NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

Solar energy systems

UNIT - 2

RER (KOE-074)

B.Tech IV, CSE- VII Sem

Vikas kumar

ME Deptt.

FACULTY INTRODUCTION

Faculty Details:

Name of Faculty:	Mr. Vikas Kumar
Higher Education :	M.Tech (Mechanical Engineering)
Department:	Department of Mechanical Engineering
Faculty Id:	Vikaskumar.me@niet.co.in
Subjects:	Fluid Mechanics & Machine Applied Thermodynamics Hybrid Vehicle Propulsion Simulation , Modeling & Analysis Basics of DBMS

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CONTENTS

- Energy and Development
- Energy demand and availability
- Energy crisis
- Conventional and Nonconventional energy
- Renewable and Non-renewable energy resources
- Environmental impacts of conventional energy usage
- Basic concepts of heat and fluid flow useful for energy systems

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EVALUATION SCHEME

COMPUTER SCIENCE AND ENGINEERING/CS

B.TECH

(COMPUTER SCIENCE & ENGINEERING/CS) CURRICULUM STRUCTURE

SEMESTER- VII													
Sl. No.	Subject Codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KHU701/KHU702	HSMC -1 / HSMC-2	3	0	0	30	20	50		100		150	3
2	KCS07X	Departmental Elective-IV	3	0	0	30	20	50		100		150	3
3	KCS07X	Departmental Elective-V	3	0	0	30	20	50		100		150	3
4	KOE07X	Open Elective-II	3	0	0	30	20	50		100		150	3
5	KCS751A	The Department may conduct one Lab of either of the two Electives (4 or 5) based on the elective chosen for the curriculum. The Department shall on its own prepare complete list of practical for the Lab and arrange for proper setup and conduct accordingly.	0	0	2				25		25	50	1
6	KCS752	Mini Project or Internship Assessment*	0	0	2				50			50	1
7	KCS753	Project	0	0	8				150			150	4
8		MOOCs (Essential for Hons. Degree)											
		Total	**12**	**0**	**12**							**850**	**18**

*The Mini Project or internship (4 - 6 weeks) conducted during summer break after VI semester and will be assessed during VII semester.

EVALUATION SCHEME

OPEN ELECTIVE-II

KOE071	FILTER DESIGN
KOE072	BIOECONOMICS
KOE073	MACHINE LEARNING
KOE074	RENEWABLE ENERGY RESOURCES
KOE075	OPERATIONS RESEARCH
KOE076	VISION FOR HUMANE SOCIETY
KOE077	DESIGN THINKING
KOE078	**SOIL AND WATER CONSERVATION ENGINEERING**
KOE079	**INTRODUCTION TO WOMEN'S AND GENDER STUDIES**

Course Objectives

CO 1
- To understand the need of energy conversion and the various renewable energy resources

CO 2
- To impart the knowledge of solar energy and apply different method of solar energy

CO 3
- To impart the knowledge of hydro power and utilize it on small scale.

CO 4
- To Explain bio gas generation and its impact on environment

CO 5
- To apply Winds energy as alternate form of energy and to know how it can be trapped

CO-PO and PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	-	-	2	-	2	-	-	3	3	2	3
CO2	3	3	2	2	-	2	2	-	2	2	-	3	3	3	3
CO3	3	3	2	-	2	3	3	2	2	2	-	3	2	3	3
CO4	3	3	2	3	2	2	2	2	2	-	-	3	3	3	3
CO5	2	2	2	-	2	-	3	-	2	2	-	3	3	3	3
Avg	3	3	2	2	1	2	2	1	2	1	-	3	2.67	3	3

Syllabus

Unit-I: Introduction: Various non-conventional energy resources- Introduction, availability, classification, relative merits and demerits. Solar Cells: Theory of solar cells. Solar cell materials, solar cell array, solar cell power plant, limitations.

Unit-II: Solar Thermal Energy: Solar radiation, flat plate collectors and their materials, applications and performance, focusing of collectors and their materials, applications and performance; solar thermal power plants, thermal energy storage for solar heating and cooling, limitations.

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Syllabus

Unit-III: Geothermal Energy: Resources of geothermal energy, thermodynamics of geo- thermal energy conversion-electrical conversion, non-electrical conversion, environmental considerations. Magneto-hydrodynamics (MHD): Principle of working of MHD Power plant, performance and limitations. Cells: Principle of working of various types of fuel cells and their working, performance and limitations.

Syllabus

Unit-IV: Thermo-electrical and thermionic Conversions: Principle of working, performance and limitations. Wind Energy: Wind power and its sources, site selection, criterion, momentum theory, classification of rotors, concentrations and augments, wind characteristics. Performance and limitations of energy conversion systems.

Unit-V: Bio-mass: Availability of bio-mass and its conversion theory. Ocean Thermal Energy Conversion (OTEC): Availability, theory and working principle, performance and limitations. Wave and Tidal Wave: Principle of working, performance and limitations. Waste Recycling Plants.

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Course Outcomes

CO1
- Understand and utilize different renewable sources of energy

CO2
- Utilize the knowledge of solar energy and apply different method of solar energy

CO3
- Understand the procedure and application of micro and small hydro energy system.

CO4
- Utilize bio mass energy and understand the process of bio gas generation

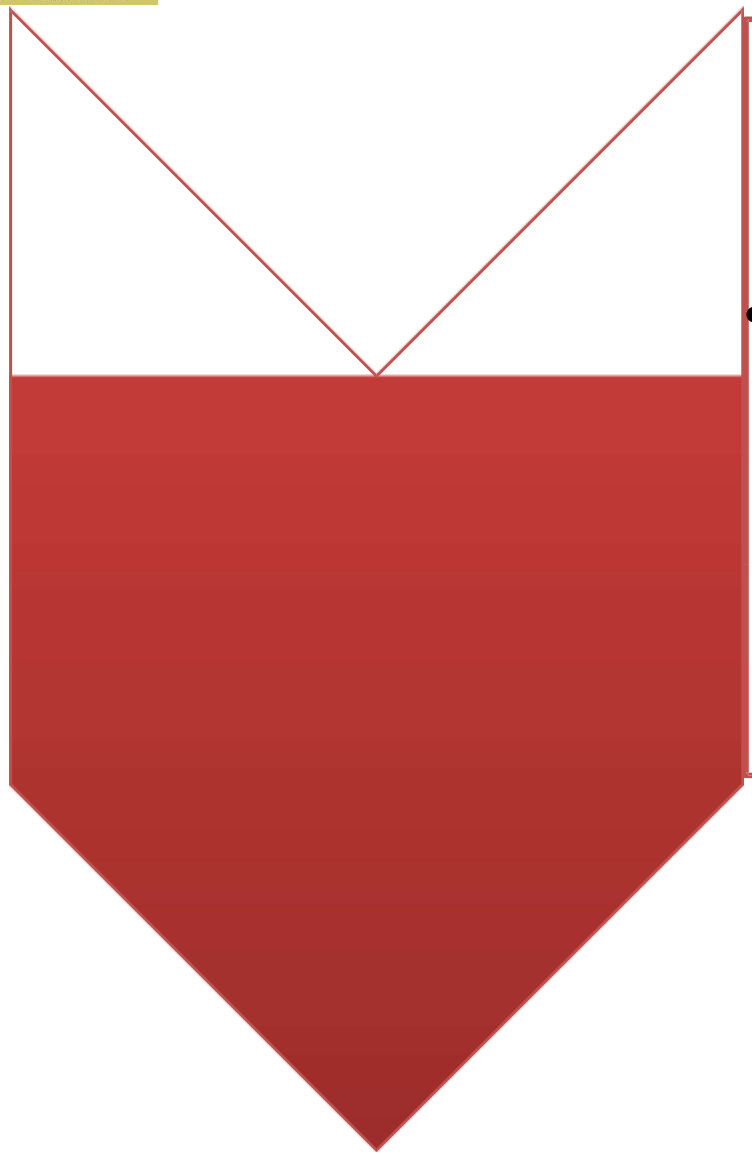
CO5
- Understand the advantage and disadvantage of Wind energy.

COURSE APPLICATION

Application of Renewable Energy System:

Renewable Energy	
Type	**Application**
Solar	Household Appliance, Water Heating
Biomass	Heat Energy
Wind	Power Generation
Biogas	Cooking

Unit Objective



- To explain solar energy system and utilization in current era.

Objective of Topic

Topic: Solar energy system

Objective of Topic: To explain solar energy and its utilization

Prerequisite And Recap

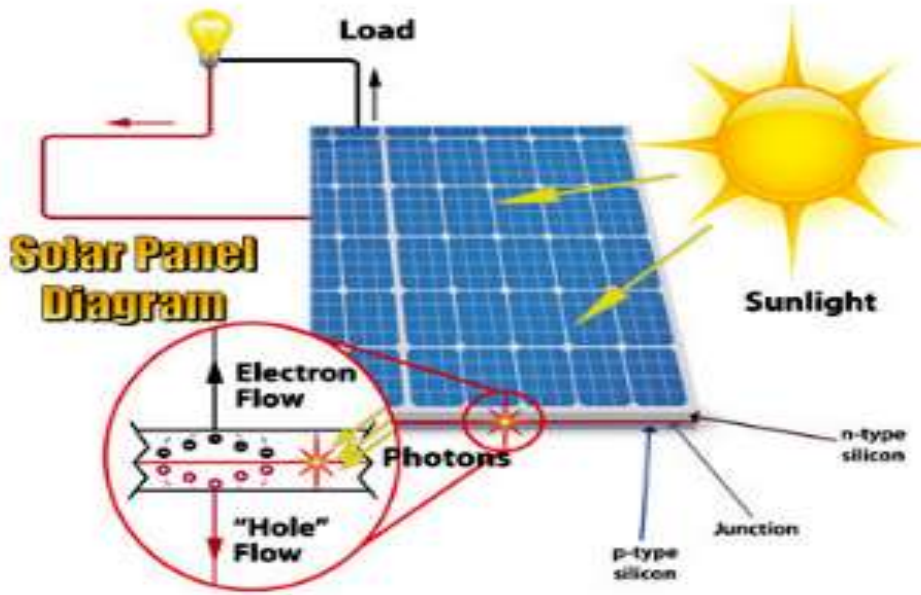
Topic: solar energy system

Prerequisite : basic of renewable energy

Recap: different types of energy system

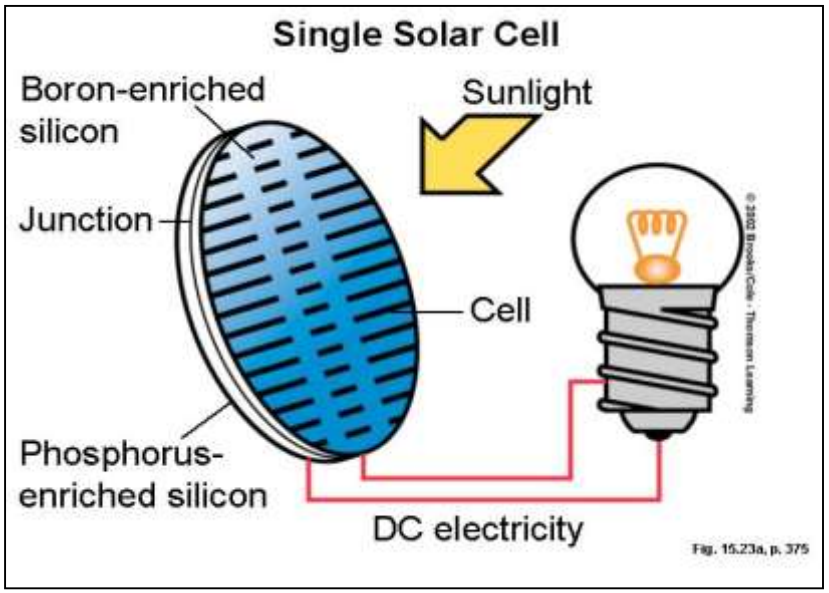
Solar power(CO2)

- **Solar power** is the conversion of energy from sunlight into electricity, either directly using photovoltaic (PV), indirectly using concentrated solar power, or a combination.
- Concentrated solar power systems use lenses or mirrors and solar tracking systems to focus a large area of sunlight into a small beam.



