Lect.-8
Solar Thermal applications in different gadgets.

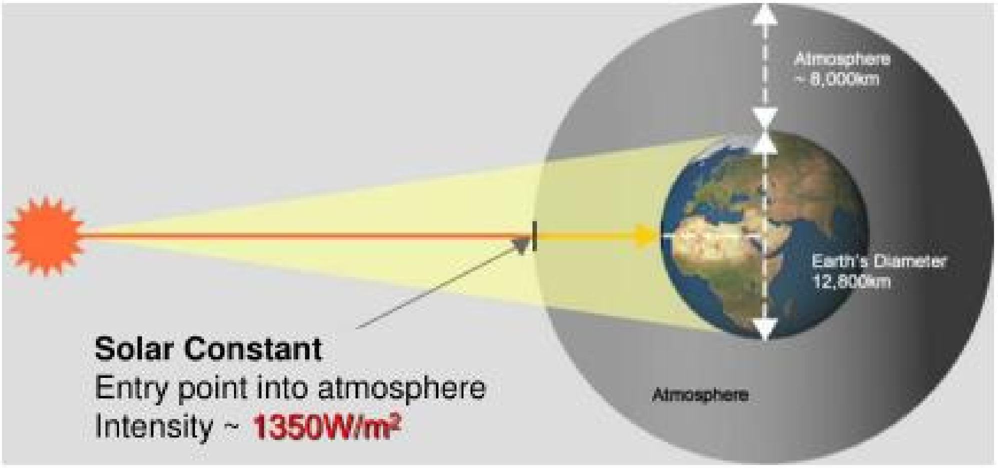
Solar thermal energy (STE) is a form of energy and a technology for harnessing solar energy to generate thermal energy or electrical energy for use in industry, and in the residential and commercial sectors.

Physics of Solar Thermal

- The solar constant – $S=1360 W/m^2$.
- Portion of light that appears to come straight from the sun – **direct radiation.**
- On a clear day, this can approach a power density of 1 kilowatt per square meter **(1 kWm^{-2}).**
- Practical peak power densities are around 900 – 1000 watts per square meter.

Solar Constant

- Amount of incoming solar radiation per unit area incident on a plane perpendicular to the rays.
- At a distance of one 1AU from the sun (roughly the mean distance from the Sun to the Earth).
- Includes a range of wavelength (not just the visible light).



Solar Collectors

Lesson -8

Stationary solar collectors

//energyinformative.org/wp-content/uploads/2012/04/solar-thermal-collectors.jp

Concentrating solar collectors

http://blog.hasslberger.com/img/concentrated-solar-power.jpg

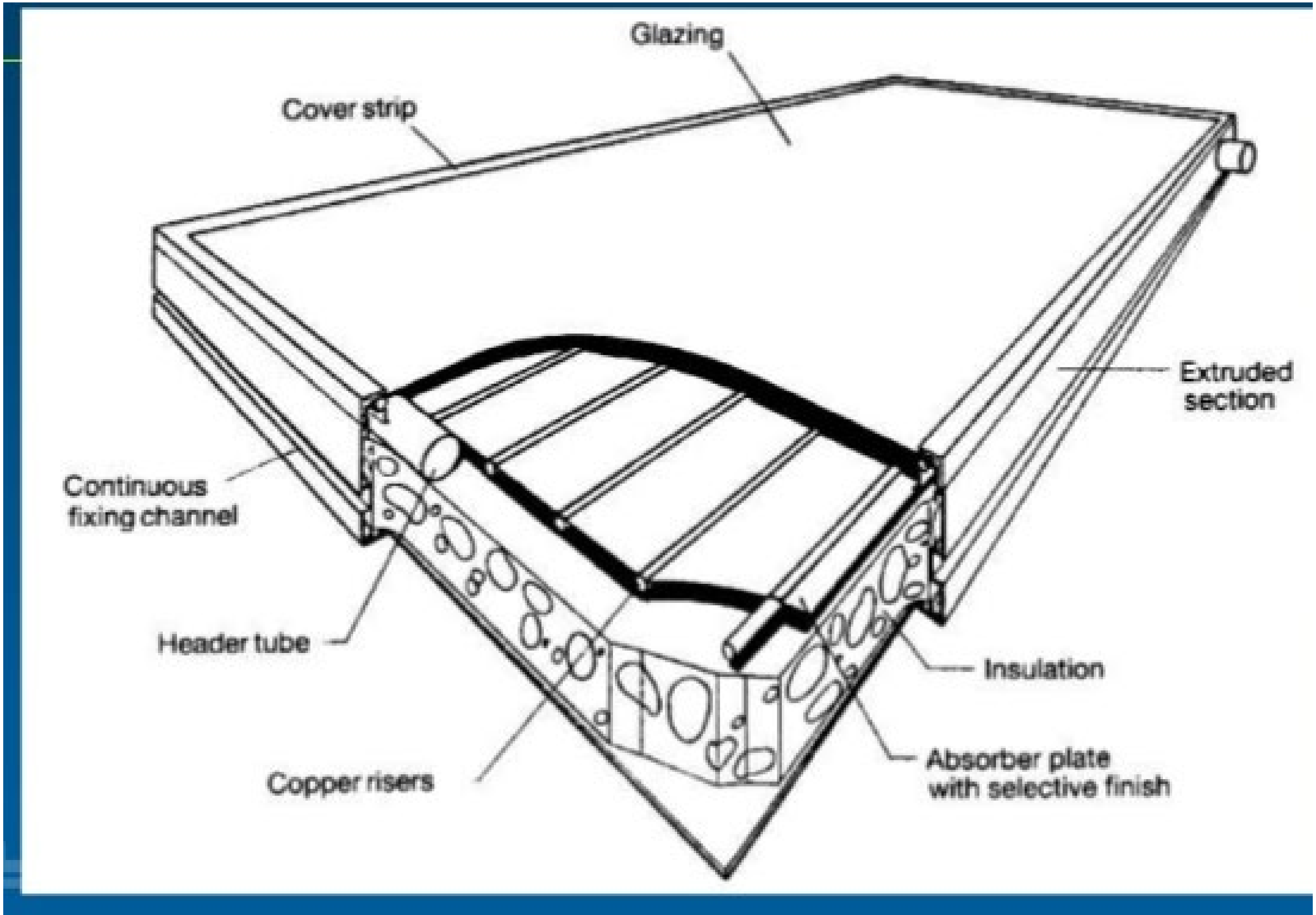
Stationary Collector Types

- 1. Flat plate collectors (FPC);
- 2. Evacuated tube collectors (ETC).
- 3. Stationary compound parabolic collectors (CPC);

