

UNIT - 01

(SUB - KOF 074)

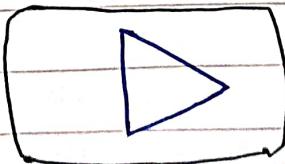
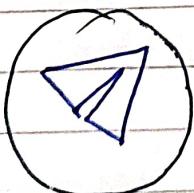
# RENEWABLE ENERGY RESOURCES

ONE - SHOT @MULTIATOMS

Topics:

- ① Various non-conventional energy resources
- ① Classification
- ① Merits and demerits
- ① Solar cells
- ① Theory of solar cells
- ① Solar cells materials
- ① Solar cell array
- ① Solar cell power plant
- ① Limitation

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# CONVENTIONAL ENERGY RESOURCES

- ① Conventional Energy resources are traditional sources of energy that have been used for many years.
- ② It is also known as non-renewable energy resources.
- ③ It cannot be replaced, if once they are used

# NON CONVENTIONAL ENERGY RESOURCES

- ① It is also known as renewable energy resources.
- ② It can be used to produce energy again and again.
- ③ Non-conventional energy resources are ways to make energy that are different from the usual fossil fuels like coal and oil.

Features	Conventional Energy	Non-Conventional Energy
Examples	Fossil fuels, nuclear energy	Solar, wind, geothermal, biomass
Reliability	Very reliable and consistent	can be variable (e.g. depend on weather)
Environmental Impact	Higher pollution and greenhouse gas emission	Lower impact, generally cleaner and more sustainable

O Discuss the main features of various types of renewable and non-renewable energy resources. Also explain the importance of non-conventional energy sources in the context of global warming.

{AKTU 2021-22}

OR

O Discuss about various conventional energy resources with renewable energy.

{AKTU 2022-23}

O Discuss the main features of various types of renewable energy and non-renewable energy resources.

{AKTU 2023-2024}

Sol Non-Renewable Energy :- Non-renewable energy comes from sources that cannot be easily replenished in a short time.

O The two main types are fossil fuels and nuclear fuels.

$\Rightarrow$  Fossil Fuels

O Fossil fuels come from the remains of ancient plant and animals that decomposed over millions of years.

1. Natural Gas:-
  - Natural gas is a fossil fuel in gas form, most made of methane.
  - It is found with oil and is used for heating, cooking, and making electricity.
  - It can also be used as vehicle fuel.

2. Coal:-
  - Coal is a solid fossil fuel that comes from plants that were buried and heated over millions of years.
  - It is mainly used in power plants to produce electricity.
  - Coal contains a lot of carbon, which make it a major contributor to pollution.

3. Oil:-
  - Oil is a liquid fossil fuel that forms tiny sea organisms like zooplankton and algae under great pressure.
  - It is crucial for transportation (like gasoline for cars), manufacturing, and making petrochemical product like plastics.

### Environmental Impact of Fossil Fuels:

- Climate Change: All fossil fuels release CO<sub>2</sub> when burned, a major contributor to the greenhouse effect and global warming.

- Pollution :- They also emit harmful pollutants that affect air quality and human health.
- Non-renewable :- These are finite resources.

## Nuclear Fuels :-

- Nuclear fuels are used in nuclear power plants to make energy.
- The most common nuclear fuel is uranium, found in small amounts in the Earth's crust.
- In nuclear power plants, uranium goes through fission (splitting atoms), which releases a lot of energy used to generate electricity.
- Nuclear submarines and some spaceships also use nuclear fuel for power.

## Environmental Impact :-

- ① Low air pollution
- ② Accidents : If a nuclear power plant has an accident (like the ones in Fukushima), it can release harmful radiation into the environment, which can cause serious health and environmental problems.
- ③ Mining impact

Renewable Energy Resources :- Renewable energy source is energy that is sustainable - something that can't run out or is endless.

## 1. Solar energy :-

- ① Solar technologies convert sunlight into electrical energy either through photovoltaic (PV) panels or through mirrors that concentrate solar radiation.
- ② This energy can be used to generate electricity or be stored in batteries or thermal storage.
- ③ There are two main types of solar energy technology - photovoltaics (PV) and concentrating solar-thermal power (CSP).
- ④ The sun sends out the energy in the form of radiation at the rate of  $3.7 \times 10^{20}$  MW.