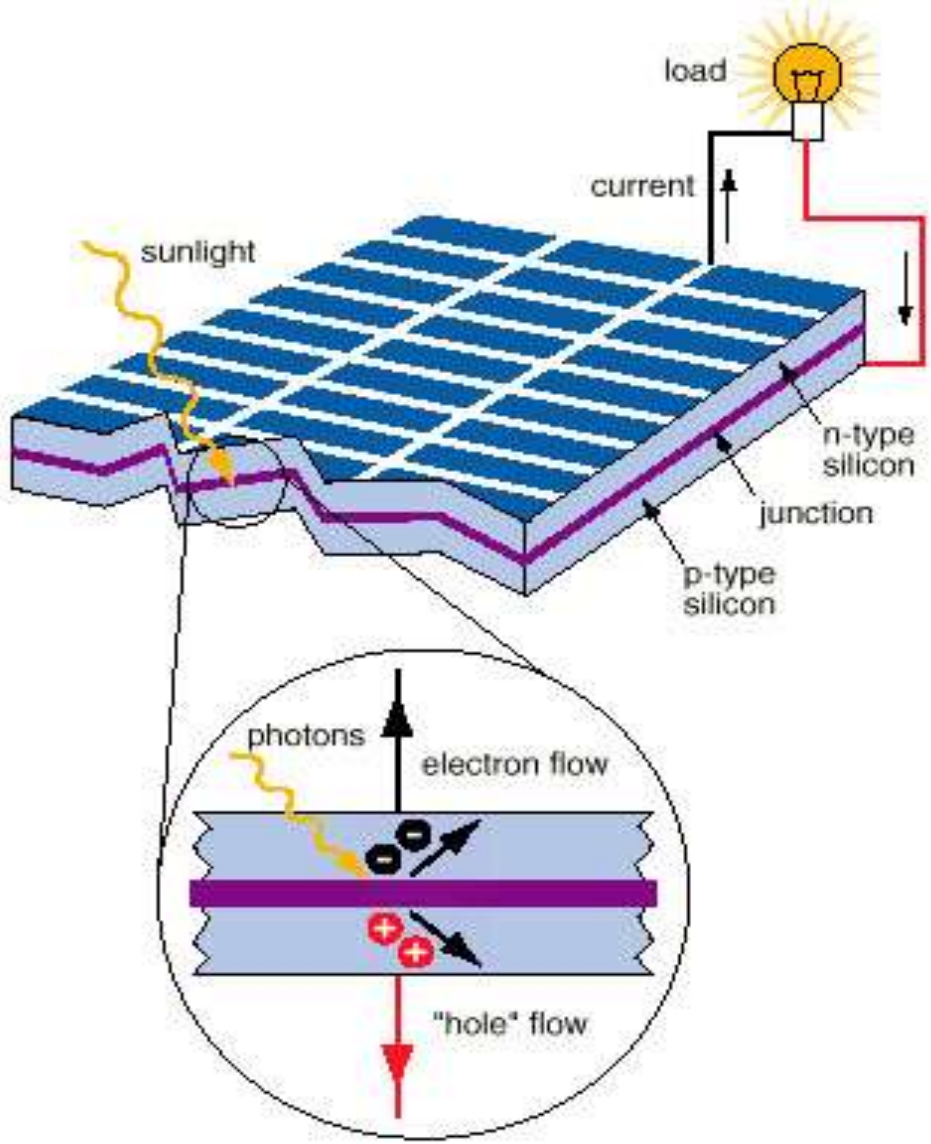
Photovoltaic(CO_2)

- **Photo+voltaic = convert light to electricity**

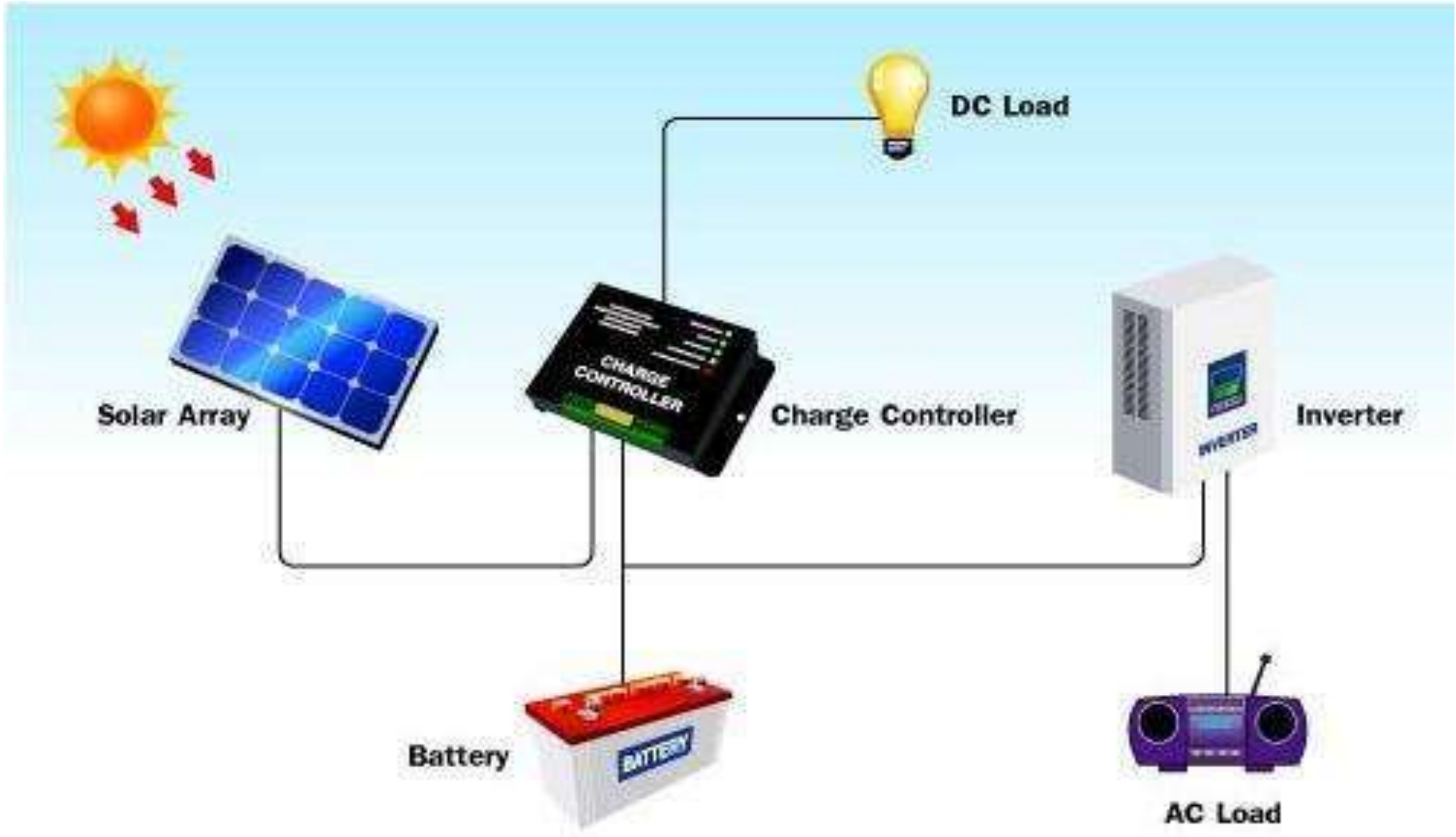


How Solar PV Cells Work(CO2)

- Photons in sunlight hit the solar panel and are absorbed by semiconducting materials.
- Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity.



Components of solar PV system(cont..)



Solar Radiation(CO2)

- Solar radiation is radiant energy emitted by the sun, particularly electromagnetic energy.
- About half of the radiation is in the visible short-wave part of the electromagnetic spectrum.
- The other half is mostly in the near-infrared part, with some in the ultraviolet part of the spectrum
- Solar constant is defined, commonly taken as 1353 W/m2 , though there are some variations in the estimates..

Calculation of solar energy(CO2)

- Calculate the energy received by earth from sun and compare the energy received from sun, with the energy usage by humankind.

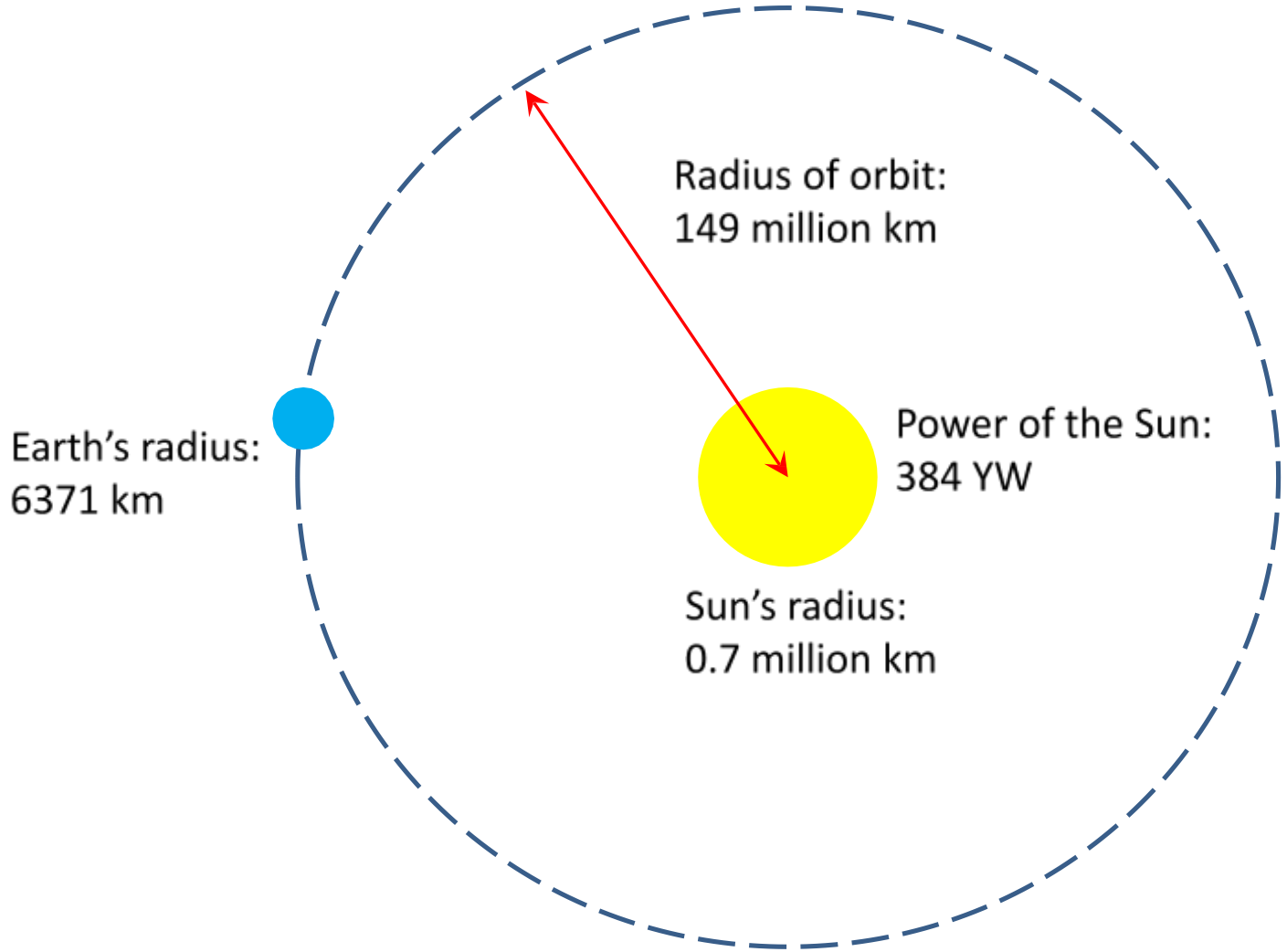
Surface of the Sun ~ 5500 °C
Core of the Sun, several million °C

Sun gives out 384 Yotta Watts

$= 384 \times 10^{24}$ W

$= 3.84 \times 10^{26}$ W

Calculation of solar energy(cont..)



Intensity of sun's radiation(CO_2)

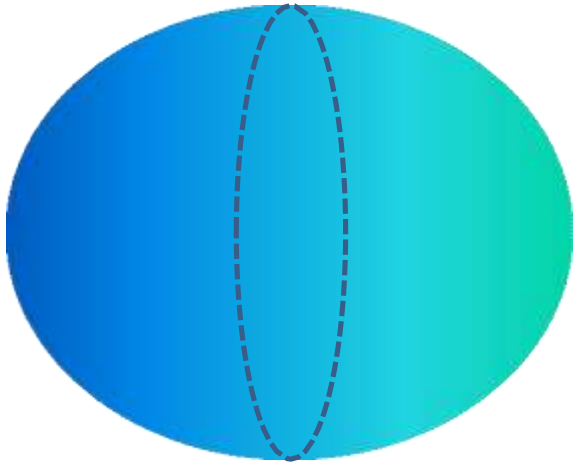
Intensity of Sun's radiation at Earth's orbit:

$$= \frac{3.84 \times 10^{26}}{4 \times 3.14 \times (1.49 \times 10^{11})^2} = 1377\ W/m^2$$

Area of earth disc(CO2)

Area of Earth's disc:

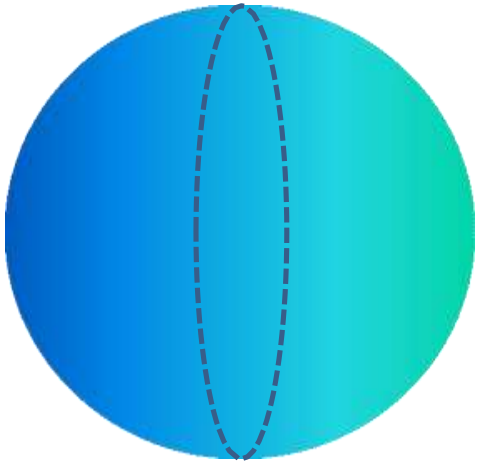
$$= \quad 3.14 \times (6.371 \times 10^{6})^{2} \quad = 1.27 \times 10^{14}\ m^{2}$$



Power received from the sun(CO2)

Power received from the Sun, by Earth:

$$= 1.27 \times 10^{14} \times 1377 = 1.755 \times 10^{17} \text{ W or J/s}$$



Energy received from the sun(CO2)

- **Energy received from the Sun, by Earth each year:**

$$= 1.755 \text{ X } 10^{17} \text{ X } 60 \text{ X } 60 \text{ X } 24 \text{ X } 365$$

$$= 5.5 \text{ X } 10^{24} \text{ J}$$

= 5.5 million Exa Joules per year

Energy usage(CO_2)

Humankind uses:

= 500 Exa Joules per year

Earth receives from the Sun:

5.5 million Exa Joules per year

This is received in :

$500 / 5.5 \times 10^{6} = 9 \times 10^{-5}$ years = 0.033 days = 0.79 hours

Since 30% of the incident energy is reflected back, on the surface of the Earth, the energy used by humankind each year is received in :

