

POWER PLANT (ME-403)

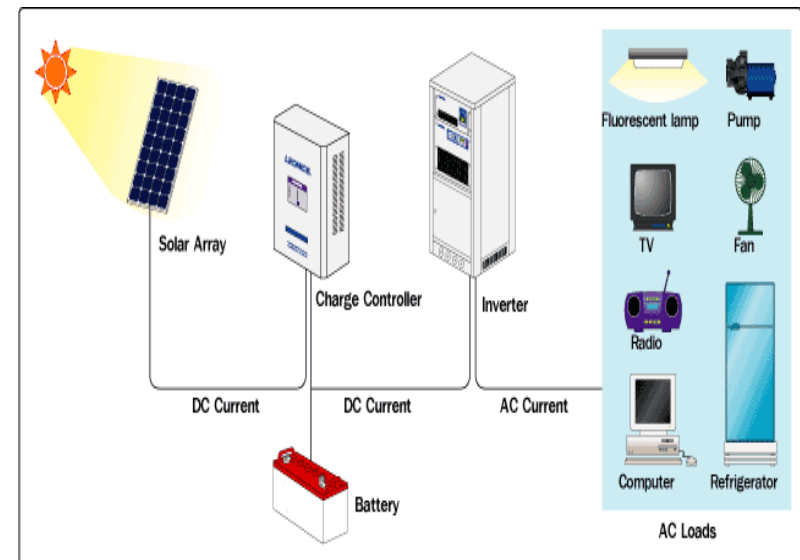
Lecture Topic: Solar Energy

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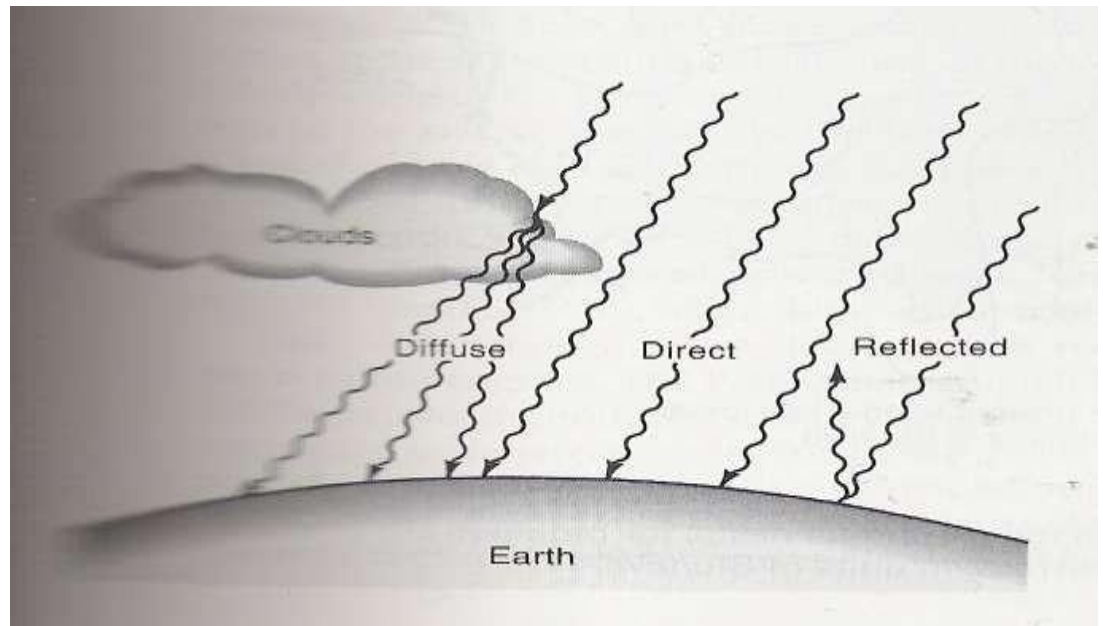


What's Solar Energy?

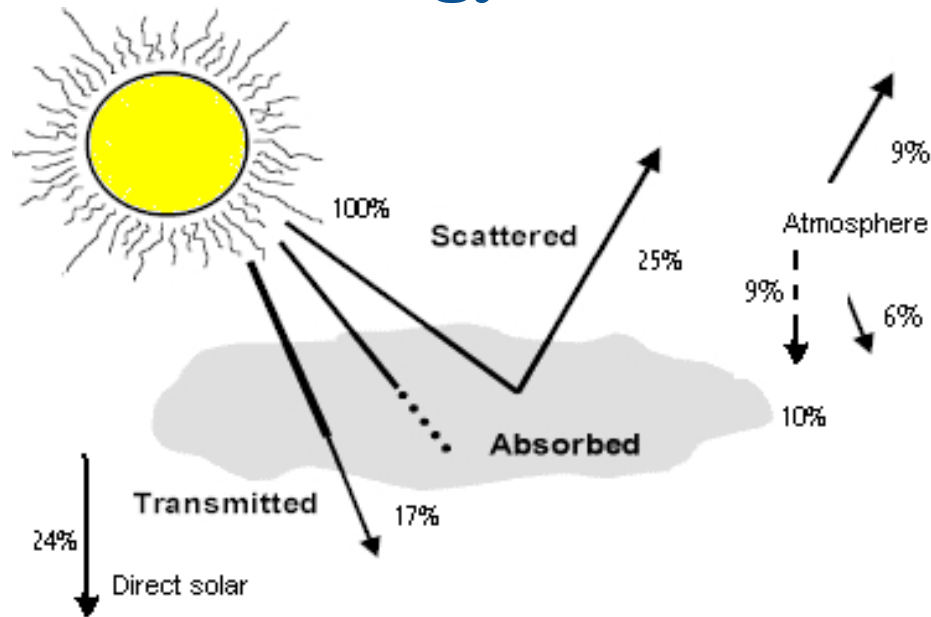
- ❑ Solar energy Originates with the thermonuclear fusion reactions occurring in the sun.
- ❑ Represents the entire electromagnetic radiation (visible light, infrared, ultraviolet, x-rays, and radio waves).
- ❑ This energy consists of radiant light and heat energy from the sun.
- ❑ Out of all energy emitted by sun only a small fraction of energy is absorbed by the earth.
- ❑ Just this tiny fraction of the sun's energy is enough to meet all our power needs.

Insolation

- Insolation is the amount of solar radiation reaching the earth. Also called Incident Solar Radiation.
- Maximum value is 1000 kW/m^2 .
- Components of Solar Radiation:
 - Direct radiation
 - Diffuse radiation
 - Reflected radiation



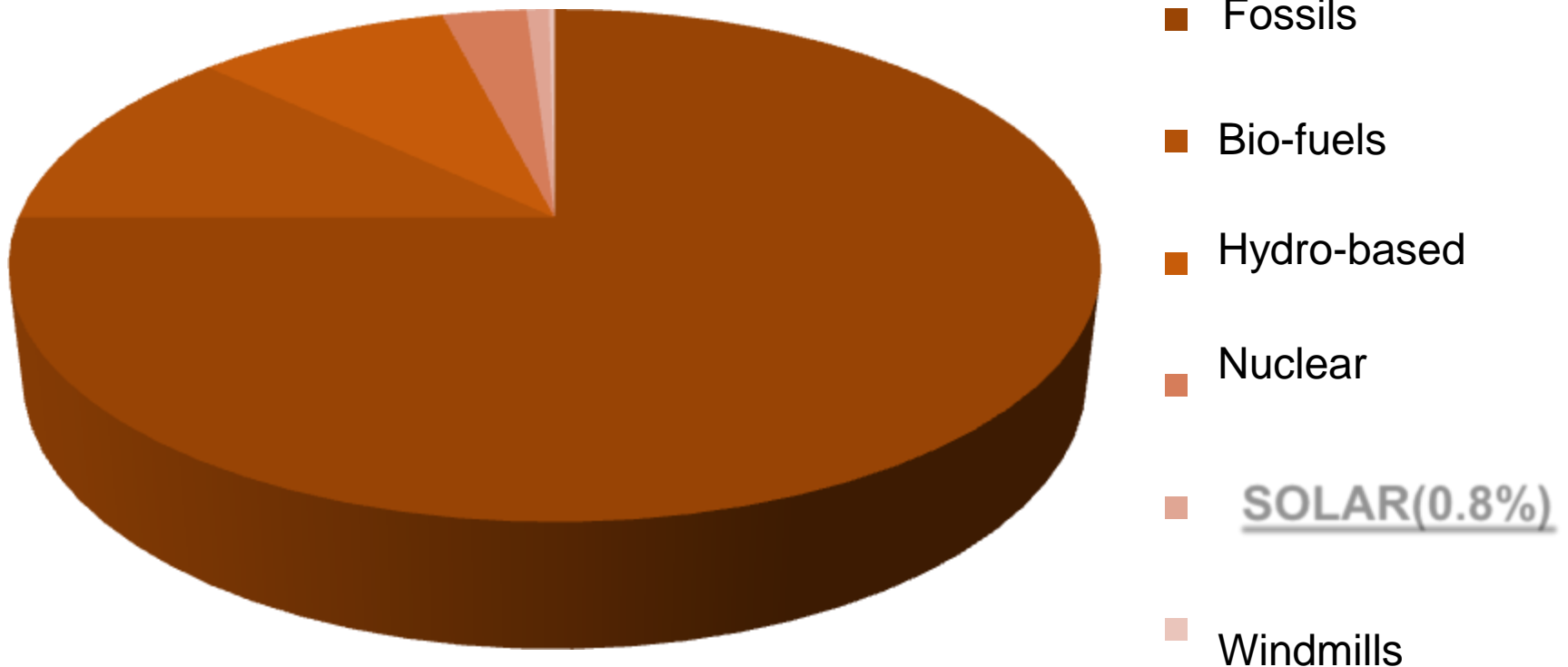
How much solar energy?



