# ALMUSTAQBAL UNIVERSITY COLLEGE
## Iraq – Babylon

# RENEWABLE ENERGY TECHNOLOGY
Sustainable Path For a Carbon Free Future

Refrigeration and Air conditioning Techniques Engineering Department

**Subject : Renewable Energy**

**Grade: 4th Class**

**Lecture :1 – Renewable Energy Resources and its Applications**

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**2023 -2024**

# Lecture Objective

## **Behavioral Objective**

**After this lecture , the students should be able to :**

- Understand the concept and the benefit of renewable energy .
- Know the types of the renewable energy resources and its applications.
- Explain the types of the solar energy systems and its applications.
- Know the solar cell types
- Know the types of the solar thermal systems and its applications.

# Contents



Cont.

# Introduction

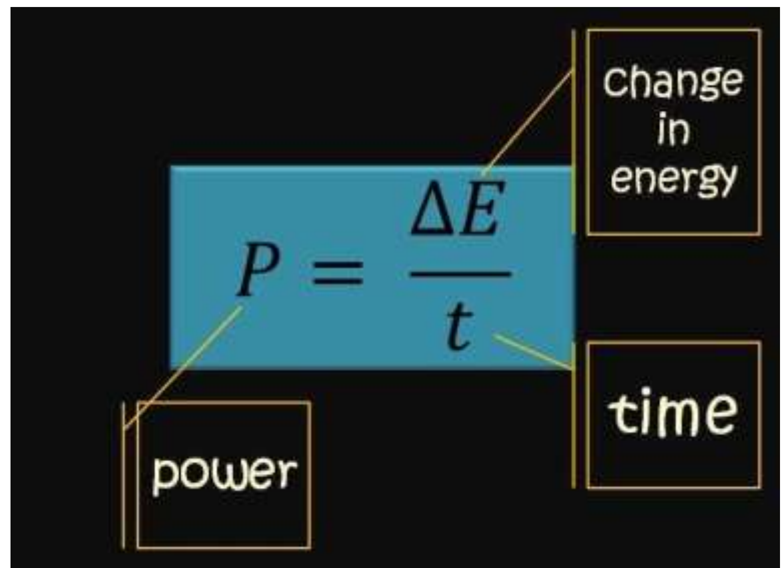
Energy : Measure of the ability of a body or system to do work or produce a change, expressed usually in joules or kilowatt hours (kWh). No activity is possible without energy and its total amount in the universe is fixed. In other words, it cannot be created or destroyed but can only be changed from one type to another. The two basic types of energy are (1) Potential: energy associated with the nature, position, or state (such as chemical energy, electrical energy, nuclear energy). (2) Kinetic: energy associated with motion (such as a moving car or a spinning wheel).

Power is defined as ability to do work.

$$\text{Power} = \frac{work}{time}$$

$$\text{Power} = \frac{force * displacement}{time}$$

$$Power = Force \times velocity$$




The Power of body.....
Strong and Fast...... (Big Force and small times..)

# Introduction

## Power Delivery

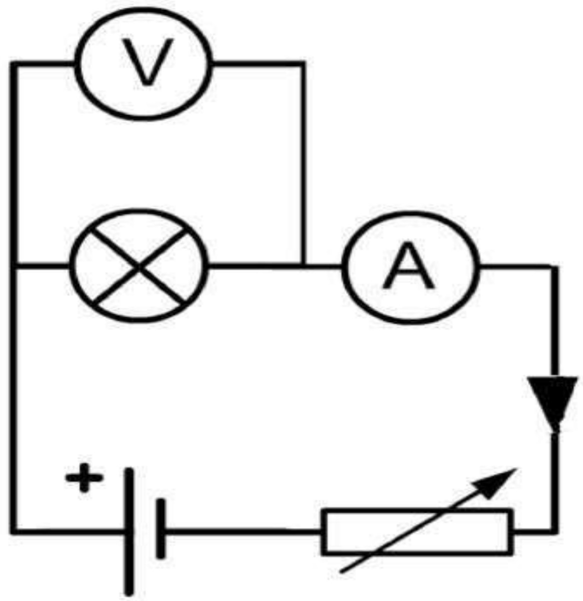
When we talk about Power what we mean is "the amount of energy delivered per second"

**1 Joule / 1 Second = 1 Watt**

It then makes sense that the Power used by a component can be found from the product of current through and voltage across the component;

Power = Voltage x Current

P = V x I



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# Introduction

## Physical measurement and express of energy

**Heat:**

*British thermal Unit (Btu)* The amount of energy to raise 1 pound of water 1 degree Fahrenheit

1 The joule : 1 J = 1 W.s
1 W= 1J/s
1 wh= 3600 J
1 kWh = 3,600,00 J

2 The calorie :
1cal = 4.184 J , and 1 kcal = 4184 J

3 The British thermal unit (Btu):
1 Btu = 1055 J.
1 Btu/h=0.294 w
1000 Btu/h= 293 W

**Power Units Conversion Table**

| Btu/hour | Watt | HP | kW |
|---|---|---|---|
| 1 | 0.293 | 0.00039 | 0.00029 |
| 3.413 | 1 | 0.00134 | 0.001 |
| 2546.10 | 746 | 1 | 0.746 |
| 3413 | 1000 | 1.341 | 1 |

| Quantity | Unit | Symbol | Name | |
|---|---|---|---|---|
| Energy | Kg $m^2/s^2$ ( N.m) | J | Joule | |
| power | Kg $m^2/s^3$ ( j/s) | w | watt | |

Cont.

# Introduction

## TEMPERATURE

1- The Celsius ( centigrade ) scale :
2- The Kelvin scale

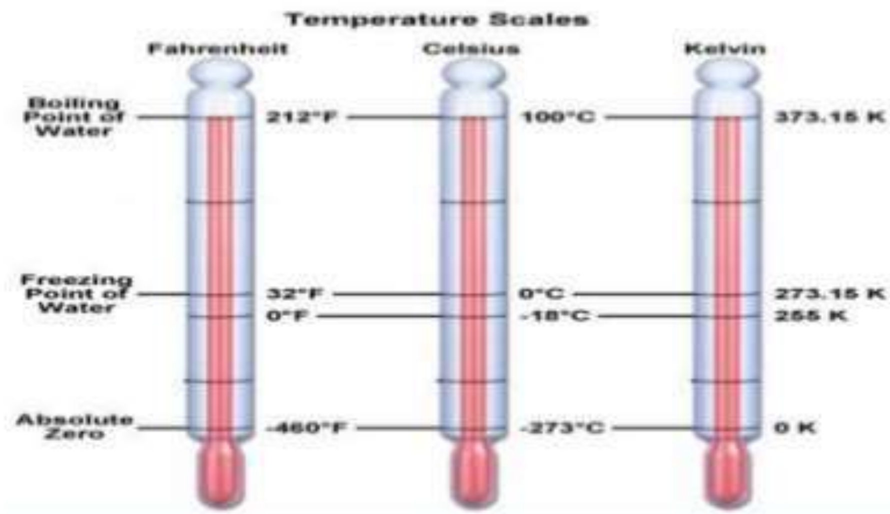
$0 \ ^{o}C = 273.15\ K$
$+ 100 \ ^{o}C = 373.15\ K$

3 The Fahrenheit scale :
$^{o}C = (5/9)(^{o}F - 32)$
$^{o}F = 1.8\ C + 32^{o}$

4 The Rankine scale :
$(T)\ R = 1.8\ (T)\ K$

## Scale

- Temperature - measure of the thermal energy.
- Measured in degrees [°]using scales.
  1. Fahrenheit.[°F]
  2. Celsius or centigrade. [°C]
  3. Kelvin .[°K]




$$T(\mathrm{K}) = T(^\circ\mathrm{C}) + 273.15$$

$$T(\mathrm{R}) = T(^\circ\mathrm{F}) + 459.67$$

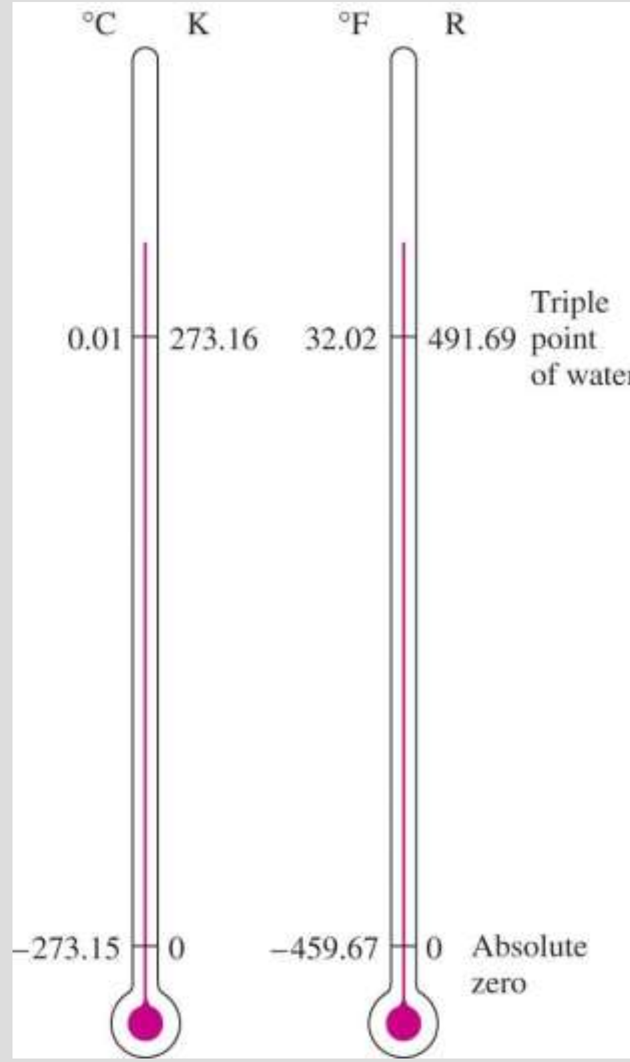
$$T(\mathrm{R}) = 1.8T(\mathrm{K})$$

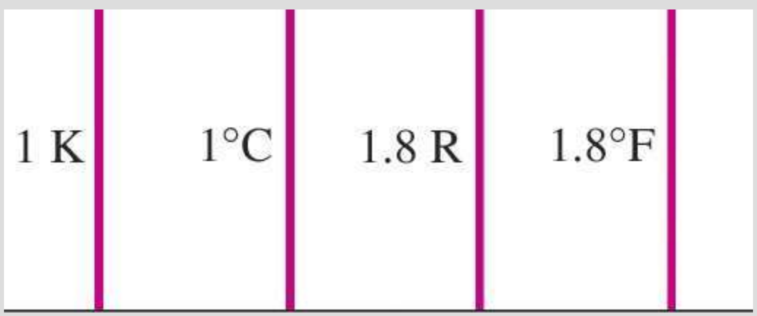
$$T(^\circ\mathrm{F}) = 1.8T(^\circ\mathrm{C}) + 32$$

$$\Delta T(\mathrm{K}) = \Delta T(^\circ\mathrm{C})$$

$$\Delta T(\mathrm{R}) = \Delta T(^\circ\mathrm{F})$$

Comparison of temperature scales.