$= 0.79/0.70 \sim$ **1 hour**

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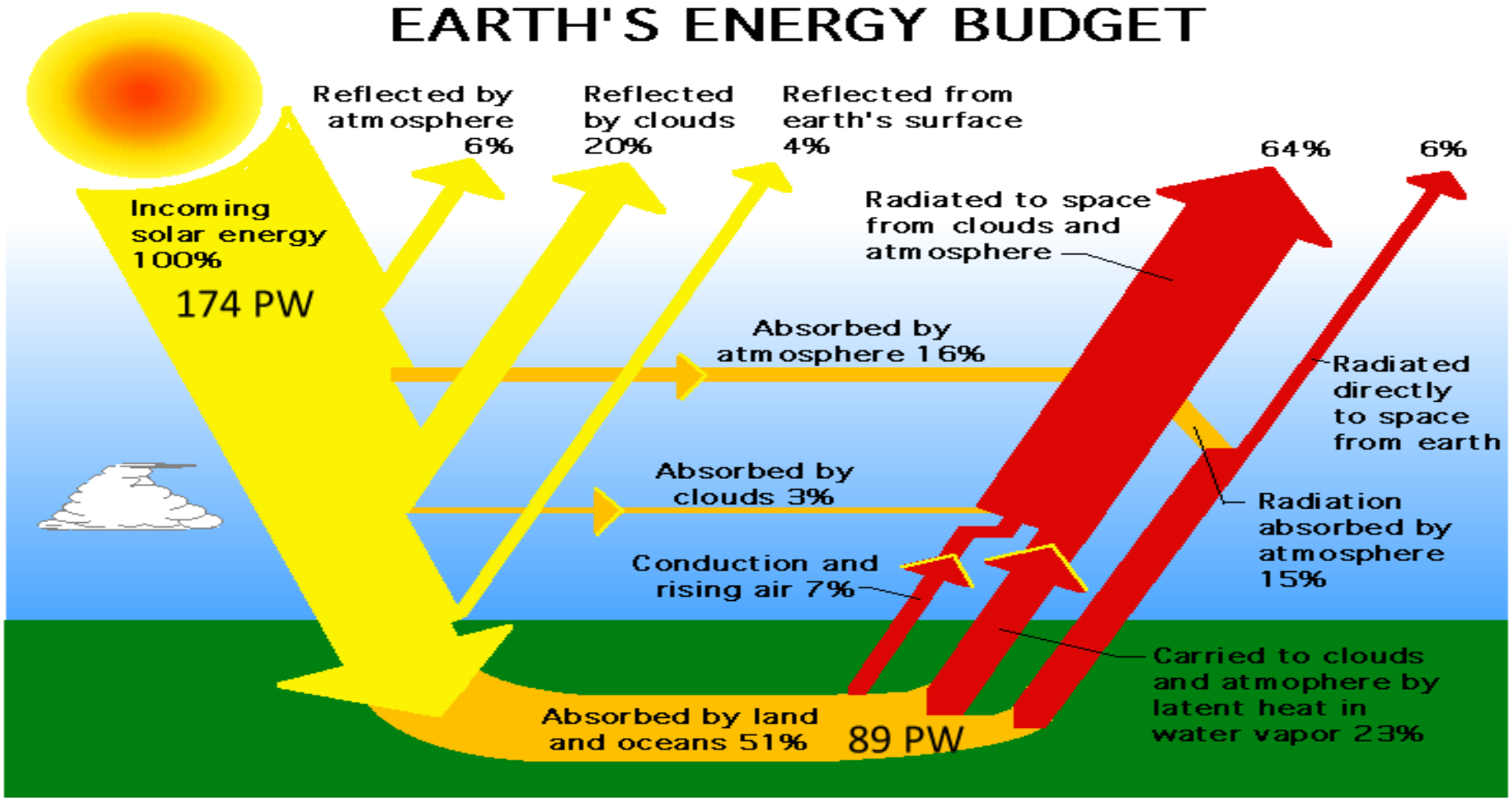
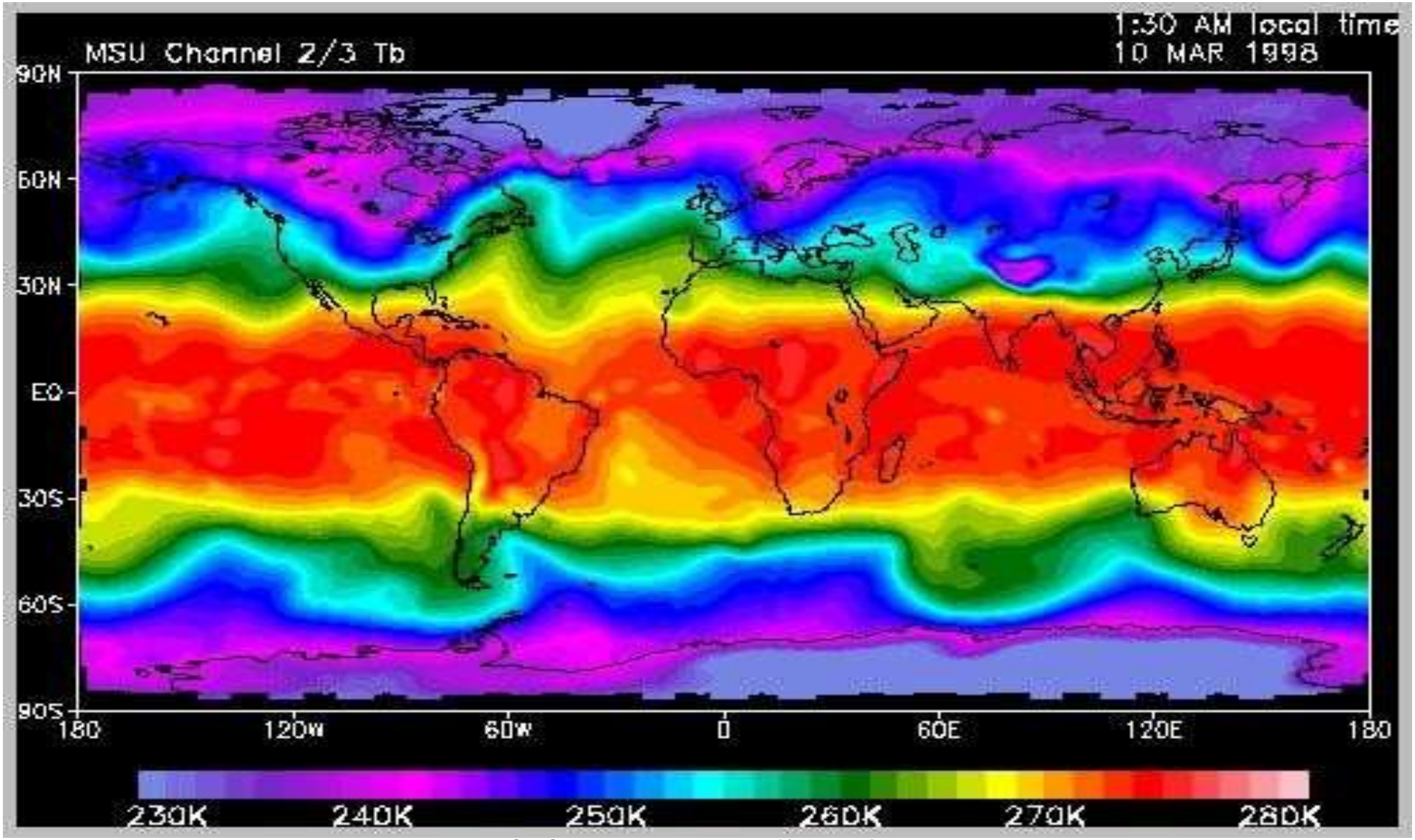
Solar budget(CO_2)



NASA

Solar budget(cont…)



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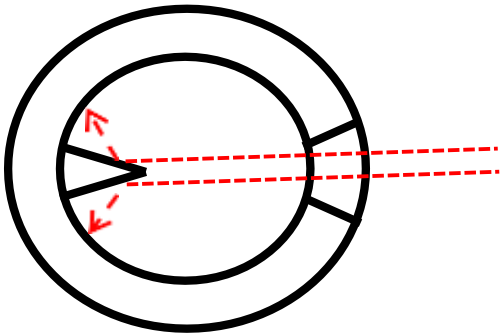
Solar spectrum(CO2)



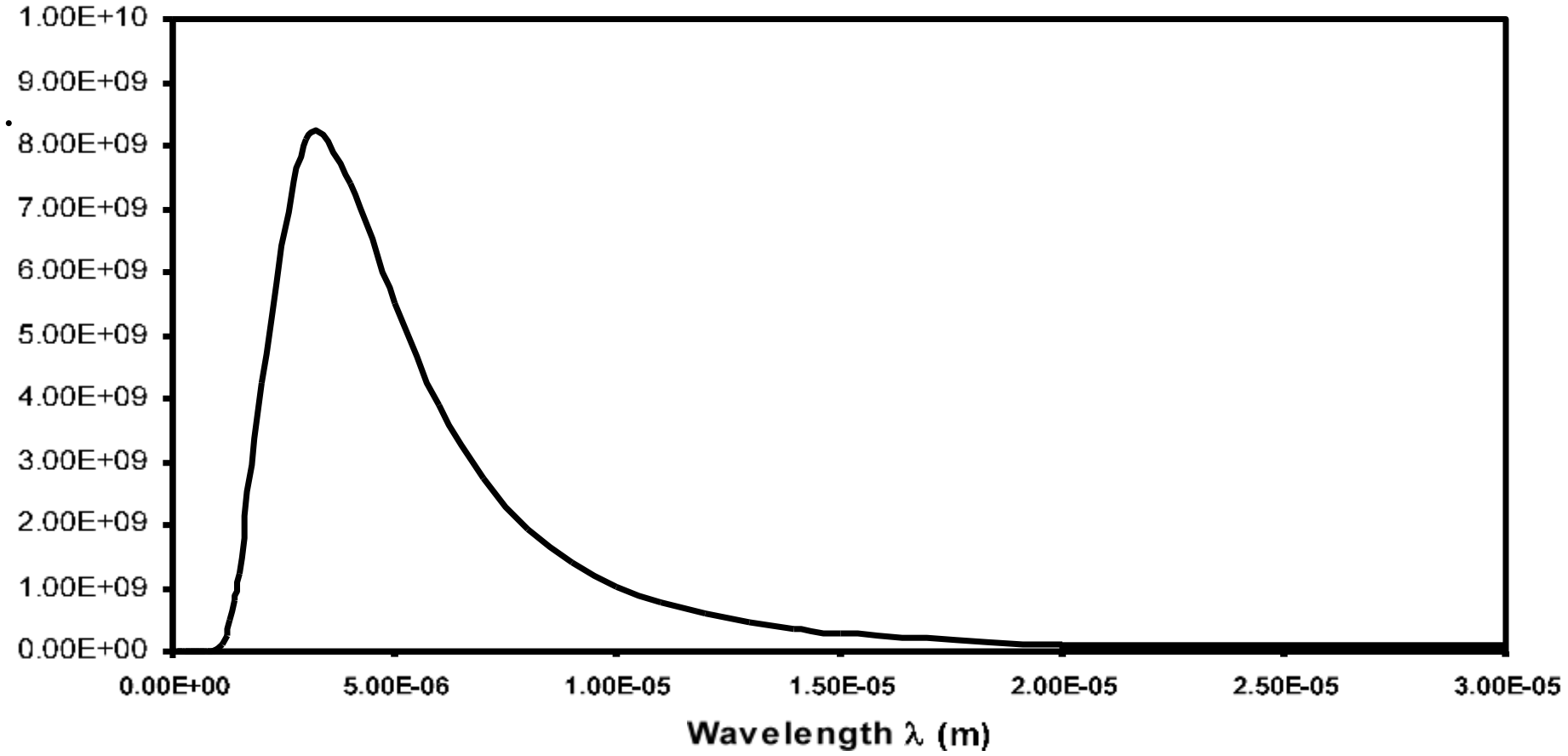
Kirchoff designed a black body in 1859

Known properties of black body radiation:

1) As temperature T of the body increases, intensity of the radiation from the body also increases