The surface receives about 47% of the total solar energy that reaches the Earth. Only this amount is usable.

Using present solar techniques some of the solar energy reaching the earth is utilized for generating heat, electricity etc....

Even then the energy demand met by using solar energy is very less.



Why Solar Energy?

- The fossil fuels are non renewable sources so we can not depend on them forever.
- Though nuclear energy is a clean and green energy there are always some problems associated with it.
- So the only option we have is solar energy because it is a nonpolluting and silent source of electricity and also low maintenance and long lasting energy.

How solar energy is used

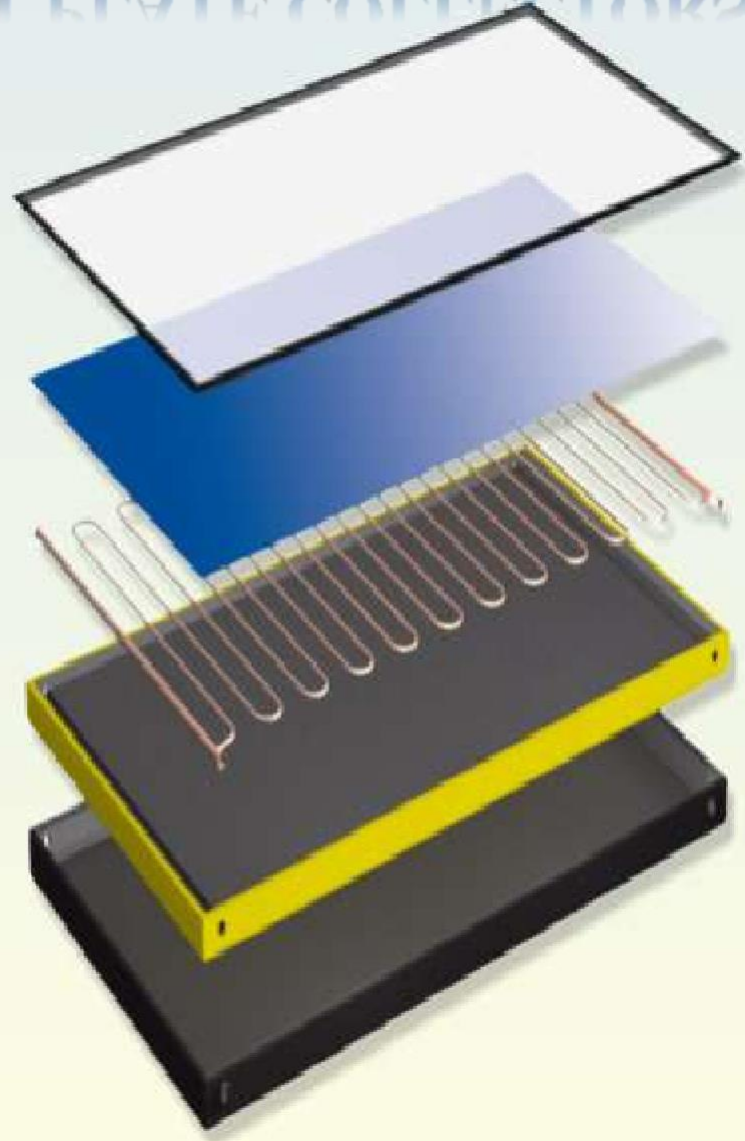
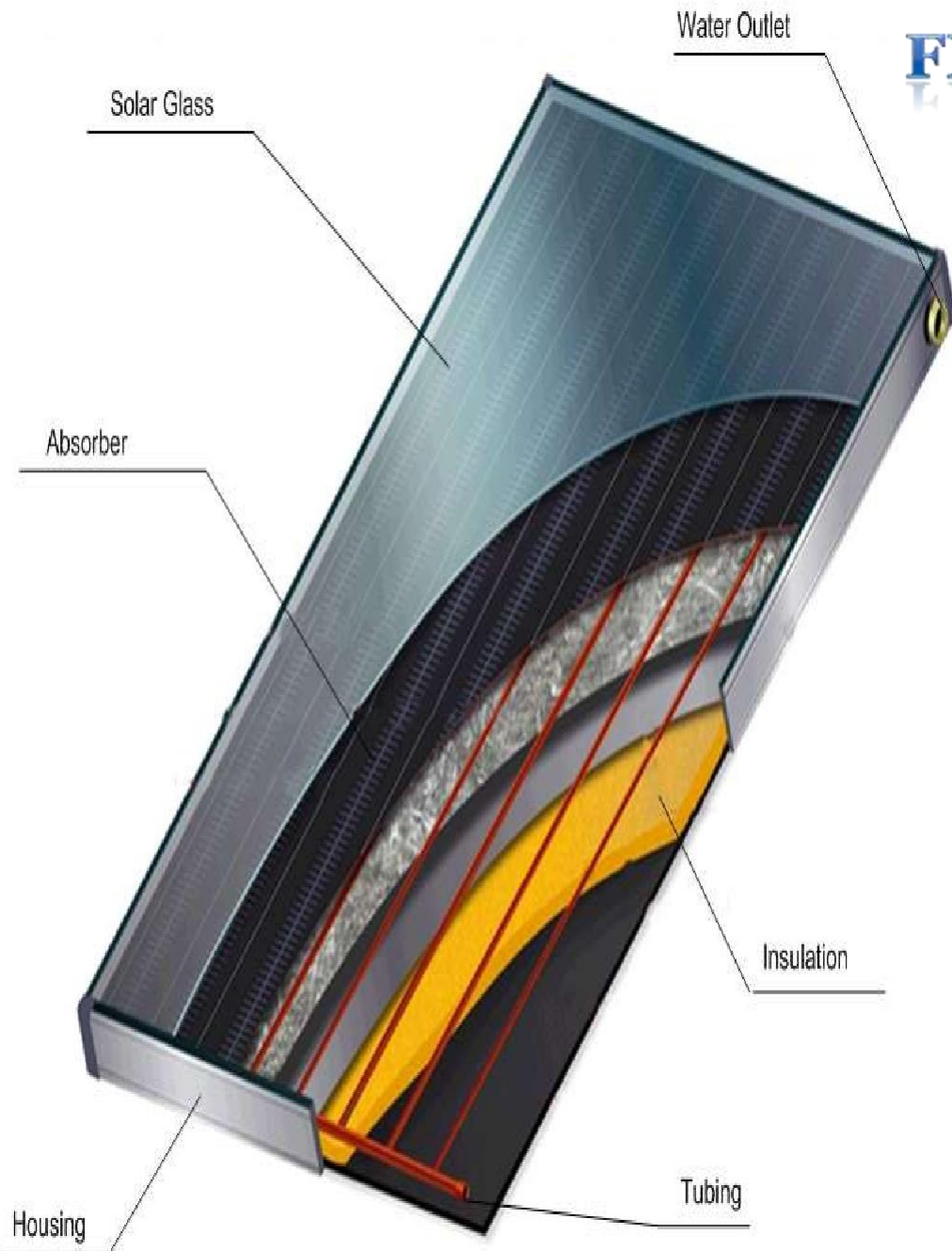
- Solar Thermal Energy
 - Solar Heating
 - – Solar Water Heating
 - – Solar Space Heating