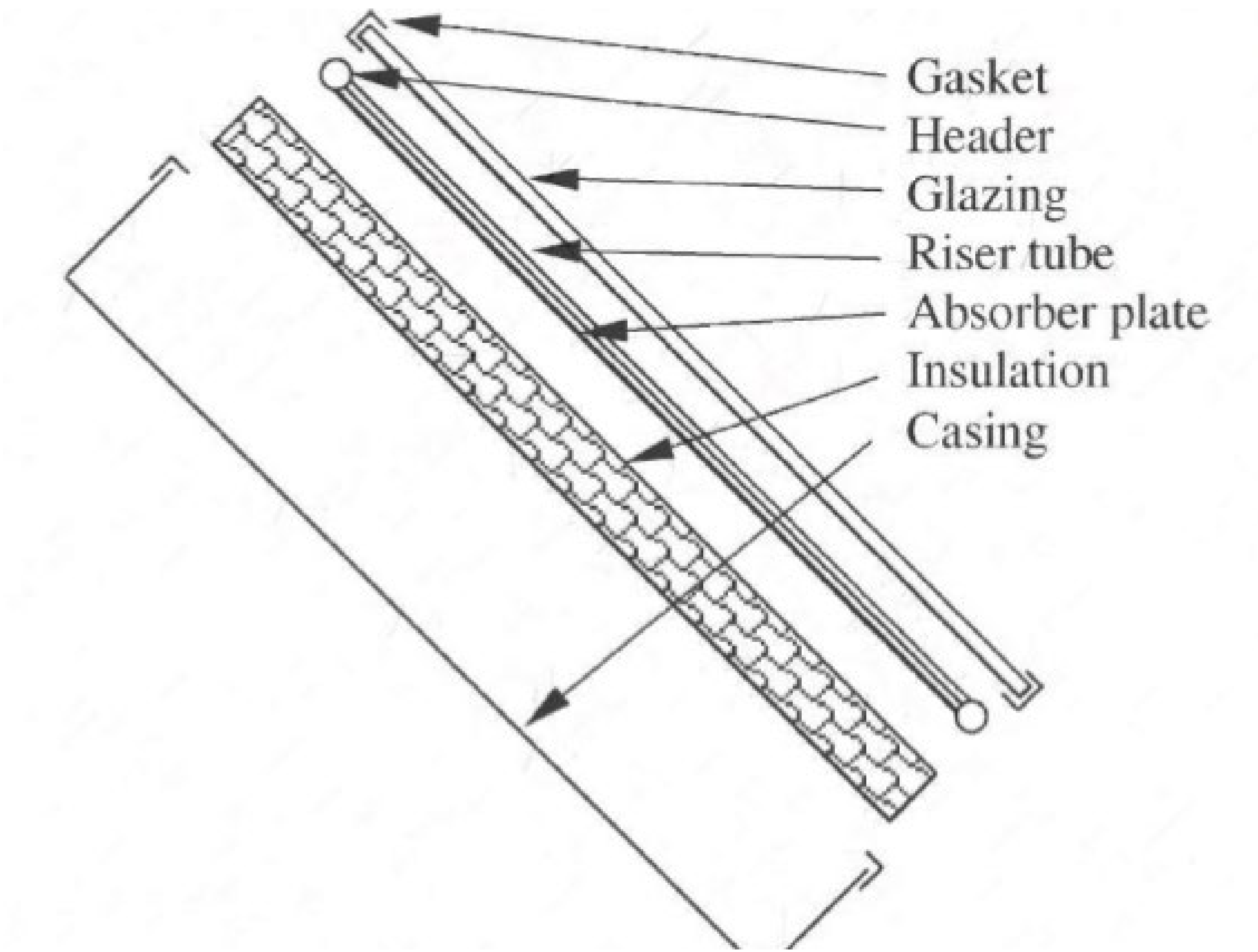
Solar energy collectors

Motion	Collector type	Absorber type	Concentration ratio	Indicative temperature range (°C)
Stationary	Flat plate collector (FPC)	Flat	1	30–80
	Evacuated tube collector (ETC)	Flat	1	50–200
	Compound parabolic collector (CPC)	Tubular	1–5	60–240