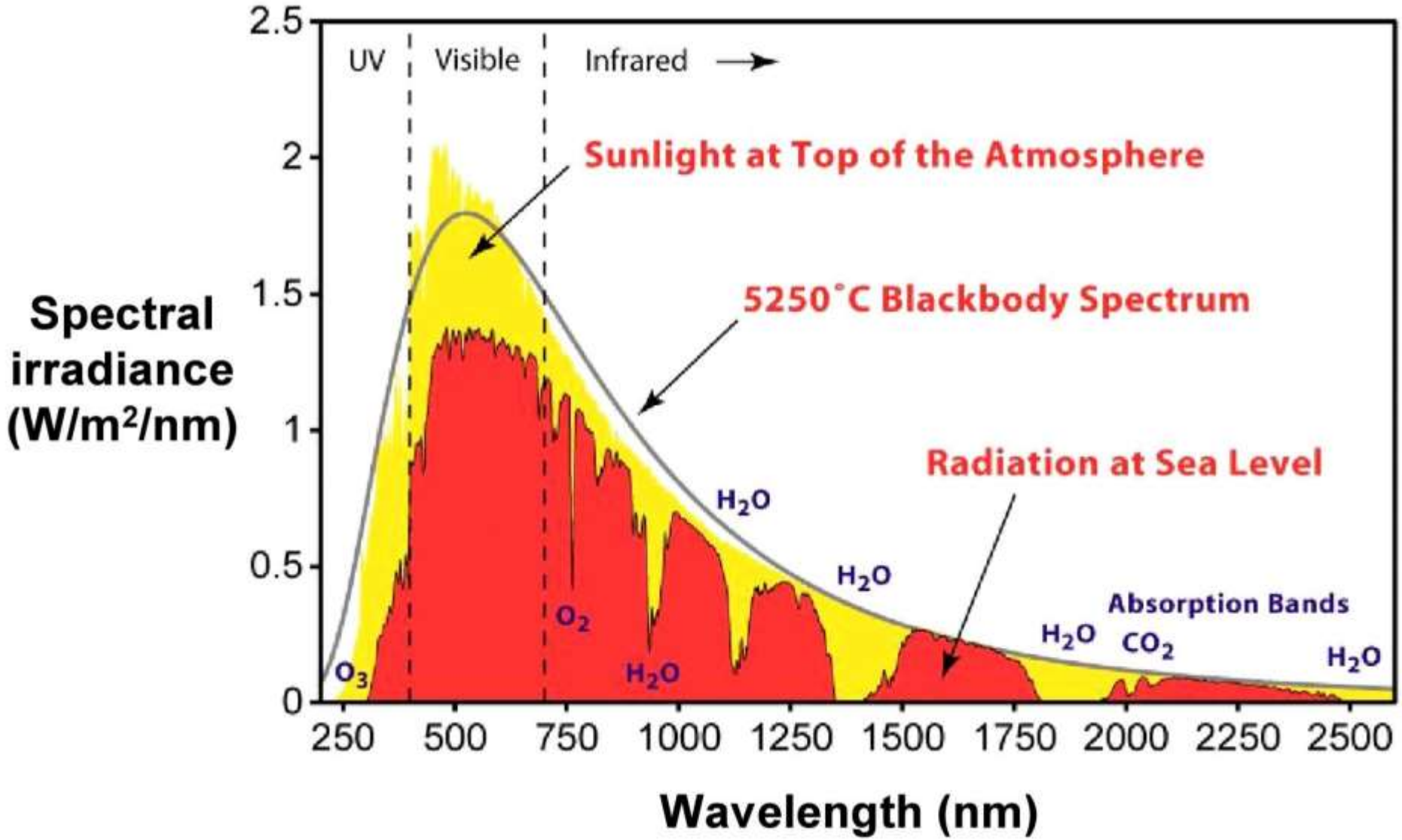
2) Higher the temperature, lower is the wavelength of the most intense part of the spectrum.

Black body radiation(CO2)

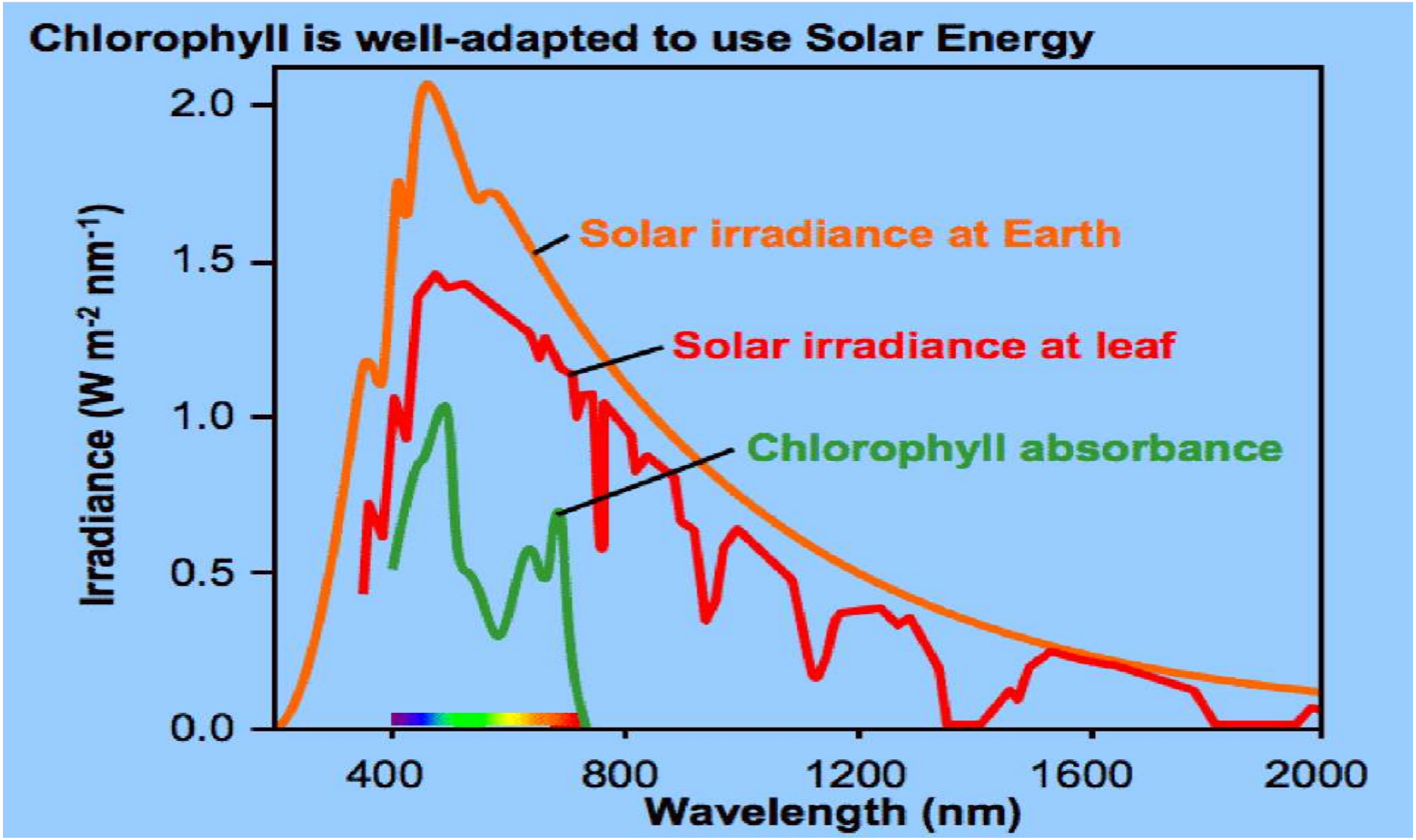


Black body Radiation

Black body radiation(cont..)



Black body radiation(CO2)



Solar Collectors (CO2)

- Solar collectors transform solar radiation into heat and transfer that heat to a medium (water, solar fluid, or air).

- Then solar heat can be used for heating water, to back up heating systems or for heating swimming pools.

- A solar collector is basically a flat box and are composed of three main parts, a transparent cover, tubes which carry a coolant and an insulated back plate.

- The solar collector works on the green house effect principle; solar radiation incident upon the transparent surface of the solar collector is transmitted through though this surface.

Solar Collectors (CO2)

- The inside of the solar collector is usually evacuated, the energy contained within the solar collect is basically trapped and thus heats the coolant contained within the tubes.

- The tubes are usually made from copper, and the back plate is painted black to help absorb solar radiation.

- The solar collector is usually insulated to avoid heat losses.

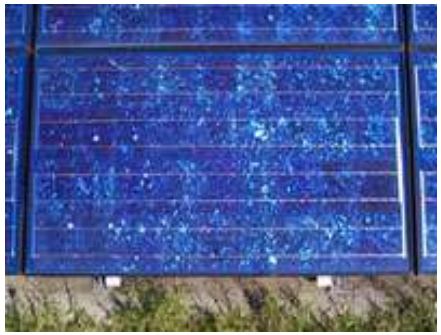
Types of collectors(CO2)

- Stationary
  - Sun tracking Applications
  - Solar water heating
  - Solar space heating and cooling
  - Refrigeration
  - Industrial process heat
  - Solar thermal power systems

Commercial Solar Cells(CO2)

- Single crystal silicon

Poly-Crystal Silicon



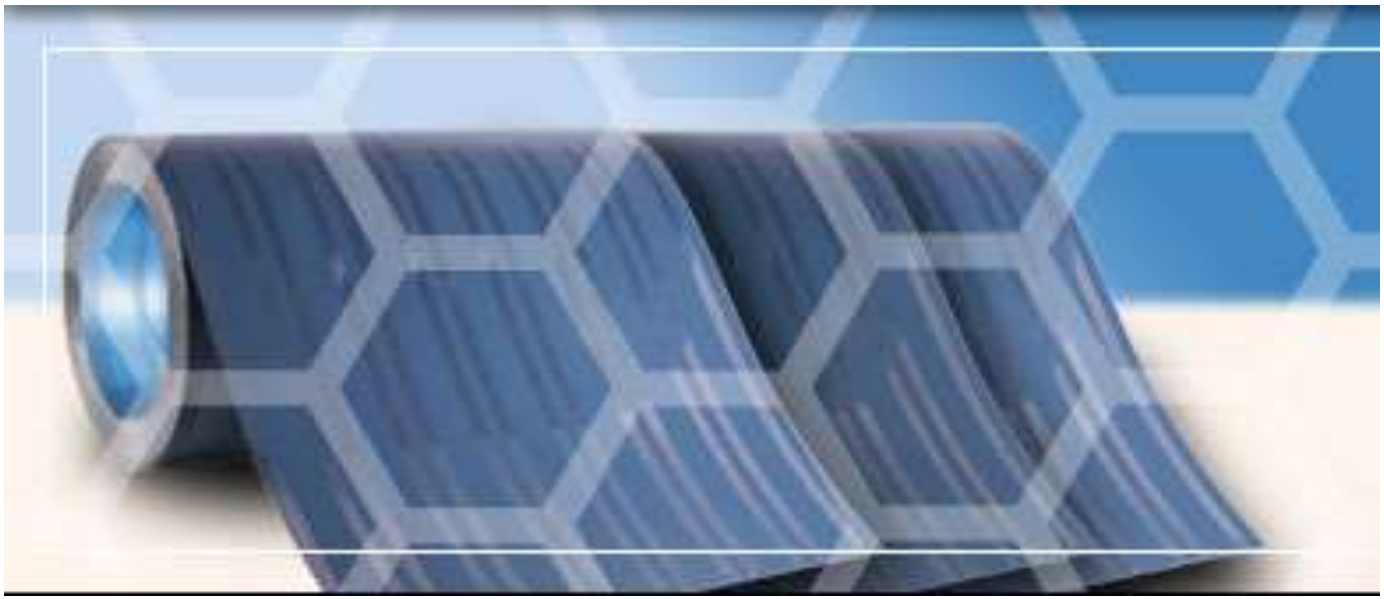
Thin Films

Emerging technologies in solar system(CO2)

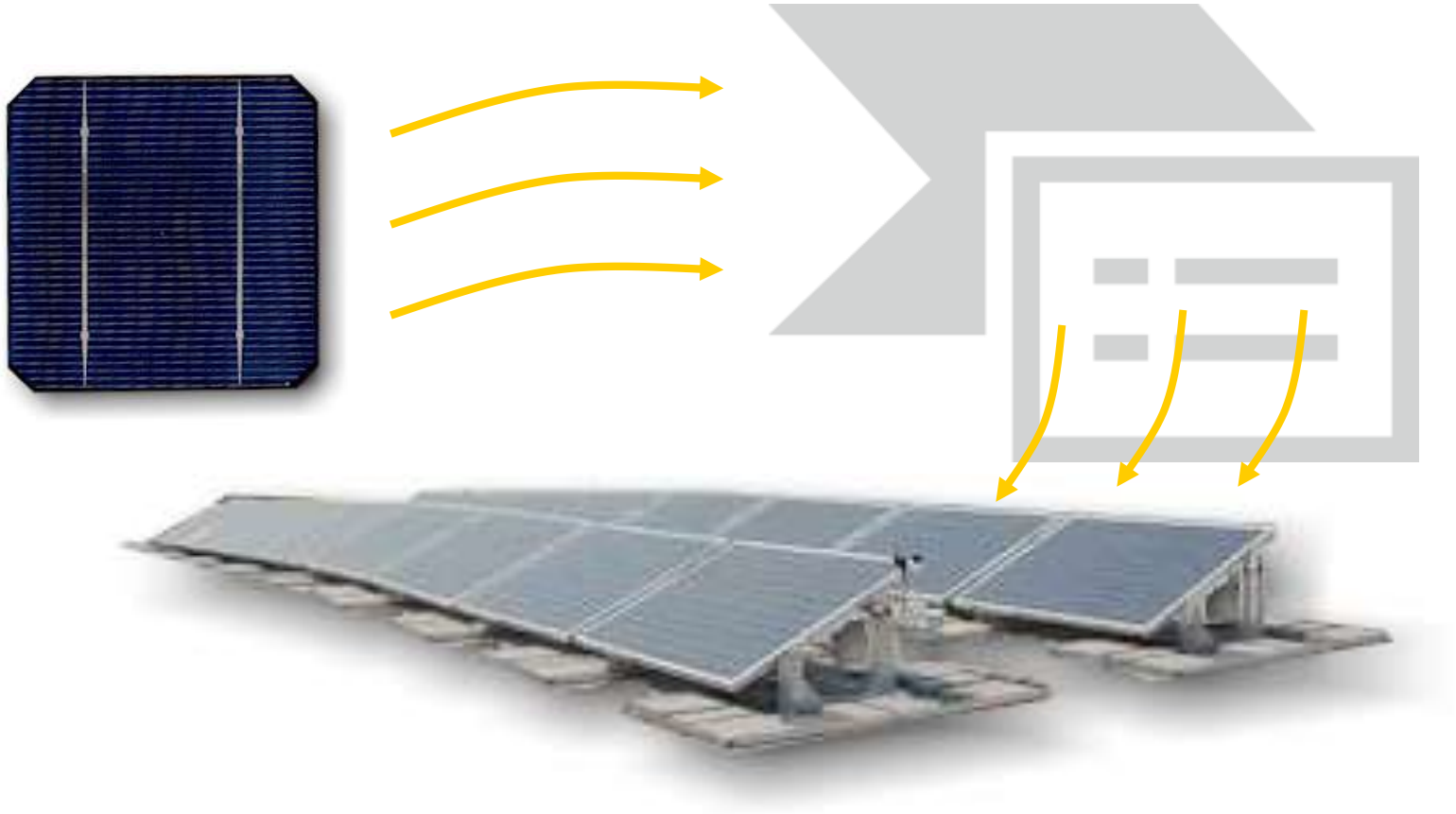
Nano-solar techniques:

•Nano-Solar – Electrically Conductive Plastics

•Konarka – Polymer and dye-sensitized solar cell have flexible cells about 5 % efficient



Cells, Modules and Arrays(CO2)



Energy Tide-bit(CO2)

The solar cells in the early 1950s were about 0.5 % efficient. Today a module is about 15 % efficient.