Comparison of magnitudes of various temperature units.

- The reference temperature in the original Kelvin scale was the ***ice point***, 273.15 K, which is the temperature at which water freezes (or ice melts).
- The reference point was changed to a much more precisely reproducible point, the ***triple point*** of water (the state at which all three phases of water coexist in equilibrium), which is assigned the value 273.16 K.

Cont.

# Introduction

## International System of Units (SI)

### SI Base Units

| Base Quantity | Name | Symbol |
|---|---|---|
| Length | meter | m |
| Mass | kilogram | kg |
| Time | second | s |
| Electric current | ampere | A |
| Temperature | kelvin | K |
| Amount of substance | mole | mol |
| Luminous intensity | candela | cd |

### SI Derived Units

| Derived Quantity | Name | Symbol | Equivalent SI units |
|---|---|---|---|
| Frequency | hertz | Hz | $s^{-1}$ |
| Force | newton | N | $m \cdot kg \cdot s^{-2}$ |
| Pressure | pascal | Pa | $N/m^2$ |
| Energy | joule | J | N·m |
| Power | watt | W | J/s |
| Electric charge | coulomb | C | s·A |
| Electric potential | volt | V | W/A |
| Electric resistance | ohm | Ω | V/A |
| Celsius temperature | degree Celsius | °C | K* |

*Unit degree Celcius is equal in magnitude to unit kelvin.

### SI Prefixes

| Factor | Name | Symbol | Numerical Value |
|---|---|---|---|
| $10^{12}$ | tera | T | 1 000 000 000 000 |
| $10^{9}$ | giga | G | 1 000 000 000 |
| $10^{6}$ | mega | M | 1 000 000 |
| $10^{3}$ | kilo | k | 1 000 |
| $10^{2}$ | hecto | h | 100 |
| $10^{1}$ | deka | da | 10 |
| $10^{-1}$ | deci | d | 0.1 |
| $10^{-2}$ | centi | c | 0.01 |
| $10^{-3}$ | milli | m | 0.001 |
| $10^{-6}$ | micro | μ | 0.000 001 |
| $10^{-9}$ | nano | n | 0.000 000 001 |
| $10^{-12}$ | pico | p | 0.000 000 000 001 |

• Adapted from NIST Special Publication 811
• SI rules and style conventions recommend using spaces rather than commas to separate groups of three digits.

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Cont.

# Introduction

**The Conversion Factors of Joule to Other Units**

| | Joule | Calorie | BTU | Foot-pound | Kilowatt-hour | Megawatt-day | Electronvolt |
|---|---|---|---|---|---|---|---|
| Joule | XX | 0.2390 | 0.000948 | 0.7375 | 2.77778E-07 | 1.15741E-11 | 6.2383E+18 |
| Calorie | 4.184 | XX | 0.00397 | 0.3238 | 1.16279E-06 | 4.85437E-11 | 2.61097E+19 |
| BTU | 1055 | 252 | XX | 778.2 | 0.000293 | 1.221E-08 | 6.57895E+21 |
| Foot-pound | 1.356 | 0.3238 | 0.001285 | XX | 3.84615E-07 | 1.60256E-11 | 8.47458E+18 |
| Kilowatt-hour | 3.6E6 | 8.6E5 | 3412 | 2.6E6 | XX | 4.16667E-05 | 2.24719E+25 |
| Megawatt-day | 8.64E10 | 2.06E10 | 8.19E7 | 6.24E10 | 24000 | XX | 5.40541E+29 |
| Electronvolt | 1.603E-19 | 3.83E-20 | 1.52E-22 | 1.18E-19 | 4.45E-26 | 1.85E-30 | XX |

Cont.

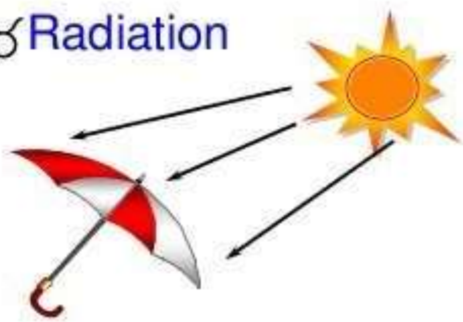
# Introduction

**How is heat transferred?**

- Conduction
  - Metal coffee cup

- Convection

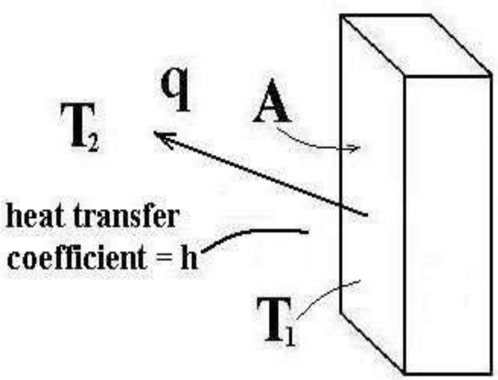
- Radiation



# Forms of Heat Transfer

## Convection

Transfer of energy involving fluid motion

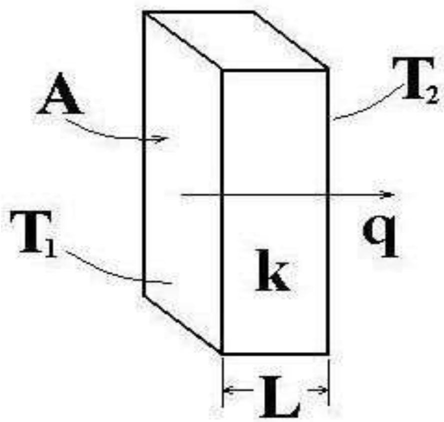



*Newton's Law*

$$Q = hA\,\Delta T$$

## Conduction

Transfer of energy by molecular interactions

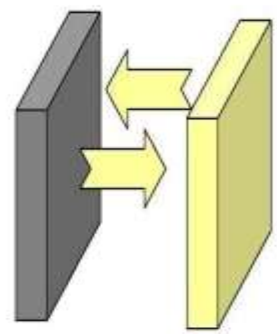



$$q = k\,A\,\frac{T_1 - T_2}{L}$$

*Fourier's Law*

## Radiation

- Heat transfer between two su'aces by emission and later absorption ٤. electromagnetic radiation



requires no physical medium .

- Stefen-Boltzmann Equation:

$$q = A\sigma\varepsilon\left(T_2^4 - T_1^4\right)$$

where $\sigma$ = Stefen-Boltzmann's constant, $5.669\times10^{-8}$ $W/m^2K^4$

$\varepsilon$ = emissivity, (varies from 0 to 1) dimensionless

A = area, $m^2$

$T_1$ = temperature of surface 1, Absolute

$T_2$ = temperature of surface 2, Absolute

# ENERGY TRANSFER BY HEAT

**Heat**: The form of energy that is transferred between two systems (or a system and its surroundings) by virtue of a temperature difference.

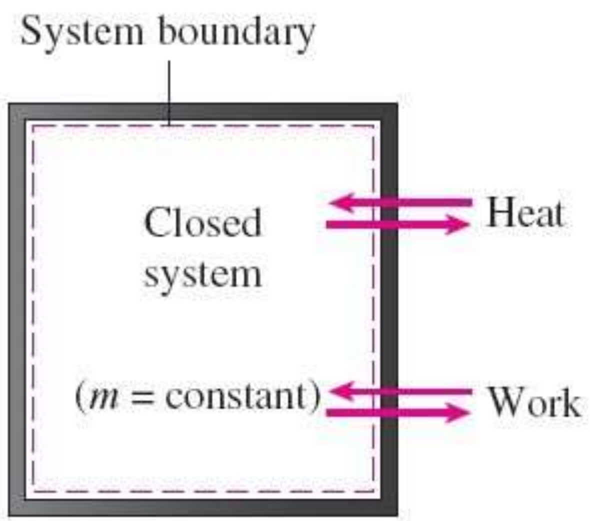



**FIGURE 2–13**
Energy can cross the boundaries of a closed system in the form of heat and work.

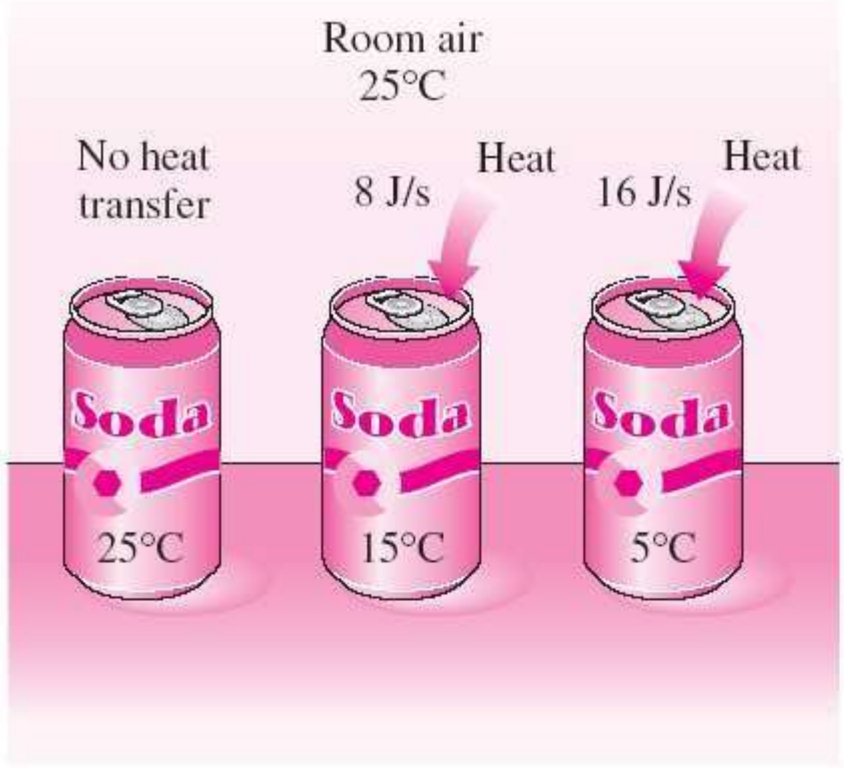



**FIGURE 2–14**
Temperature difference is the driving force for heat transfer. The larger the temperature difference, the higher is the rate of heat transfer.

