UNIT - 1

Introduction

Electric Energy system → thermal, mechanical, electrical

↓

Perform to work

oil, gas, coal, nuclear, fossil fuel (2%) (renewable energy)

SO_2

energy → Greek word

↓

en-ergon → in-work or work content

India – 60 KWH GDP → 9.51 USD

~~USA – 90~~

China – 157.5 KWH is highest consumer of energy.

UN utilizing 99 KWH power energy and converting only 4 KWH electrical energy.

World's highest hydro plant → china

Sectors Using Energy -

1) Commercial sector
2) Industrial
3) Residential → Electrical energy, Thermal energy
4) Transport

Steam power plant efficiency of 48 %. (100 → 48% electrical)

52 % energy is being lost

steam circulate through house to heat them. (Company charge for this)

↳ and we can't discharge it in atmosphere. Temperature is 75cd.

Classification of Energy :-

- By source -
  - → Renewable (solar, wind, hydroelectric)
  - → Non-Renewable (coal, Natural gas, oil)

- By Use -
  - To generate electricity
  - heat home & business
  - Power transportation

- By environmental impact -

renewable → less/min impact on environment.
non-renewable → high

- By Cost -

Renewable - Provide costly wrt N.R.
Non-Renewable - Less costly in comparison to Renewable

Classification

Based on Origin :

1. Fossil Fuels → Coal, gas, oil
2. Nuclear Energy → radioactive material
3. Hydro Energy
4. Solar Energy
5. Wind Energy
6. Biomass
7. Geothermal Energy
8. Tidal Energy
9. Ocean Thermal Energy
10. Ocean wave Energy

Importance of Non-Conventional Energy Resources -

1. Sustainability - freely available & long-lasting
   ↳ is high
2. Environmental Impact - Conventional Resources produced harmful gases like CO_2, CO etc. & global warming, greenhouse effect increase.
   Impact of Global Warming → Sea level ↑ so ~~2~~ shore cities can be submerged.
3. Economic Viability - (Maintenance ↑, Production cost ↑, cost ↑)
   Solar Cells must have efficiency of 18 - 20%. (Needs to be ↑ed)
   Land available is less.

① → Whenever empty space available, deploy non-convention resources.

NOTE - By 2050, population of India will drop to 1 billion

Sun rays should directly come in contact with panels.

② - Dusty area need to have a cleaning tech.

③ Production cost is high. (more than conventional CO_2 tech. is more).

Awareness is spread more using subsidies etc. by government.

Most important Non-Conventional Energy Sources.

1. ~~Wind~~ Solar
2. Wind
3. Hydro-electric
4. Giothermal
5. Biomass

Benefits of using N.C. Energy Sources —

1. Sustainable & Renewable
2. They have low environmental impact
3. They are becoming more economically viable. (overall) → in future

Challenges for of N.C Energy Sources —

1. ~~Judicial~~ Initial Installation Process - Initial inst. cost is very high.
2. The efficiency of N.C. Energy sources can be low.
3. The infrastructure or using N.C. energy sources may not be in place.

Make in India
Made in India

Advantages of Conventional Energy Sources -

(1) Cost -

(a) Cheaper than cost of electricity produced by non-conventional resources

(2) Security - The storage is easy & beoz of that we get security of electricity

(3) Convenience - These sources are very convinient to use as technology for the conversion & use of is universally available.

Disadvantages of Conventional E.S. -

(1) These produce pollutants.

CO, CO_2, OX (NO_2, N_2O_2), SOX (H_2SO_4, SO_2) → makes body weak

Water & Ground water contamination etc.

Water Treatment Plant.

Utilise natural colours etc.

Utilization of H_2SO_4.

Disposing of used & recatilization

These pollutants degrade the environment, cause health hazards & cause various other problems.

Coal will be exhausted.

Coal is also a valuable ~~renewable~~ petro-chemical & is used as raw material for ~~crotonal Acid~~. Various chemicals, pharmaceuticals & paints.

→ Storage of radio-active materials
→ Plants should be tightly sealed.

From long-term POV, it is ~~designed~~ desirable to conserve coal for future needs.

Major problems

- There are safety technical issues with Nuclear Energy. Major problems associated with Nuclear energy

are as follows -

→ Unavailability of Radioactive ~~mate~~
→ storage
→ Plant should be shielded
→ Waste disposal is challenging
→ Controlling chain reaction.

Grid
1) Hybrid Energy system
2) Distributed Energy system
} we are now considering these for modulation of electricity not energy.

Nuclear in Maharastra
Thermal in UP
Hydro in UK etc.

3) Dispersed generation → Off-grid
↳ not connected to Grid (placed where grid is not available)

Balancing of load is necessary for balancing of supply & demand.

Hybrid → two or more sources are utilized
It is a restriction, costly

Distributed - We are installing particular plants at locations suitable for them. (One set in one state & other set in other

Benefits -
1) Grid connect
2) Cost efficient.

Dispersed - ~~Production~~ Electricity is not ~~possible~~ available, but consumption of energy is required.
Eg.- Ladakh.
Develop canopy that absorbs temp in daytime & remain heated at night.

DGCL

If a state is not producing enough energy, other states have to supply energy.

Benefits of using these -

⇒ All of them will be able to work
eg. - DG sets (used for backup source)
If extra electricity is produced, it can be transferred to other localities.
When electricity will go out, remove main source, you'll still be connected to whole n/w.

Dispersed - Can still use DG set.

Benefits -

1) Reduced reliance on centralized power generation. (Grid) ↳ in Delhi in Maharashtra (as backups)

Solar, wind etc all are independent sources. Not completely dependent on Grid.
When grid is not there, they will be feeding the n/w locally.

2) Improved energy security. - Security comes from uninterrupted energy.
Ensured availability on energy in most cases.
With coal, energy may be deficit.

Giga fit - Tesla
Instead of batteries, ultra small capacitors can be used.
↳ disposal is hard
↳ less charging time
⇒ High amts of current
Need a cooling system

Right now the ultra capacitor along with cooling system ~~is~~ will be bigger in size than battery. Small cooling devices are trying to be made.

3) Increased efficiency –
If we can place the plant inside the city, the transmission cost & loss will be reduced & efficiency ↑ sd.
But this is not possible (hydro ✗, coal plants emit carbon, ~~avg~~ lot of land is required).
↓ destroys crops/area productivity → avg. temp. will ↑ sd
Govt. has asked plants to have very high chimney so that carbon can be filtered.
Renewable resources can be planted at house (solar de)
↓ costly
(battery replenished every 3 years)

4) Lower emission –
Emissions of harmful gases would be reduced if we shift to renewable sources.
(Target – 0 carbon emission)
Adaptibility is not so easy

5) Lower cost – since efficiency ↑, fuel cost, only infrastructure cost ↑, therefore less cost.

Challenges –

1) They can be more expensive to install than centralized power plants.
Infrastructure very costly. Demand ~~is~~ has to be ↑ sd

2) They can be more difficult to regulate & control.
Eg. - 1MW solar plant, inverters needed for DC to AC conversion.

We'll ~~connect~~ disconnected from grid, mains ~~to~~ if voltage ↑ or ↓ by 10% — to protect our plant from damage.
~~Bc~~ Not reliable.
But now, the rule is even if voltage drops by 90%, you'll have to be connected for 4 - 5 seconds atleast.
Current will shoot up. We'll have to design control mechanism/circuit s.t. from our side, that will restrict the ~~con~~ current supply.

Harvest max. power available
— But when voltage drops, current will ↑ so too much.

~~discon~~

UNIT - 2

Solar, Thermal System

Active solar system & passive solar system.