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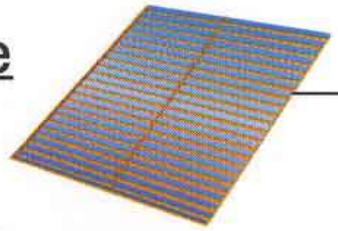
A 1 kW system:

- **In 1950 = 2,400 square feet**
- **In 2005 = 80 Square feet**

Typical PV systems(CO2)

Typical PV Systems

Stand-alone



PV Array

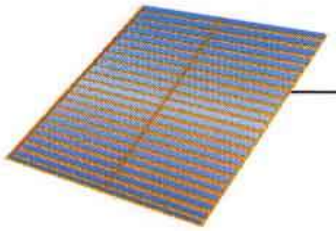
Controller

Battery Bank

DC Loads

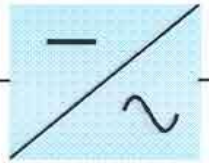
Pumps, Lights, Homes, Appliances

Grid-connected



PV Array

Inverter



Meter

Utility Grid

Solar thermal system(CO2)

- Solar thermal systems convert sunlight (Solar Radiations) to heat.

- Categorized by:

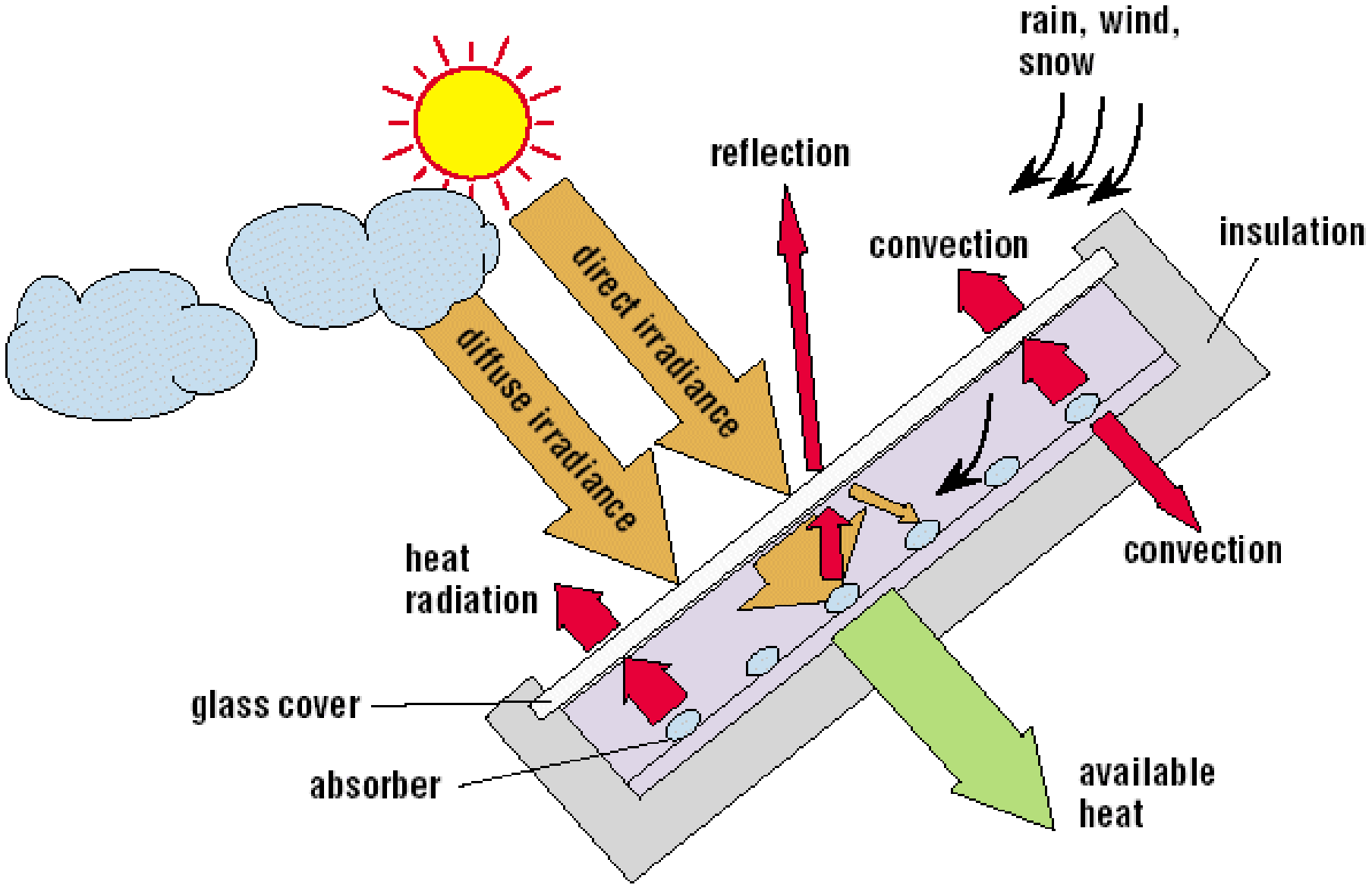
FLAT PLATE COLLECTORS

CONCENTRATING COLLECTORS

  - using lens; regular or Fresnel
  - Flat mirror (possibly many of them)
  - Parabolic/cylindrical: single axis forms “trough”
  - Paraboloidal: axis of revolution forms “dish”

Flat plate collector(CO2)

Processes at a flat-plate collector(CO2)



Rooftop Heaters(CO2)

- Thermo syphon units place the storage tank above the panels, and heated water rises into the tank.
- Cooler return water flows from the tank to the bottom of the collectors to enter at the cold end.
- No pump is needed to circulate the water.

Solar Cooker(CO2)

- A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize drink.
- Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves, and advanced, large-scale solar cookers can cook for hundreds of people.
- Because they use no fuel and cost nothing to operate, many non-profit organizations are promoting their use worldwide in order to help reduce fuel costs (especially where monetary reciprocity is low) and air pollution, and to slow down the deforestation and desertification caused by gathering firewood for cooking.
- Solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high, and the health and environmental consequences of alternatives are severe.

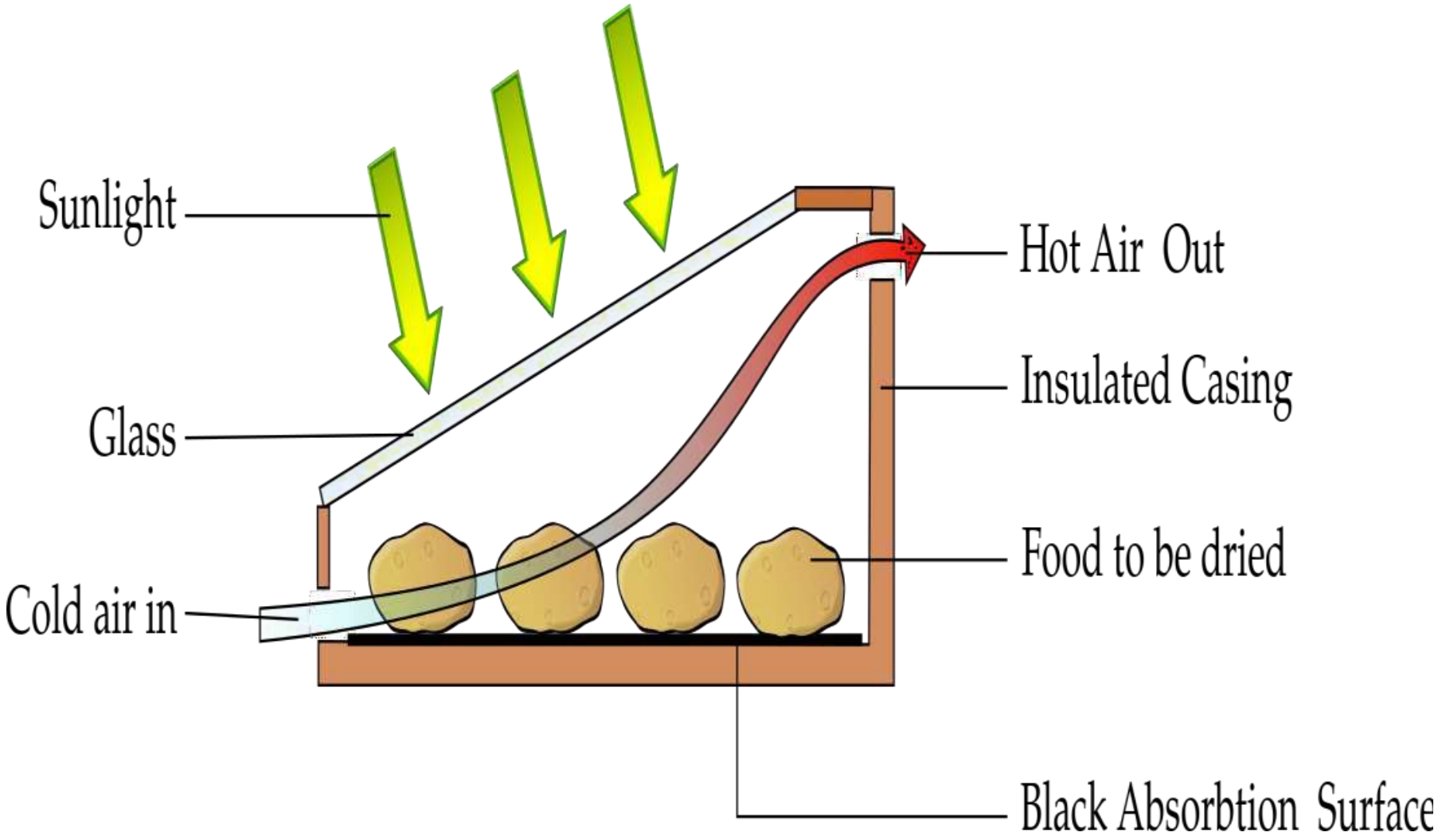
Solar Dryer(CO2)

- Solar dryers are devices that use solar energy to dry substances, especially food. There are two general types of solar dryers: Direct and indirect.

- **Direct solar** dryers expose the substance to be dehydrated to direct sunlight. Historically, food and clothing was dried in the sun by using lines, or laying the items on rocks or on top of tents.

- **In indirect solar** dryers, the black surface heats incoming air, rather than directly heating the substance to be dried. This heated air is then passed over the substance to be dried and exits upwards often through a chimney, taking moisture released from the substance with it.

Solar Dryer(CO2)



Domestic hot water and heat system(CO2)

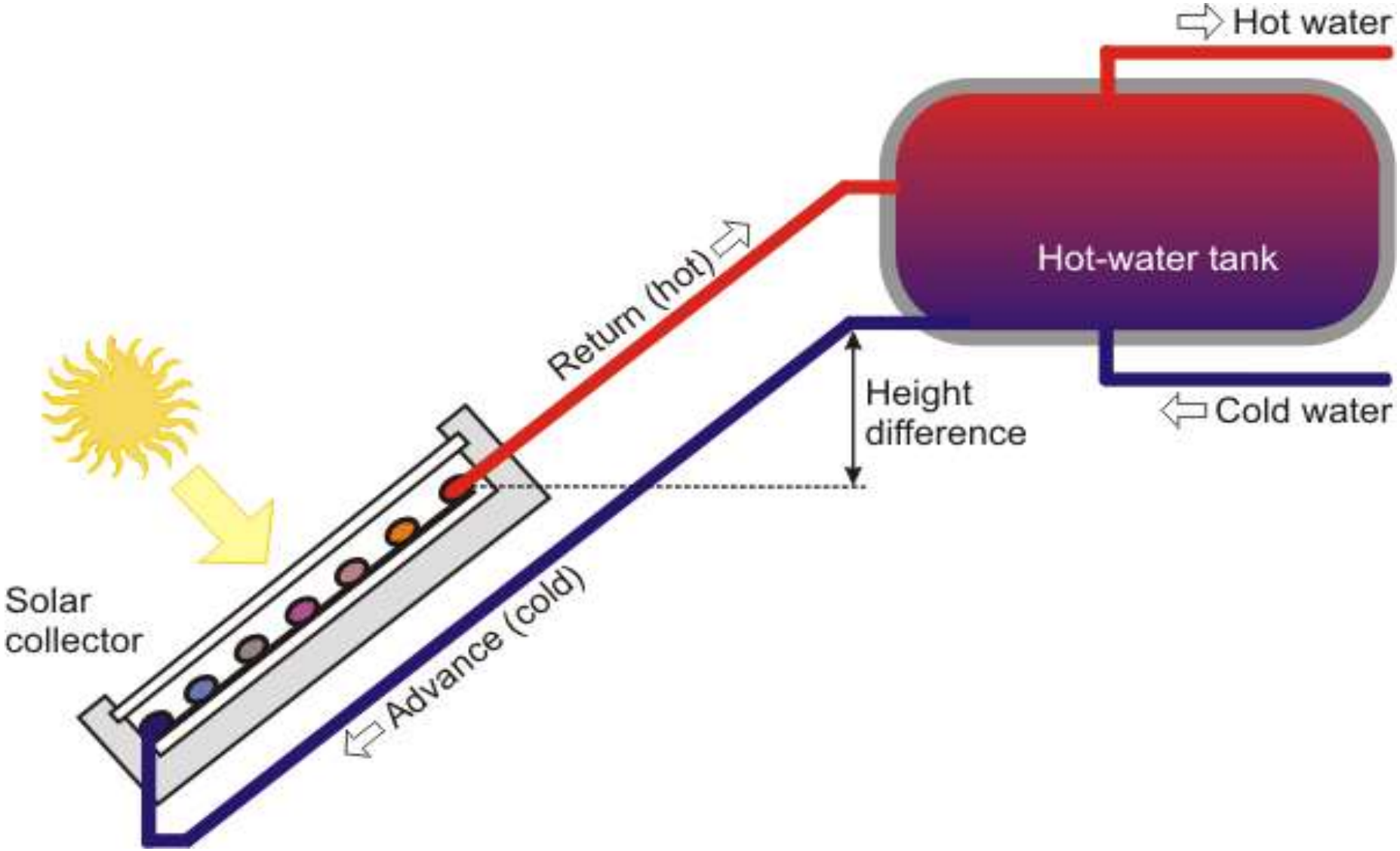
- Water heating is a thermodynamic process that uses an energy source to heat water above its initial temperature.
- Typical domestic uses of hot water include cooking, cleaning, bathing, and space heating.