- Electricity Generation Using Solar Concentrators
- Photovoltaic Cells

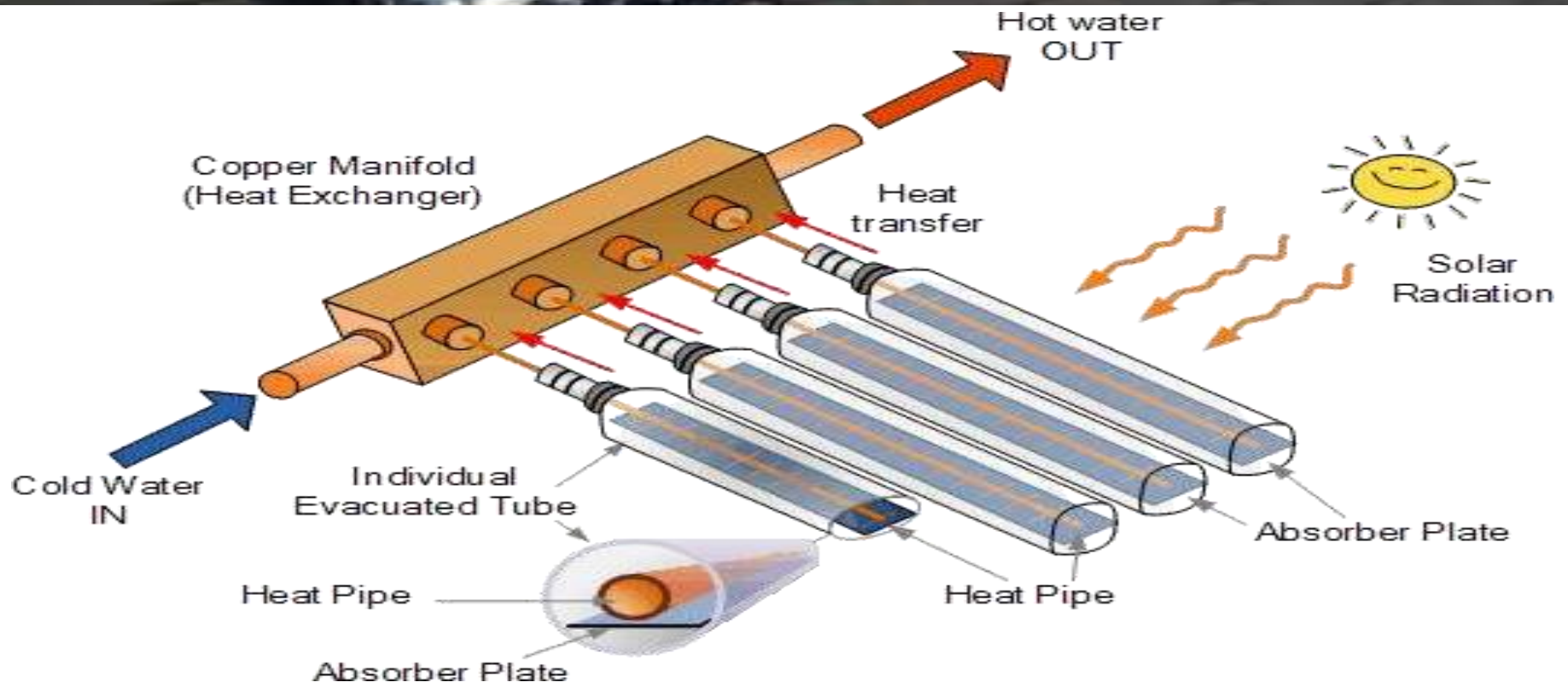
Solar Thermal Energy

- ❑ Solar thermal technologies involve harvesting energy from the sun for heating water or producing electrical power.
- ❑ Solar collectors are used for this purpose.
- ❑ **Three Types:**
 - ❑ Flat-plate collectors
 - ❑ Evacuated-tube collectors
 - ❑ Integral collector-storage systems (Batch or Bread Box)