Numerical -

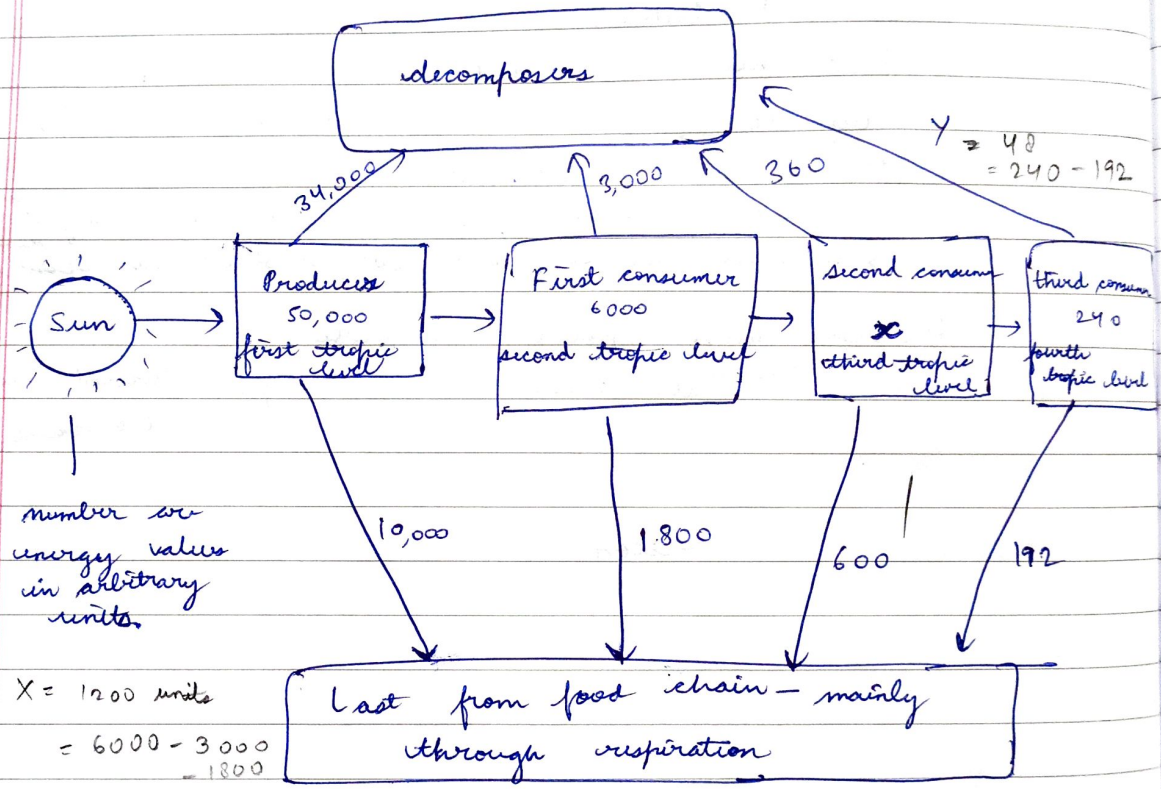


Figure above shows the flow of energy to a complete food chain.

1) Which form of the sun's energy is trapped by the producer? (Solar Light Energy)

2) Into which energy form is the sun's energy converted when it is trapped by the producer?
Chemical energy

3) The first consumer has received 6000 units of energy. How many units of energy (x on the figure) have been passed to the second consumer.

1200 (60,000 − 44000)
⇒ 6000 − 4800
= 6000 − 4800
= 1200

4) How many units of energy (y on the figure) are lost from the third consumer to the decomposer?

y = 240 − 192 = 48

5) Suggest ~~propag~~ proportion of the energy ~~in~~ intake which a producer uses to the environment (20%.) is smaller than that lost to environment by a first consumer (30%).

6) Many countries have difficulty in producing enough food for their population. How might then, a help to overcome this problem, if humans were always ~~treated~~ fed as first consumers rather than second or third consumer?

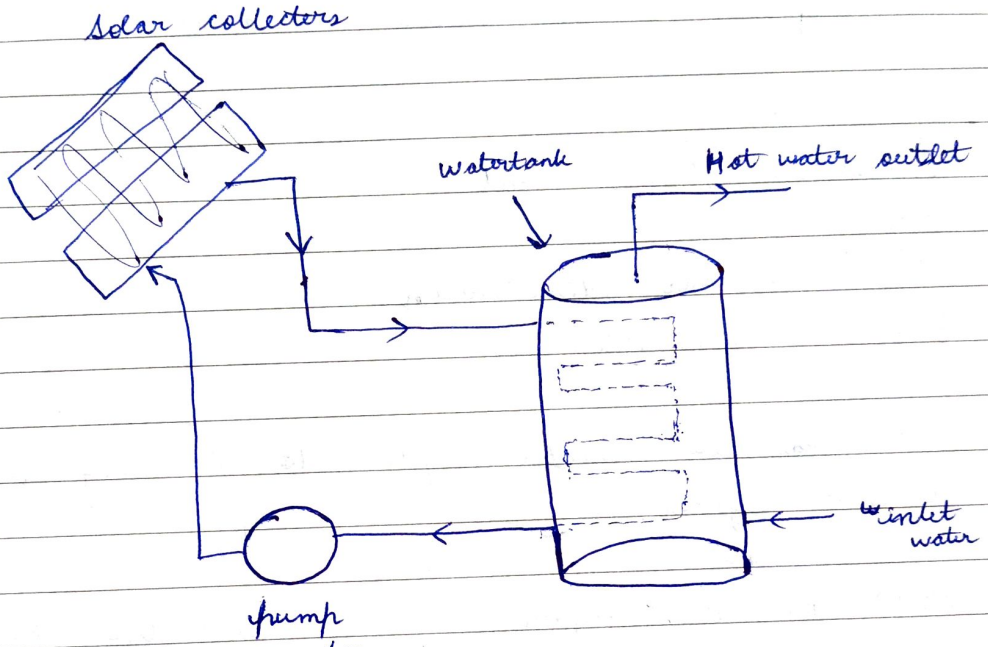
5) The consumer may be warm blooded so some energy is lost as heat. Consumer usually move around to find food, mate, or escape from predators which uses up energy, but producers do not move

6) Feeding as a first consumer involves eating plants, so less energy is lost to the environment when feeding at this level. so, food production is more efficient in terms of energy (conviction. (More plantation required.)

Solar Thermal System -

Active Solar Thermal System -

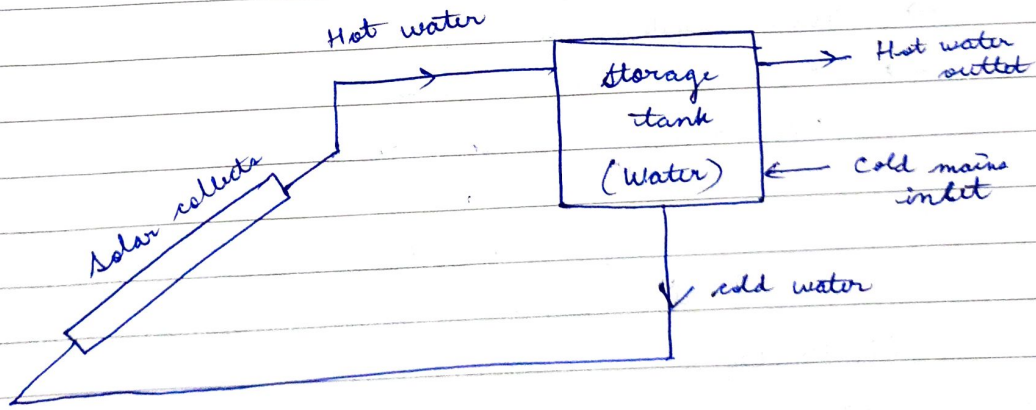
→ Circulating pumps, fans - utilised.



Tank can be anywhere.

Passive Solar Thermal System -

→ Not utilised in fans, circulating pumps.



Tank should be on the top of your system.

Areas where you will be utilising Solar Thermal System -

1) Heating water for domestic or commercial use.
(74% energy used for heating water (not to the BP))
Eg- Majority of the hotels use solar water heater.

2) Space Heating
3) Industrial Process Heat
4) Drying
5) Distillation and desalination.
6) Electricity generation

Water can be heated upto 180°C using solar thermal system.

MHD (Magneto Hydro___) - conductive fluid, generate electricity & through this ionised gas.

Advantages -

→ These systems are clean
→ Not using fossil fuels
→ Not disposing carbon emissions in atmosphere.

0.7% people have EV
Govt. proposes after 10 years, 10% people having EV.

Disadvantages -
Once water is not used & hence not circulated in the plant, algae & other dirt can come.

Benefits of using Solar Thermal System -

1) Clean & renewable energy -

Solar thermal systems use the sun's energy which is green & renewable source of energy. This can help to reduce reliance on fossil fuel & can help improve air quality.

CNG also produce smoke but it is invisible.
↳ cost-effective ↳ particles are not visible but its highly dangerous to human beings.

2) Energy efficiency -

Solar thermal systems can be very energy-efficient, meaning that they can save you money on electricity bills.

3) Comfort -

Solar thermal systems can help to keep your home or business warm in winters & cool in summer.

4) Investment -

Solar thermal systems can be a good investment as they can save you money on energy bills over time.

(Half an hour geyser works, gives 1 unit bill)
Once installed, plant will run for 20-25 years.

5) Government Incentives -

There are often govt. incentives available to help offset the cost of installing can solar thermal system

SOLA, govt. come up with subsidy on thermal plants,

first-time cost reduced to Rs. - 12K to 20 k & it can be used upto 10 years.

~~Comp.~~ Never connect computer to such sources (uncirculation) can short-circuit.

Things to keep in mind before installing a solar panel system -

1) Size of your system will depend on mains. Will be useful only if utilisation is more (cost will be saved only then).

2) The cost of your system will depend on the size & type of system you choose.

3) Location of your system is imp. System should be placed in the ~~sun~~ sun.

4) You will need to maintain ~~your~~ the system regularly —
Clean your collectors, water tank

Fluids ~~are anti & frog~~ can also be there in system running separately.

reflects 30% of sun

CLASSMATE
Date
Page

The Sun as Energy source -

core temperature = 15 million degree celsius
surface temp. = 5800 K

nuclear fusion

$$4(_1H^1) \longrightarrow {}_2He^4 + 26.7\ MeV$$

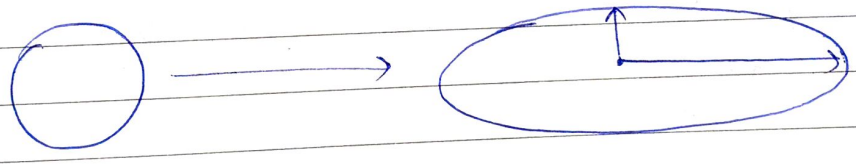
$$1\,MeV = 1.6021 \times 10^{-13}\ J$$

This can only be achieved when high no. of fusion takes place.