- In industry, hot water and water heated to steam have many uses.

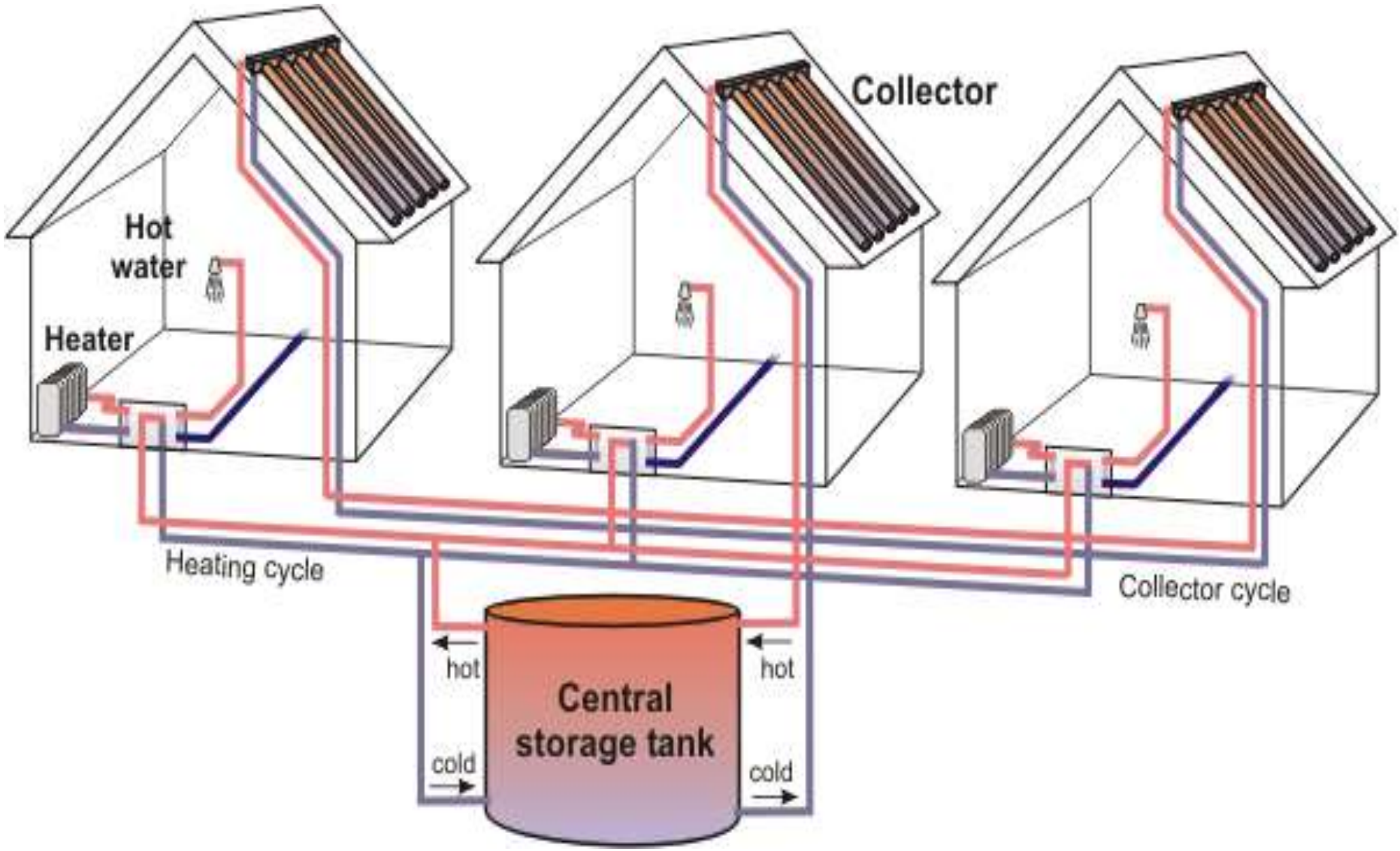
- Domestically, water is traditionally heated in vessels known as water heaters, kettles, cauldrons, pots, or coppers.
-
- These metal vessels that heat a batch of water do not produce a continual supply of heated water at a preset temperature.

- Hot water occurs naturally, usually from natural hot springs. The temperature varies with the consumption rate, becoming cooler as flow increases.

A thermo syphon system(CO2)



A solar district heating system(CO2)

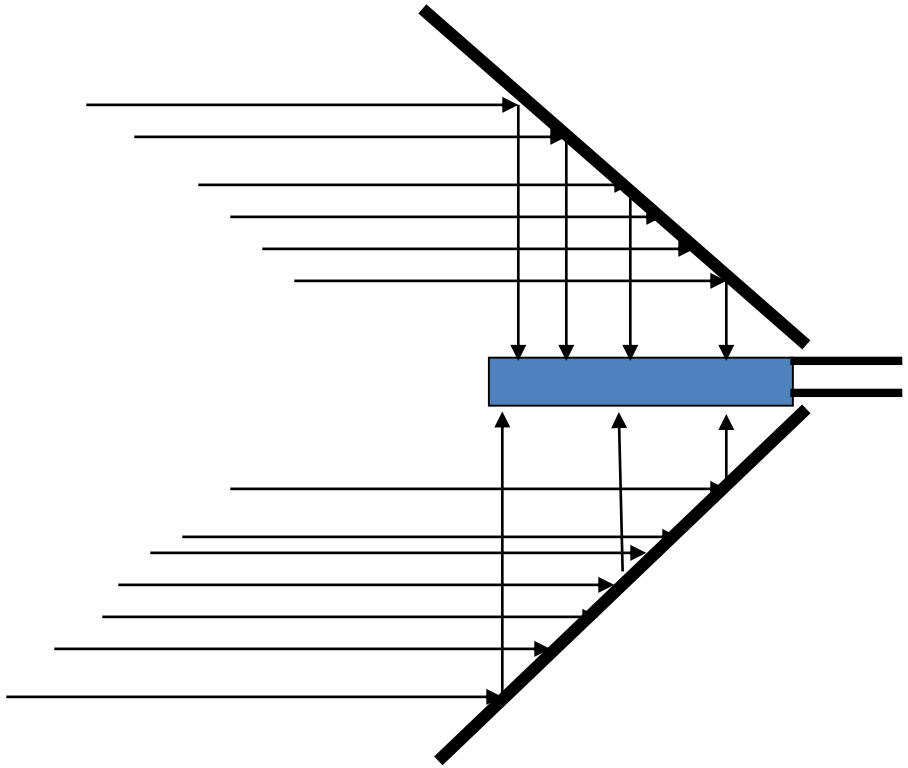


Concentrating Collectors(CO2)

- Axicon Conical Reflector
- .Parabolic Trough
- Paraboloidal Dish
- Solar Power Tower

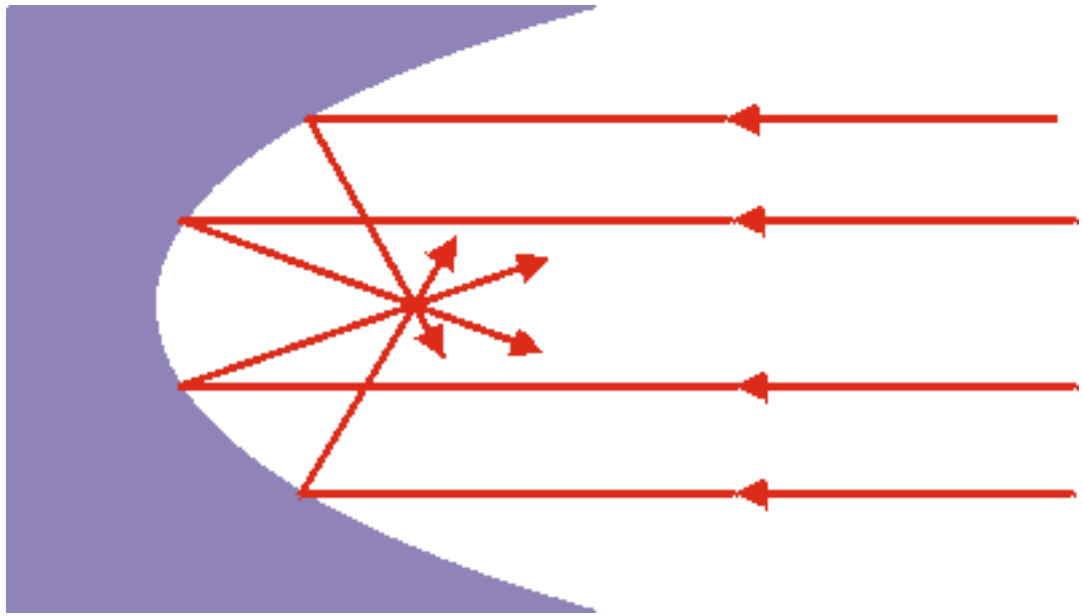
Axicon conical reflector(CO2)

- A polished mirror cone reflects the sun onto a water-filled pipe and can boil the water
- The surface of polished metal or foil is cheap to make and form
- First used in the 1800s



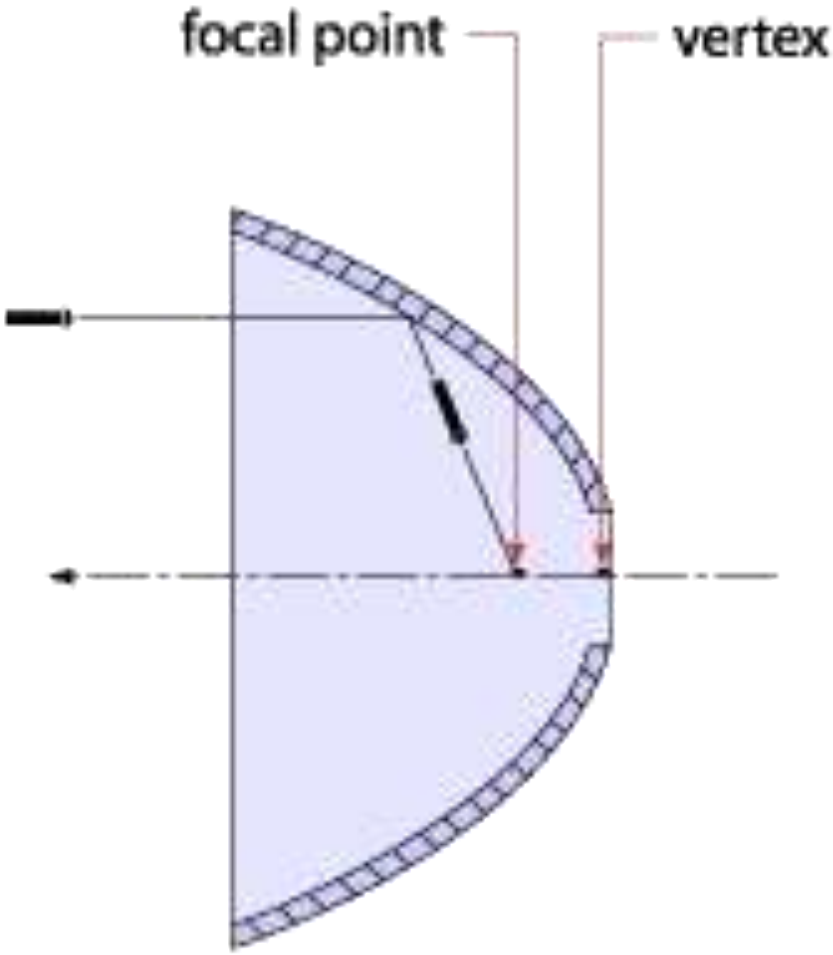
Solar Focusing Systems: Parabolic(CO2)

- Focuses parallel rays to a line
- A black pipe is placed with its center at the focus
- Pipe can be in a vacuum or could have a glass cover tube to reduce convection
- Cylindrical reflector can be on one half of the vacuum tube and approximates the parabolic shape



Solar Focusing Systems: Paraboloidal(CO2)

