1.4 SOLAR POWER PLANT

Solar power plant uses the solar irradiation of the Sun and converts it into electricity. This is a renewable source of energy.

Solar radiation reaching the Earth's surface:

Solar radiation received at the earth's surface is attenuated (or) reduced because it depends on the mechanism of Absorption and Scattering as it passes through the earth's atmosphere. This can be observed in fig.1.8.

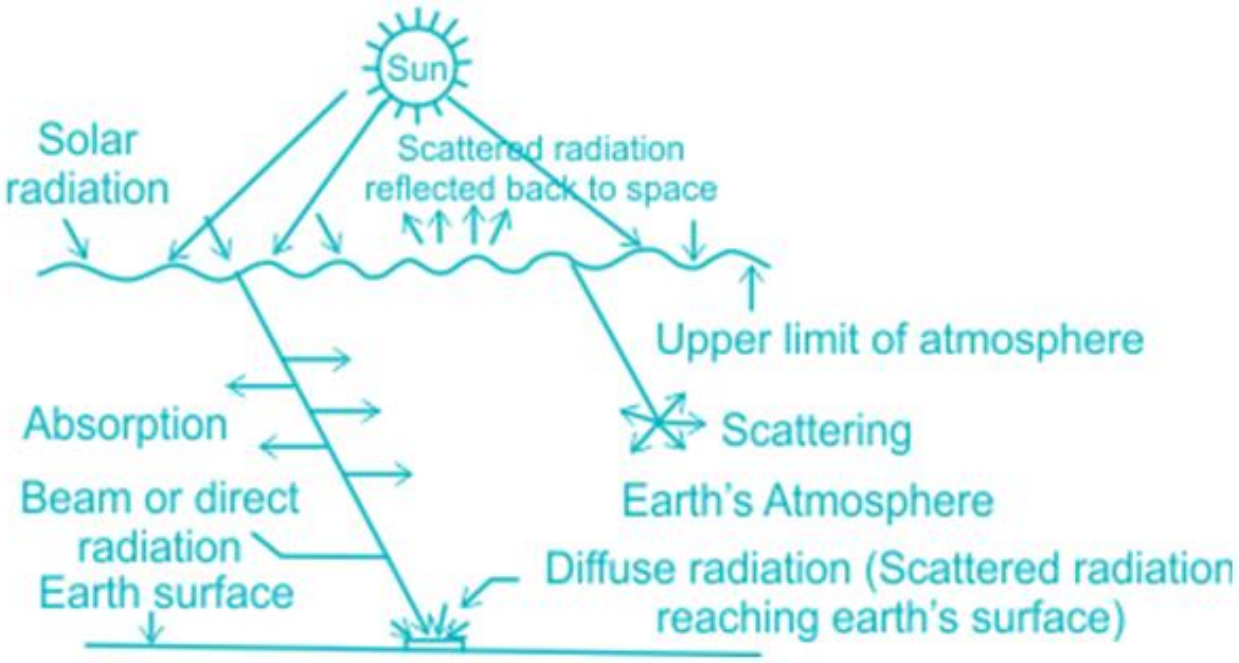

Fig.1.8 Solar radiation reaching the Earth

[Source: https://testbook.com/electrical-engineering/solar-power-plant-definition-types-and-components]

ABSORPTION:

It is mainly due to the presence of ozone, water vapour, carbon dioxide, carbon monoxide, oxygen, nitrogen and other particulate matter. The X-rays and extreme ultraviolet (UV) radiations of the Sun are absorbed by Nitrogen, Oxygen and other atmospheric gases.

SCATTERING:

It is mainly due to air molecules, gas molecules as well as dust and water droplets. The scattered radiation is redistributed in all directions, some to space and some reaching earth's surface.

DIRECT RADIATION:

Solar radiation received at the earth's surface without a change of direction (in line) with the Sun is called Direct radiation or Beam.

