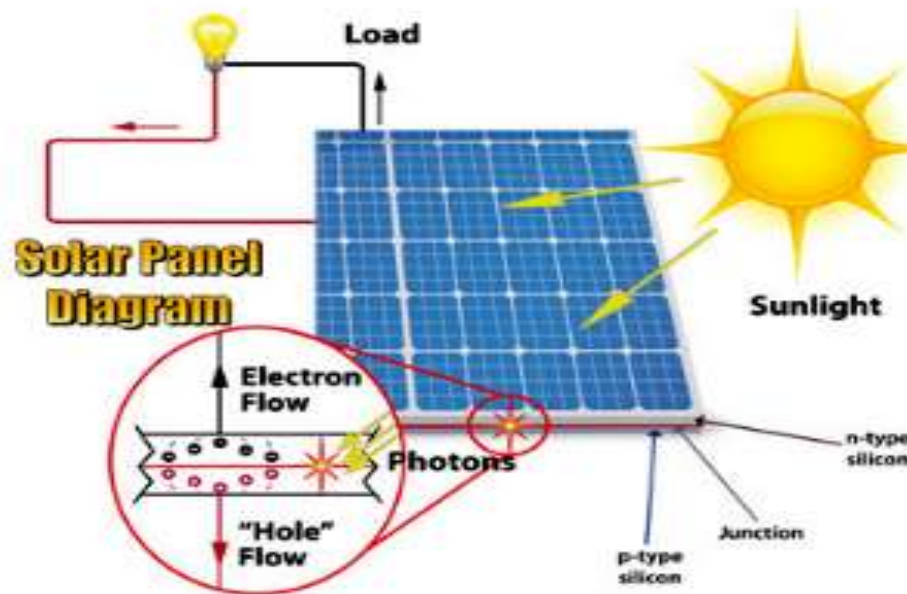


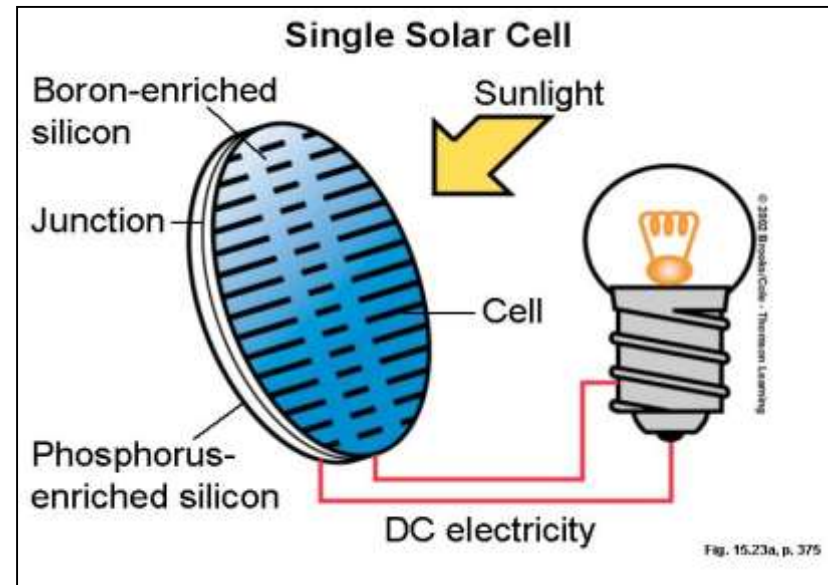
Solar power(CO2)

- **Solar power** is the conversion of energy from sunlight into electricity, either directly using photovoltaic (PV), indirectly using concentrated solar power, or a combination.
- Concentrated solar power systems use lenses or mirrors and solar tracking systems to focus a large area of sunlight into a small beam.



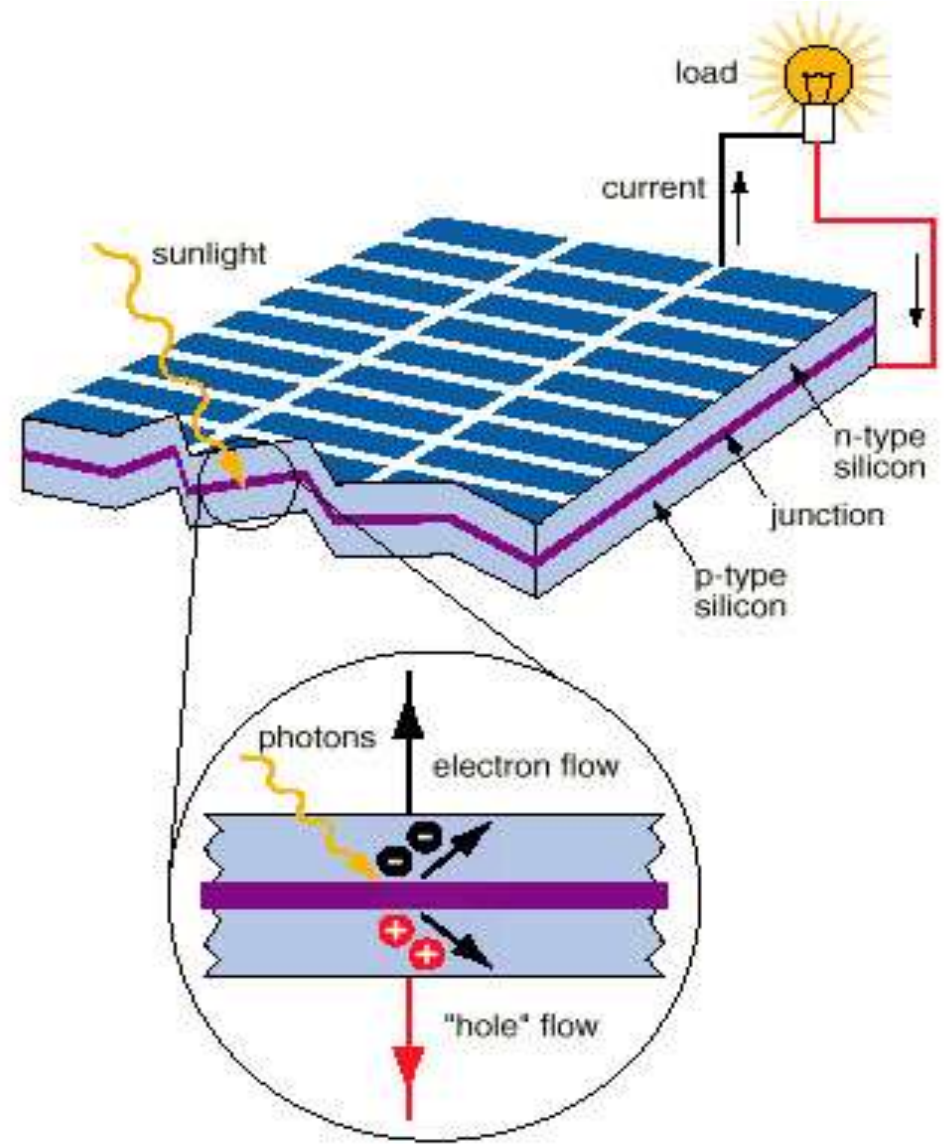
Photovoltaic(CO2)

■ **Photo+voltaic = convert light to electricity**

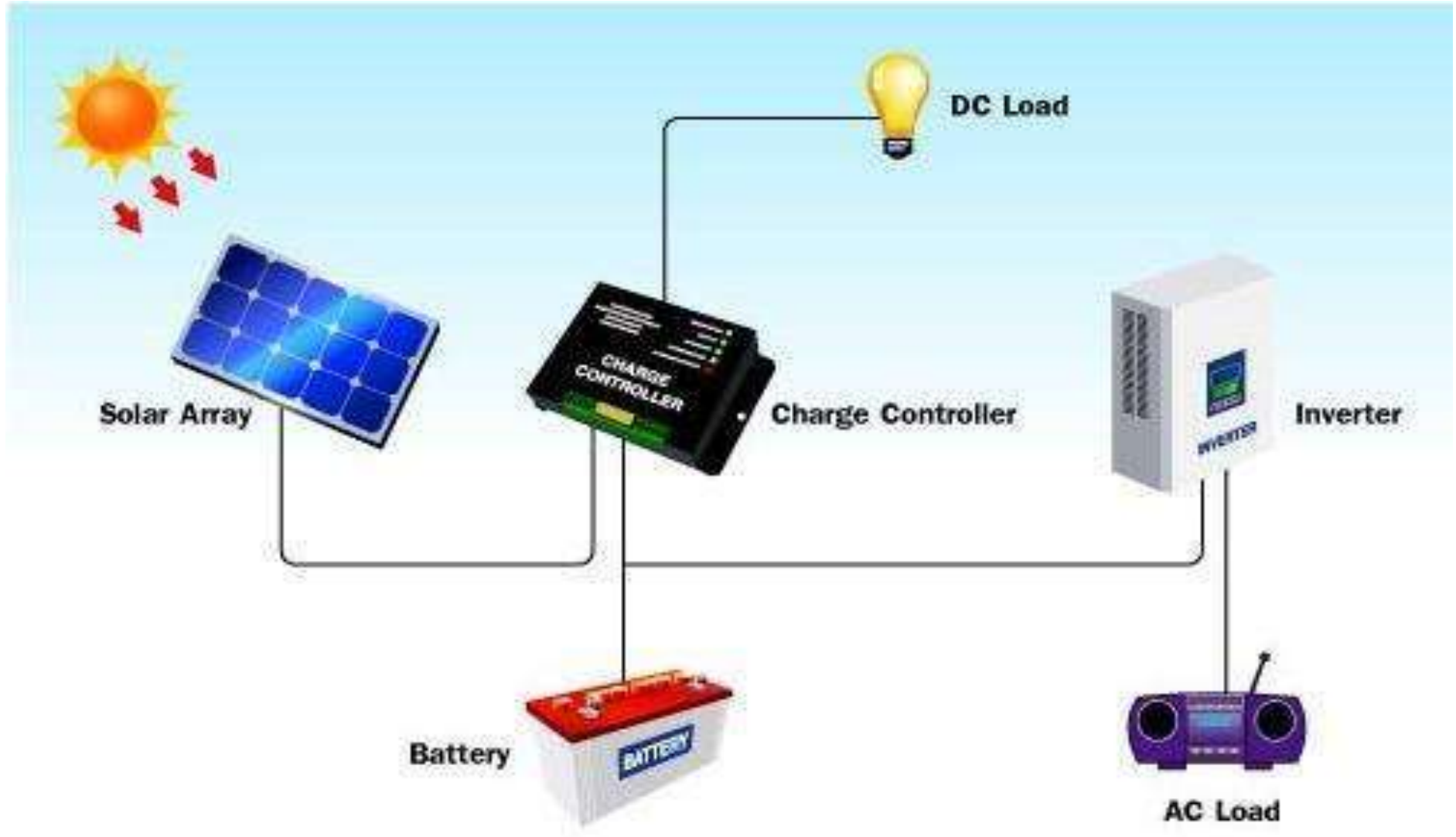


How Solar PV Cells Work(CO2)

- Photons in sunlight hit the solar panel and are absorbed by semiconducting materials.
- Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity.



Components of solar PV system(cont..)



Solar Radiation(CO₂)

- Solar radiation is radiant energy emitted by the sun, particularly electromagnetic energy.
- About half of the radiation is in the visible short-wave part of the electromagnetic spectrum.
- The other half is mostly in the near-infrared part, with some in the ultraviolet part of the spectrum
- Solar constant is defined, commonly taken as 1353 W/m^2 , though there are some variations in the estimates..