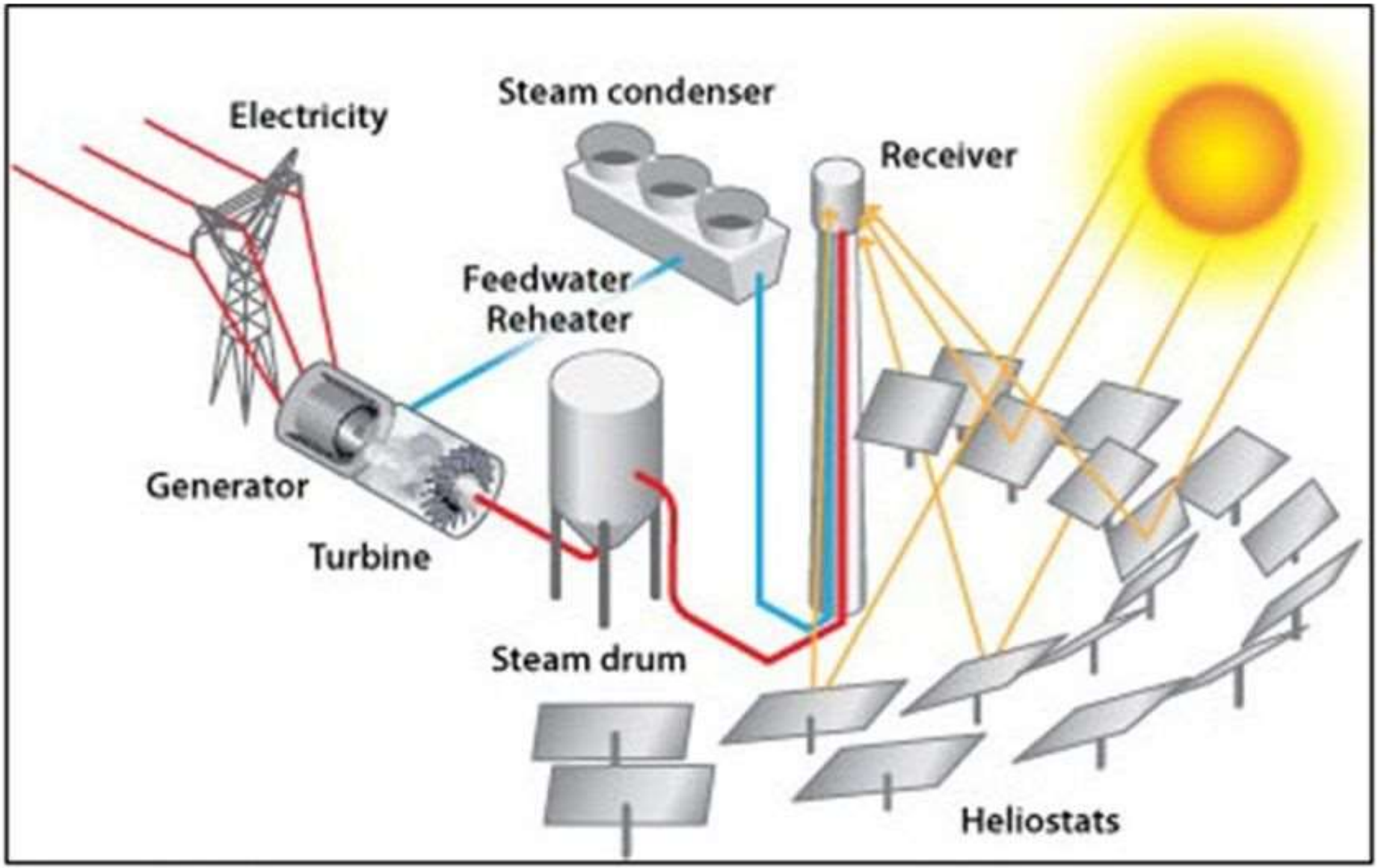
- The focus at one spot is achieved by the parabolic cross-section
- Flat mirror segments may be used to approximate the curve at much lower expense



Solar Power Towers(CO2)

- Solar power towers were developed using Heliostats (Heliostatic .mirrors) to focus sunlight at central receiver tower.
  - The heliostat mirrors are about ten feet square and mounted on the azimuth-elevation mounts (like a radar antenna mount) about 10 feet off the ground.
  - Normally water is used to produce steam, but the system is being modified for molten salt.

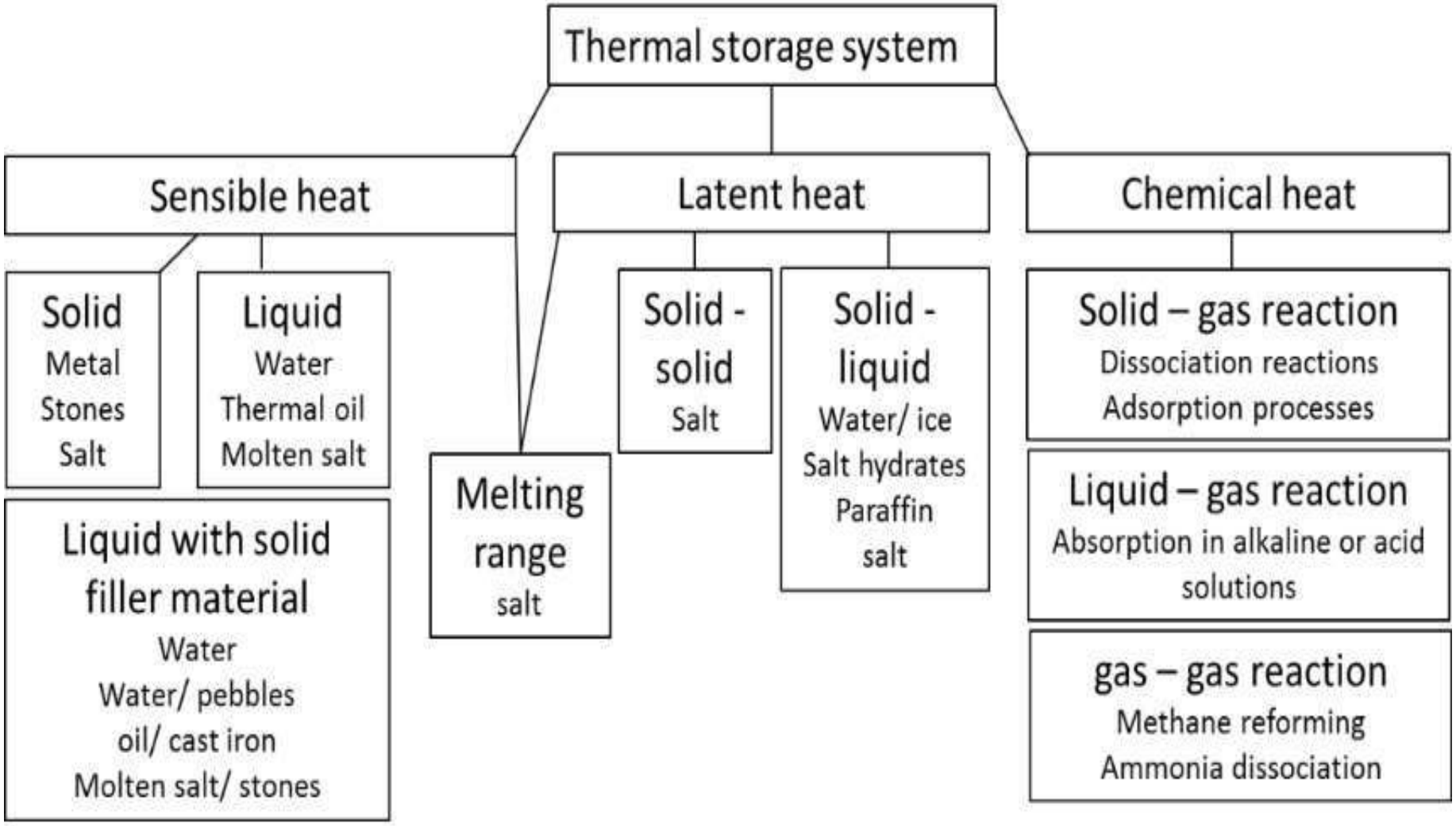
Solar Power Towers(CO2)



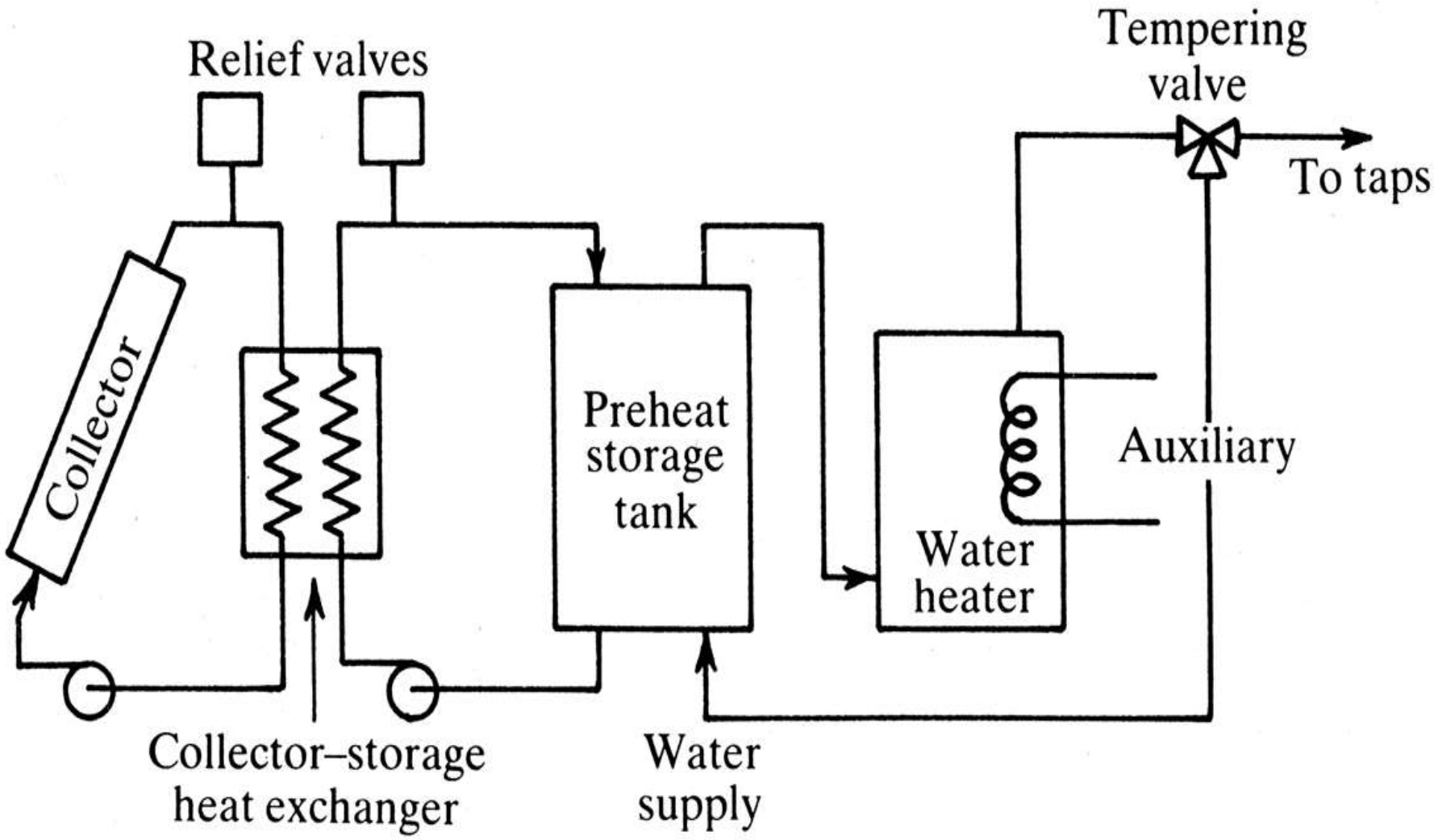
Advantages & Disadvantages of solar thermal system(CO_2)

- Solar thermal systems work efficiently at lower temperatures since cheap flat collectors can work economically
- Reflecting systems need broad acceptance angles so that the optics don't cost too much
  - The beam need only strike the absorber, not form a picture image (noncoherent)
- Reflectors must be kept clean by frequent washing
- Reflectors wouldn't be wise in hailstorm country!
  - Could be protected by a quickly erected tarp