DIFFUSE RADIATION:

The radiation received at the earth's surface from all parts of the sky's hemisphere after scattering is called diffuse radiation.

GLOBAL RADIATION:

Global Radiation = Direct radiation + Diffuse Radiation

Types of Solar Power Plant:

Solar energy has often been employed in conjunction with two major technologies. These include:

- ❖ Solar Photovoltaic Power Plant
- ❖ Solar Thermal Power Plant

1.4.1 SOLAR PHOTOVOLTAIC POWER PLANT

Photovoltaic (PV) power plant or solar arrays transform solar energy into electricity.

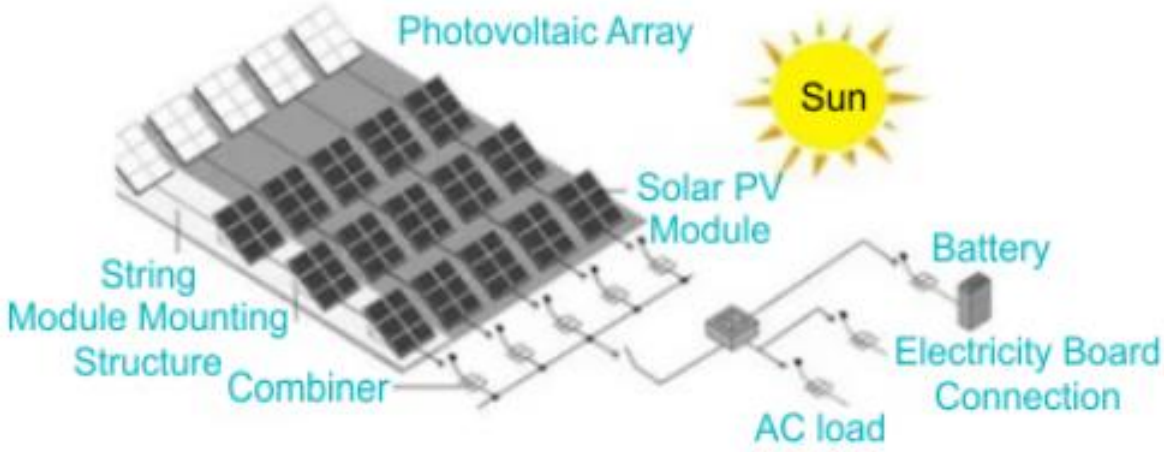

Fig.1.9 Solar Photovoltaic Power plant

[https://testbook.com/electrical-engineering/solar-power-plant-definition-types-and-components]

SOLAR CELL:

A solar cell, also known as a photovoltaic (PV) cell, is the smallest component that directly converts sunlight into electricity. It typically uses semiconductor materials to create a flow of electrons when exposed to light. A typical solar cell is depited in fig.1.10.

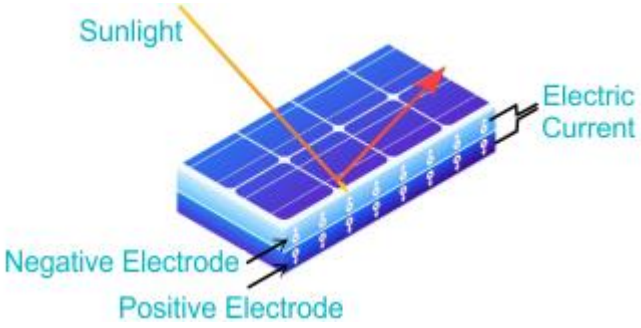

Fig.1.10 Solar Cell

[https://testbook.com/electrical-engineering/solar-power-plant-definition-types-and-components]

SOLAR PANEL:

A solar panel is a collection of multiple solar cells, usually enclosed in a protective frame.

SOLAR ARRAY:

A solar array is a group of interconnected solar panels. It's the complete system that generates electricity, often including inverters to convert DC power to AC for household use and batteries for energy storage.