Calculation of solar energy(CO₂)

- Calculate the energy received by earth from sun and compare the energy received from sun, with the energy usage by humankind.

Surface of the Sun ~ 5500 °C

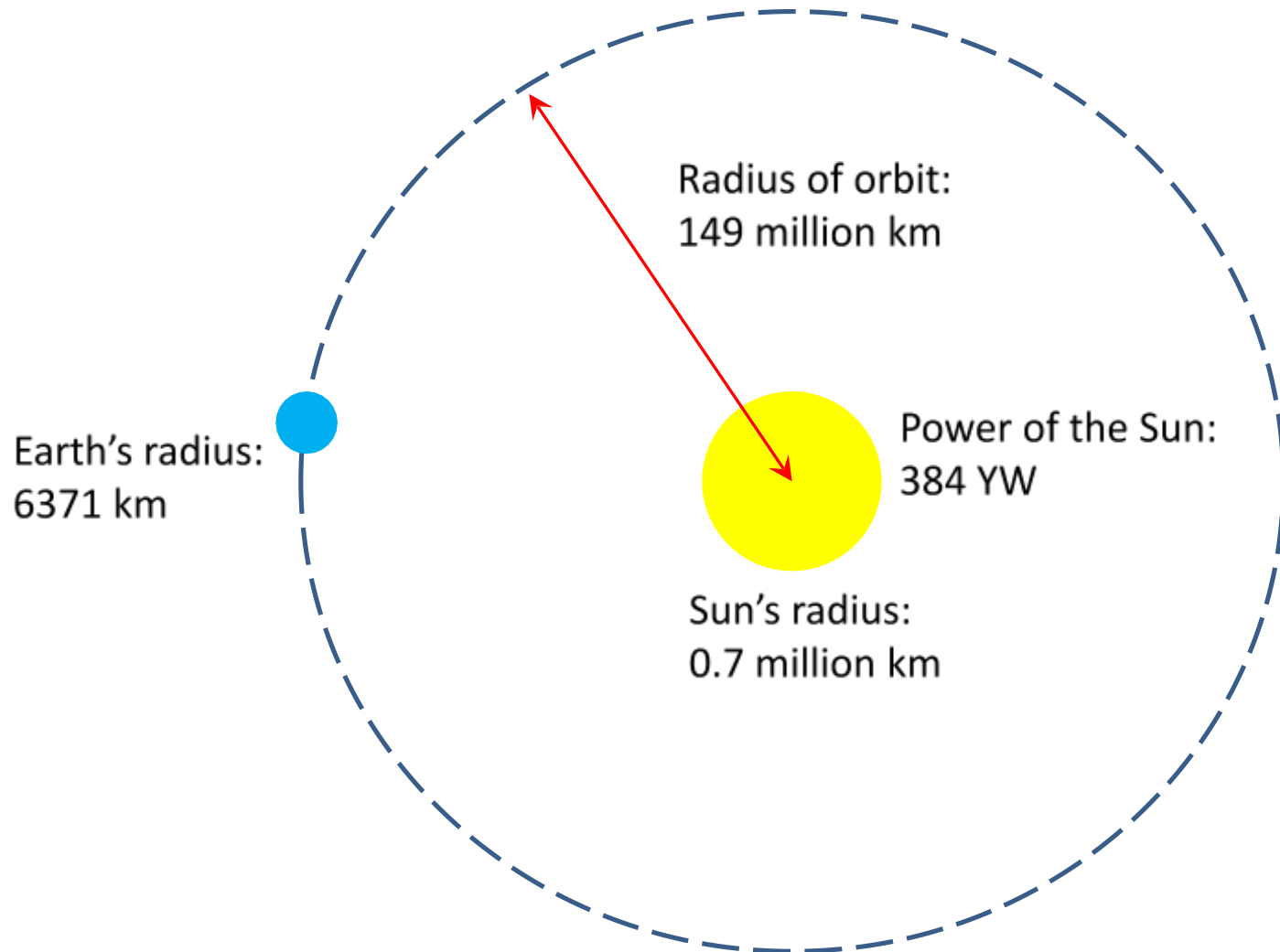
Core of the Sun, several million °C

Sun gives out 384 Yotta Watts

$$= 384 \times 10^{24} \text{ W}$$

$$= 3.84 \times 10^{26} \text{ W}$$

Calculation of solar energy(cont..)



Intensity of sun's radiation(CO2)

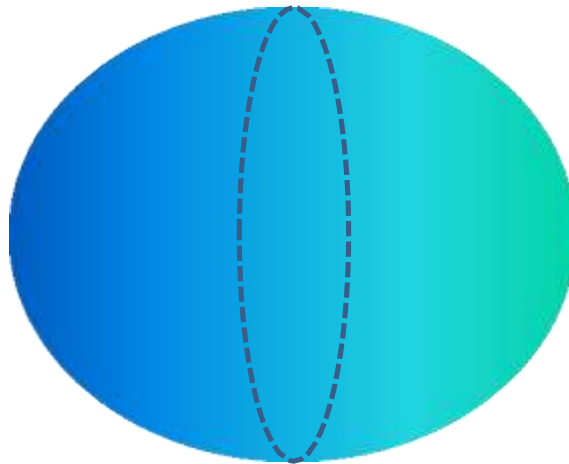
Intensity of Sun's radiation at Earth's orbit:

$$= \frac{3.84 \times 10^{26}}{4 \times 3.14 \times (1.49 \times 10^{11})^2} = 1377 \text{ W/m}^2$$

Area of earth disc(CO₂)

Area of Earth's disc:

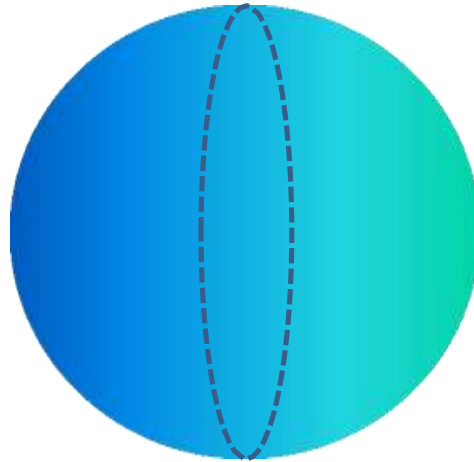
$$= 3.14 \times (6.371 \times 10^6)^2 = 1.27 \times 10^{14} \text{ m}^2$$



Power received from the sun(CO2)

Power received from the Sun, by Earth:

$$= 1.27 \times 10^{14} \times 1377 = 1.755 \times 10^{17} \text{ W or J/s}$$



Energy received from the sun(CO2)

Energy received from the Sun, by Earth each year:

$$= 1.755 \times 10^{17} \times 60 \times 60 \times 24 \times 365$$

$$= 5.5 \times 10^{24} \text{ J}$$

= 5.5 million Exa Joules per year

Energy usage(CO₂)

Humankind uses:

= 500 Exa Joules per year

Earth receives from the Sun:

5.5 million Exa Joules per year

This is received in :

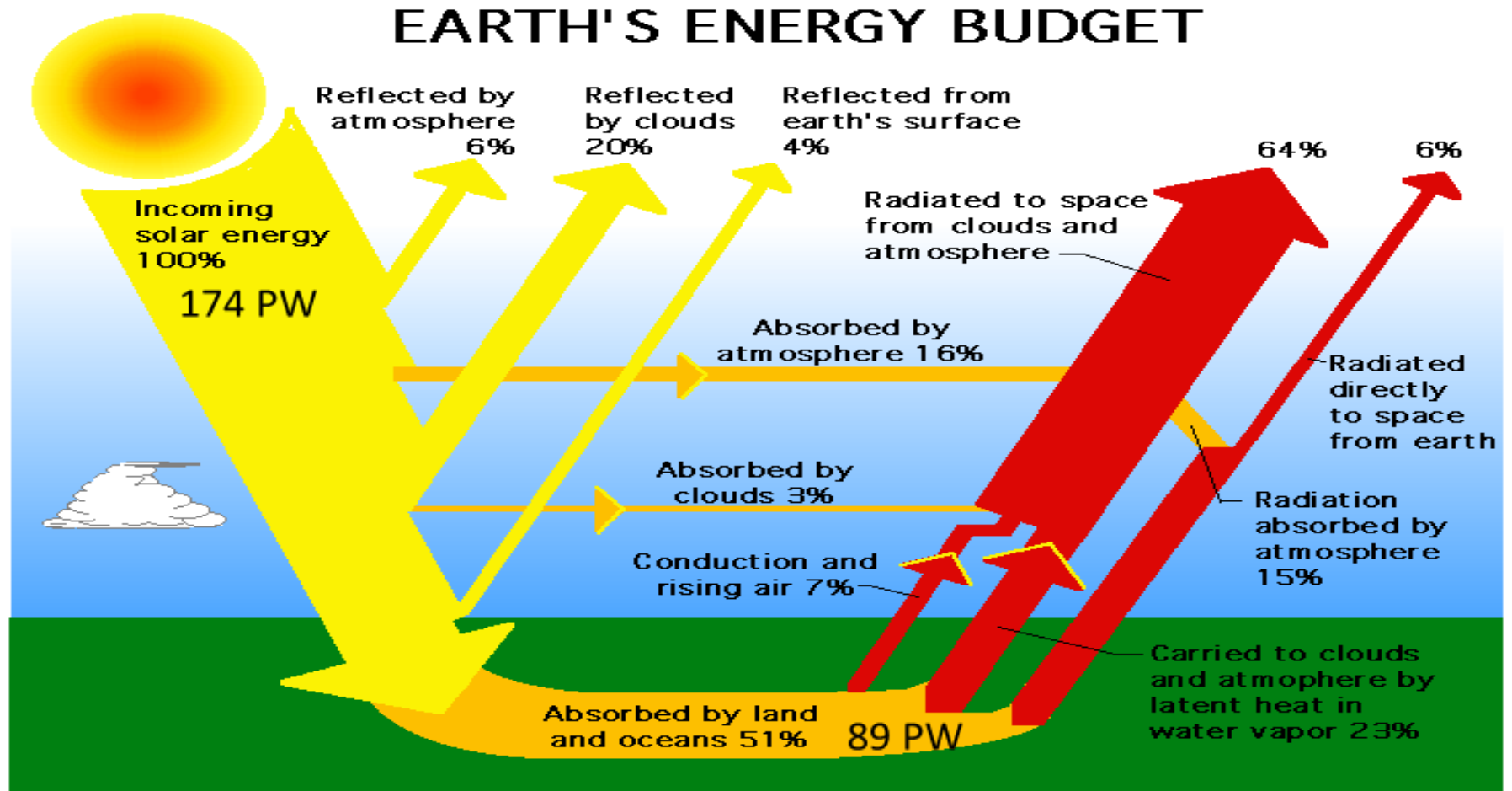
$$500 / 5.5 \times 10^6 = 9 \times 10^{-5} \text{ years} = 0.033 \text{ days} = 0.79 \text{ hours}$$