Merits:-

- ① Noiseless operation
- ② cheaper ~~initial~~ cost maintenance
- ③ produces little pollution

Demerits :- Solar equipments fail to work in nights, cloudy days or rainy seasons.

## 2. Wind Energy :-

- ① Wind is used to produce electricity by converting the kinetic energy of air in motion into electricity.
- ② In modern wind turbines, wind rotates the motor blades, which convert kinetic energy into rotational energy, this energy is transferred by a shaft which connect to the generator, thereby producing electrical energy.
- ③ Wind power is a clean and renewable energy source.

Merits :

- ① Produces minimal pollution.
- ② Creates jobs for maintenance and operations.

Demerits :

- ① Some find wind turbines unattractive or noisy.

## 3. Biomass Energy :-

- ① It is renewable energy source.
- ② Biomass energy comes from organic materials like plant, wood and waste.

① It can be generated by burning these materials to produce heat or by allowing them to decompose, which creates gases like methane that can be captured for fuel.

② The materials used for biomass are known as feedstocks.

Merits:- ① Can be carbon neutral if managed properly through reforestation.

② Doesn't increase greenhouse gases.

Demerits:- ① Growing plants take longer than burning them.

#### 4. Geothermal Energy:-

① Geothermal energy is heat energy from the earth - geo (earth) + thermal (heat).

② Geothermal energy is produced from the Earth's internal heat, which is continually replenished.

① Hot molten rocks called 'magma' are present in the core of the earth. This causes sometimes volcanic action.

Merits:- ① cheap and clean source of energy  
② Geothermal plants require little land area

Demerits :- ① Air pollution, resulting in release of small gases like  $H_2S$ ,  $NH_3$ , present in the steam water.

### 5. Tidal Energy :-

- ① Tides are caused by the gravitational pull of the Sun and the Moon, resulting in the rise and fall of sea levels.
- ② This movement can be harnessed through a tidal barrage, which functions like a dam to capture tidal energy.
- ③ During high tide, seawater flows into the barrage reservoir, turning turbines to generate electricity.

Merits :- ① Low greenhouse gas emissions.  
② Energy from both high and low tides.

Demerits :- ① High initial cost.  
② Limited location.

### 6. Hydrogen Energy :-

- ① Hydrogen is considered as an alternative future source of energy.
- ② It is a non conventional energy resources.
- ③ Hydrogen can be generated from water by means of electricity.

Merits :-

- ① Hydrogen energy has very high energy content.

- ② It's burning is non-polluting

Demerits :-

- ① It is more expensive

- ② Highly flammable.

## # Importance of Renewable Energy Resources w.r.t Global Warming

- ① Renewable: nature, limited, finite, independent.
- ② Environmentally friendly.
- ③ Reduce global warming.
- ④ Conserve natural resources.
- ⑤ Training importance.

## MNRE :-

- ① MNRE stands for Ministry of New and Renewable Energy. It is India's nodal ministry for new and renewable energy matters.

- ② Aims to develop and deploy new and renewable energy to supplement the country's energy needs.

- ③ New and renewable energy's role gains significance for India's energy security.

- ① Energy self-sufficiency became a priority post the oil shocks in the 1970's
- ② The commission for Additional Source of Energy was established in 1981 to formulate policies, implement programs, and coordinate R&D in new and renewable energy.

### MISSION:-

- ① Jawaharlal Nehru National Solar Mission launched on January 11, 2010, by the Prime Minister.
- ② Deploy 20,000 MW of grid-connected solar power by 2022.
- ③ Aims to reduce solar power generation costs through:-
  - long term policy
  - large scale deployment goals
  - Aggressive R&D, and
  - Domestication production of critical raw materials
- ④ Mission focuses on creating an enabling policy framework to establish India as a global leader in solar energy

# CLASSIFICATION OF ENERGY RESOURCES

## (a) Primary Energy Resources :-

→ These resources are obtained from the environment.  
Ex :- Fossil fuels, solar energy, hydro energy and tidal energy.