The earth -

The sun fuses about 620 million metric tonnes of hydrogen every second, converting it into Helium

shape : oblate sphere



$d_{earth} = 1.275 \times 10^7$ m
↓ average

$d_{sun} = 1.39 \times 10^9$ m

Avg. distance b/w sun & earth is 1.495×10^{11} m
This distance is called 1 astronomical unit.

Earth's axis is inclined by 23.5°.
Earth reflects 30% of sunlight that falls on it due to Earth's albedo.

Earth take 365.25 days for one complete rotation around sun.

Intensity of Solar Energy → W/m^2

↓

measured per unit area

Measurement of Solar Radiation -

We have the following instruments -

1. Pyranometer
2. Pyrheliometer
3. Sunshine recorder

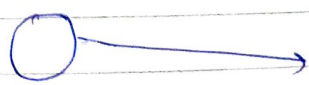
(1) A pyranometer is designed to measure global radiation, usually on a horizontal surface but can also be used on an inclined surface. When shadded from beam radiation by using a shadding ring, it measures the diffused radiation only.

(2) An instrument that measure beam radiation by using a long & narrow tube, collect only beam radiation from the sun at normal incidence.

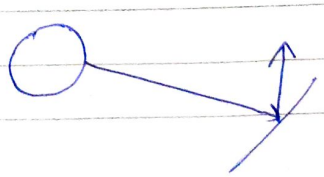
(3) It measures the sunshine hours in a days.

Two types of radiations -

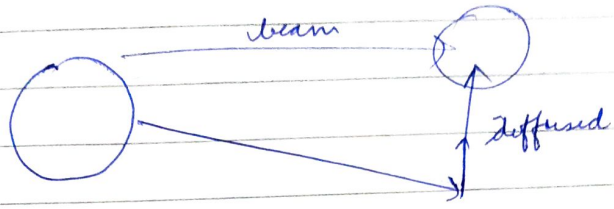
1) Beam radiation



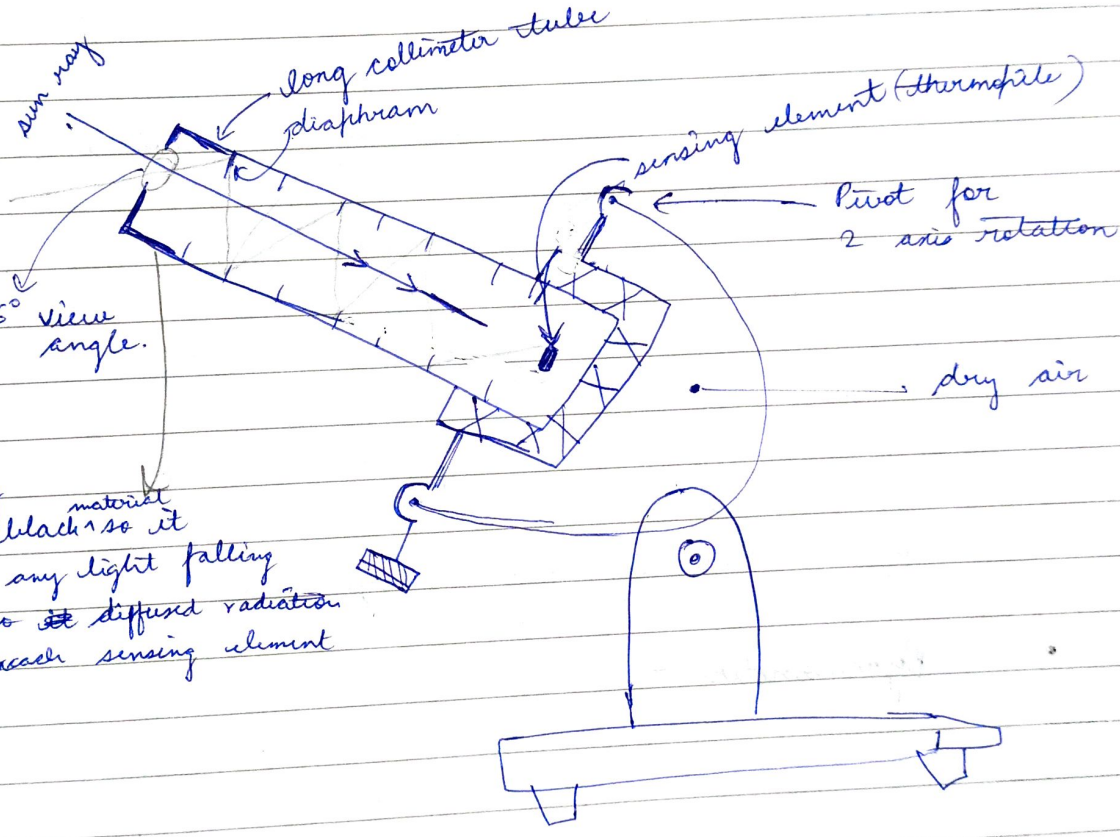
2) Diffused radiation
— Not direct
(less intensity)



Pyranometer will measure both radiations so it will be a bit high (not correct)



- **Pyrheliometer –**



Only hot junc is exposed to direct beam

sensing element is thermopile. It has 2 junctions hot & cold.

Thermo couple (hot & cold junction)

↳ so there will be voltage generation (measured by voltmeter)

do

We will shed diff. type of ~~type~~ lights & calibrate the sensing element, & then see voltage generation for diff. lights.

' Hinge 2 sides so that Instrument can be moved in the dirⁿ of sun.

→ sensitivity of sensing element = 8 mV / W/m²

↓

For 1 W/m² intensity, 8 mV voltage is produ.

⇒

→ Resistance of sensing element = 200 R

Purpose of Dry air — to avoid diffused radiations.

Transformers -

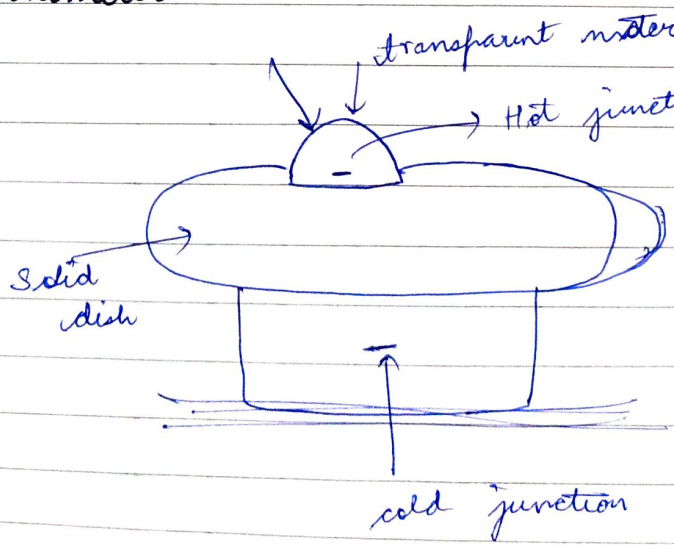
In case of AC you need 4 inductors.

In case of DC ——— 2 ———.

Inverters

When there is a fault, the inductors will avoid current not for long. They are replaced by virtual synchronous generator.

- **Pyranometer -**



sensitivity = 9 MV / W/m²
Resistance / Impedance = 650 Ω

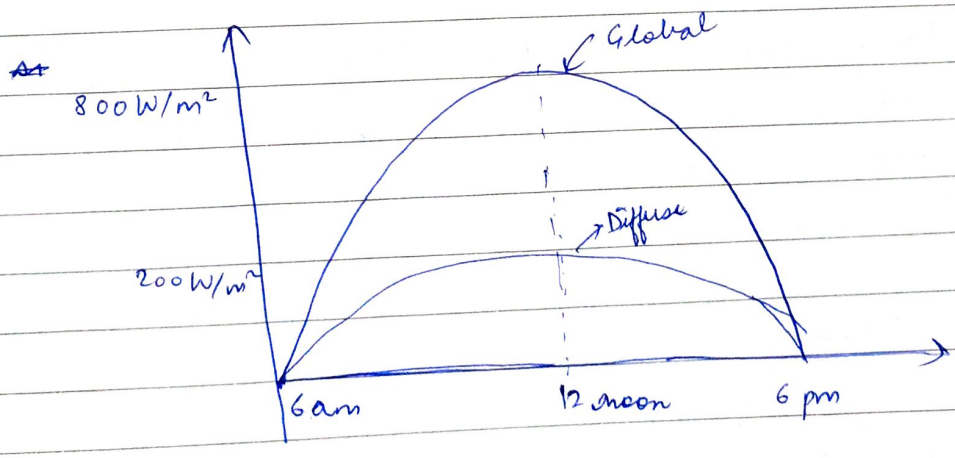
Precision pyranometer is designed to the ~~spot~~ respond to radiations of all wavelengths & hence ~~~~ measures accurately the total power in the incident spectra.
It contains thermopile whose sensitive surface consists of circular, blackened, naked hot junctions exposed to the sun & old junctions are completely shaded.