Since 30% of the incident energy is reflected back, on the surface of the Earth, the energy used by humankind each year is received in :

$$= 0.79/0.70 \sim \mathbf{1 \text{ hour}}$$

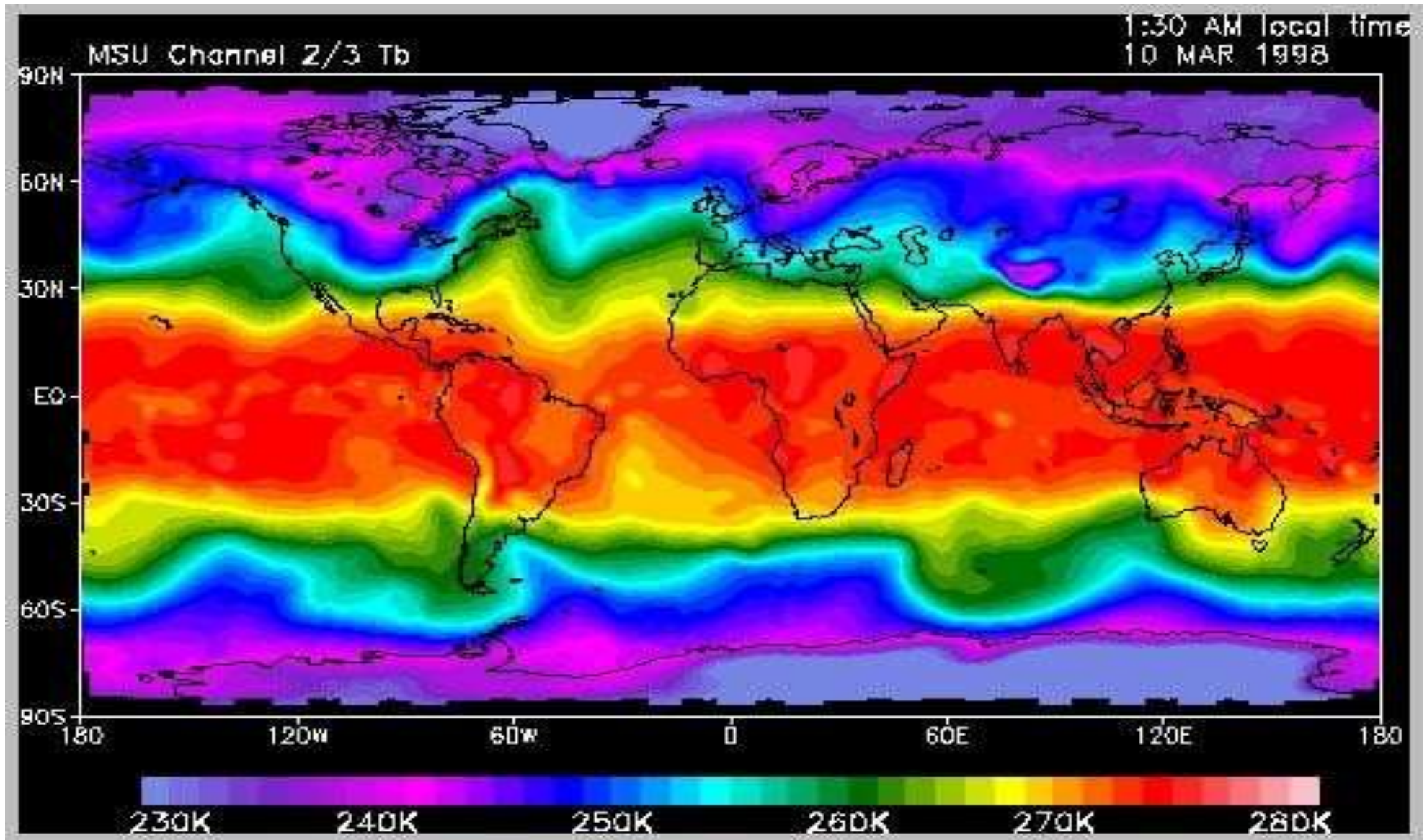
Vikas kumar

Solar budget(CO2)



NASA

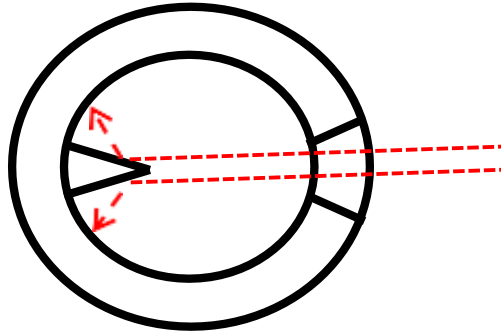
Solar budget(cont...)



Vikas kumar

(AMTME01
13)

Solar spectrum(CO₂)

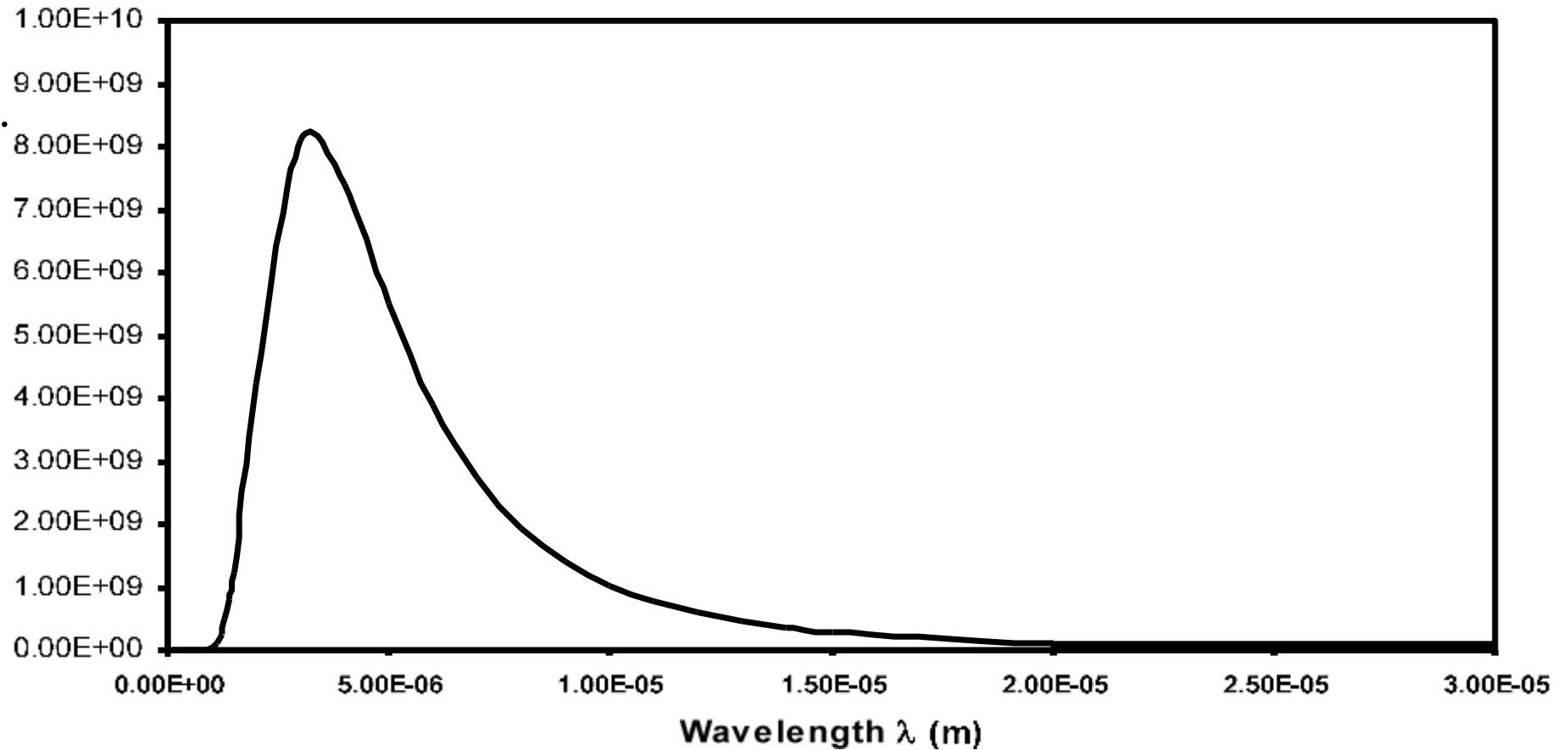


Kirchoff designed a black body in 1859

Known properties of black body radiation:

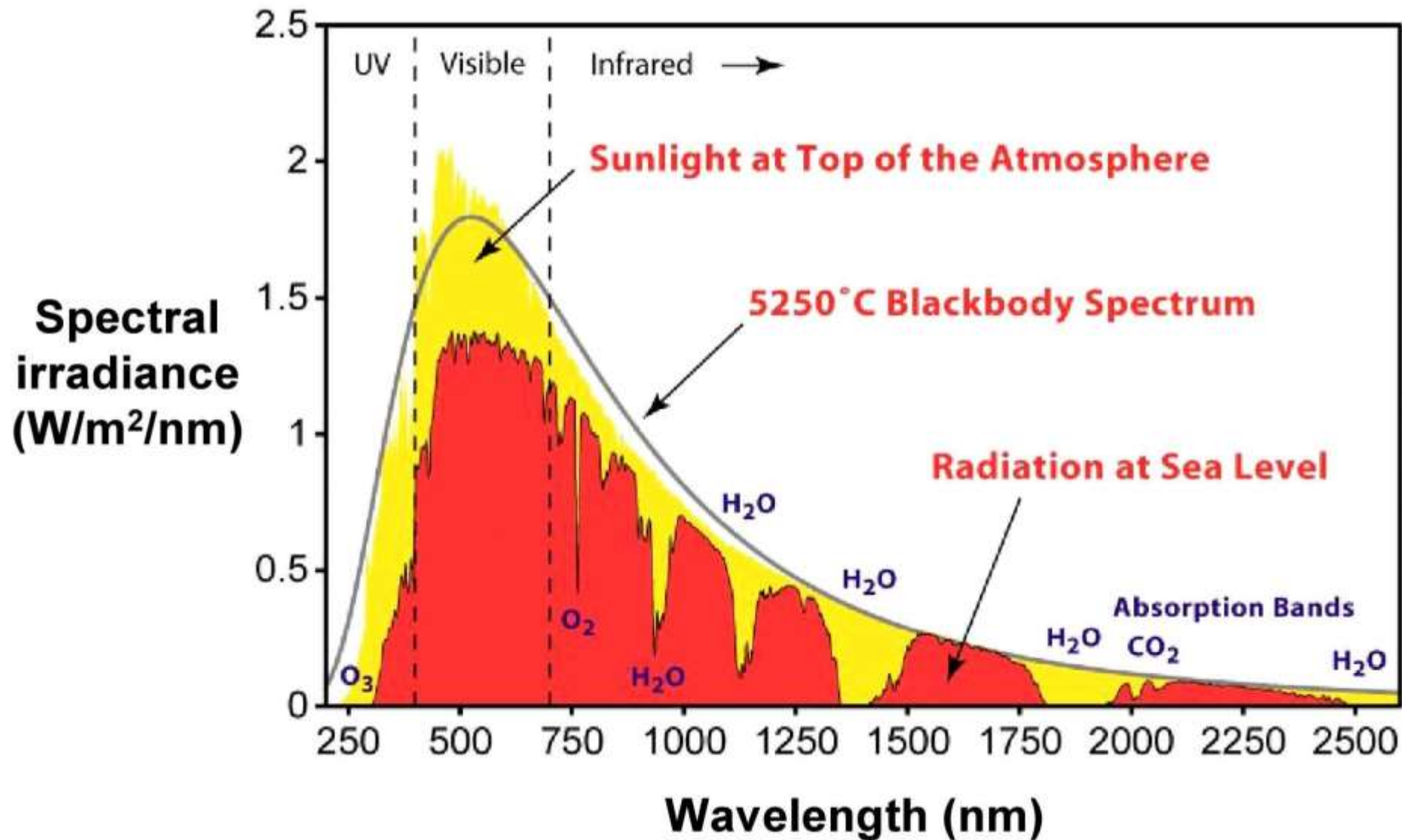
- 1) As temperature T of the body increases, intensity of the radiation from the body also increases
- 2) Higher the temperature, lower is the wavelength of the most intense part of the spectrum.

