EN 671: Solar Energy Conversion and Technology

Lecture -2: Overview of solar energy conversion devices and applications

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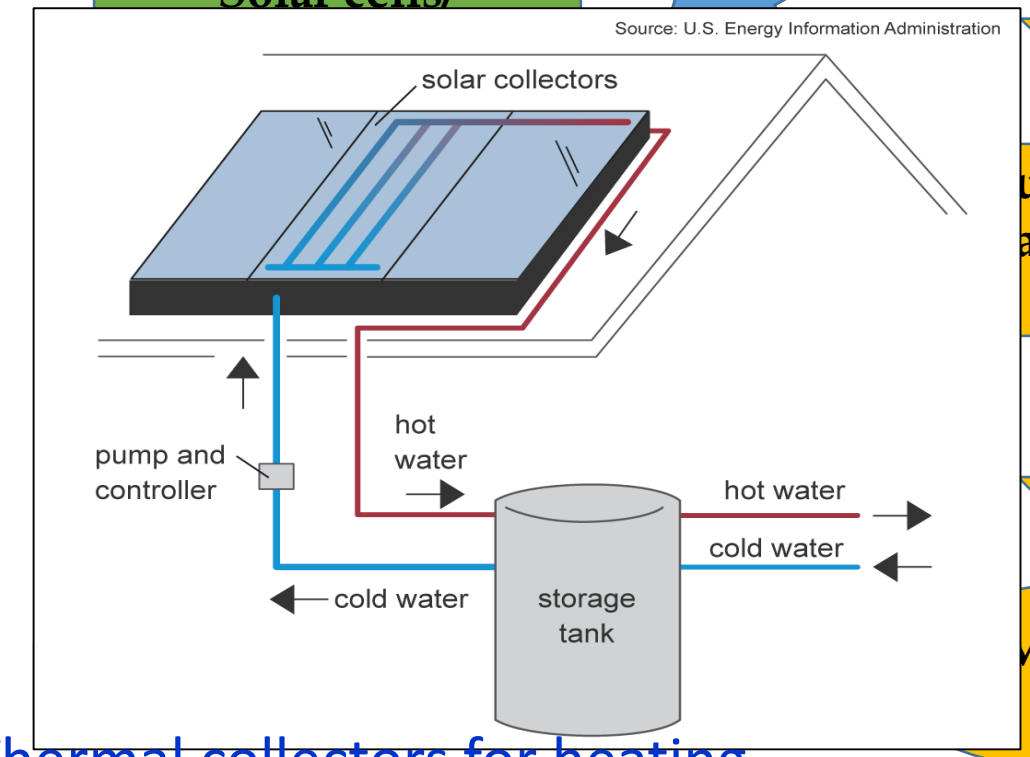
Different modes of exploiting solar energy

Solar Thermal collectors for heating

Solar PV for generation of electricity

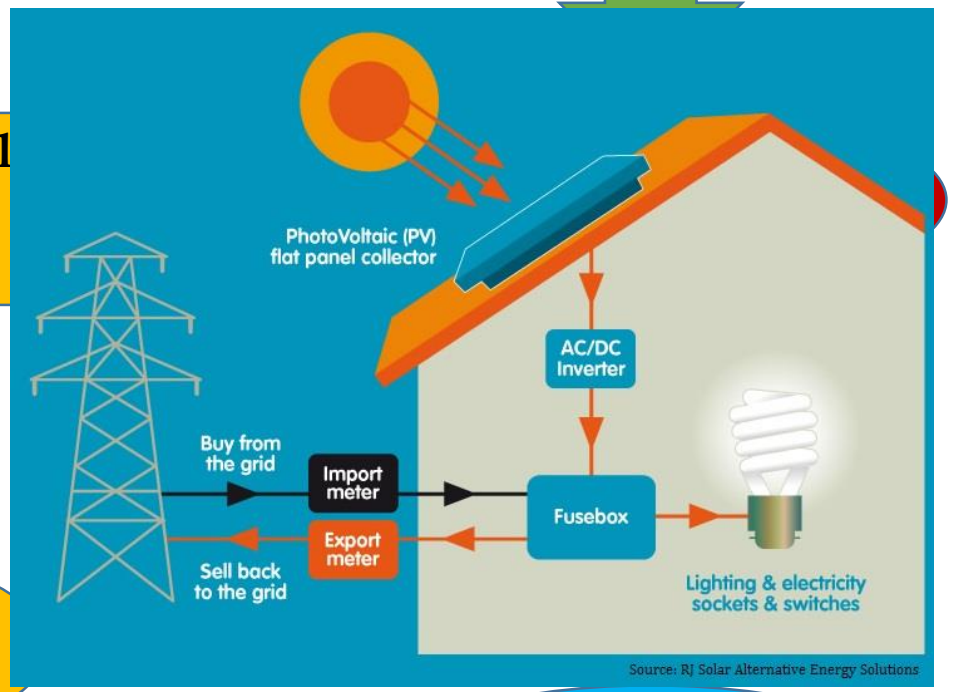
Concentrators

Solar cells/



ubular panel
ar hot water
system

Moderate Heat



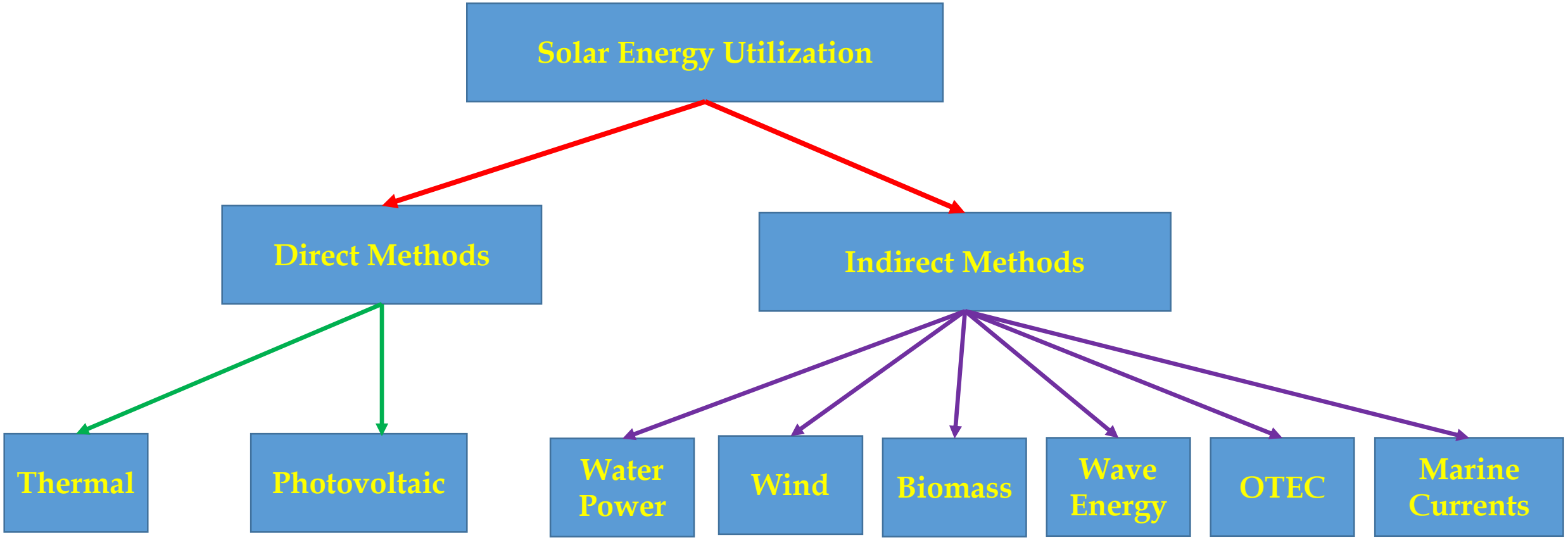
- Thermal collectors for heating
- PV for generation of electricity (for thermal use low efficiency and much more expensive)