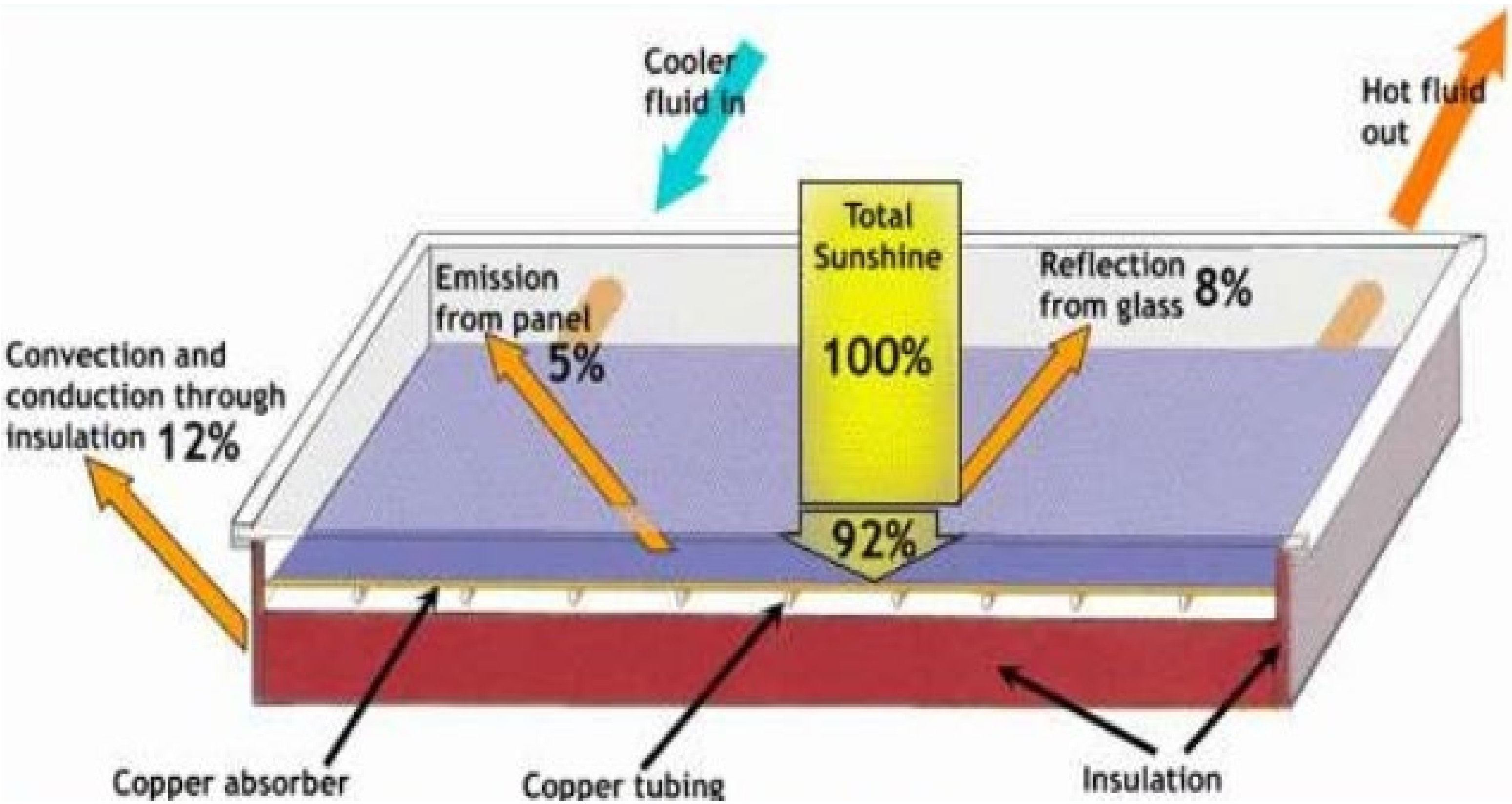
Flat plate collector components



Flat plate collector components



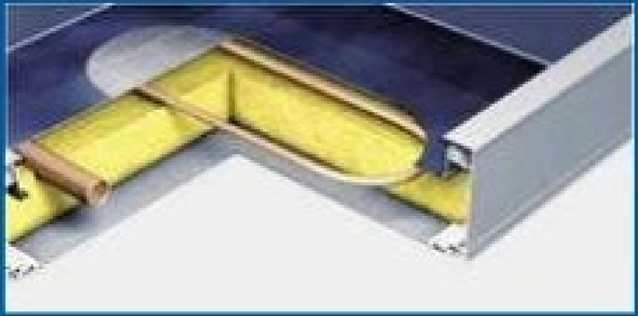
Working of flat plate collector



Opperating temperature

Low temperature applications up to 100˚C.

200˚C can be achieved due to highly selective coatings



. Evacuated Tube Collectors (ETC)

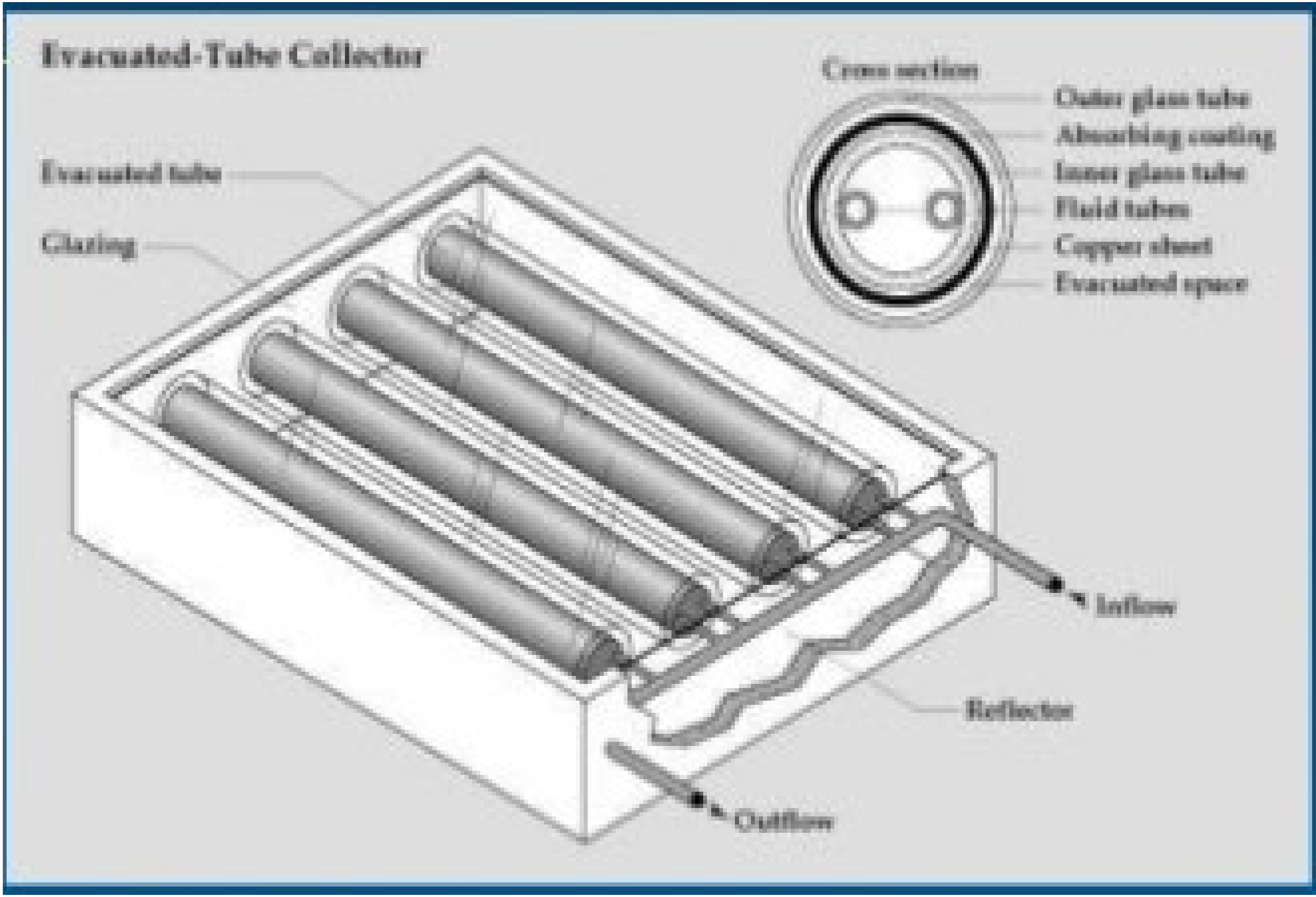
Evacuated Tube Collectors

Evacuated collectors consist of a heat pipe inside a vacuum-sealed tube.

Good performance at high temperatures.

Collectors can operate at higher temperatures than FPC.

