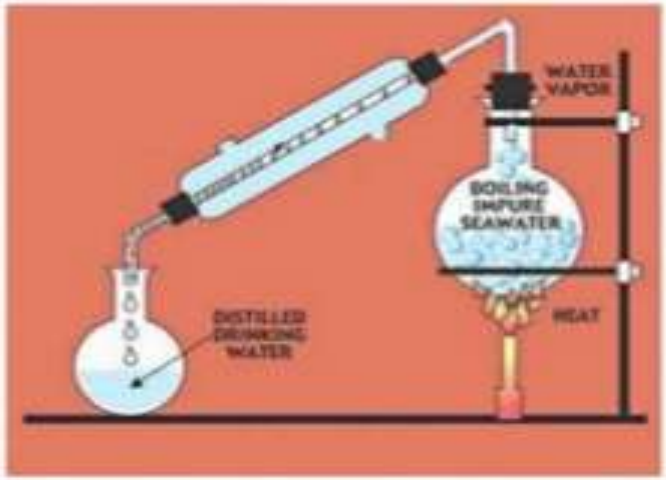
DISADVANTAGES

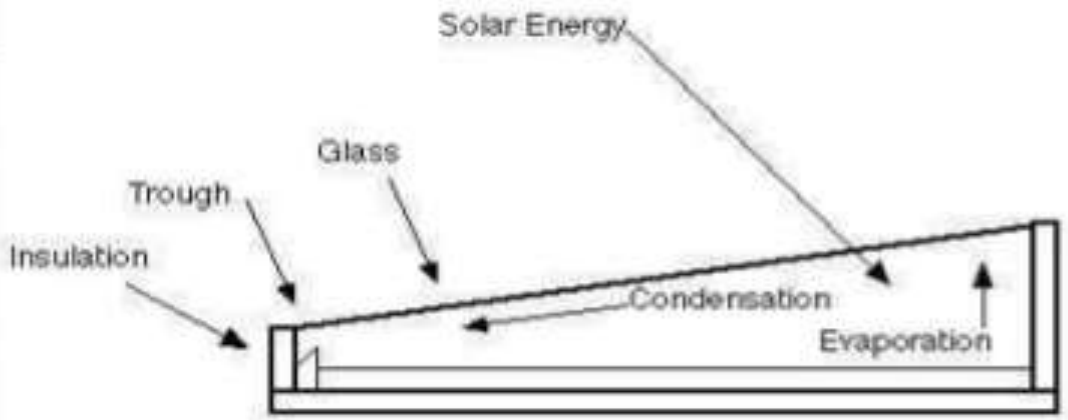
- Solar cookers are less useful in cloudy weather and near the poles (where the sun is low in the sky or below the horizon).
- Some solar cookers, especially solar ovens, take longer to cook food than a conventional stove or oven.
- Cooks may need to learn special cooking techniques to fry common foods, such as flatbreads like chapatis and tortillas.
- Some solar cooker designs are affected by strong winds, which can slow the cooking process, cool the food due to convective losses, and disturb the reflector.

SOLAR DISTILLATION

Water Distillation

- Process that removes impurities & contaminants
- How?
  - Heat water to point of vaporization
  - Water vapor condenses on cooler surfaces
  - Condensate runs off into collection bin

