Sustainable Energy Alternatives

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Institute of Chemical Technology

Institute of Chemical Technology

- Established in 1933 - Industry's wish
- Chem Engg + Pharma + seven Chem Tech
- 250 graduate with Bachelors/yr (~1050)
- 100 to 150 complete Doctorates/yr (~700)
- Close to 200 complete post graduation/yr (~450)
- Highest Chemical Tech/ Engg publications in India
- 4th rank by publications per faculty across the globe
- 42% of Chem + Pharma Industry in India votes for ICT
- ~30% are enterpreneurs - who's who in CI
- CII-AICTE award for best industry related institute

Outline

1. Introduction
2. Sources of Energy
3. Solar Energy
   - Collection
   - Energy Ladder
   - Conversion
   - Solar Energy Utilization
4. Technologies Under Exploration

Outline

1 Introduction

2 Sources of Energy

3 Solar Energy

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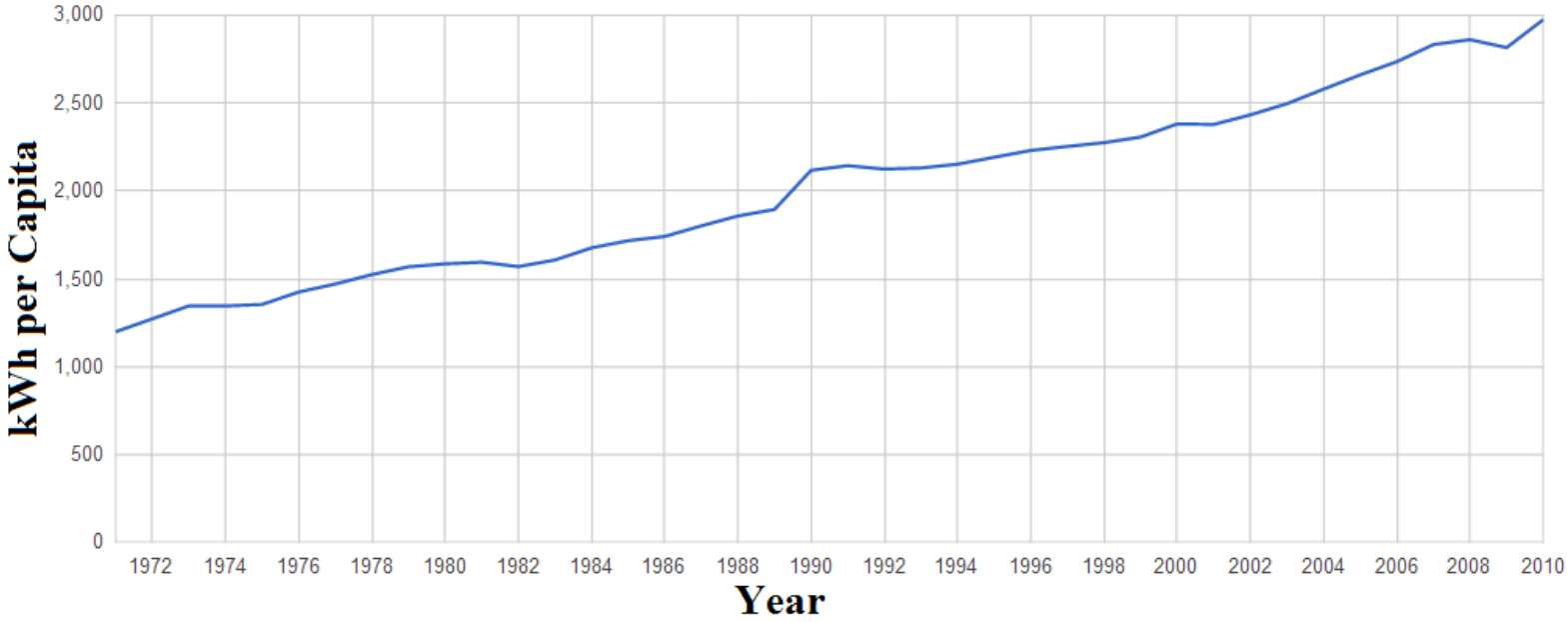
4 Technologies Under Exploration

Global Energy Supply System

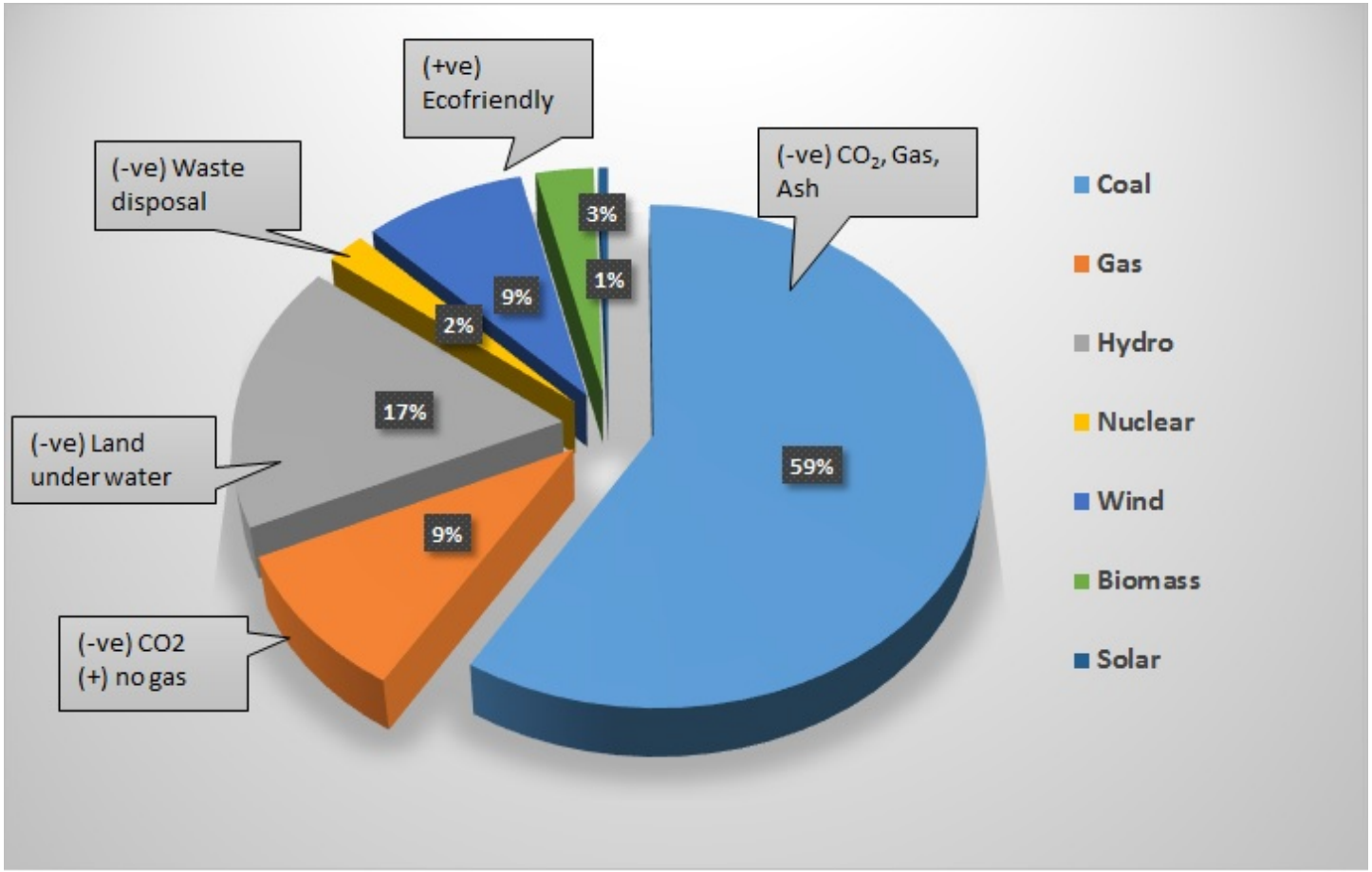
- Energy consumption till 16^{th} century - highly sustainable
- Fossil fuels: 20 tonnes plants + millions of yrs $\equiv$ 1 liter of gasoline
- Limited availability (and bad distribution) of fossil fuels,
- Climate change by coal electricity
  - ~ 1.6 kg of CO_2 /kWh
  - ~ 0.2 kg of ash/ kWh
  - ~3 kg of water/ kWh
- Nuclear option : weapons and radioactivity risk
- Alternative sources of Energy / Sustainable living with reduction of consumption

World Electricity Consumption



Energy Consumption has Tripled In Last 50 Years

India's Electricity 280 GW Generation Capacity



Indian Energy Scenario

- Fourth largest energy consumer in the world
- Installed electricity generation capacity - 280 GW
- 150 GW is based on fossil fuels (56 % on coal)
- Electricity shortage - 8 % overall & 12-15% peak requirement
- per capita electricity consumption (571 kWh & rising- India & 12,917 - USA)
- per capita CO_2 emission (1400 kg & rising- India & 17200 kg - USA)
- Doha - Kyoto - Paris - China - India
- Hydroelectricity - Sociopolitical issues

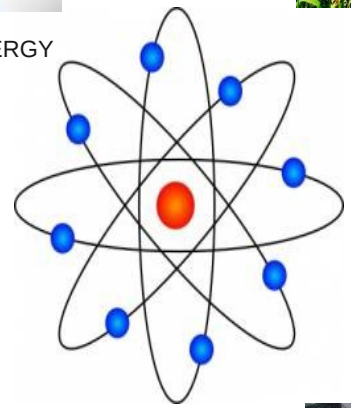
India- Energy Actions

- Europe : 80% of all added power capacity in the last 2 years -based on solar energy
- Over 20 GW of solar PV added in europe in less than 2 years
- India: Tropical country with abundant sunshine, lack of oil
- Solar power : 0.1 to 1.0 GW today, 22GW by 2022
- Warm climate - high sink temperature - low efficiency

Sustainable Energy Sources

SOLAR ENERGY

BIOMASS



WIND ENERGY

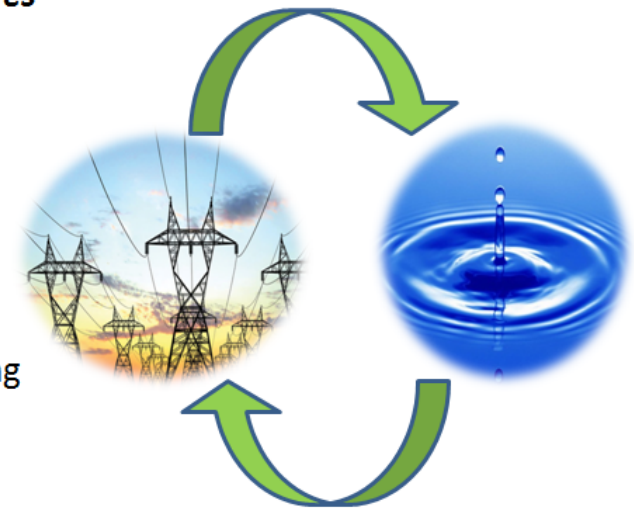
HYDRO ENERGY

Energy-Water Nexus

Water for Energy

Energy and power production requires water:

- Thermoelectric cooling
- Hydropower
- Energy minerals extraction / mining
- Fuel Production (fossil fuels, H_2, biofuels/ethanol)
- Emission controls



Energy for Water

Water production, processing, distribution, and end-use requires energy:

- *Pumping*
- *Conveyance and Transport*
- *Treatment*
- *Use conditioning*
- *Surface and Ground water*

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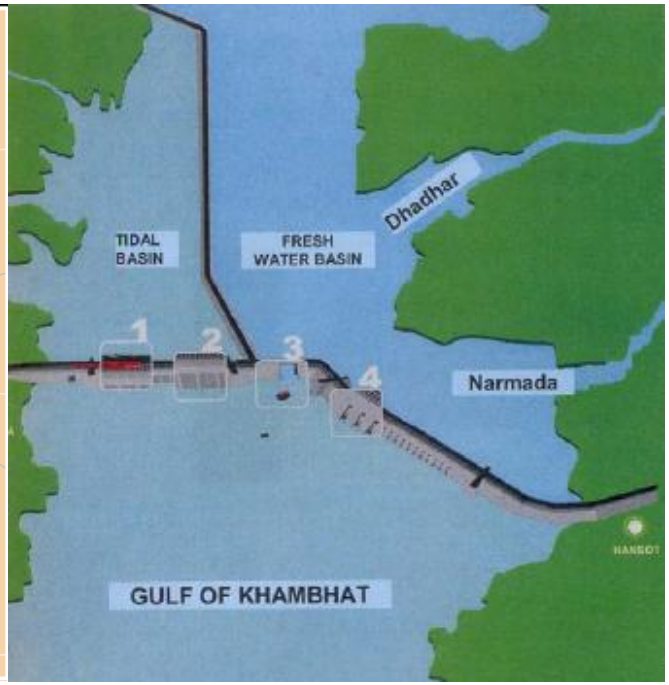
Hydropower