Eefficiency is higher at low incidence angles than FPC.



Evacuated-Tube Collector
Cross section
Outer glass tube
Absorbing coating
Inner glass tube
Fluid tubes
Copper sheet
Evacuated space
Evacuated tube
Glazing
Inflow
Reflector
Outflow

Electricity is generated from solar thermal energy.

Solar thermal power plants use the sun's rays to heat a fluid to high temperatures. The fluid is then circulated through pipes so that it can transfer its heat to water and produce steam.

The steam is converted into mechanical energy in a turbine, which powers a generator to produce electricity.

CST and CSP

High-temperature collectors concentrate sunlight using mirrors or lenses and are generally used for fulfilling heat requirements up to 300 deg C / 20 bar pressure in industries, and for electric power production.

Two categories include Concentrated Solar Thermal (CST) for fulfilling heat requirements in industries, and Concentrated Solar Power (CSP) when the heat collected is used for power generation. CST and CSP are not replaceable in terms of application.

Solar Thermal Systems

There are two types of solar thermal systems:

Passive: A passive system requires no equipment, like when heat builds up inside your car when it's left parked in the sun.

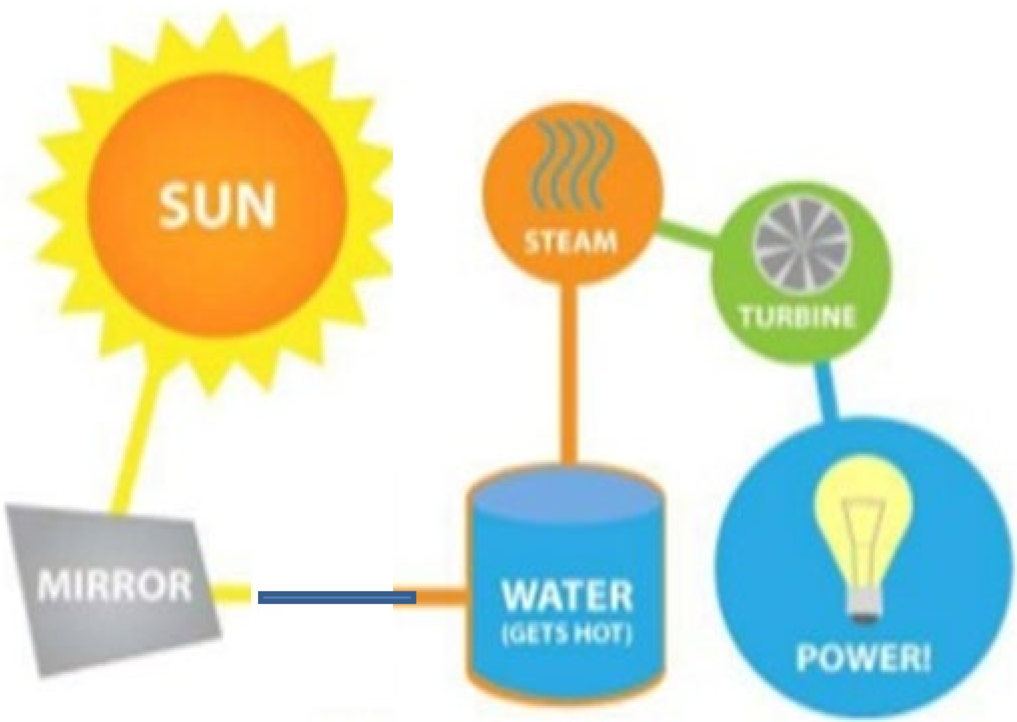
e.g. Thermal chimneys

Active : An active system requires some way to absorb and collect solar radiation and then store it.

e.g. Solar thermal power plants

Basic Working Principle

- Mirrors reflect and concentrate sunlight.
- Receivers collect that solar energy and convert it into heat energy.
- A generator can then be used to produce electricity from this heat energy.

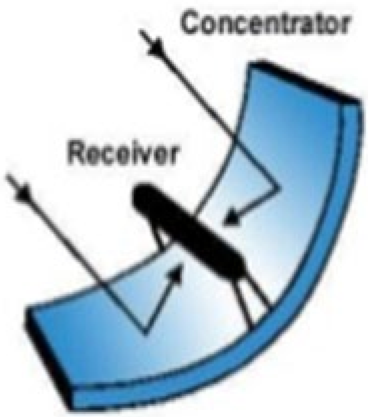


Thermal energy storage (TES)

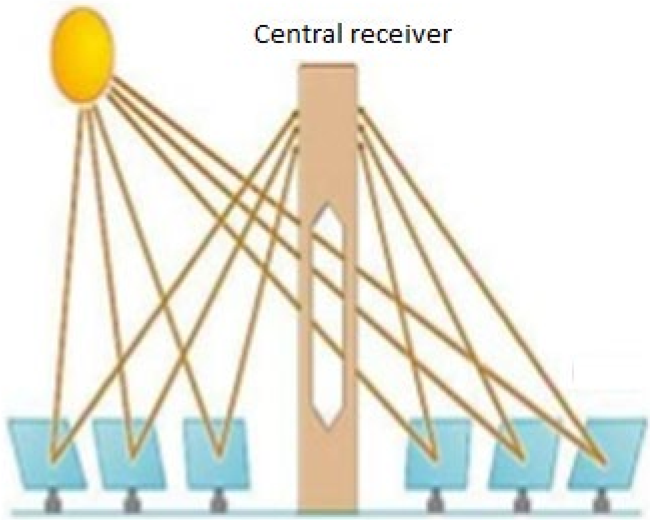
TES are high-pressure liquid storage tanks used along with a solar thermal system to allow plants to bank several hours of potential electricity.

- **Two-tank direct system**: solar thermal energy is stored right in the same heat-transfer fluid that collected it.
- **Two-tank indirect system**: functions basically the same as the direct system except it works with different types of heat-transfer fluids.
- **Single-tank thermocline system**: stores thermal energy as a solid, usually silica sand.