Solar Thermal Energy

Electricity

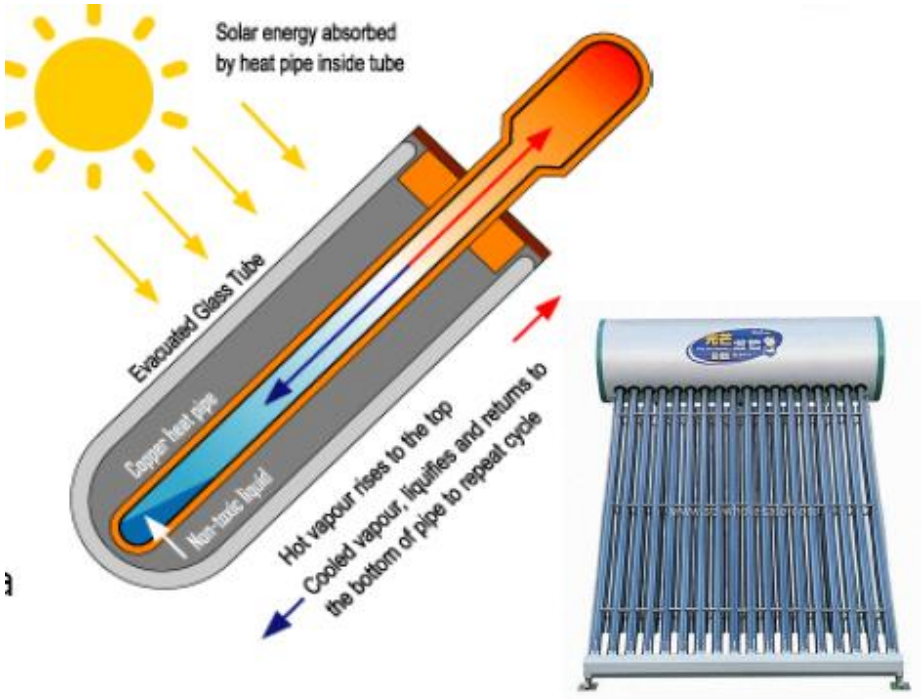
Large power station

Methods of solar energy utilization



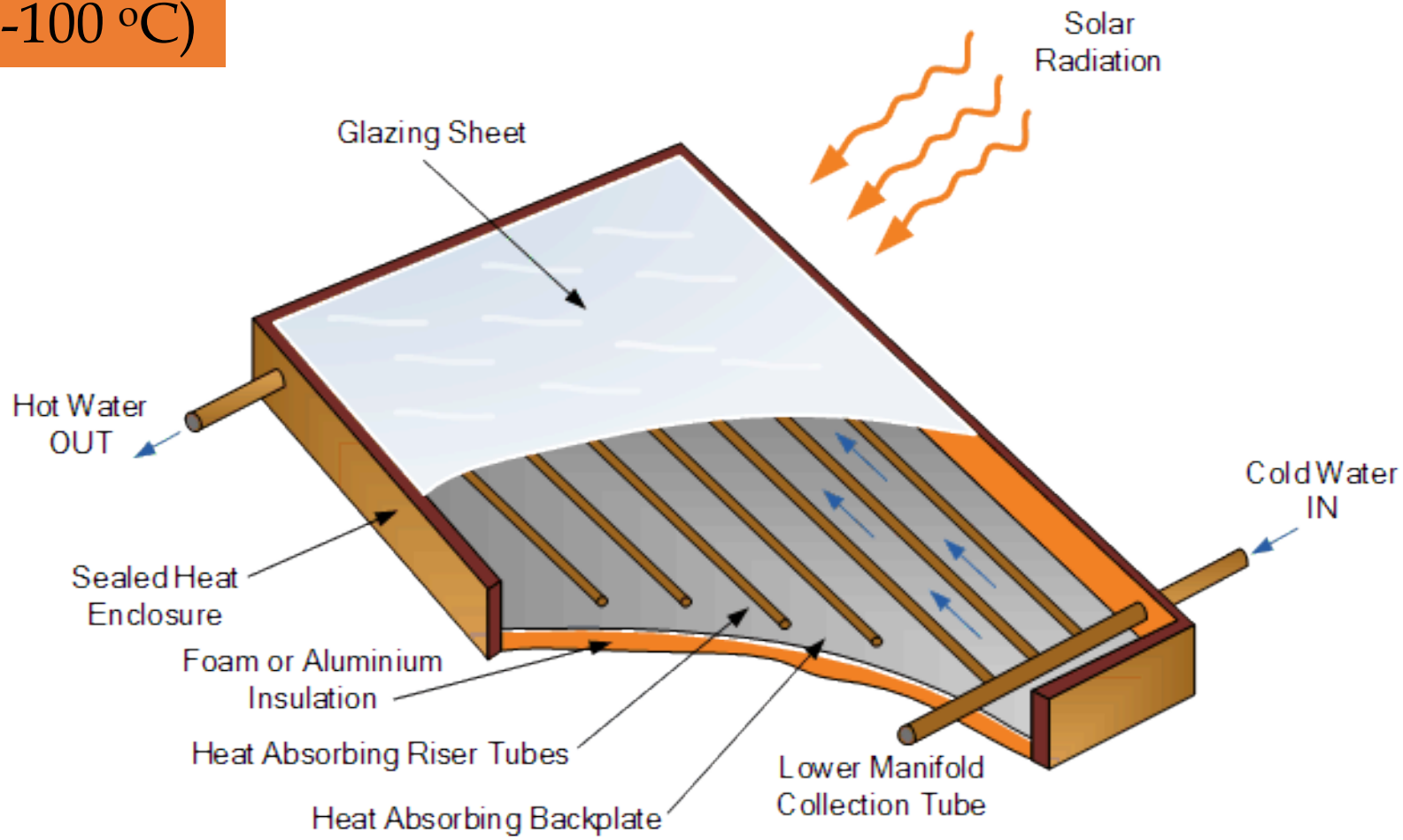
Devices for thermal collection

- Liquid flat-plate collector (40 – 100 °C)
- Evacuated tube collector (ETC) (40 – 130 °C)
- Solar Air heater (up to 90 °C)
- Cylindrical parabolic concentrating collector (up to 400 °C)
- Paraboloid concentrating collector (more than 400 °C)