$$q = \frac{Q}{m} \qquad \text{(kJ/kg)}$$

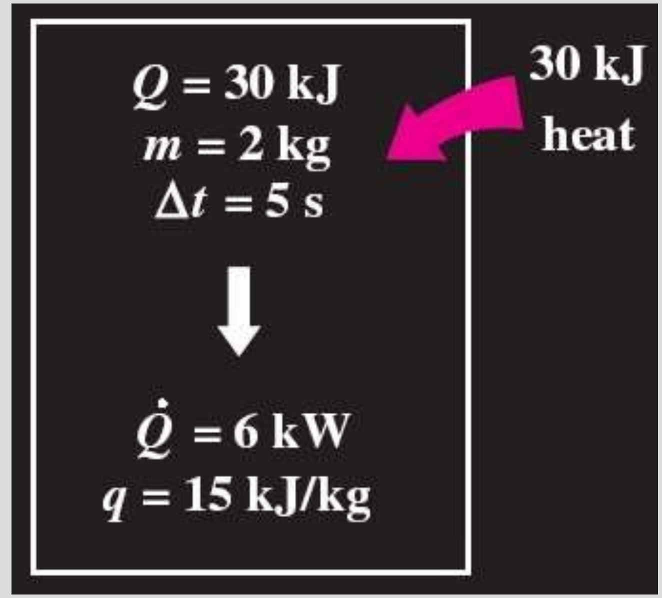
Heat transfer per unit mass

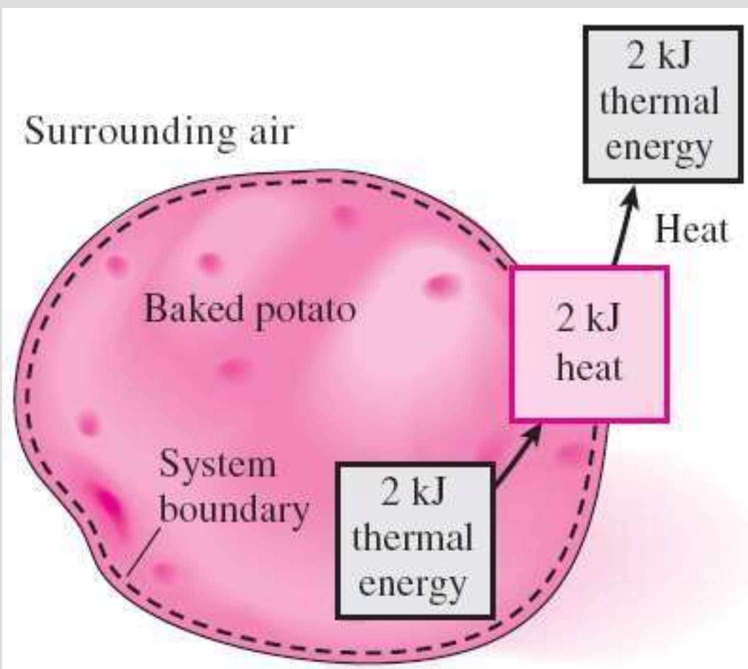
$$Q = \dot{Q}\,\Delta t \qquad \text{(kJ)}$$

Amount of heat transfer when heat transfer rate is constant

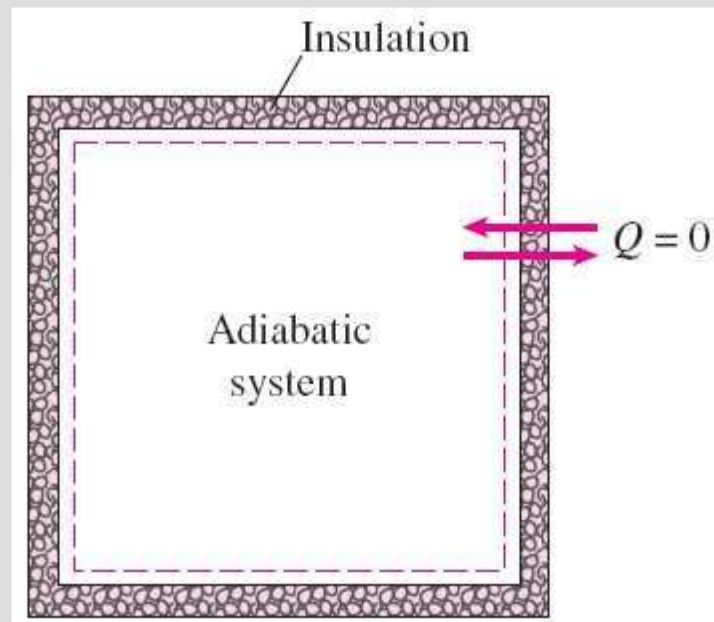
$$Q = \int_{t_1}^{t_2} \dot{Q}\,dt \qquad \text{(kJ)}$$

Amount of heat transfer when heat transfer rate changes with time




Energy is recognized as heat transfer only as it crosses the system boundary.



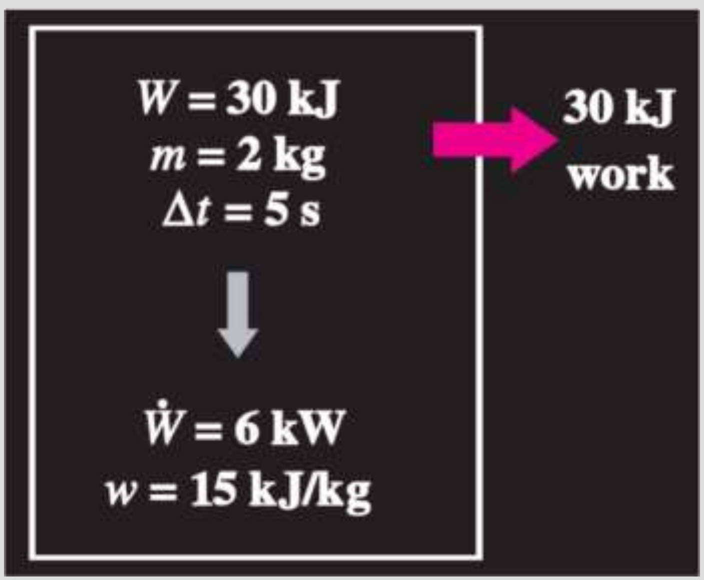

During an adiabatic process, a system exchanges no heat with its surroundings.

# ENERGY TRANSFER BY WORK

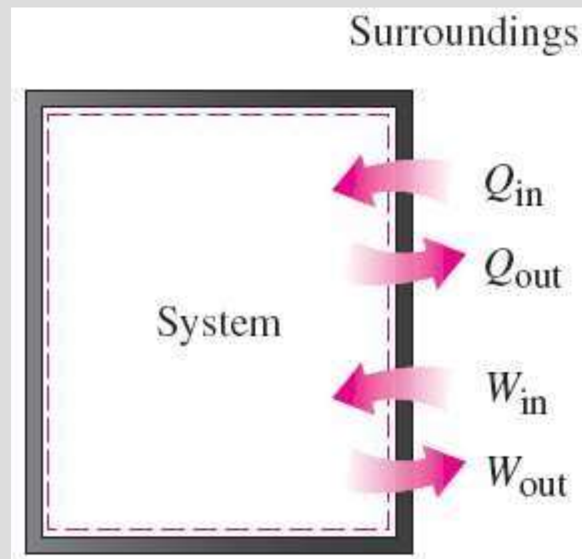
- **Work**: The energy transfer associated with a force acting through a distance.
  - ✓ **A rising piston, a rotating shaft,** and **an electric wire crossing the system boundaries** are all associated with work interactions
- **Formal sign convention**: *Heat transfer to a system and work done by a system are positive; heat transfer from a system and work done on a system are negative*.
- Alternative to sign convention is to use the subscripts ***in*** and ***out*** to indicate direction. This is the primary approach in this text.

$$w = \frac{W}{m} \qquad (\text{kJ/kg})$$

Work done per unit mass




Power is the work done per unit time (kW)




Specifying the directions of heat and work.