∴ These resources can further be classified as :-

### (a) Conventional Energy Sources :-

Example : Thermal power

### (b) Non Conventional Energy Sources :-

Example : Wind energy, geothermal, ocean energy, solar energy and tidal energy.

### (c) Renewable : These sources are being continuously produced in nature and are inexhaustible.

Ex :- Wind Energy, Biomass, Solar energy etc.

### (d) Non Renewable : - These are finite and exhaustible

Ex :- Coal, petroleum etc.

## (b) Secondary Energy Resources :-

These resources do not occur in nature but are derived from primary energy resources.

Ex :- H<sub>2</sub> obtained from hydrolysis of H<sub>2</sub>O

## ⇒ MERITS OF Renewable Energy Resources!

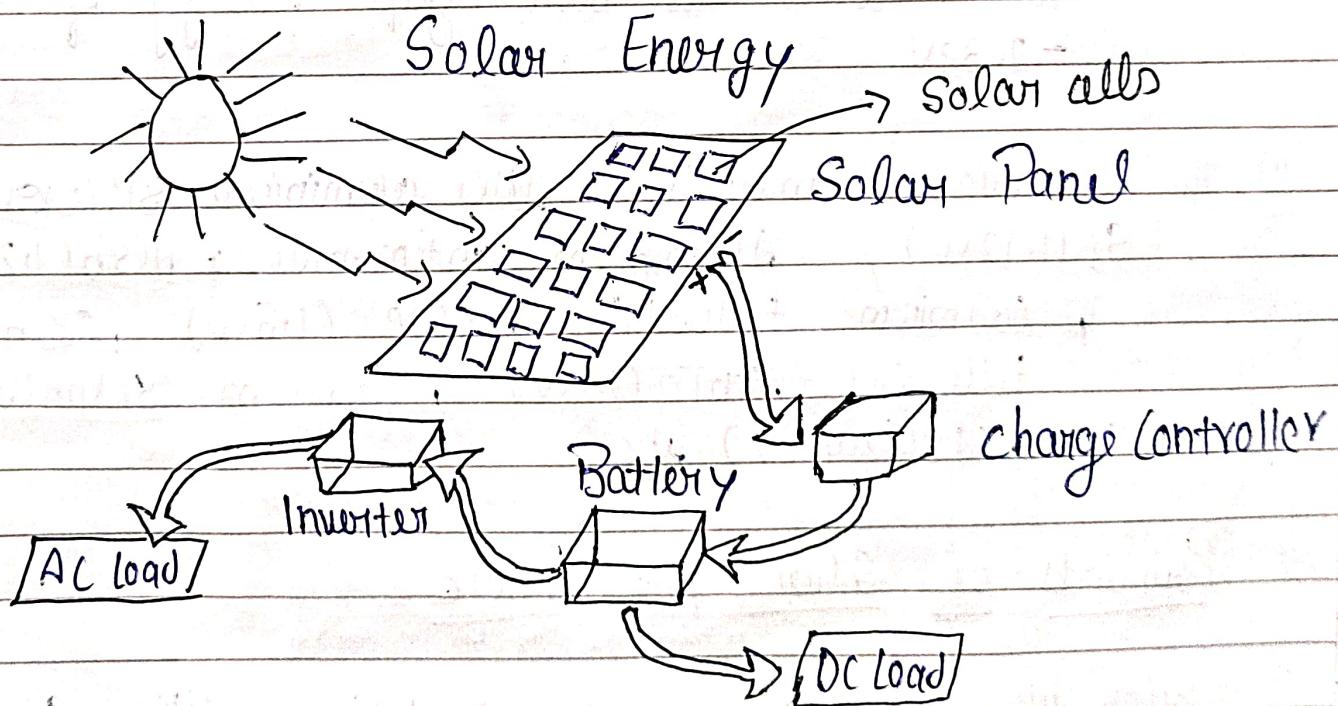
- ① Sustainable :- They can be replenished naturally and won't run out.
- ① Environmentally friendly :- no greenhouse gas emission, reducing pollution.
- ① Reduces Dependence on Fossil Fuels
- ① Job Creation :- Growing renewable energy sectors create new jobs in various fields.
- ① Low Operating Costs.
- ① Technological Advancements