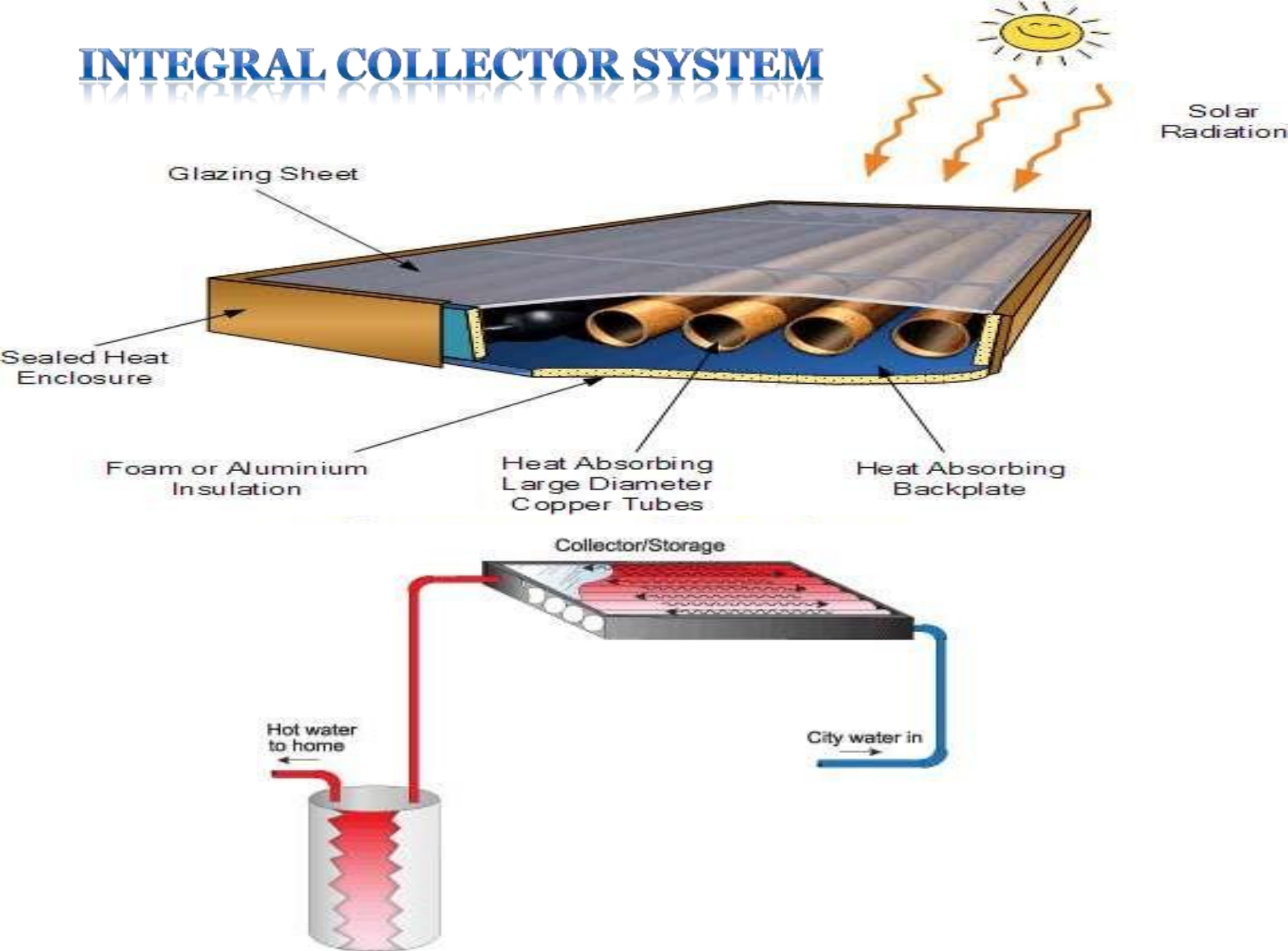
FLAT PLATE COLLECTORS



EVACUATED TUBE COLLECTORS



INTEGRAL COLLECTOR SYSTEM



Water Heating

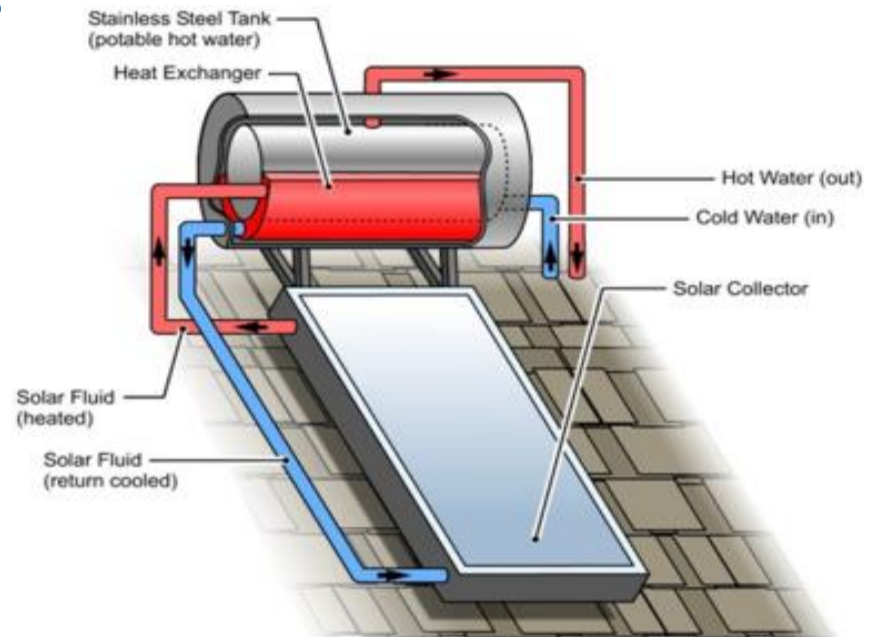
Passive systems

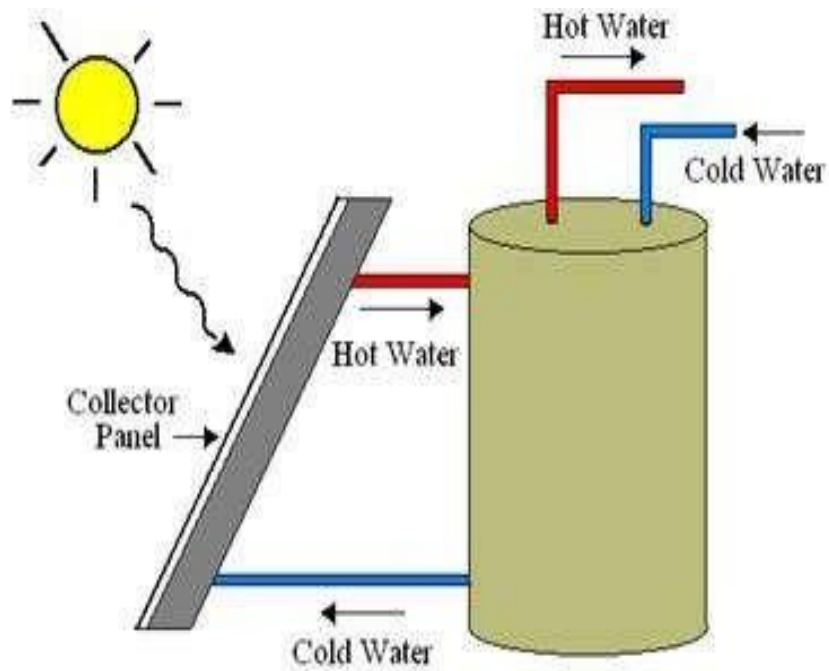
- Thermosyphon
- Collector storage systems

Active systems

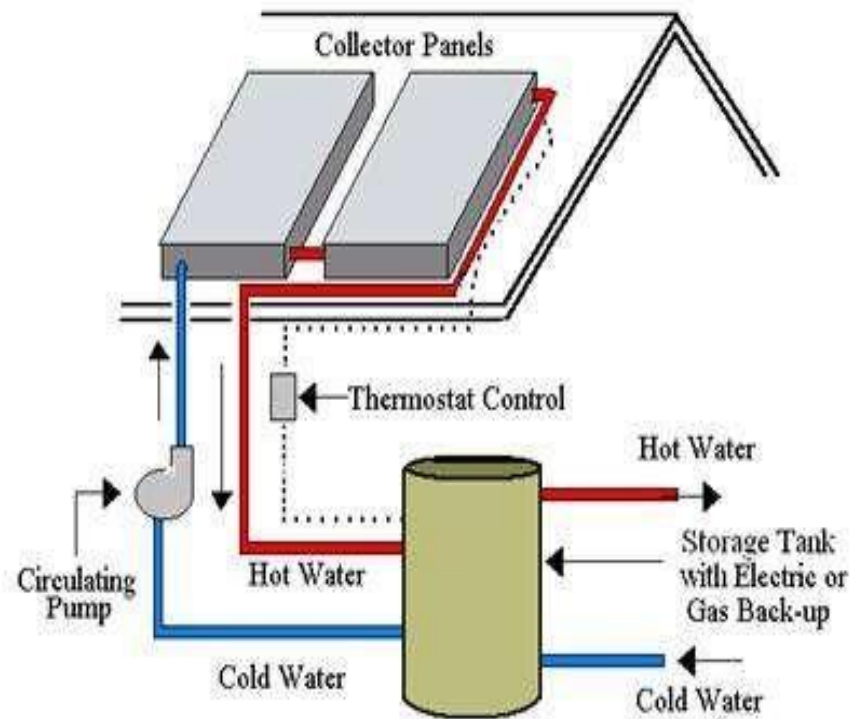
- Direct circulation systems
- Indirect circulation systems
- Hot air systems.

Thermosyphon





Passive Solar Water Heating



Active Solar Water Heating System

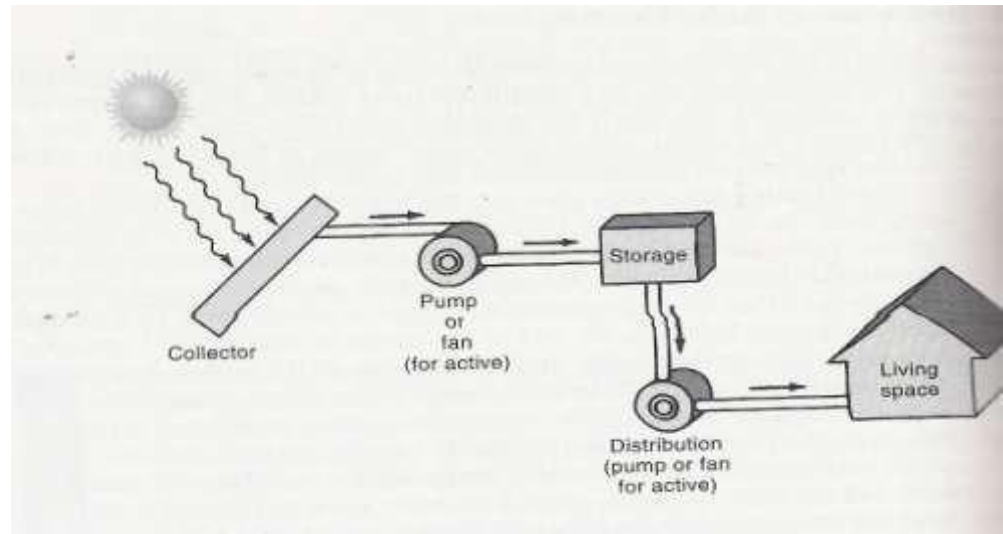
□ Space Heating

□ *Active Solar Heating System*

- A system that uses water or air that the sun has heated and is then circulated by a fan or pump.