Sensing element is covered by two concentric, semi-spherical glass domes to shield it from wind and rain.

Solar Radiation :

Direct Radiation } → Global Radiation
Diffuse Radiation

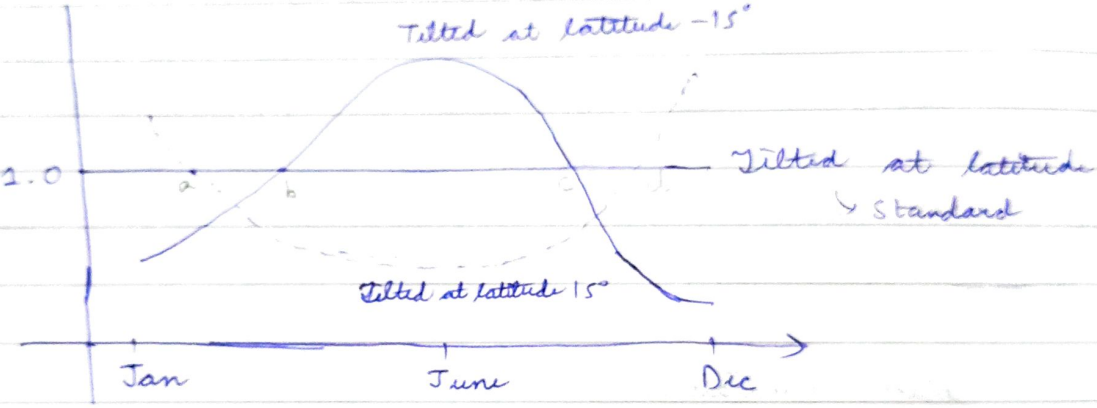
6am – 6pm



e - radiance

Length of collector should be longitude of Earth & it should face towards south
Angle will be different for different locations.

If a place my collector at 0° latitude, -15° latitude, 15° latitude, what will be the energy incident in W/m²?



To absorb max. radiation, we will keep moving the collector.

Place collector at +15° initially, then ~~keep~~ tilt it to latitude from a to b, again change the position to -15° from b to c, then again latitude, then again +15°.
Solar Axis Tracking Device

Tracking system
Size of panel / collector } costly
What efficiency you want? How you are utilising

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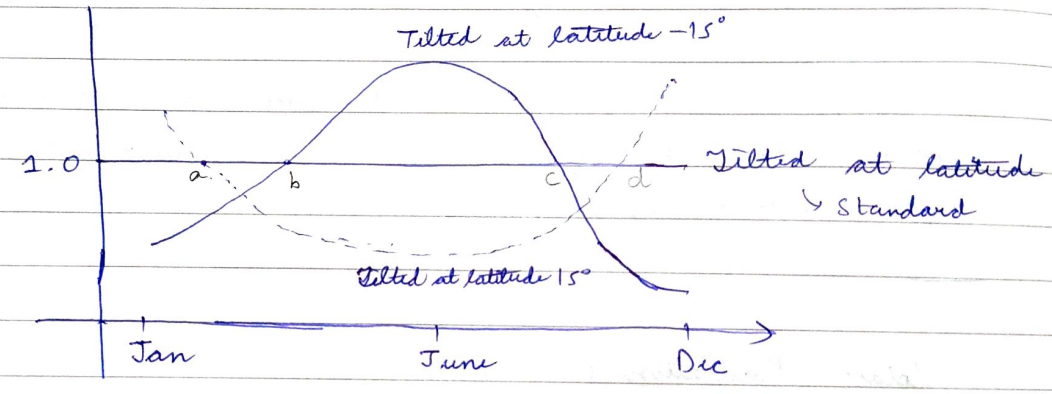

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Solar Axis Tracking Device

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What efficiency you want? How you are utilising

Solar Thermal System -

Used for heating water / house / power production

use some thing / liquid with lower BP
↳ absorbs highest amt. of heat

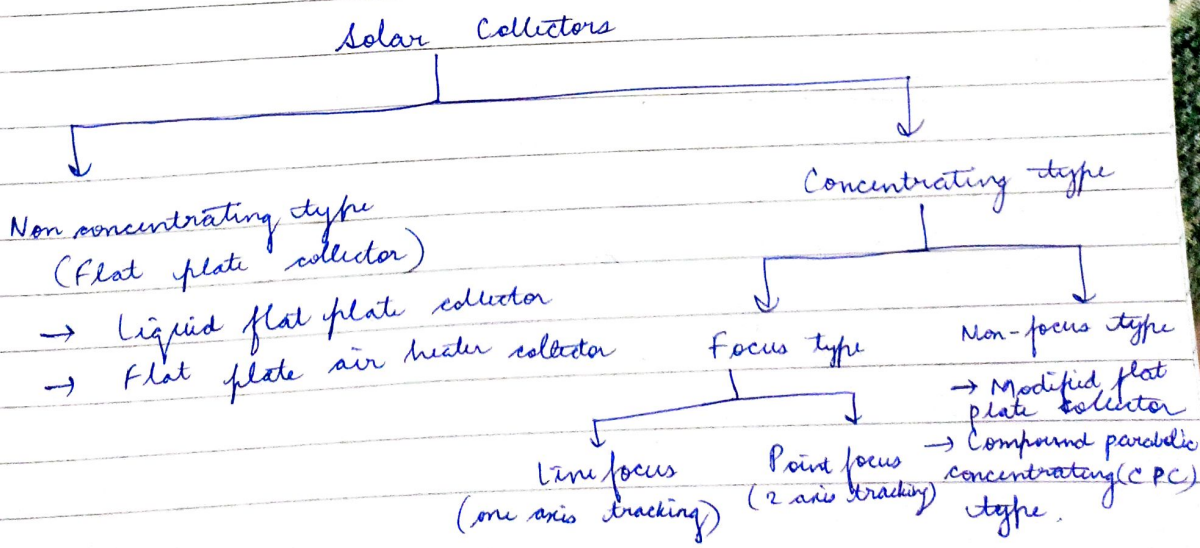
- **Solar Collectors -**

solar cooker - 2 types
① Big reflecting material → req. large space for area by reflecting material (direct radiations) concentrating light on cooker
↳ Concentrated collector — more energy req.

② Black coated cooker with two layers of glass material on top.
↳ for greenhouse effect (to trap heat).
Flat collectors
↳ less energy req.
↳ Both direct & diffused beams (global radiations)

Black coated

Classification of Solar Collector -



Solar tree

Focus type

Line focus (one axis tracking)
→ Cyndrical Parabolic concentrators
→ Find mirror solar concentrator
→ Linear Fresnel Lens Collector

Point focus (2 axis tracking)
→ Paraboloidal dish collector

Performance Analysis -

1) Collector efficiency - It is defined as the ratio of the energy actually absorbed and transfered to heat transporting fluid by the collector to the energy incident on the collector.
(Part of energy may be lost to convection, conduction).
Can never be 100%.

2) Concentration ratio - It is defined as the ratio of the area ~~of~~ aperture of the system to the area of the received.
The aperture of the system is the projected area of the collector facing the heat.

3) Temperature range - It is the range of the temperature to which the heat ~~trap~~ transport fluid is heated up by the collector.
Eg - Black collectors have no concentrating device.
Flat plate — ~~no~~ have no ~~concentrating device~~ optical device to concentration radiation for minimizing cost
conc. ratio < 1
temp < 100°

Line focus collector

Moving your collector in 1 direction.