## Natural Resources fall under 2 main Categories:

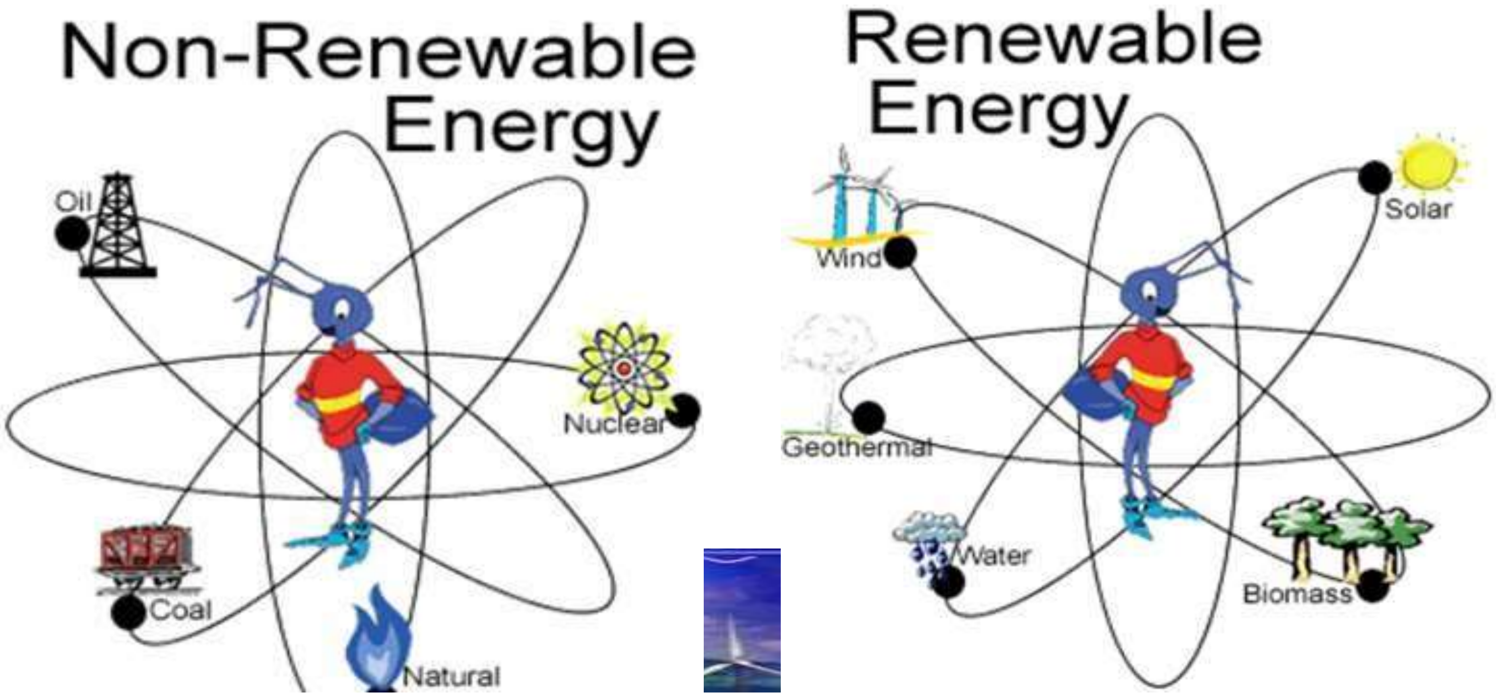
**Renewable Energy**

**Non-renewable Energy**

# Energy Categories

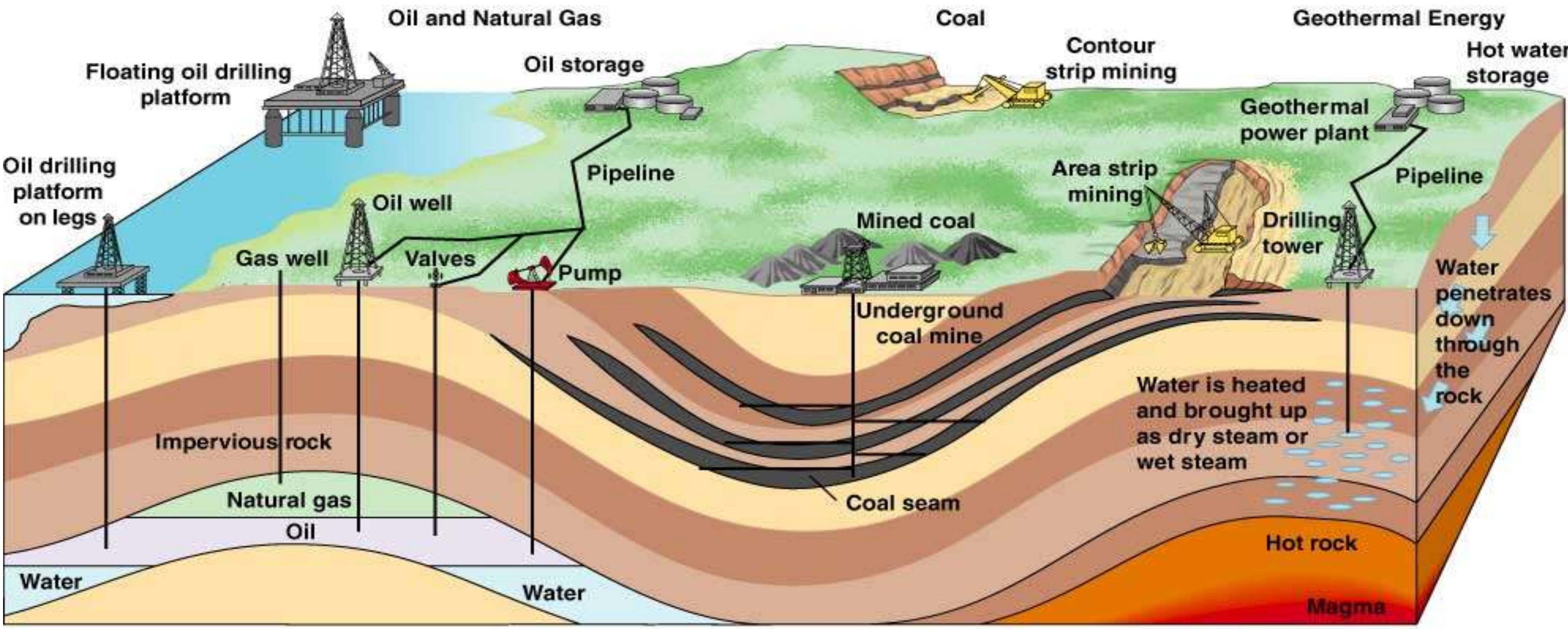
Energy can be broken down into two distinct categories

- Non-renewable :- comes from fossil fuels (coal, oil, natural gaas) and uranium.
- Renewable –Renewable energy is the energy which is generated from natural sources i.e. sun, wind, rain, tides and can be generated again and again as and when required.




# NON RENEWABLE **ENERGY**

**<u>A nonrenewable</u> Energy is a natural resource that cannot be re-made or re-grown at a scale comparable to its consumption.**

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# RENEWABLE ENERGY

**Renewable** Energy **are natural resources that can be replenished in a short period of time.**

## What are the differences between nonrenewable and renewable Energy ?

**nonrenewable is:**

- **Non-renewable (finite resources).**
- **Becoming too expensive.**
- **Have a high impact on environment.**

# Renewable energies Energy

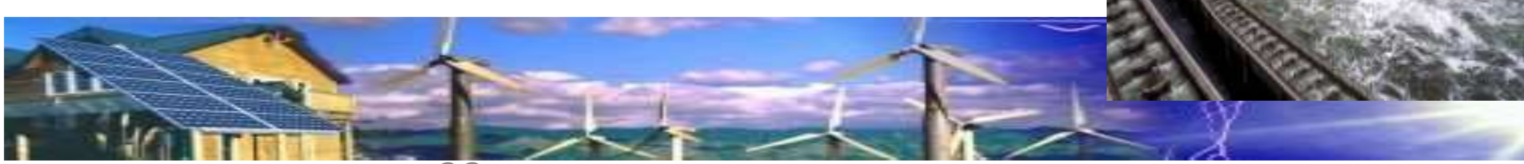
## -- Clean. s

-Clean.

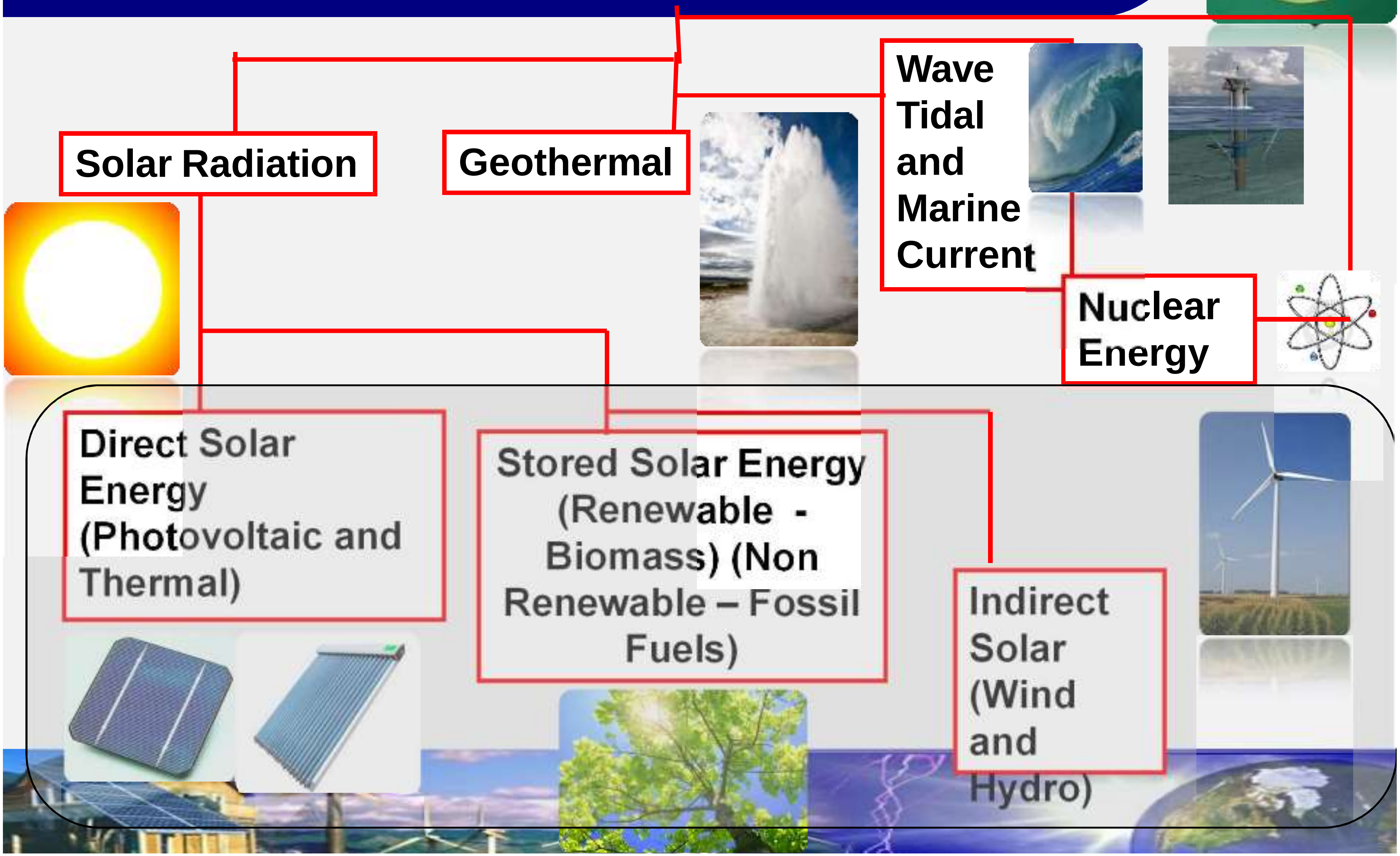
- Non-depleted.
- Have a very small impact on the environment
- Constantly replenished
- Does not have significant pollutant emissions

# Types of Renewable Energy resources

**Solar Energy**
**Wind Energy**
**Biomass Energy**
**Hydrogen Energy & Fuel Cell**
**Hydropower Energy**
**Ocean Energy**
**Geothermal Energy**