□ *Passive Solar Heating System*

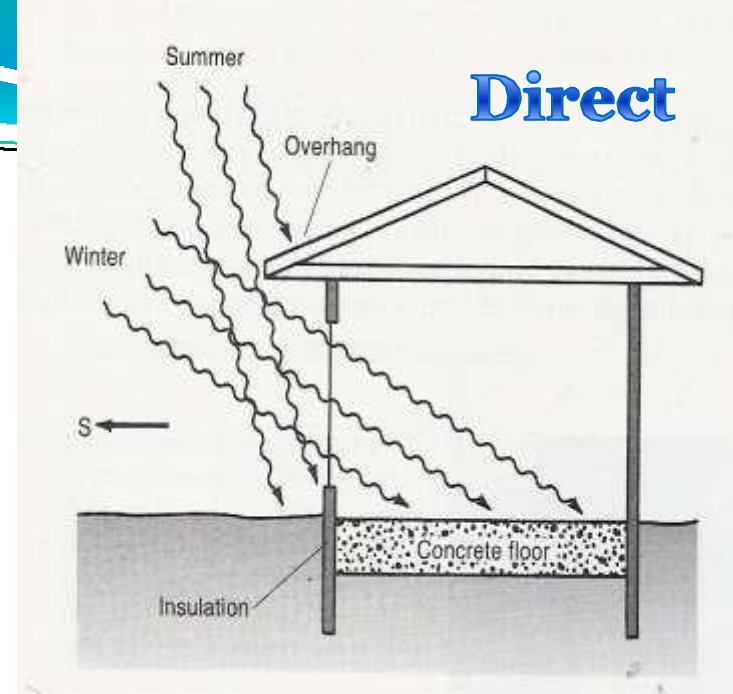
- The house itself acts as the solar collector and storage facility.
- No pumps or fans are used.
- This system makes use of the materials of the house to store and absorb heat.



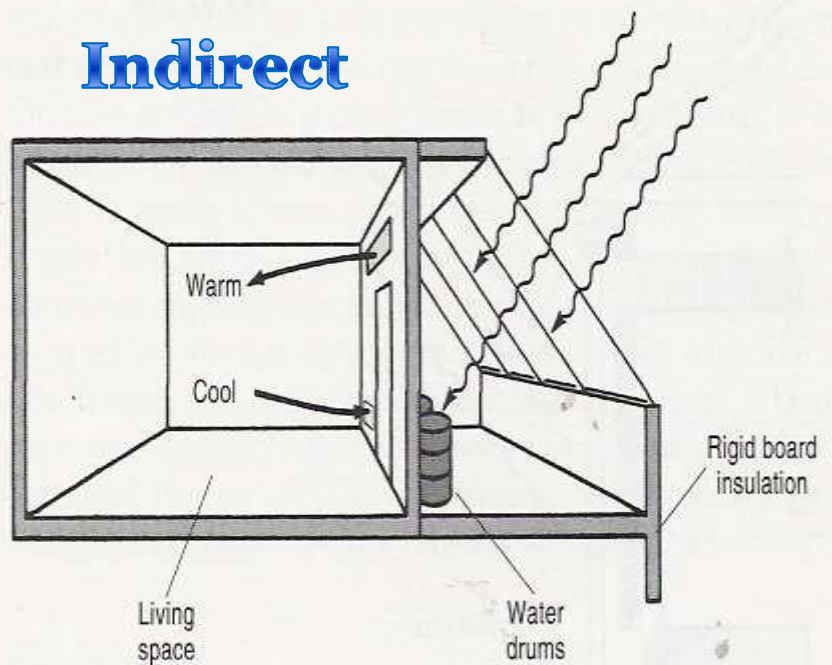
□ *Passive Solar Heating System*

□ **Three Types:**

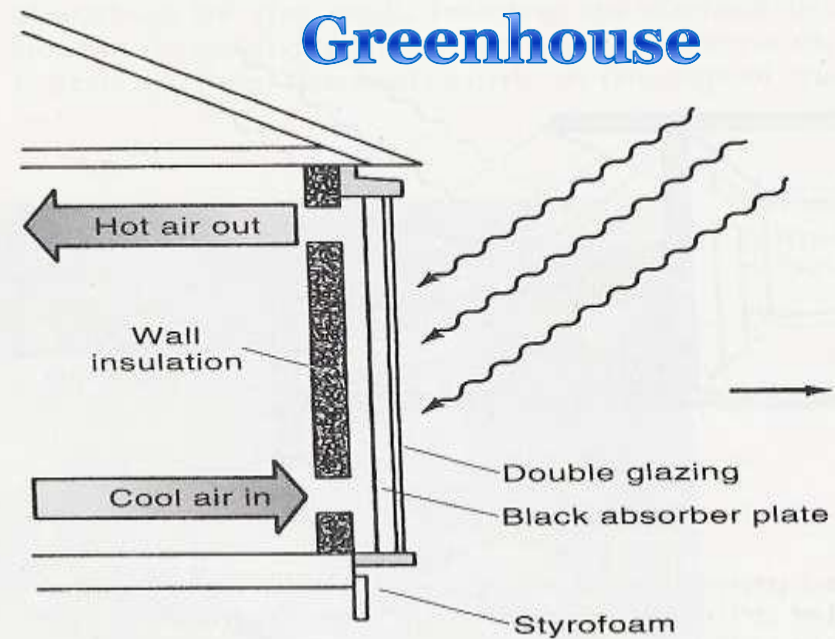
- Direct-Gain
- Indirect-Gain
- Attached Greenhouse



Indirect



Greenhouse



Electricity from Solar Energy

- Solar power is described as the conversion of sunlight into electricity. Sunlight could be changed into electricity with the use of :
 - Directly using **PV or photovoltaic** or
 - Indirectly by **CSPs**.

Concentrated Solar Power

- CSP is a power generation technology that uses mirrors or lenses to concentrate the sun's rays and,
- That heat a fluid and produce steam.
- The steam drives a turbine and generates power in the same way as conventional power plants.

Solar power is concentrated in various ways:

- There are now several devices and structures created which focus and concentrate solar power.
- **Solar Parabolic Troughs**
- **Stirling Dish**
- **Solar Power Tower**
- **The Linear Fresnel Reflector**