conc. ratio ≤ 100

temp range = 190° – 300°C

Point focus collector

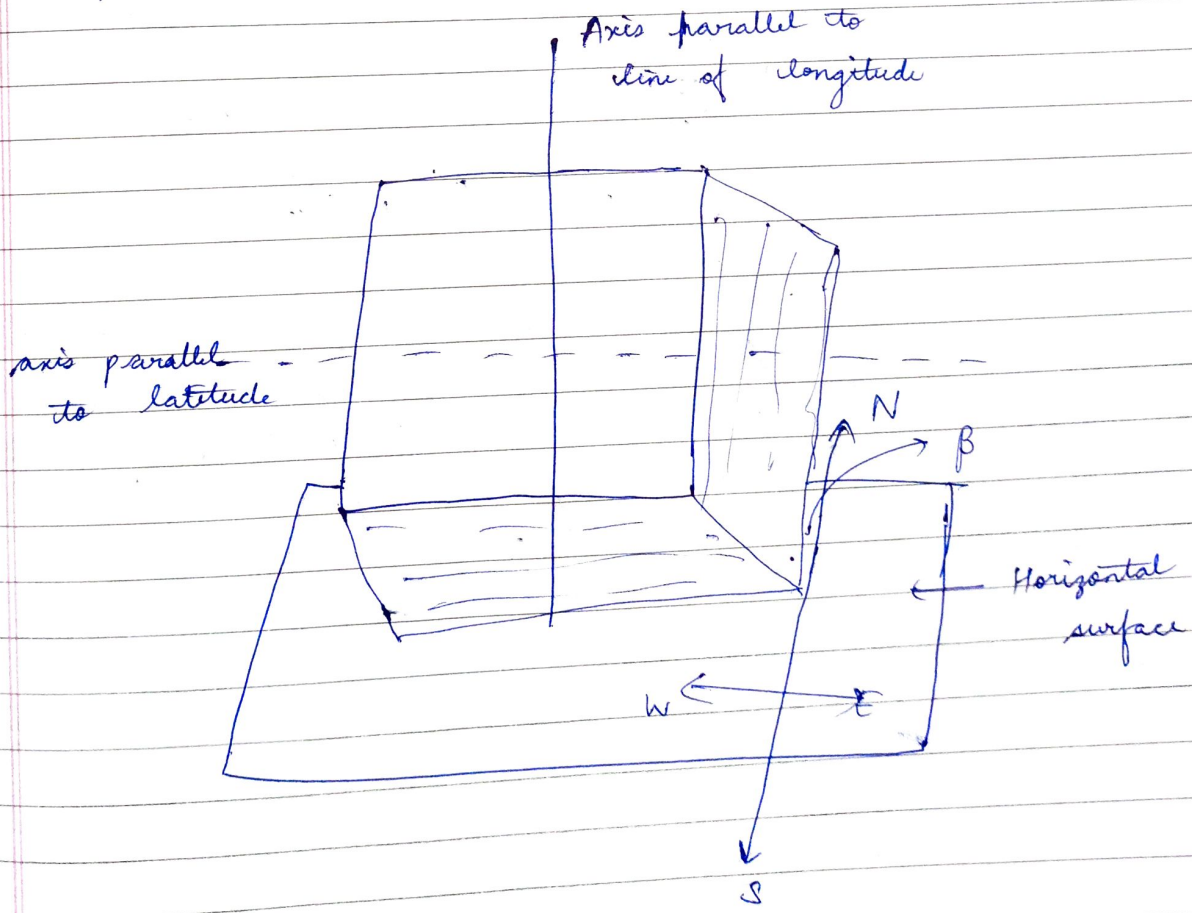
2 axis

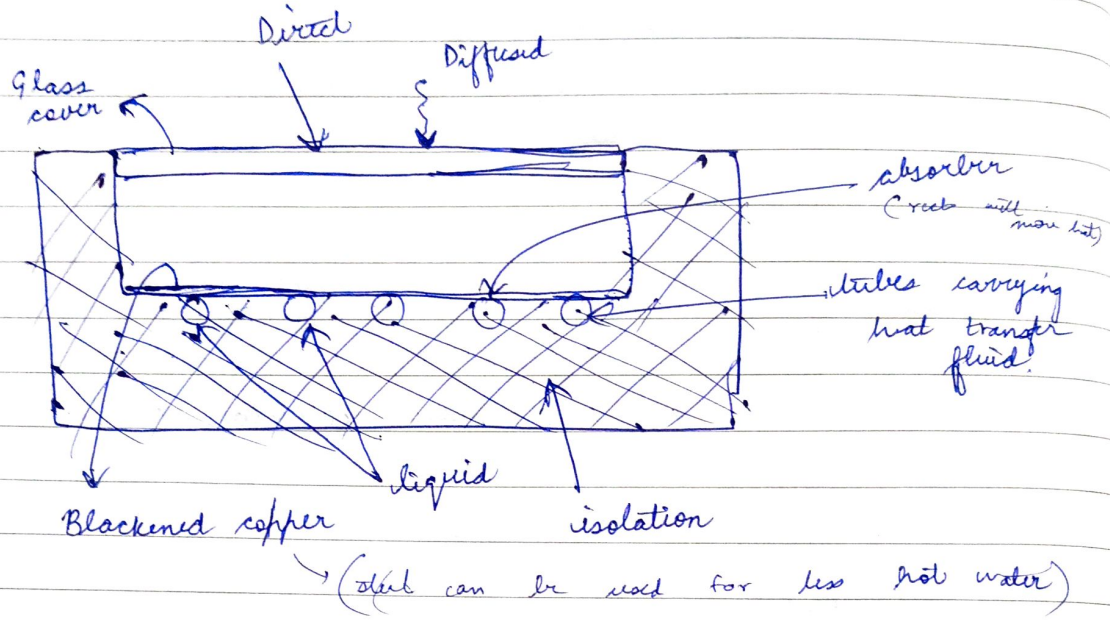
Projecting your collecta to exactly follow sun.

conc. ratio = 1000

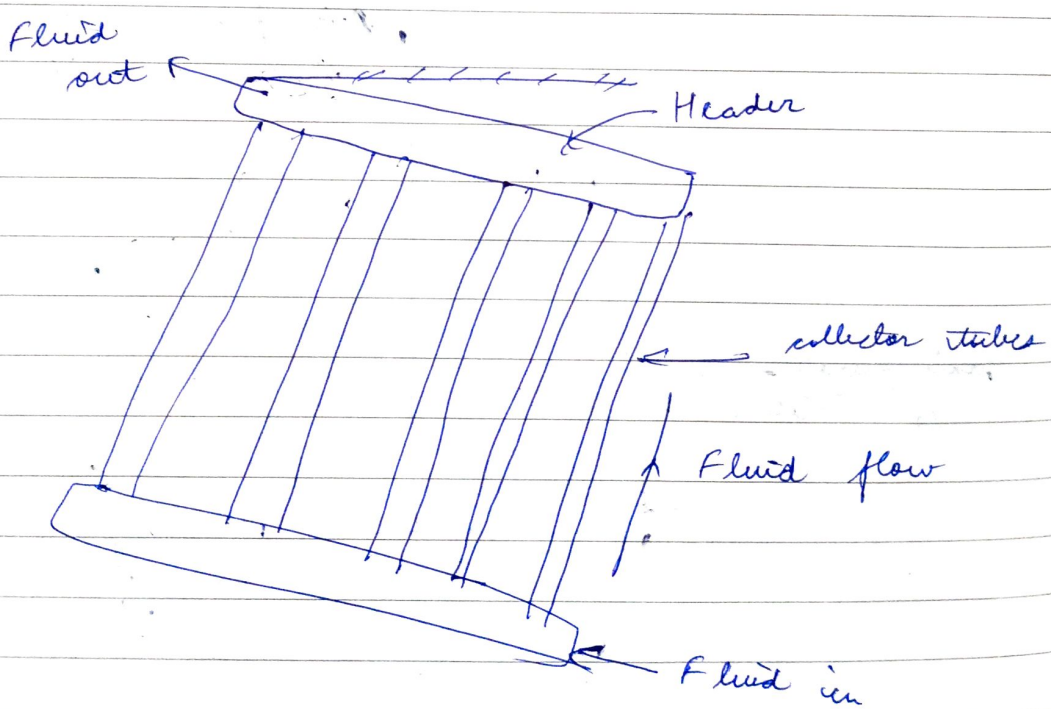
temp range = 500°C to 1000°C

Liquid Flat Plate Collector –





(black can be used for less hot water)



The absorber plate thickness ranges from 0.2 to 1 mm.
The diameter of header pipe ranges from 2 to 2.5 cm
The diameter of horizontal pipe is 0.2

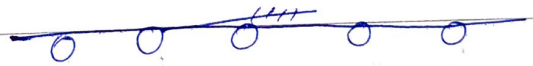
The basic elements in the majority of these collectors are -

1) Transparent cover (1 or 2 sheets) of glass or plastic
2) Blackened absorber plate, usually of copper, aluminium or steel.

Eg- Cooler — nowadays uses less voltage.
Copper winding — more weight, more metallic strength
Aluminium winding of motor - cheaper & less life

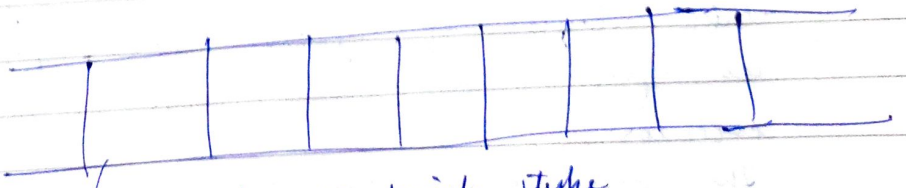
In Hotels, we go with

by changing collector tube size



Small weighted area in contact with collector material
⇒ more hot

Pipe and fin type



Water sandwich type
large weighted area in contact with tube → less hot water (used in hotels)

1.5 to 3 cm

semi water sandwich type

(roll-bond)

To avoid water from freezing in places with $<0^{\circ}C$

Water + Ethylene Glycol → Anti-freeze mixture
↳ Exchanger ↳ lower B.P.

Volume of water ↑ses, when it freezes.
⇒ Pipeline will have more pressure.

Thickness of glass cover = 4 to 5 mm
toughened

15% of radiation from this toughened glass reflects back through convection.

Only 85% energy is retained in collector.
To reduce loss, glass cover is used (thickness is 1.5 to 3 cm).
To further reduce, it can be coated with anti-reflectory material.

In the bottom & along the side walls, thermal insulation provided by 2.5 to 8 cm thick layer of glass wool, prevents heat loss from the rear surface & sides of the collector.
The glass cover permits the entry of solar

radiation as it is transparent for incoming short wavelengths but is largely opaque to the longer infra red radiation reflected from the absorber. As a result, heat it remains trapped in the air space between the absorber plate & glass top cover in a manner similar to greenhouse effect.