Black body radiation(CO₂)



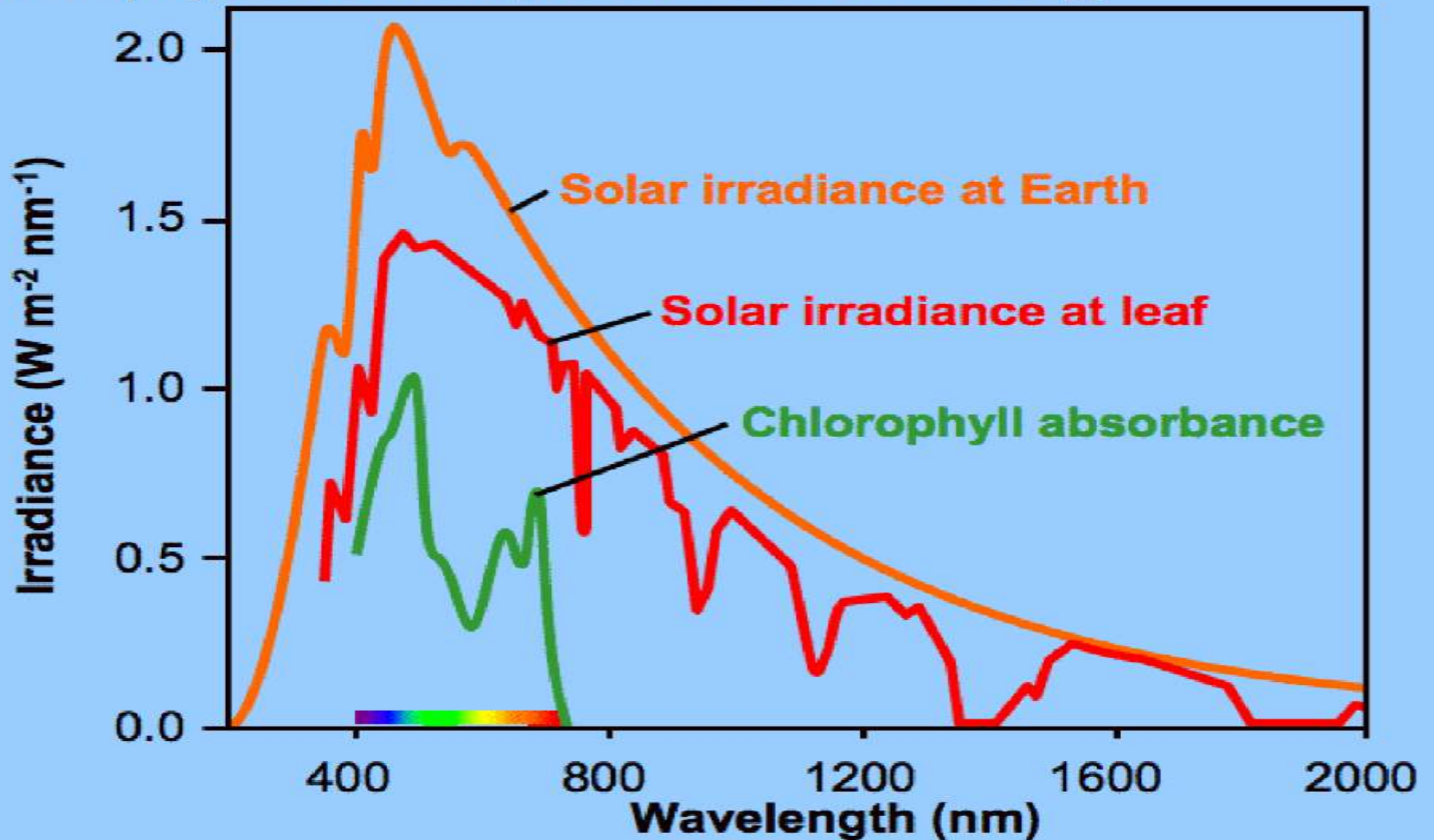
Black body Radiation

Black body radiation(cont..)



Black body radiation(CO₂)

Chlorophyll is well-adapted to use Solar Energy



Solar Collectors (CO₂)

- Solar collectors transform solar radiation into heat and transfer that heat to a medium (water, solar fluid, or air).
- Then solar heat can be used for heating water, to back up heating systems or for heating swimming pools.
- A solar collector is basically a flat box and are composed of three main parts, a transparent cover, tubes which carry a coolant and an insulated back plate.
- The solar collector works on the green house effect principle; solar radiation incident upon the transparent surface of the solar collector is transmitted through though this surface.

Solar Collectors (CO₂)

- The inside of the solar collector is usually evacuated, the energy contained within the solar collector is basically trapped and thus heats the coolant contained within the tubes.
- The tubes are usually made from copper, and the back plate is painted black to help absorb solar radiation.
- The solar collector is usually insulated to avoid heat losses.

Types of collectors(CO₂)

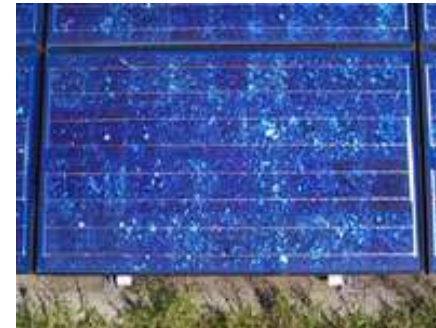
- Stationary
 - Sun tracking Applications
 - Solar water heating
 - Solar space heating and cooling
 - Refrigeration
 - Industrial process heat
 - Solar thermal power systems

Commercial Solar Cells(CO2)

- Single crystal silicon



Poly-Crystal Silicon



Thin Films



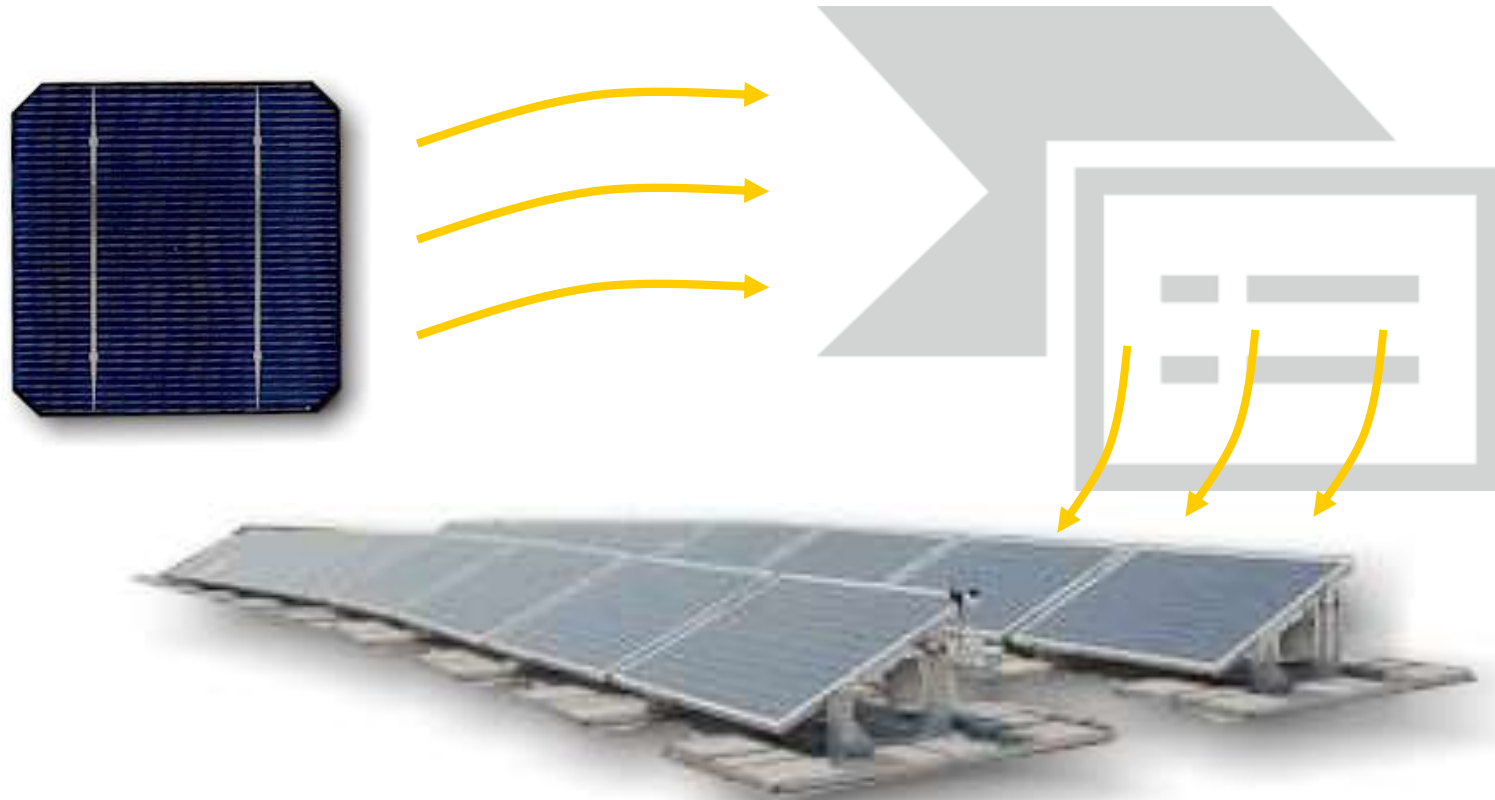
Emerging technologies in solar system(CO2)

Nano-solar techniques:

- Nano-Solar – Electrically Conductive Plastics
- Konarka – Polymer and dye-sensitized solar cell have flexible cells about 5 % efficient



Cells, Modules and Arrays(CO2)



Energy Tide-bit(CO₂)

The solar cells in the early 1950s were about 0.5 % efficient. Today a module is about 15 % efficient.