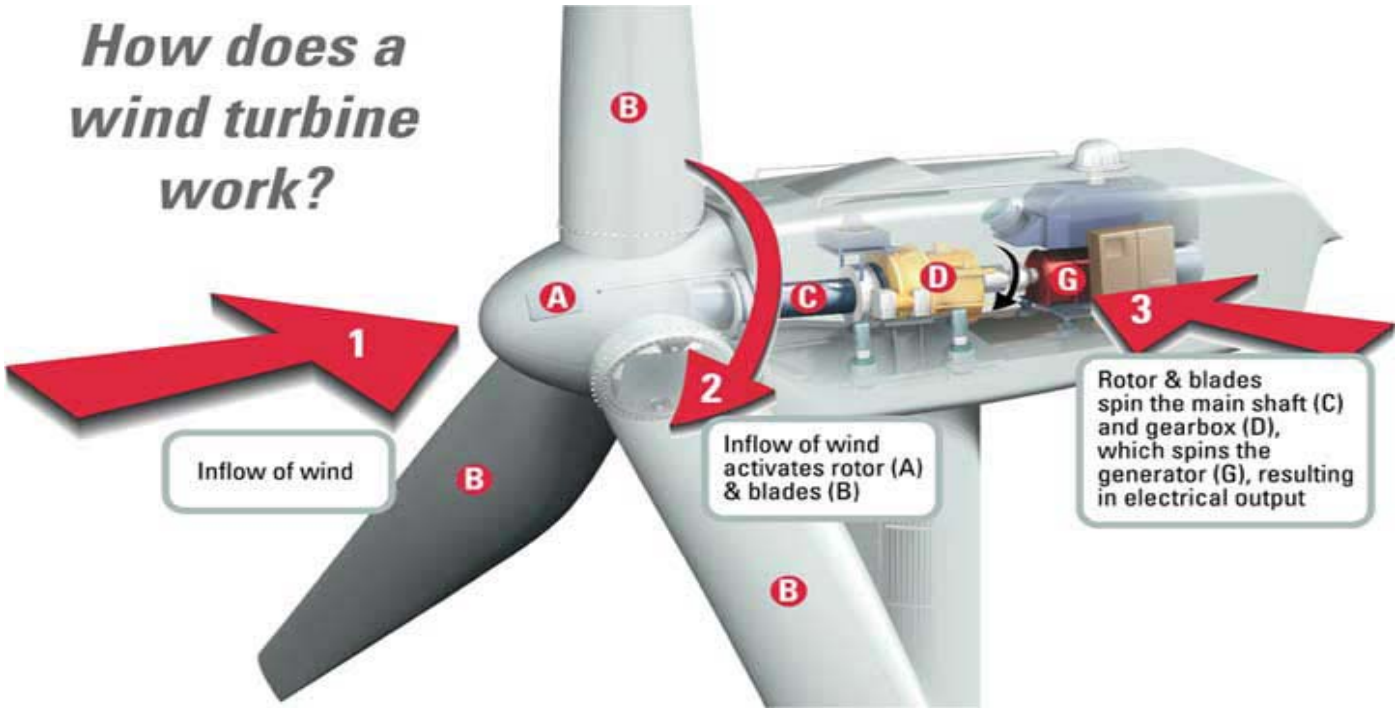
- Limited and non-distributed locations
- Socio-political issues - displacement
- Geological effects
- Kalpasar Project - Bhagirath efforts

Kalpasar

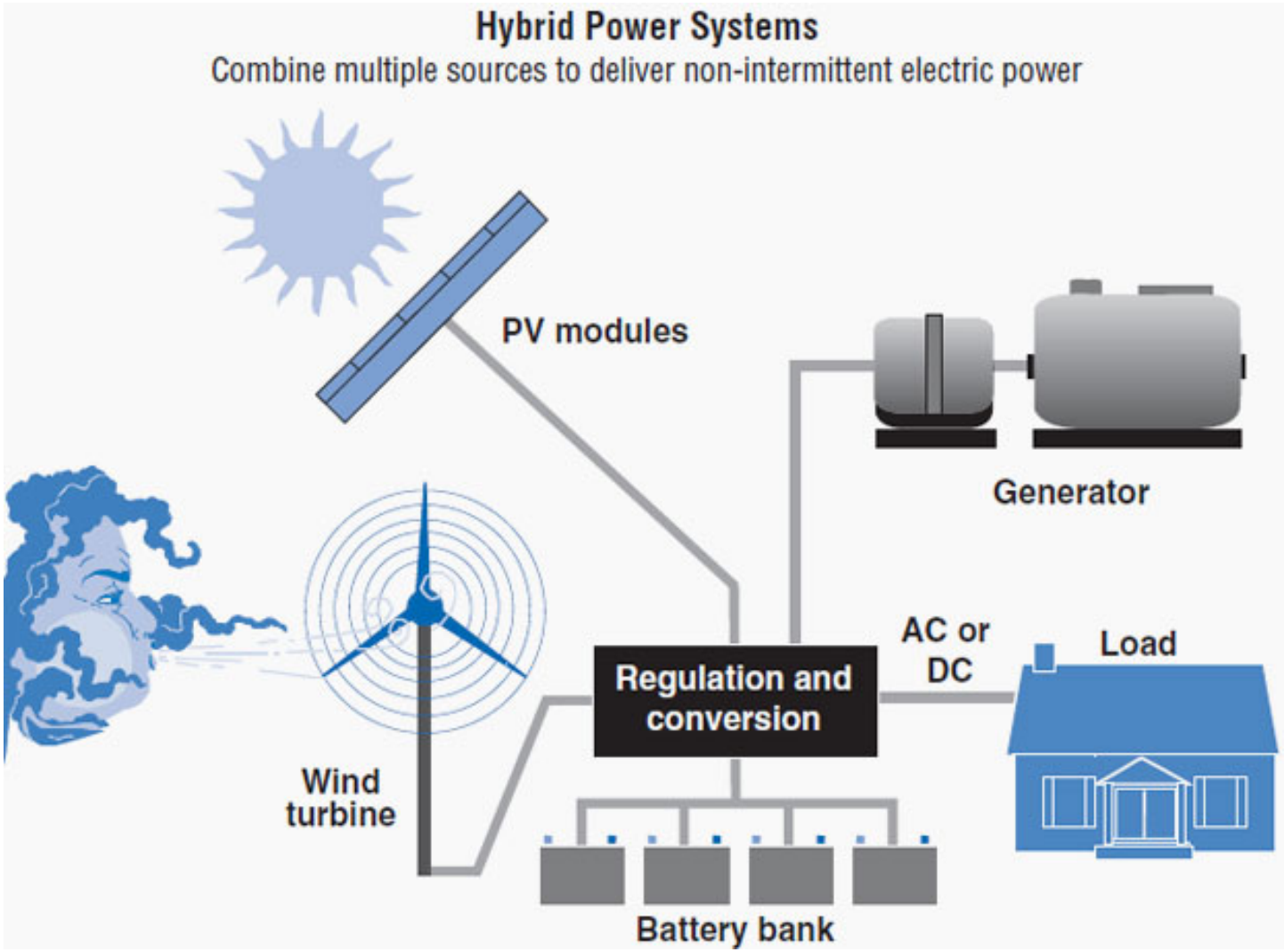


Wind Energy

- Sun warms the land
- Land warms the air, which expands & rises

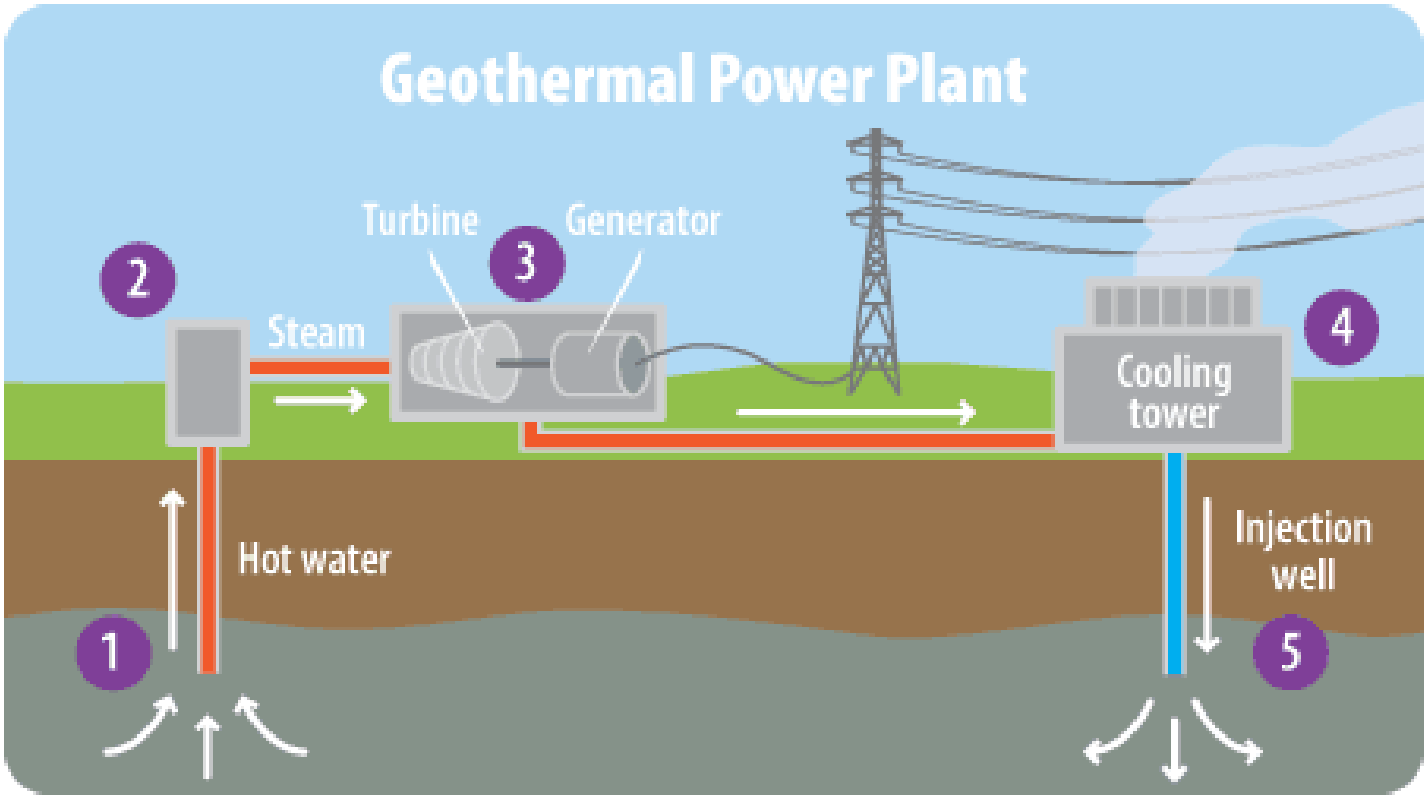


Hybrid Power Systems



Geothermal Energy

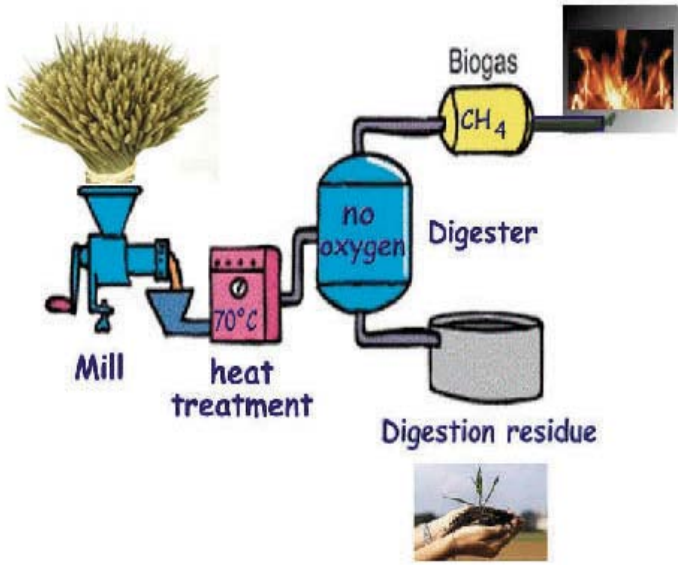
- Geothermal energy is thermal energy generated and stored in the Earth



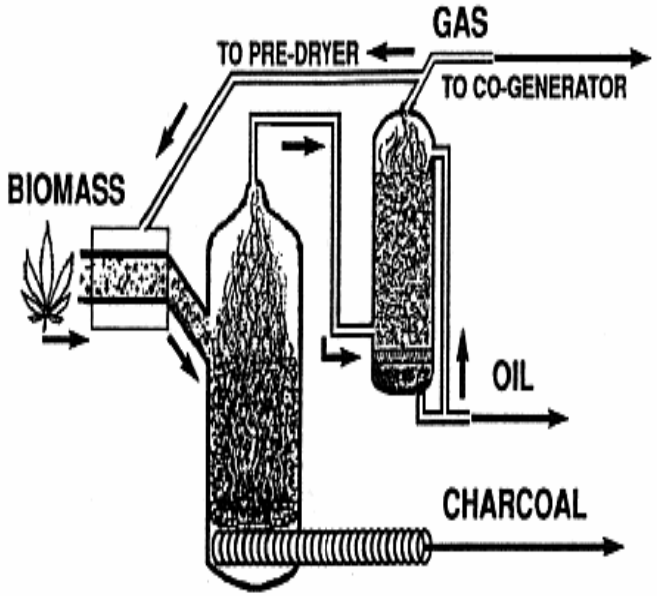
Bioenergy

BIOMASS

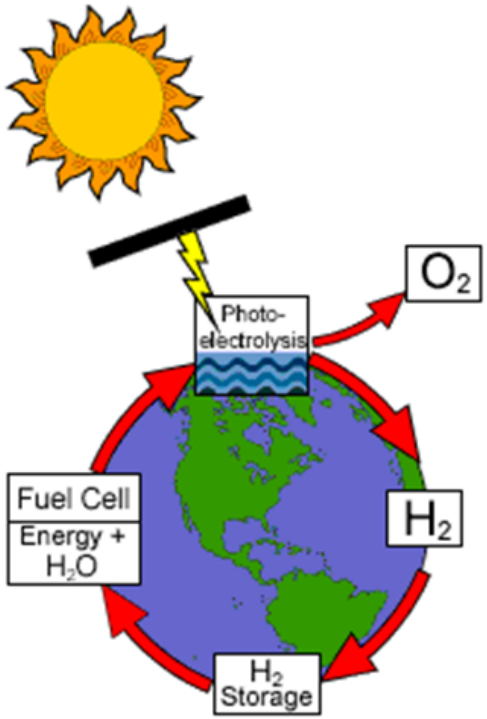
ANEROBIC DIGESTION



PYROLYSIS



Hydrogen Fuel



- Solar energy can split water into hydrogen & oxygen
- A fuel cell can make electricity from hydrogen and oxygen, making water
- A completely clean, renewable cycle