## DEMITS OF Renewable Energy Resources :-

- ① Intermittent Supply :- Energy production can be inconsistent.
- ① High Initial Costs
- ① Land and Space Requirements
- ① Resource location :- Availability of renewable sources can be location dependent.
- ① Environmental Impact :- Some renewable projects can disrupt local ecosystems.  
(e.g. hydropower dams)
- ① Limited Energy Density

# SOLAR CELLS

- ① Solar cells are the small units that make up solar panels.
- ② Solar cells is used to convert sunlight into electricity.
- ③ Each solar cell is like a mini power generator.
- ④ When sunlight hits the cell, it creates an electric current that can be used to power lights, gadgets, or even a house.



- ① Solar cells contain a material as silicon that absorbs light energy.
- ② The energy knocked electrons loose so they can flow freely and produce a difference in electric potential energy, or voltage.

- ① The flow of electrons or negative charge creates electric current.
- ② Solar cells have positive and negative contacts, like the terminals in a Battery.

### Solar Cell Materials:-

- ① The solar cell is made of different materials and silicon, silicon is one used for nearly 90% applications.
- ② The maximum efficiency of solar cell is achieved with the band gap energy of 1.12eV - 2.3eV
- ③ The various materials like aluminium silicium, Si (1.12eV), Aluminium antimonide, AlSb (1.27eV), Cadmium telluride, CdTe (1.5eV), Zinc telluride, ZnTe (2.1eV), Cadmium Sulphide, CdS (2.42eV) etc.

### Principle of Solar photovoltaic

- ① Solar cells are made from materials like silicon (Si) or gallium arsenide (GaAs), known as semiconductors
- ② In Semiconductor, each atom has four electrons in its outer orbit, which can be removed if they receive extra energy (like sunlight)

Q. When sunlight hits the solar cell, it gives energy to the electrons, freeing them and allowing them to move.

Q This movement of electrons generates an electric current, which is how the solar cell produces power

Q Describe the main elements of a PV system by giving a suitable diagram. {AKTU 2023-2024}

Sol. Solar Panels : There are made up of many solar cells that convert sunlight into direct current electricity (DC)

• Charge Controller :- A charge controller protects the battery from overcharging

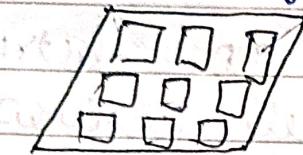
• Battery Storage :- Batteries store excess energy generated during the day for use at night or during periods of low sunlight

• Inverter :- An inverter converts DC electricity into Alternating current electricity.

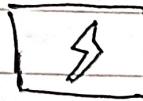
• Power Meter :- A power meter measures how much electricity you use for your home and how much you send back to the grid.

- Electric grid :- During peak periods and at night electricity imported from the electric grid