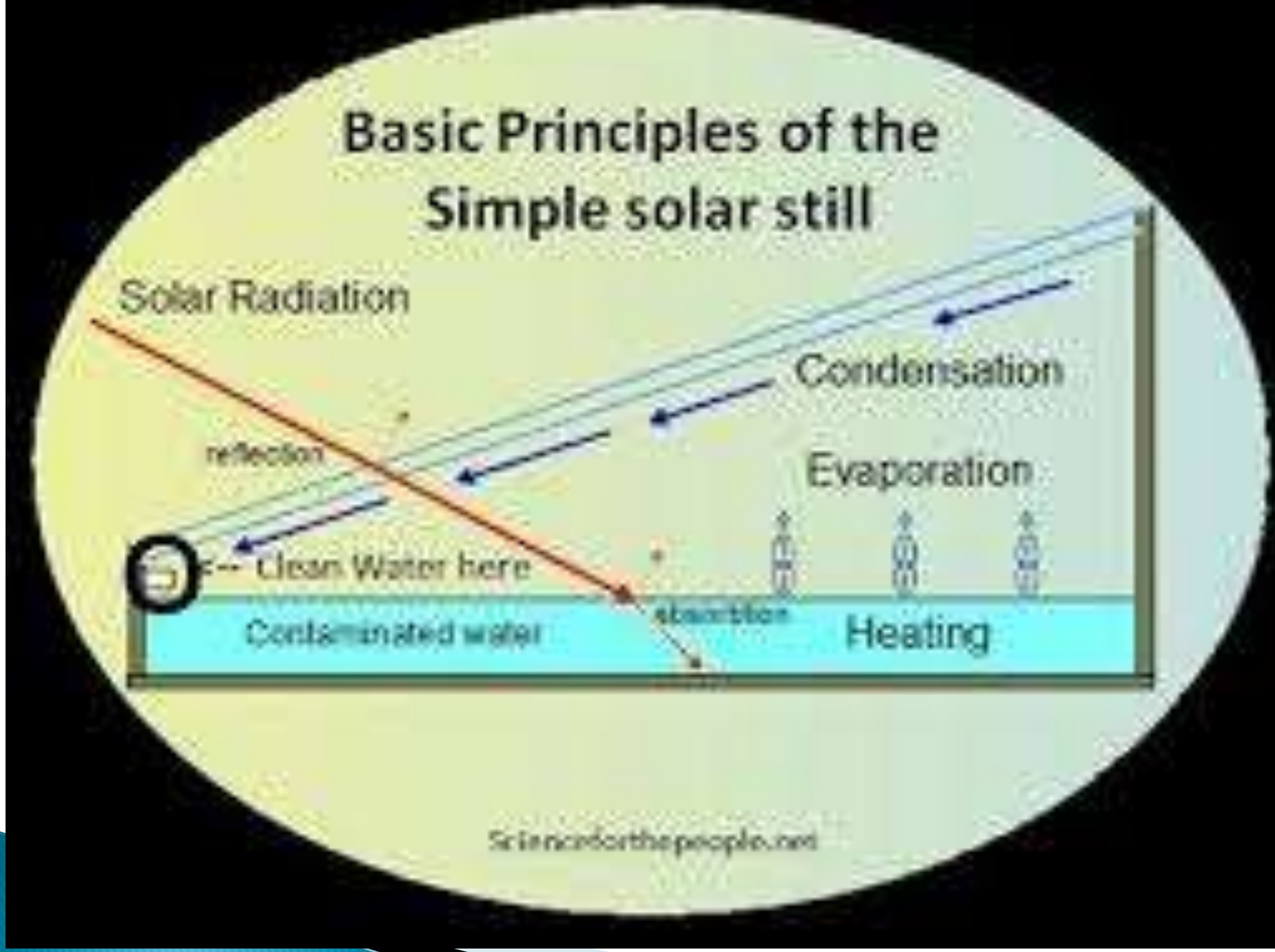




Solar water purification

In solar distillation water is evaporated; using the energy of the sun then the vapor condenses as pure water. This process removes salts and other impurities.