Ancient wisdom

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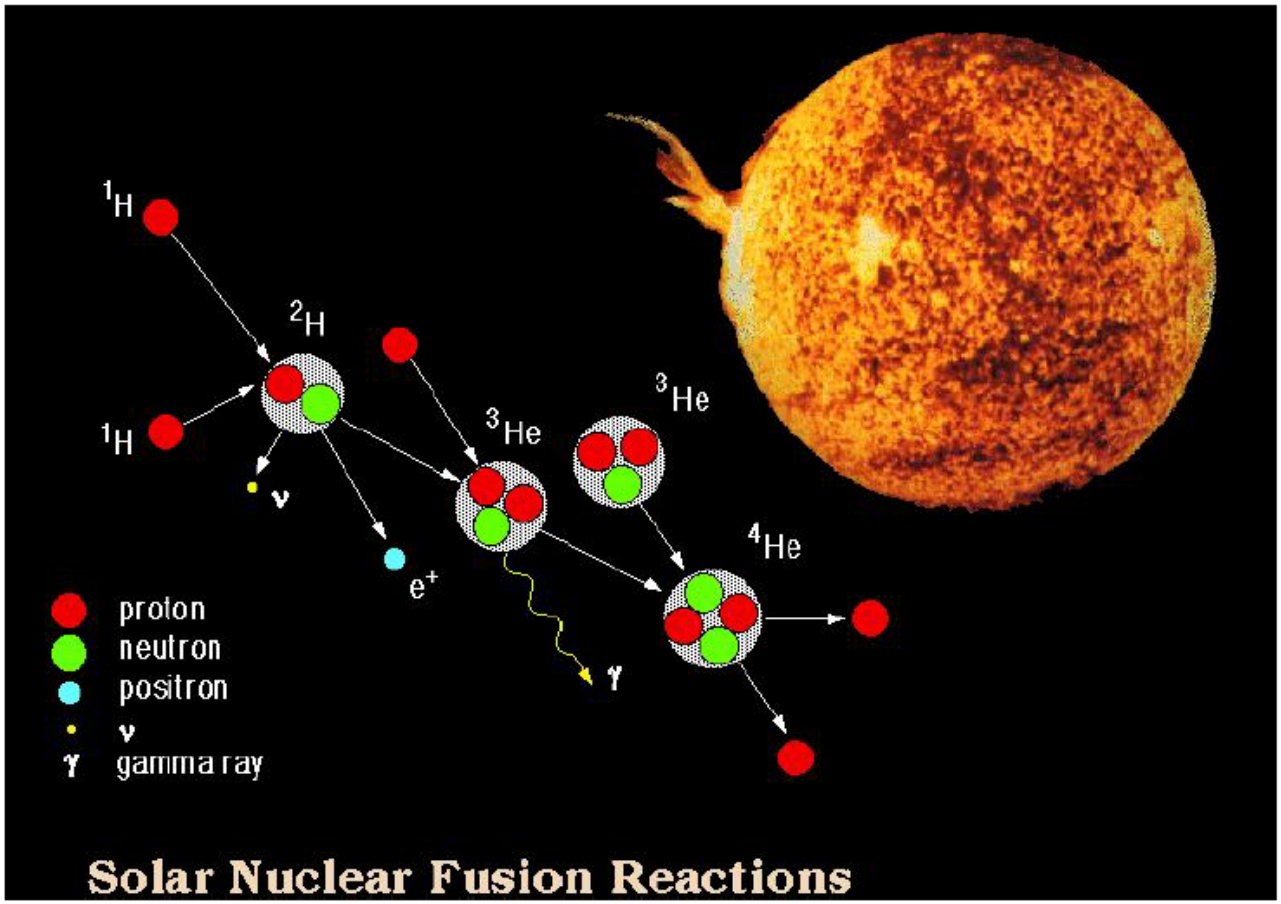
Why Solar Energy ?

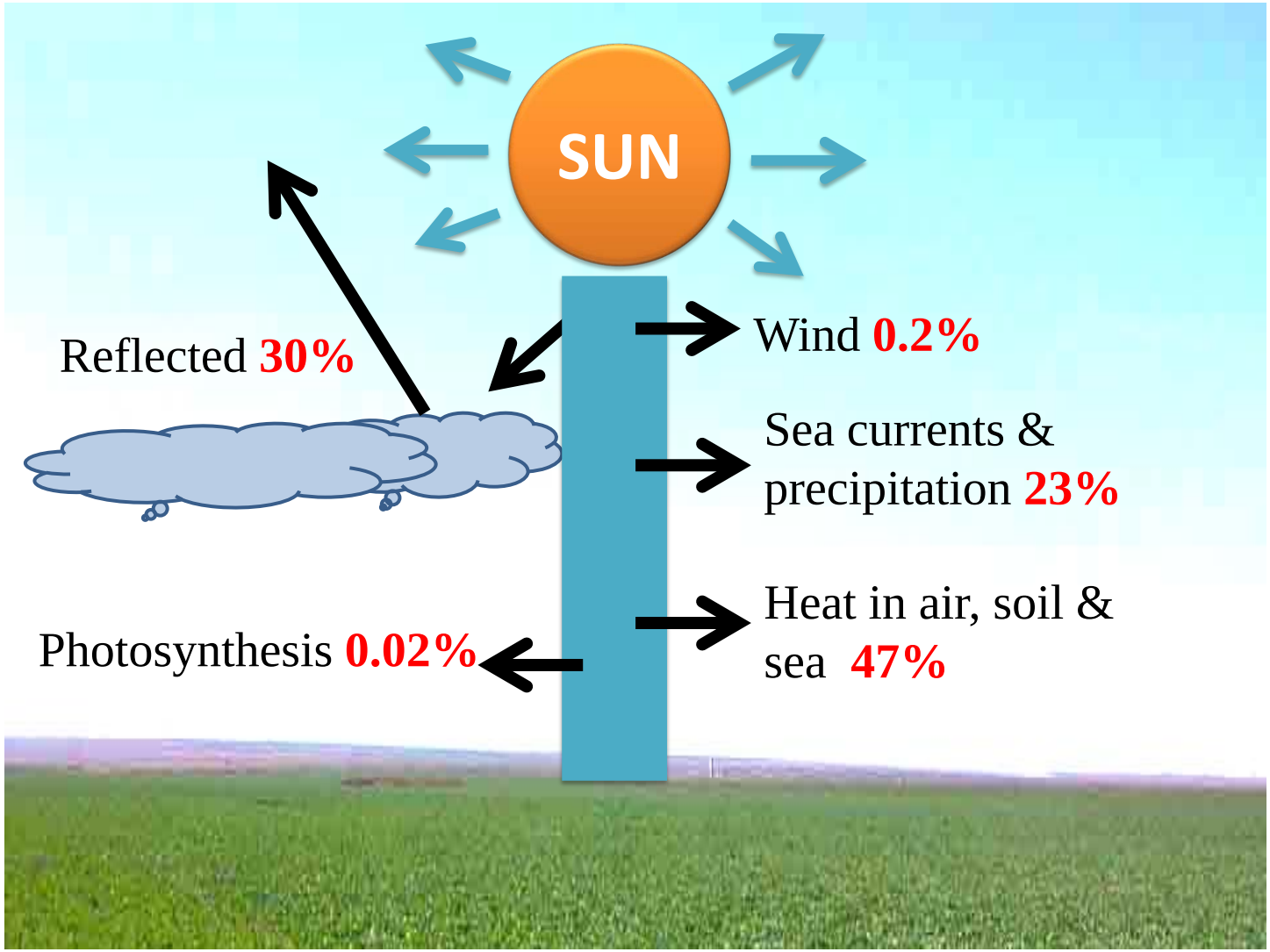
- Advantages
  - Non polluting
  - Non depletable
  - Free availability
  - Distributed
- Challenges
  - Large collectors and hence costs
  - Variations - diurnal/ seasonal/ geographical
  - Dilute in form - Land cost
  - Suitable technology
  - Artificially low fuel cost