# Renewable Energy Resources



# R.E. Energy Resources

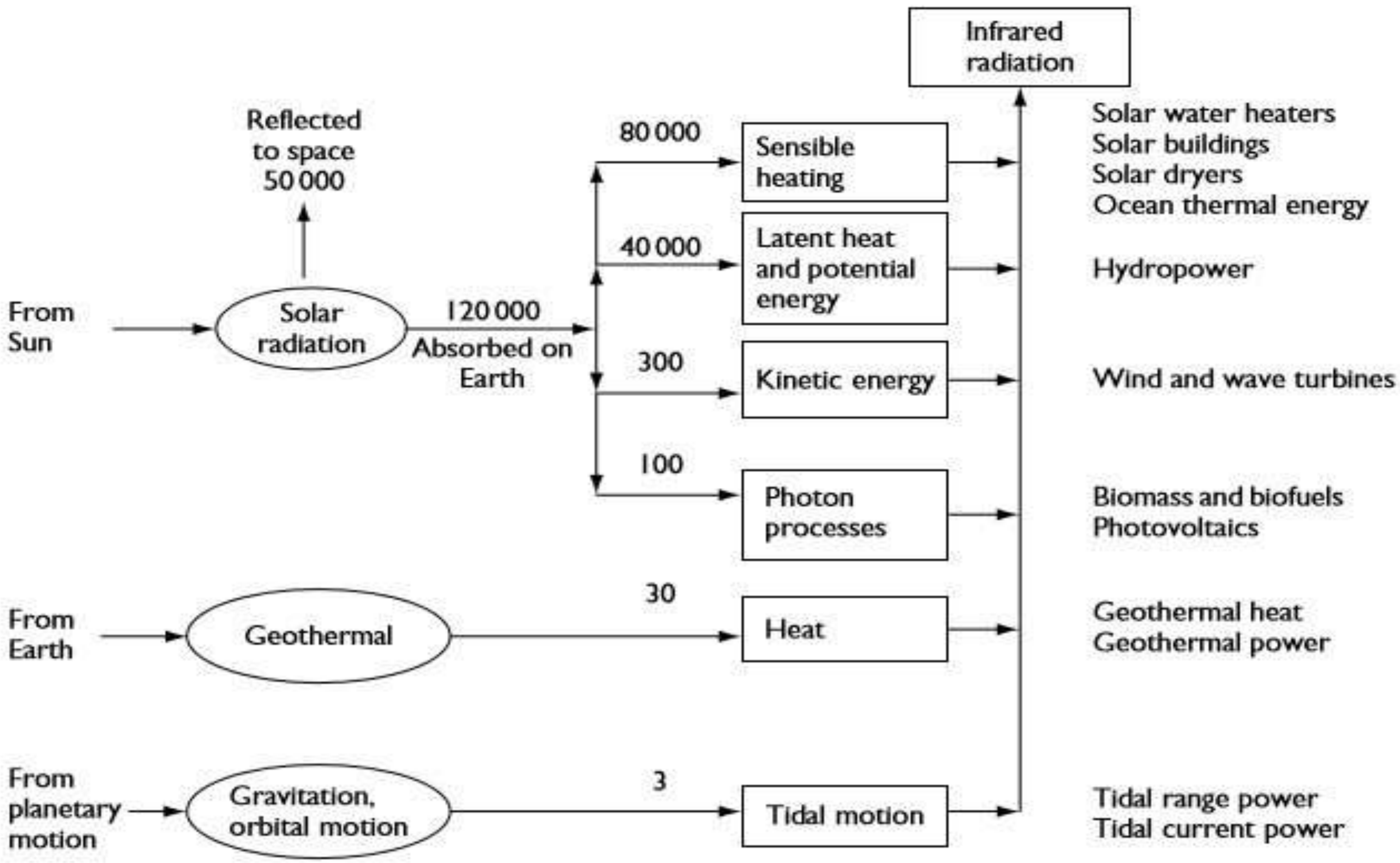



*Figure 1.2* Natural energy currents on earth, showing renewable energy system. Note the great range of energy flux ($1:10^5$) and the dominance of solar radiation and heat. Units terawatts ($10^{12}$ W).

# Global Drivers

من اهم الاسباب التي تدفع نحو استخدام الطاقة المتجددة او الطاقة البديلة هو مشكلة تلوث البيئة نتيجة استخدام الوقود بالإضافة الى التغير او التذبذب في اسعار الوقود وغيرها من الاسباب التي جعلة من التفكير في استخدام الطاقة المتجددة كحل امثل

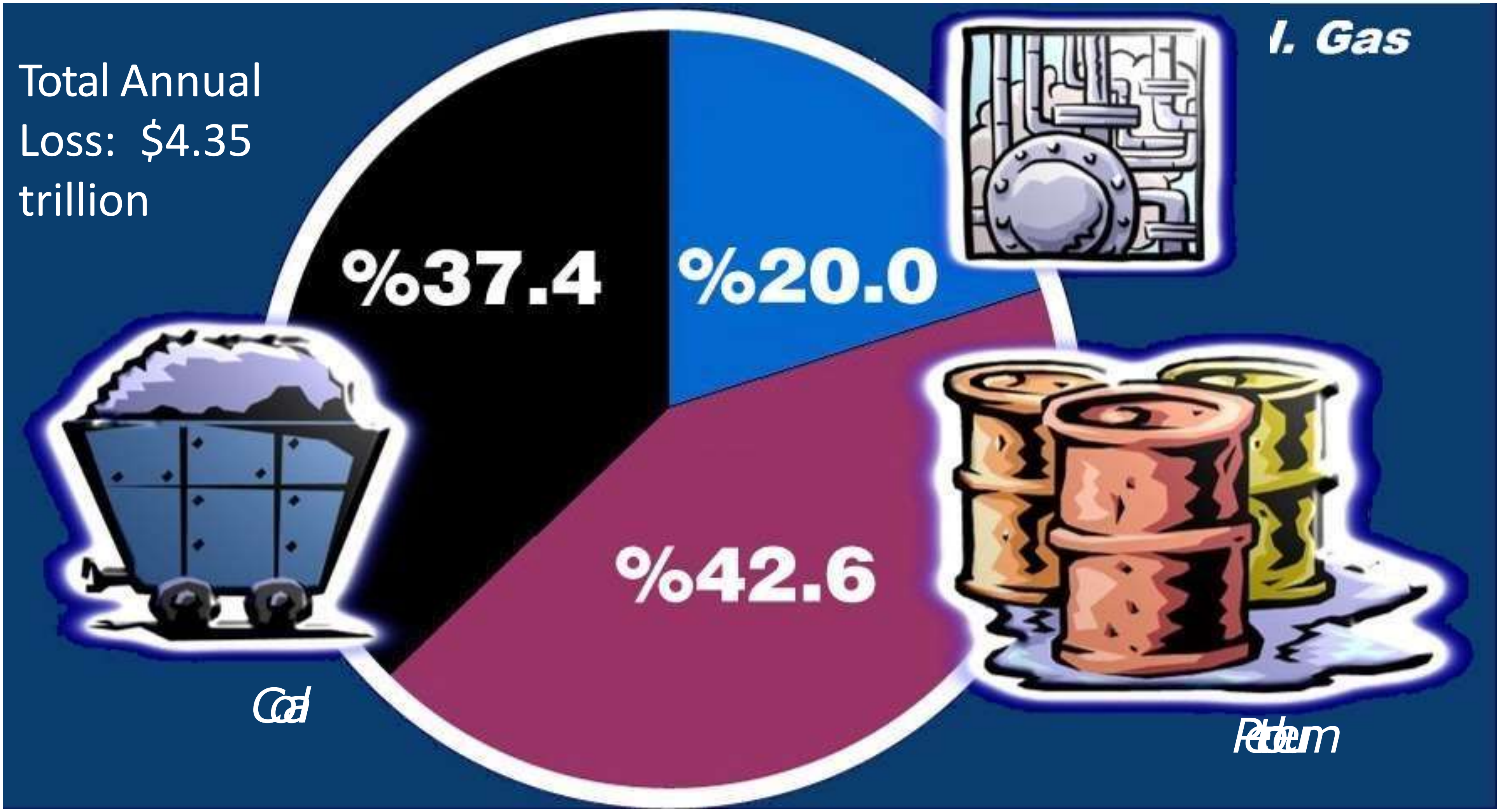
**ENERGY SECURITY**

**FOSSIL FUEL PRICE INCREASE**

**ENVIRONMENTAL PROBLEMS**

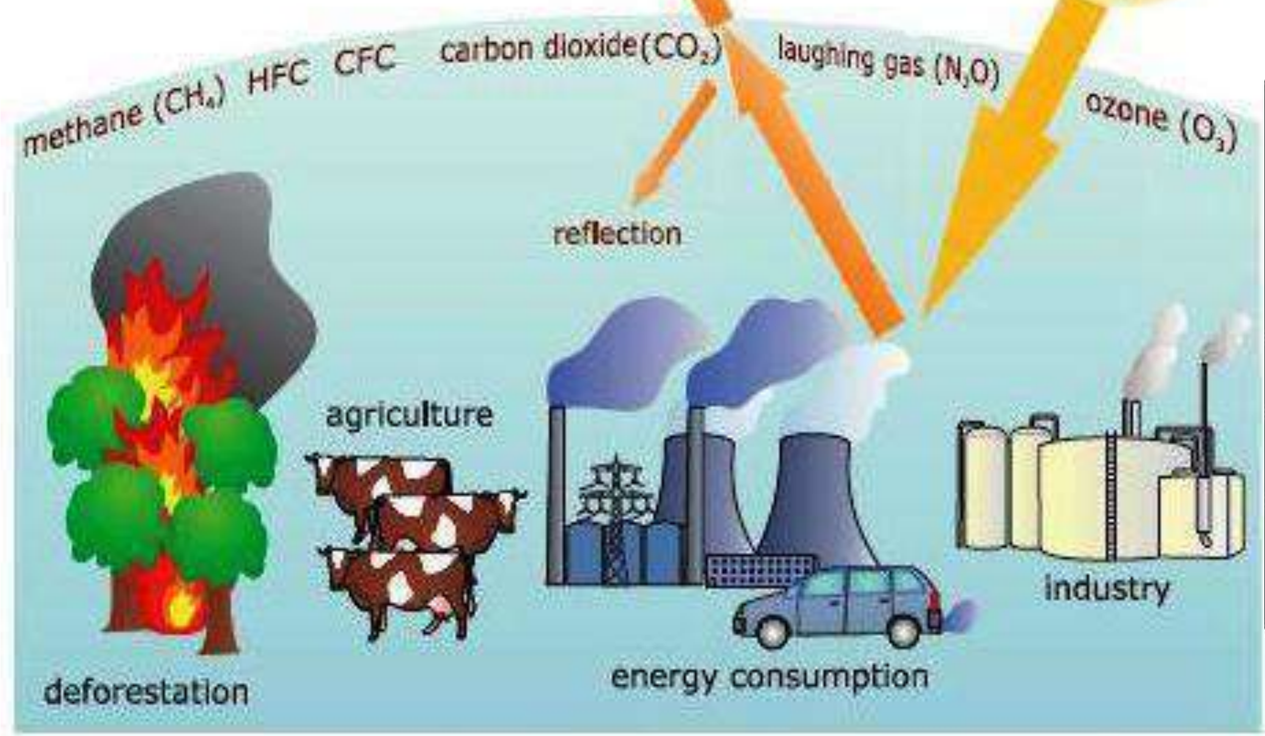
# Environmental damage due to fossil fuels

**Fossil fuels are hydrocarbons containing traces of nitrogen, sulfur and other elements.**



# Effects of Human Activities

significant contribution to the CO2 emitted to the atmosphere is attributed to fossil fuel combustion



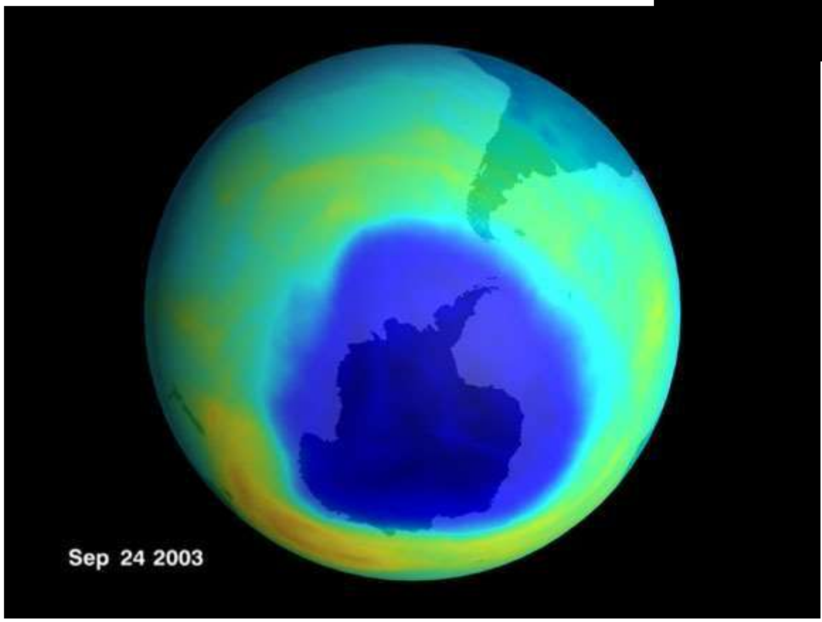

Causes of anthropogenic greenhouse effects due to human activities

| Pollutant | A Major Impact of This Pollutant | Marginal Emissions Rate (kg/MWh) |
|---|---|---|
| $SO_2$ | Acid rain | 1.48 |
| $NO_X$ | Smog, asthma | 0.5 |
| $CO_2$ | Global climate change | 606.8 |