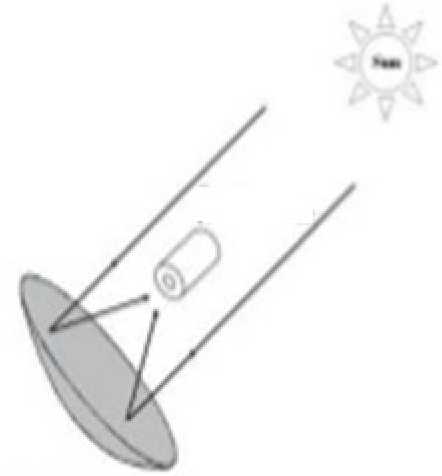
Types of Solar Thermal Power Plants



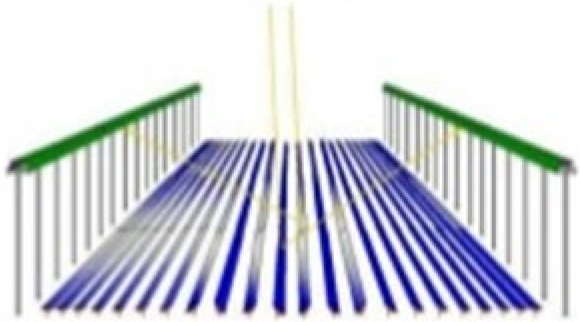
Parabolic trough system



Solar power tower systems



Solar dish/engine system

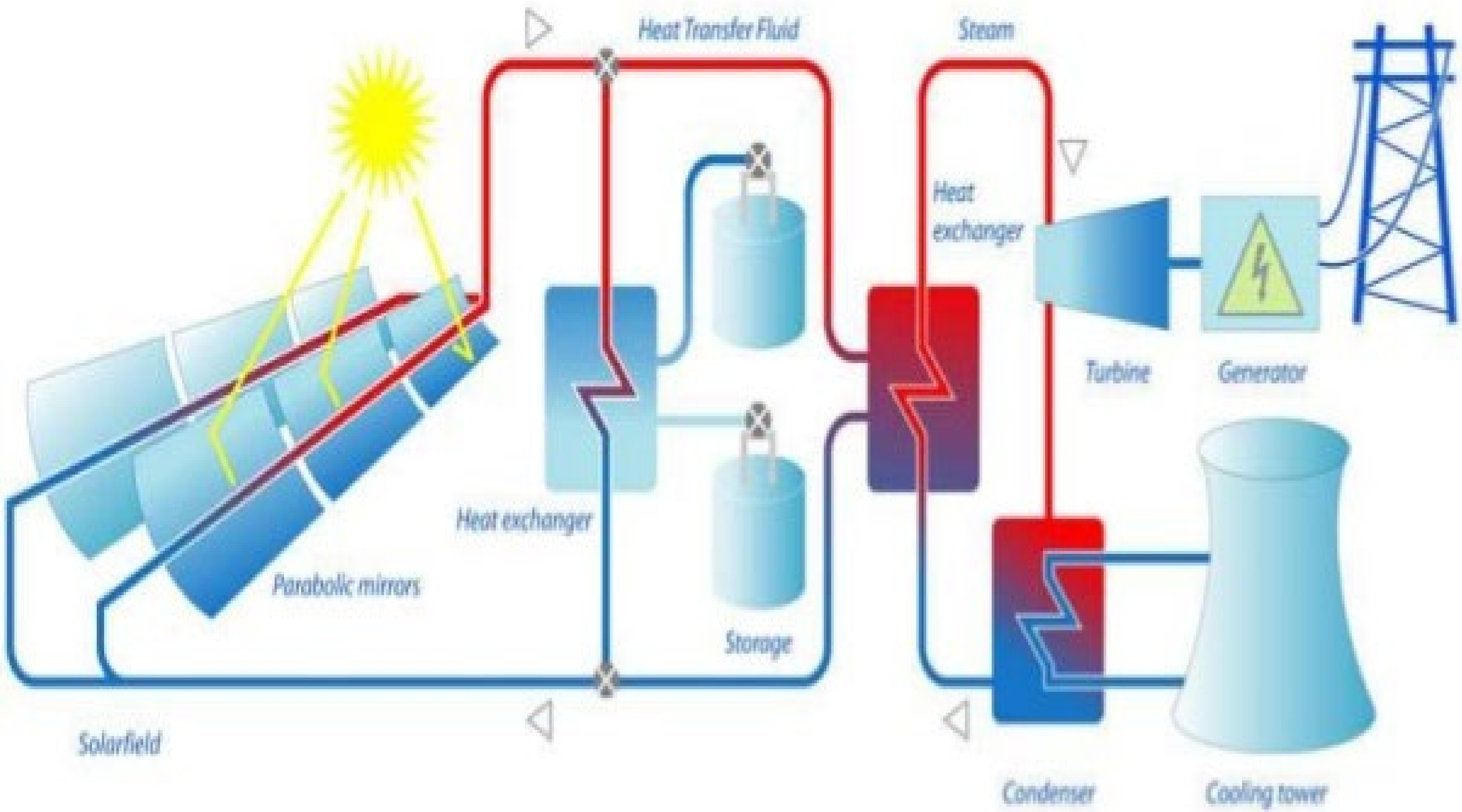


Compact linear Fresnel reflector

Parabolic Trough System

Parabolic trough System

- A parabolic trough consists of a linear parabolic reflector that concentrates light onto a receiver positioned along the reflector's focal line.
- The receiver is a tube positioned directly above the middle of the parabolic mirror and filled with a working fluid.
- The reflector follows the sun during the daylight hours by tracking along a single axis.
- A working fluid (e.g. molten salt) is heated to 150–350 °C (423–623 K (302–662 °F)) as it flows through the receiver and is then used as a heat source for a power generation system.


Heat Transfer Fluid
Steam
Heat
exchanger
Turbine
Generator
Heat exchanger
Parabolic mirrors
Storage
Solarfield
Condenser
Cooling tower