Devices for thermal collection and storage

Liquid Flat Plate Collector (40-100 °C)

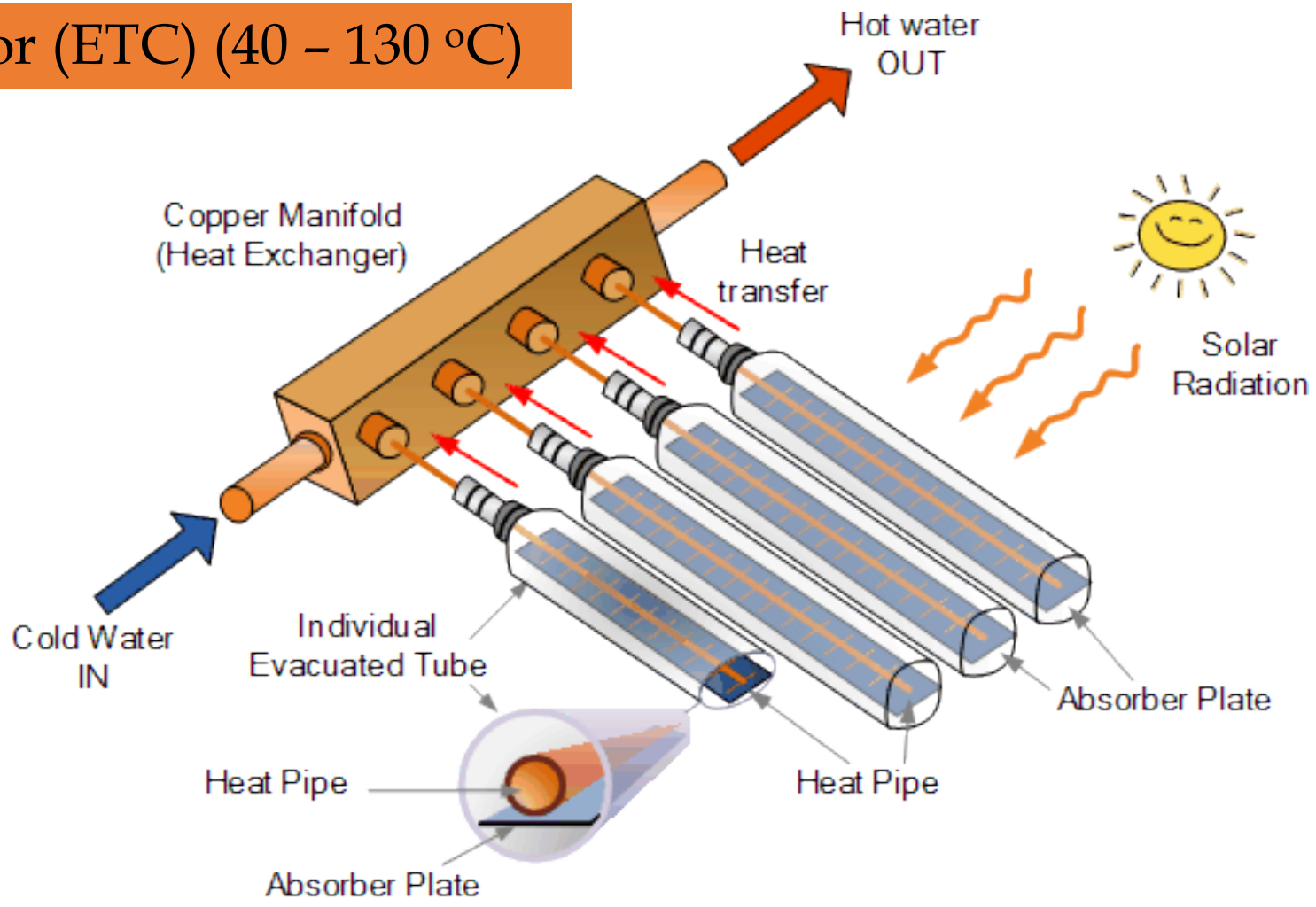


- **Simple in design**
- **No moving parts**
- **Requires little maintenance**

Facing south if located in the northern hemisphere

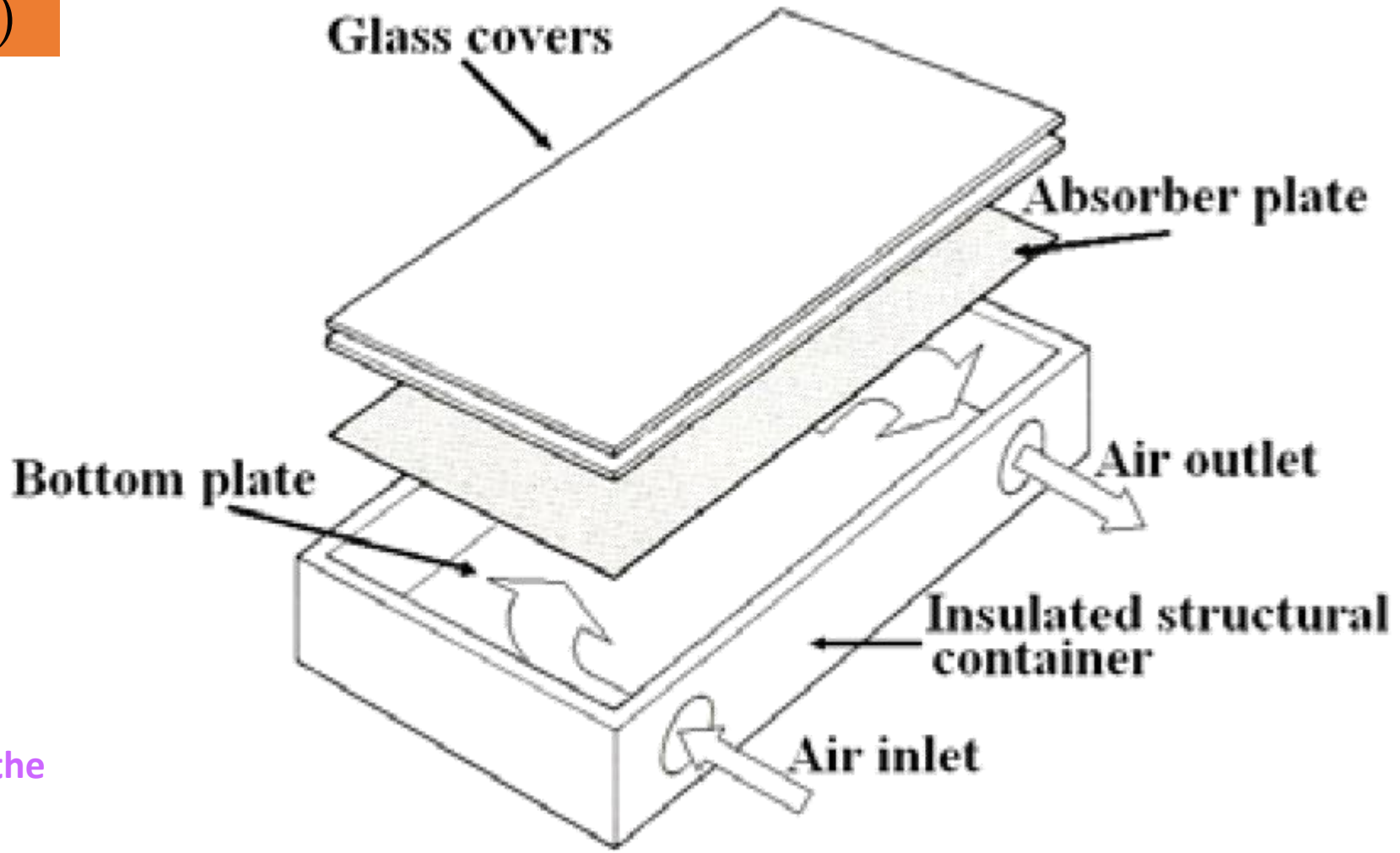
Devices for thermal collection and storage

Evacuated tube collector (ETC) (40 – 130 °C)



Devices for thermal collection and storage

