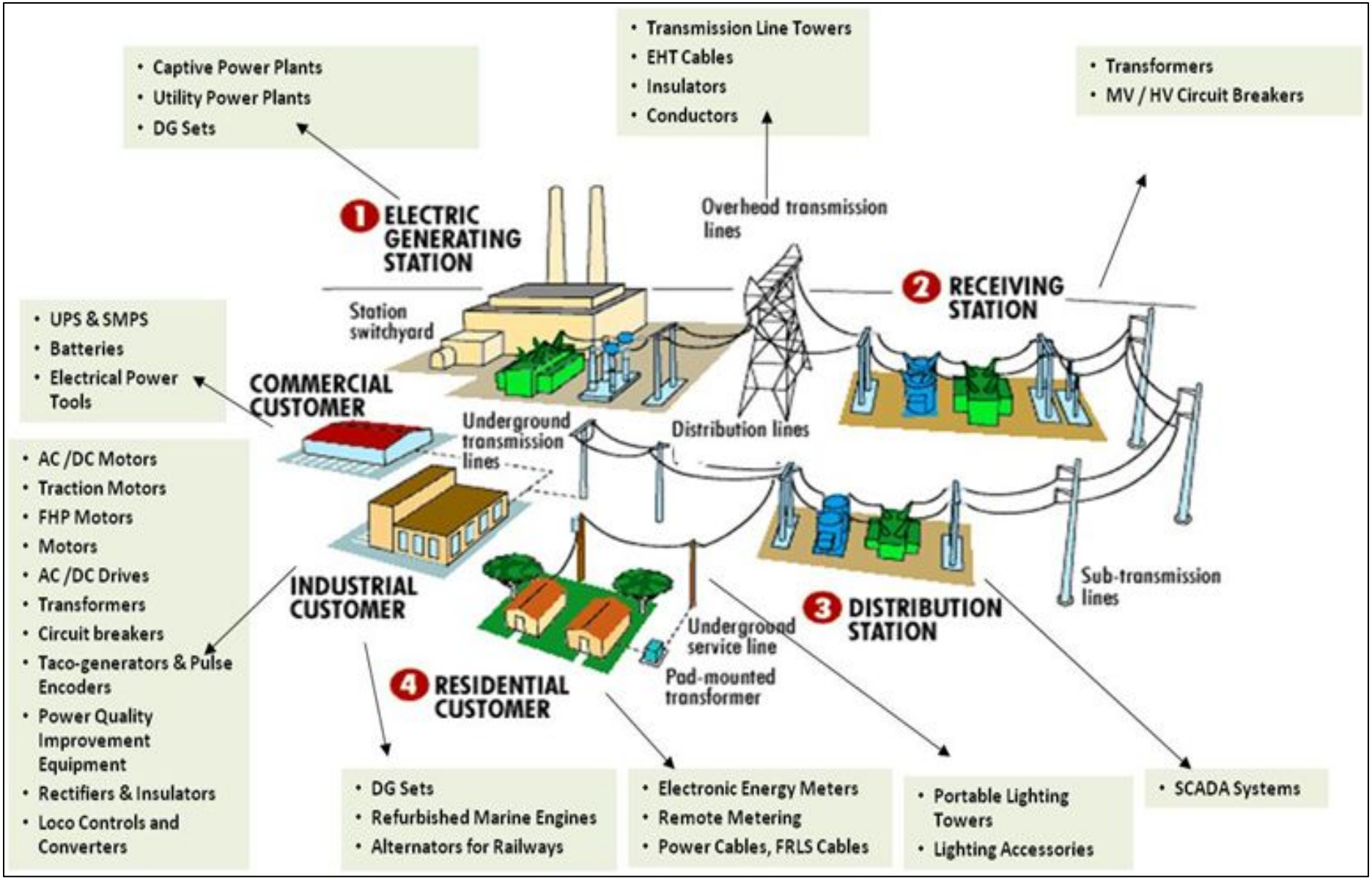
UNIT – 5

Power Engineering

Layout of Generation Transmission & Distribution



Transmission of Electrical Energy

Two systems by which electrical energy can be transmitted.

(1) High voltage DC electrical transmission system.

(2) High voltage AC electrical transmission system.

Advantages in using DC transmission system-

i) Only two conductor are required for DC transmission system. It is further possible to use only one conductor of DC transmission system if earth is utilized as return path of the system.

ii) The potential stress on the insulator of DC transmission system is about 70% of same voltage AC transmission system. Hence less insulation cost is involved in DC transmission system.

iii) Inductance, capacitance, phase displacement and surge problems can be eliminated in DC system. No F, Power Factor problem Skin effect proximity effect. **Disadvantage :** power Electronic switching devices installation

Advantage of AC transmission system

Even having these advantages in DC system, generally electrical energy is transmitted by three phase AC transmission system.

i) The alternating voltages can easily be stepped up & down, which is not possible in DC transmission system.

ii) Maintenance of AC substation is quite easy and economical compared to DC system.

iii) The transforming in AC electrical sub station is much easier than motor-generator sets in DC system.

Disadvantages of AC transmission system

i) The volume of conductor used in AC system is much higher than that of DC.

ii)The reactance of the line, affects the voltage regulation of electrical power transmission system.