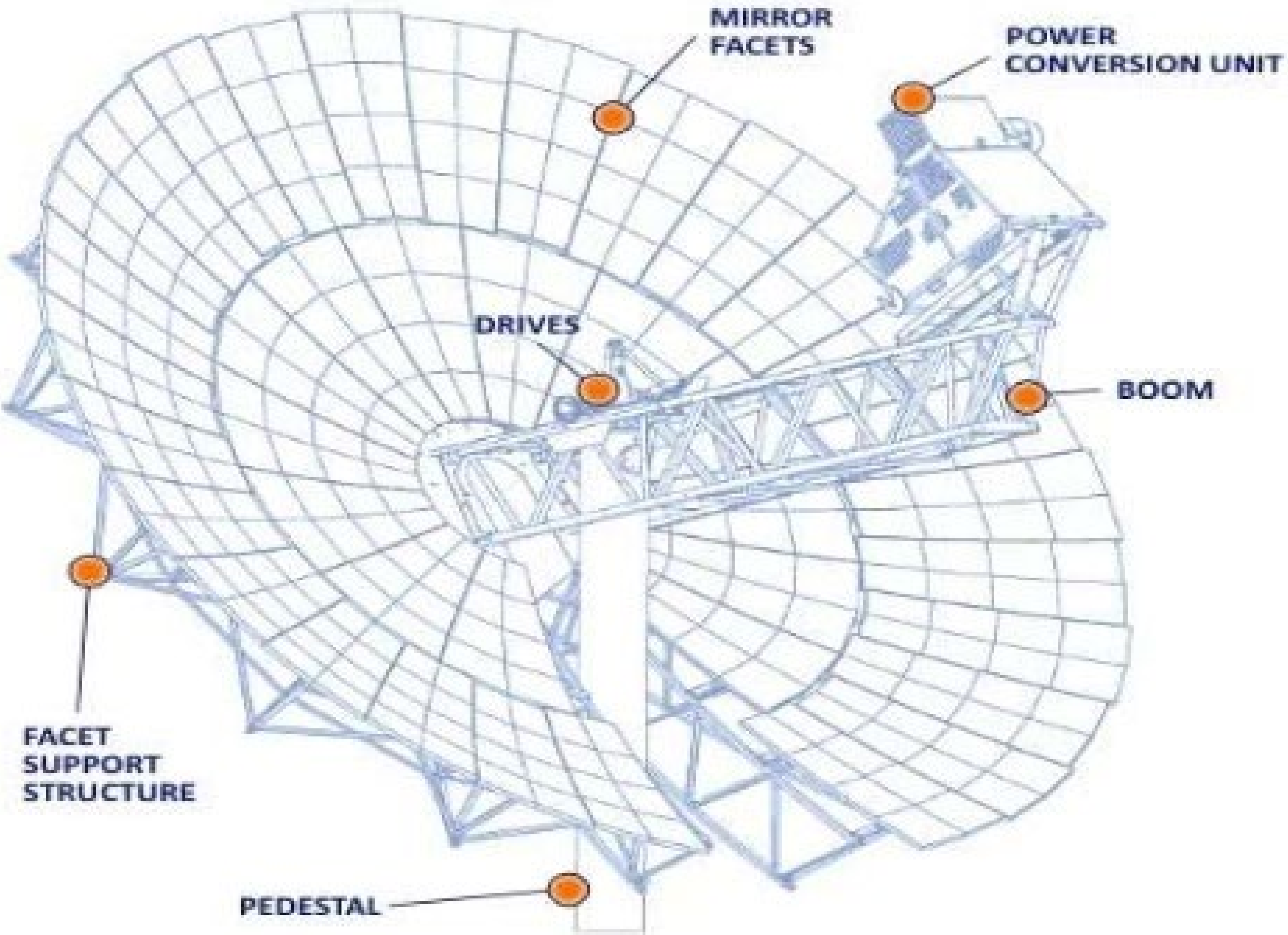
Solar Power Tower System

Solar power tower systems

- Power towers (also known as 'central tower' power plants or 'heliostat' power plants).
- These designs capture and focus the sun's thermal energy with thousands of tracking mirrors (called heliostats) in roughly a two square mile field.
- A tower resides in the center of the heliostat field. The heliostats focus concentrated sunlight on a receiver which sits on top of the tower.
- Within the receiver the concentrated sunlight heats molten salt to over 1,000 °F (538 °C).
- The heated molten salt then flows into a thermal storage tank where it is stored, maintaining 98% thermal efficiency, and eventually pumped to a steam generator.
- The steam drives a standard turbine to generate electricity.

Solar Dish/Engine System

Solar Dish/Engine System



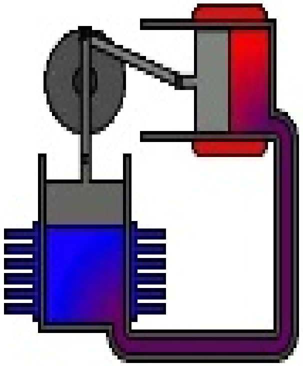
Solar dish/engine system

The system consists of a stand-alone parabolic reflector that concentrates light onto a receiver positioned at the reflector's focal point.

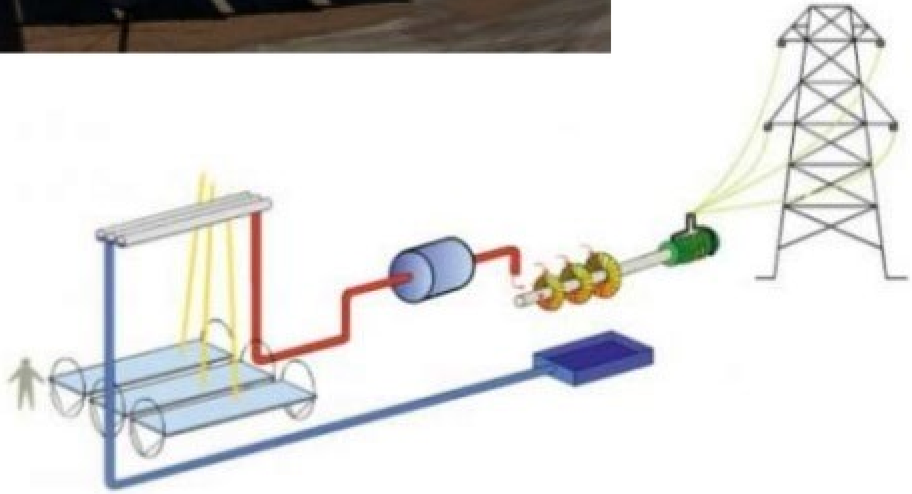
The working fluid in the receiver is heated to 250–700 °C (523–973 K (482–1,292 °F)) and then used by a Stirling engine to generate power.

Parabolic-dish systems have the highest efficiency of all solar technologies provide solar-to-electric efficiency between 31–32%.

Stirling Engine →



Compact Linear Fresnel Reflector



Compact linear Fresnel reflector

- Linear Fresnel reflectors use long, thin segments of mirrors to focus sunlight onto a fixed absorber located at a common focal point of the reflectors.
- These mirrors are capable of concentrating the sun's energy to approximately 30 times its normal intensity.
- This concentrated energy is transferred through the absorber into some thermal fluid.
- The fluid then goes through a heat exchanger to power a steam generator.

Major Challenges

- The major challenge are the Installation Cost and energy storage.
- The costs are still far higher than fossil fuel plants based on units of energy produced.
- The hot water storage products are often stretched to their limits.
- Alternatives could be phase change materials (PCMs) or thermo-chemical materials (TCMs).
- In addition to sensible heat, the technologies of latent heat and thermo-chemical energy storage are on their way to becoming very promising solutions for the future of solar heating and cooling.

