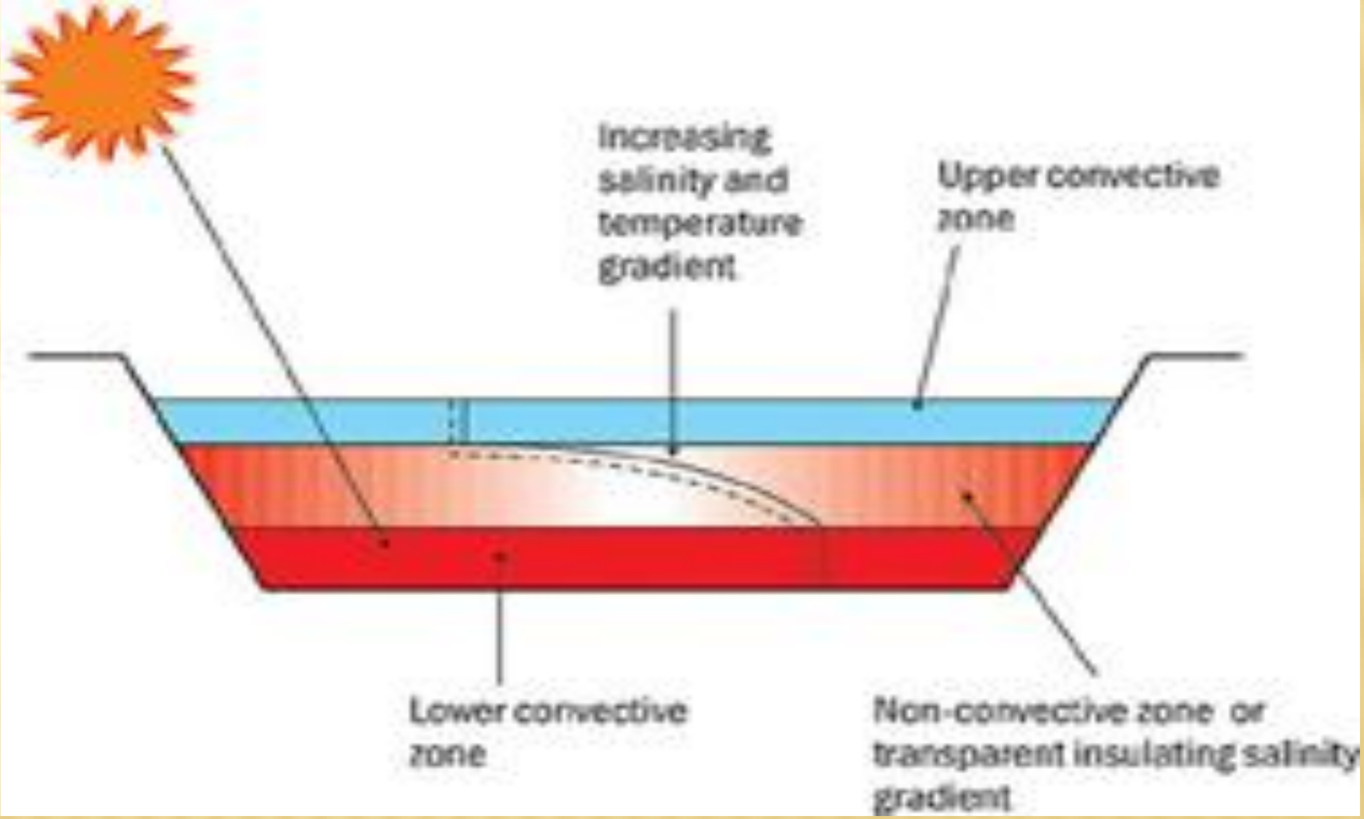
SOLAR APPLICATIONS

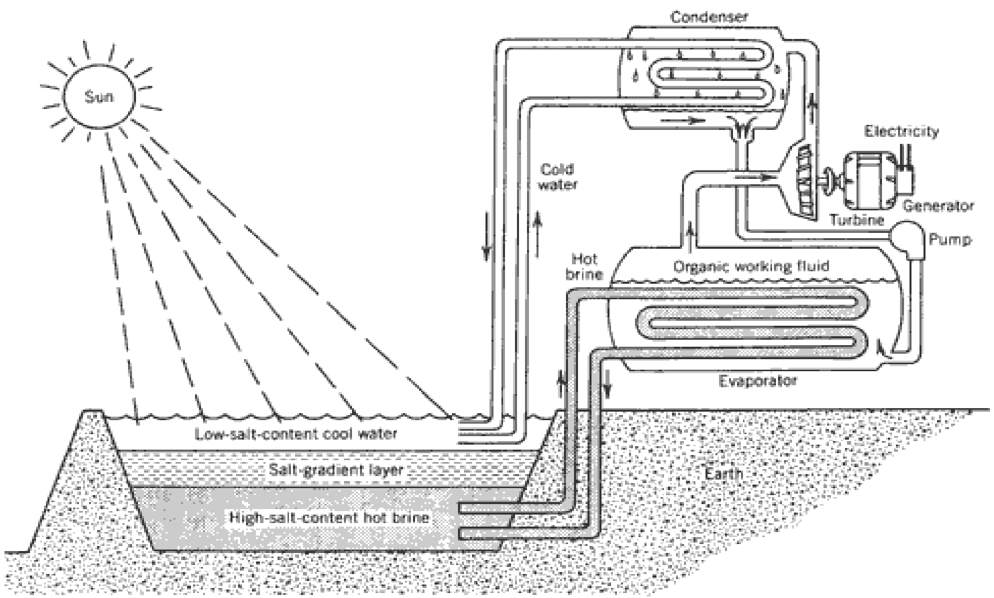
SOLAR POND

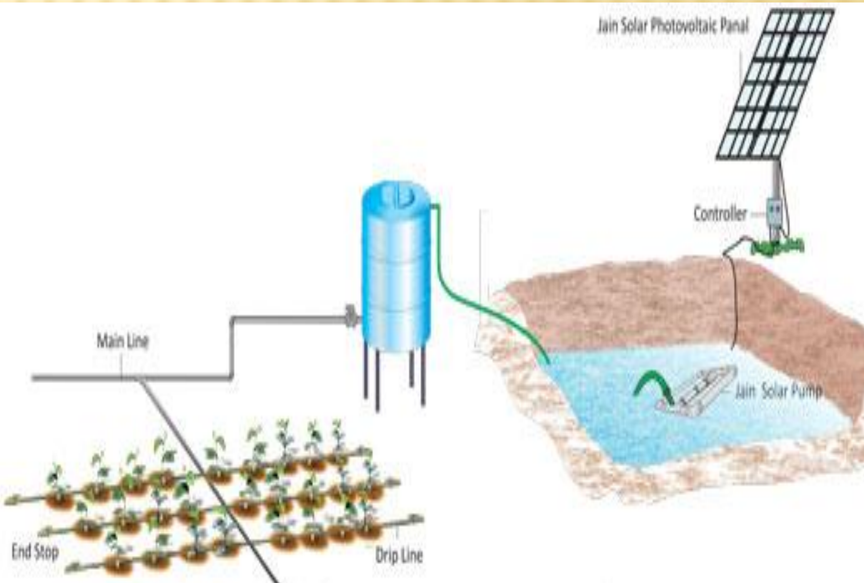
- Solar pond have three layers and can attain 90 C at the bottom layer and 30 C at the top layer.
- 1) The top layer-***Surface convection zone:*** thickness of 0.3 to o.5m. low, uniform concentration(low salinity<5%) temp. Close to atm.



2) Intermediate insulating layer with a salt gradient- ***Non-convective zone:*** thicker up to 1 to 1.5m concentration and temp. increase with depth. Due to density gradient prevent heat exchange by nature convection.

3) ***Lower convective or storage zone:*** thicker about 0.5 to 1m and high salinity about 20%. Serves as main heat collection as well as thermal storage medium





Schematic of Solar Powered Jain DripKit sourced through farm pond.

SOLAR ENERGY APPLICATIONS AND TYPE OF COLLECTORS USED

Application	System	Collector
Solar water heating		
Thermosyphon systems	Passive	FPC
Integrated collector storage	Passive	CPC
Direct circulation	Active	FPC, CPC ETC
Indirect water heating systems	Active	FPC, CPC ETC
Air systems	Active	FPC
Space heating and cooling		
Space heating and service hot water	Active	FPC, CPC ETC
Air systems	Active	FPC
Water systems	Active	FPC, CPC ETC
Heat pump systems	Active	FPC, CPC ETC
Absorption systems	Active	FPC, CPC ETC
Adsorption (desiccant) cooling	Active	FPC, CPC ETC
Mechanical systems	Active	PDR
Solar refrigeration		
Adsorption units	Active	FPC, CPC ETC
Absorption units	Active	FPC, CPC ETC

SOLAR ENERGY APPLICATIONS AND TYPE OF COLLECTORS USED

Application	System	Collector
Industrial process heat		
Industrial air and water systems	Active	FPC, CPC ETC
Steam generation systems	Active	PTC, LFR
Solar desalination		
Solar stills	Passive	-
Multi-stage flash (MSF)	Active	FPC, CPC ETC
Multiple effect boiling (MEB)	Active	FPC, CPC ETC
Vapour compression (VC)	Active	FPC, CPC ETC
Solar thermal power systems		
Parabolic trough collector systems	Active	PTC
Parabolic tower systems	Active	HFC
Parabolic dish systems	Active	PDR
Solar furnaces	Active	HFC, PDR
Solar chemistry systems	Active	CPC, PTC, LFR

SOLAR WATER HEATING SYSTEMS

Thermosyphon systems
Integrated collector storage systems
Direct circulation systems
Indirect water heating systems
Air systems

THERMOSYPHON SYSTEMS (PASSIVE)

- Thermosyphon systems heat potable water or heat transfer fluid and use natural convection to transport it from the collector to storage.
- The water in the collector expands becoming less dense as the sun heats it and rises through the collector into the top of the storage tank.
- There it is replaced by the cooler water that has sunk to the bottom of the tank, from which it flows down the collector.
- The circulation continuous as long as there is sunshine.
- Since the driving force is only a small density difference larger than normal pipe sizes must be used to minimise pipe friction.
- Connecting lines must be well insulated to prevent heat losses and sloped to prevent formation of air pockets which would stop circulation.

SCHEMATIC DIAGRAM OF A THERMOSYPHON SOLAR WATER HEATER

- Storage tank is located above level of collector, at least 0.3m above the top edge of collector.

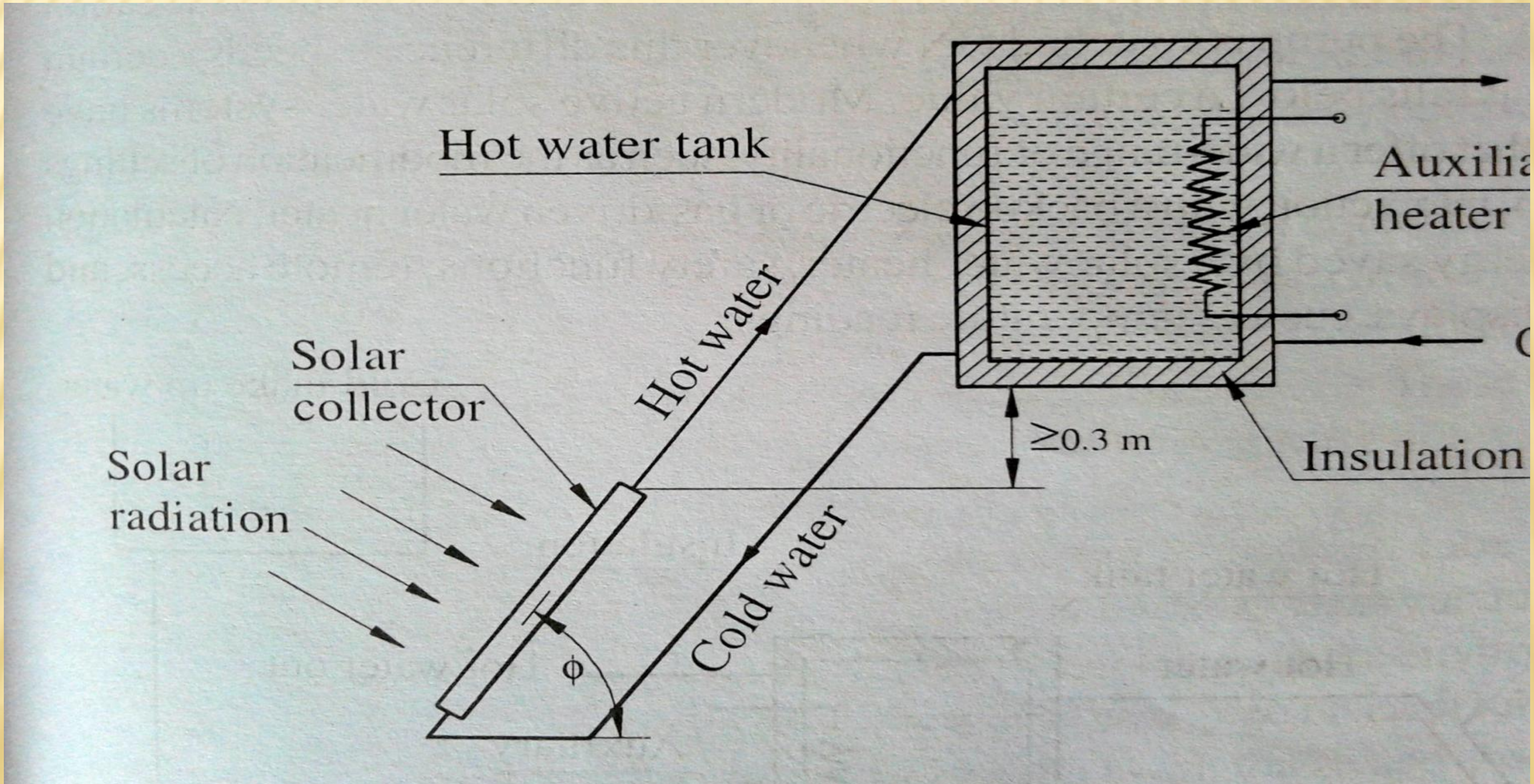
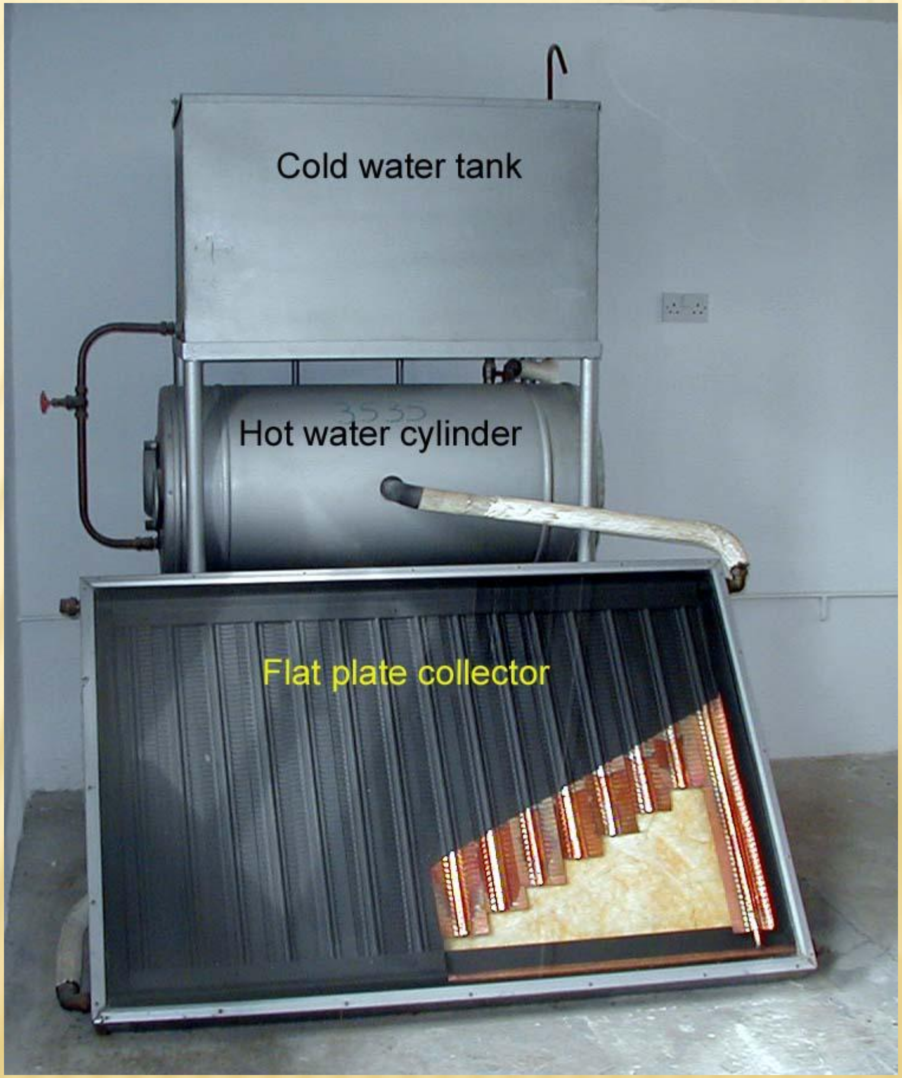