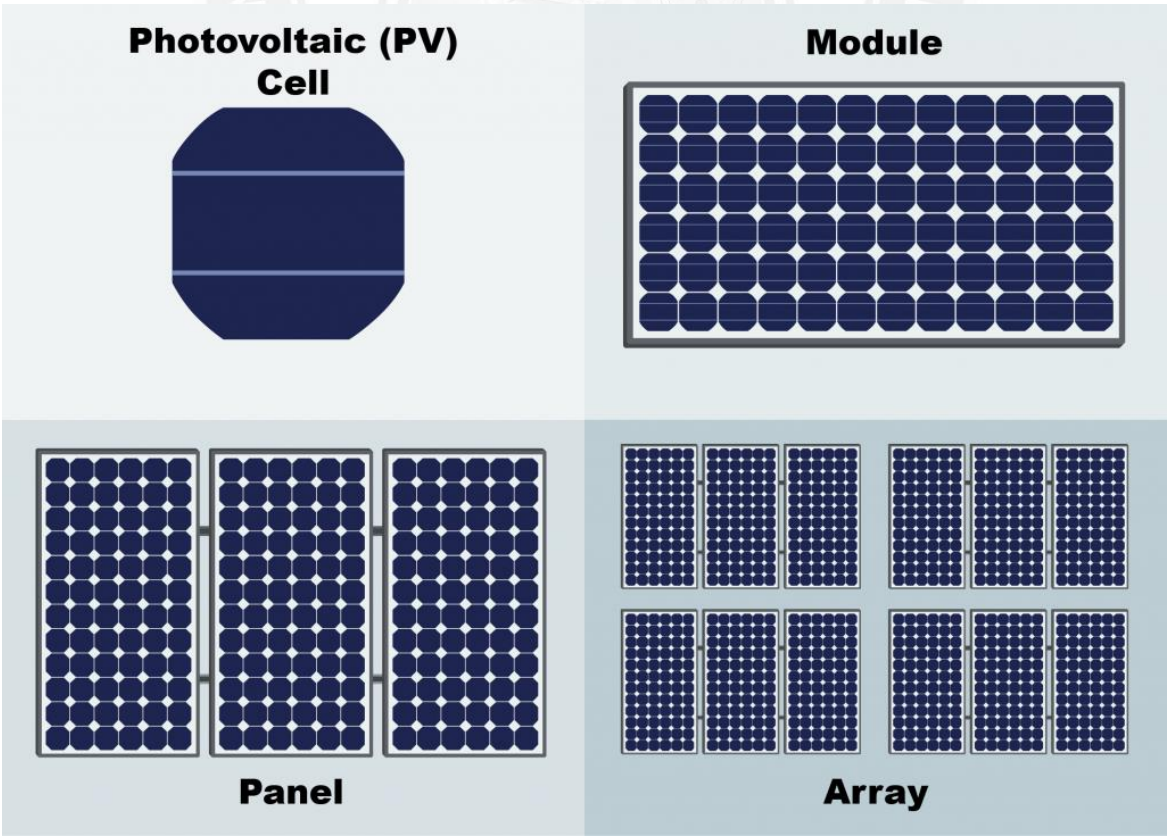

Fig.1.11 Solar cell, Module, Panel and Array

[Source: https://energyresearch.ucf.edu/consumer/solar-technologies/solar-electricity-basics/cells-modules-panels-and-arrays/]

COMPONENTS OF THE SOLAR PV POWER PLANT:

The major components of the plant are:

- Photovoltaic (PV) panel
- Inverter
- Energy storage Devices
- Charge Controller
- System balancing Component

OPERATION OF PV POWER PLANT:

1. **Sunlight Absorption:**

   Solar panels, composed of photovoltaic cells, are designed to capture sunlight.

2. **Photovoltaic Effect:**

   When sunlight (photons) strikes the semiconductor material (like silicon) within the solar cells, it excites electrons, causing them to be released and creating an electric current.