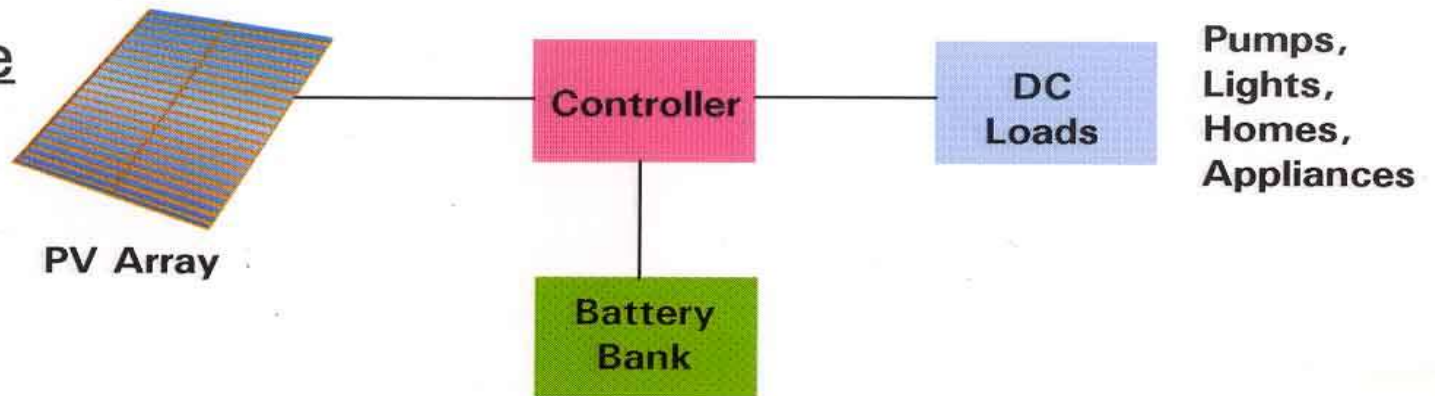
•
A 1 kW system:

- **In 1950 = 2,400 square feet**
- **In 2005 = 80 Square feet**

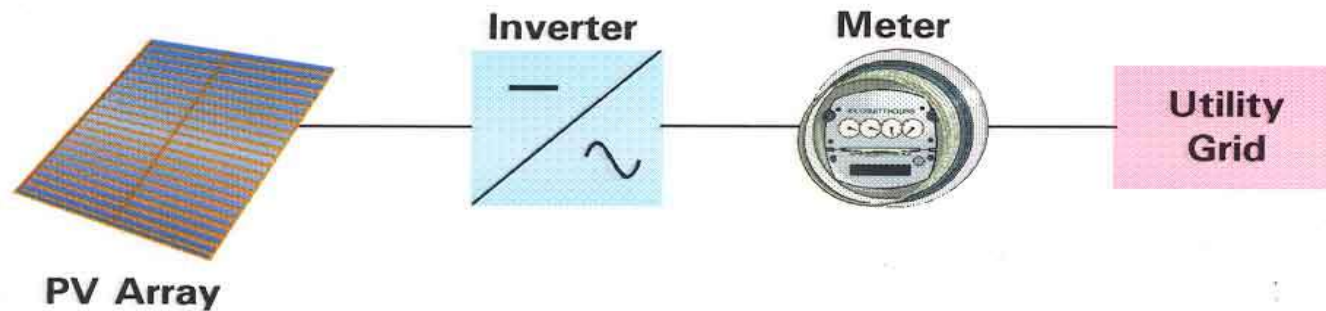
Typical PV systems(CO2)

Typical PV Systems

Stand-alone



Grid-connected



Solar thermal system(CO₂)

- Solar thermal systems convert sunlight (Solar Radiations) to heat.
- Categorized by:

FLAT PLATE COLLECTORS

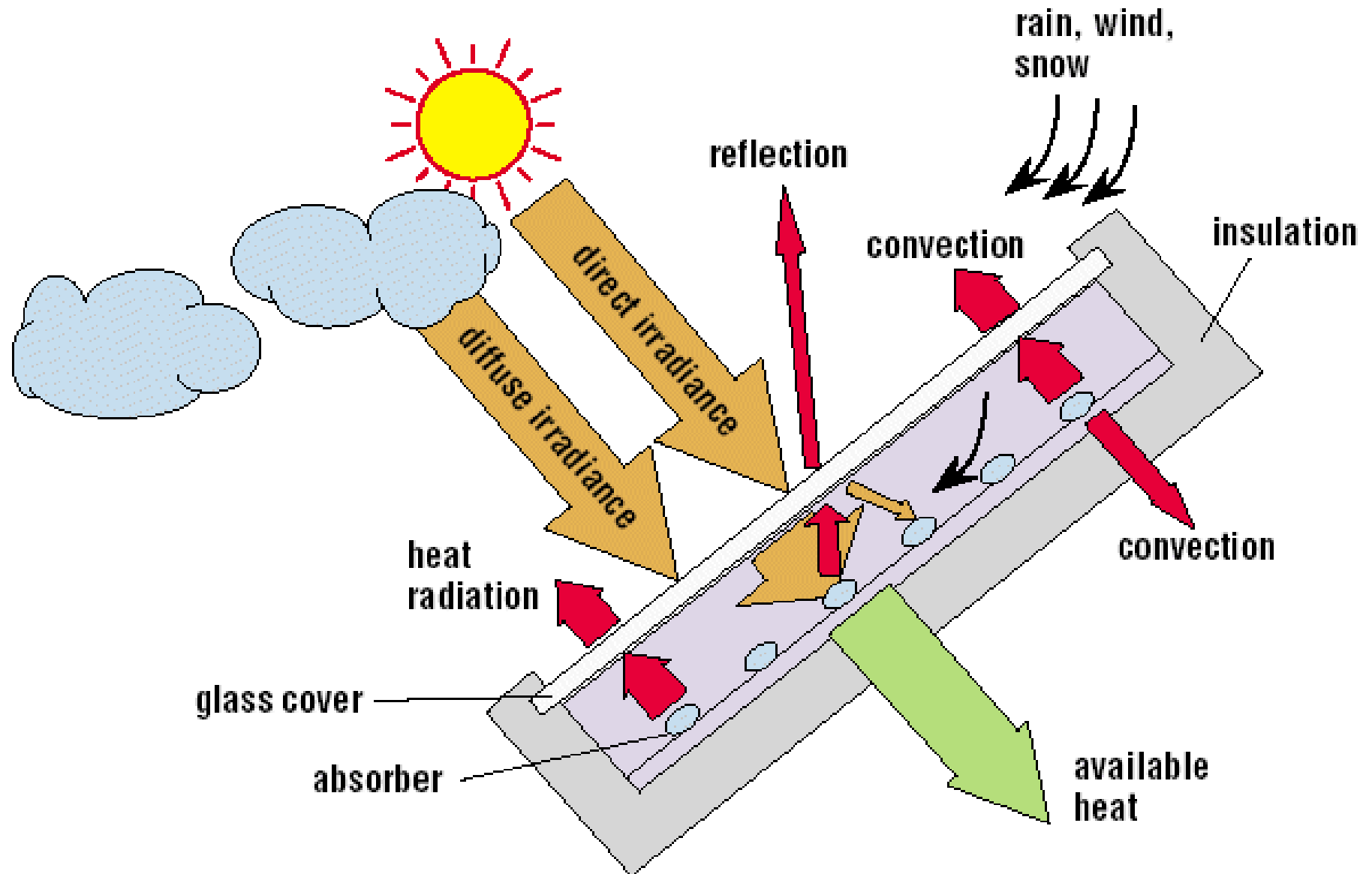
CONCENTRATING COLLECTORS

- using lens; regular or Fresnel
- Flat mirror (possibly many of them)
- Parabolic/cylindrical: single axis forms “trough”
- Paraboloidal: axis of revolution forms “dish”

Flat plate collector(CO₂)



Processes at a flat-plate collector(CO₂)



Rooftop Heaters(CO₂)

- Thermo syphon units place the storage tank above the panels, and heated water rises into the tank.
- Cooler return water flows from the tank to the bottom of the collectors to enter at the cold end.
- No pump is needed to circulate the water.



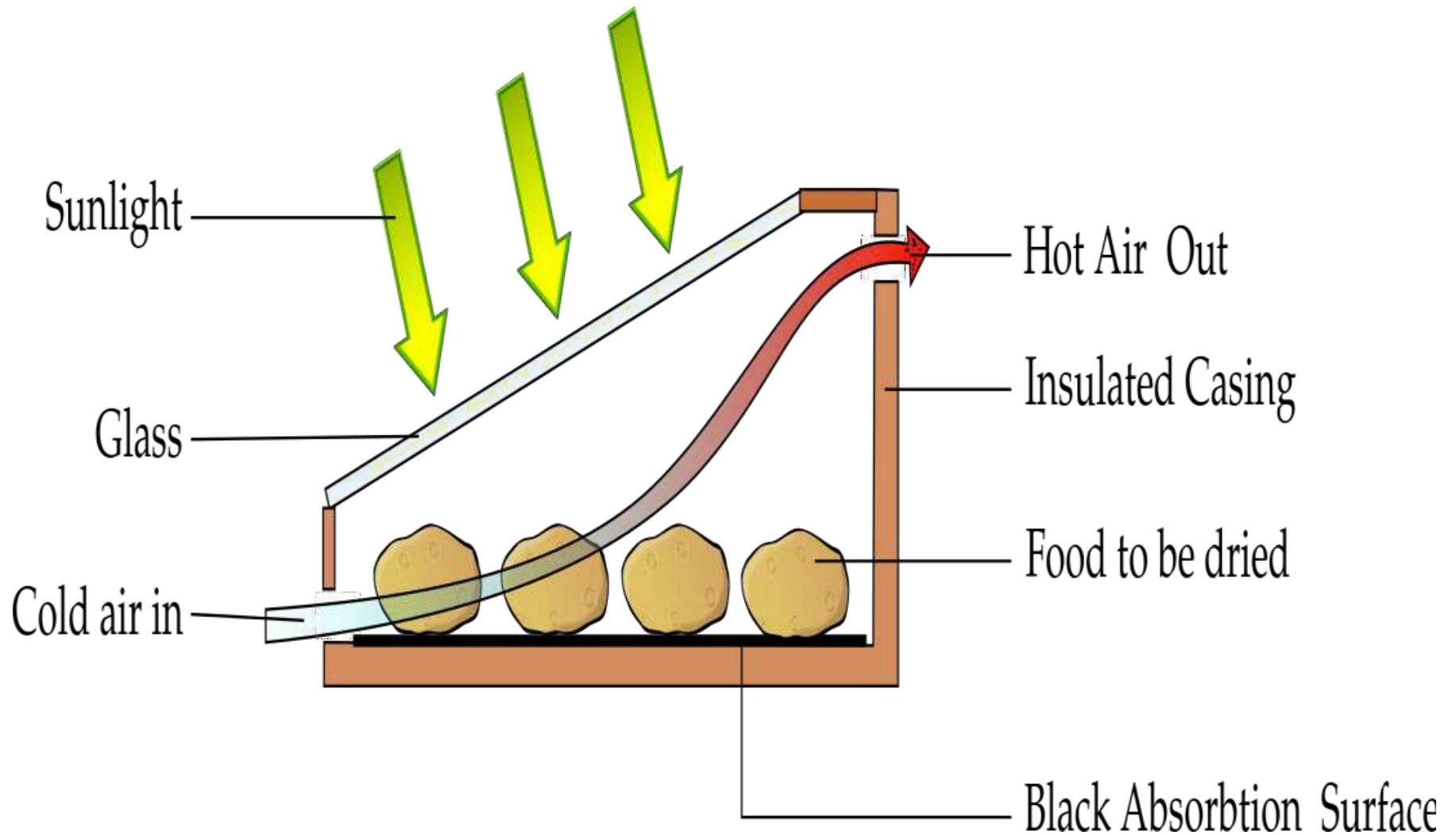
Solar Cooker(CO₂)

- A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize drink.
- Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves, and advanced, large-scale solar cookers can cook for hundreds of people.
- Because they use no fuel and cost nothing to operate, many non-profit organizations are promoting their use worldwide in order to help reduce fuel costs (especially where monetary reciprocity is low) and air pollution, and to slow down the deforestation and desertification caused by gathering firewood for cooking.
- Solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high, and the health and environmental consequences of alternatives are severe.

Solar Dryer(CO₂)

- Solar dryers are devices that use solar energy to dry substances, especially food. There are two general types of solar dryers: Direct and indirect.
- **Direct solar** dryers expose the substance to be dehydrated to direct sunlight. Historically, food and clothing was dried in the sun by using lines, or laying the items on rocks or on top of tents.
- **In indirect solar** dryers, the black surface heats incoming air, rather than directly heating the substance to be dried. This heated air is then passed over the substance to be dried and exits upwards often through a chimney, taking moisture released from the substance with it.