Fig.2.51 Natural circulation solar water heater

TYPICAL THERMOSYPHON SOLAR WATER HEATER

LABORATORY MODEL



FORCE CIRCULATION SWH OR ACTIVE HEATING SYSTEM

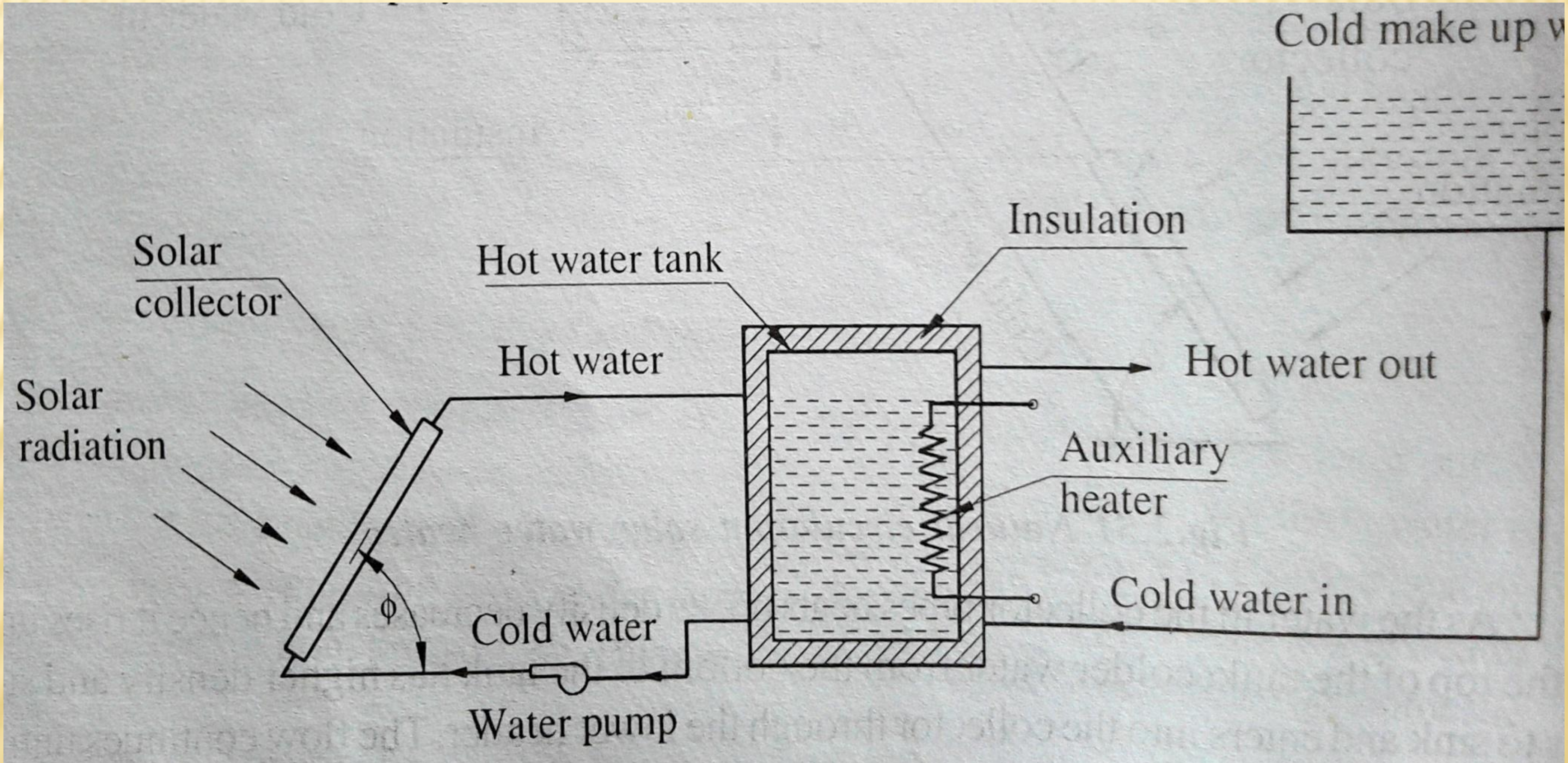


Fig. 2.52 Forced circulation solar water heater

PRESSURIZED SYSTEM ON INCLINED ROOF

SOLAR DISTILLATION OR SOLAR STILL

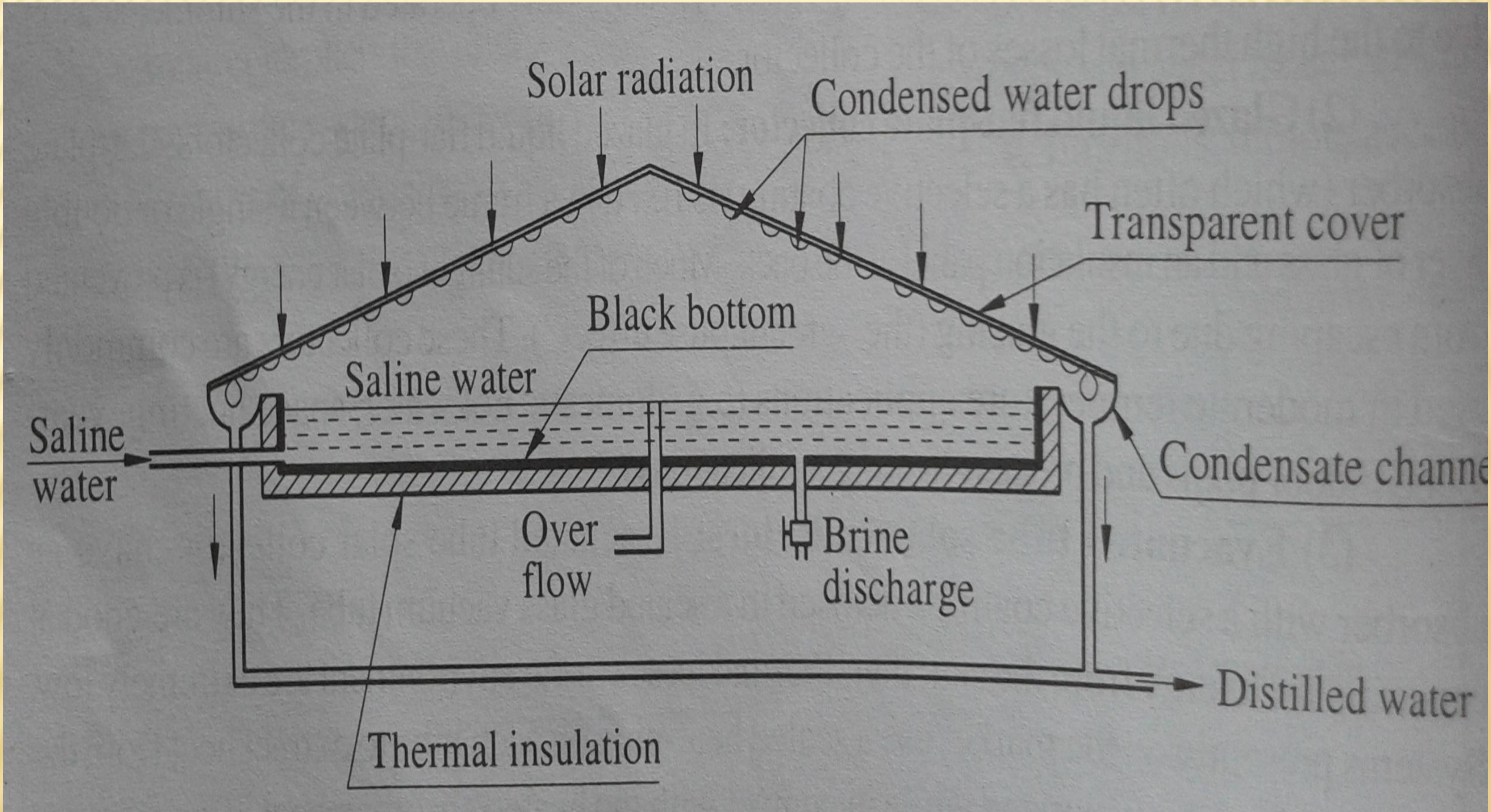
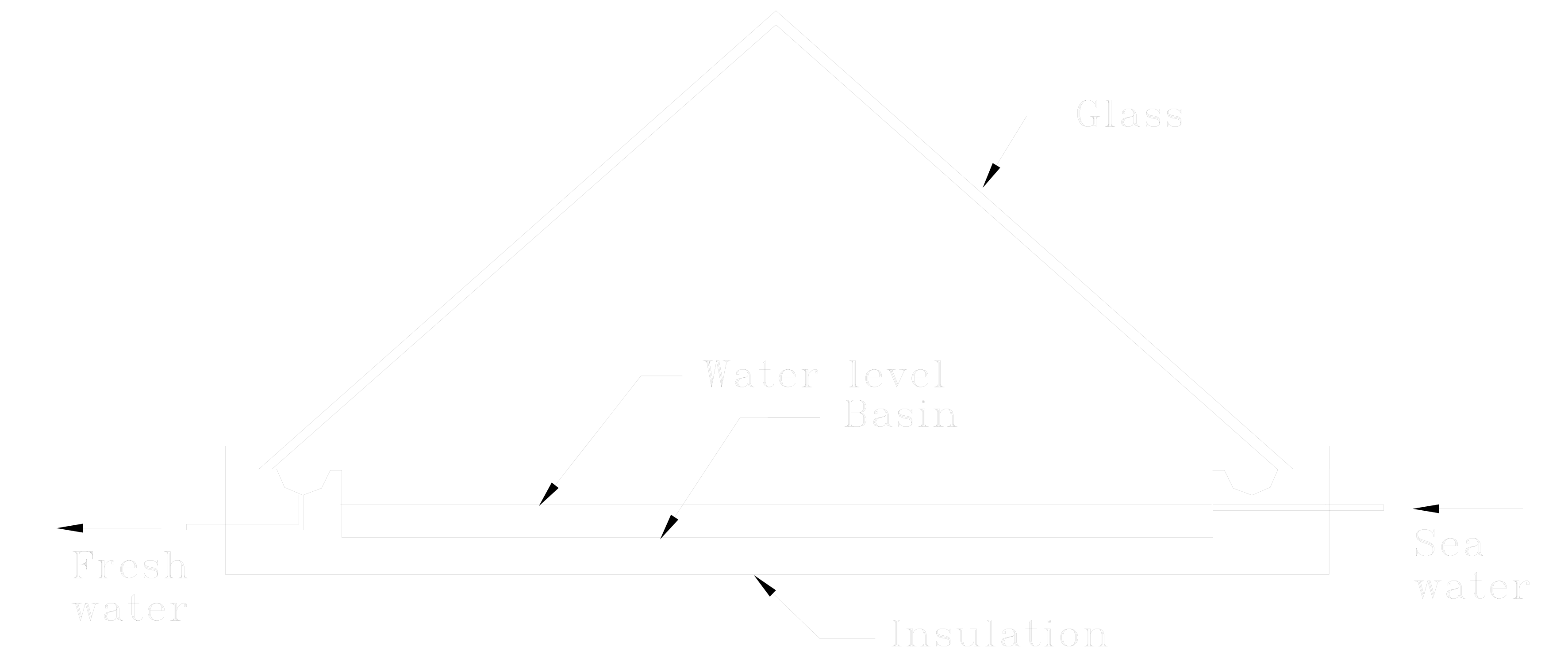


Fig. 2.53 Simple basin type solar still

SOLAR STILL

- The depth of water is kept about 5-10cm.
- Output about 3 liter/m2 with efficiency of 30-35% in sunny day.