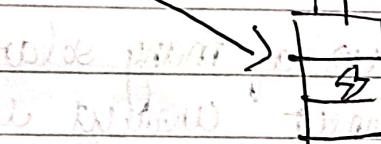
PV array



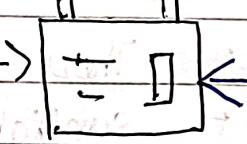
Solar Panel



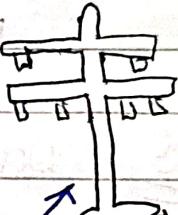
charge controller



Battery Storage



Inverter



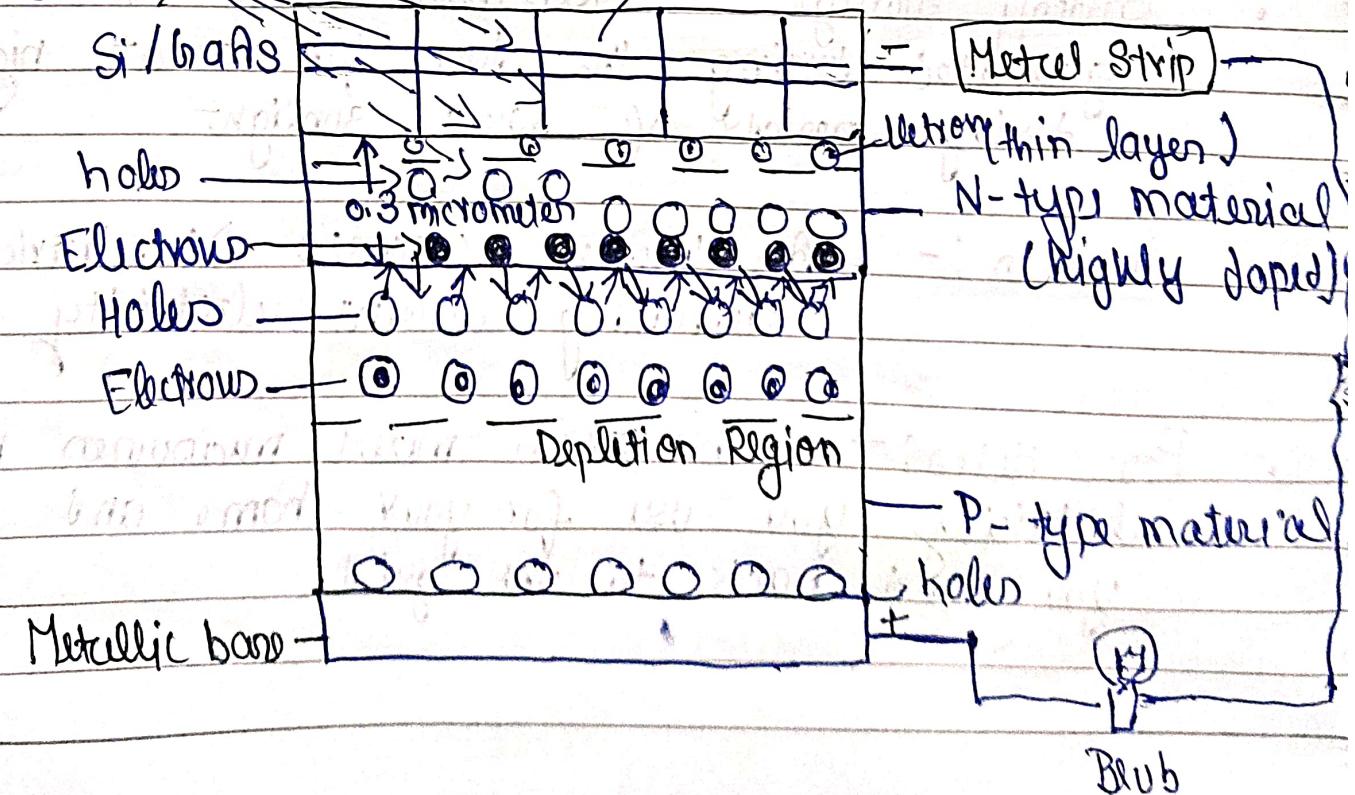
Electric grid



Power meter

$\Rightarrow$  Mechanism of Photon conduction in a PV cell

Sun



- ① In P-n junction, if the photons (sun light particles) are absorbed, the free  $e^-$  of n side will tend to flow to the p-side and the holes of the p-side will tend to flow to n-side.
- ② This depletion layer will create Electric Field from n-region to P-region
- ③ This field will increase until it reached equilibrium of  $V_c$ , sum of diffusion potential for holes and electrons
- ④ If electrical contacts are made with two semi-conductor materials & the contacts are connected through external metallic strip, the free electrons will flow from n-type material through conductor to p-type material
- ⑤ The flow of  $e^-$  through external conductor constitutes an electric current which will continue as long as more free  $e^-$  and holes are being formed by solar radiation.
- ⑥ This is the basis of photovoltaic conversion that is conversion of solar energy to electrical energy.

# CLASSIFICATION OF SOLAR CELLS

## ① Monocrystalline Solar cells :- (1.1ev)

- They are made from a single crystal of silicon
- They are the most efficient type because they have high purity and can convert more sunlight into electricity.
- They are usually more expensive.