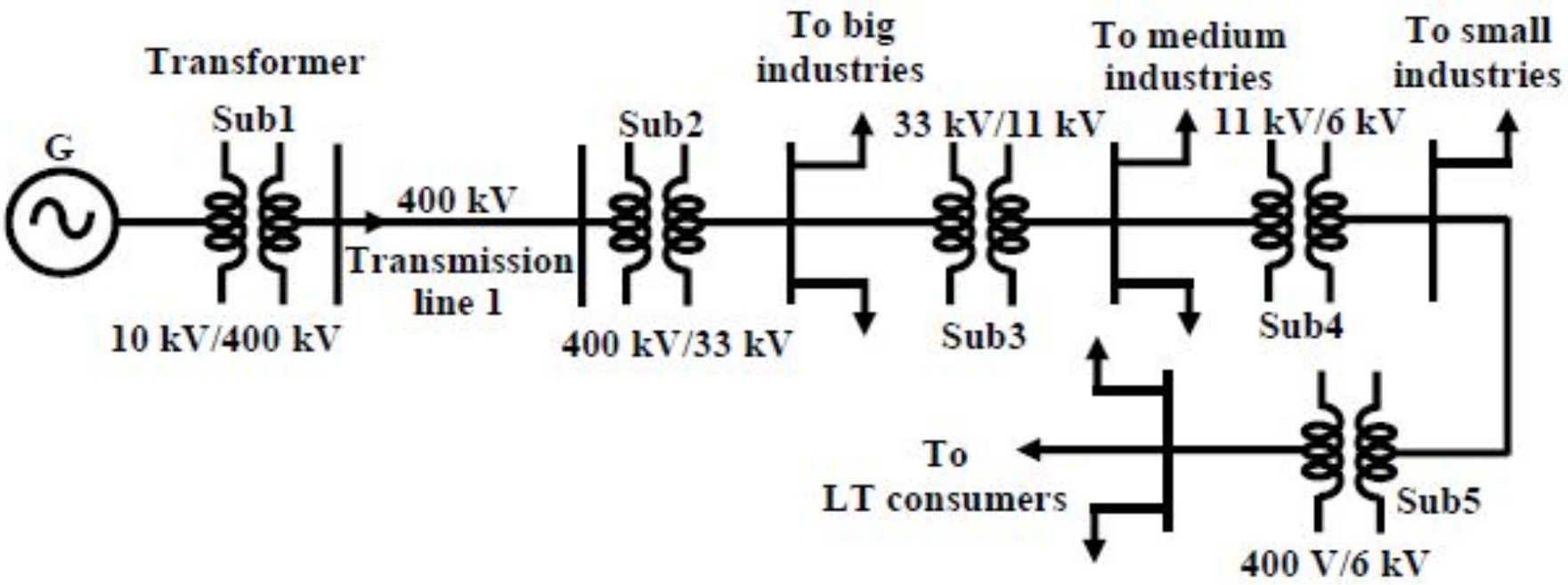
iii) Problems of skin effects and proximity effects only found in AC system.

iv) AC transmission system is more likely to be affected by corona effect than DC system.

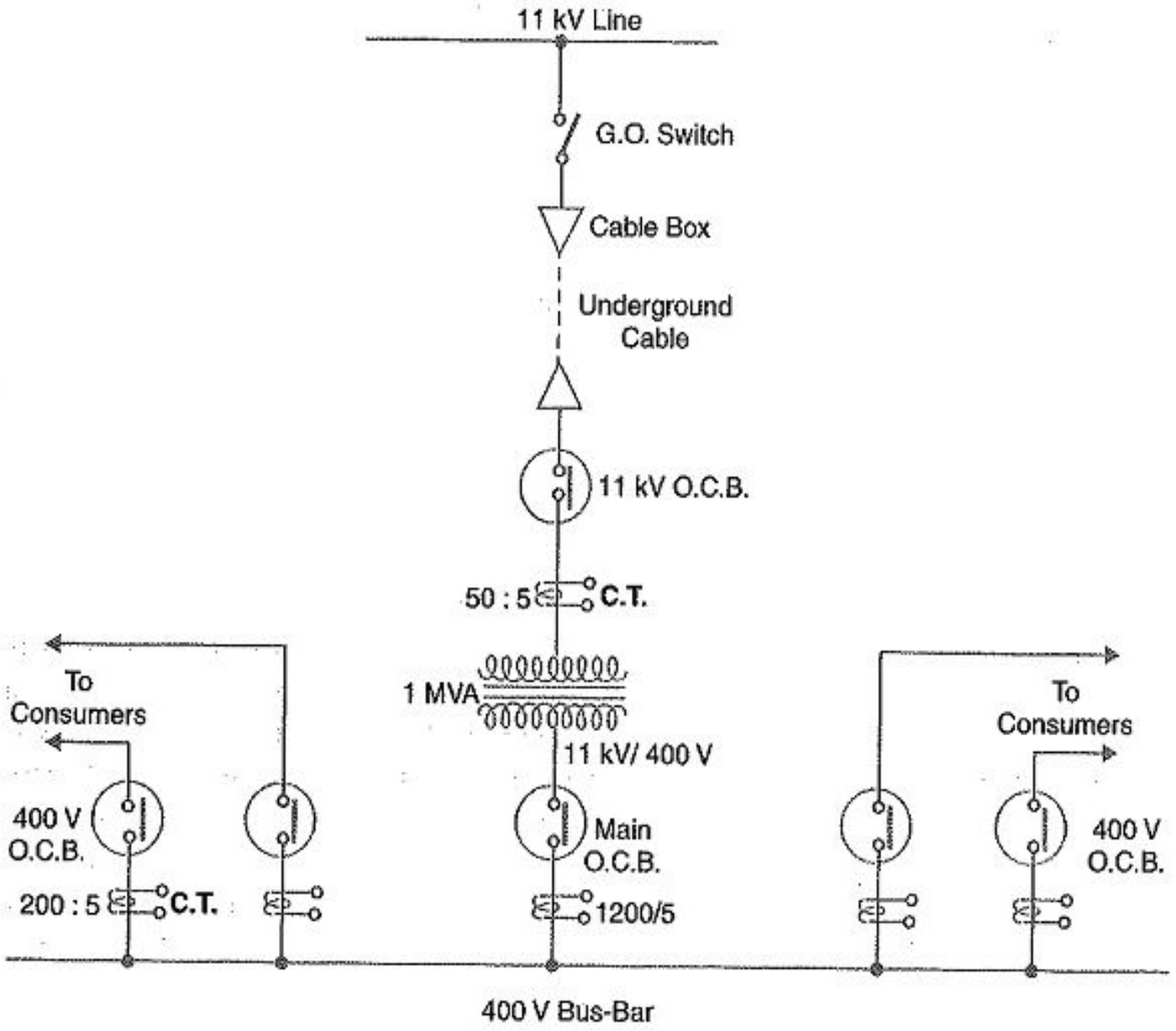
v) Construction of AC electrical power transmission network is more complicated than DC system.