SOLAR STILLS

COMPARISON OF PASSIVE AND ACTIVE SYSTEM

- System operates without pumps, blower, or other mechanical devise.
- Special building design is necessary.
- The various elements of the buildings like wall, roof, windows, partitions etc., are so selected and so selected and so architecturally integrated that they participate in the collector, storage, transportation and distribution of thermal energy.
- Less expensive than active system to construct and operate.

- System require pumps, blower, or other mechanical devise for circulate the working fluid for transportation of heat
- Special building design is not necessary.
- Solar radiation may be stored in sensible heat storage materials, or in latent heat storage material and the energy is redistributed in the building space using pumps, blowing, fans etc.
- More expensive

PASSIVE SOLAR SPACE HEATING SYSTEM

- Direct gain

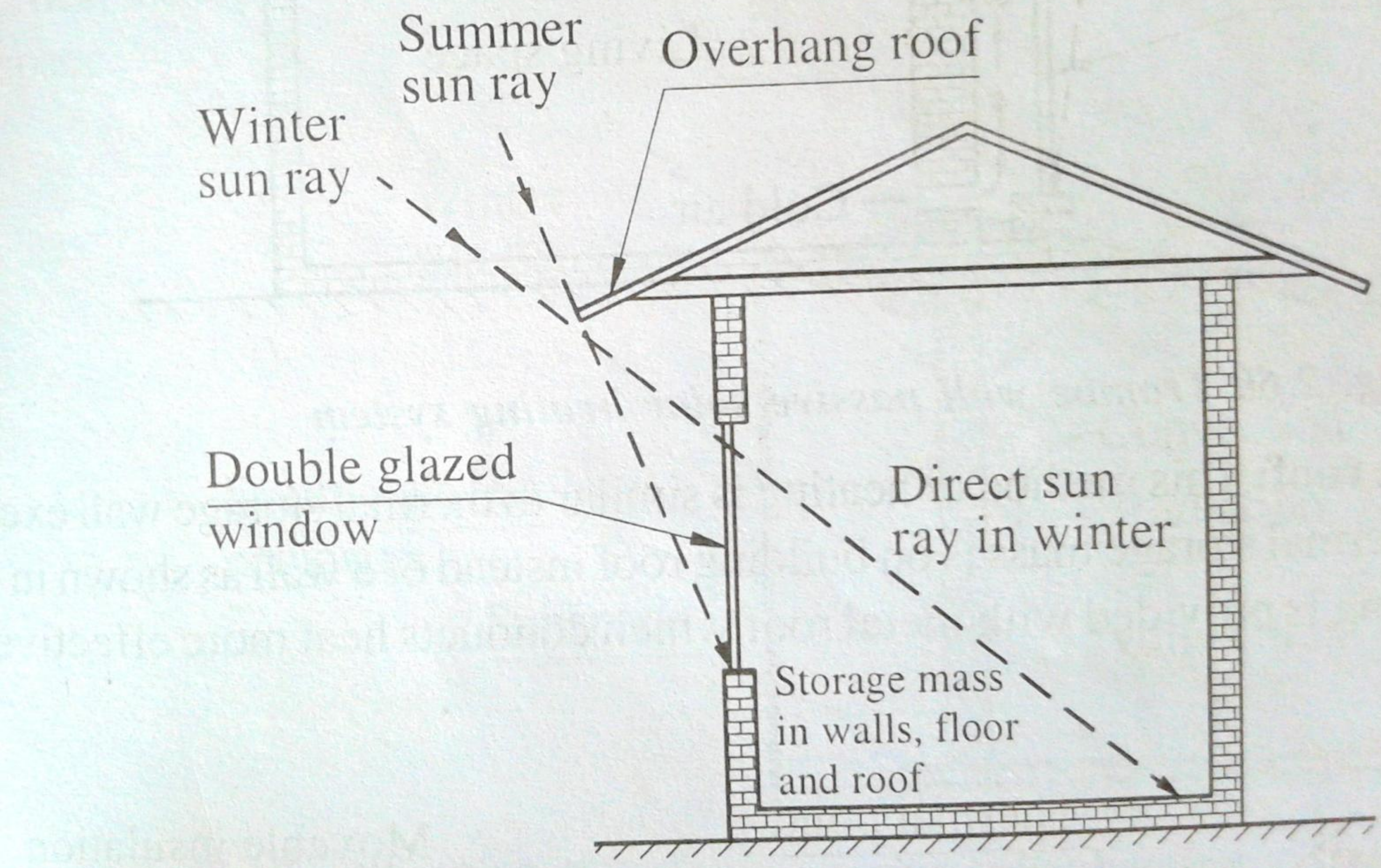


Fig. 2.59 Direct gain passive solar heating system

- Thermal storage wall

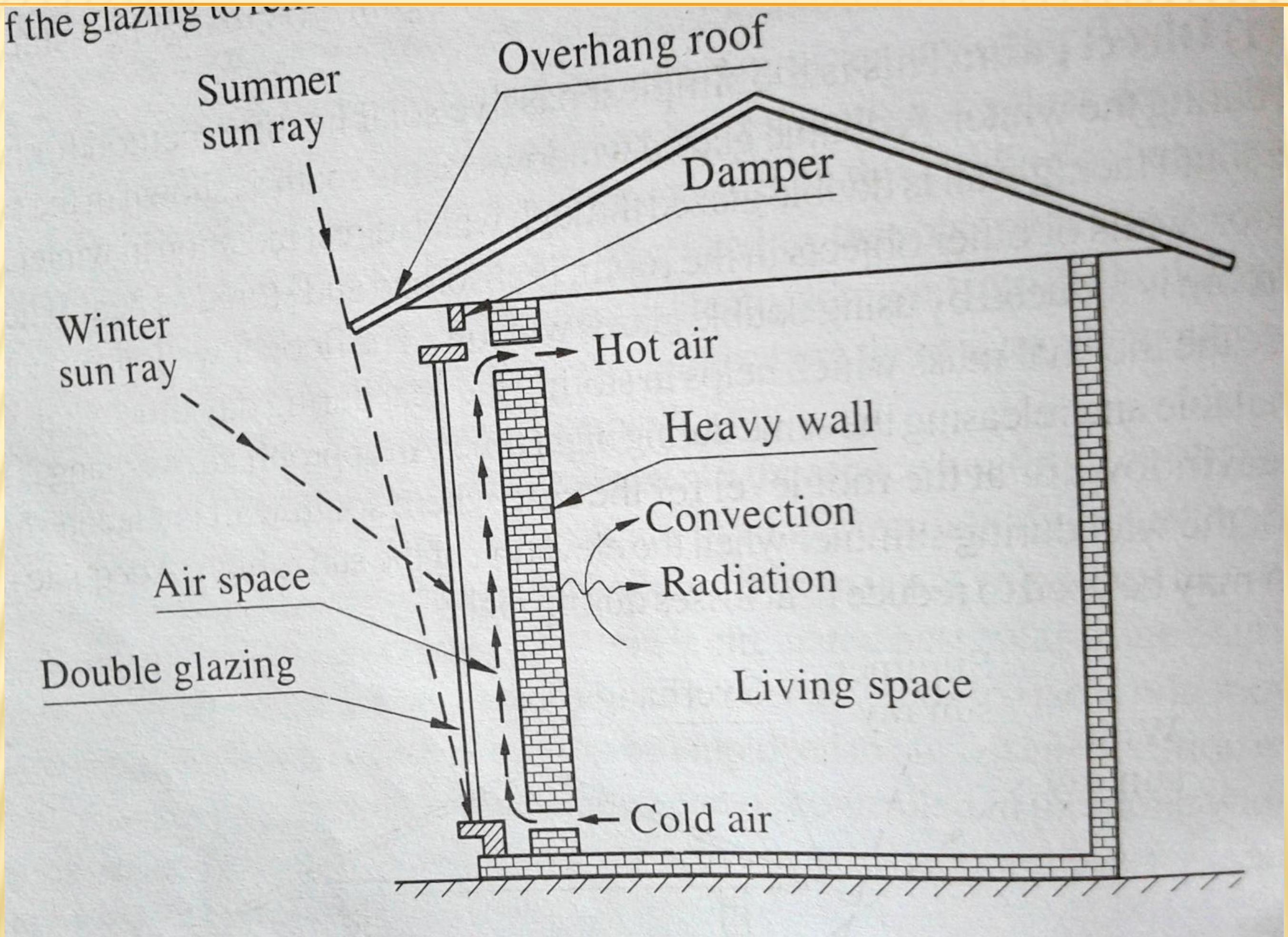


Fig. 2.60 Trombe wall passive solar heating system

- Thermal storage roof:

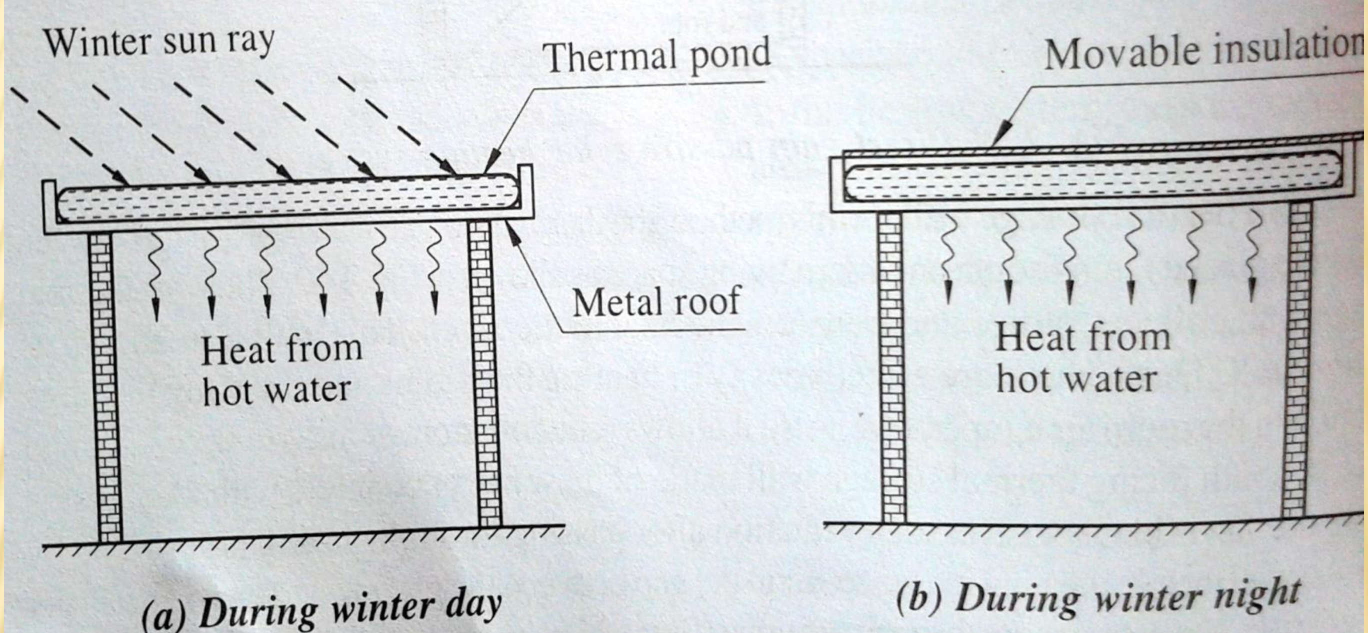


Fig.2.61 Thermal storage roof passive solar heating system

* Attached sun space (green house):