## ② Poly-crystalline Solar cells :- (1.1ev)

- Made from many silicon crystals melted together
- They are less expensive to produce but also slightly less efficient than monocrystalline cells.

## ③ Thin-film Solar cells :- (1.5ev)

- They are made by layering thin sheets of photovoltaic material like cadmium telluride or amorphous silicon.
- They are flexible and cheaper.
- They are usually less efficient than silicon-based cells.

① Perovskite Solar cells: - (1.5V) A newer type, these use materials called perovskites.

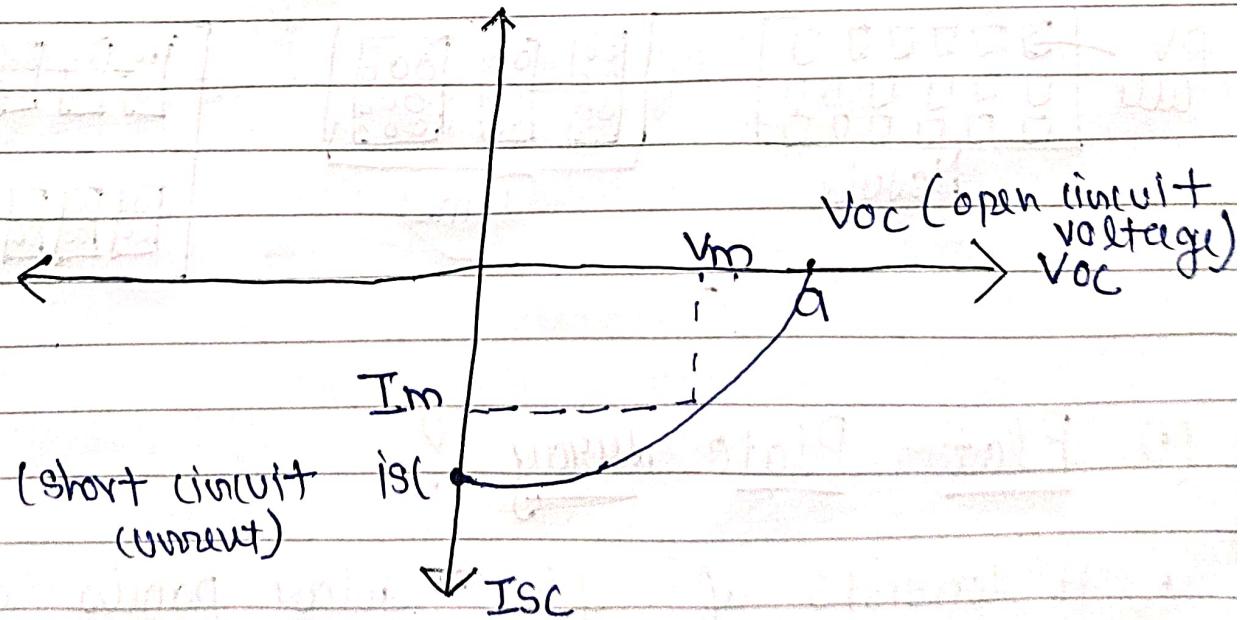
→ They are still being developed but show great potential because they can be cheaper and more efficient than traditional cells.

⇒ V-I characteristics:-

① V-I characteristics of solar cell lies in 4th quadrant.

② V-I characteristics of normal p-n junction diode lies in 1<sup>st</sup> and 3<sup>rd</sup> quadrant.

③ In p-n junction diode we provide voltage source using battery while solar cell produces voltage itself.