vi) Proper synchronizing is required before inter connecting two or more transmission lines together, synchronizing can totally be omitted in DC transmission system.

Single line representation of power system

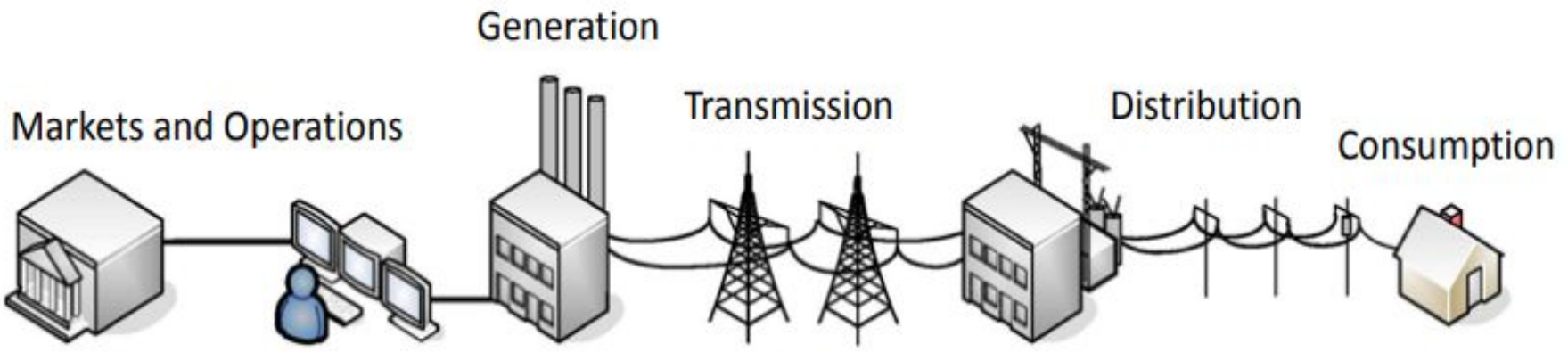


11kV/400V Indoor Substation



- The 3-phase, 3-wire 11 kV line is tapped and brought to the gang operating switch installed near the sub-station. The G.O. switch consists of isolators connected in each phase of the 3-phase line.
- From the G.O. switch, the 11 kV line is brought to the indoor sub-station as underground cable. It is fed to the H.T. side of the transformer (11 kV/400 V) via the 11 kV O.C.B. The transformer steps down the voltage to 400 V, 3-phase, 4-wire.
- The secondary of transformer supplies to the bus-bars via the main O.C.B. From the bus-bars, 400 V, 3-phase, 4-wire supply is given to the various consumers via 400 V O.C.B. The voltage between any two phases is 400 V and between any phase and neutral it is 230 V. The single phase residential load is connected between any one phase and neutral whereas 3-phase, 400 V motor load is connected across 3-phase lines directly.