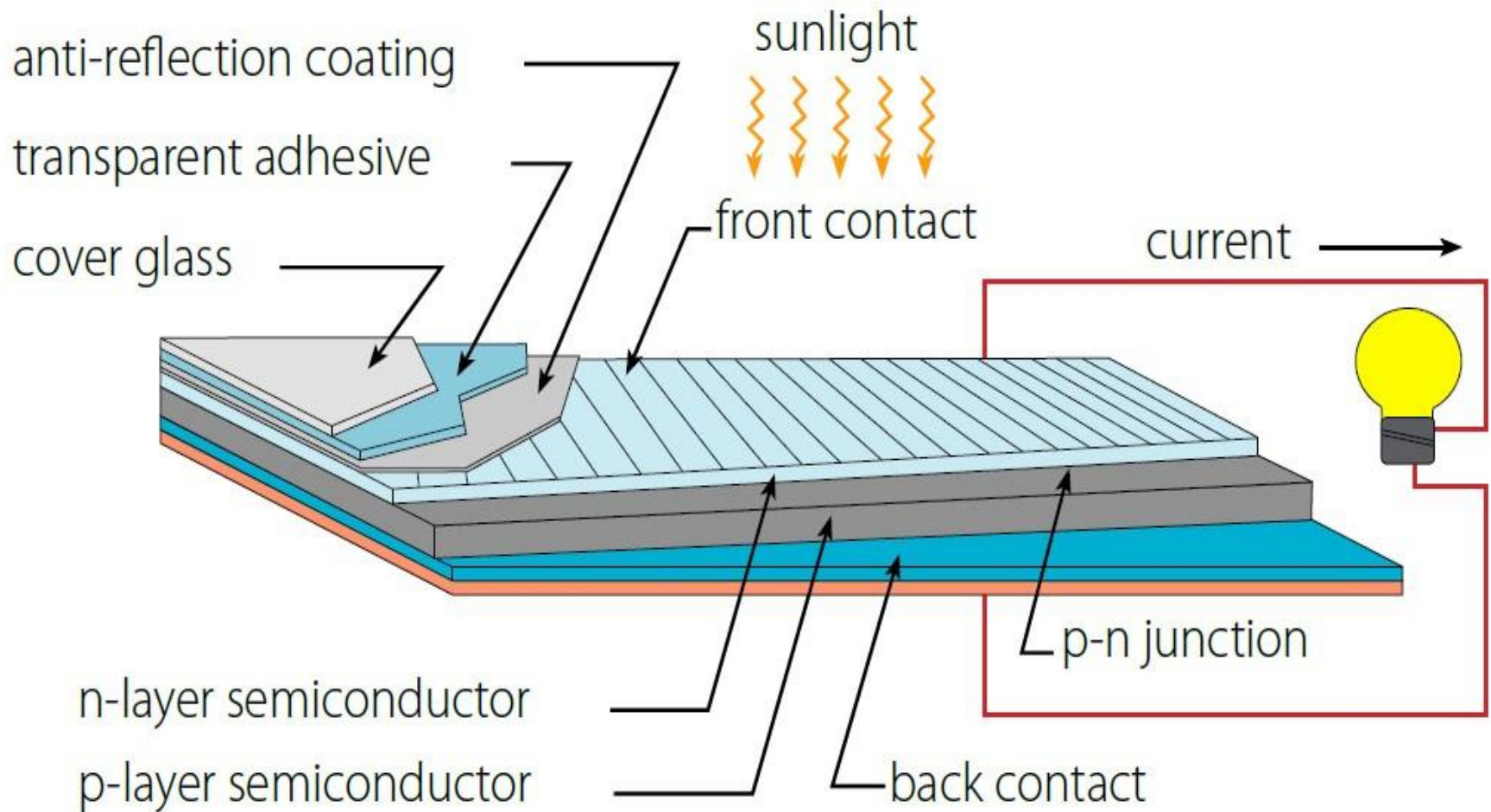


Photovoltaics

- Converting solar energy directly into electrical energy .
- Devices used are called solar panels.
- Solar panel is a group of solar cells.
- Solar cells work on the principle of photoelectric effect.

Structure of a Solar Cell

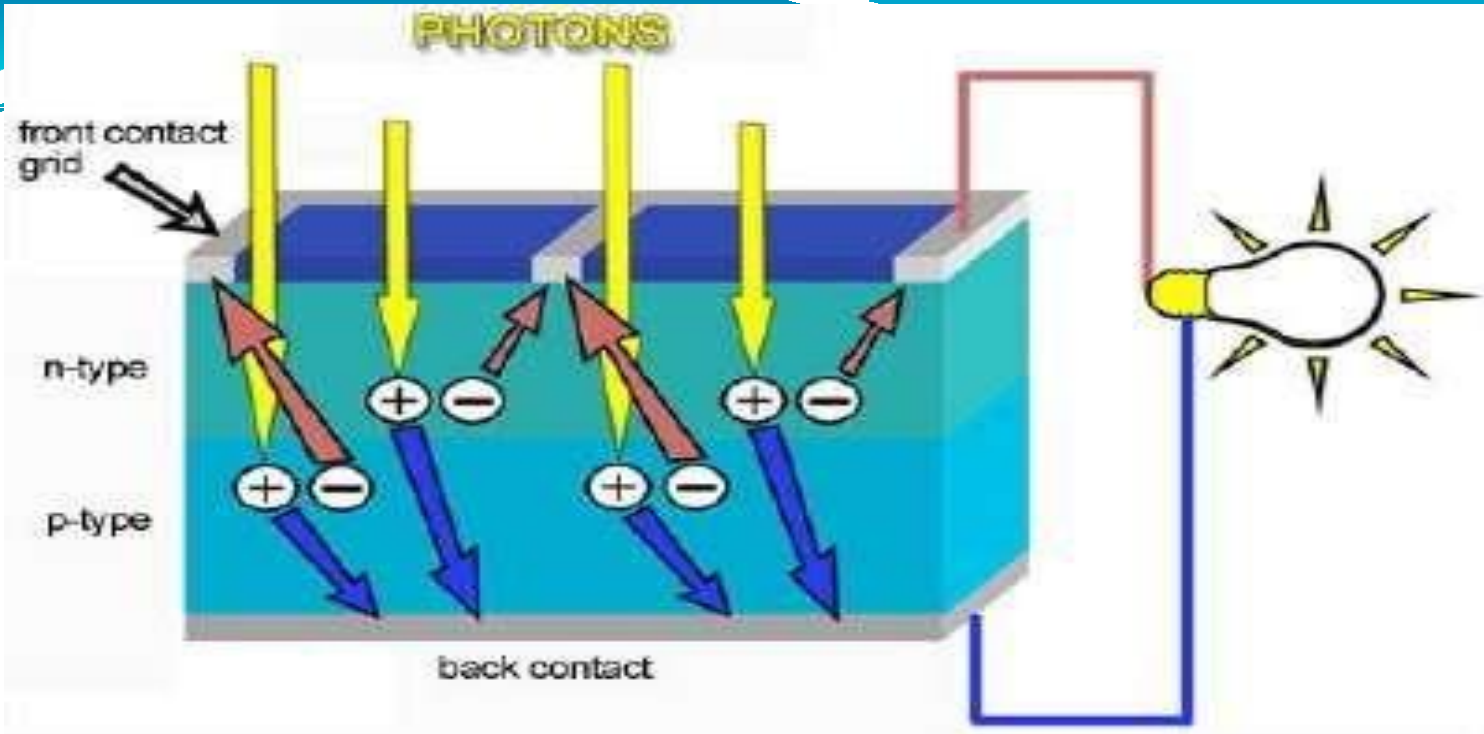
- A typical solar cell is a multi-layered unit consisting of a:
- **Cover** - a clear glass or plastic layer that provides outer protection from the elements. Transparent Adhesive - holds the glass to the rest of the solar cell.
- **Anti-reflective Coating** - this substance is designed to prevent the light that strikes the cell from bouncing off so that the maximum energy is absorbed into the cell.
- **Front Contact** - transmits the electric current.
- **N-Type Semiconductor Layer** - This is a thin layer of silicon which has been mixed (process called doping) with phosphorous.
- **P-Type Semiconductor Layer** - This is a thin layer of silicon which has been mixed or doped with boron.
- **Back Contact** - transmits the electric current.



Working of A solar cell

- **Photoelectric effect**

- When a light of certain frequency falls on the surface of a metal
- Electrons will absorb the energy
- If incident light energy is greater than the work function (minimum energy required to remove the loosely bound valence electrons) of the metal
- Then the photo electrons will be emitted and
- The excess energy is converted to the kinetic energy of electron.



- When solar panels are placed in the sunlight , photons will strike the surface and emits electrons.
- As a result electron hole pair is created in the solar cell.
- When external circuit is connected to the solar cell , electrons flow in the circuit and the current is generated.