- Effect of various parameters on performance -

→ Selective surface -

Material Selection :-

① **Absorber Plate -**

Cu, Al, steel, brass, and zinc

Thermal conductivity ↑ ⇒ More heat transfer to liquid

Material	Thermal Conductivity (W/m°C)
Al	204
Steel	54
Cu	386
Brass (70/30)	111
Zinc	112
Silver	419

↳ can't be used coz of cost

Cu for higher heat absorption, Al for little lower heat absorption.

② Insulation -

shouldn't allow radiations to pass out of it (traps radiation)

Material	Thermal conductivity
Crown white wool	0.034
Sphinter 300 industrial	0.075
Glass wool	0.044
Thermocole	0.035
Foam	0.017

Making 2 walls nowadays for less conduction of heat.
Insulating material btw. 2 walls.

③ Cover Plate -

The ideal cover should -

1) Transmit max. energy to the absorber plate.
2) Minimize upward heat loss from the absorber plate to the environment.
3) Shield the absorber from direct exposure to weather.
4) Be of light - weight & easy to move.

The most imp. factors are — Material, Durability, Strength, Non-degradability & good incoming solar energy transmittence.

Ruding of Al,
It should behave transparent for the incoming radiation & opaque to outgoing radiations.

if glass cover is not proper & sealed then moisture may enter collector & damage the absorber plate.

Transmittence of glass depends on its iron content.
High iron content ⇒ less transmittence

Tempered glass – rigid, more strength
Transparent plastic materials such as Acrylic polycarbonate, Tedlar, Mylar, Lexan.

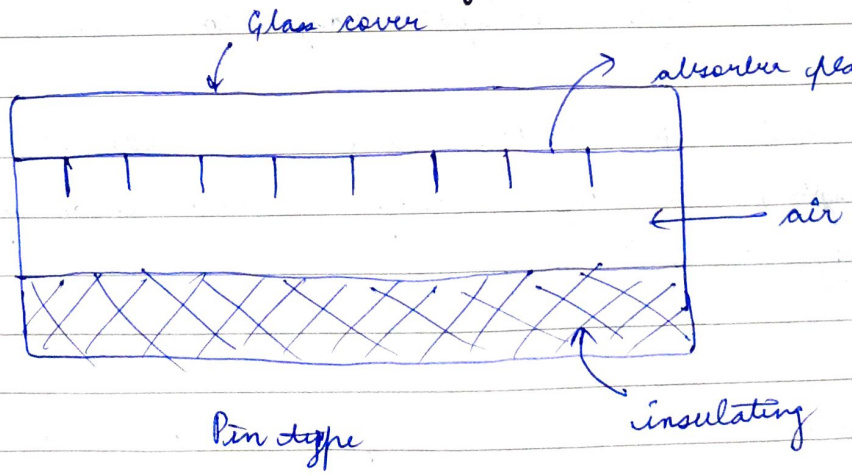
Radiations from sun – Lower wavelength
↳ from reflected radiations – longer λ should be low

Disadvantages –

1) Plastic materials have partial transmittence of longer wavelength.
2) Plastic materials have limited life exposure to UV radiations. It reduces their transmitivity.

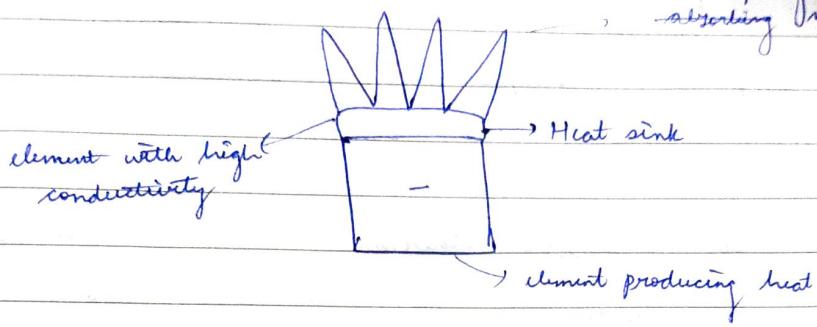
To heat air – More area of absorber plate needed

Flat Plate Air Heating Collector –

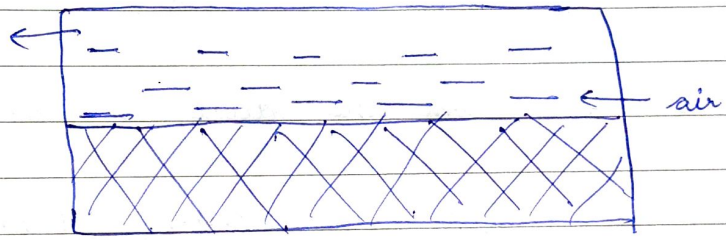


Pin type

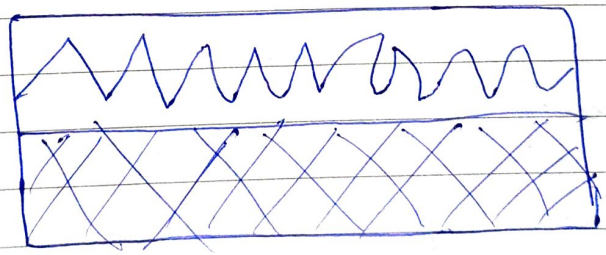
exposing more surface area of material to



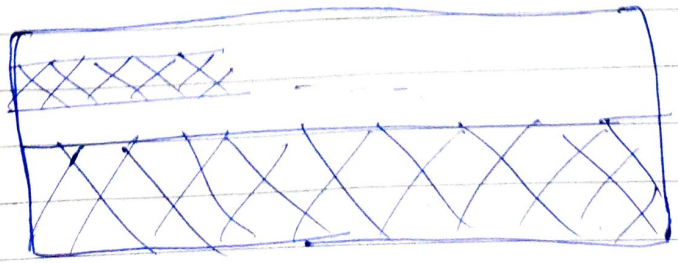
Metal Matrix Type -



Corrugated Type -



Thermal trap type -



Advantages of Air Heating Collector -

→ It is compact, simple in construction & require little maintainence.

→ The need to transfer thermal energy from working field to another field is eliminated as air is used directly as working fluid

→ Corrosion is completely eliminated.

→ Leakage of air from the duct is less severe.

→ Possibility of freezing the working fluid is also eliminated.

→ The pressure inside the collector does not become very high.

Disadvantages -

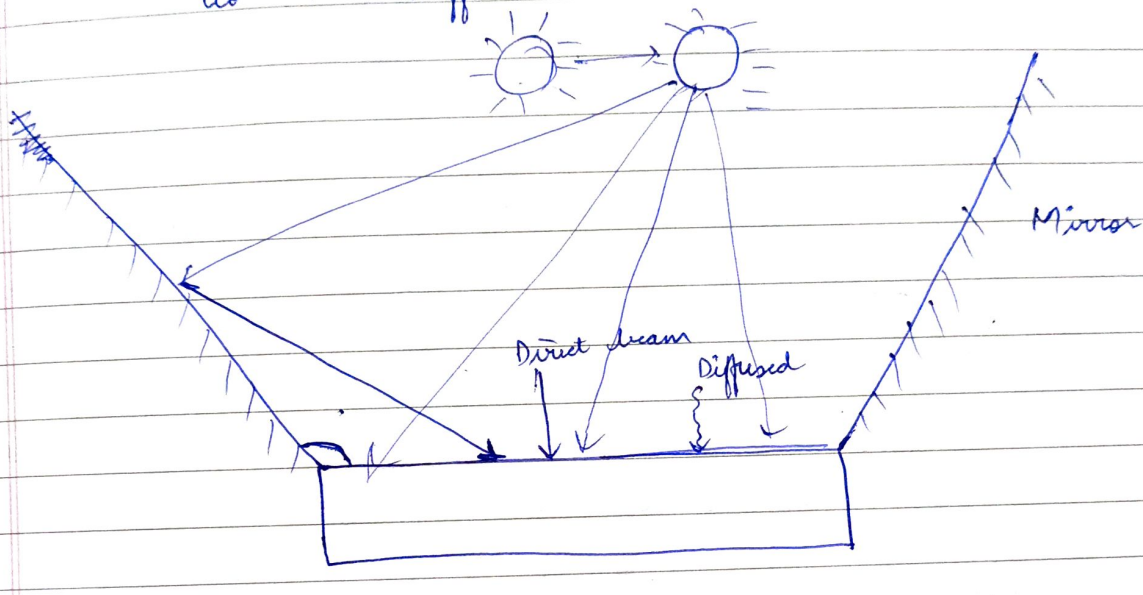
→ Large amount of fluid is to be handled due to low density, as a result the electrical power required to blow the air to the system can be significant.

→ Heat transfer betw. absorber plate & air is poor. Bcoz thermal conductivity of air is poor.

→ There is less storage of thermal energy due to low heat capacity.