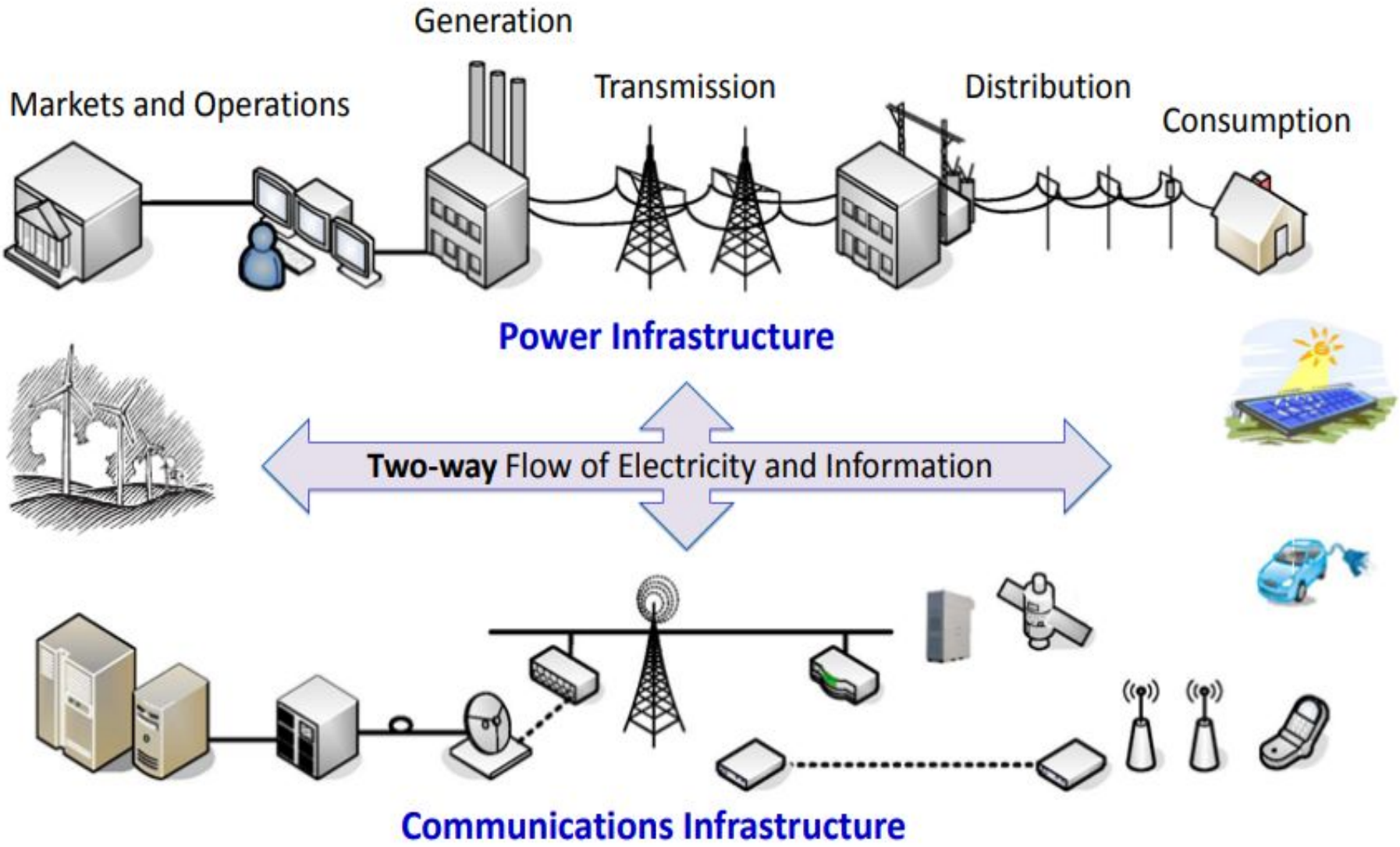
Traditional Power Grid



One-way flow of electricity

Centralized, bulk generation
Heavy reliance on coal and oil
Limited automation
Limited situational awareness
Consumers lack data to manage energy usage

Smart Grid


Generation
Markets and Operations
Transmission
Distribution
Consumption
Power Infrastructure
Two-way Flow of Electricity and Information
Communications Infrastructure

Safety Precautions when Working with Electricity

1. Never touch or try repairing any electrical equipment or circuits with **wet hands**. It increases the conductivity of electric current.

2. Never use equipment with **damaged insulation** or **broken plugs**.

3. If you are working on any electrical socket at your home then always **turn off the mains**.

4. Always **use insulated tools while working**.(never_use_aluminium or steel ladder)

5. Electrical hazards include exposed **energized parts** and unguarded electrical equipment which may become **energized unexpectedly** -carries warning signs like "**Shock Risk**". Always be observant such electrical signs.

6. when working electrical circuit always use appropriate insulated rubber gloves and goggles.

7. Never try repairing energized equipment. Always check that it is de-energized first by using a tester. When an electric tester touches a live or hot wire, the bulb inside the tester lights up showing that an electrical current is flowing through the respective wire.

8. Know the wire code of your country.

9. Always use a circuit breaker or fuse with the appropriate current rating. Circuit breakers and fuses are protection devices that automatically disconnect the live wire when a condition of short circuit or over current occurs. The selection of the appropriate fuse or circuit breaker is essential.

