CHAPTER 1

Solar energy

Expected Outcomes

Learn the operating principles of photovoltaic cells and specific characteristics of various types and also explain the “quality/quantity” paradox of solar energy.

What is solar energy?

radiant energy provided by the sun.

Why Solar Energy ?

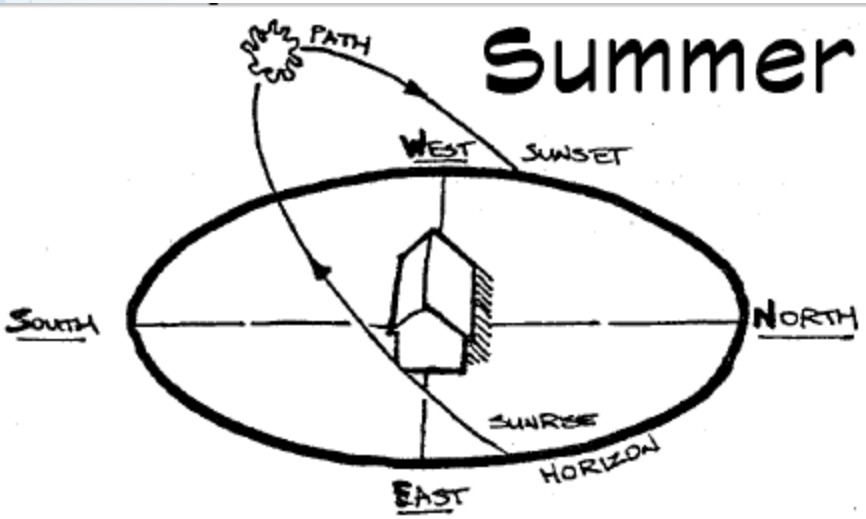
- It is **free**.

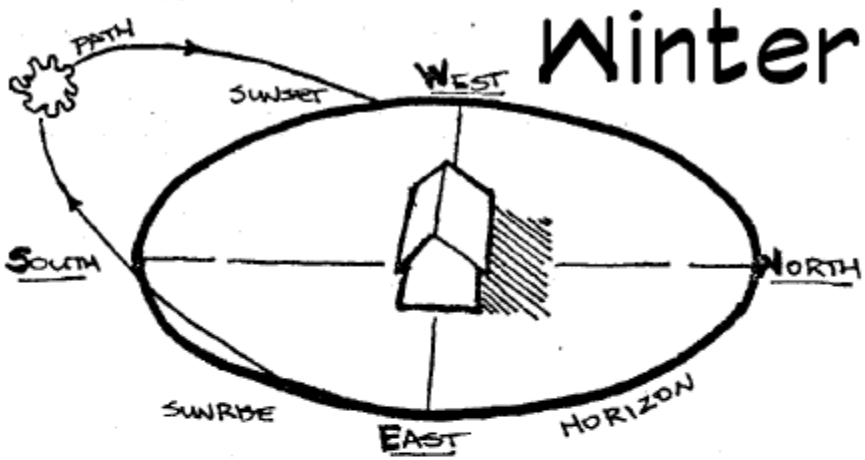
- It is a clean and infinite source of energy.

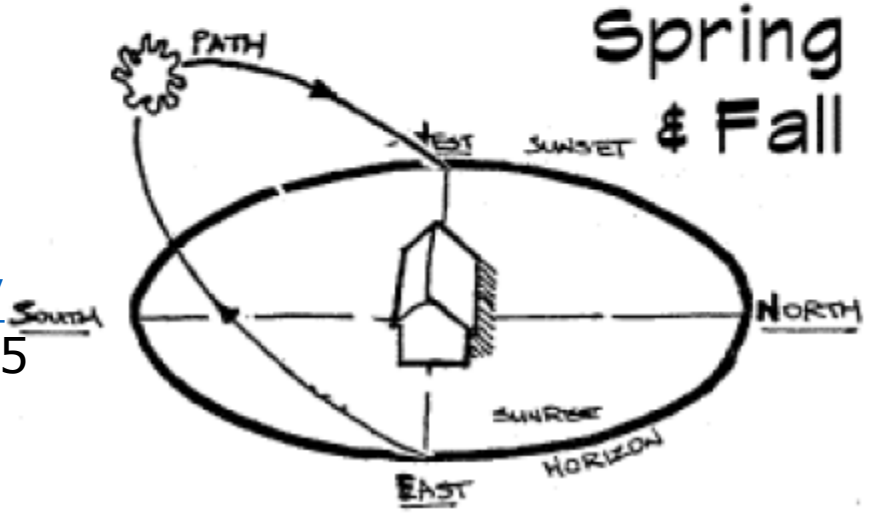
Sun structure and Characteristics: The sun is the star located in the center of the solar system, with a diameter 1.392 X 10^9 m and is average distance of 1.5 X 10^{11} m (150 million KM) from earth. Unlike the earth, the **Sun** is completely gaseous mainly H2, He2, and small amount of nearly all known elements.

Solar constant (G_{sc}): is the amount of energy normally fall on the unit area of the earth atmosphere in a per second surface when the earth is at its mean earth distance (1.495 X 10^{11} m).