Solar Air heater (up to 90 °C)

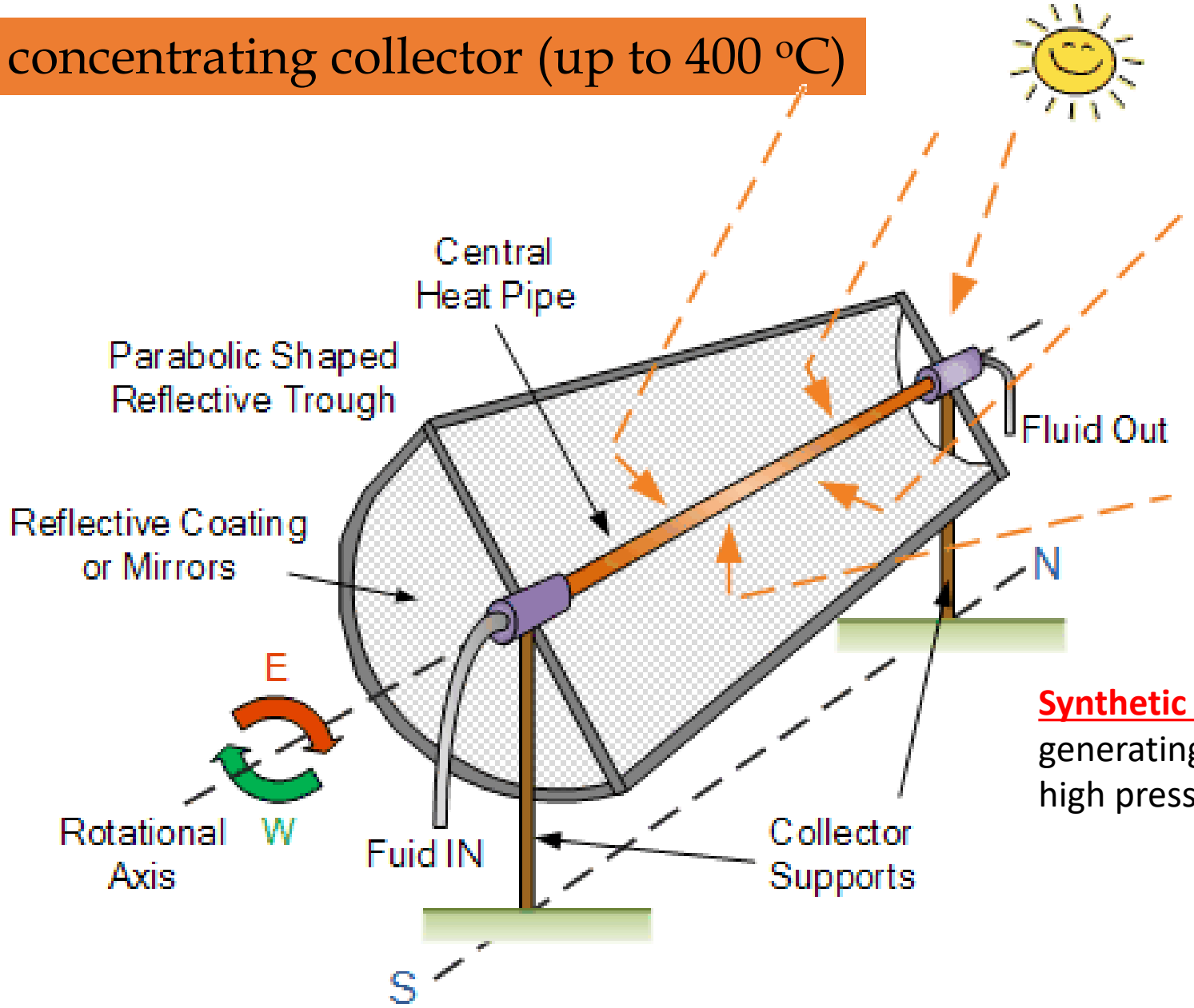


Air passages have to be made larger in order to keep the pressure drop across the collector within manageable limit.

Devices for thermal collection and storage

Cylindrical parabolic concentrating collector (up to 400 °C)

The concentrator has to be rotated to focus the sun's rays onto the absorber tube- the movement is called tracking.