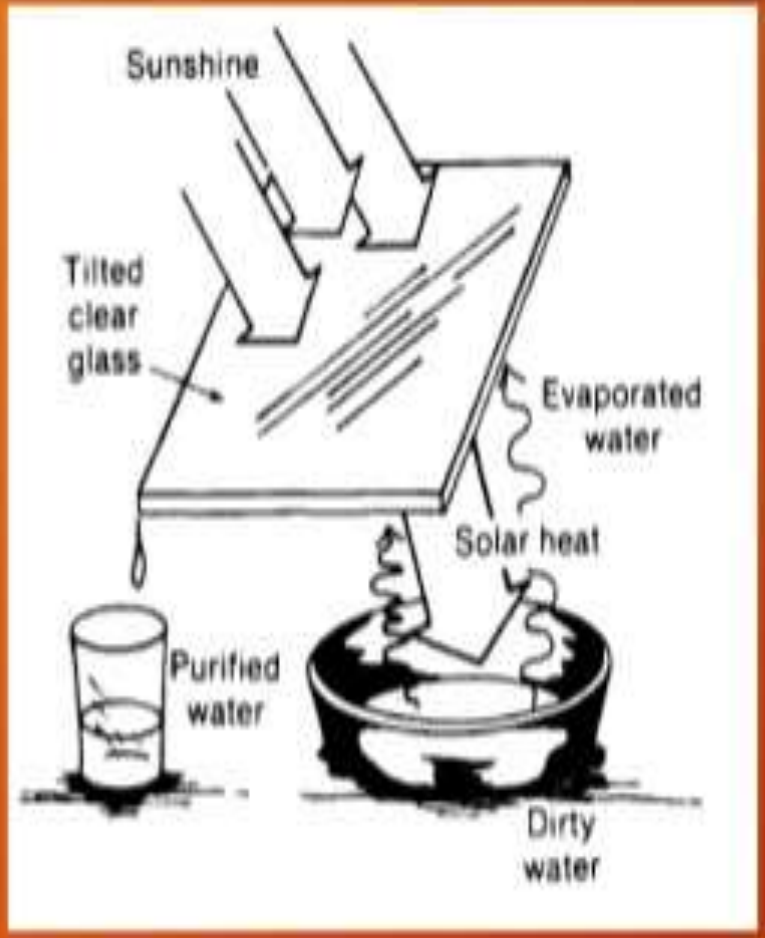
Solar energy is allowed into the collector to heat the water. The water evaporates only to condense on the underside of the glass. When water evaporates, only the water vapor rises, leaving contaminants behind. The gentle slope of the glass directs the condensate to a collection trough, which in turn delivers the water to the collection bottle.


Basic Principles of the
Simple solar still
Solar Radiation
Condensation
reflection
Evaporation
<-- Clean Water here
Contaminated water
absorption
Heating

- solar distillation divided in to two

    1. Basin type
    2. wick type solar still

BASIC CONCEPT:



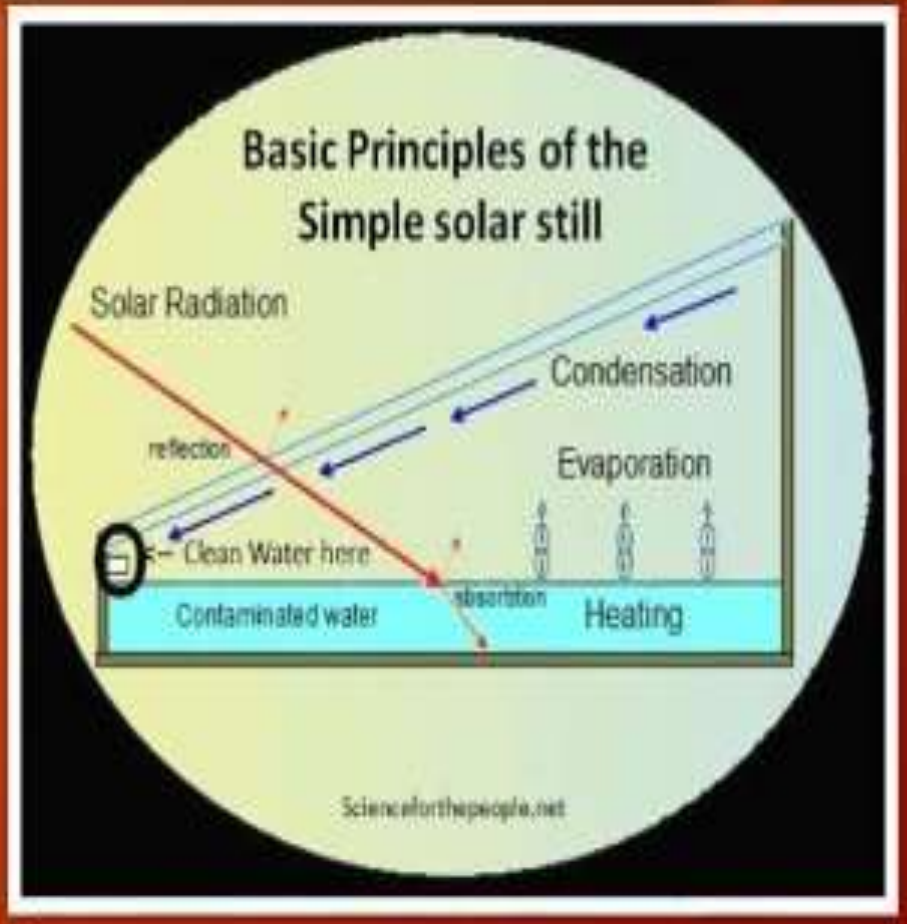
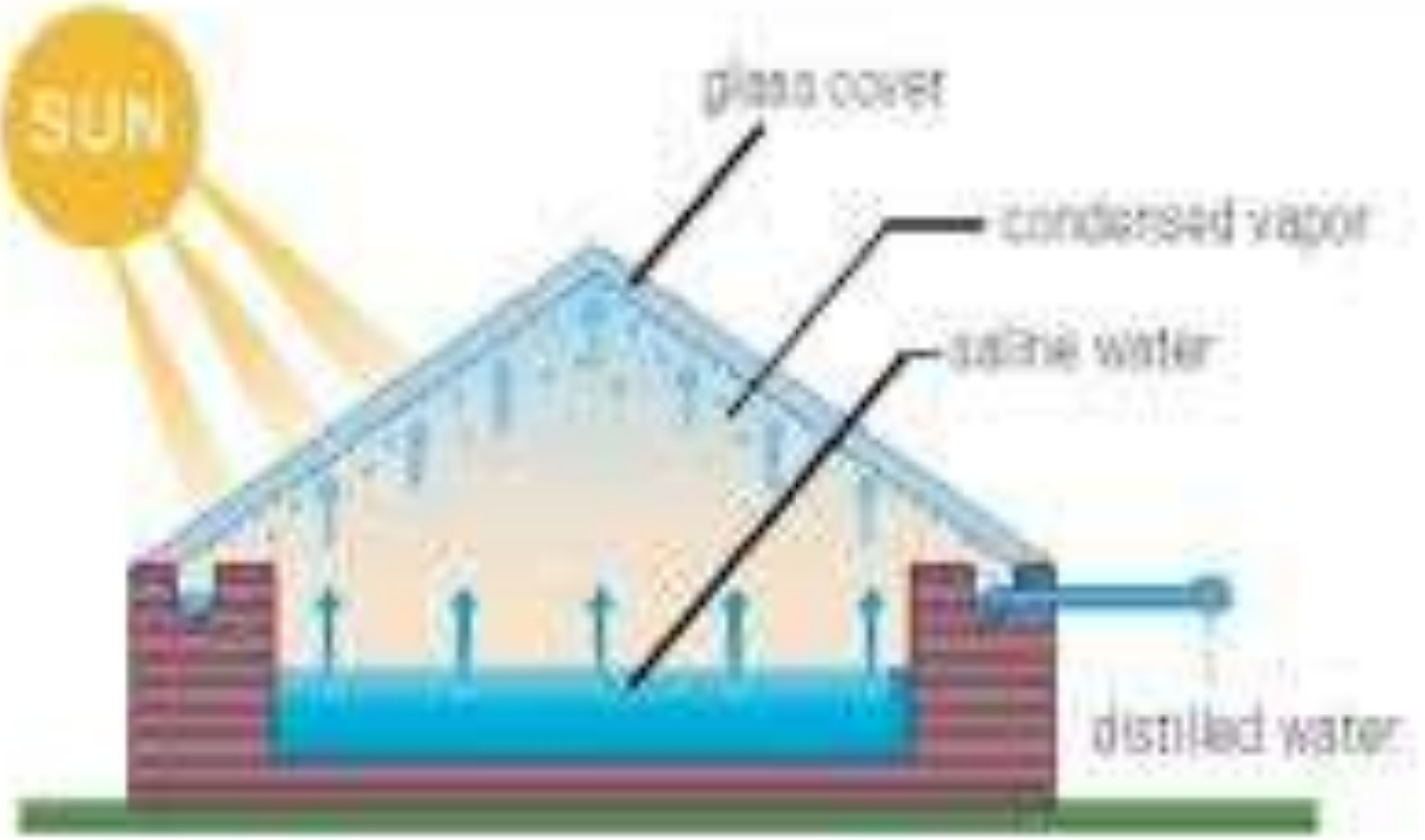


