PHOTOVOLTAIC

❖ Introduction

Photovoltaic energy is the conversion of sunlight into electrical energy through a photovoltaic (PVs) cell, commonly called a solar cell. Solar cells are the solid state electronic device used to convert the electromagnetic energy of solar radiation directly into direct current electricity. This conversion takes place inside the cell. The PV cell itself is the most common form and made of almost entirely (95%) from silicon available on earth's crusts in large amount.

➢ Metals

Based on the electric conductivity behavior the solid through them, the metals are classified in three categories.

➢ Conductors

The conductor contains many electrons in its conduction band at normal room temperature and does not have band gap between valance and conduction band. The energy of both the band is same and overlaps in some portion between these bands. The conductor has many electrons to conduct electricity without application of external source of energy.

- **Insulators**

  These metals do not conduct electricity because of large band gap between valance band and conduction band and no transfer of electrons takes place from valance band to empty conduction band.

- **Semiconductors**

  The electrical characteristics of these materials lie between conductors and the insulators. The band gap (forbidden gap) in these semiconductors is less than the insulator and able to transfer the electrons from valance band to the conduction band after acquiring some energy. The minimum energy required to jump the electron is equal to the forbidden gap ($hv \geq hg$).

- **The Photoelectric Effect**

  Operation of solar cells is based on the Photovoltaic effect. Sunlight is composed of photons and these photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a transparent photovoltaic cell, they may be reflected, pass through or absorbed by material. These absorbed photons provide the thermal energy to excited electrons to generate electricity. When enough solar energy is absorbed by the material of cell, electrons break through from the atoms.

According to quantum theory electrons are forming a bond to hold the material together and remain in the lower energy level. This lower energy state is called the valance band state. However, in certain conditions some electrons after acquiring some energy move to higher energy level, called conduction band. The energy difference between these two levels is called band gap energy and measured in ‘eV’. The electrons in conduction band move around to conduct electricity.

Incident light on cell material generates mobile charge carriers. The photon incident must have sufficient energy to remove (1.12eV for silicon) the electrons from valance band and allow them to reach on conduction band. The energy lower than this will go as wastage. However excess energy of photon is dissipated as a heat.

❖ Terminology

- **Solar Cell:** The solar cell is responsible for converting solar energy to electricity. Some materials (e.g., silicon is the most common) produce a photovoltaic effect, where sunlight frees electrons striking the silicon material. The solar cell is also called PV cell

- **Doping:** The semiconductors are having very less electrons in conduction band than metal. In order to improve the conductivity some impurity is being added. This method is known as doping.

- **PV Module:** A PV module is composed of interconnected solar cells. A packaged weather-tight module is used to connect the cells and these modules can be further connected to form an array.

- **PV Array:** PV modules are connected in series and parallel to form an array of modules, therefore increasing total available power output to the desired voltage and current for a particular application.

❑ Solar Cell Materials

The solar cell is made of different material and silicon is one used for nearly 90% applications. The choice of material depends on the band energy gap, efficiency and cost. The maximum efficiency of solar cell is achieved with the band gap energy of 1.12eV-2.3eV. The various materials like aluminum silicon, Si (1.12eV) Aluminium antimonide, AlSb (1.27 eV), Cadmium telluride, CdTe (1.5eV), Zink telluride, ZnTe (2.1 eV), Cadmium sulphide, CdS (2.42eV) etc. are the materials suitable for solar cell. The smaller the energy gap, the large number of photon of solar spectrum will be useful to produce the required energy for electrons to jump the forbidden band gap. The semiconductor should meet the requirement that electron hole pair should produce near the junction otherwise they will get combined within without giving the cell output

❖ Advantages and Disadvantages of PV System

➢ Advantage:

Silicon PV cells manufactured today can provide over thirty years of useful service life. PV systems are cost effective for many remote power applications, as well as for small stand-alone power applications in comparison to existing electric grid. The various advantages are:

- Direct conversion of electricity from sunlight and avoiding bulky systems.
- The modular characteristic allows arrays to be installed quickly and in any size required.
- The environmental impact of a photovoltaic system is minimal.
- It requires no water for system cooling.
- The photovoltaic have been used at remote sites to provide DC electricity which can be converted to AC by using inverter.
- No moving part
- Unlimited life.
- The PV systems are expandable and components easily repaired or replaced if needed.
- Sun tracking is not essential.
- Easy to fabricate.
- Used in space application because of high power to weight ratio.

- **Disadvantages:**
  - High cost because of costly production process.
  - Energy storage system is needed.
  - Large area is required for solar power plant.
  - Energy required in manufacturing increase the pay back time of Photovoltaic.

❖ Applications of PV System

The PV systems are used for various purposes by suitably designing the system as per the need. The PV systems are used to supply power in remote areas for their use as well as supply excess power to national grid. It does not have moving part and therefore can supply power for indefinite period without damage. Solar radiation gets converted into DC electricity directly. This electricity can either be used as it is or can be stored in the battery and can be used. Most solar electric systems are more cost effective in remote areas where there is no existing power supply.

The various applications of PV system are:

- Used in watches, calculator etc.
- Small capacity system are mounted at house wall / roof and used for various purposes at residences.
- Solar power is used on road, lighting tower, parking light, traffic signaling, radio stations etc.
- Space satellite power generation.
- Solar water pump
- Central power station. One 50 Watt PV module is enough to power four or five small fluorescent bulbs, a radio, and a 15-inch black – and – white television set for up to 5 hours a day.

❖ Solar Photo Voltaic Water Pump

The system comprises of SPV module, panel frame structure, mono block pump set with suction and delivery pipe lines, foot valve and electrical accessories. The solar modules are a day from east to west during the day.