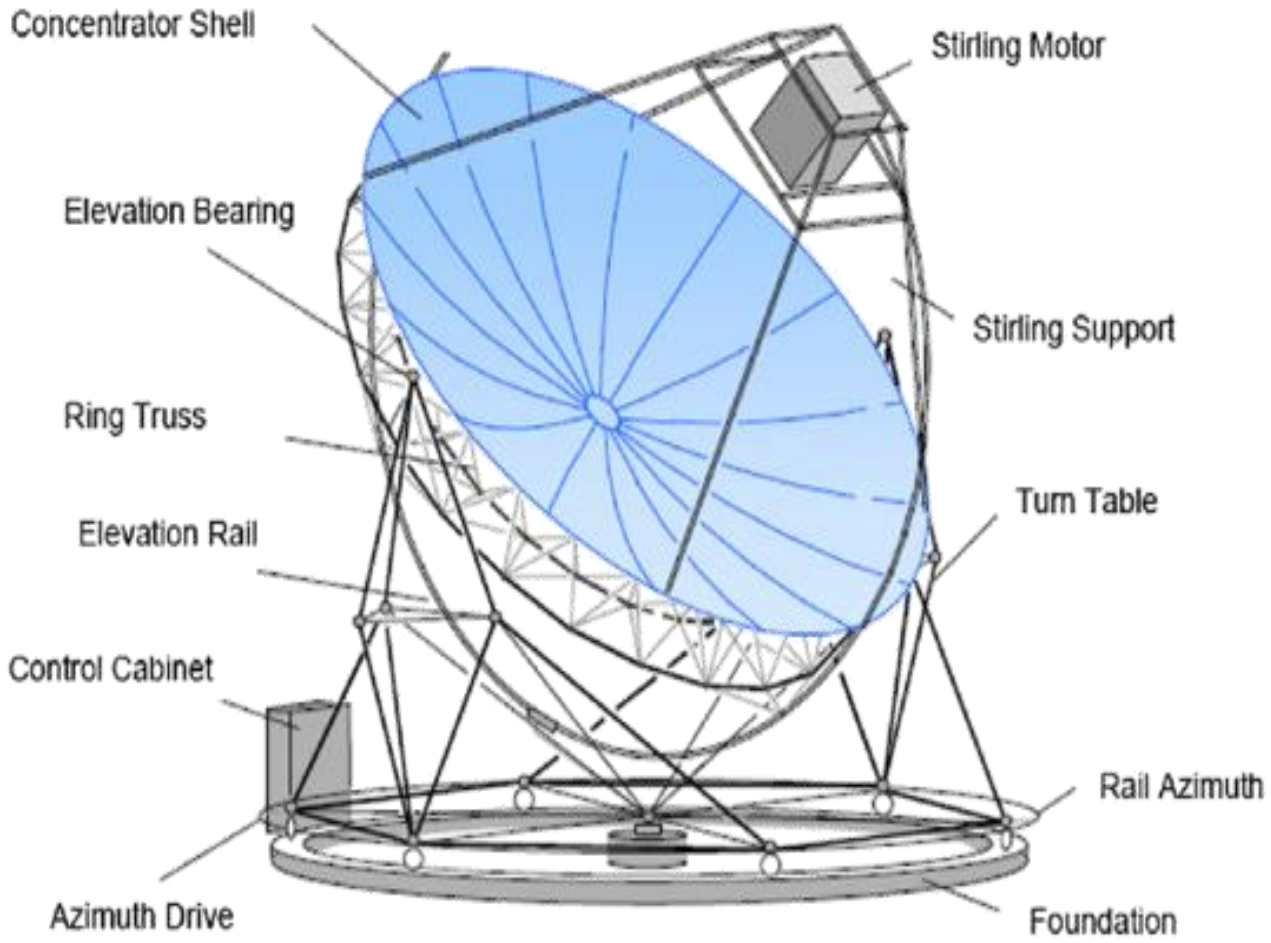


Synthetic oil is used for generating superheated high pressure steam.

Devices for thermal collection and storage

Paraboloid concentrating collector (more than 400 °C)

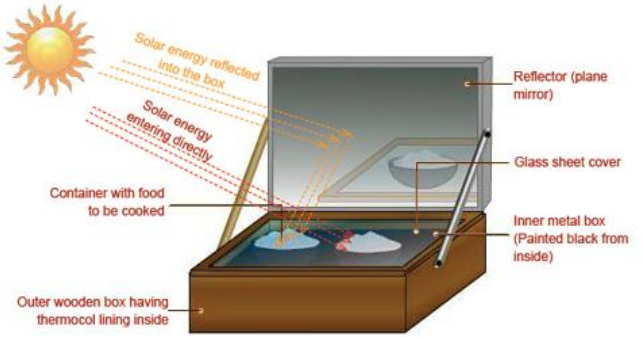
- **Parabolic Disc Concept** (Dish-Starling system)
- **Central Receiver Concept** (Power Tower)