3. **Direct Current (DC) Generation:**

   The released electrons flow through the cell, generating a DC electrical current.

4. **Inversion to Alternating Current (AC):**

   The DC electricity is then fed into an inverter, which converts it into AC electricity, the type of electricity used by most appliances and the power grid.

5. **Grid Connection or Storage:**

   The AC electricity can be used to power local loads, stored in batteries for later use, or fed into the electrical grid for wider distribution.

1.4.2 SOLAR THERMAL POWER PLANT

Solar thermal power plants capture sunlight in order to produce electricity. There are some categories used to collect solar Radiation. These include Flat plate collectors, concentrated solar parabolic, Cylindrical type of power plants, and linear solar dish power plants.

Conversion of Solar Radiation into Heat:

The energy radiated by the sun has electromagnetic waves of which 99% have wavelengths in the range of (0.2 to 4×10^{-6}m). Solar energy reaching to the earth's

surface constitutes of 8% ultraviolet radiation (short wavelength - less than 0.39×10^{-6}m), 46 % visible light (0.39 to 0.78×10^{-6}m), and 46% infrared radiation (long wavelengths more than0.78×10^{-6}m).

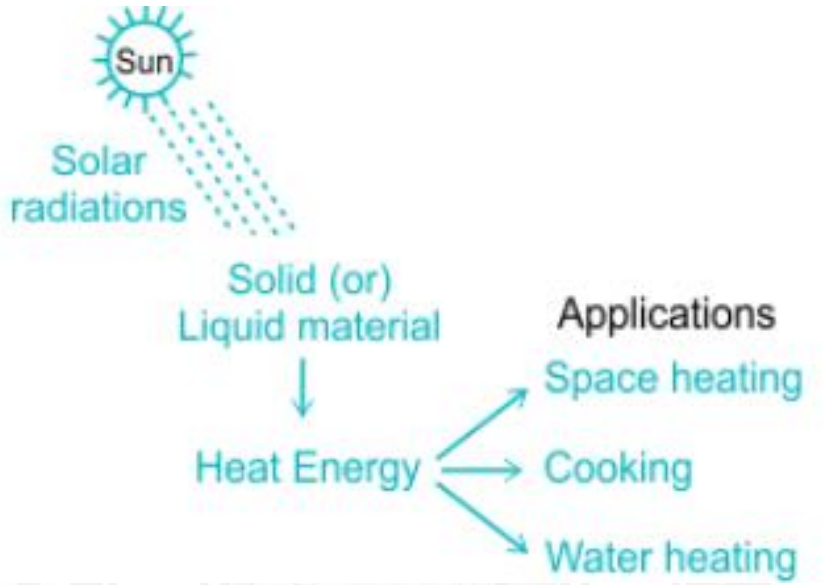

Fig.1.12 Conversion of solar radiation to heat

[https://testbook.com/electrical-engineering/solar-power-plant-definition-types-and-components]

Energy received from the sun is in the form of light at short wave radiation. When this radiation strikes a solid (or) liquid material it is absorbed and transferred into heat energy. Subsequently the solid (or) liquid material becomes warm and stores the energy in the form of heat. This stored heat energy in the liquid (or) solid material can be utilized for the required purpose like space heating, cooking, water heating, etc.

CONSTRUCTION AND WORKING OF SOLAR THERMAL POWER PLANT:

The basic elements of a solar power plant basically consist of large parabolic collectors for collecting solar energy, which is used to heat a fluid (water, sodium, gases, etc). This collector system results in temperatures of about 150° C to 500° C in the heat transfer medium (fluid). When the transfer medium is water, then steam can be generated directly in the receiver. The solar heat from the receiver or storage converts feed water into steam. This steam is utilized to run a prime-mover (steam turbine) coupled to an electric generator, which generates electric power. Steam is condensed in the condenser and water returns to the boiler for reuse as feed water. The condensed can be utilized for some other purpose.