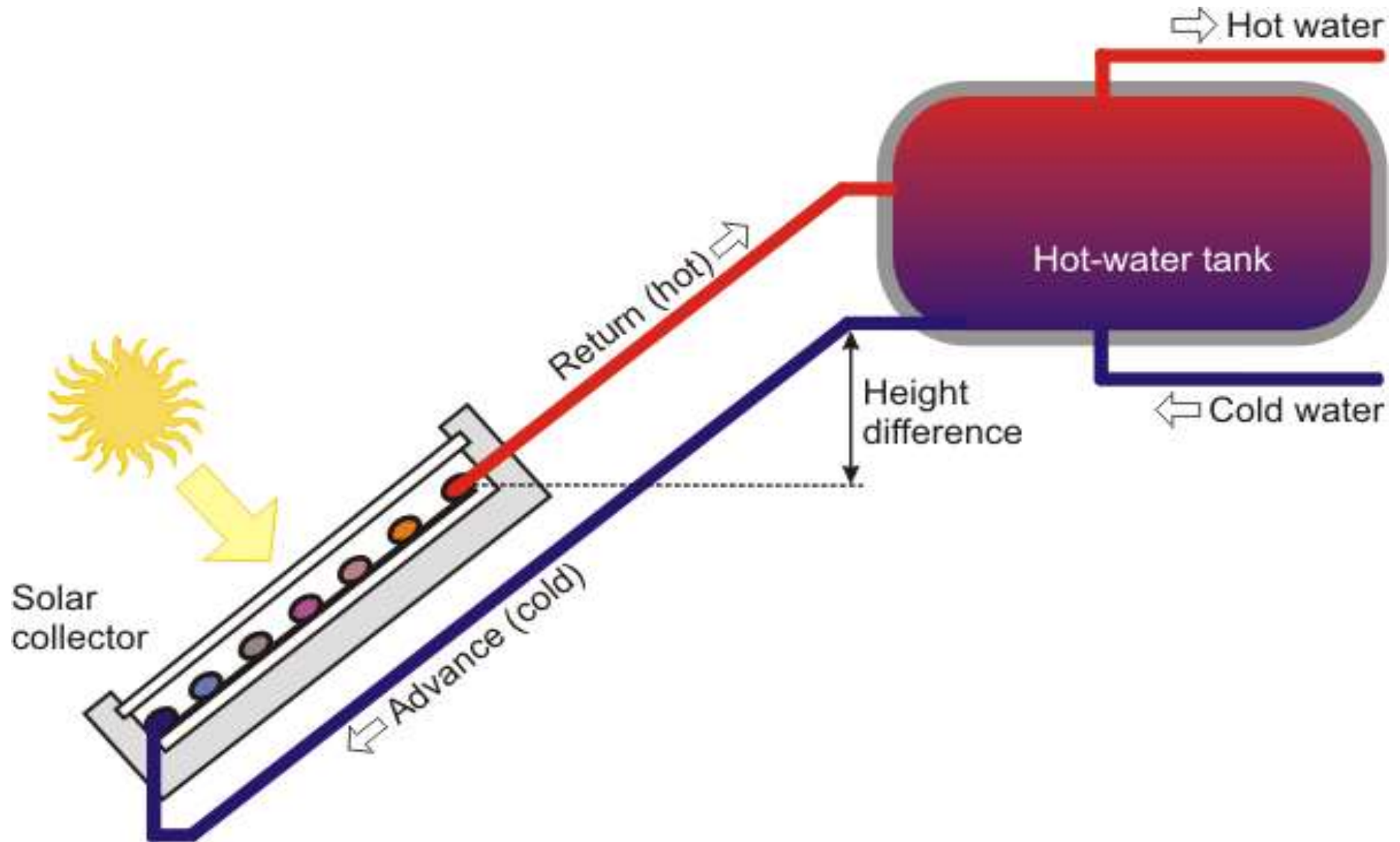
Solar Dryer(CO₂)



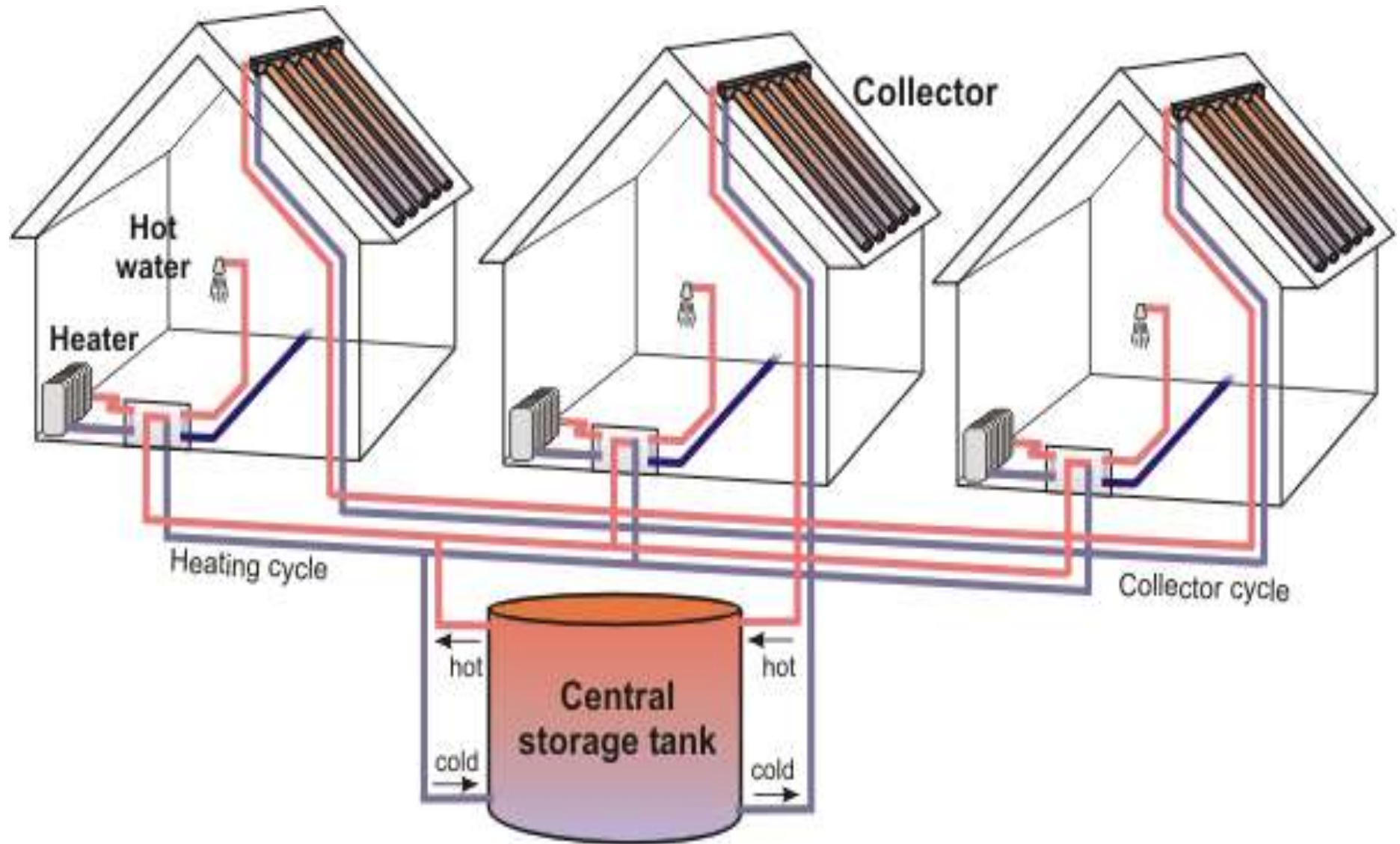
Domestic hot water and heat system(CO₂)

- Water heating is a thermodynamic process that uses an energy source to heat water above its initial temperature.
- Typical domestic uses of hot water include cooking, cleaning, bathing, and space heating.
- In industry, hot water and water heated to steam have many uses.
- Domestically, water is traditionally heated in vessels known as water heaters, kettles, cauldrons, pots, or coppers.
-
- These metal vessels that heat a batch of water do not produce a continual supply of heated water at a preset temperature.
- Hot water occurs naturally, usually from natural hot springs. The temperature varies with the consumption rate, becoming cooler as flow increases.

A thermo syphon system(CO₂)



A solar district heating system(CO₂)

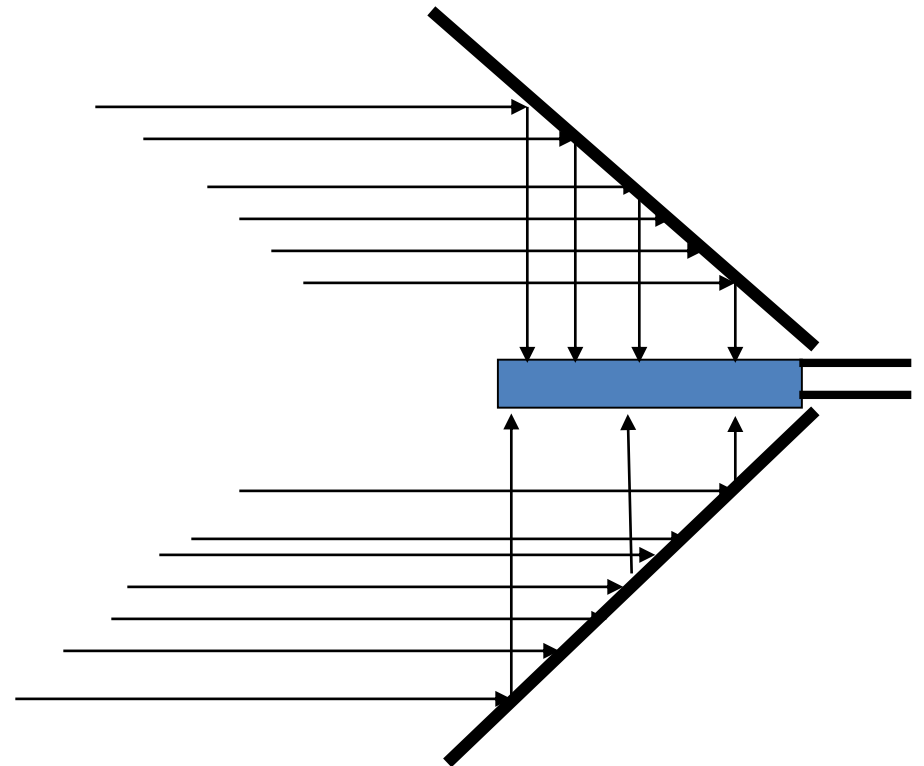


Concentrating Collectors(CO₂)

- Axicon Conical Reflector
- Parabolic Trough
- Paraboloidal Dish
- Solar Power Tower