Solar Energy : Thermonuclear Fusion Reaction

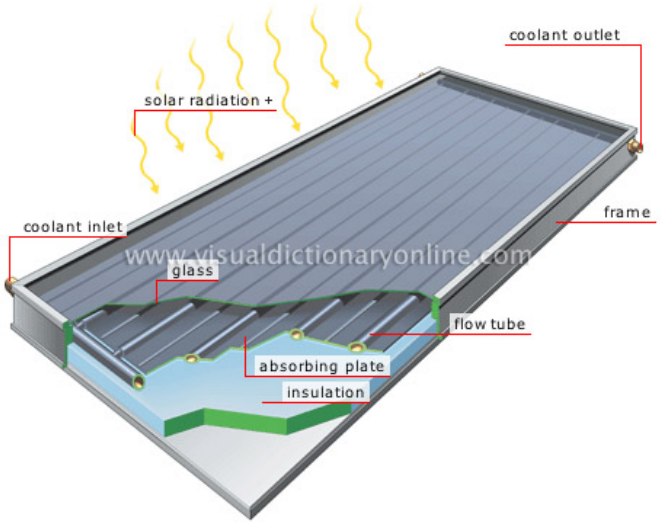
Fusion Reactor at Safe Distance



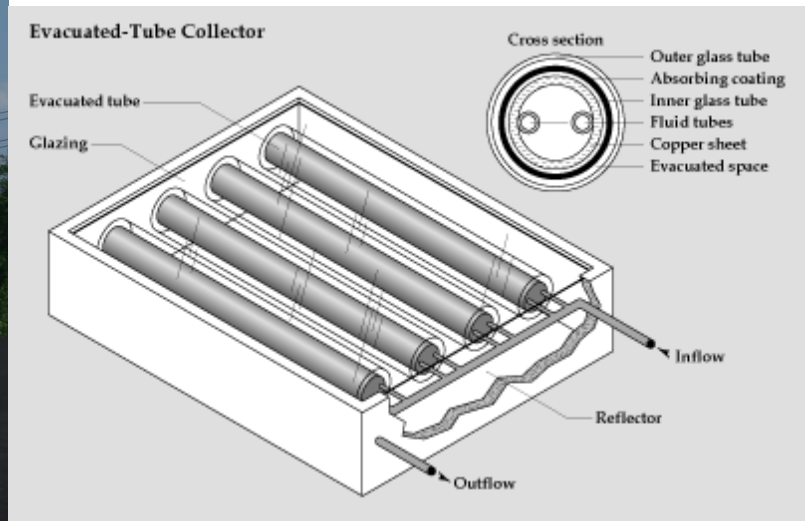
Global Energy Budget



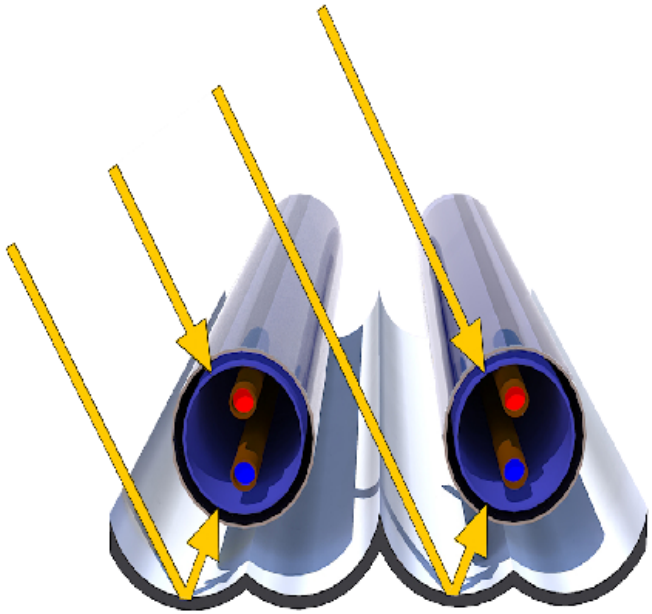
Flat Plate Collectors



Evacuated Tube Collectors

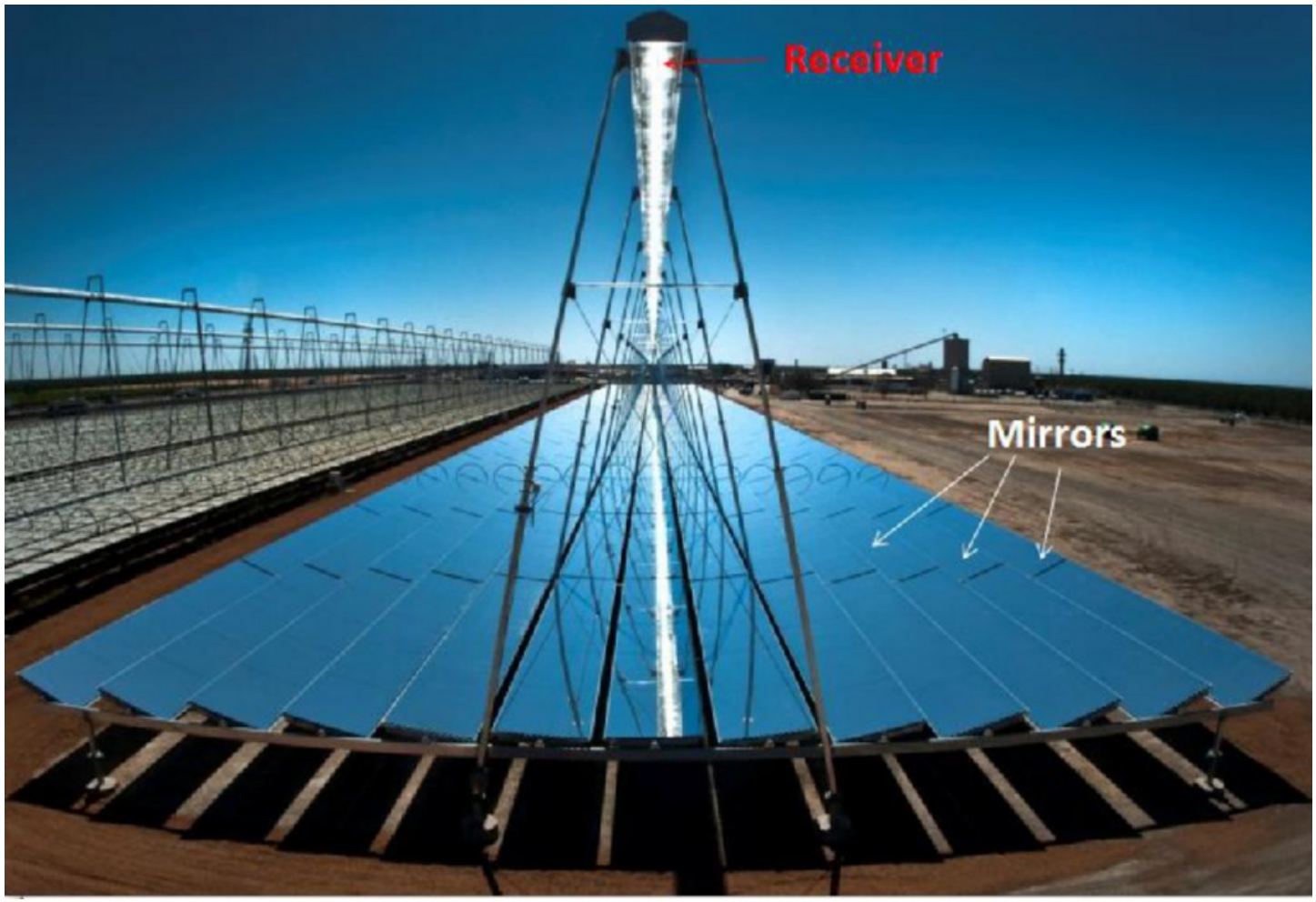


Compound Parabolic Collectors

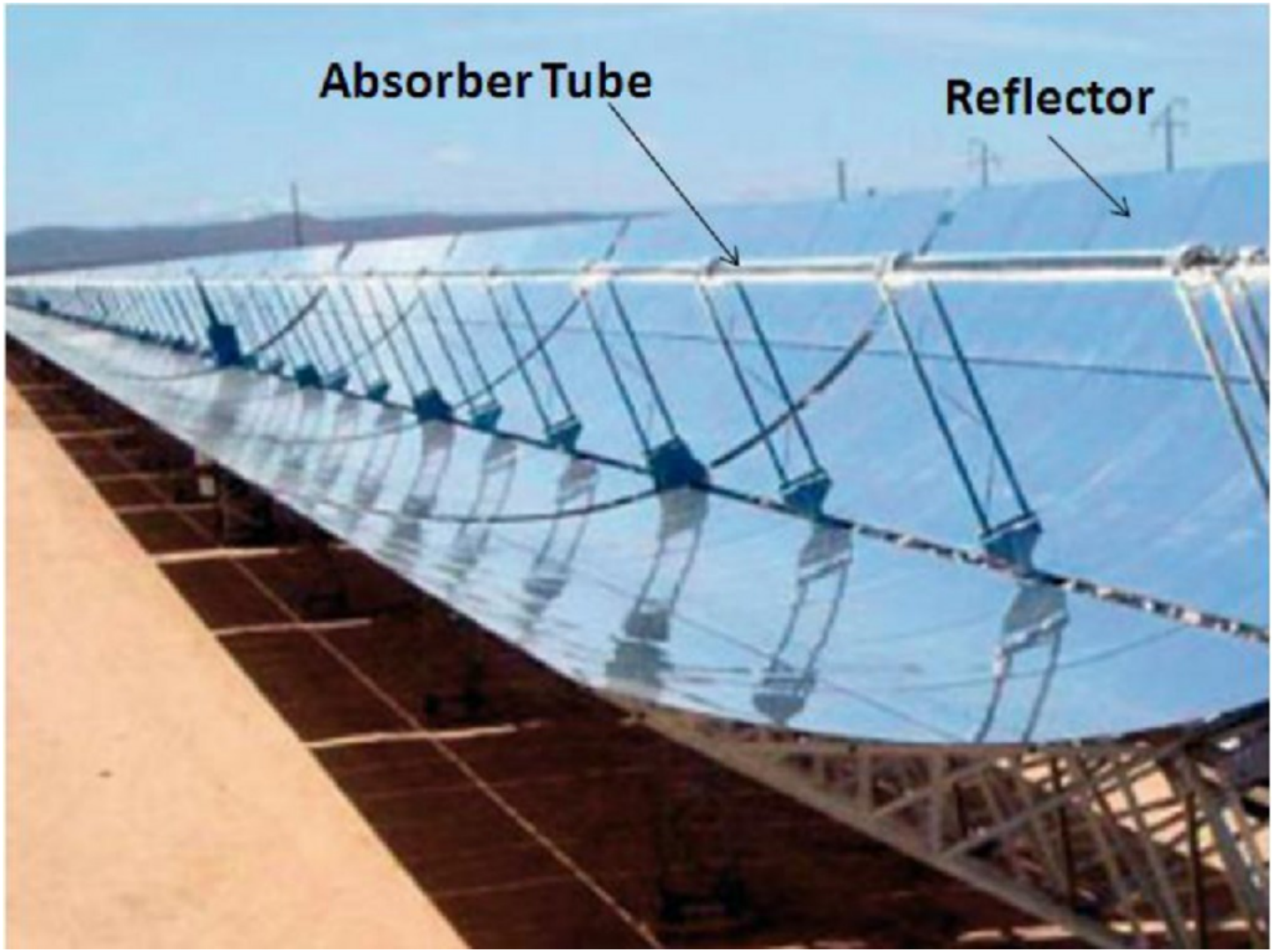


Tracking costs almost eliminated

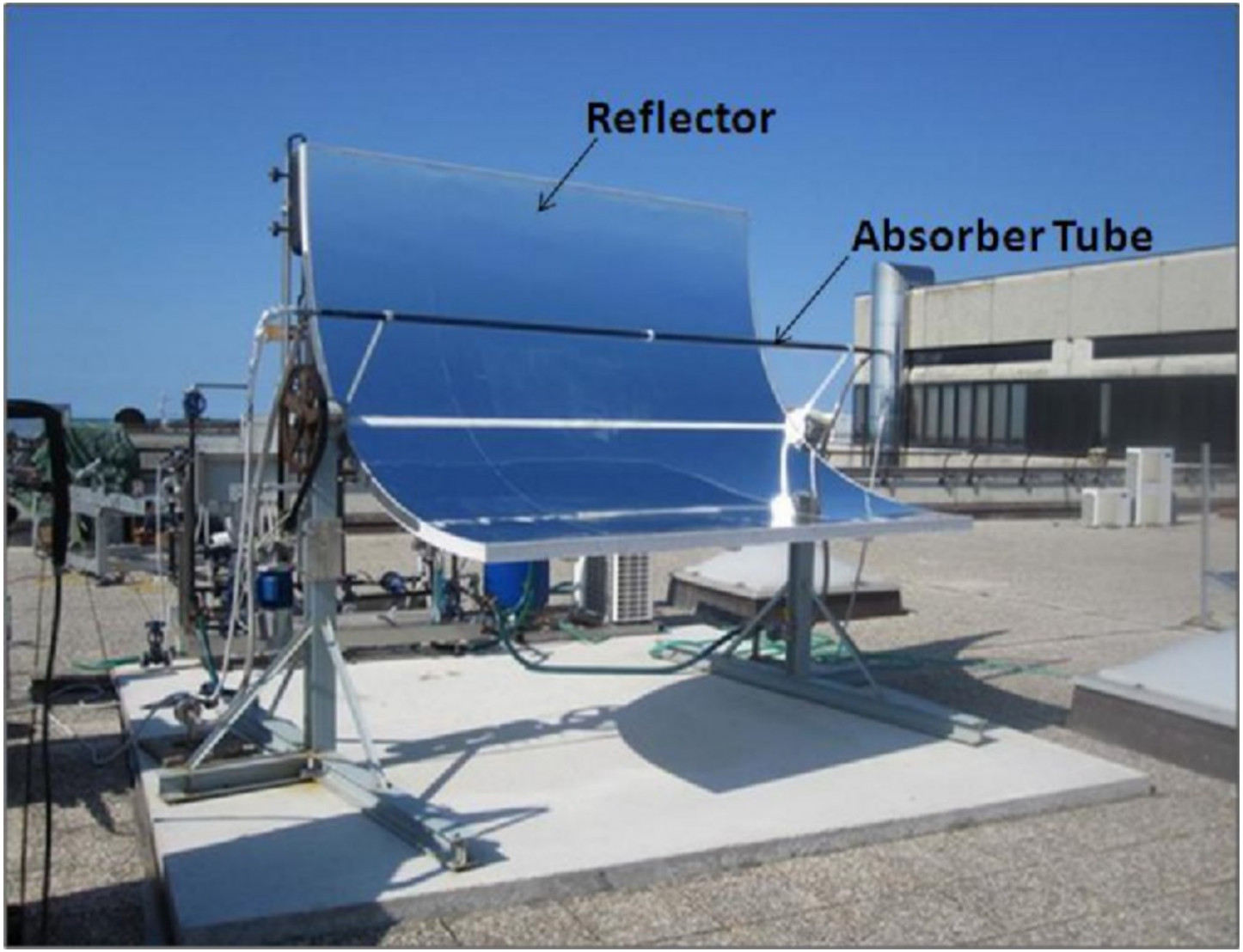
Linear Frensel Reflector



Parabolic Trough Collector

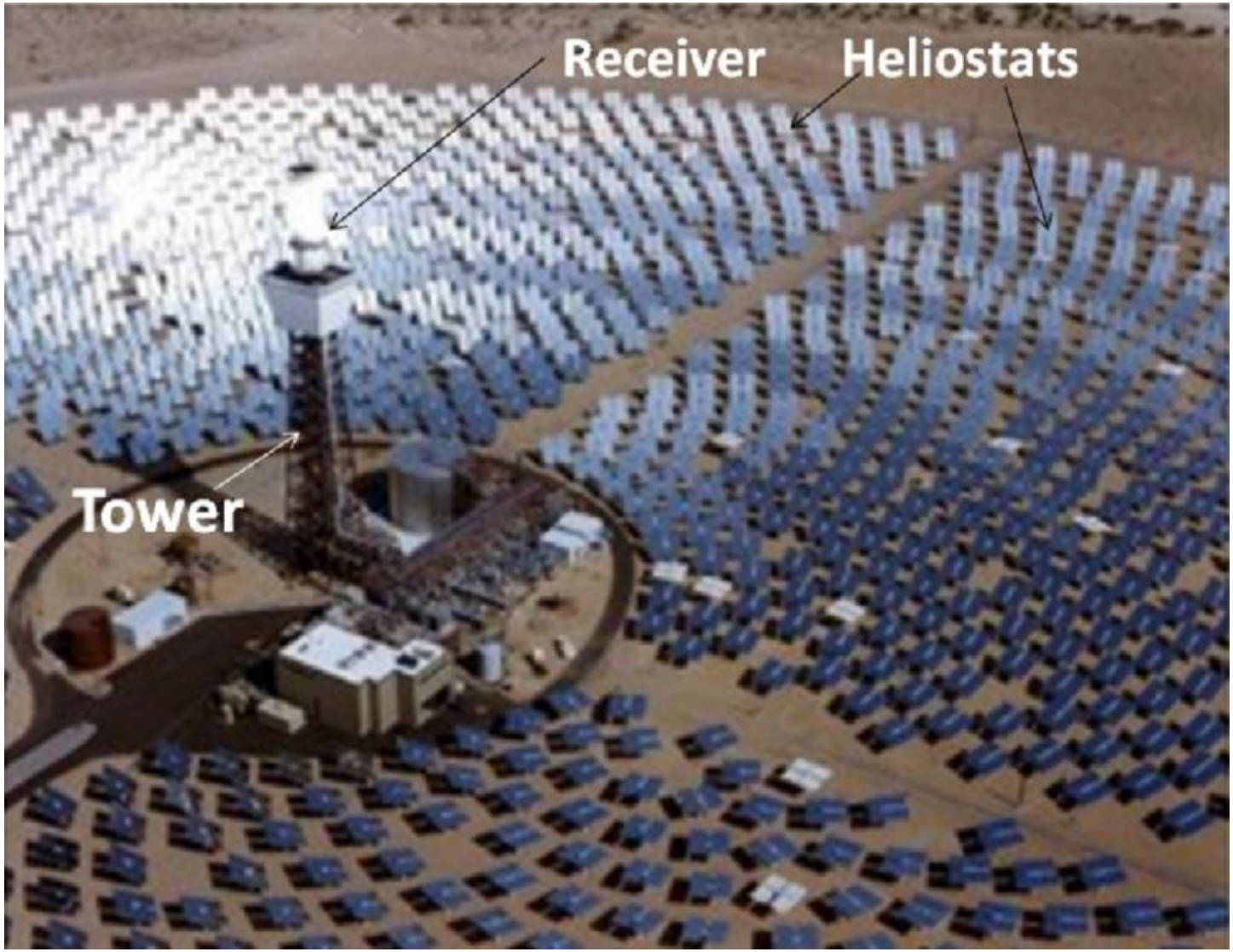


Cylindrical Trough Collector



Parabolic Dish Reflector

Heliostat Field Collector