The Types of Solar Electric Systems

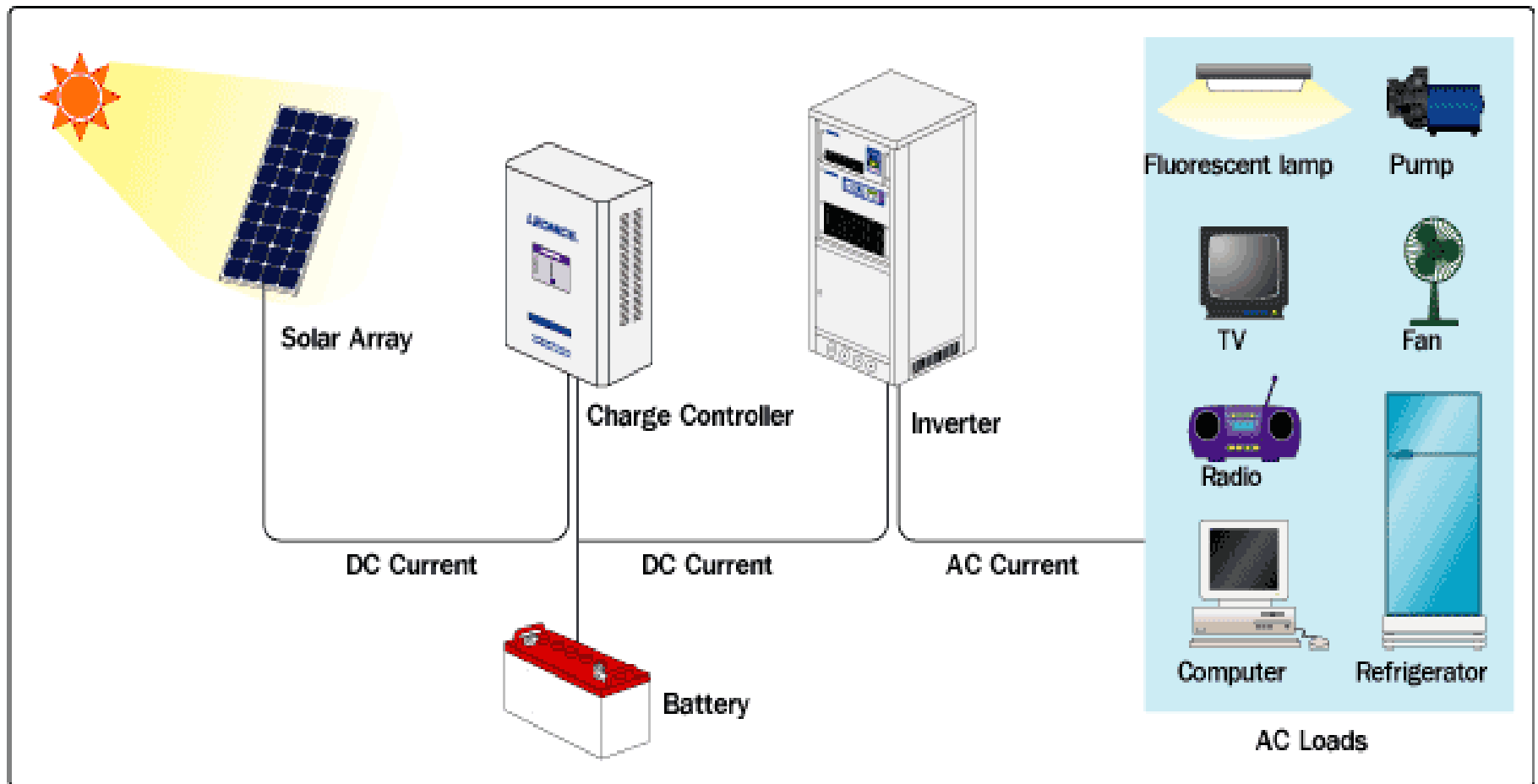
□ The Stand Alone System

- Standalone, or off-grid, solar power systems consist of solar panels and a battery bank.
- Used in rural areas and regions where there is no access to the utility grid.
- Very good at giving economical electricity.

□ Grid-Tie Solar System

- Very useful for homes that are already linked to the utility grid.
- Primary advantage is the cheap price of utility.
- The system needs to be wired with an inverter that creates ac electricity, which is needed for linking to the utility grid.

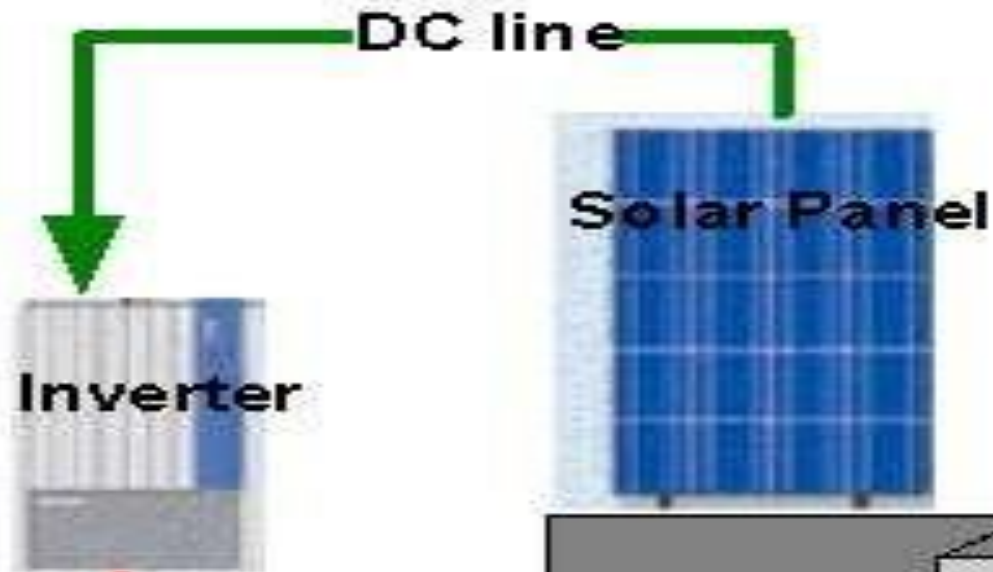
Stand Alone-off grid



Grid connected

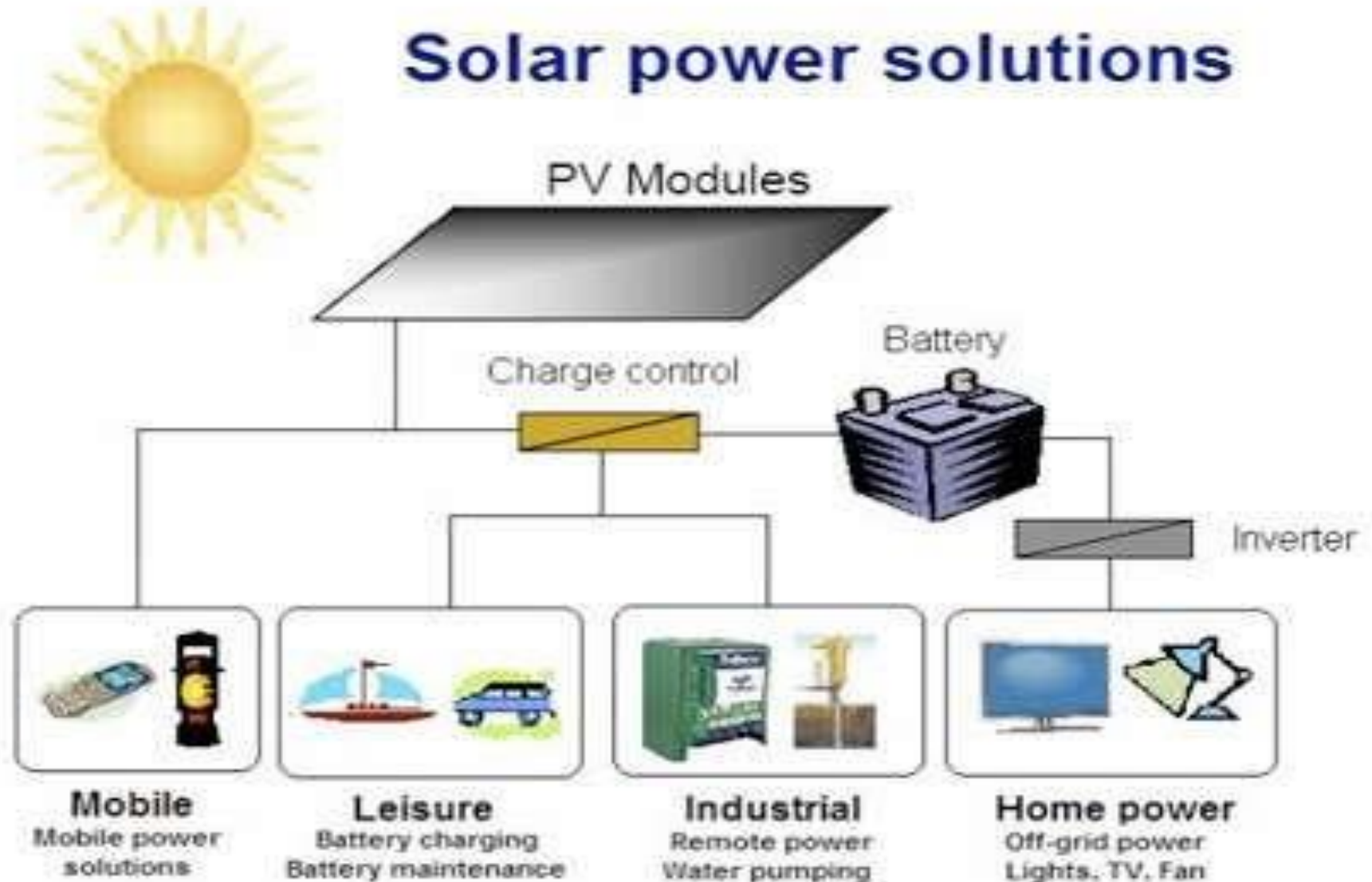


**Grid
Supply**



Suburban home

Solar power solutions



USES OF SOLAR ENERGY

- Heaters
- Cars
- Lights
- Satellites
- Dryers
- Calculators
- Green houses
- water pumps
- Desalination
- Chilling
- Solar ponds
- Thermal

Commercial use

- On an office building , roof areas can be covered with solar panels .
- Remote buildings such as schools , communities can make use of solar energy.
- In developing countries , this solar panels are very much useful.
- Even on the highways , for every five kilometres ,solar telephones are used.