Electrical safety devices

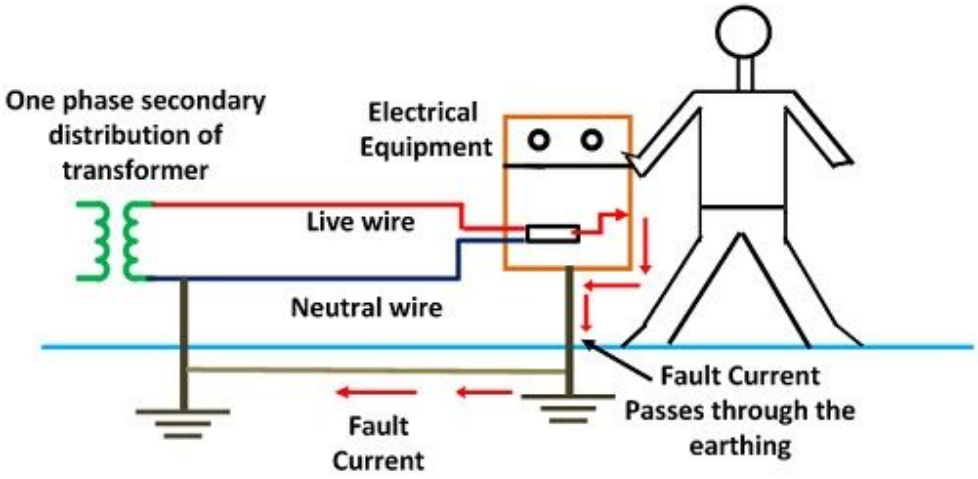
- It is extremely important to have various safety devices to protect from fire and electrocution.

FUSE: A fuse is an electrical safety device that has the capability to protect an electric circuit from excessive electric current. It is designed to allow current through the circuit, but in the event that the current exceeds some maximum value it will open, severing the circuit.

Circuit breaker: Circuit breakers are devices that protect circuits from overload current conditions. They do the same job as fuses, but they are not destroyed when activated.

Earthing

- The potential of the earth is considered to be at zero for all practical purposes.
- Earthing is to connect any electrical equipment to earth with a very low resistance wire, making it to attain earth's potential.
- This ensures safe discharge of electric energy, which may be due to reasons like failure of the insulation, line coming in contact with the casing etc.
- Earthing brings the potential of the body of the equipment to ZERO i.e. to the earth's potential, thus protecting the operating personnel against electrical shock.