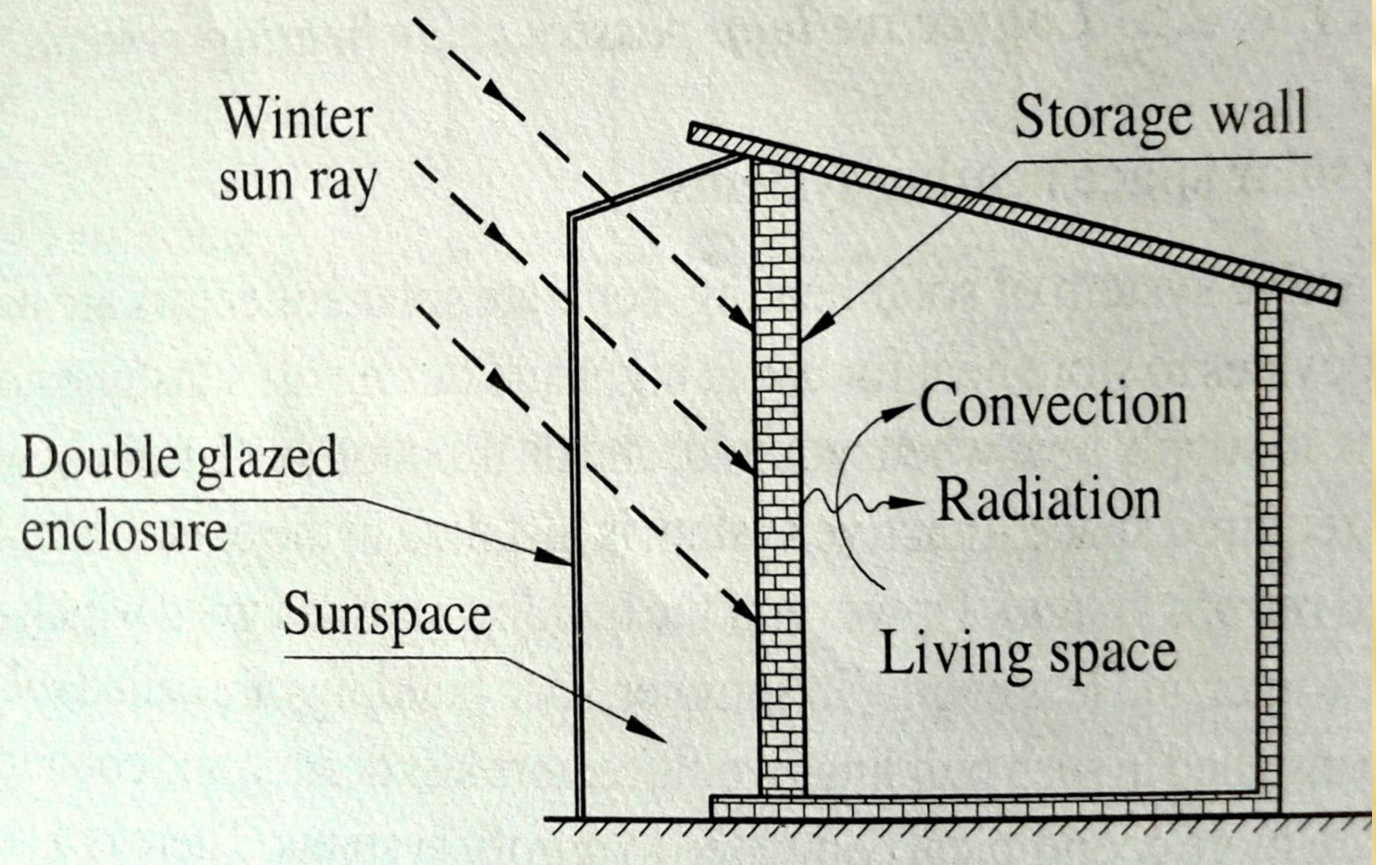


Fig. 2.62 Sun space passive solar heating system

- Convective loop: thermo-syphon principle

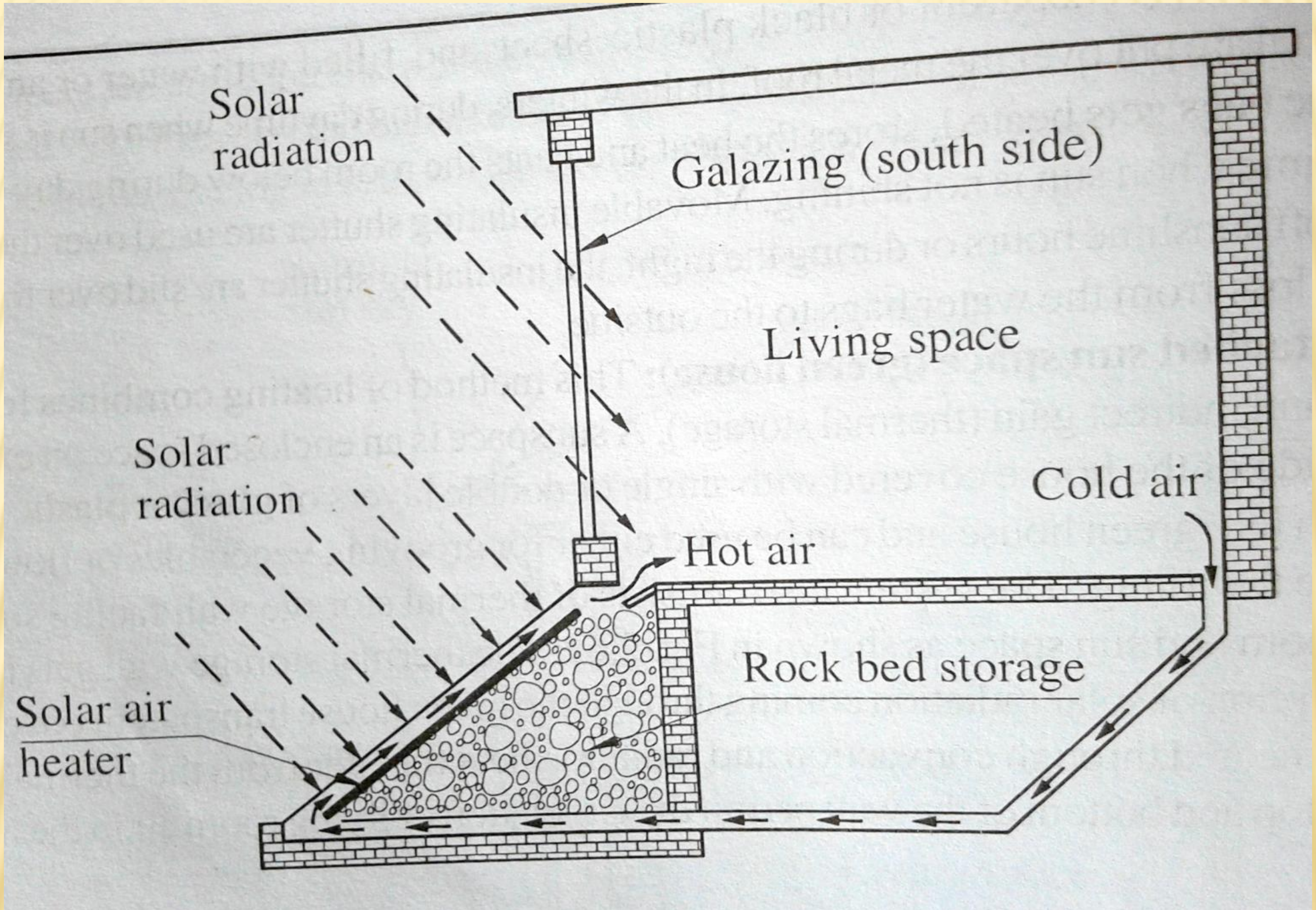


Fig. 2.63 Convective loop passive solar heating system

ACTIVE SOLAR SPACE HEATING SYSTEM

I. Solar water collectors
II. Heat storage device
III. Pumping device or distribution system
IV. Auxiliary heating system
V. Control system