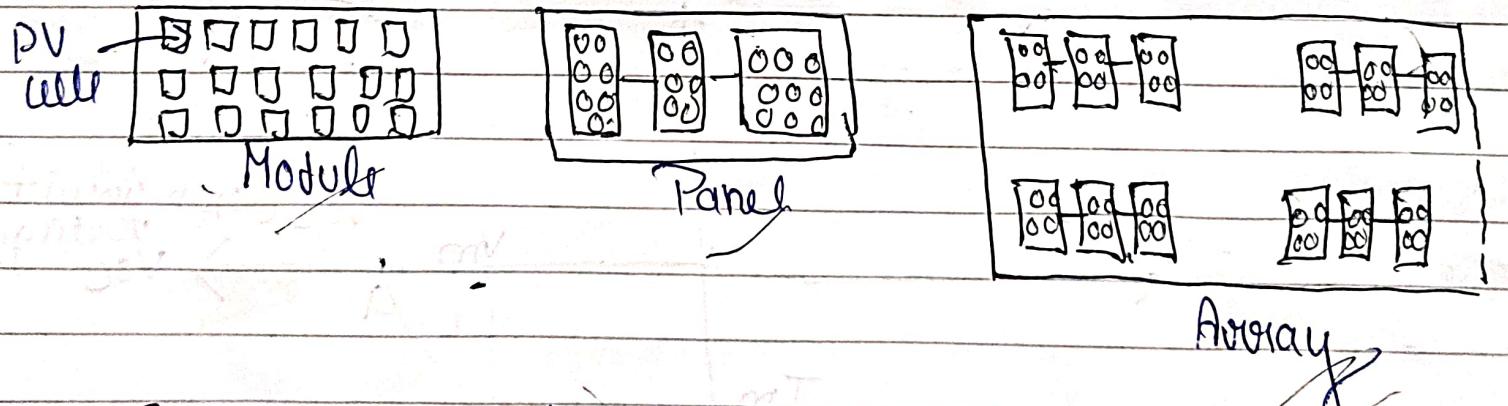


Maximum Power output

$$P_{max} = V_{max} \times I_{max}$$

# SOLAR CELL ARRAY

- ① A solar cell array is a large group of solar cells connected together to produce more electricity.
- ② A collection of individual solar cells linked to work together.
- ③ Its main function to captures sunlight and convert it into a significant amount of electrical power.
- ④ Solar cells are arranged in panel and many panels make up an array.



## (\*) Flat Plate Array

- It consists of flat solar panels arranged in a fixed position to capture sunlight.

① It doesn't use mirrors or lenses to concentrate sunlight, just relies on the direct and diffuse light hitting the panels.

② This is the most common and widely used type of solar array for homes and business.

Adv :-

① Simple to install

② No moving parts

Disadv :- ① Less efficient

② Large Area Needed

## (c) Concentrated Solar Array

① It's an array that uses optical devices (like mirrors or lens) to focus sunlight onto a small area of solar cells.

② Concentrated Photovoltaics (CPV) and Concentrated Solar Power (CSP) are the type of concentrated solar array.

Adv :- ① Higher Efficiency

② Suitable for large-scale Projects

Disadv :- ① Requires Direct Sunlight

② Expensive

Q write short note on PV arrays and P System  
charge controller. What are the advantages and  
disadvantages of photovoltaic Solar energy:  
SAIK TU 2021-2022

Sol

### Advantage of Photovoltaic Solar energy conversion

- ① Renewable Energy
- ① Environmentally friendly
- ① Low operating costs
- ① Energy Independence
- ① Scalability

### Disadvantage of Photovoltaic Solar energy conversion

- ① High initial cost
- ① Weather Dependent
- ① Energy Storage Requirement
- ① Large Space requirement

Q Describe Various direct and indirect application of solar energy. [AKTU 2021-2022]

Sol

### Direct Application:-

- ① Solar Photovoltaic (PV) system:- Directly converts sunlights into electricity using solar panels.
- ② Solar thermal system!- Converts sunlight into heat energy, which can be used for various heating purposes.
- ③ Concentrated Solar Power! - Uses mirror or lenses to focus sunlight onto a small area to generate heat.
- ④ Solar lighting! - Uses solar panels to capture sunlight and store it in batteries, which is used to power light during the night.
- ⑤ Solar Desalination! - Uses solar heat to evaporate and then condense water, removing salt and other impurities to produce clean drinking water.

### Indirect Application!-

- ⑥ Biomass Energy :- Plants absorb ~~sunlight~~ sunlight.
- ⑦ Wind Energy :- Solar energy heats the Earth unevenly and creates wind.

- ① Hydropower :- Solar energy drives the water cycle
- ② Fossil fuels such as coal, oil and natural gas are ancient forms of solar energy

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