Electrical System With Earthing

Circuit Globe

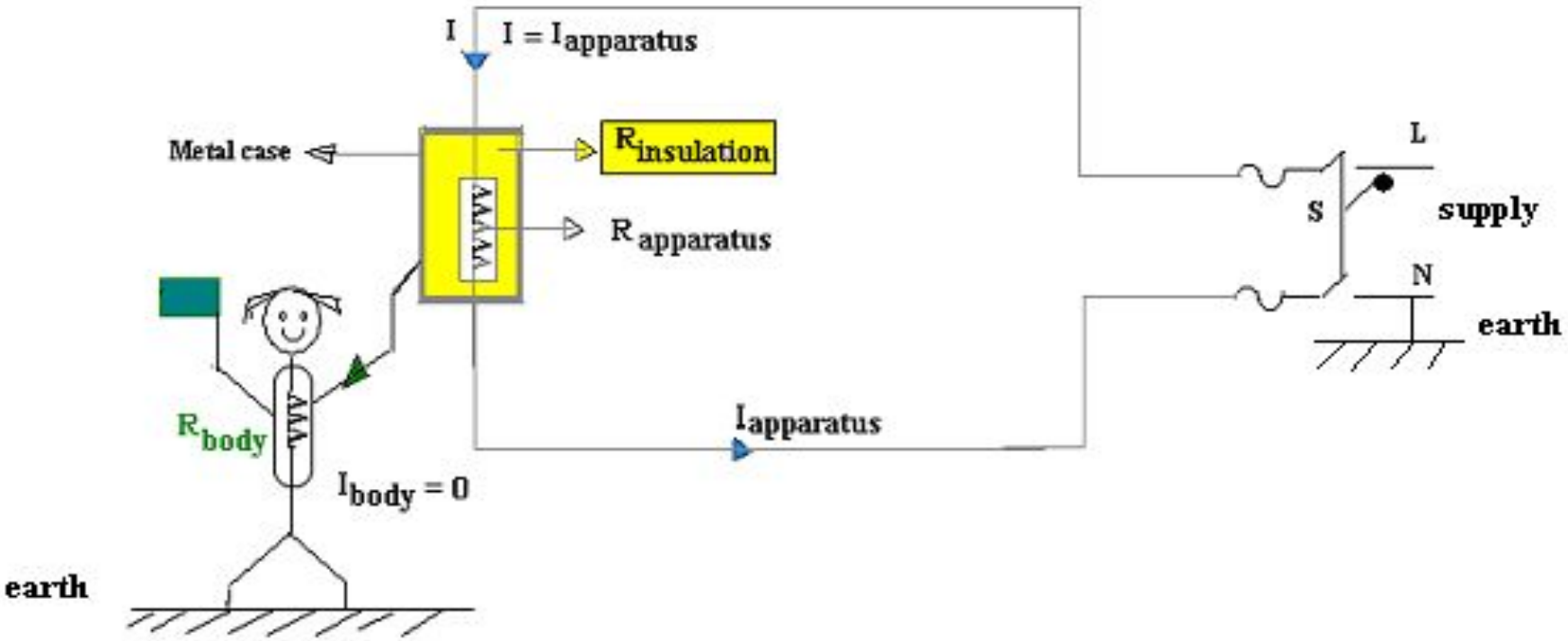
Plug with no earth PIN

Importance of Earthing

Case I

Healthy insulation

Apparatus not earthed

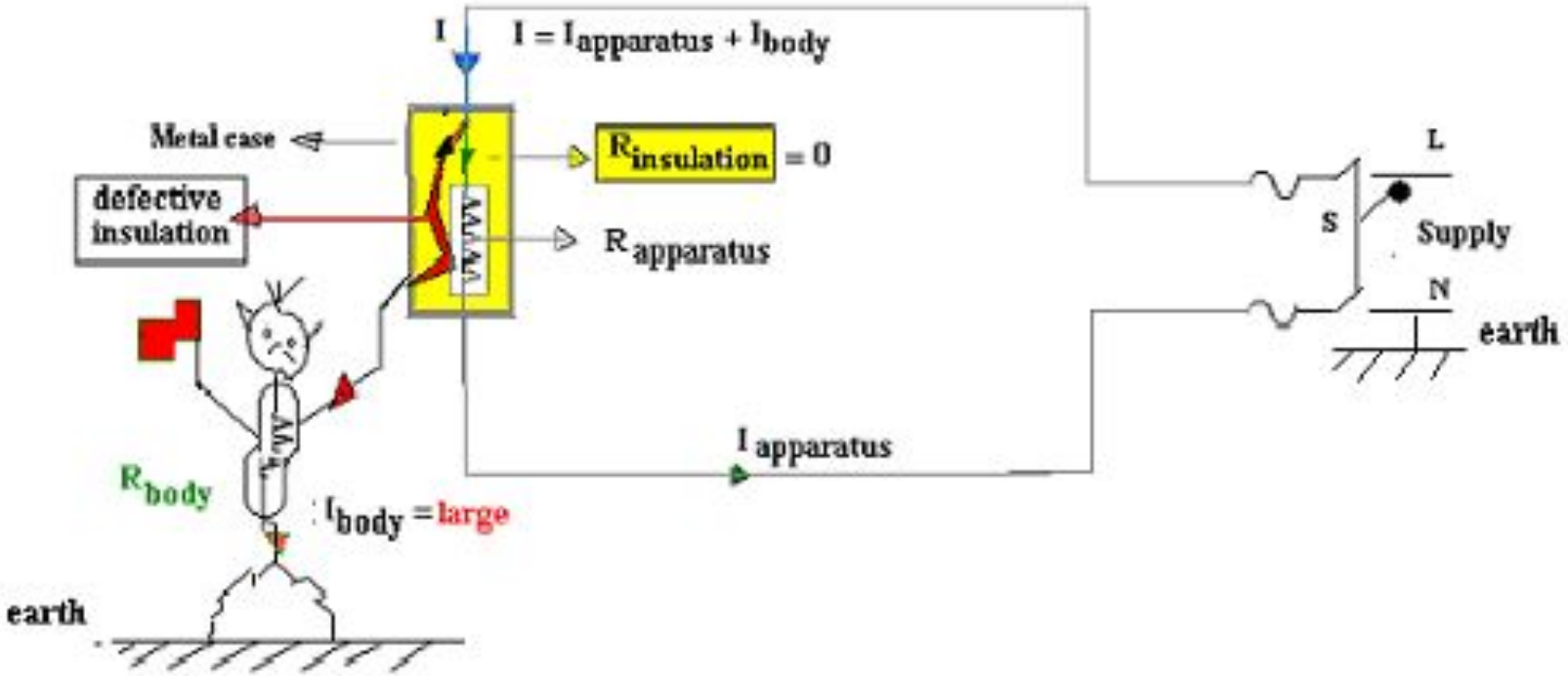


1. Insulation is healthy (R insulation $= \infty$)
2. Supply current flows through the resistence of the apparatus only ($R_{apparatus}$)
3. No current flows through the body resistance ($I_{body} = 0$)
4. The person is safe even if the apparatus is not earthed