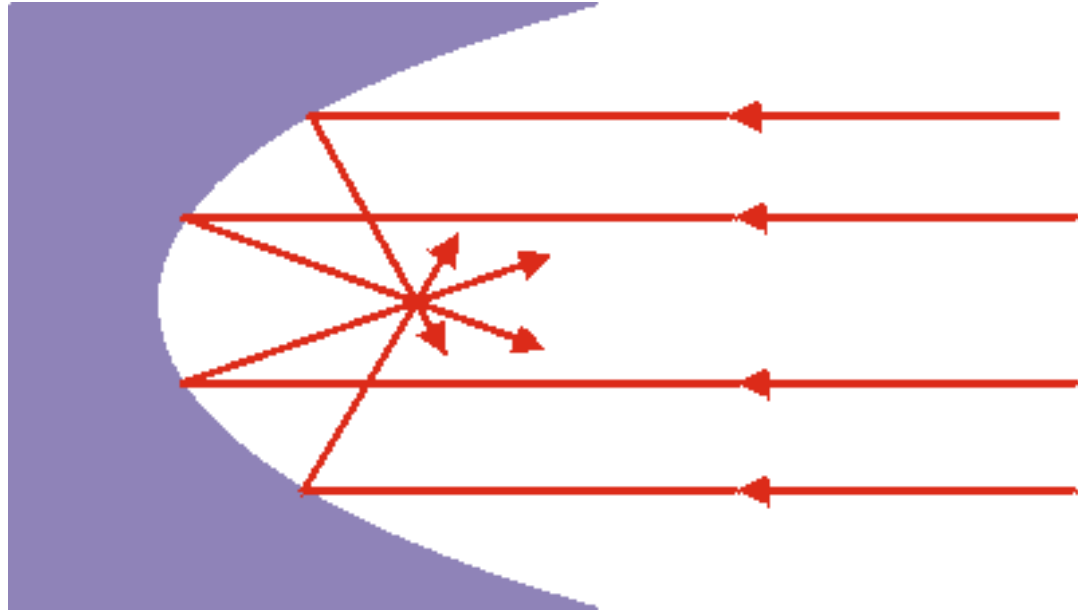
Axicon conical reflector(CO2)

- A polished mirror cone reflects the sun onto a water-filled pipe and can boil the water
- The surface of polished metal or foil is cheap to make and form
- First used in the 1800s



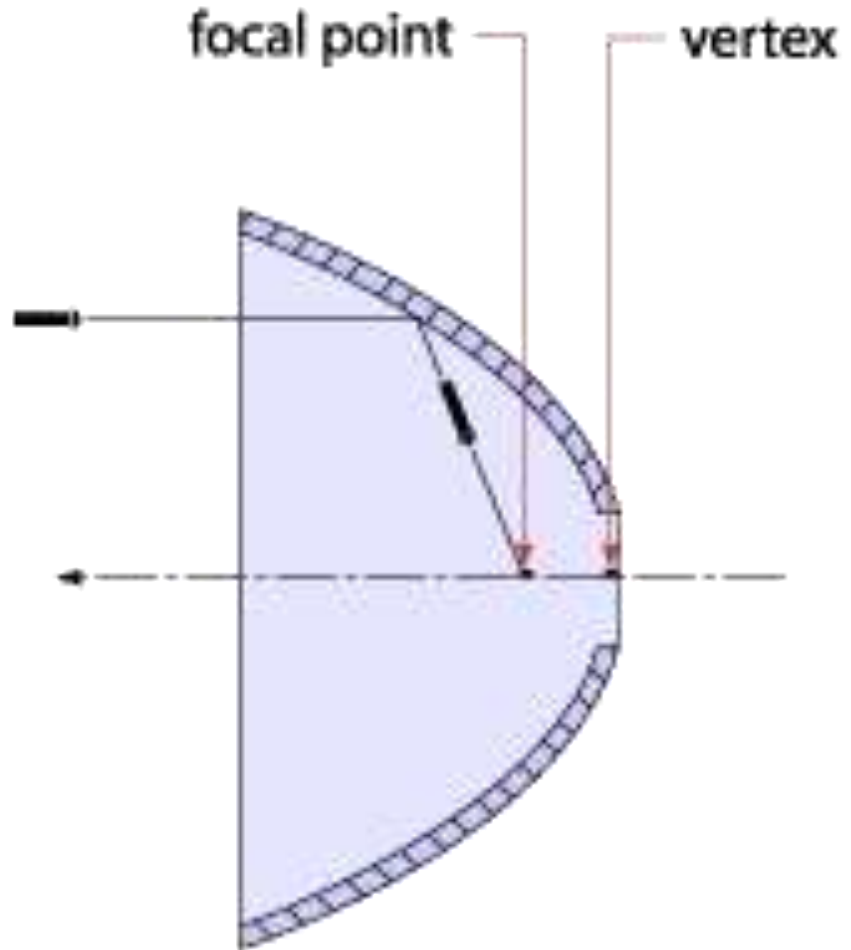
Solar Focusing Systems: Parabolic(CO₂)

- Focuses parallel rays to a line
- A black pipe is placed with its center at the focus
- Pipe can be in a vacuum or could have a glass cover tube to reduce convection
- Cylindrical reflector can be on one half of the vacuum tube and approximates the parabolic shape



Solar Focusing Systems: Paraboloidal(CO2)

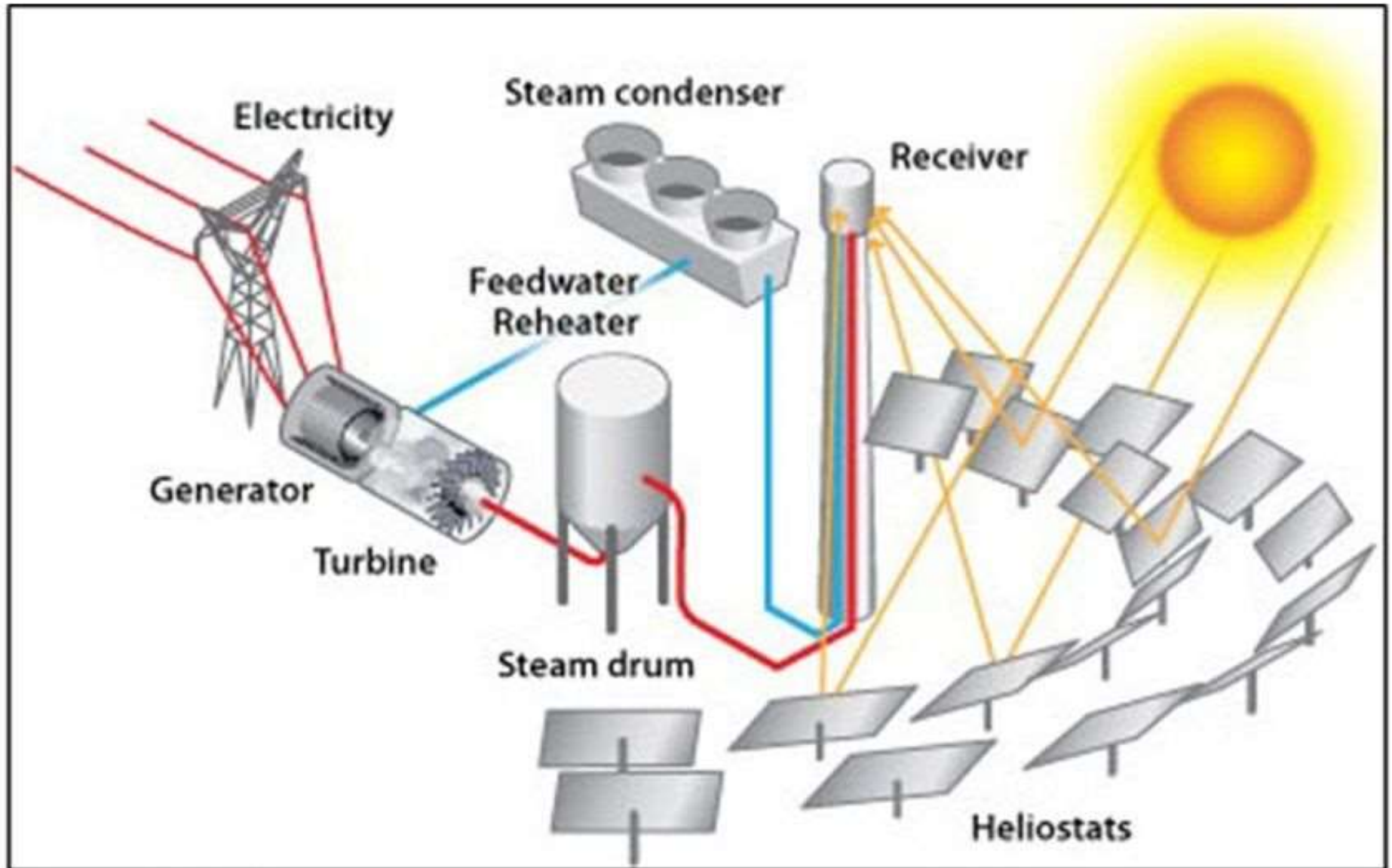
- The focus at one spot is achieved by the parabolic cross-section
- Flat mirror segments may be used to approximate the curve at much lower expense



Solar Power Towers(CO₂)

- Solar power towers were developed using Heliostats (Heliostatic mirrors) to focus sunlight at central receiver tower.
- The heliostat mirrors are about ten feet square and mounted on the azimuth-elevation mounts (like a radar antenna mount) about 10 feet off the ground.
- Normally water is used to produce steam, but the system is being modified for molten salt.

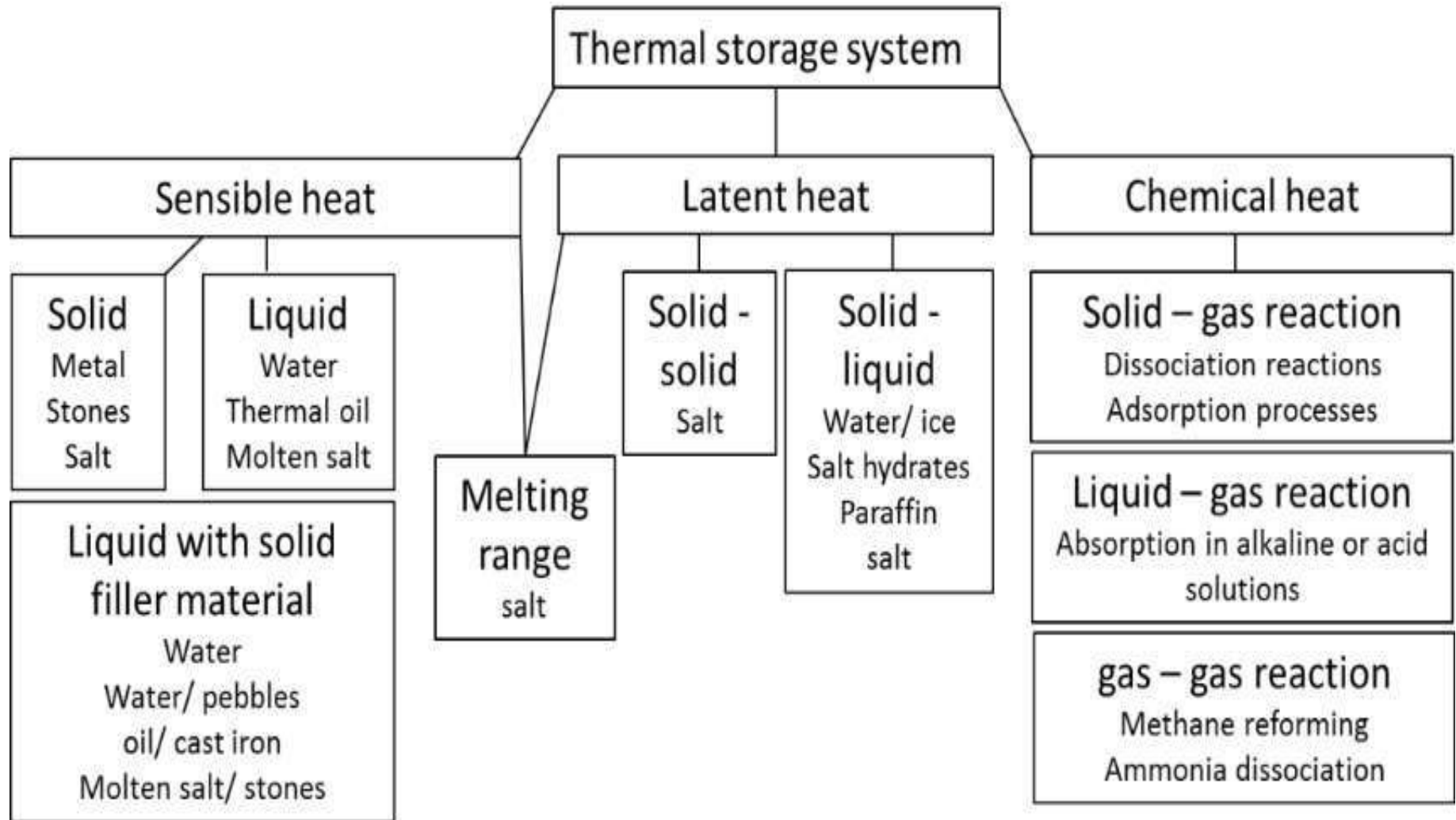
Solar Power Towers(CO₂)