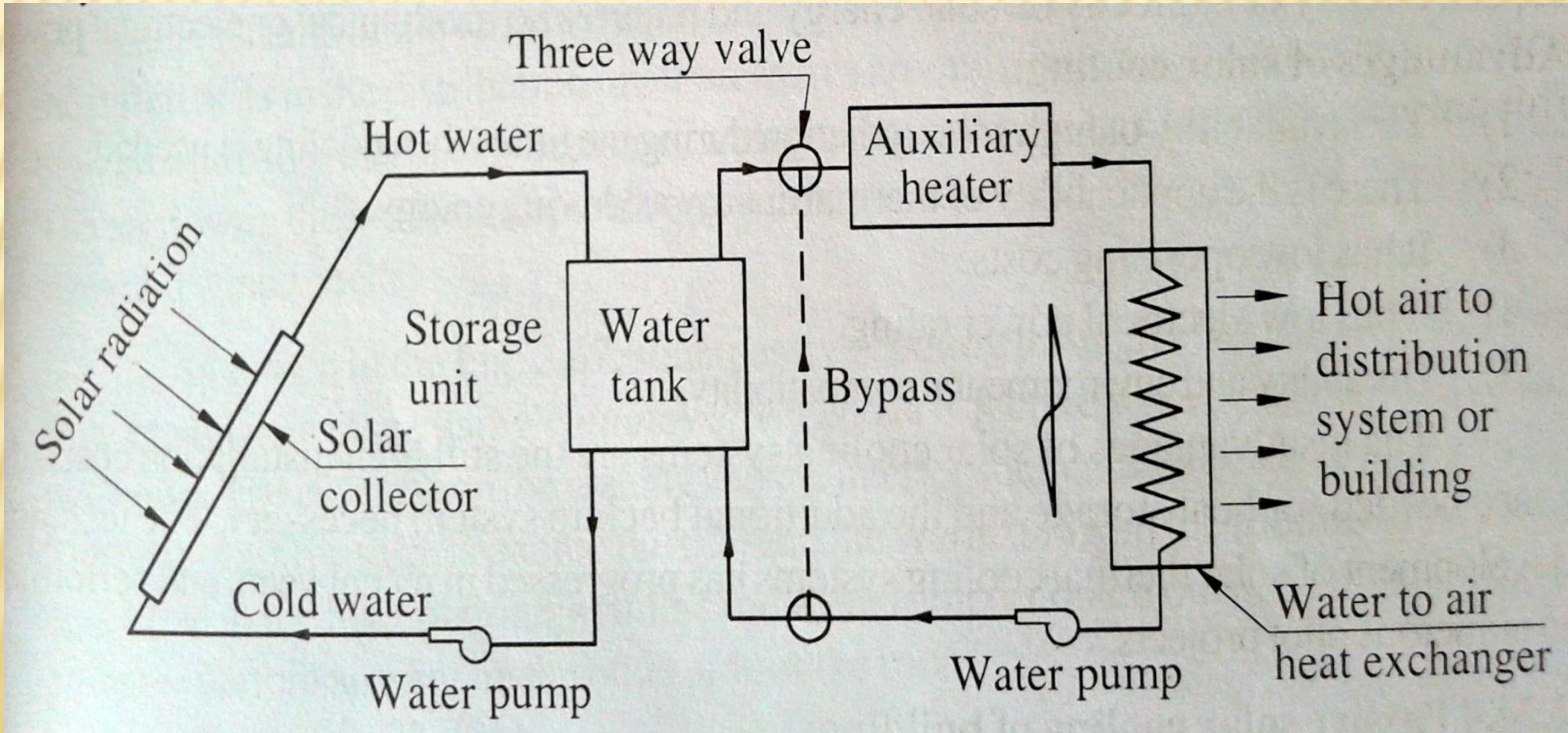


Fig. 2.64 Active hot water solar space heating system

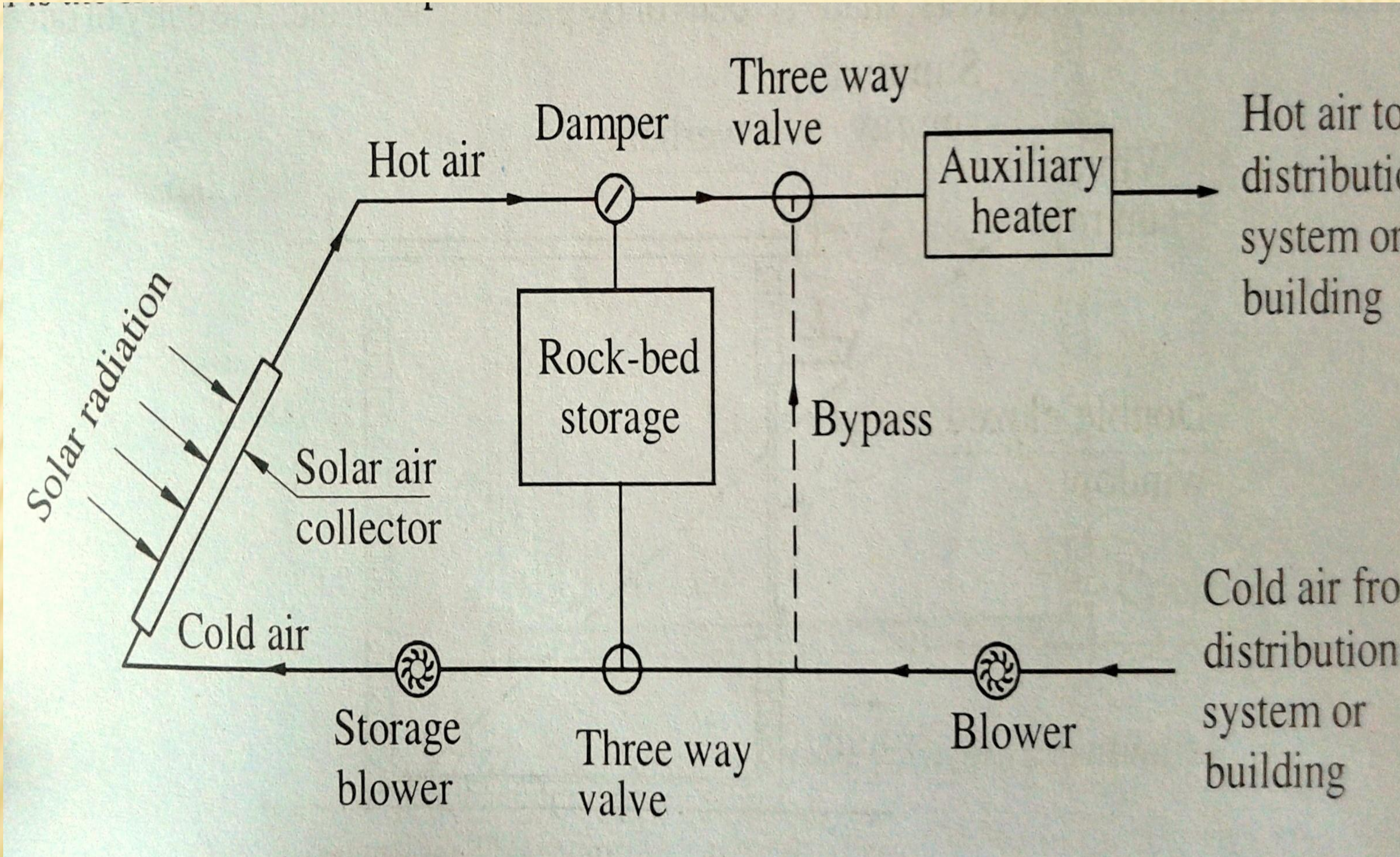


Fig 2.65 Active hot air solar space heating system

PASSIVE SOLAR COOLING OF BUILDING

Shading

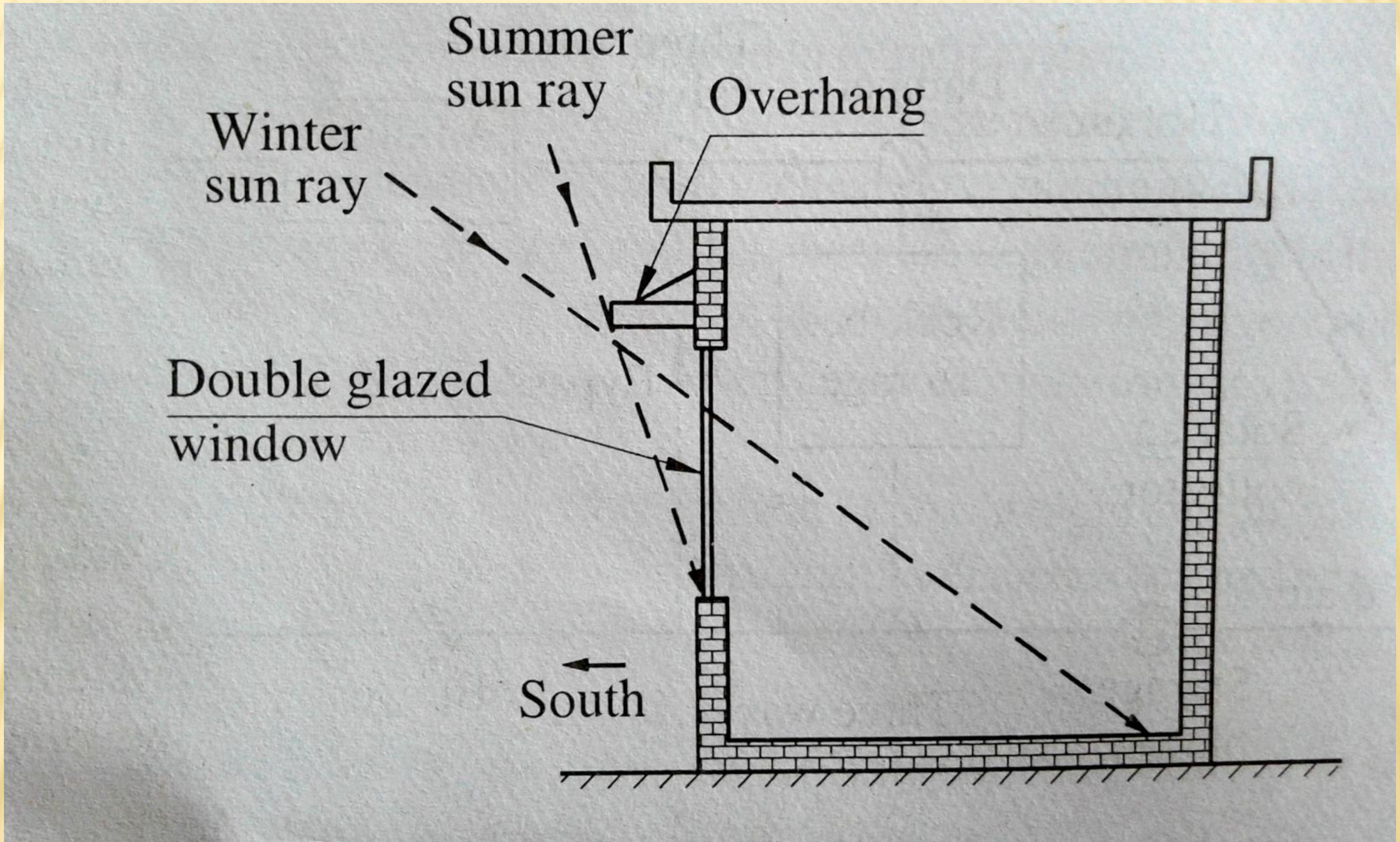


Fig. 2.66 Shading of window using overhang

VENTILATION

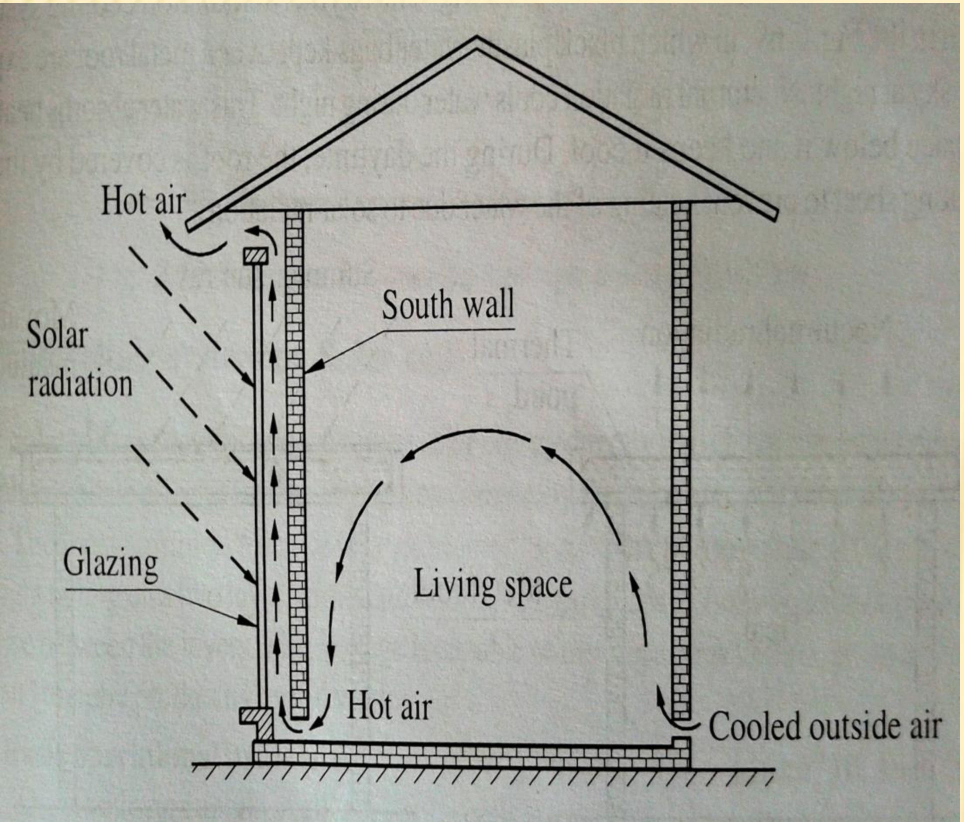


Fig. 2.67 Solar passive cooling through ventilation

EVAPORATION

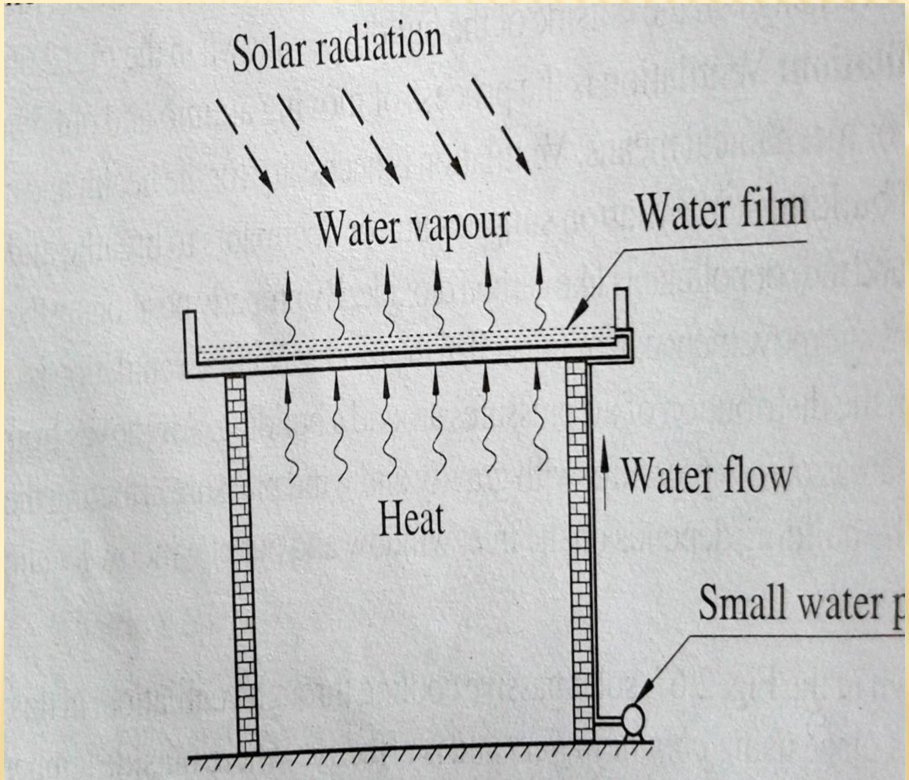


Fig. 2.68 Solar passive cooling through evaporation

RADIATION COOLING

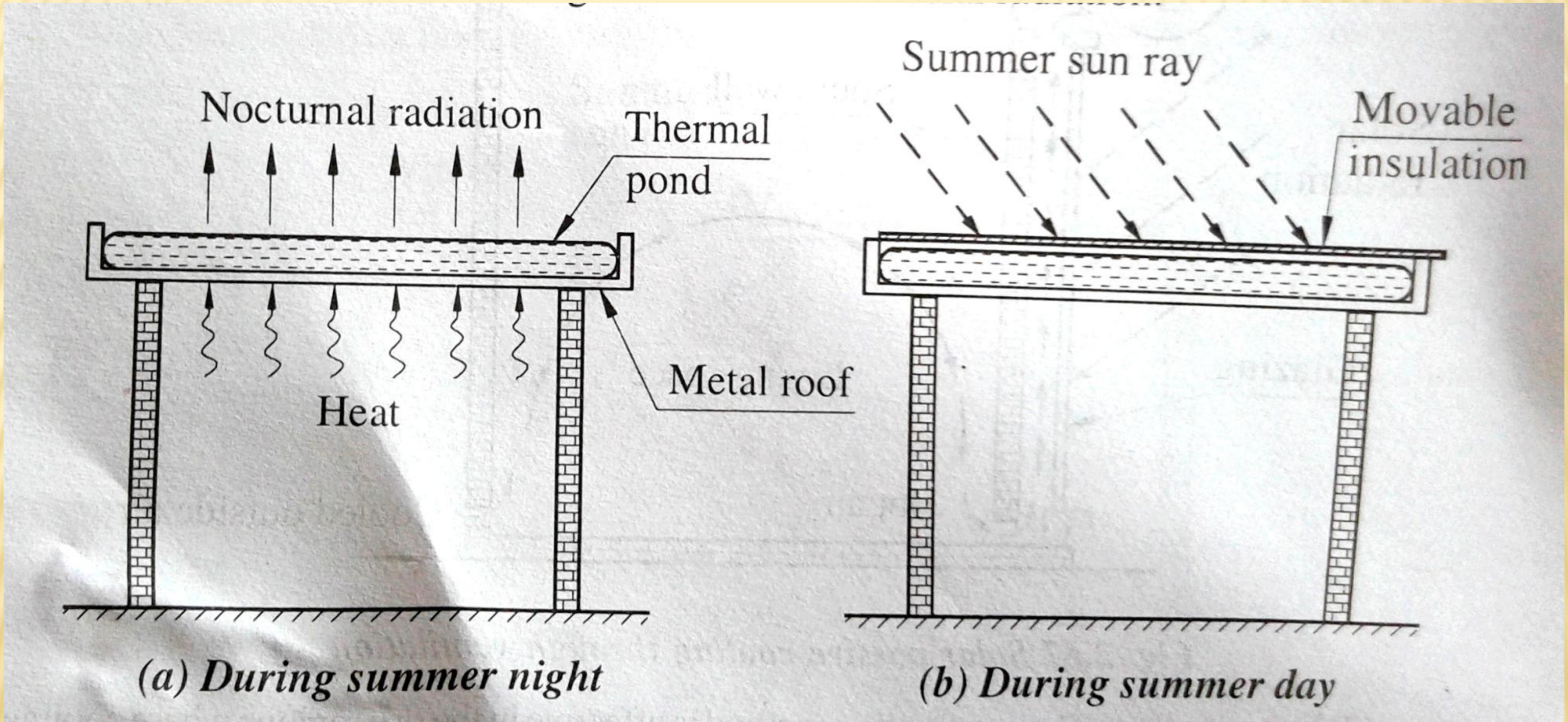


Fig. 2.69 Skytherm radiation cooling system

GROUND COUPLING

- The ground temp. is always lower than the air temp. Lower temp. ground can be used for cooling the building by partially sinking it into the ground.