Case II

Defective insulation

Apparatus not earthed

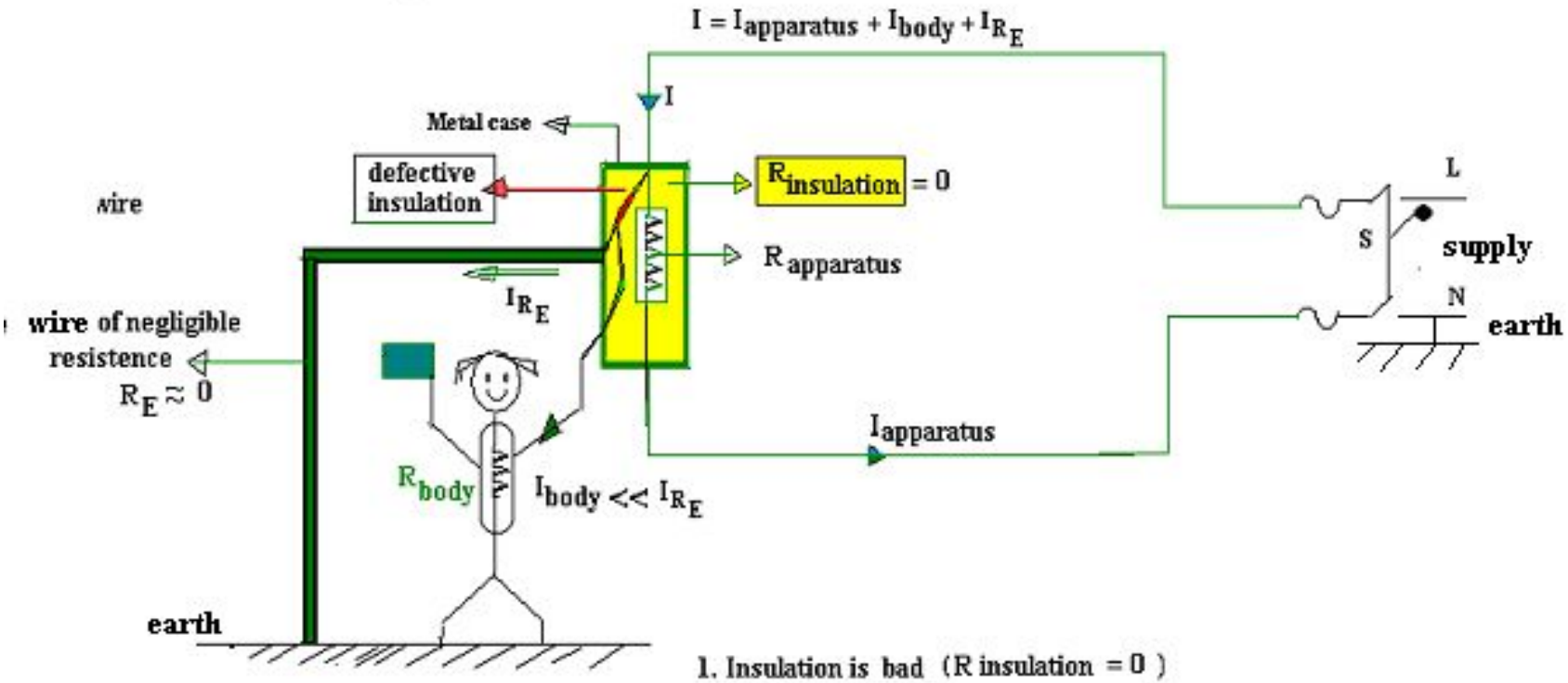


1. Insulation is bad ($R_{insulation} = 0$)
2. Supply current now divides into $I_{apparatus}$ and I_{body}
3. A part of the supply current flows through the body to the ground I_{body}
4. The person experiences shock as the apparatus is not earthed

Case III

Defective insulation

Apparatus earthed



1. Insulation is bad ($R_{insulation} = 0$)
2. Supply current now divides into $I_{apparatus}$ I_{body} and I_{R_E}
3. A part of the supply current I_{body} flows through the body to the ground
4. Now I_{body} is very less compared to the current flowing through wire of negligible resistance connecting the apparatus metal case to ground

   $I_{body} << I_{R_E}$
5. The person in contact with the apparatus does not experience any shock as the metal casing is earthed

Necessity of Earthing

- To protect the operating personnel from danger of shock in case they come in contact with the charged frame due to defective insulation.
- To maintain the line voltage constant under unbalanced load condition.
- Protection of the equipments
- Protection of large buildings and all machines fed from overhead lines against lightning.

Methods of Earthing

- Conventional Earthing

- Maintenance Free Earthing

Maintenance Free Earthing

Its Benefits are

- Maintenance Free
- Consistency
- More Surface Area
- Low Earth Resistance: Highly Conductive. Carries High Peak Current Repeatedly.
- No Corrosion
- Long Life
- Easy Installation

Methods of Conventional Earthing

1. **Plate Earthing**
2. **Pipe Earthing**
3. Rod Earthing
4. Strip Earthing

1 Earthing through a G.I. Pipe

In this method a G.I. pipe used as an earth electrode. The size of the pipe depends upon the current to be carried and type of soil in which the earth electrode is buried.

For ordinary soils the length of the G.I. pipe used as an earth elctrode is 2 m long and 38 mm in diameter or 1.37 m long and 51 mm in diameter. For dry and