The pump is very compact and light, the motor and pump are in a mono block. The pump is provided with a volute type casing. It is provided with a dynamically balanced impeller. The pump is mounted on a stainless steel shafting with deep grove ball bearings. It is also provided with mechanically sealed stuffing box. The motor rotates in clock wise direction from driving end. The d.c motor pump set is manufactured by M/S. Kirloskar Brothers Ltd. Pune. The SPV module is manufactured by Central Electronic Ltd, Sahibabad (U/P). The solar photo voltaic consists of suitable number of PV modules connected in series or in parallel combination to give the required power out put (900).

- **Working of the system:** All the photo voltaic cells in the panel are connected in series. When the solar light falls on the panel, it is converted into electricity. The power so generated is in series and is available at a controlling switch. The controlling switch is provided below the panel boards. When the switch is on, the motor gets power and starts pumping water from the well. When the switch is off, the motor stops pumping water. Maximum discharge can be obtained on a clear day. The SPV pump can be adopted for open well as well as bore well with in the limits of total head.

- **Specifications:**
  - Model = SW 900
  - Type of motor = DC motor
  - Capacity = 1.2 HP
  - Maximum suction head = 7.5
  - Maximum total head = 15m
  - Capacity of SPV array = 900 w
  - Require shade free area = 30 sq.m
  - Water out put = 65000 liters / day
  - Cost = Rs. 55000/-

✓ **Dimensions of SPV Panel**

- Panel = 864 w, 60 v, panel
- Length = 2470 mm
- Width = 2070 mm

❖ Solar Street Light

A solar street light mainly consists of a PV module battery, CFL tube light, electronic controller, mounting lamp post etc. A 36 cells photovoltaic module converts the solar light incident on it to electricity (70 w). The electricity is used to charge a lead acid battery of 12 volts and 75 amp hr capacity. The module is fixed on top of the pole at an inclination of 150 facing south. A metallic box containing battery is arranged to the lamp post with suitable clamps at a height of 75 cm from the ground. A CFL tube light is arranged to the pole at suitable or required direction. The lamp post is fixed with two clamps at the bottom and given a concrete foundation to a depth of 0.5m and 0.6 m wide into the ground. The foundation is a must for the lamp post to keep it in erect position in all conditions of weather. The lamp post is designed to with stand a wind speed of 120 km/hour. The lamp post and other mountings are galvanized to avoid any kind of rusting. The battery is arranged in a safe box to protect the battery from weather and rain. The electronic controller is arranged inside to make the system more compact. The system is to be installed as in the installation diagram. The battery, PV module and controller are connected with suitable cable as shown in circuit diagram. Erect the lamp post and place it in the pit. Adjust the position of the lamp post such that the PV module is facing south direction and luminaire is facing the street.

- **Auto working system:** When once the street lighting system is installed, the solar light is converted into electricity and the battery is charged in the day time. When the day light falls to a particular level the lamp gets on in the night and glows. Again before the sun rises when the light comes up to a certain level the light puts off itself automatically. The system is not provided any ON and OFF controlling switch

- **Maintenance of the System**

1. Clean the PV module surface with a neat cloth at least once in a month
2. The electrolyte level in the battery is to be checked once in a month
3. The electrolyte level in the battery to be maintained at least 14 mm above the plates
4. To top up the battery open the vent plugs, fill distilled water up to the specified level and close the vent plugs.
5. Equalizing or freshening charge is recommended once in six months for proper mixing of electrolyte
6. After long working the CFL becomes blackened and finally may not glow, then replace the lamp with new lamp
7. Before replacing the lamp remove battery connections and after replacing lamp give battery connections properly if there is no Switch
8. If On and OFF switch is available the switch is put off and replace the lamp and on the switch again.

❖ Solar lantern

A Solar lantern is a simple application of solar photovoltaic technology, which has found good acceptance in rural regions where the power supply is irregular and scarce. Even in the urban areas people prefer a solar lantern as an alternative during power cuts because of its simple mechanism. A solar Lantern is made of three main components - the solar PV panel, the storage battery and the lamp. The lamp, battery and electronics all placed in a suitable housing made of metal, plastic or fiber glass. The operation is very simple. The solar energy is converted to electrical energy by the SPV panel and stored in a sealed maintenance-free battery for later use during the night hours. A single charge can operate the lamp for about 4-5 hours. The lantern is basically a portable lighting device suitable for either indoor or outdoor lighting, covering a full range of 360 degrees.

❖ Solar Fencing System

Solar Fencing is the modern day's alternative to the conventional type of perimeter protection. These are active fences and punish the unwelcome intruder the moment they touches the fence or try to tamper the fence. The conventional types of fences are only passive fences and cannot resist the intruder if they try to forcibly intrude into the protected area. The Solar Fence gives a sharp, short but a safe shock and creates psychological fear. Against any tampering the alarm incorporated in the system gets activated and alerts the inmates of the protected area, which facilitates them to counter the unwelcome intruders.

The Solar Fence is scientific fence and works on Solar Energy with backup facility to run uninterruptedly during the nights as well as cloudy days.

❖ Working principle:

The Solar module generates the DC energy and charges the Battery. The output of the battery is connected to Energizer or Controller or Charger or Fencer. The energizer will produce a short, high voltage pulse at regular rate of one pulse per second. The live wire of the energizer is connected to the fence wire and the earth terminal to the Earth system. Animal / Intruder touching the live wire creates a path for the current through its body to the ground and back to the energizer via the earth system and completes the circuit. Thus the intruder will receive a shock, the greater the shock the intruder receives the more lasting the memory will be avoided in future.