Applications



Solar car



Solar heater



Solar lights

Developing Solar Power In PAKISTAN

- In PAKISTAN, about 70% of the population lives in some 50,000 villages dispersed around the country.
- Many of these villages are far from the main transmission lines of the national grid because of their relatively small populations.
- It is not usually economically viable to connect these villages to the grid.

- Solar energy has great potential in areas of PAKISTAN that receive high solar radiation throughout the year.
- For e.g. 19 mega Joules of solar energy per square meter is received everyday.
- The nation wide average is 5.5 kWh/mess/day.
- Enough energy potential for solar energy because there are 250-300 sunny days per year.
- Continuous cloudy days are rare.

Advantages of solar power development to PAKISTAN

- ❑ The power source of the sun is absolutely free.
- ❑ The production of solar energy produces no pollution.
- ❑ The technological advancements in solar energy systems have made them extremely cost effective.
- ❑ Most systems do not require any maintenance during their lifespan, which means you never have to put money into them.

- Solar energy systems are now designed for particular needs. For instance, you can convert your outdoor lighting to solar. The solar cells are directly on the lights and can't be seen by anyone. At the same time, you eliminate all costs associated with running your outdoor lighting.
- Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid.
- It is estimated that the world's oil reserves will last for 30 to 40 years. On the other hand, solar energy is infinite (forever). Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid.

- ❑ Solar cells are long lasting sources of energy which can be used almost anywhere.
- ❑ Solar cells are also totally silent



Disadvantages Of Solar Power

- ❑ **Initial Cost :** The initial cost of purchasing and installing solar panels always become the first disadvantage. Although subsidy programs, tax initiatives and rebate incentives are given by government to promote the use of solar panels we are still way behind in making full and efficient use of solar energy.



Location: The location of solar panels is of major importance in the generation of electricity. Areas which remains mostly cloudy and foggy will produce electricity but at a reduced rate and may require more panels to generate enough electricity homes. Houses which are covered by trees, landscapes or other buildings may not be suitable enough to produce solar power.



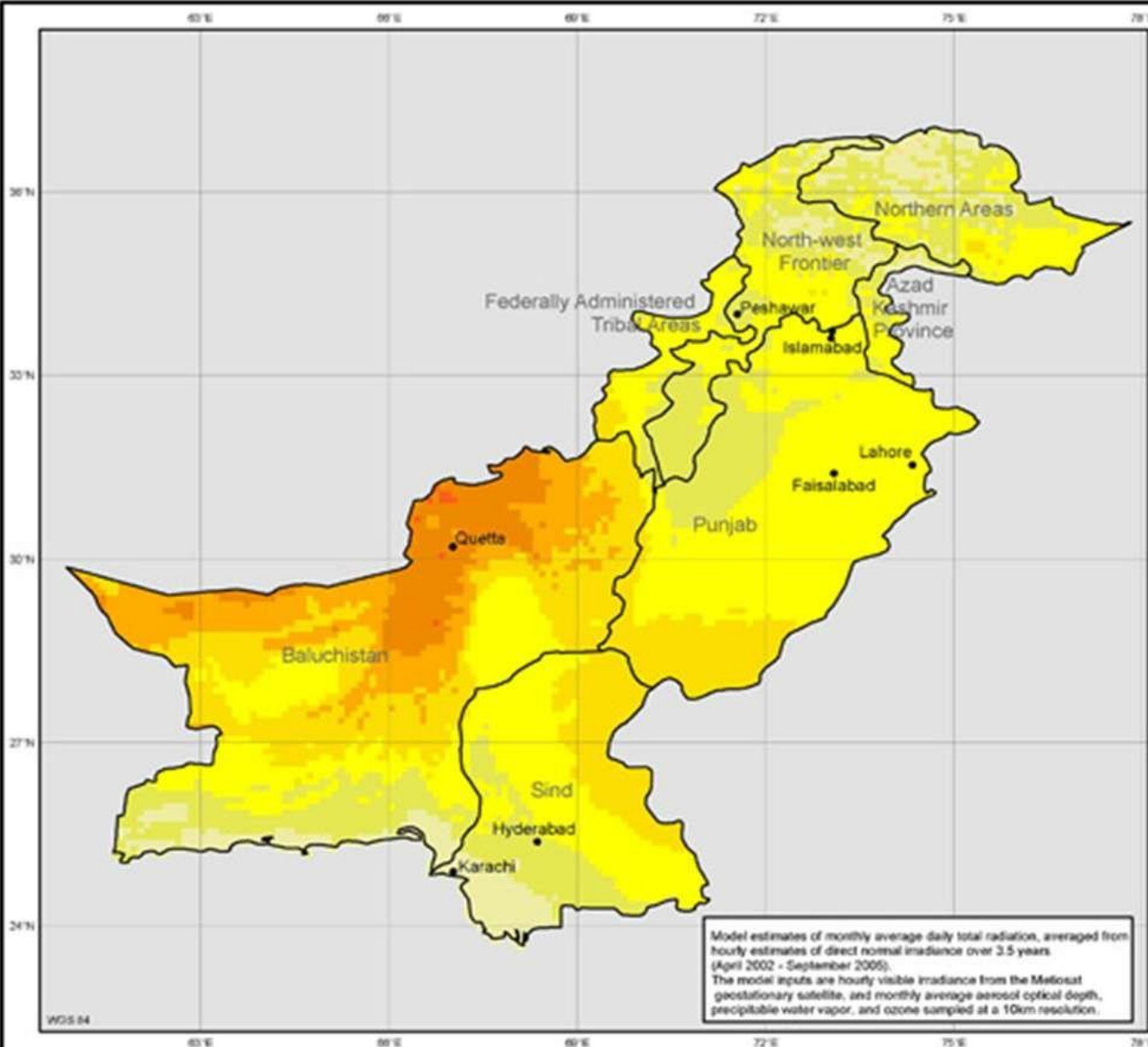
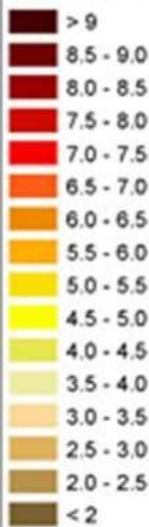
- **Pollution:** Most of the photovoltaic panels are made up of silicon and other toxic metals like mercury, lead and cadmium. Pollution in the environment can also degrade the quality and efficiency of photovoltaic cells. New innovative technologies can overcome the worst of these effects.
- **Reliability:** Unlike other renewable source which can also be operated during night, solar panels prove to be useless during night which means you have to depend on the local utility grid to draw power in the night.

- ❑ **Inefficiency:** Since not all the light from the sun is absorbed by the solar panels therefore most solar panels have a 40% efficiency rate which means 60% of the sunlight gets wasted and is not harnessed.
- ❑ **Installation areas:** For home users, a solar energy installation may not require huge space but for big companies, a large area is required for the system to be efficient in providing a source of electricity.



Pakistan Direct Normal Solar Radiation Annual

kWh/m²/day



Model estimates of monthly average daily total radiation, averaged from hourly estimates of direct normal irradiance over 3.5 years (April 2002 - September 2006). The model inputs are hourly visible irradiance from the Meteosat geostationary satellite, and monthly average aerosol optical depth, precipitable water vapor, and ozone sampled at a 10km resolution.



February 2007

WGS 84

Current solar power plants functioning in PAKISTAN

Station	<u>Location</u>	Capacity (<u>MW</u>)	Status
<u>Quaid-e-Azam Solar Park</u>	<u>Bahawalpur, Punjab</u>	400	2016
<u>Gharo Solar Power Plant</u>	<u>Gharo, Sindh</u>	50	2020