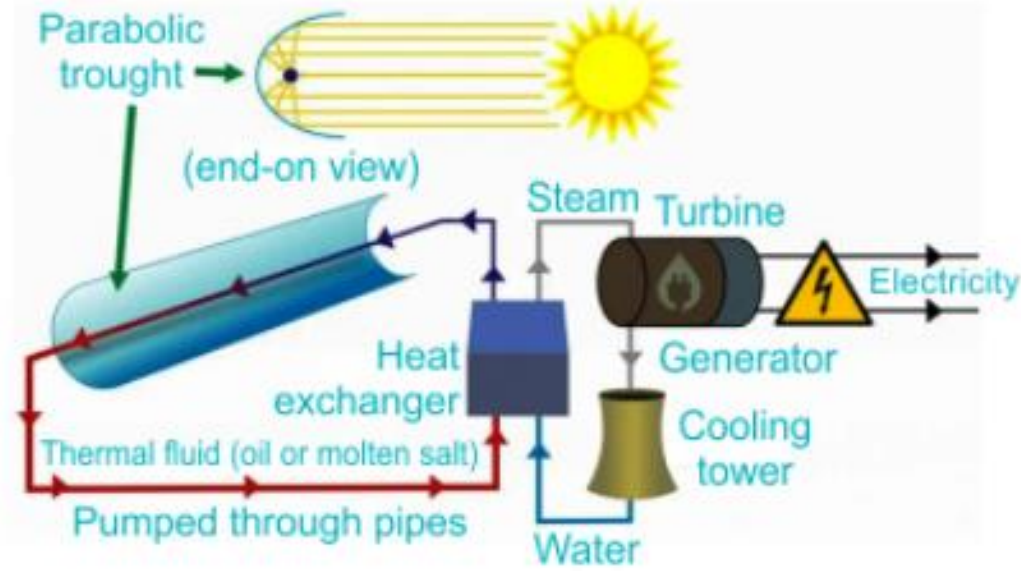

Fig.1.13 Solar Thermal Power plant

[https://testbook.com/electrical-engineering/solar-power-plant-definition-types-and-components]

Types of Solar Collectors:

1. Flat plate solar collector
2. Concentrating collector
    a. Flat plate with plane reflectors
    b. Compound parabolic concentrating collector
    c. Cylindrical parabolic collector
    d. Collector with a fixed circular concentrator and moving receiver
    e. Fresnel lens concentrating solar collector
    f. Paraboloidal dish collector

Site Selection of Solar Power Plant:

- Solar Irradiance: High levels of solar radiation are crucial for efficient energy generation.
- Land Availability and Cost: Sufficient land area is needed, and its cost can significantly impact project feasibility.
- Proximity to Transmission Lines: Minimizing the distance to existing power grids reduces transmission losses and costs.
- Environmental Impact: Consideration of protected areas, water bodies, and potential ecological consequences is essential.

- Accessibility: Road access for construction and maintenance is important for reducing costs and facilitating operations.
- Climatic Conditions: Temperature, rainfall, and cloud cover affect solar panel efficiency.
- Slope and Terrain: Gentle slopes are preferable for easy installation and maintenance.
- Flood Risk: Areas prone to flooding should be avoided to protect the investment.

Advantages:

i. Renewable and Sustainable
ii. Reduced Greenhouse Gas Emissions
iii. Lower Electricity Bills
iv. Energy Independence
v. Technological Advancements
vi. Low Maintenance
vii. Government Incentives
viii. Can be Used in Remote Areas
ix. Increased Property Value

Disadvantages:

a) High Initial Costs
b) Weather Dependency
c) Space Requirements
d) Energy Storage Needs
e) Environmental Impact During Manufacturing and Disposal
f) Aesthetic Concerns
g) Potential for Limited Savings in Some Areas