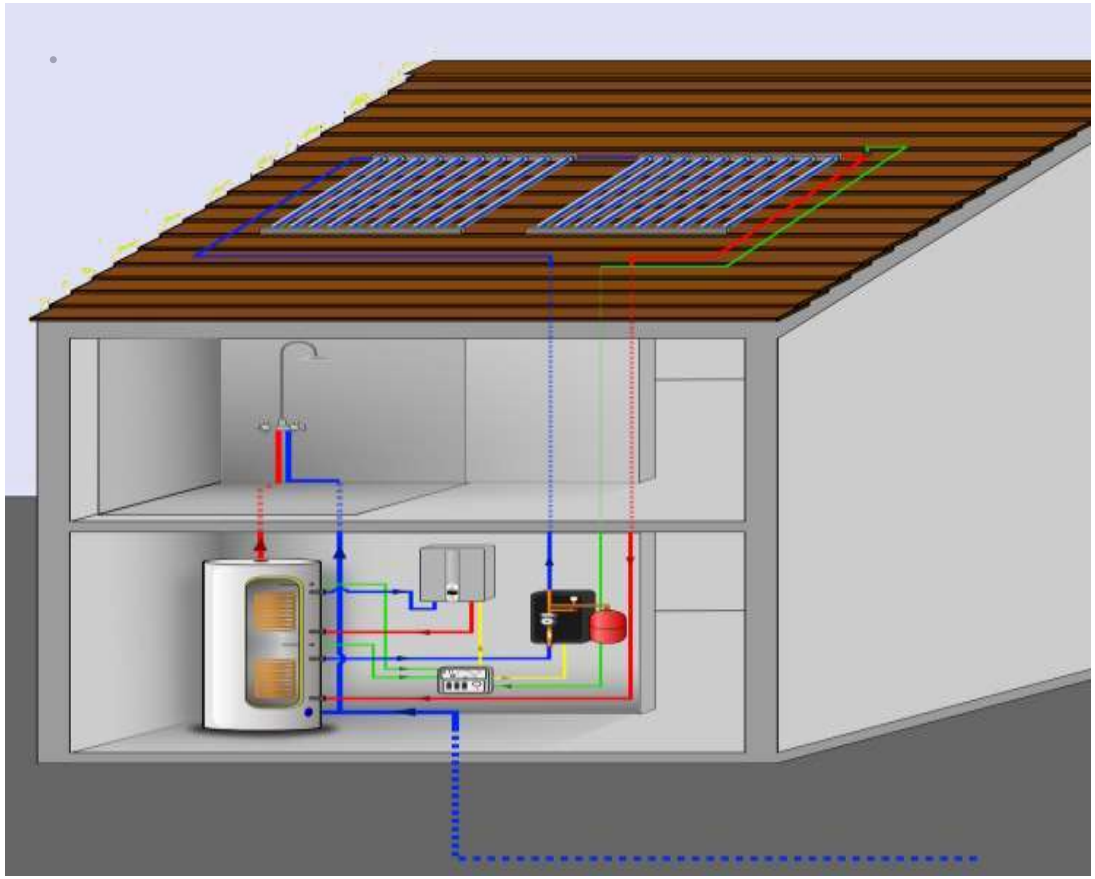
Methods For Storing Solar Thermal Energy

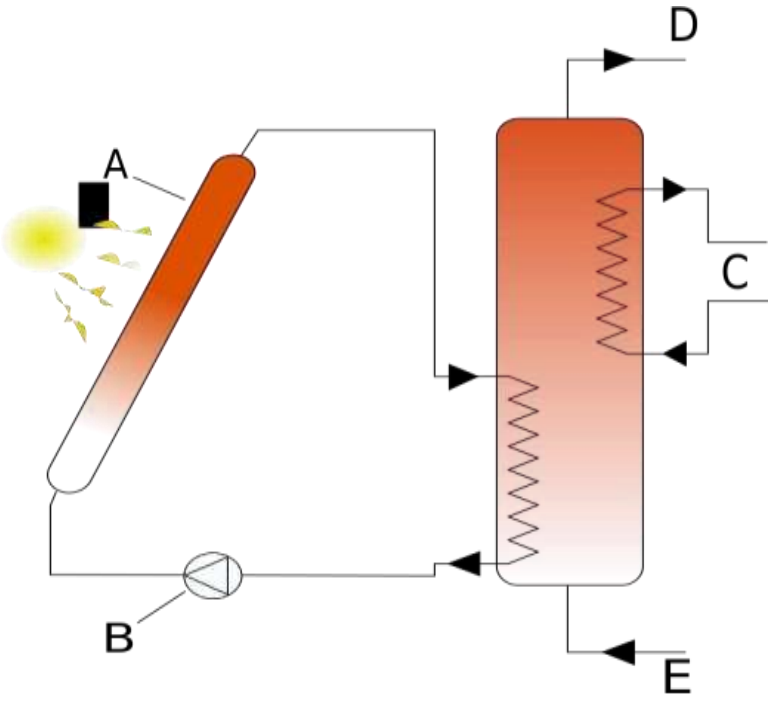


Solar Power Plant (CO2)



Solar Power Plant (CO2)

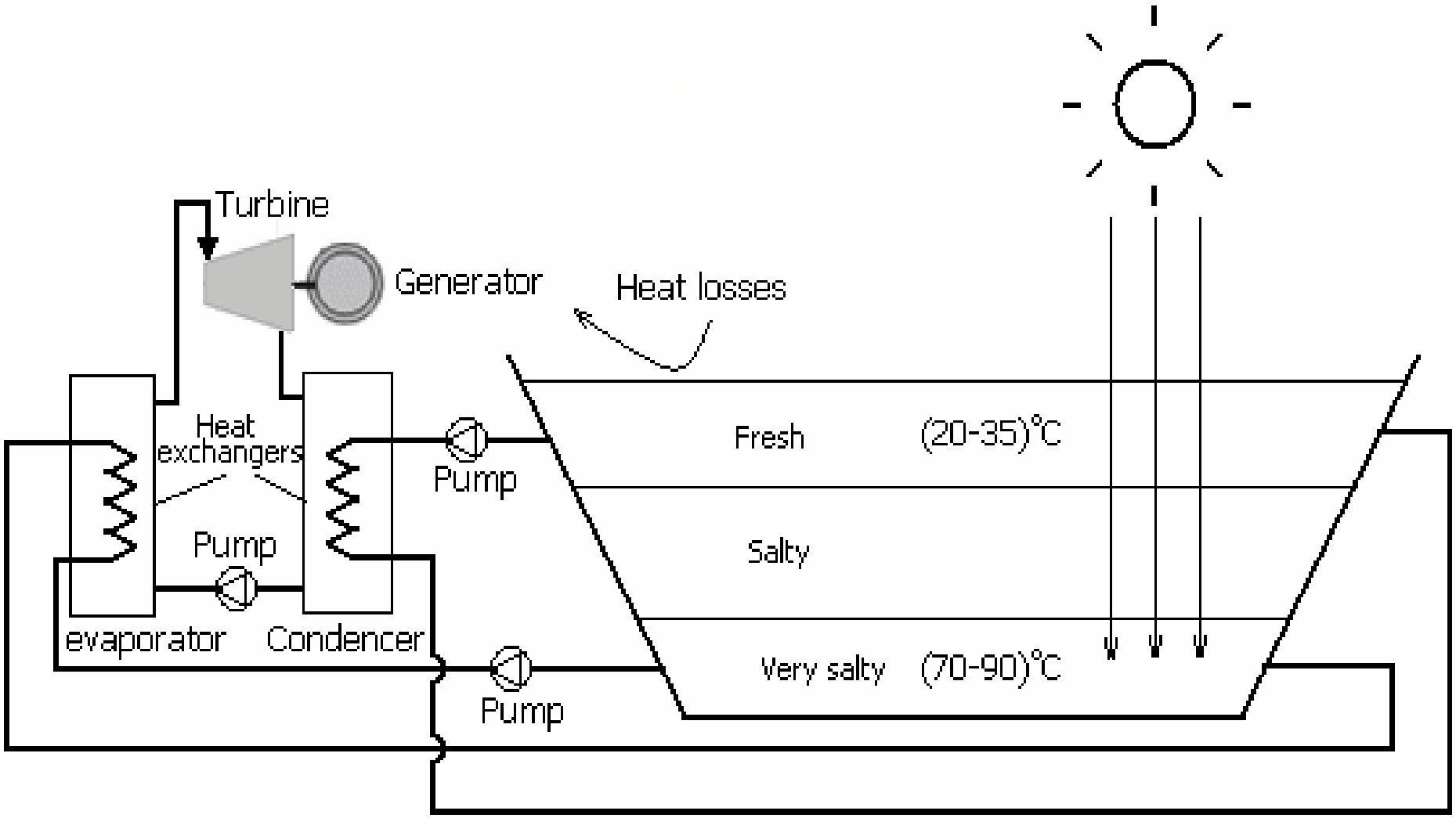




SOLAR PONDS(CO2)

- Normal ponds receive sunlight a part of which is reflected at the surface, a part is absorbed and the remaining is transmitted to the bottom.
- Due to this the lower part gets heated up and the density decreases as a result of which it rises up and convection currents are set up.(As a result, the heated water reaches top layer and looses its heat by convection and evaporation).
- A natural or artificial body of water for collecting and absorbing solar radiation energy and storing it as heat.
- Thus a solar pond combines solar energy collection and sensible heat storage.
- They are large shallow bodies of water that are arranged so that the temperature gradient are reversed from the normal.
- This allows the use for collection and storage of solar energy which may under ideal conditions be delivered at temperature 40-50 `C above normal.
- It can be use for various applications, such as process heating, water desalination, refrigeration, drying and power generation.

SOLAR PONDS(CO2)



FACULTY VIDEO LINKS, YOUTUBE & NPTEL VIDEO LINKS AND ONLINE COURSES DETAILS

- Youtube /other Video Links

- https://www.youtube.com/watch?v=m6UgO6-HELc
- https://www.youtube.com/watch?v=2-I4jC7CoBc
- https://www.youtube.com/watch?v=od5yWB5aE0c
- https://www.youtube.com/watch?v=_wCG1zB8-ms

DAILY QUIZ

1. Which of the following is true about solar energy?

- **It is becoming cheaper to produce electricity**
- Solar energy can currently replace all of the energy created by fossil fuels
- Most solar panels convert more than 25% of the light that strikes them
- None of the above

2. Solar power is considered a renewable energy source.

- **True**
- false

DAILY QUIZ

3. Solar power can be used to generate heat or _____

- Heat
- **Electricity**
- Sunlight
- Cold

4. Which of the following is another name for solar cells?

- Active cells
- **PV cells**
- Voltage cells
- Passive cells

DAILY QUIZ

5. Which of the following is a drawback to using solar cells to produce electricity?

- Cost of the cells
- It takes a lot of cells to produce energy
- It is dependent on the weather
- **All of the above**

6. Solar energy is a _____ energy resource.

- **Renewable**
- Nonrenewable

GLOSSARY QUESTIONS

Kindly choose answer from following Glossary:

a) Renewable source of Energy
b) Non renewable source of Energy
c) None

QUESTIONS

Q. 01. solar is,

Q. 02 wind is,

Q. 03. water is,

WEEKLY ASSIGNMENT

1. How do solar panels actually work?
2. Is solar energy reliable and powerful enough for home or business?
3. How does solar energy benefit the environment?
4. What is photovoltaic (solar electricity) or "PV"?
5. How can we get electricity from the sun?
6. What are the components of a photovoltaic (PV) system?
7. What's the difference between PV and other solar energy technologies?
8. How does a solar water-heating system work?

MCQ

1-Direct Solar energy is used for

(A) Water heating

(B) Distillation

(C) Drying

(D) All of the above

2-The power from the sun intercepted by the earth is approximately

(A) 1.8×10^{8} MW

(B) 1.8×10^{11} MW

(C) 1.8×10^{14} MW

(D) 1.8×10^{17} MW

3-The following is indirect method of Solar energy utilization

(A) Wind energy

(B) Biomass energy

(C) Wave energy

(D) All of the above

MCQ

4-The efficiency of various types of collectors __with __temperature.

(A) increases, decreasing

(B) decreases, increasing

(C) remains same, increasing

(D) depends upon type of collector

5-Maximum efficiency is obtained in

(A) Flat plate collector

(B) Evacuated tube collector

(C) Line focussing collector

(D) Paraboloid dish collector

6-The following type of energy is stored as latent heat

(A) Thermal energy

(B) Chemical energy

(C) Electrical energy

(D) Mechanical energy

OLD QUESTION PAPER

MME272

Printed Pages: 01 **Sub Code: MME272**

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M. TECH.

(SEM-II) THEORY EXAMINATION 2018-19

RENEWABLE ENERGY SYSTEMS

Time: 3 Hours *Total Marks: 100*

Note: Attempt all Sections. If require any missing data; then choose suitably.

SECTION A

1. Attempt *all* questions in brief. **2 x 10 = 20**

a) Define solar constant.
b) What are the conventional and non-conventional energy sources?
c) Define collector efficiency.
d) Define declination angle.
e) Define global radiation.
f) What are the different biomass energy resources?
g) Which element of hydroelectric power plant prevents the penstock from water hammer phenomenon?
h) What are the basic components of WECS?
i) What is biomass?
j) Explain how renewable energy is spreading wings in India.

SECTION B

2. Attempt any *three* of the following: **10 x 3 = 30**

a) Discuss the prospects of renewable energy sources in India.
b) Discuss Zenith angle, hour angle and day length.
c) What are the advantages and disadvantages of small hydro power plants?
d) Classify biomass conversion technologies. Explain anaerobic digestion process for production of methane.
e) Describe the main considerations in selecting a site for wind farm. Discuss merits and demerits of wind energy.

OLD QUESTION PAPER

SECTION C

3. **Attempt any *one* part of the following:** 10 x 1 = 10
   a) Discuss the environmental impacts of conventional energy usage.
   b) Differentiate between Conventional and Non-conventional energy resources.
4. **Attempt any *one* part of the following:** 10 x 1 = 10
   a) Explain the measurement of solar radiation.
   b) Briefly explain solar energy system economics.
5. **Attempt any *one* part of the following:** 10 x 1 = 10
   a) Explain the working of single basin tidal plant.
   b) Explain various energy storage systems. Give advantages and disadvantages of each.
6. **Attempt any *one* part of the following:** 10 x 1 = 10
   a) Describe the factors that affect the size of biogas plant and the material used for biogas generation.
   b) Explain internal engine modification and its performance.
7. **Attempt any *one* part of the following:** 10 x 1 = 10
   a) Explain the principles of power generation in wind mills. Derive an expression for maximum efficiency.
   b) Describe the basic principle of wind energy conversion and derive the expression for power developed due to wind.

References

1. Energy Efficient Buildings in India Mili Majumdar Tata Energy Research Institute
2. Understanding Renewable Energy Systems Volker Quaschning
3. Renewable Energy Systems Simmoes Marcelo Godoy CRC Press
4. Renewable Energy Resources John Twidell Taylor and Francis
5. Renewable Energy Sources and Their Environmental Impact Abbasi & Abbasi Prentice Hall of India

Thank you