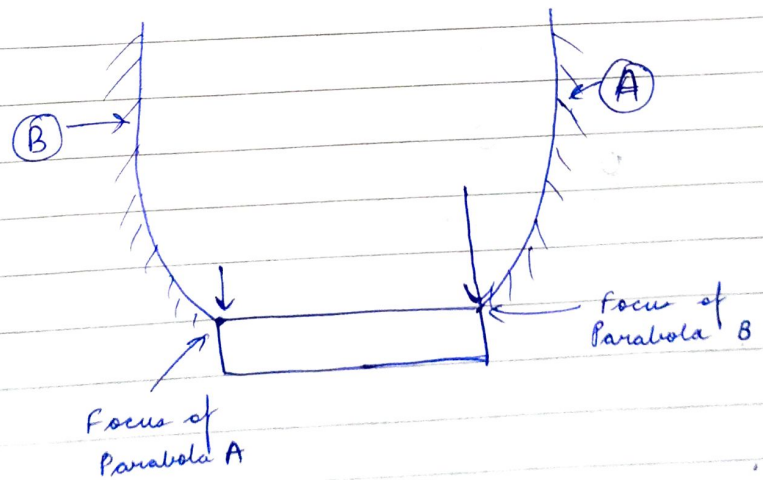
Modified Flat Plate Conductor -

to ↑ in diffused e-radiance.



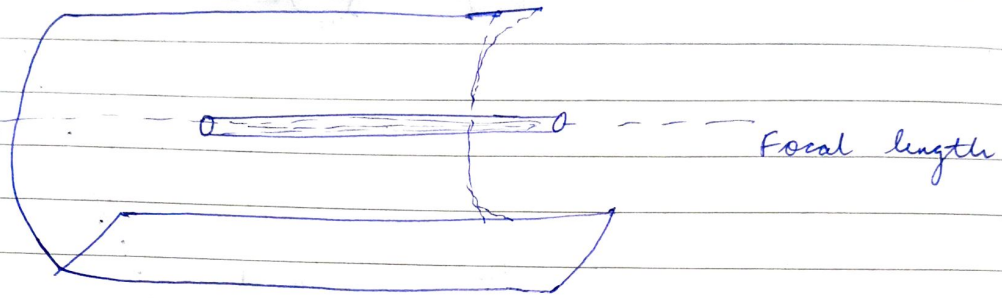
Concentration Ratio = ~~3 to 7~~ < 4

Compound Parabolic Concentrator -



CR = 3 to 7

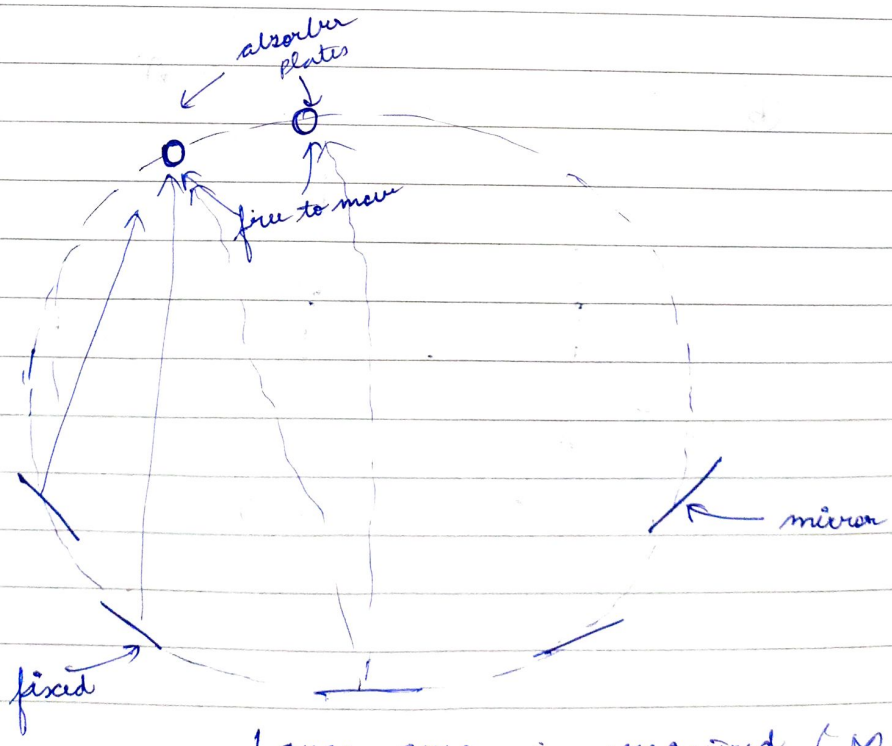
Cylindrical Parabolic Concentrator –



CR = 5 to 100

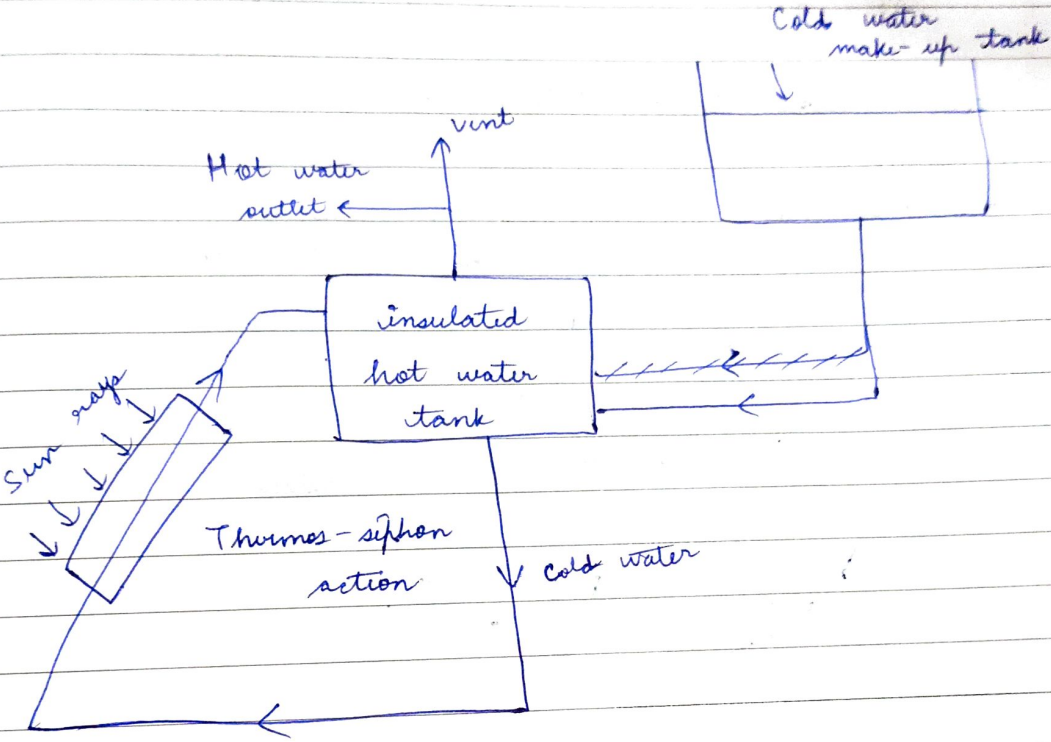
All radiation falling on parabola will be concentrated on focal length.

Fixed Mirror Solar Concentrator –



Large area is required. (Maintainance will ↑se).

Solar Water Heater :



Can heat water till 60 - 80°C

Life of this kind of system is 10 - 15 years

Cost of this system in 2020 10 - 20000 Rs.

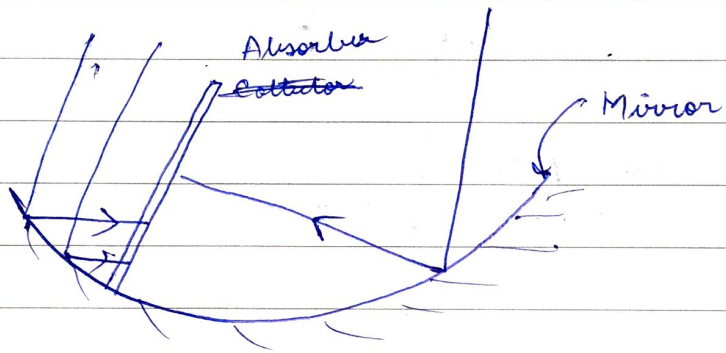
Every years price ↑s by 3-4 %.

Paraboloidal Dish Collector -

Here CR can be 10 - few thousands.
Temp. rise can be upto 3000°C.

Hemispherical Bowl Mirror -

- Also has 2 - axis tracker system
  → to move with sun.