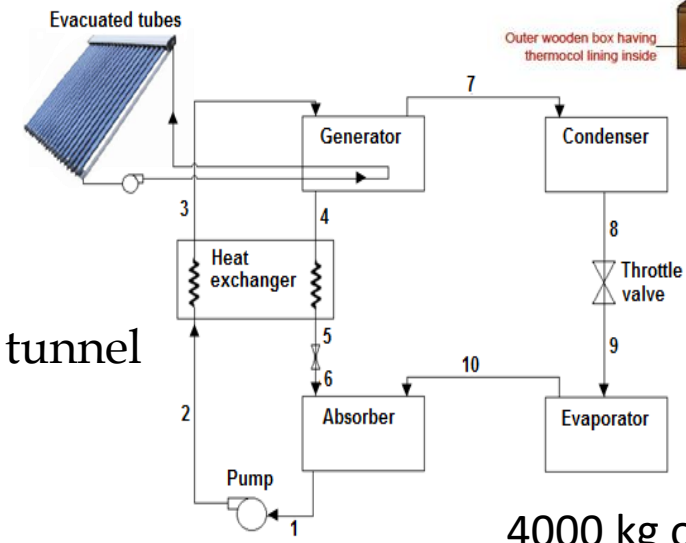


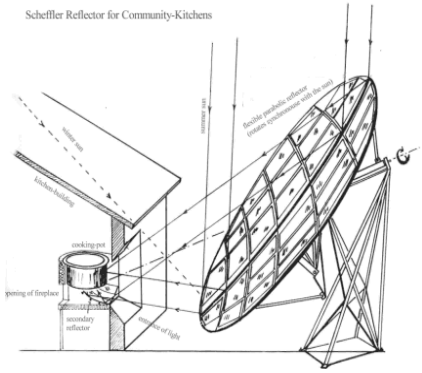
Cost and Reliability

Thermal applications

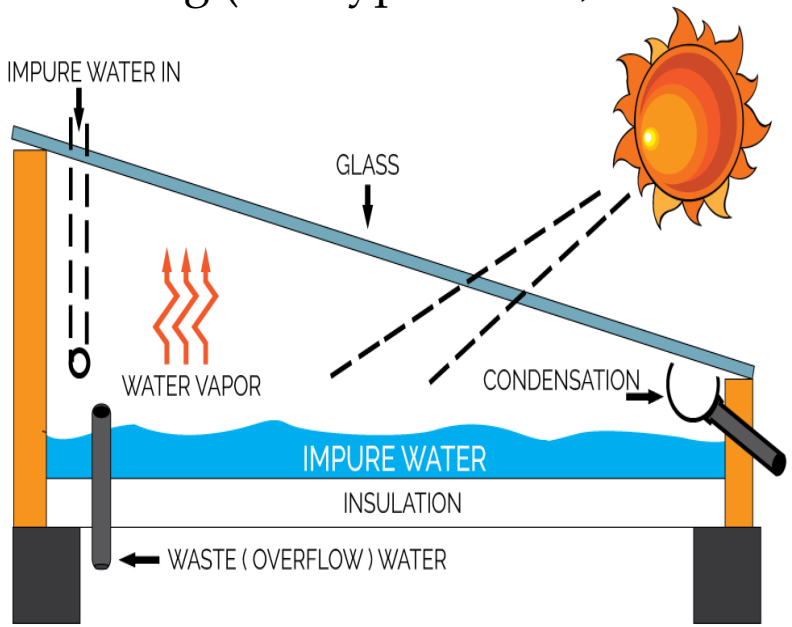
- ✓ Water heating (natural circulated system and forces circulated system)
- ✓ Space heating (active and passive methods)
- ✓ Space cooling and refrigeration
- ✓ Power generation (low, medium and high temperature)
- ✓ Distillation
- ✓ Drying (cabinet, direct and indirect forces circulation dryer, tunnel dryer etc.)
- ✓ Cooking (box-type cooker, scheffler cooker)

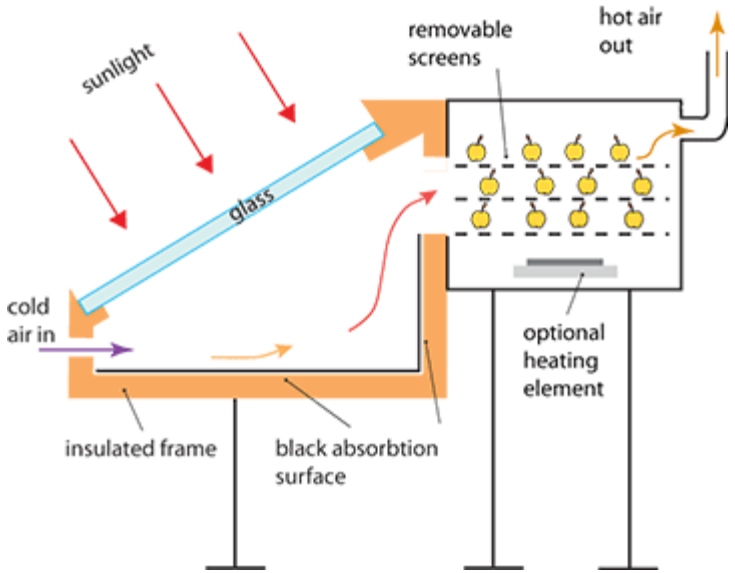


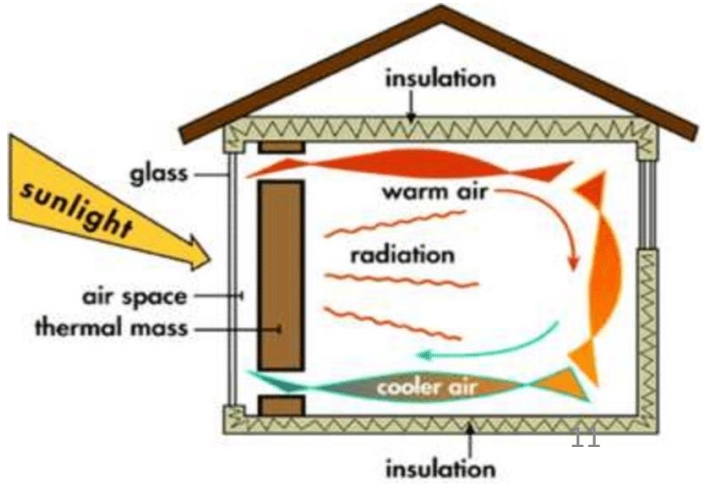




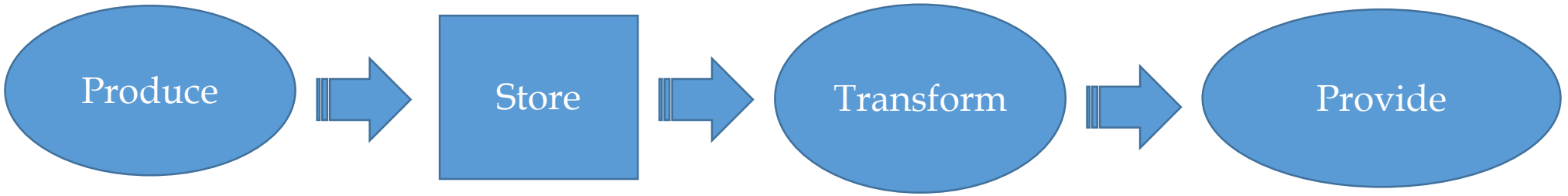
4000 kg of steam per day at 180 °C and 10 bar, capacity: food for 15000 persons per day.







PV Generator



Two major families of PV generators:

- *Stand-alone*
- *Grid-connected*

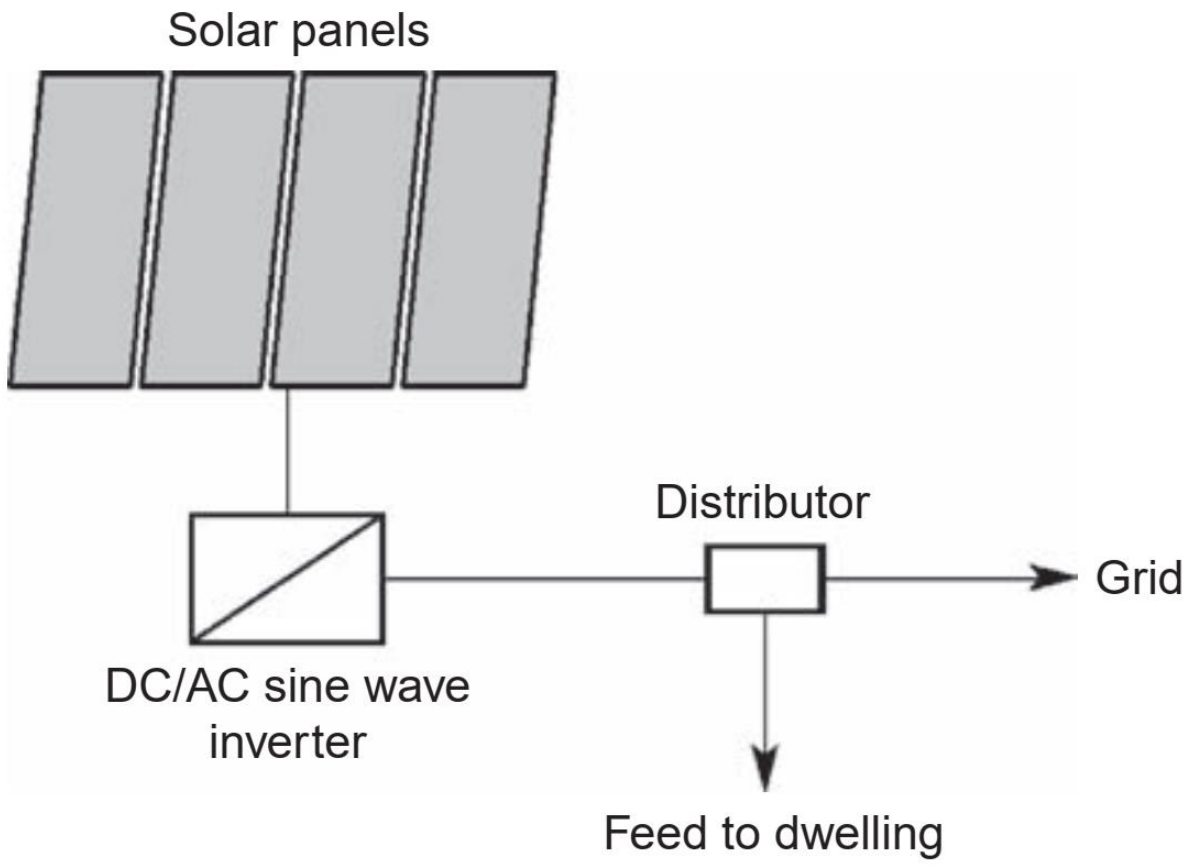
Stand alone system

Direct feed solar pump

Stand-alone PV system with storage by a battery (with or without energy conversion)