DEHUMIDIFICATION

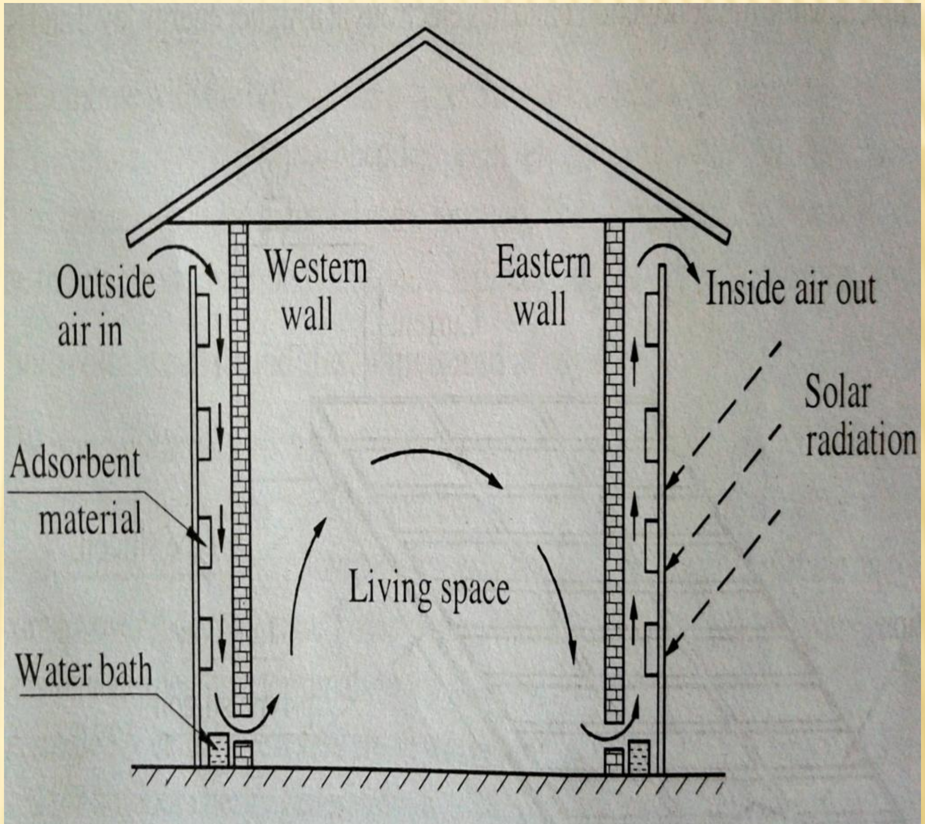
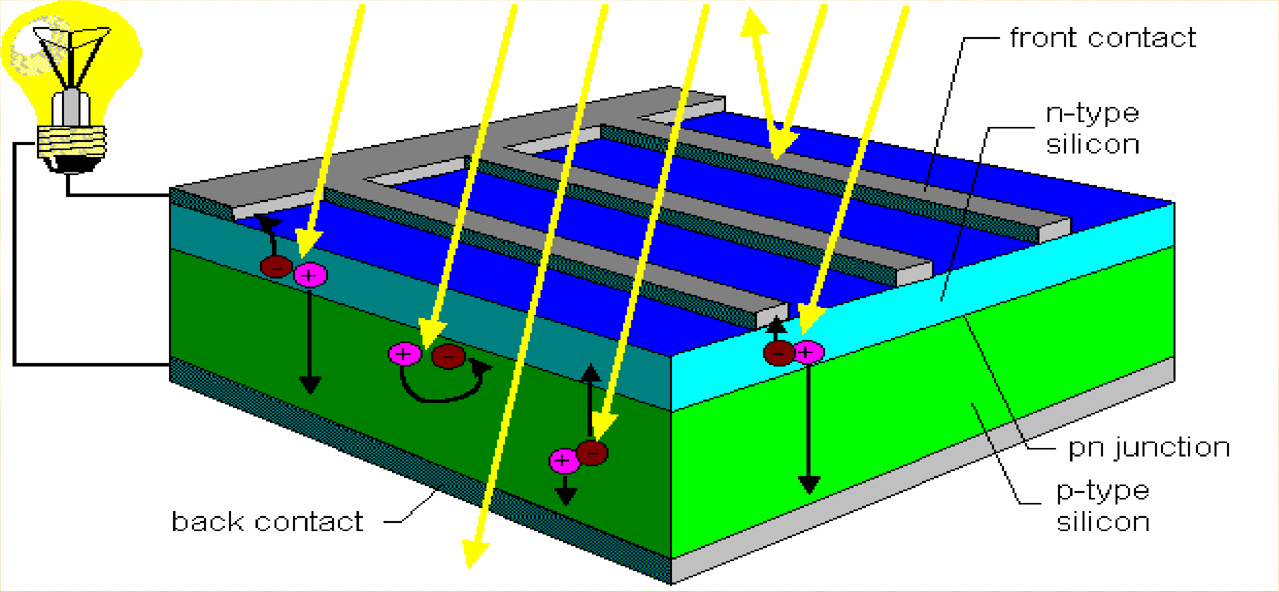


Fig. 2.70 Solar passive cooling through dehumidification

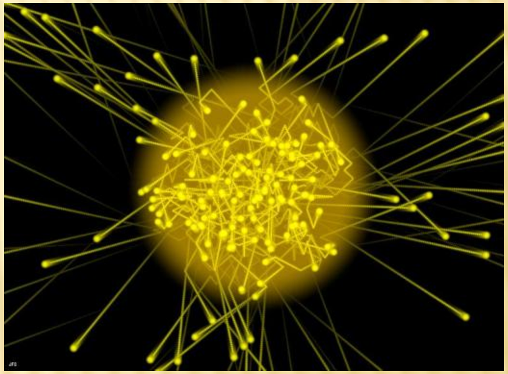
HOW CAN THIS ENERGY BE CAPTURED ?

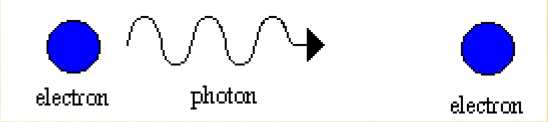
- Radiated energy from sun has to be captured
- Then converted into electricity by the *Photovoltaic effect*
- Use special panels called Photovoltaic (PV) Cells
- These cells make up Solar Panels



PHOTONS AND SEMICONDUCTORS

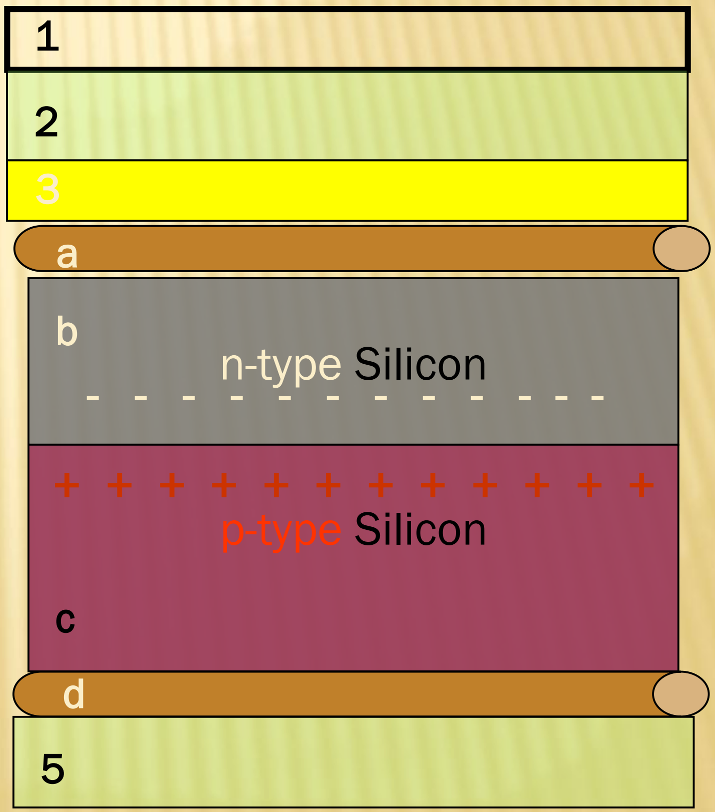
- Energy from the sun hits the surface of the cell, in the form of Photons
- Photons :Energy in the form of light and electromagnetic radiation , no charge and no mass.
- PV cell is a semiconductor made from a crystalline silicon (Si) material.
- Semiconductor materials (Si and Ge) have a conductivity in-between conductors and insulators





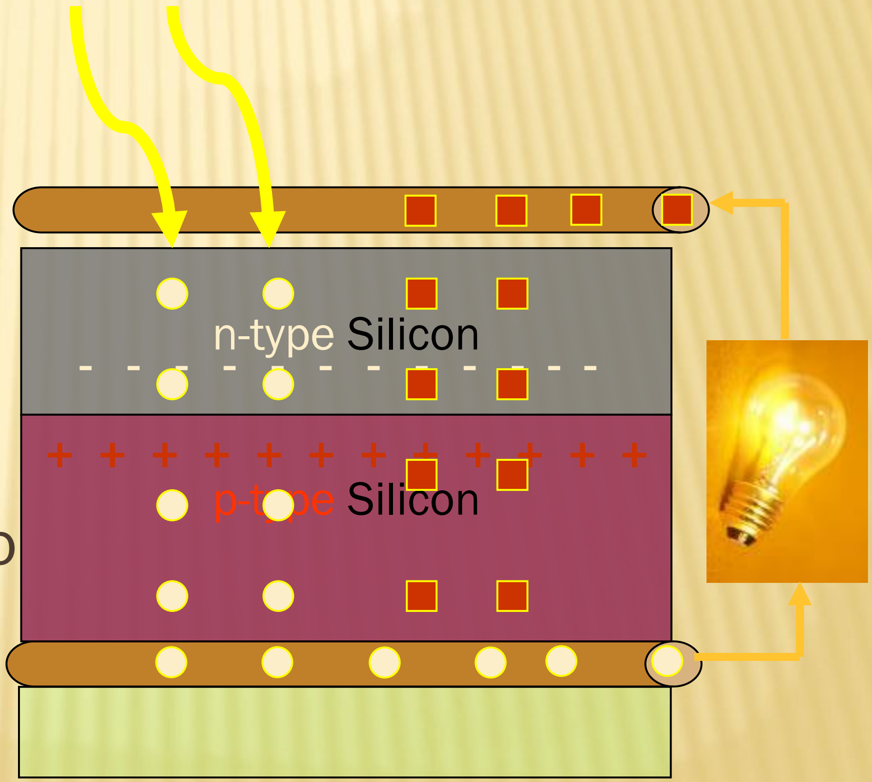
PV CELL CONSTRUCTION

1) Low Iron Glass
2) Polymer layer (EVA)
3) Anti-reflective coating
4) PV Cell consisting of
   a) Contact for electricity
   b) Emitter (n-type Si)
   c) Base (p-type Si)
   d) Contact
5) Back polymer layer



CONVERTING LIGHT INTO ELECTRICITY

- Photons reach emitter layer
- Energy releases electrons from silicon
- Electrons (-) are attracted to base region (+)
- Holes (+) in the base are then attracted to emitter region
- This is a flow of electricity
- Electricity will flow through the two contacts
- Same principle as a diode



PHOTOVOLTAIC CELL, MODULE, PANEL AND ARRAY

- Pv cell have very small voltage about 0.5V. The most common connection of 32 or 36 silicon cell to produce and capable of charging a 12V storage battery.
- When series or parallel to increase the voltage or current rating called solar PV panel.
- When large number of panels are interconnected and installed in an array field, are called solar PV array.

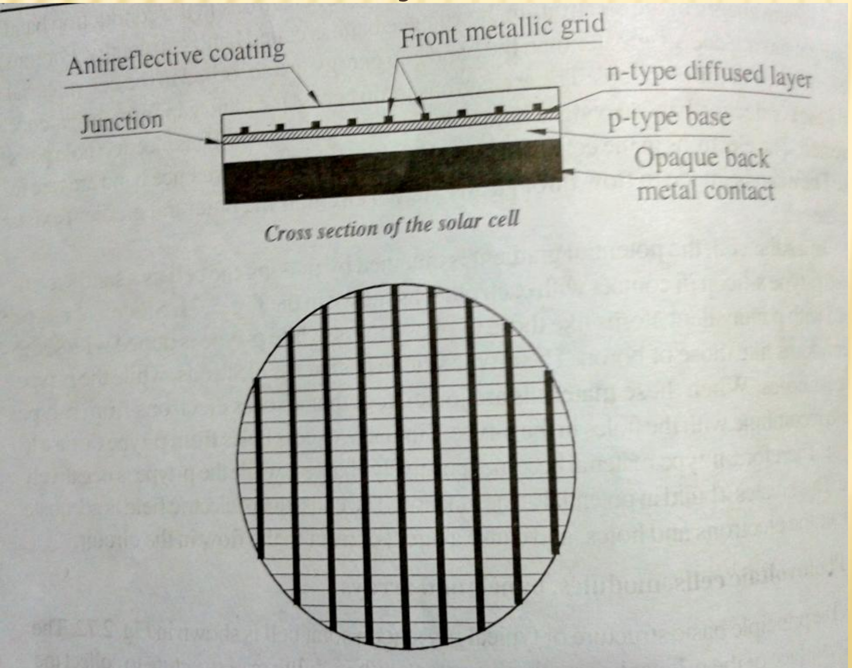


Fig. 2.72 Structure of solar cell

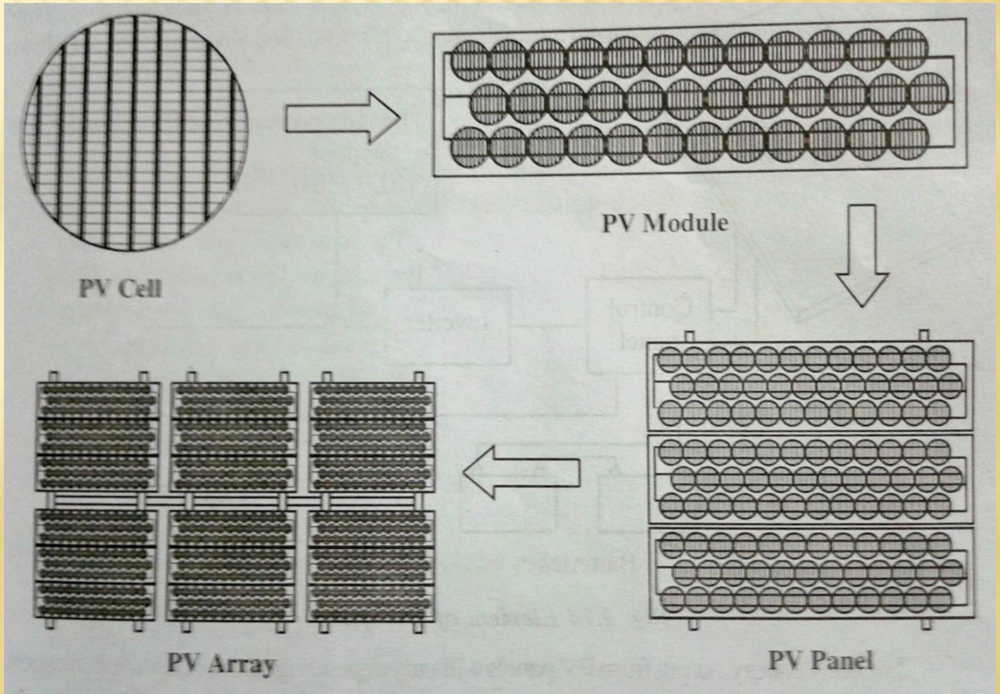


Fig. 2.73 Photovoltaic cell, module, panel and array

PANEL CATEGORIES

- Low voltage/low power panels connecting 3 to 12 small segments of amorphous silicon PV voltage between 1.5 and 6V and outputs of a few mill-watts. Used for **watches, clocks and calculators, cameras and devices for sensing light and dark, such as night light.**
- Small panels of 1-10 watts and 3-12V, with area from 100cm2 to 1000cm2. uses for **radios, toys, small pumps, electric fences and trickle charging of batteries**.
- Large panels, ranging from 10 to 60 watts and generally either 6 or 12 volts, area of 1000cm2 to 5000cm2 are usually made by connecting from 10 to 36 full sized cells in series. Used for **small pumps and caravan power or in arrays to provide power for houses, communications pumping and remote area power supplies.**