# Ozone Layer Depletion

طبقة الأوزون، هي طبقة من الغلاف الجوي، تشكل درع
الأرض الواقي من حرارة الشمس القاتلة للحياة،
ومن الأشعة فوق البنفسجية التي تصدرها

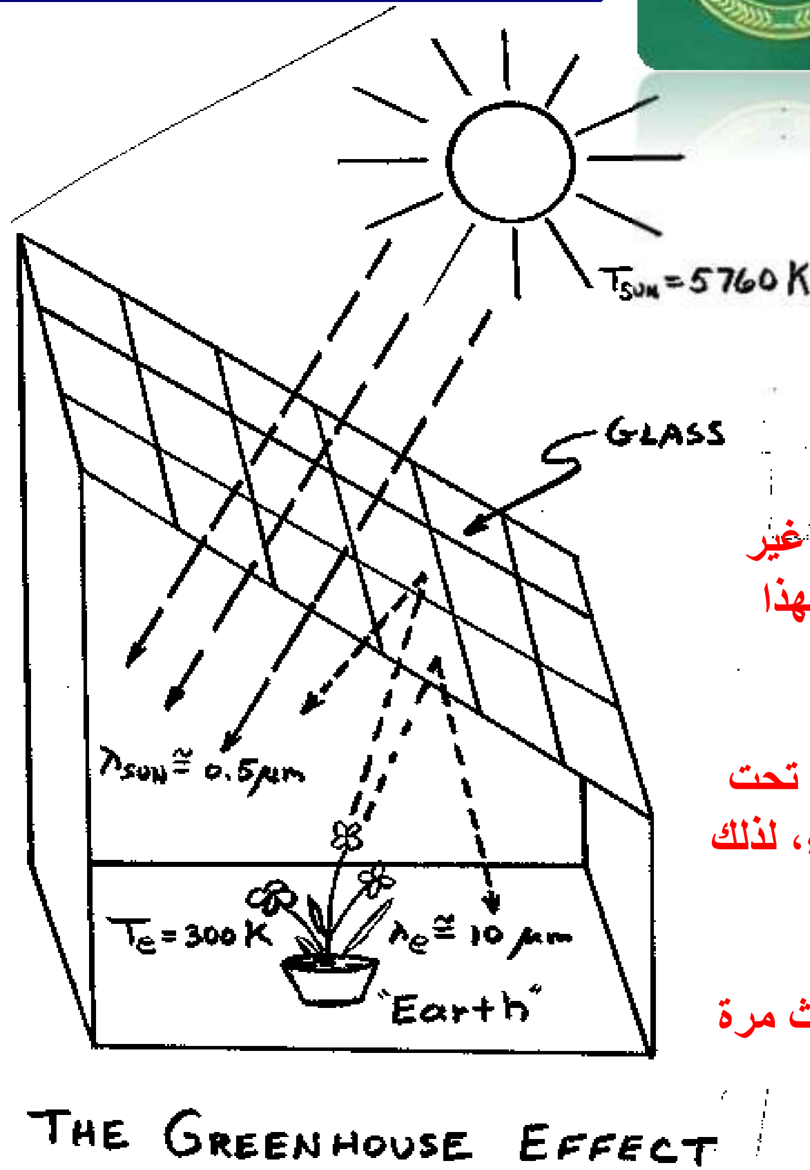
- Ozone is a good absorber of solar ultraviolet radiation, and depletion of upper atmosphere ozone results in increased surface levels of UV radiation.
- Increased levels of UV at the surface enhance global warming, but more importantly, can result to increased human skin cancer and plant damage.



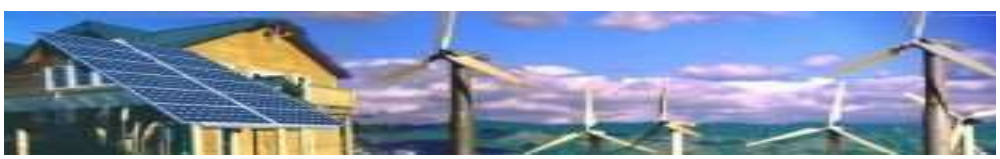

The ozone hole at its peak in 2003 over Antarctica

# A Greenhouse...

- Sunlight at $\lambda = 0.5\ \mu m$ mostly passes through the glass
- Re-emitted radiant energy from the ~300 K interior is at $\lambda \cong 0.5\ \mu m$
- The glass is nontransparent to this infrared wavelength, so re-emitted energy cannot radiate away
- The greenhouse warms up



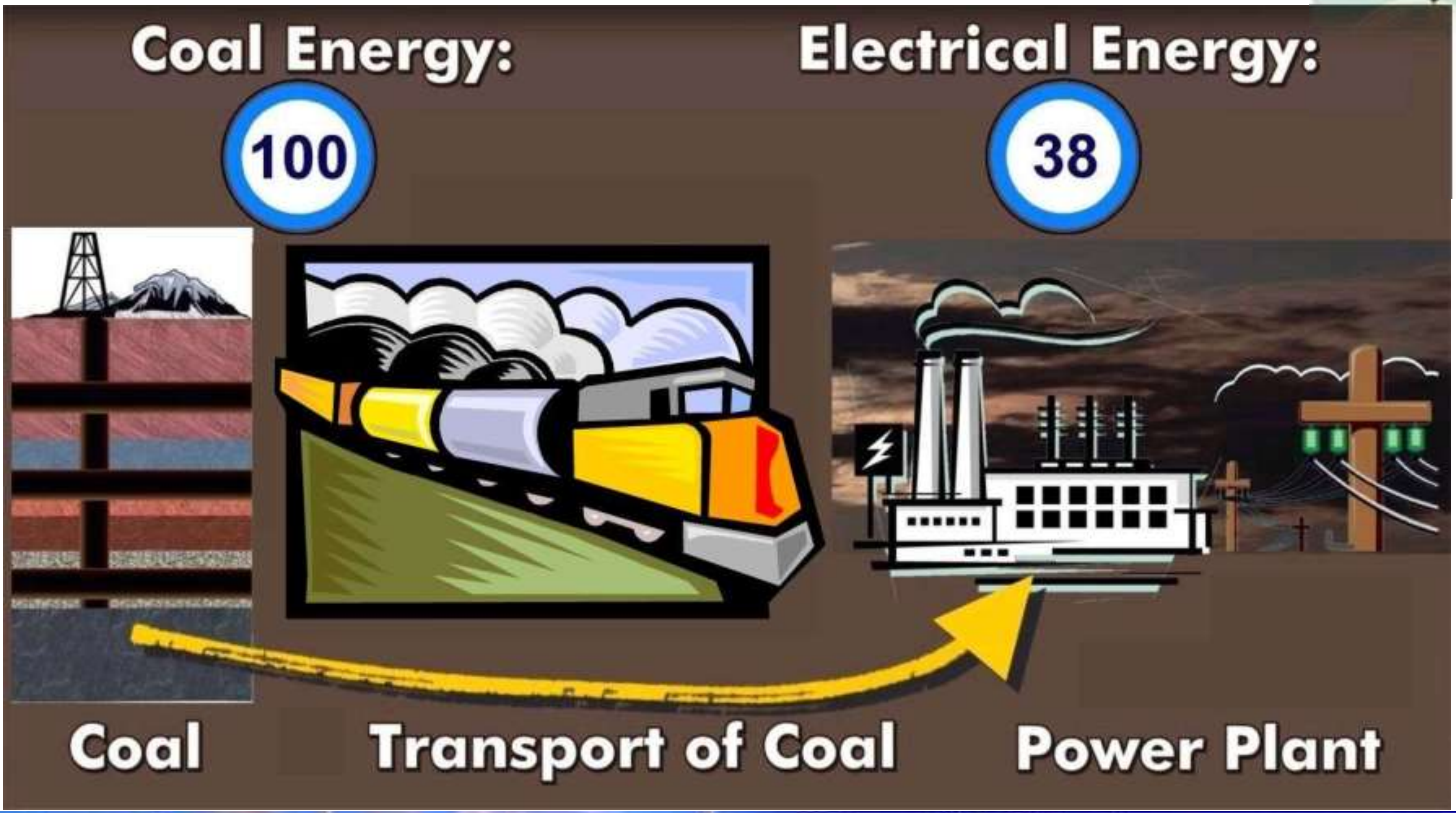

الزجاج غير شفافة لهذا الطول الموجي بالأشعة تحت الحمراء، لذلك لا يمكن للطاقة أن تنبعث مرة أخرى



# How Can Global Warming Be Reduced?

- Increased energy efficiency.  This is simplest and most cost-effective.
- Substitution of natural gas for coal and oil (short term, limited supplies)..
- Safe nuclear power (fission).
- Alternative renewable energy: OTEC, wind, solar thermal, solar photovoltaic, biofuels.
- Hydrogen transportation fuel (needs research).
- Other alternatives???

# COAL UTILISATION TODAY



# Benefits of Renewable Energy Use

Renewable energy provides substantial benefits for our climate, our health, and our economy. Each source of renewable energy has unique benefits and cost.