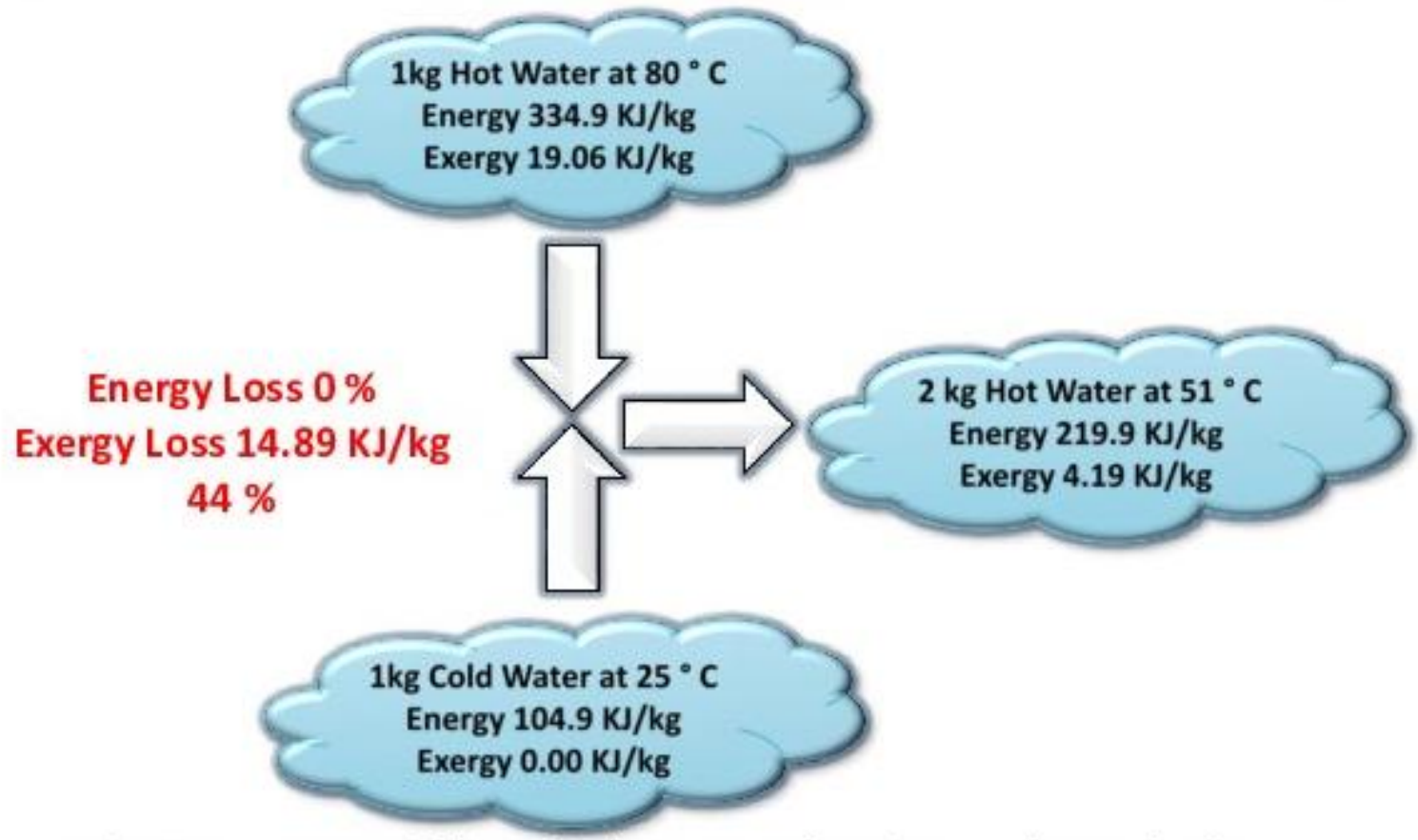
Comparison of Useful Temperature Range

Tracking Method	Collector Type	Absorbtion Method	Temp Range$^o C$
Stationary	Flat Plate	Flat	30–80
	Evacuated Tube	Flat	50–200
	Compound Parabolic	Tubular	60–240
Single axis tracking	Linear Frensel Reflector	Tubular	60–300
	Parabolic Trough	Tubular	60–250
	Cylindrical Trough	Tubular	60–300
Two axes tracking	Parabolic Dish Reflector	Point	150-200
	Heliostat field	Point	100-500

Concept of Energy Ladder

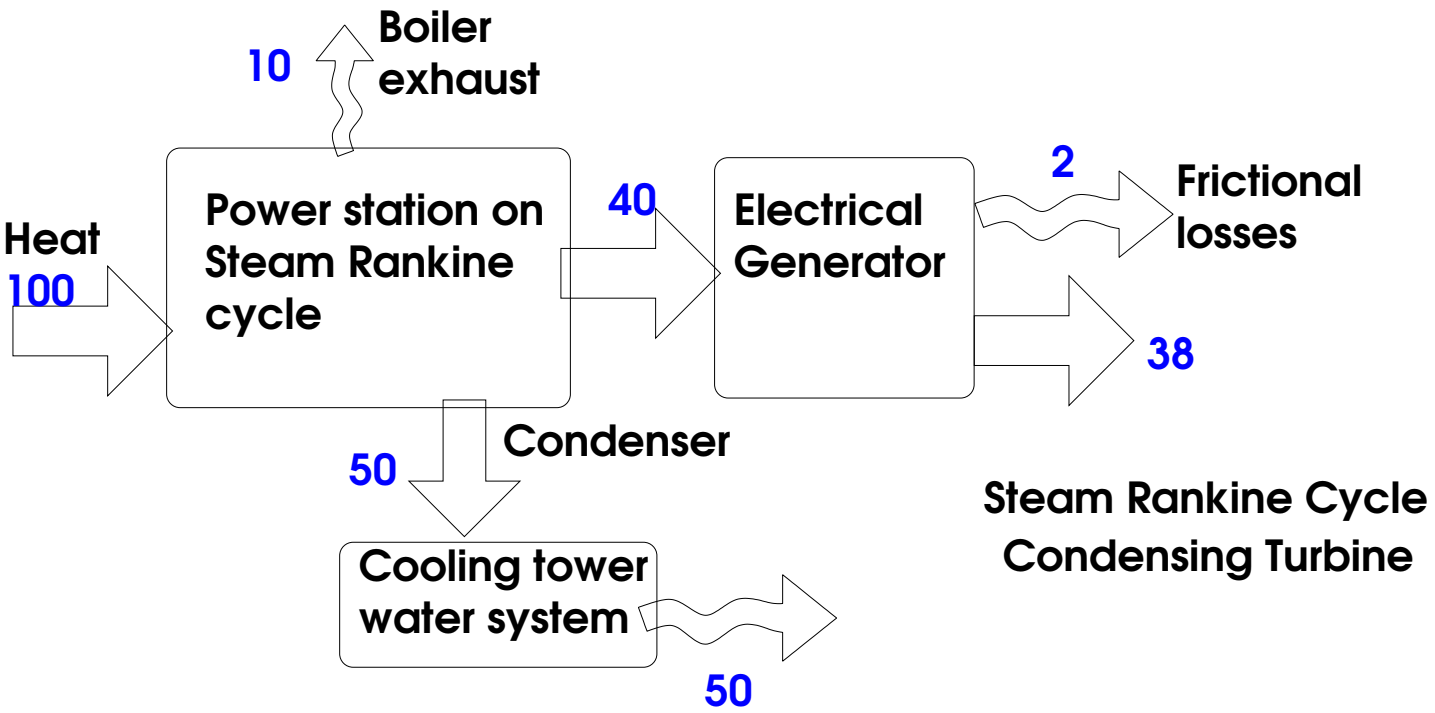
Electricity	Most useful
Fuel	
Hot oil	
40 bar steam	
10 bar steam	
3 bar steam	
1 bar steam	
Hot water/gas	Least useful