PHOTOVOLTAIC SYSTEM FOR POWER GENERATION

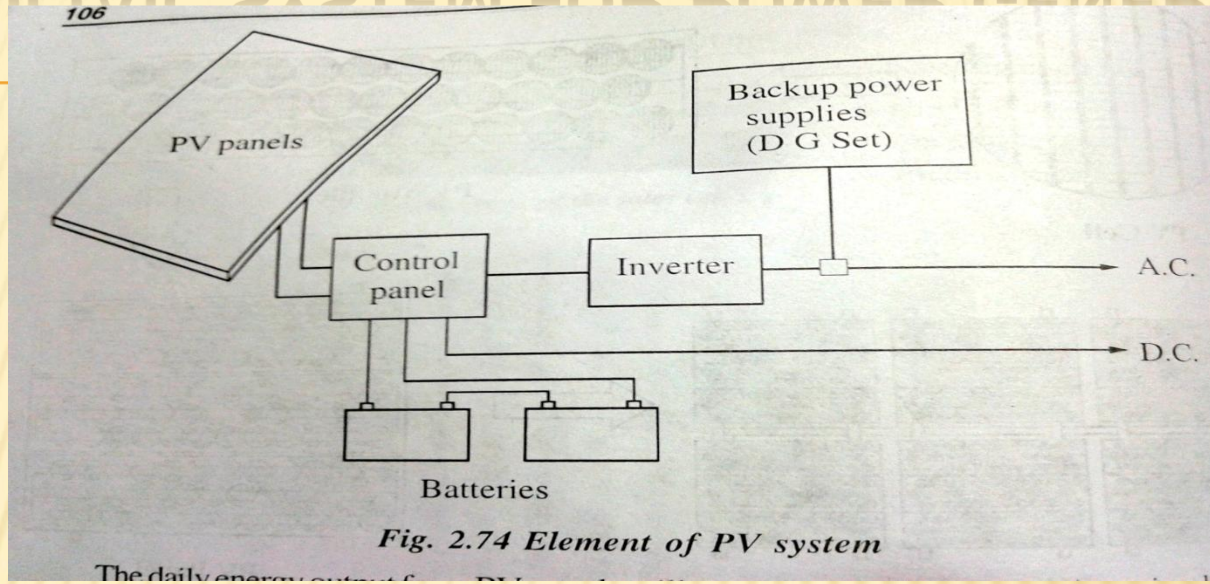


Fig. 2.74 Element of PV system

a) A PV panel array ranging from to two to many hundreds of panels
b) Control panel: regulate power from the panels.
c) Power storage system: contains number of designed batteries.
d) Inverter: converting the DC to AC power(eg 240 V AC)
e) A backup power supplies such as diesel start up generators.

PV TECHNOLOGY CLASSIFICATION

Silicon Crystalline Technology

- Mono Crystalline PV Cells
- Multi Crystalline PV Cells

Thin Film Technology

- Amorphous Silicon PV Cells
- Poly Crystalline PV Cells
  (Non-Silicon based)

SILICON CRYSTALLINE TECHNOLOGY

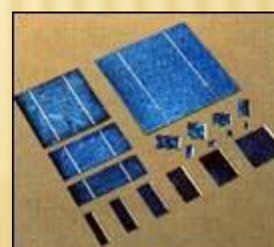
- Currently makes up 86% of PV market
- Very stable with module efficiencies 10-16%

Mono crystalline PV Cells

- Made using saw-cut from single cylindrical crystal of Si
- Operating efficiency up to 15%

Multi Crystalline PV Cells

- Caste from ingot of melted and recrystallised silicon
- Cell efficiency ~12%
- Accounts for 90% of crystalline Si market



THIN FILM TECHNOLOGY

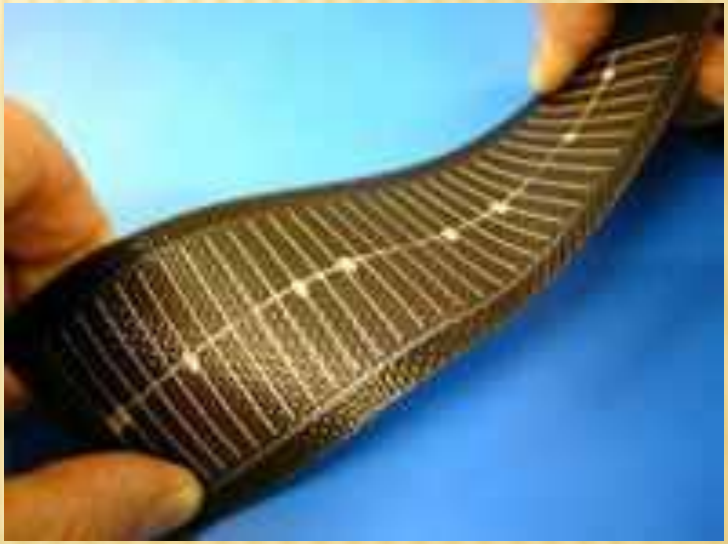
- Silicon deposited in a continuous on a base material such as glass, metal or polymers
- Thin-film crystalline solar cell consists of layers about 10µm thick compared with 200-300µm layers for crystalline silicon cells

PROS

• Low cost substrate and fabrication process

CONS

• Not very stable



AMORPHOUS SILICON PV CELLS

- The most advanced of thin film technologies
- Operating efficiency ~6%
- Makes up about 13% of PV market

PROS
• Mature manufacturing technologies available

CONS
• Initial 20-40% loss in efficiency

POLY CRYSTALLINE PV CELLS

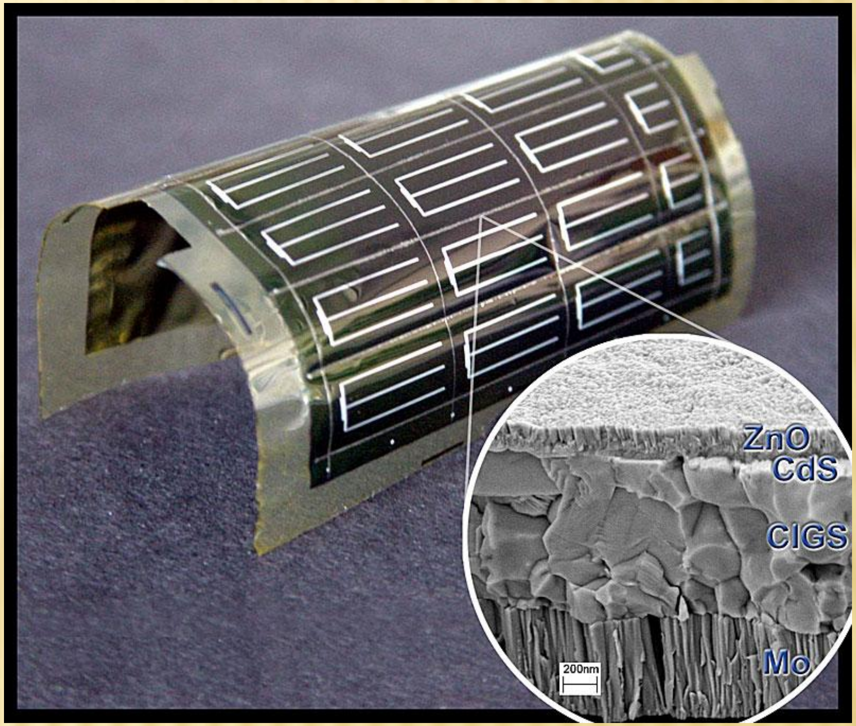
Non – Silicon Based Technology

Copper Indium Diselinide

- CIS with band gap 1eV, high absorption coefficient $10^5 cm^{-1}$
- High efficiency levels

PROS
- 18% laboratory efficiency
- >11% module efficiency

CONS
- Immature manufacturing process
- Slow vacuum process



POLY CRYSTALLINE PV CELLS

Non – Silicon Based Technology

Cadmium Telluride (CdTe)

- Unlike most other II/IV material CdTe exhibits direct band gap of 1.4eV and high absorption coefficient

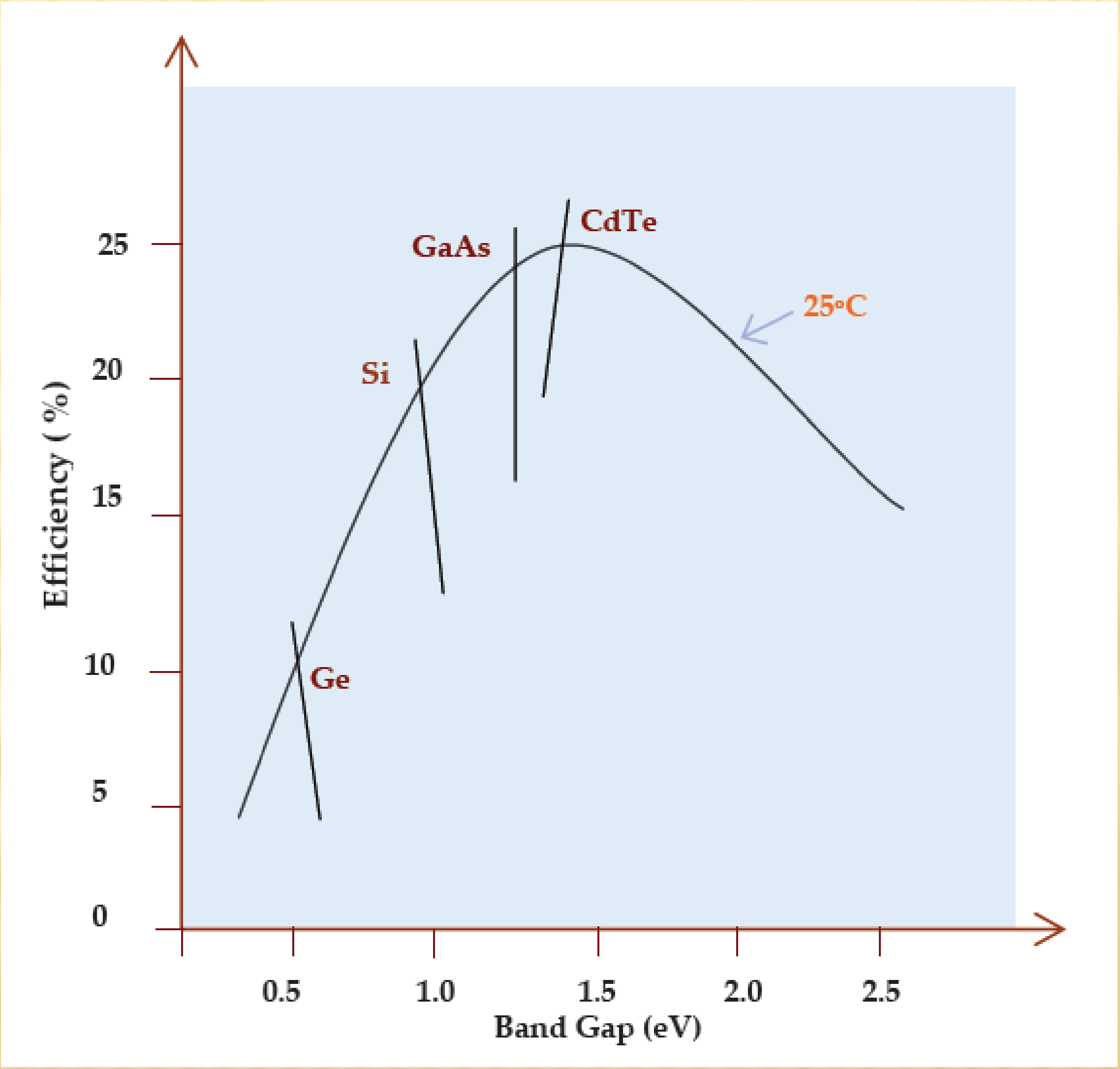
PROS

- 16% laboratory efficiency
- 6-9% module efficiency

CONS

- Immature manufacturing process

SEMICONDUCTOR MATERIAL EFFICIENCIES



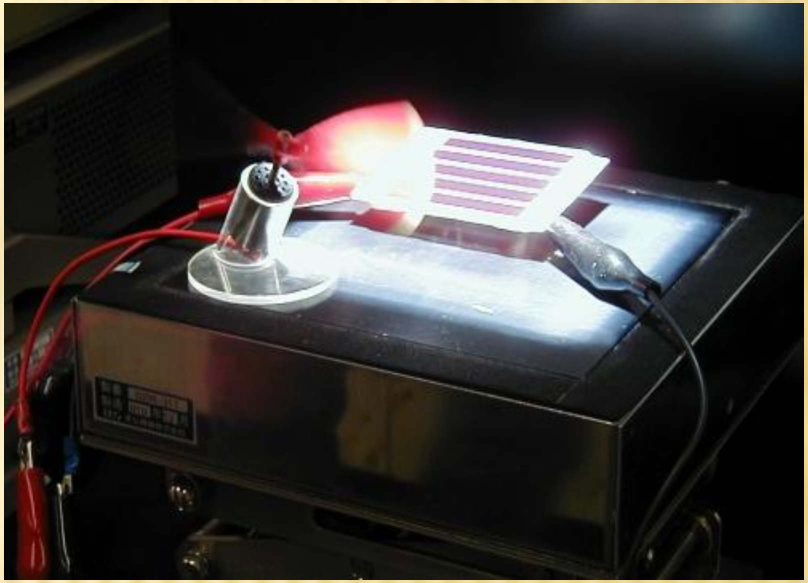
EMERGING TECHNOLOGIES

' Discovering new realms of Photovoltaic Technologies '