Sun Angles







http://www.weather.gov/images/cle/Education/EarthOrbit.png 12/19/2015

Solar time: is the reckoning of the passage of **time** based on the motion of the sun across the sky.

Beam radiation: The part of the solar radiation that receive the earth without any change in direction.

Diffuse radiation: The solar radiation received by the earth after having been scattered.

Irradiance: The solar irradiance G is the rate at which the radiant energy is incident on a unit area of a surface. Denoted in terms of W/m^2

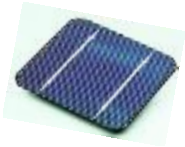
Measurement of solar radiation

Pyranometer: A pyranometer is used to measure the broadband solar irradiance on a planar surface. **Pyranometer** is designed to measure the solar radiation in the wavelength range of about 0.13-3 µm from a field of view of 180 degrees.

Pyrheliometer: is an equipment for measurement of direct (or beam) solar radiation. Pyrheliometer must follow the sun to measure only direct sunlight.

Albedometer: is a device that measure both the global solar radiation as well as the reflected radiation.

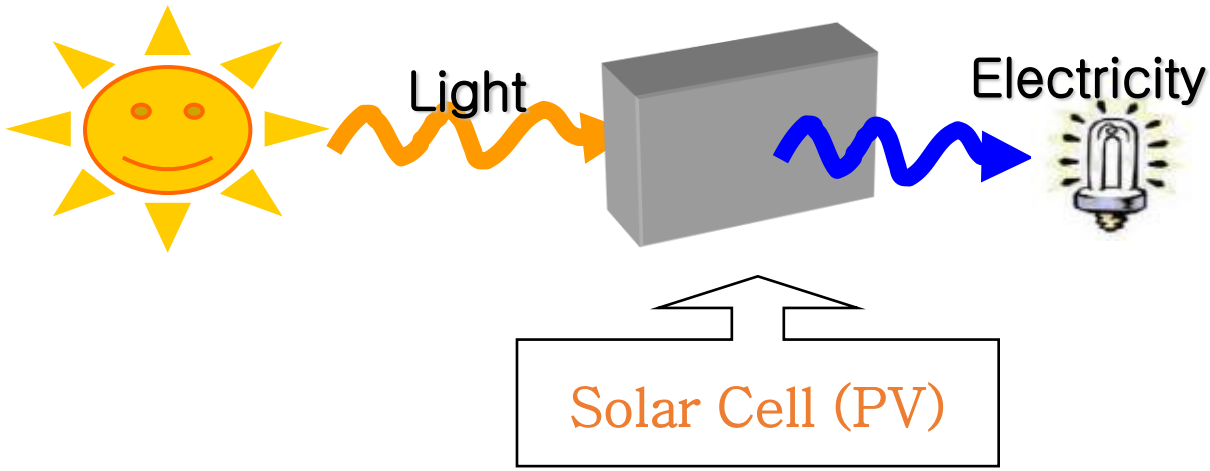
What is a Photovoltaic Cell?



also called solar cell, is an electrical device that converts the visible light directly into direct current.

Three methods are essential for the PV action.

1. Solar radiation falling on the solar cell should be capable of producing EHPs.
2. Excess charge carriers of opposite sign must be separated at a p-n junction
3. Photo generated carriers in the materials must be able to move through the region to the junction.



Requirement for a material to form solar cells

One main requirement of an effective solar cell is the capacity to convert as much sunlight into electricity. These parameter are:

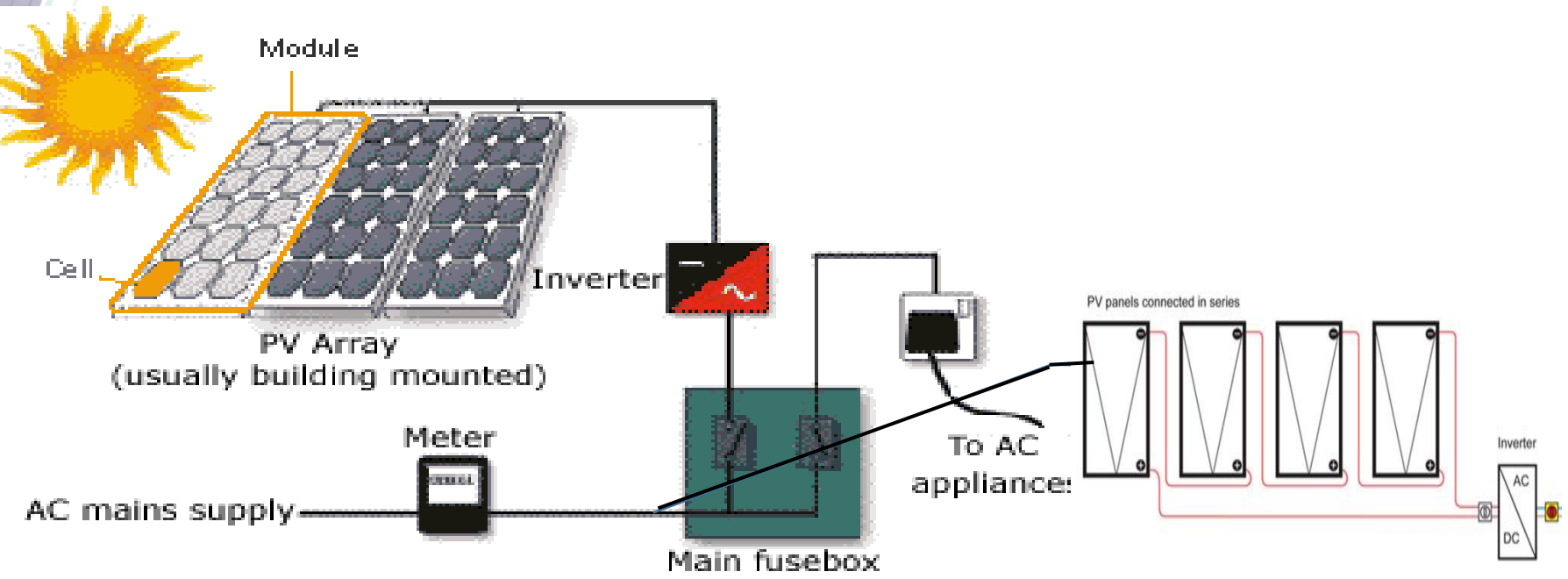
Semiconductor band gap:

Absorption coefficient:

Diffusion length:

Minority carriers lifetime:

PV modules



Source: Donald A. Neaman, "Semiconductor Physics and devices", fourth edition, Tata McGraw Hill Pvt. Ltd., pg:- 177-197. 12/19/2015

Types of PV cells

Silicon Crystalline Cells

made by using **crystalline silicon** solar cells,developed from the microelectronics technology industry.

- Mono Crystalline PV Cells
- Multi Crystalline PV Cells

Thin Film Cells

made by depositing one or more **thin layers** (thin film) of photovoltaic material on a substrate.

- Amorphous Silicon
- Poly Crystalline (based on Non-Silicon)

Thin Film Technology

- Thin-film crystalline solar cell contains **10µm thick** of layers compared with crystalline silicon cells layers 200-300µm.

- **Advantage**
  - Cheaper substrate

Disadvantage

- Less stability.

Amorphous Silicon PV Cells

- The most innovative of thin film technologies .
- Working efficiency **~6%** .
- **13%** of PV **market** .

- **PROS**
  - Established manufacturing technologies existing.

  CONS
- •20-40% loss in efficiency .

Organic solar cell: Organic solar cell production uses cheaper materials and a less energy-intensive manufacturing method compared to conventional solar cell.

Working of organic solar cell: Organic PV materials release electrons when light strike on them. Electron donor materials conduct negatively charged particles to the negative electrode, while the electron acceptor material conduct holes to the positive electrode. The separation of charge created by this effect flows through the circuit as electricity.

Solar Thermal generation of electricity

Solar thermal technology uses the sun's energy, to produce, environmentally friendly, low-cost energy. This energy is used to heat water, and can also use for solar cooling systems.

Water heating and cooking

Source: B.H.Khan, "Non –conventional energy resources", second edition , Tata McGraw Hill Pvt. Ltd., pg:-88-192 12/19/2015

APPLICATIONS OF SOLAR ENERGY

- The list of solar energy applications includes cooling and space heating through, potable water, solar architecture via distillation and disinfection, daylighting, solar cooking, solar hot water, and high temperature process heat for industrial purposes.

Agriculture and horticulture

- Applications of solar energy in agriculture aside from growing crops include drying crops, drying chicken manure, drying crops, pumping water, brooding chicks etc.

Water treatment

Solar water heater

- Solar distillation can be used to make brackish water or saline water drinkable
- Solar water disinfection (SODIS) involves exposing water-filled plastic polyethylene terephthalate (PET) bottles to sunlight for several hours. (https://www.flickr.com/photos/118306054@N07/15246141064/in/photostream).

Cooking

- Solar cookers use sunlight for cooking, drying and pasteurization. They can be grouped into three broad classes:, reflector, panel and box cookers.

The Solar Bowl in Auroville, India,

Solar chemical

- Solar chemical is a number of possible processes use solar energy to drive chemical reactions. Solar induced chemical reactions can be divided into photochemical or thermochemical.
- Hydrogen production technologies been a significant area of solar chemical research since the 1970s.

Solar vehicles

- A **solar vehicle** is an electric vehicle used completely by direct solar energy. E.g. solar bike, solar car, solar bus, etc..

SOLAR ENERGY ADVANTAGES

- Solar energy produces electricity very gently.
- It is indefinitely renewable.
- Very effective in large areas of the globe.
- Solar panels can be fitted on top of many rooftops
- It is inexpensive in the long run.

SOLAR ENERGY DISADVANTAGES

- The major con of solar energy is the initial cost of solar cells.
- Solar energy is only able to generate electricity during daylight hours.
- The weather can affect the efficiency of solar cells.

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ThankYou!!