Mixing Fluids & Exergy Loss

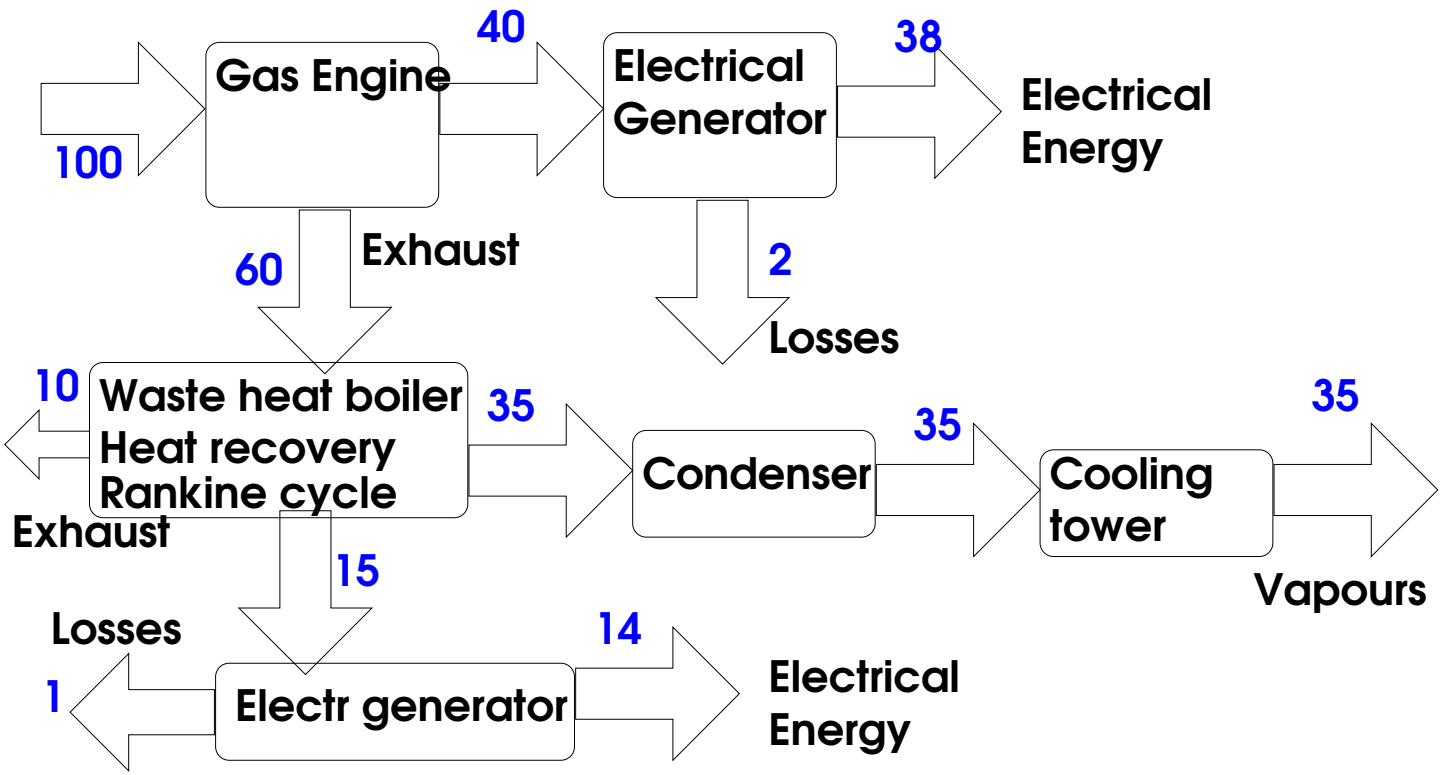


A heat pump would be a far better option thermodynamically

Coal Thermal Power Cycle budget



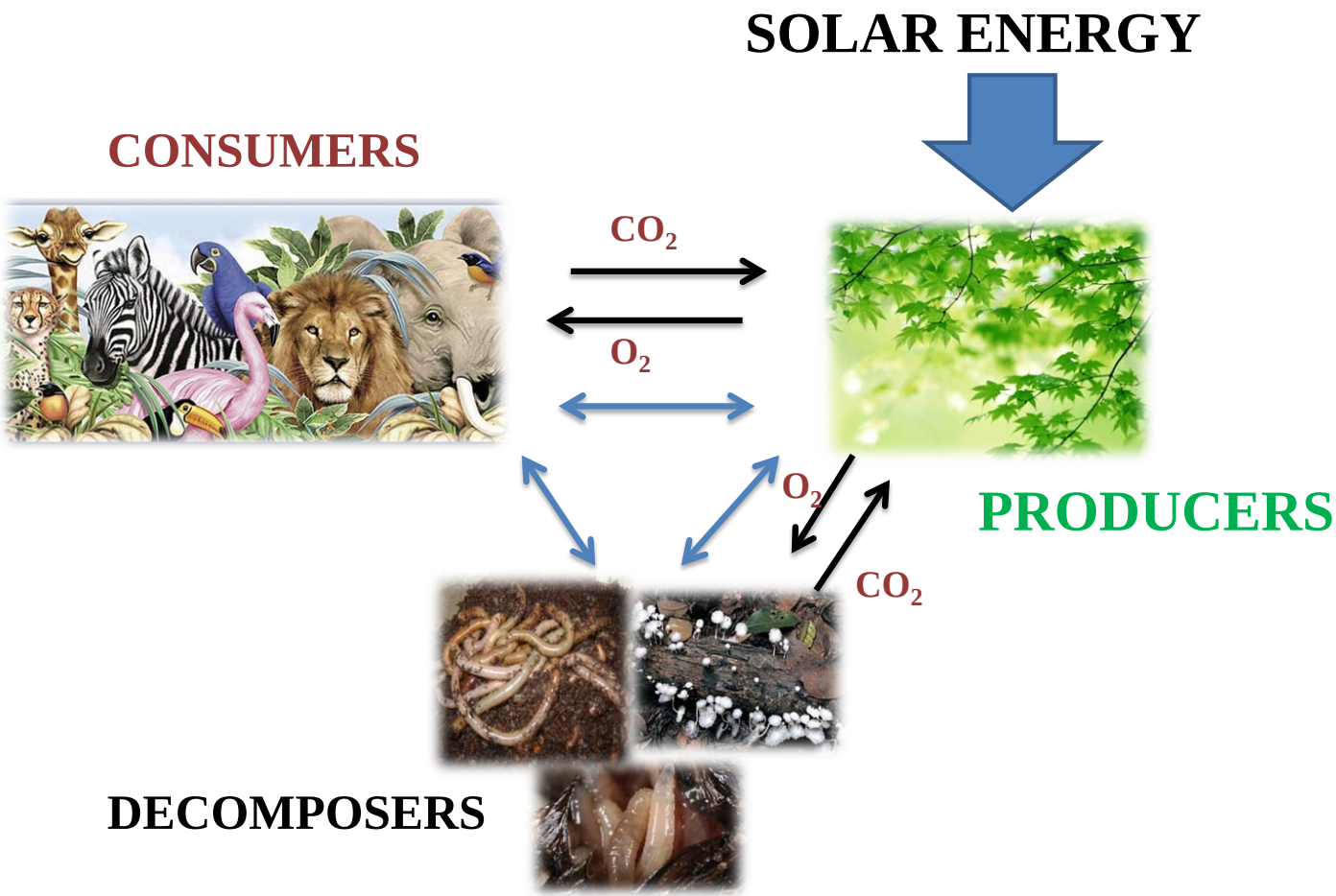
Combined Cycle



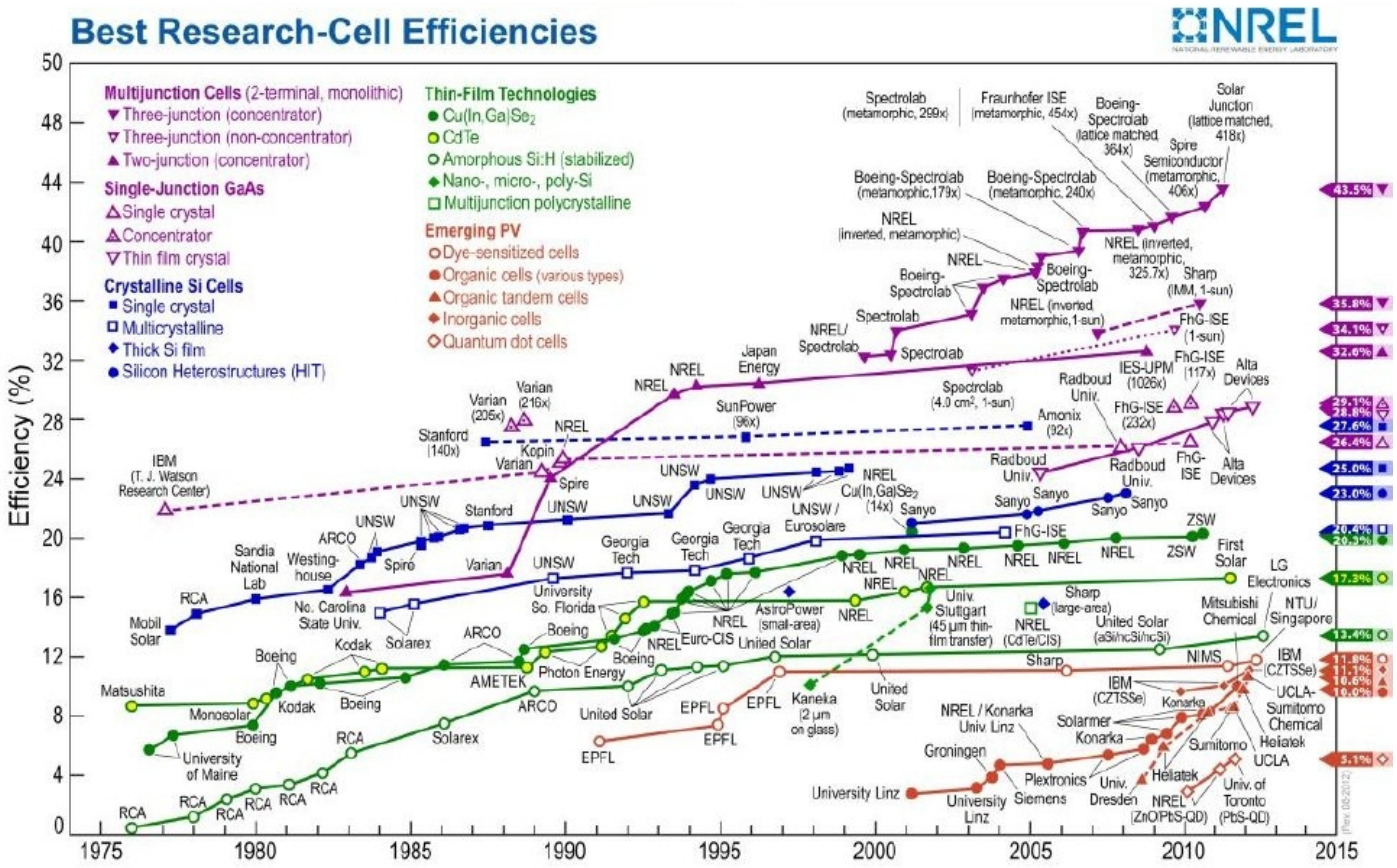
Technologies for Solar Energy Conversion

- Heliochemical : Photosynthesis (Chlorophyll)
- Helioelectrical : Photovoltaic (solar cells)
- Heliothermal : Heating of a secondary fluid (solar thermal)