- Electrochemical solar cells have their active component in liquid phase

- Dye sensitizers are used to absorb lig`ht and create electron-hole pairs in nanocrystalline titanium dioxide semiconductor layer

- Cell efficiency ~ 7%

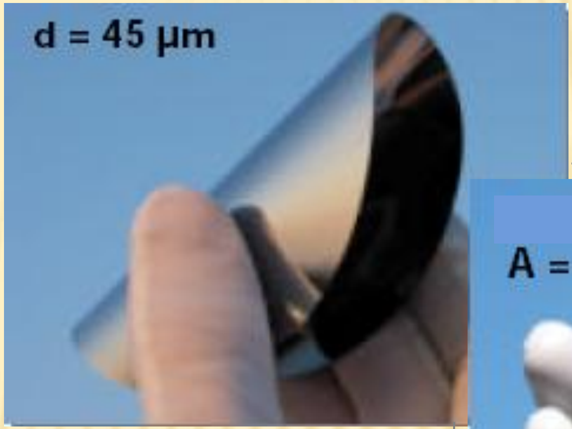


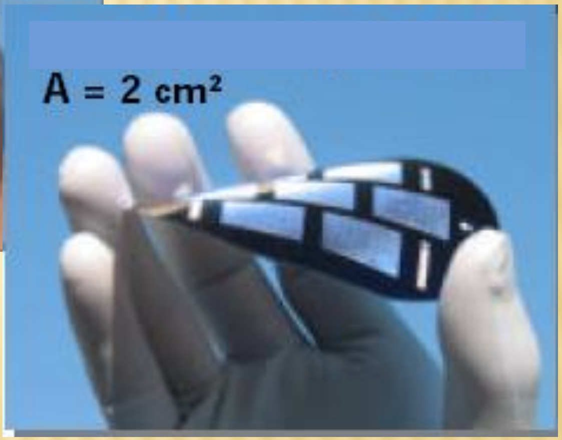
Electrochemical solar cells

EMERGING TECHNOLOGIES

Ultra Thin Wafer Solar Cells

- Thickness ~ 45μm
- Cell Efficiency as high as 20.3%





Anti- Reflection Coating

- Low cost deposition techniques use a metalorganic titanium or tantanum mixed with suitable organic additives

PV'NOMICS

- PV unit : Price per peak watt (Wp)

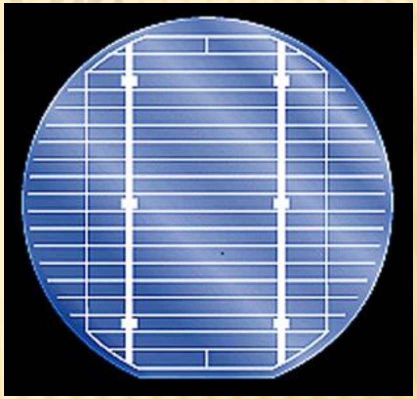
  (Peak watt is the amount of power output a PV module produces at Standard Test Conditions (STC) of a module operating temperature of 25°C in full noontime sunshine (irradiance) of 1,000 Watts per square meter)

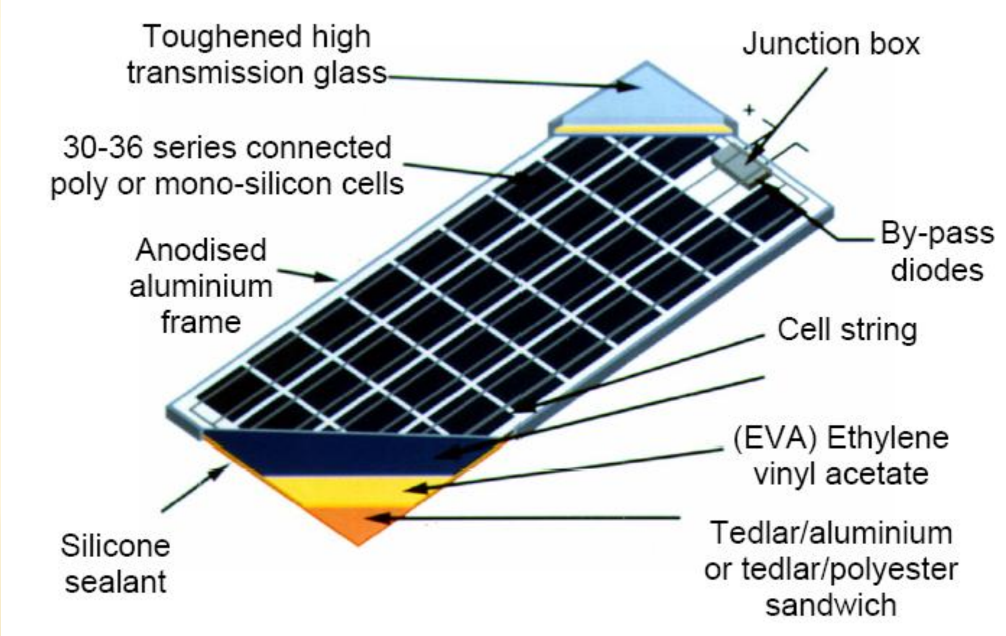
- A typical 1kWp System produces approximately 1600-2000 kWh energy in India and Australia

- A typical 2000 watt peak (2KWp) solar energy system costing $8000 (including installation) will correspond to a price of $4/Wp

SOLAR PANEL CONSTRUCTION

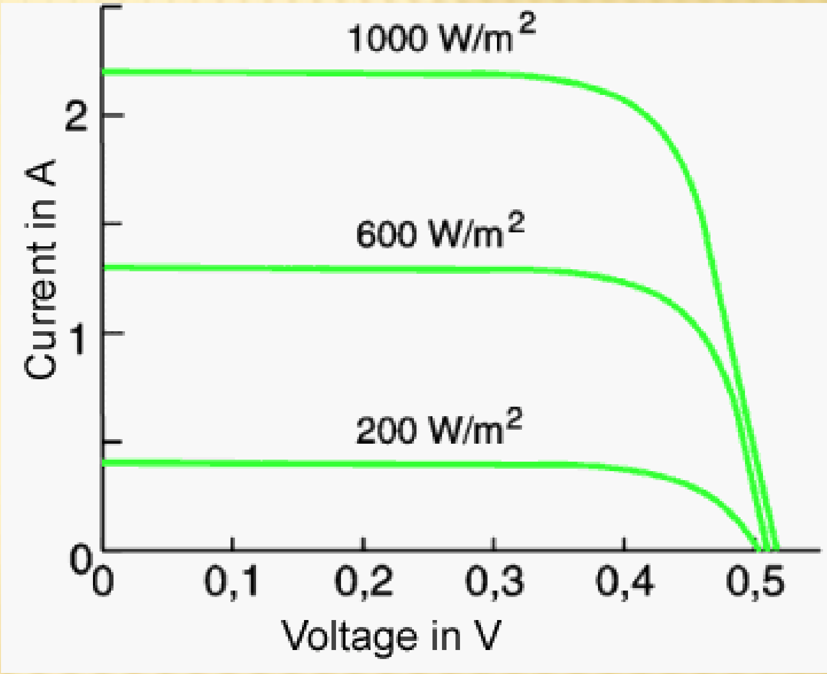
- One PV Cell is approx 150mm in diameter
- In bright sunshine it produces 0.4V d.c.
- One Module is an array of approx 30 cells
- Connected together in series/parallel for desired voltage
- Life span is about 25 yrs
- Cost varies
- €300 - €600 per m^2





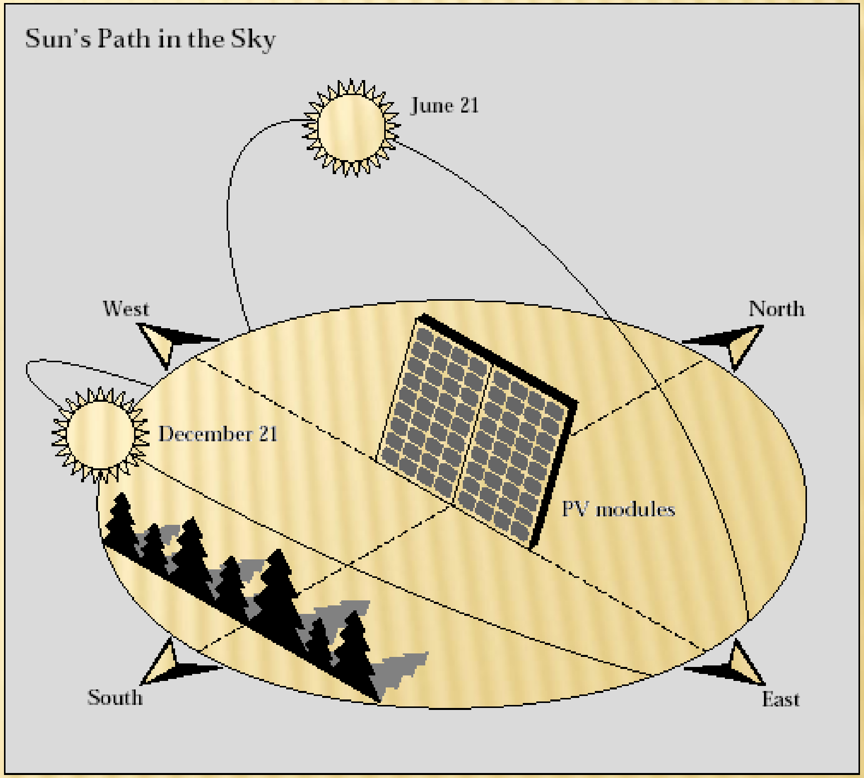
SOLAR PANEL RATINGS

- Max voltage in single PV Cell is approx 0.4V (D.C.)
- Current depends on sun intensity
- Max of 2.5A
- Average voltage from a module is 20V (D.C.)



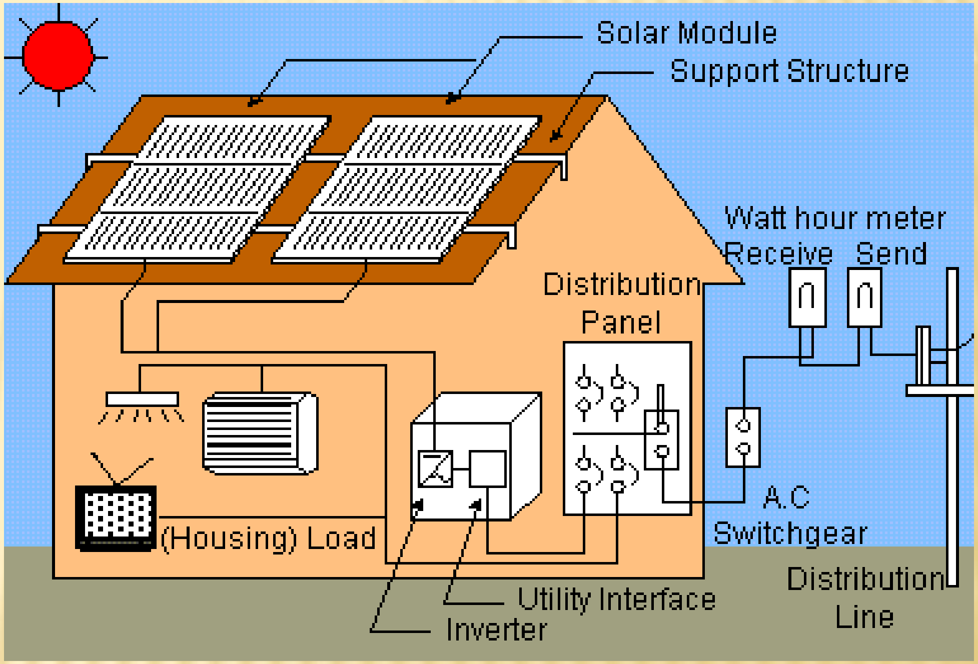
PERFORMANCE OF SOLAR PANELS

- Various factors effect power o/p from panels
- Shade or Clouds
- Panel position or angle
- Active panels can track the sun
- Temperature and solar irradiance variations
- Air gap required for cooling
- Partial shading will reduce performance and can cause damage



DOMESTIC SOLAR PANELS

- Panels connected to inverter
- This changes DC to AC
- Fed into Distribution Board
- Can supply domestic needs (e.g. hot water)
- Or feed into main grid



TYPES OF SOLAR PANELS

1) **Monocrystalline**

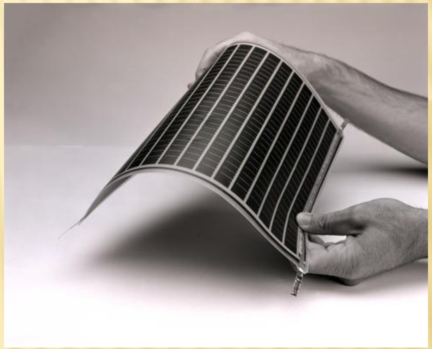
- Uniform Blue Colour
- Oldest and most efficient PV cell
- Production process is slow and expensive
- 20 Year guarantee (usually for 80% rated Watts)
- BP Solar, Siemens

2/ POLYCRYSTALLINE

- Module efficiency ~ 9 - 13%
- Irregular blue colour
- Less expensive to produce due to simpler manufacturing process
- Advantage over monocrystalline is that it is less likely to be damaged when it is partly shaded
- 20 Year guarantee (usually for 80% rated Watts)
- Solarex, Kyocera

3/ AMORPHOUS SILICON

- Low Module efficiencies
- Only 3 - 10%
- Production process considerably less expensive than crystalline cells
- Light and ***flexible***, so can meet a range of applications
- 10 year guarantee
- Unisolar, Intersolar



APPLICATION OF SOLAR CELLS

- Catholic protection system
- Electric fences
- Remote lighting systems
- Telecommunications and remote monitoring system
- Solar powered water pumping
- Rural electrification
- Water treatment system
- Miscellaneous application.....
- https://jimmeijer.com/solar-cell-working-principle-explain-construction-and-working-of-solar-cell/