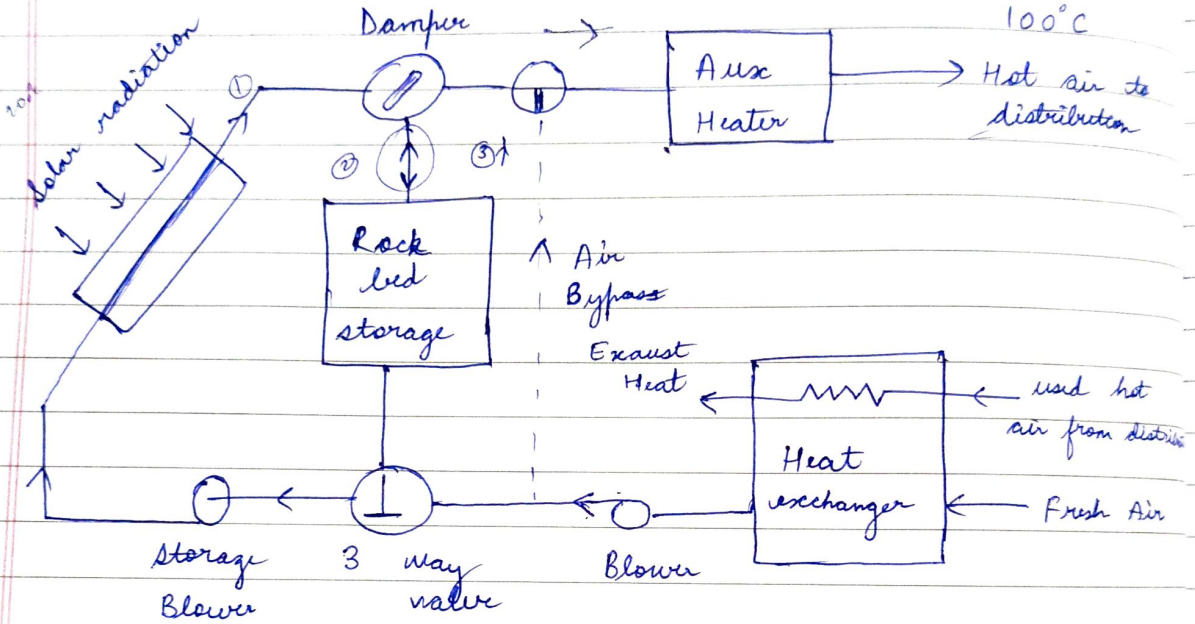


If >100°C, ↓s volume, air will expand & temp ↑ will ↓

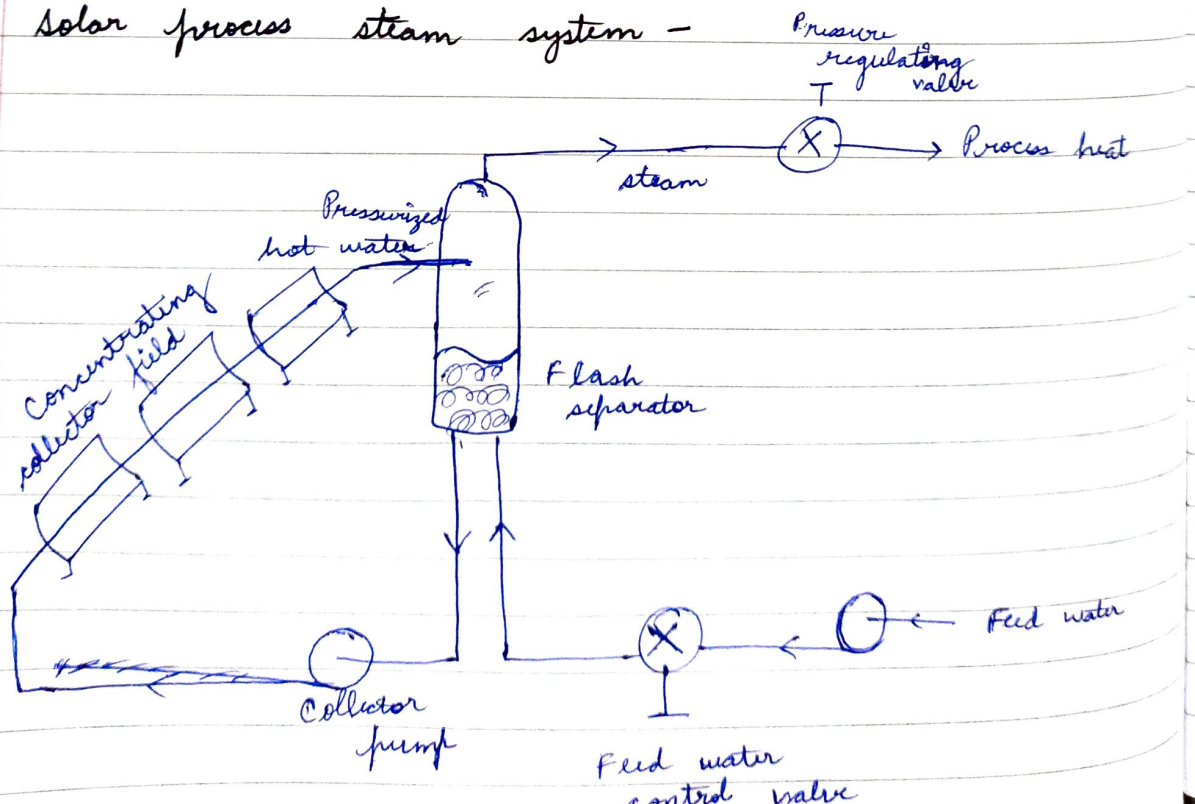
More pressure ⇒ Bo Temp ↑

Solar Industrial Heating system

① Hot air industrial process heat system –



Solar process steam system –



Solar Cooker :-

LPG formed by Natural gas
Reduce usage

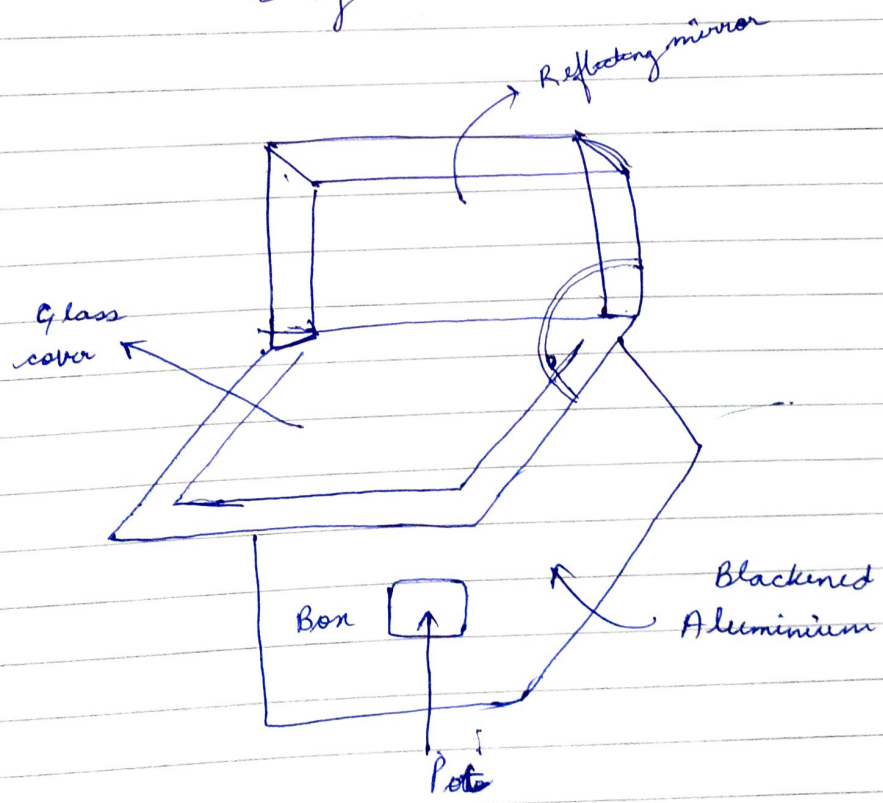
Temp. rise is low & cooking is delayed.

CR ↑ std

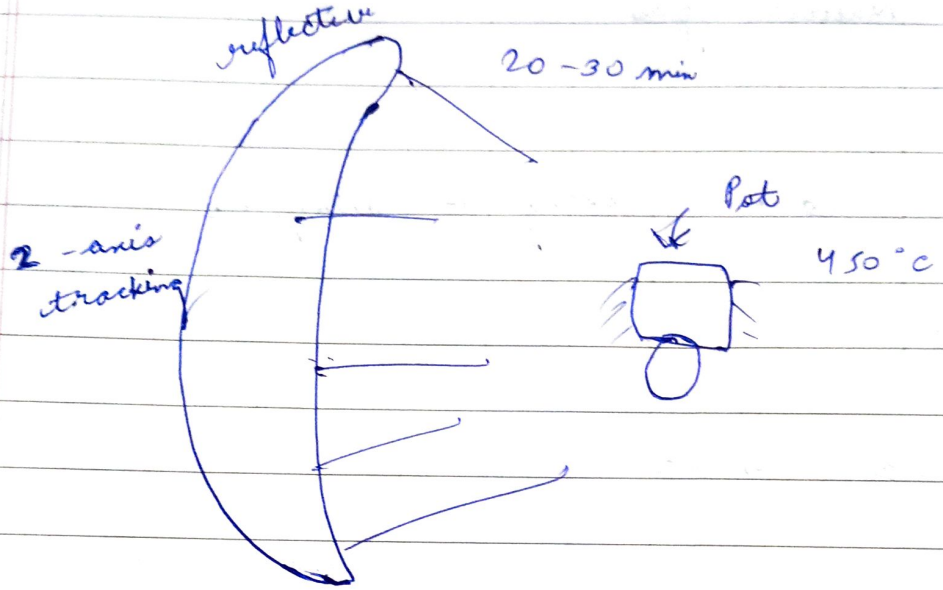
Box Type Solar Cooker

60cm × 60cm × 60cm

2 kg



Paraboloidal Dish Type -



- Community Solar Cooker