Cooking

Box type solar cooker

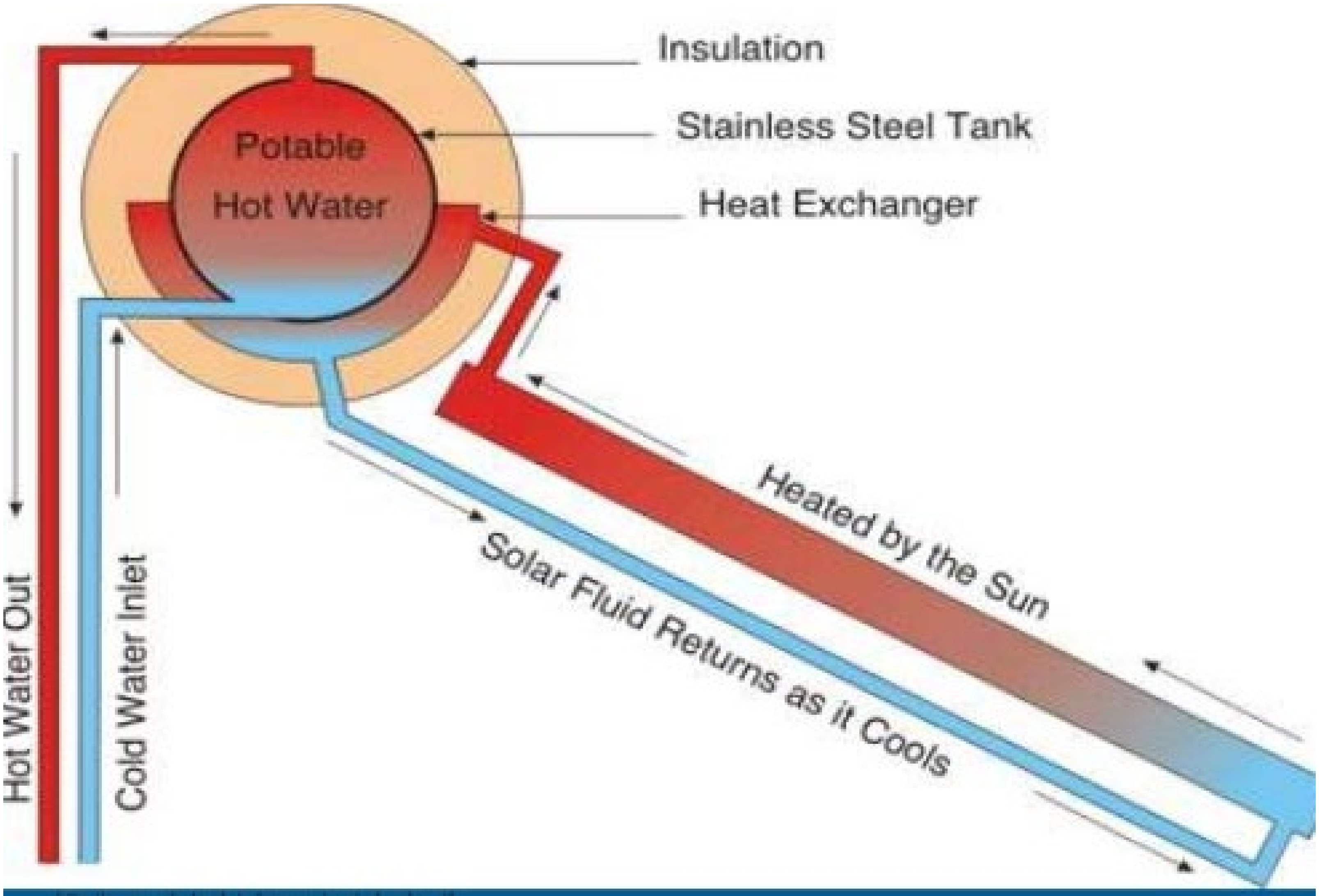
Panel type solar cooker

Parabolic type solar cooker

Solar oven

Water heating

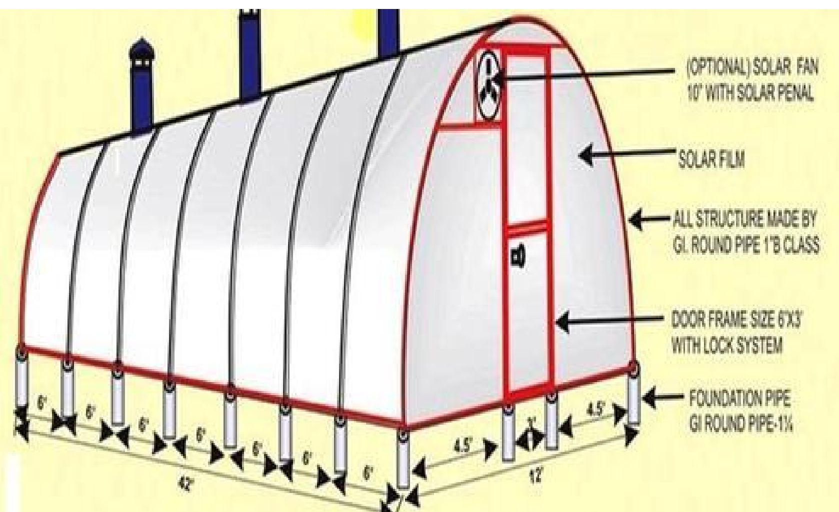
Thermosyphon Systems



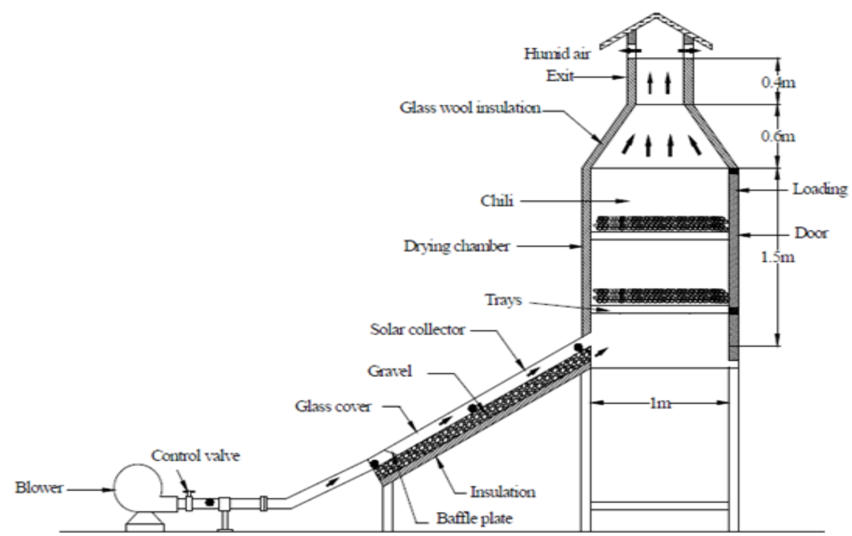
Drying

Direct heating

In direct heating

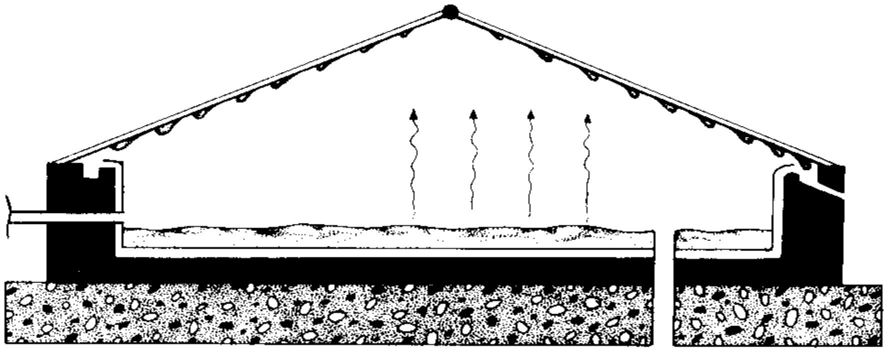


Solar tunnel dryer



Forced convection solar dryer

Solar Distillation Plants



solar still

Solar energy heats up the water in the still. The water then evaporates and condenses on the bottom of the covering glass.

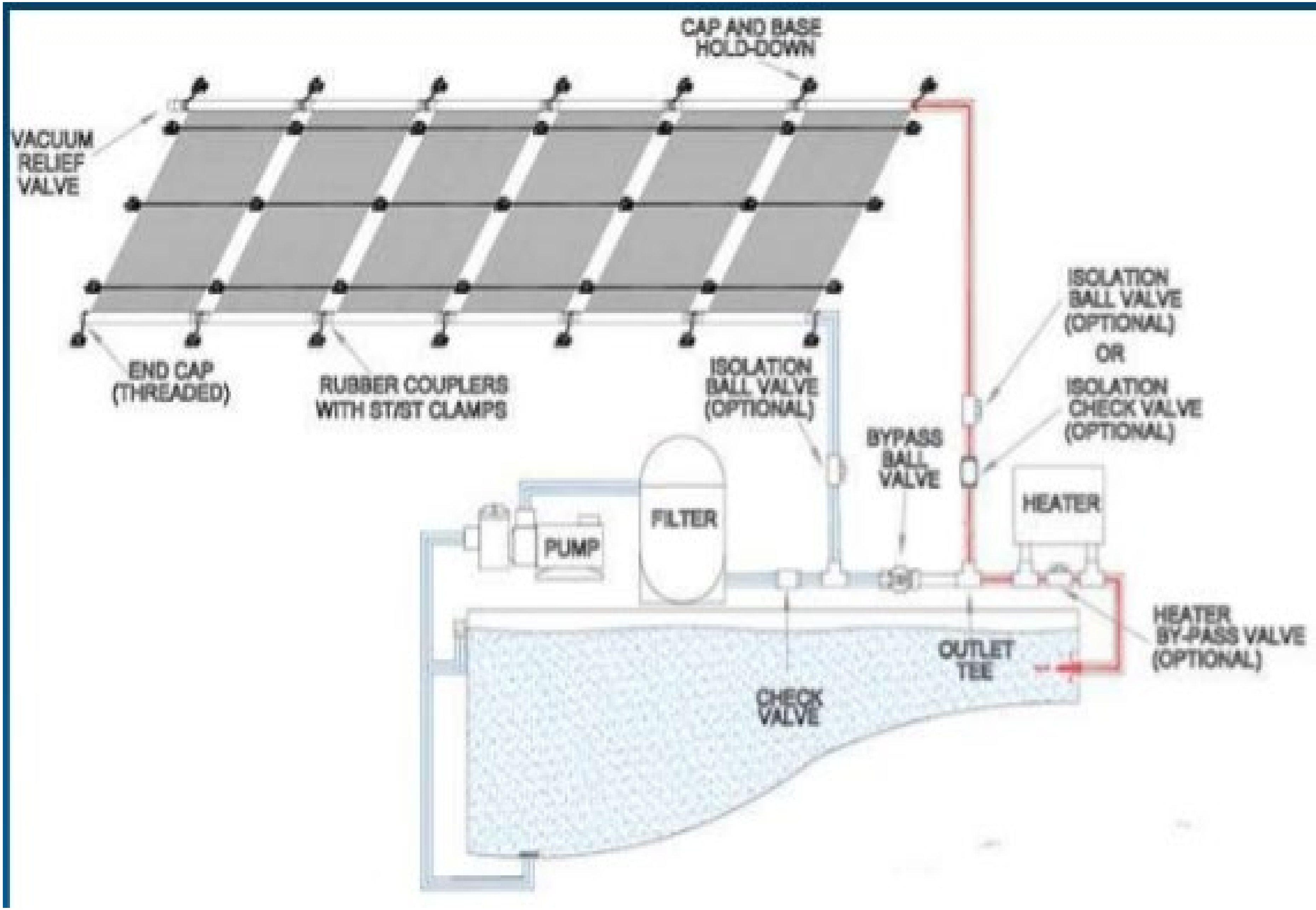
Solar stills can be used to make drinking water in areas where clean water is not common. Solar distillation is necessary in these situations to provide people with purified water.

Soil Solarization

Solar Animal Feed Cooker

Solar Steam Generator for Steam Engine

Solar Pool Heating System


CAP AND BASE
HOLD-DOWN
VACUUM
RELIEF
VALVE
END CAP
(THREADED)
RUBBER COUPLERS
WITH ST/ST CLAMPS
ISOLATION
BALL VALVE
(OPTIONAL)
ISOLATION
BALL VALVE
(OPTIONAL)
OR
ISOLATION
CHECK VALVE
(OPTIONAL)
BYPASS
BALL
VALVE
FILTER
PUMP
HEATER
HEATER
BY-PASS VALVE
(OPTIONAL)
OUTLET
TEE
CHECK
VALVE

Plant photosynthesis (micro climate control)

Poly house

Glass house

Poly tunnel

Low tunnels