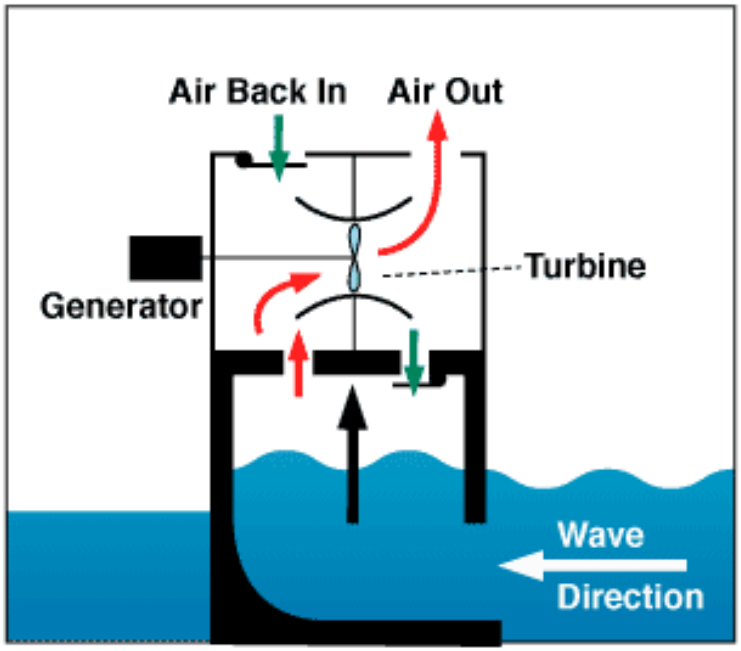
Carbon Cycle

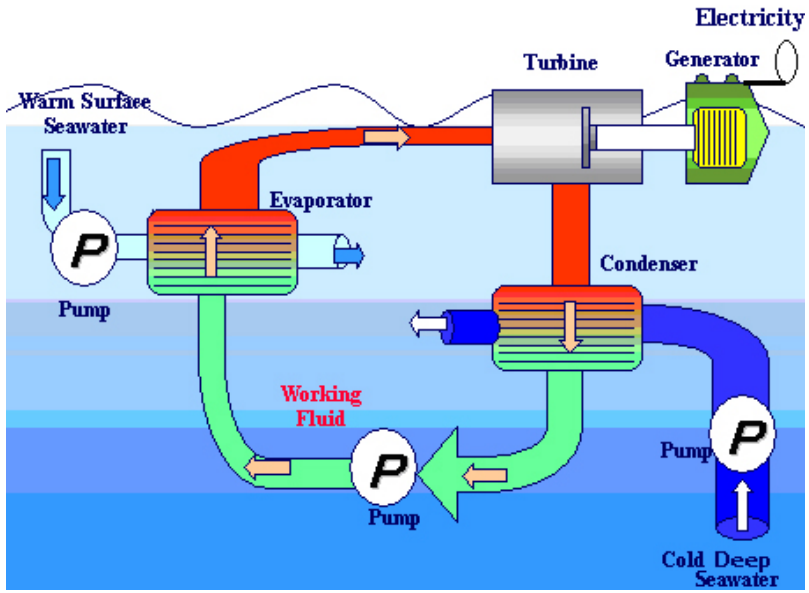


Photovoltaic cell progress

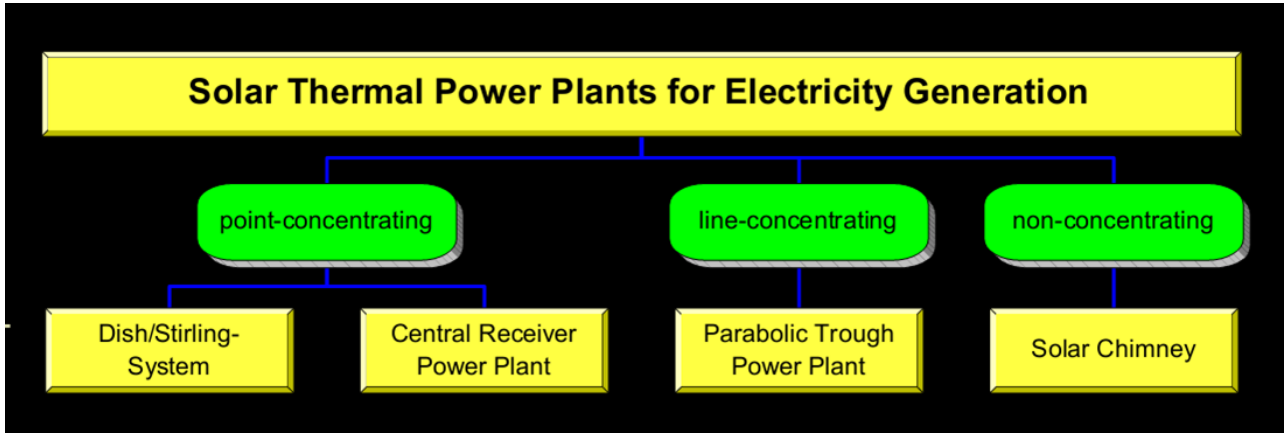


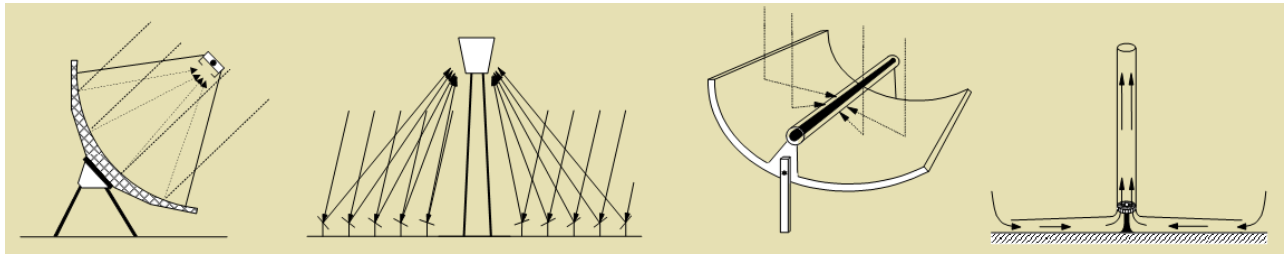
Ocean Thermal Energy



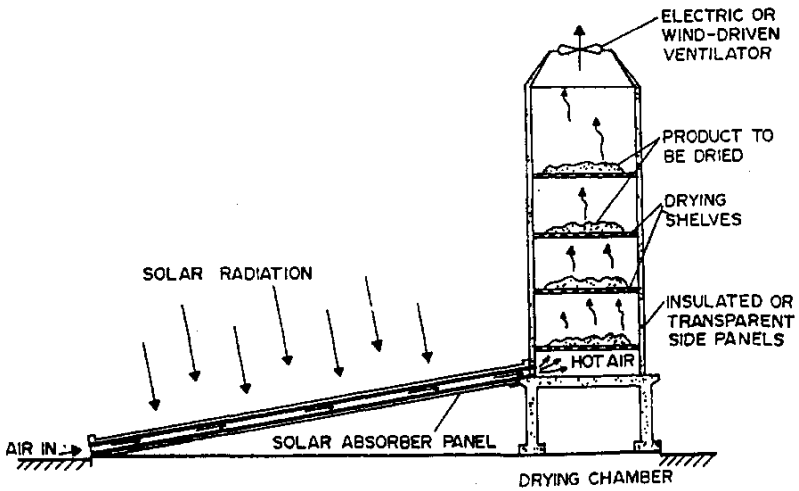


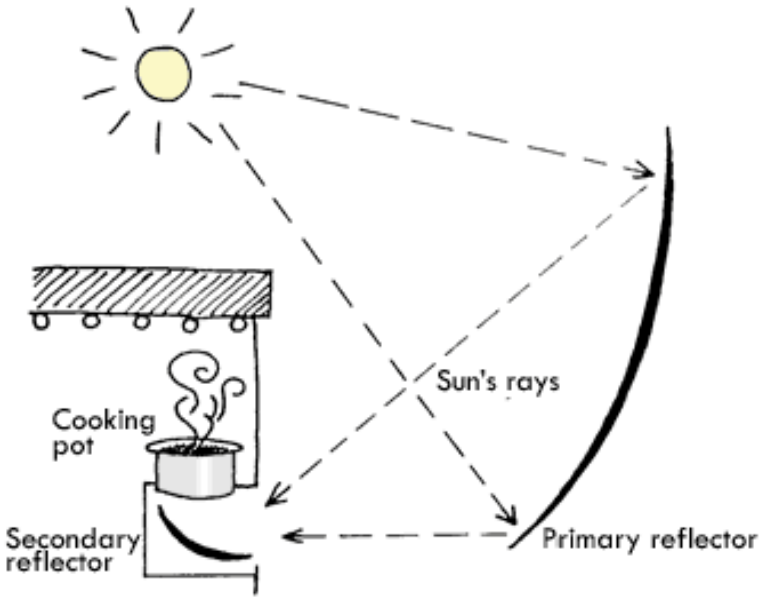
Electricity generation



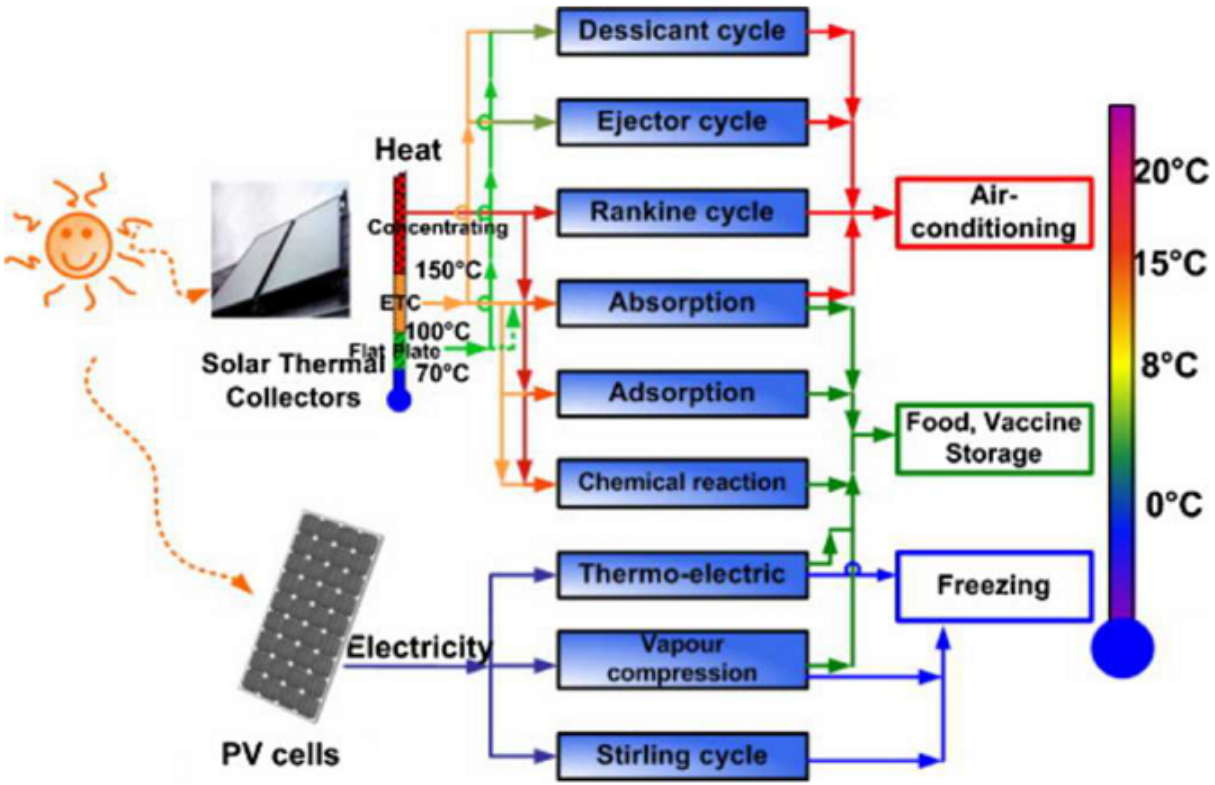


Solar dryer & cooker





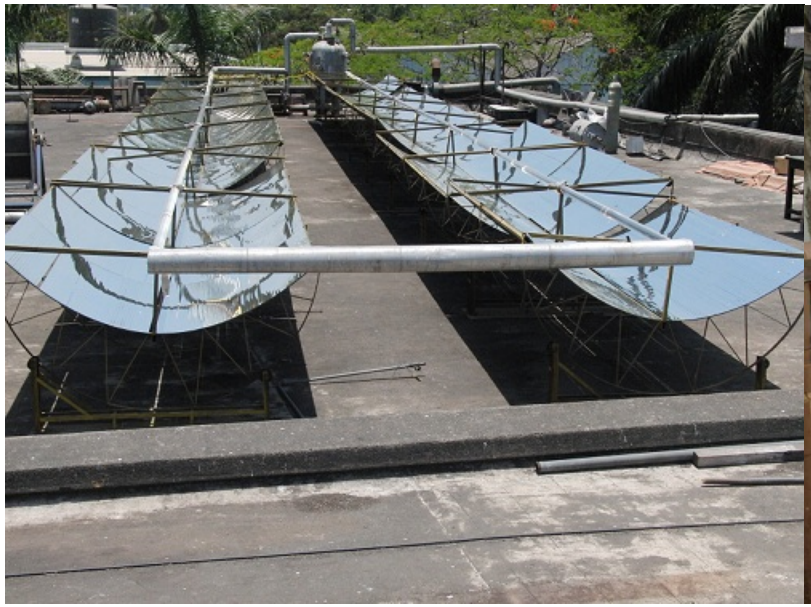
Solar based refrigeration system



Heat based Refrigeration

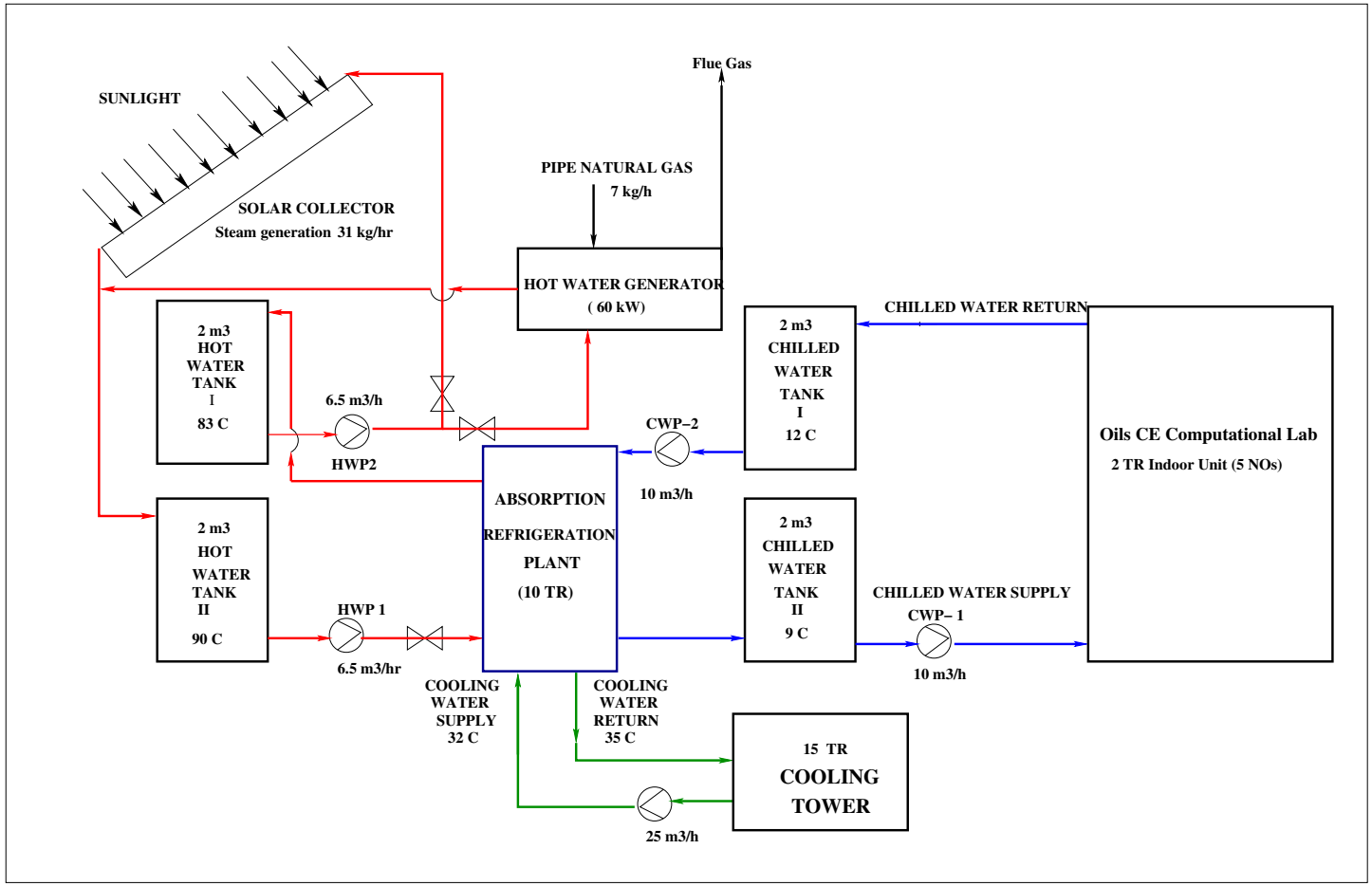
Vapor Absorption Refrigeration Unit

Solar based Continous Rice Cooking Setup

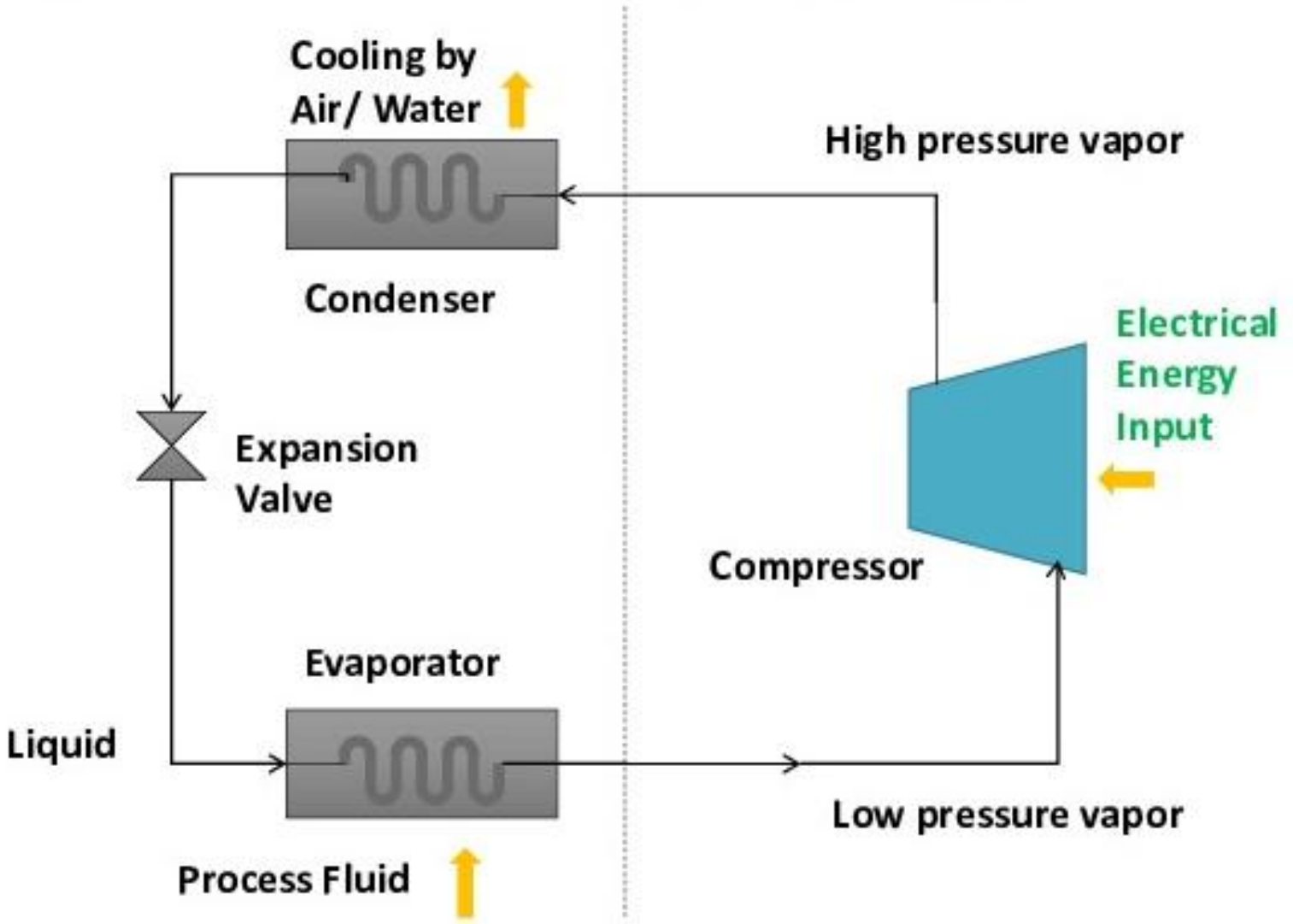


10 TR Solar Air Conditioning Setup

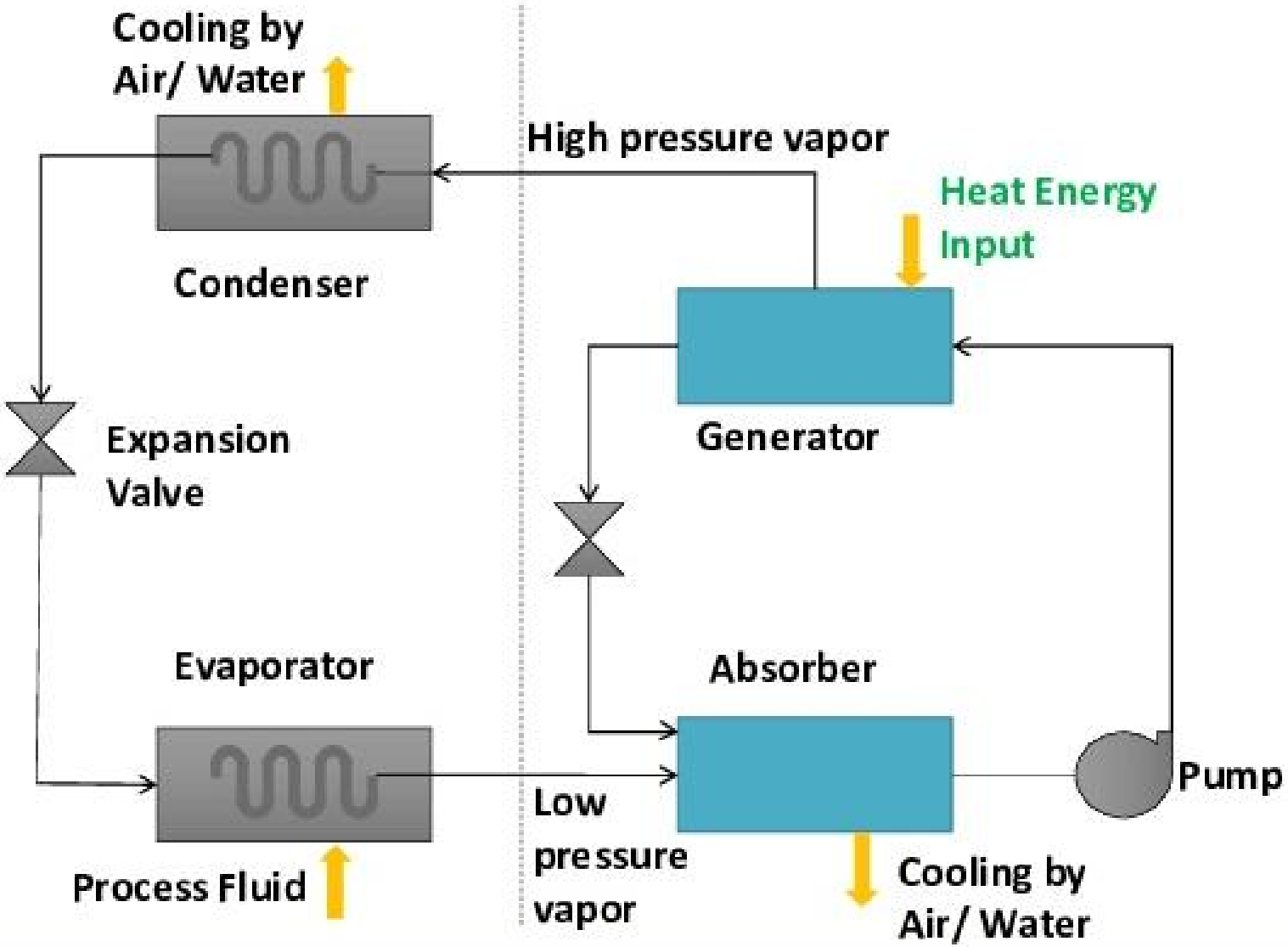
Solar based absorption refrigeration system



Common Regrigeration (VCR)



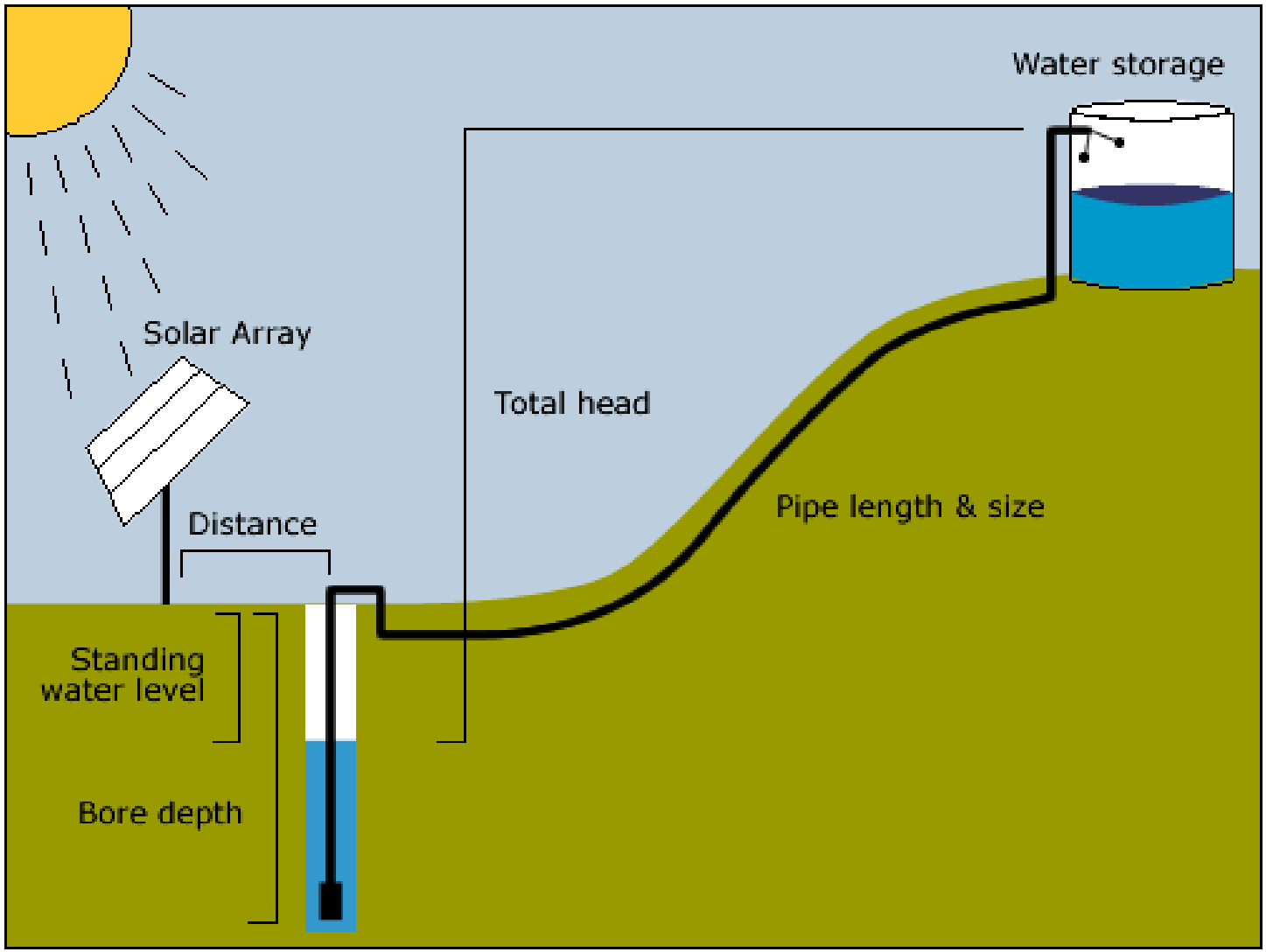
Heat Based (Absorption Cycle) Refrigeration



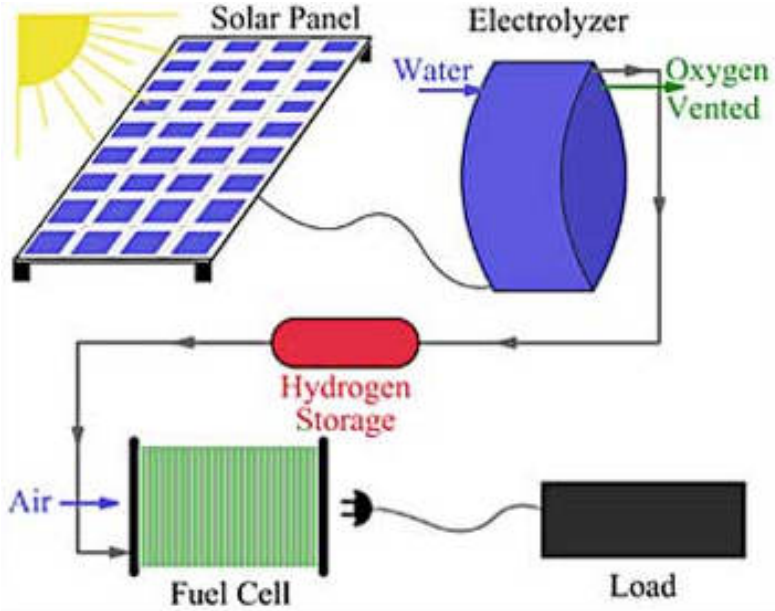
Outline

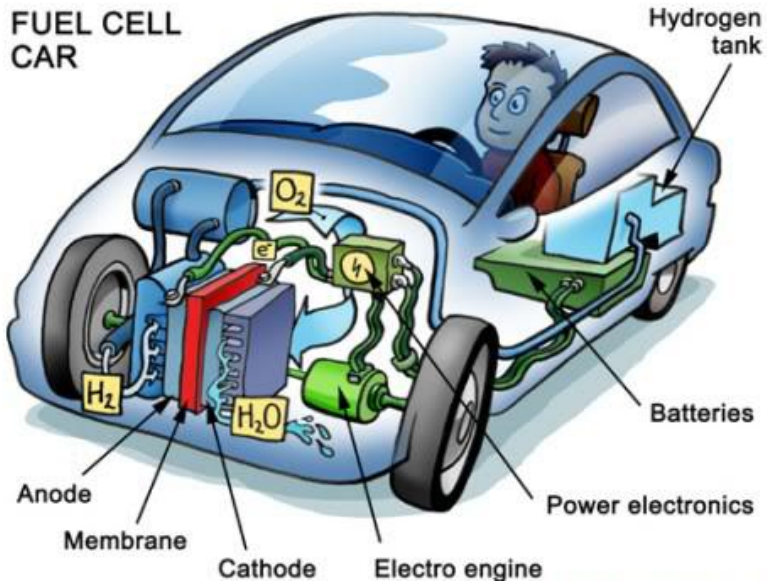
Gujarat Solar Canal

Solar Pump



Stored Energy Source: Hydrogen





Indian Opportunities

- Solar energy potential: 100 x 100 km with 25% use and 10% $\eta \approx 200$ GW
- Possible applications:
  - Rural electrification
  - Hybrid biomass based gasifier
  - Solar thermal power plants integration
    - with existing power guzzling industries
    - with existing grid

The Energy Frontier

- The country with most dire need (development, shortage) and the most technological capability to conquer this frontier: **INDIA**
- The generation to attack this frontier: **OURS/YOURS**