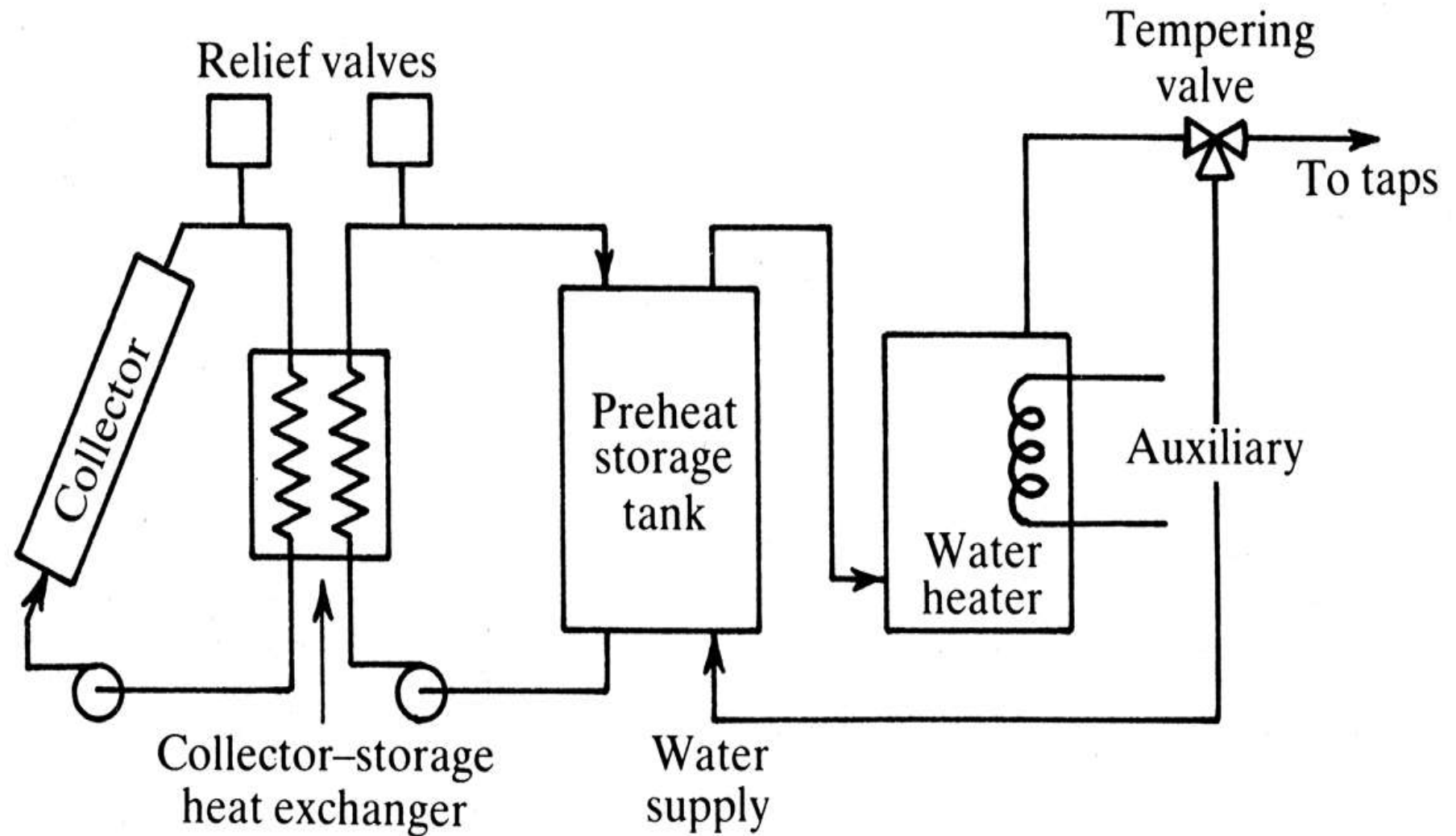
Advantages & Disadvantages of solar thermal system(CO₂)

- Solar thermal systems work efficiently at lower temperatures since cheap flat collectors can work economically
- Reflecting systems need broad acceptance angles so that the optics don't cost too much
 - The beam need only strike the absorber, not form a picture image (noncoherent)
- Reflectors must be kept clean by frequent washing
- Reflectors wouldn't be wise in hailstorm country!
 - Could be protected by a quickly erected tarp

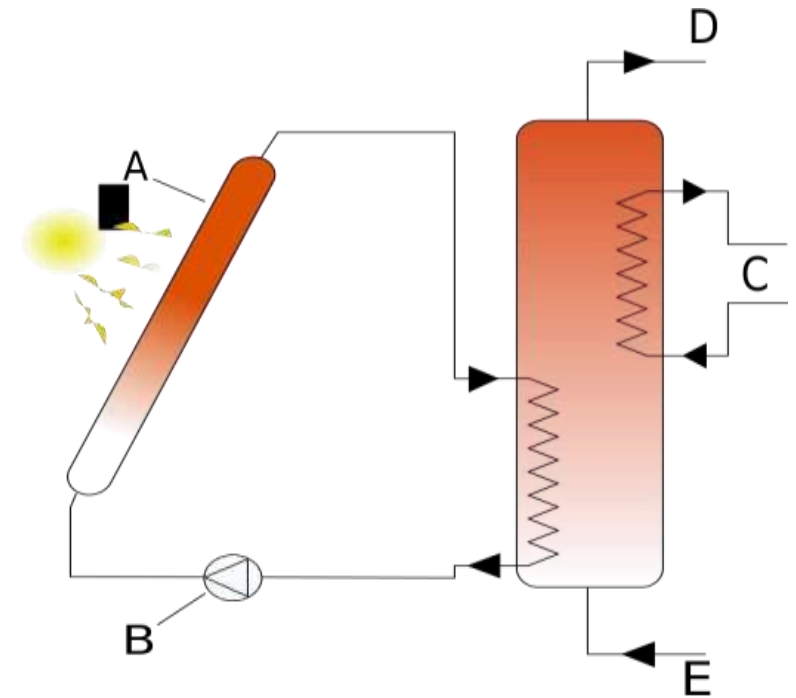
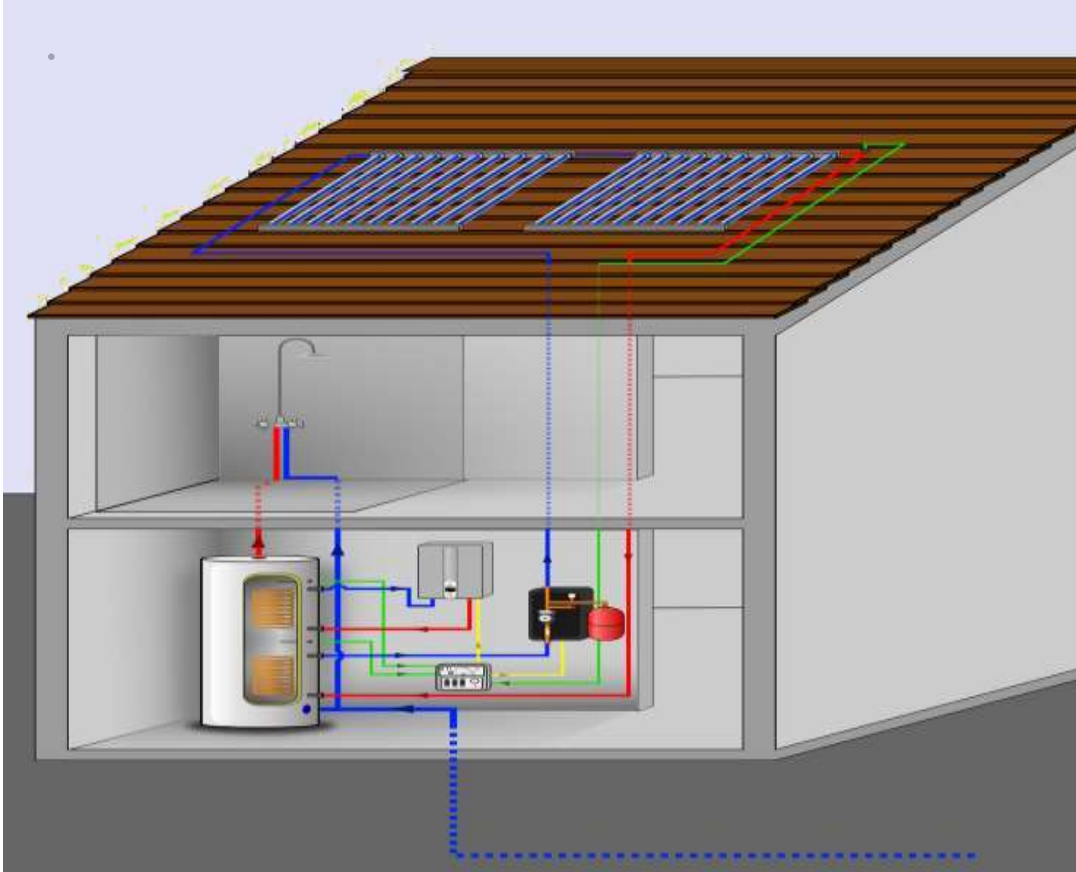
Methods For Storing Solar Thermal Energy



Solar Power Plant (CO₂)



Solar Power Plant (CO₂)



SOLAR PONDS(CO₂)

- Normal ponds receive sunlight a part of which is reflected at the surface, a part is absorbed and the remaining is transmitted to the bottom.
- Due to this the lower part gets heated up and the density decreases as a result of which it rises up and convection currents are set up.(As a result, the heated water reaches top layer and loses its heat by convection and evaporation).
- A natural or artificial body of water for collecting and absorbing solar radiation energy and storing it as heat.
- Thus a solar pond combines solar energy collection and sensible heat storage.
- They are large shallow bodies of water that are arranged so that the temperature gradient are reversed from the normal.
- This allows the use for collection and storage of solar energy which may under ideal conditions be delivered at temperature 40-50 °C above normal.
- It can be use for various applications, such as process heating, water desalination, refrigeration, drying and power generation.

SOLAR PONDS(CO₂)