# Applications and Potential of Solar Energy

**Solar Thermal (low-temperature)**



**Photovoltaics-PV**

**Concentrating Solar Power-CSP** ***(high-temperature)***

**Distributed Generation, on-site or near point of use**

**Centralized Generation, large users or utilities**

Transportation

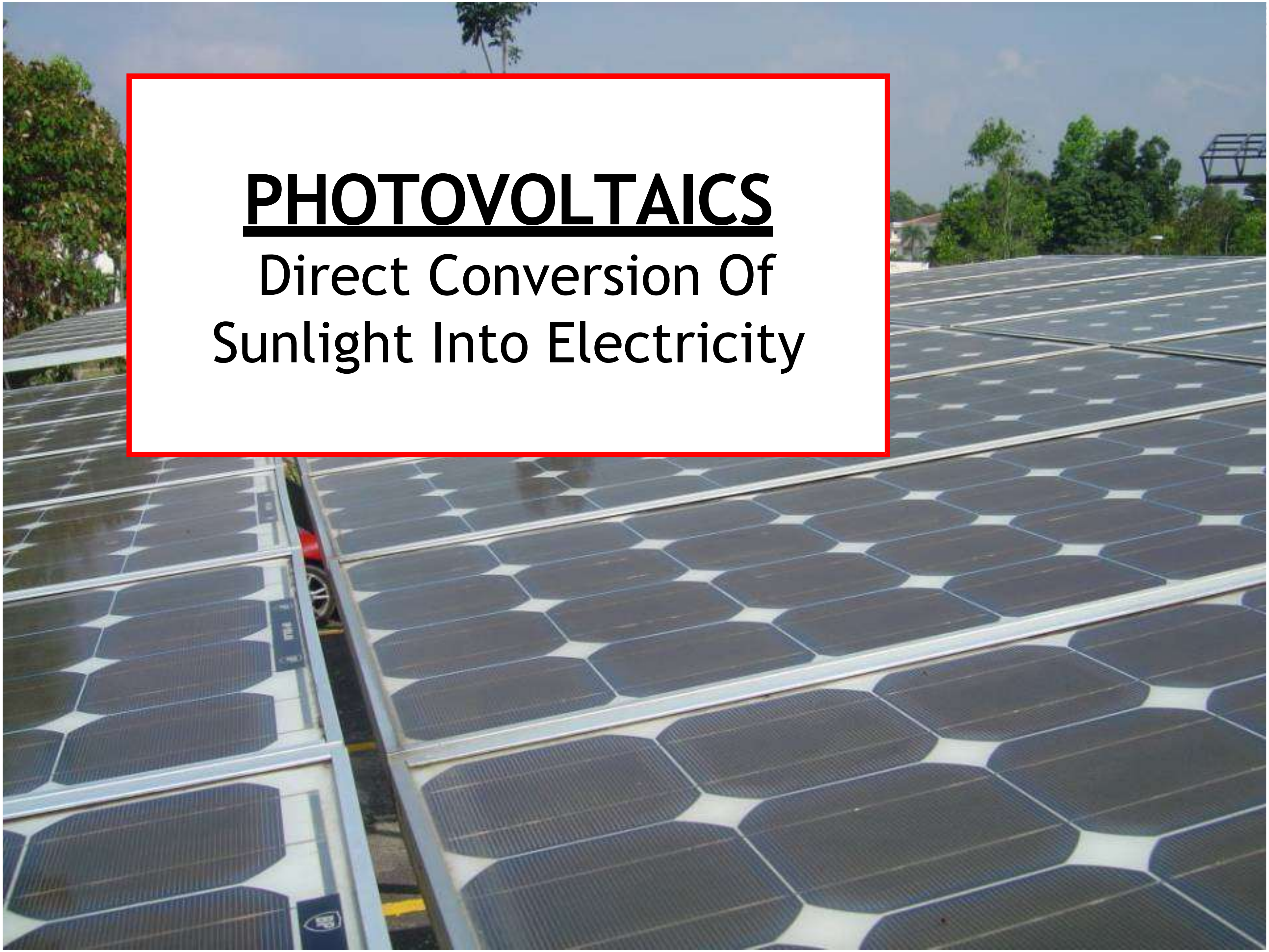
Residential & Commercial Buildings

Industrial

Solar Thermal and Solar Electricity

# PHOTOVOLTAICS

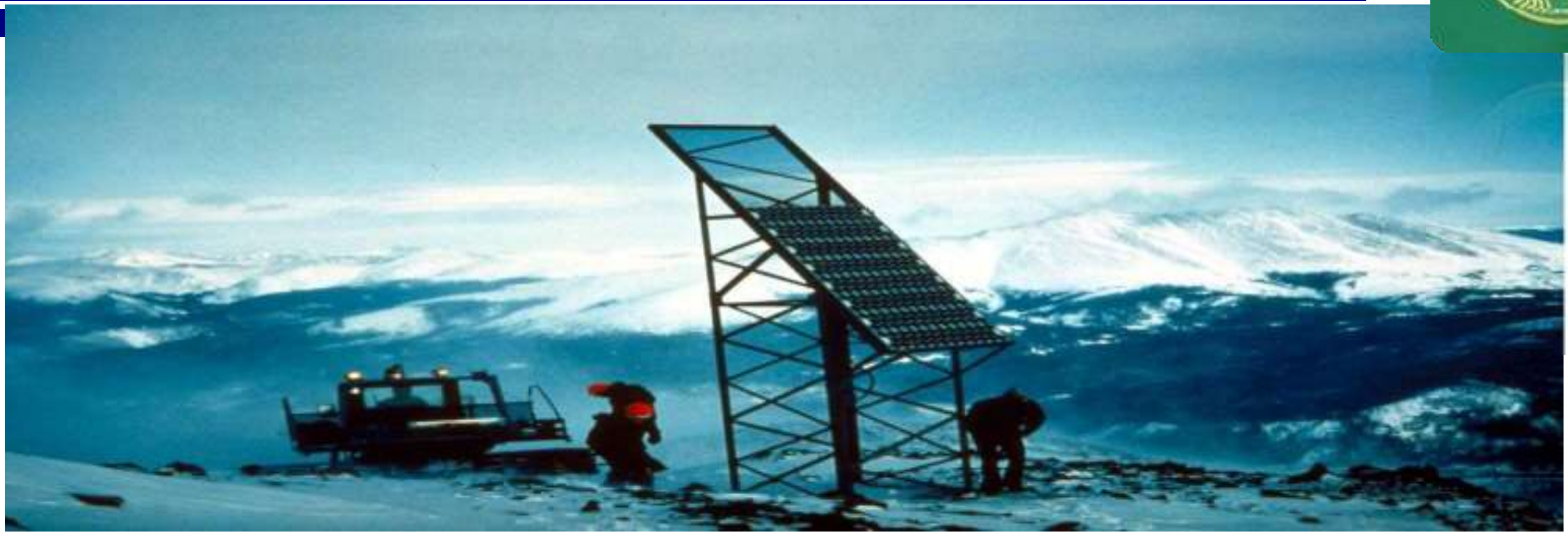
Direct Conversion Of Sunlight Into Electricity



# PV Applications

- PV can be applied in any environment
  - Snow
  - Sea
  - Desert
  - Space
- Some of the most typical are shown in the next slides