- The time : **NOW**

Plastics: curse or boon?

- Half the world will be sans clothes had it not been for polyester
- Cars would be at least 50% heavier if metals were not replaced by polymers such as nylon
- Half the world will be without footwear had it not been for PVC
- The polymeric LEDs touted as the most eenergy saving lighting devices are made with polymers

Plastics: The favourite of critics today!

- For every seven trucks needed to deliver paper grocery bags to the store. only one truck is needed to carry the same number of plastic grocery bags.
- Plastic packaging delivers greater volumes of liquid. For instance, a kilo of plastic can carry 30 litres of a beverage such as juice or water.
- This same amount of liquid would require ~1.3 kg of aluminum, ~3.5 kgs of steel or 12 kgs of glass.

Plastics : an example

- Through the use of plastic in packaging, American product manufacturers conserve enough energy each year to power a city of one million homes for three and a half years.
- In 1993, the outdoor clothing company Patagonia became the first to use fleece made out of recycled plastic bottles. It now offers more than forty different products made from recycled plastic fleece, including jackets, hats, vests and socks.
- One recycled plastic bottle would save enough energy to power a 60-watt light bulb for three hours.

Overall Summary

- Solar energy is non-polluting & primary source of energy
- Solar - heat to mechanical energy, wind - mechanical engergy
- Direct usage of solar
- Solar energy is available uniformly
- Biomass : proportional to population

THANK YOU