Hybrid stand-alone system using PV and diesel generator

Grid connected PV system



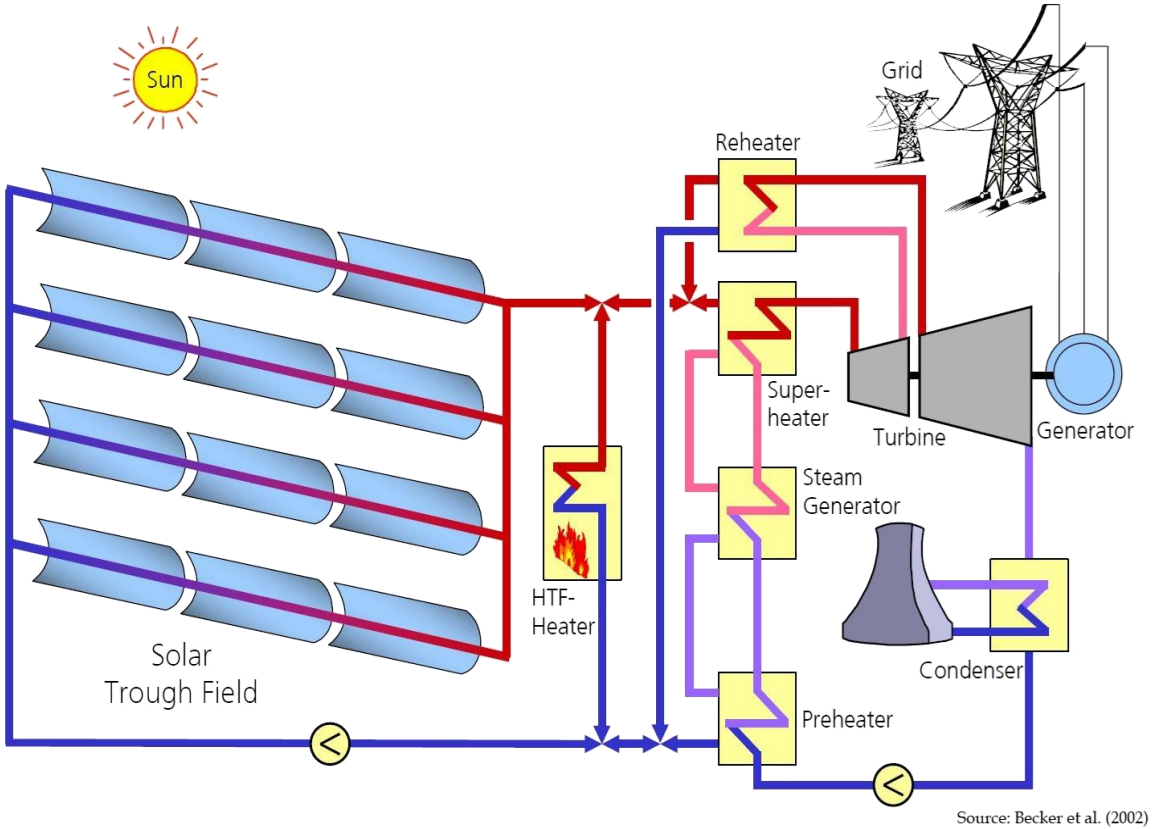
Storage of Energy

Thermal, Electrical, Mechanical or Chemical

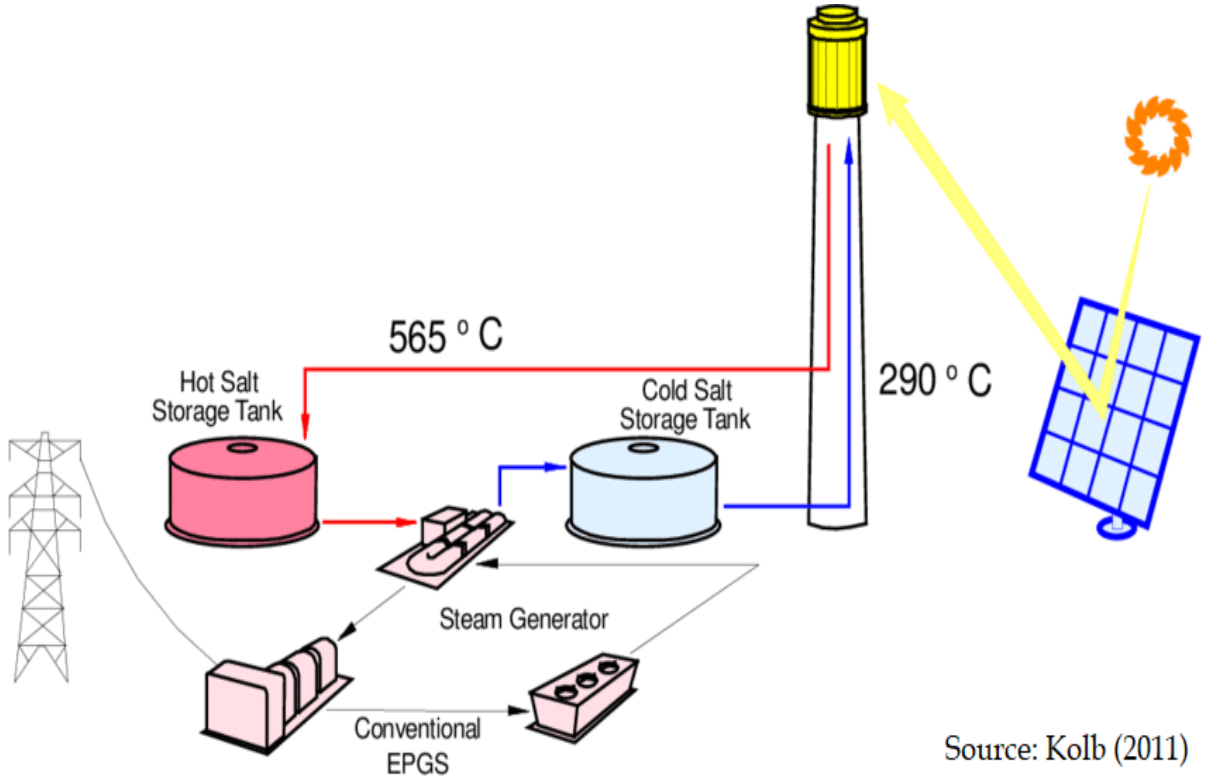
- Thermal
  - Sensible Heat Storage (operate over a range of temperatures)
  - Latent Heat Storage (operates at which phase change takes place)
  - Novel device: Solar Pond
- Electrical
  - If the electrical power is being obtained after conversion, storage could be in the form of electrical batteries (Lead-Acid batteries)
- Mechanical
  - Compressed air system
  - Flywheel
- Thermochemical Storage
  - The solar energy to be stored is used to produce a certain endothermic chemical reactions and the products of the reaction are stored.

Solar Power plant

- Low temperature power generation (Using FPC)
- Medium temperature (Using Cylindrical Parabolic Concentrating collector)
- High temperature (central receiver system)



Source: Becker et al. (2002)



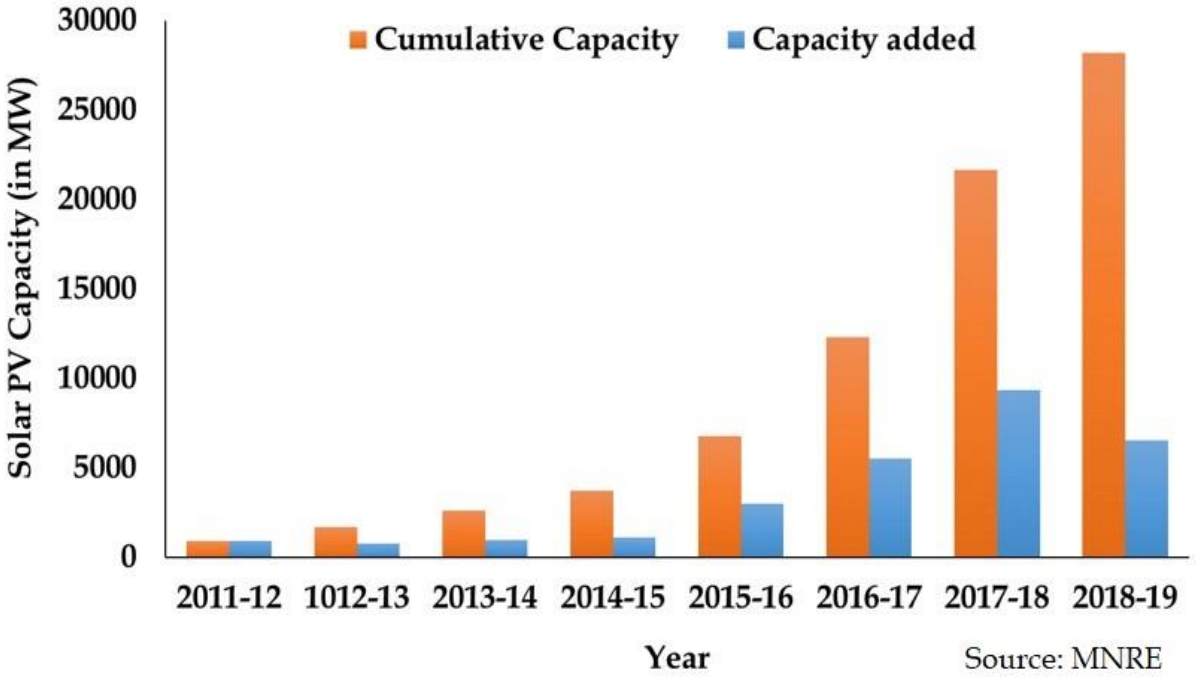
Source: Kolb (2011)

Solar Power Plants in India

Off-grid Solar PV installations in India till March 2019

- Solar Lamps/Lanterns: 65,17,180 units
- Solar Pumps: 2,37,120 units
- Solar Street Lights: 6,71,832 units
- Solar Home Lighting Systems: 17,15,639 units
- Solar Power Plants/Packs: 212 MWp

Grid connected PV installed capacity in India



Largest PV power plants in India

Pavagada Solar Park (Shakti Sthala), Karnataka (2050 MW)

The installed capa lar thermal power plants (non storage type) in India is 227.5 MW with 50 MW in Andhra Pradesh and 177.5 MW in Rajasthan.

Bhadla Solar Park, Rajasthan (1515 MW)

wer Project, Tamil Nadu (648 MW)

Kurnool Ultra Mega Solar Park, Andhra Pradesh (1000 MW)

Charanka Solar Park, Gujarat (615 MW)

Summary

- We have learned the different routes of exploiting solar energy
- Methods of Energy utilization
- Devices for thermal collection and storage
- To understand the basic functioning of LFPC a numerical example has been solved
- How does a PV generator work and its different routes of utilization has been discussed.
- Introduced the concept of Solar power plant and installation of different solar power plant are summarized.

Thank you