# PV in snow



Portable unit

# PV in Alaska

PV transmission station

# PV in sea

# Solar car

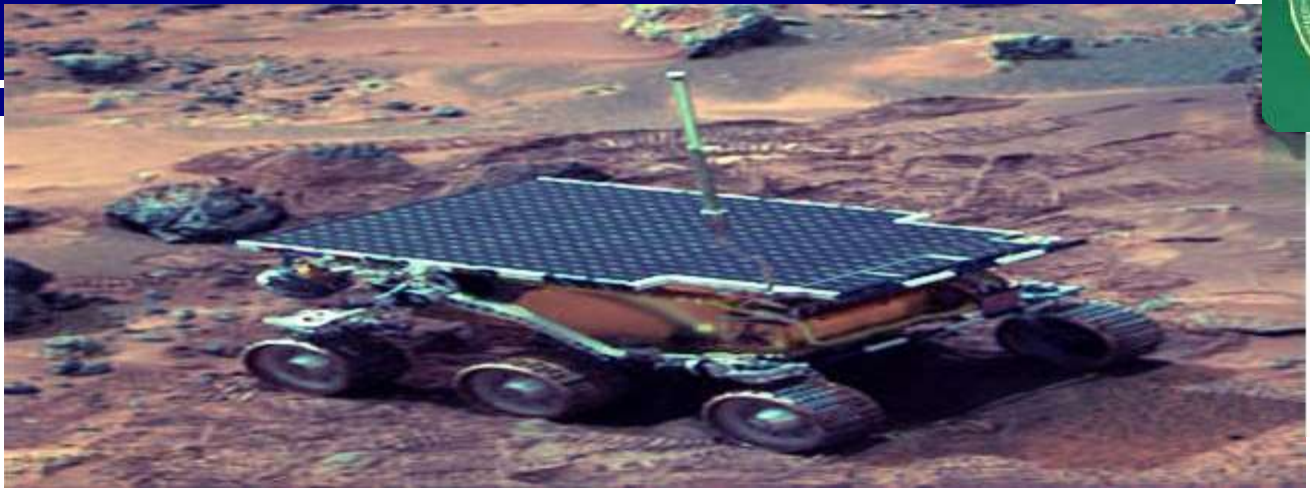
# PV in desert

Concentrating PV

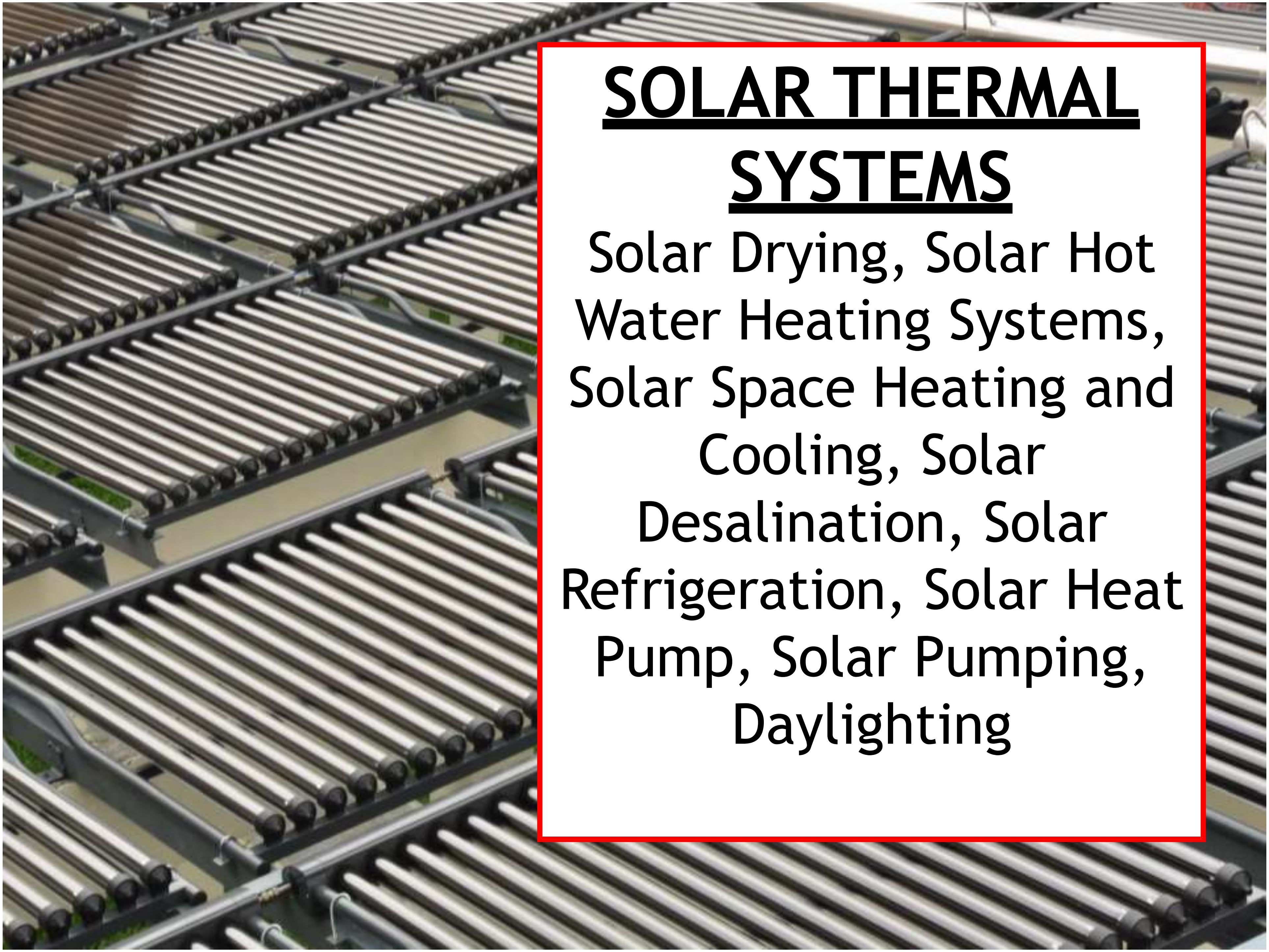
# PV in space

Roof system-daylight

# PV on Mars



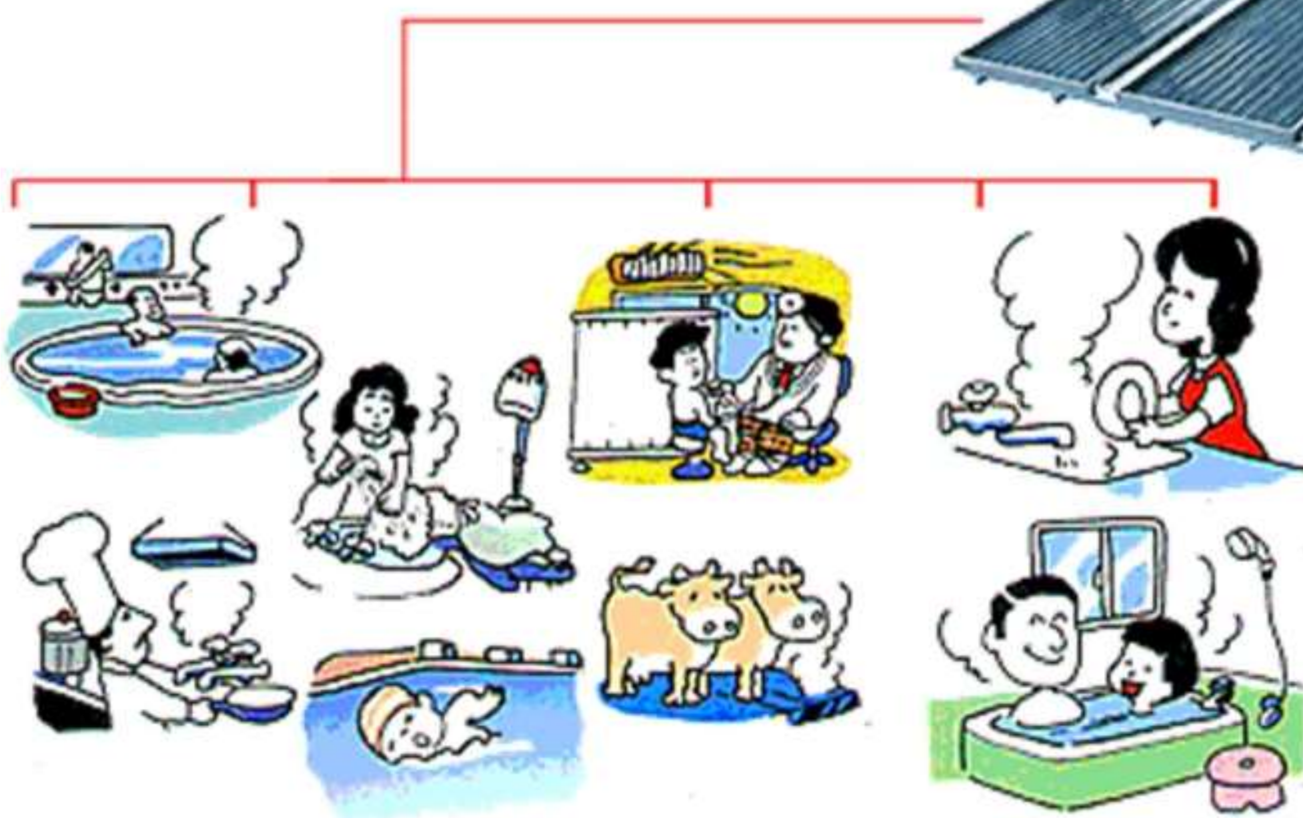
# PV tracking



# SOLAR THERMAL SYSTEMS

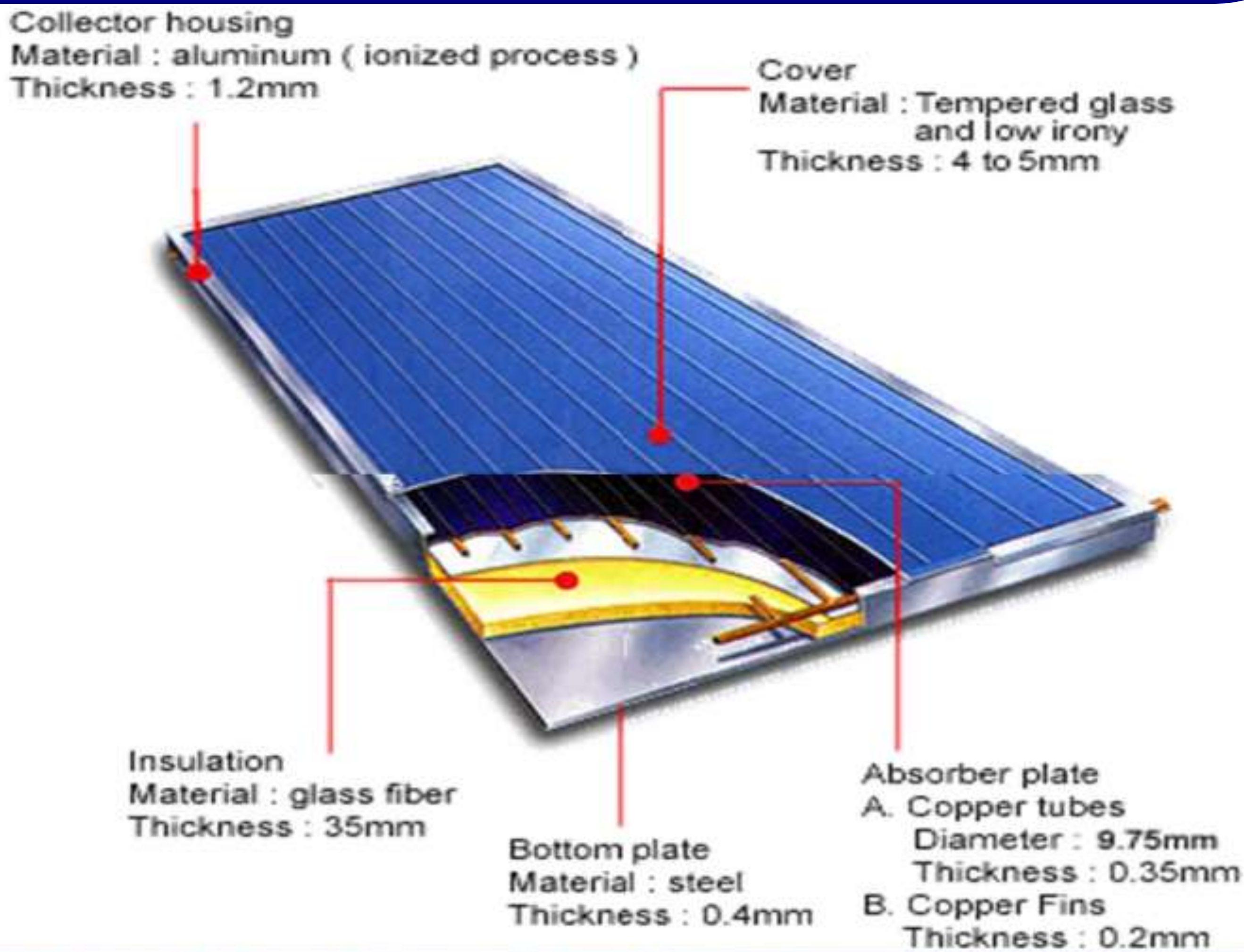
Solar Drying, Solar Hot Water Heating Systems, Solar Space Heating and Cooling, Solar Desalination, Solar Refrigeration, Solar Heat Pump, Solar Pumping, Daylighting

# Applications of Solar Thermal system



- Domestic Water Heating
- Pool and Spa Heating
- Process Water Heating
- Air Conditioning "Reheat"

# Solar Thermal Colltor Details




# Solar Cooling Technologies

## DRIVEN SYSTEM

**HEAT**

**ELECTRICITY**

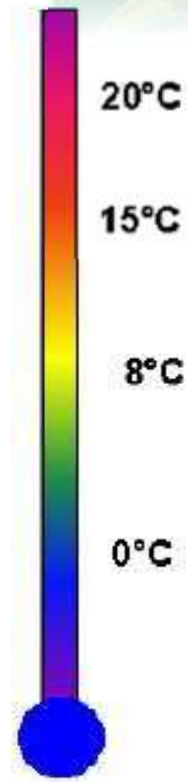
## REFRIGERATION CYCLE

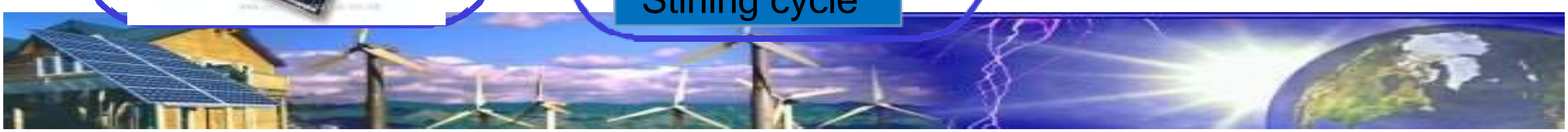
Heat-driven:
- Dessicant cycle
- Ejector cycle
- Rankine cycle
- Absorbtion
- Absorption
- Adsorption
- Chemical reaction

Electricity-driven:
- Thermo-electric cycle
- Vapour compression
- Stirling cycle

## APPLICATION

- AIR CONDITIONING
- FOOD, VACCINE STORAGE
- Freezing



# HOMEWORK ASSIGNMENT

1- What is renewable Energy and its types ?

2- Why is renewable energy important?

3 What is solar electricity?

4 What Technologies Generate Solar Electricity?

5-Draw diagram for house connected with PV system .

6- How a PV system works?

7- What is the Solar Cooling System?

# References


1J. Twidell. and T. Weir " Renewable Energy Resources " Taylor and Francis Group, 2006.

2J. A. Duffie and W. A. Beckman" Solar Engineering of Thermal Processes" John Wiley & Sons, Inc., Hoboken, New Jersey , 2013.

# Do You Have Any Questions?