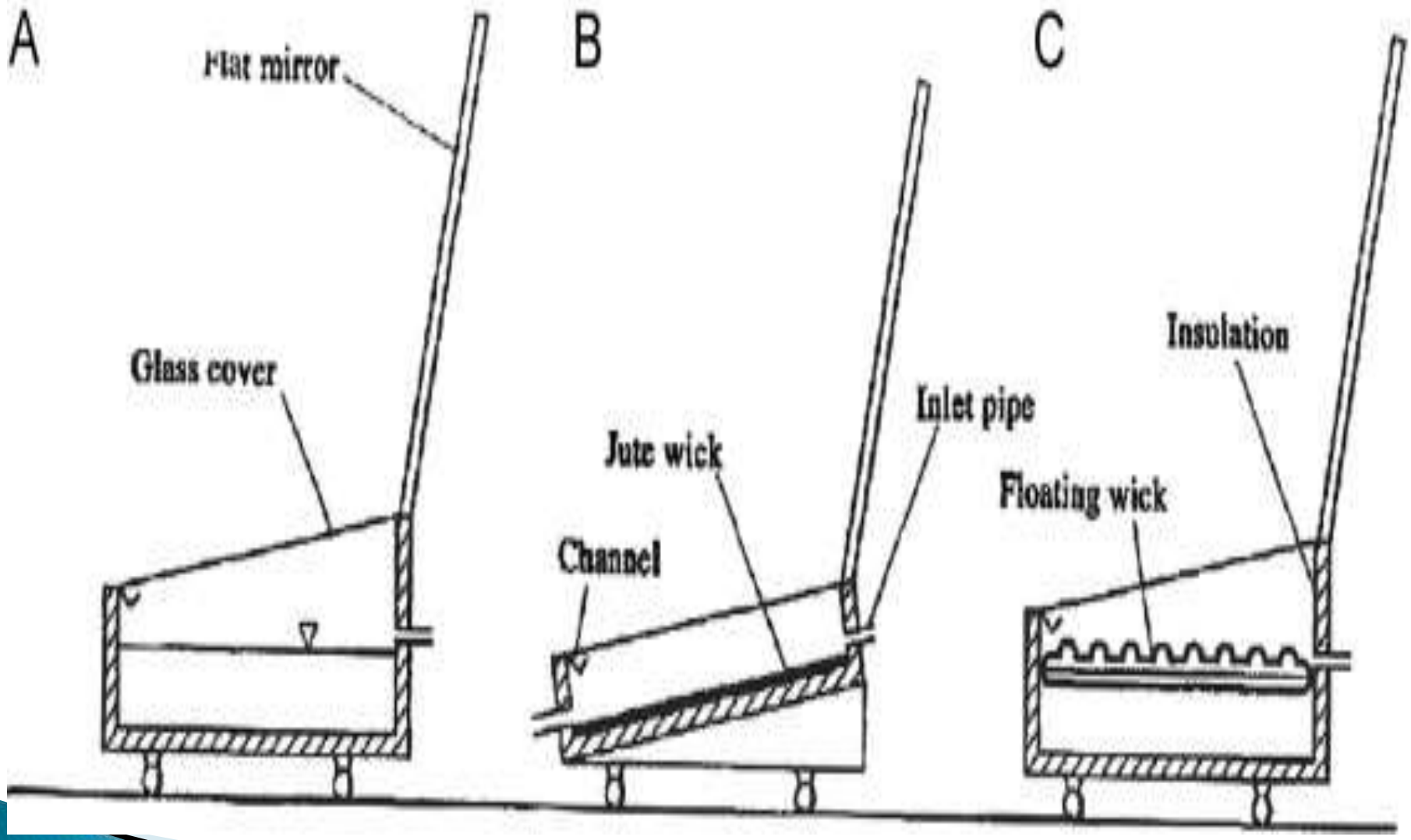
Figure 1: Solar Still



Solar stills can differ in size and shape. Using the sun's radiation, they effectively remove many impurities such as salts and microorganisms.

Editor's Note: A coastal greenhouse can simultaneously distill seawater, grow crops, and provide cooling

Al-Karaghouli AA and Minasian AN [5]



Advantages and Disadvantages

- Advantages
  - All chemical and radioactive polluting byproducts of the thermonuclear reactions remain behind on the sun, while only pure radiant energy reaches the Earth.
  - Energy reaching the earth is incredible. By one calculation, 30 days of sunshine striking the Earth have the energy equivalent of the total of all the planet's fossil fuels, both used and unused!
- Disadvantages
  - Sun does not shine consistently.
  - Solar energy is a diffuse source. To harness it, we must concentrate it into an amount and form that we can use, such as heat and electricity.
  - Addressed by approaching the problem through: 1) collection, 2) conversion, 3) storage.