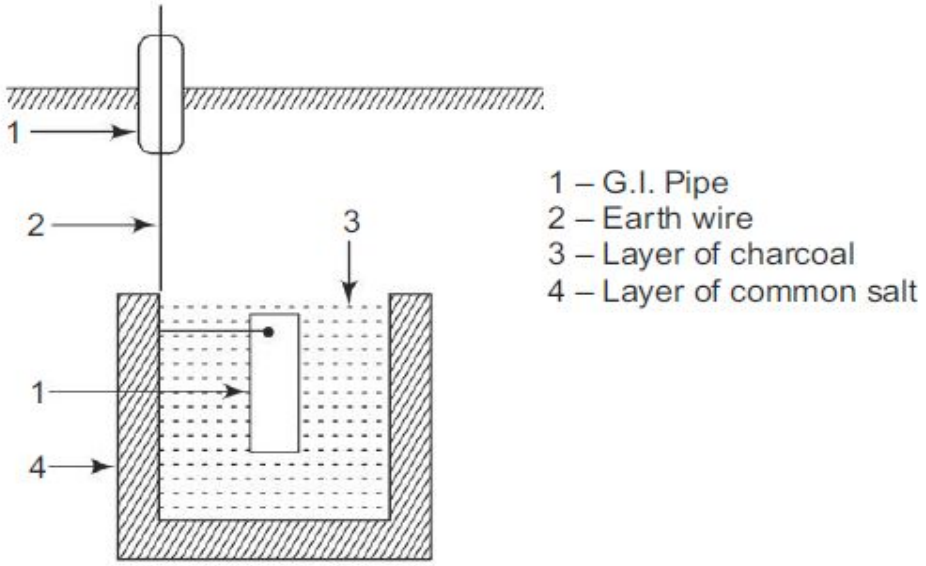
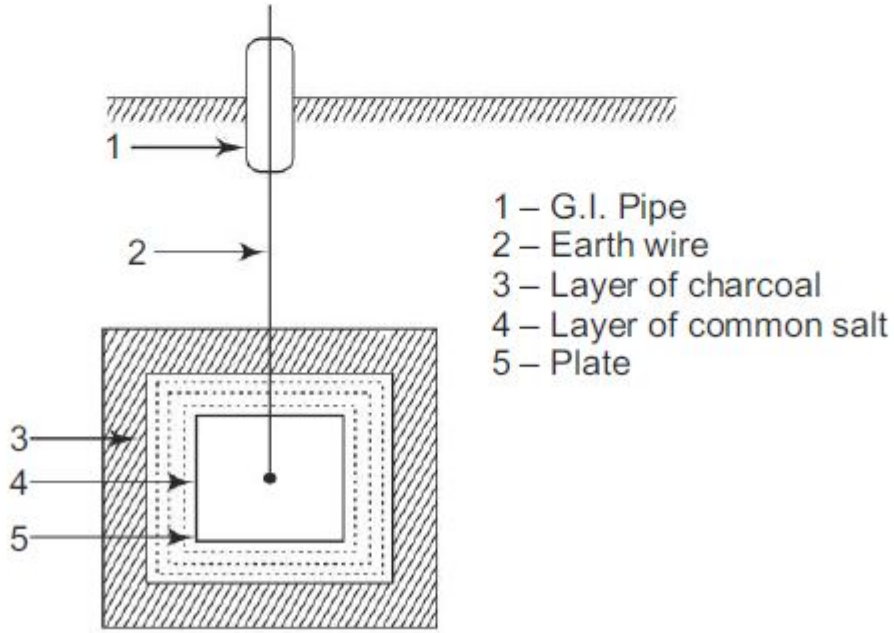


Fig. 8.3

rocky soils the length may be increased to about 2.75 metres and 1.85 metres respectively. The pipe is placed vertically, burying to a depth not less than 2 metres in as moist a place as possible, preferably in close proximity of water tap, water pipe or water drain and at least 0.6 metre away from all building foundations, etc as shown in Fig. 8.3. The pipe shall be completely covered by 80 mm of Charcoal with the layer of common salt 30 mm all around it. The charcoal and salt decreases the earth resistance.

.2 Earthing through a Plate

A G.I. or copper plate is used as an earth electrode. If a G.I. plate is used it shall be of dimensions 0.3 m × 0.3 m and 6.35 mm thick and if a copper plate is used it shall be of dimensions 0.3 m × 0.3 m and 3.2 mm thick. The plate is buried to a depth of not less than 2 m in as moist a place as possible preferably in close proximity of water tap, water pipe or water drain and at least 0.6 m away from all building foundations, etc. The plate shall be completely covered by 80 mm of charcoal with a layer of common salt of 30 mm all around it, keeping the faces of the vertical as shown in Fig. 8.4.



Renewable Energy

- Renewable energy is a term used to refer to forms of energy that are naturally obtained from the environment and from sources that can be replenished naturally.
- These include **solar energy, wind energy, geothermal energy, hydropower, and biomass**.

Advantages of Renewable Energy

- Less maintenance cost as most sources entail few or no moving parts, hence, less mechanical damages.
- Economical and can cut costs spent on fossil fuel.
- They emit little or no waste in the environment.
- Renewable energy sources do not deplete.

The Disadvantages of Non-Conventional Sources of Energy

- Inconsistent, Unreliable Supply.
- Pollution.
- Harmful to Wildlife and Surrounding Environment. ...
- High Cost.
- Not Every Non-Conventional Energy Source Is Commercially Viable.
- Location Specificity Means Lower Chances of Universality.
- Low Efficiency Levels.

	Renewable	***Non-renewable***
(i)	These resources are renewed or replenished by nature in a short span of time.	These resources may not be replenished by nature or take very long geological time to be formed again.
(ii)	Often these are available continuously like, solar energy, water etc.	These resources are exhausted after use, Ex-fossils etc.
(iii)	Renewable resources can be divided into continuous or flow.	Non-renewable resources can be recyclable or non-recyclable.

Biomass energy

Hydro energy

Wind energy

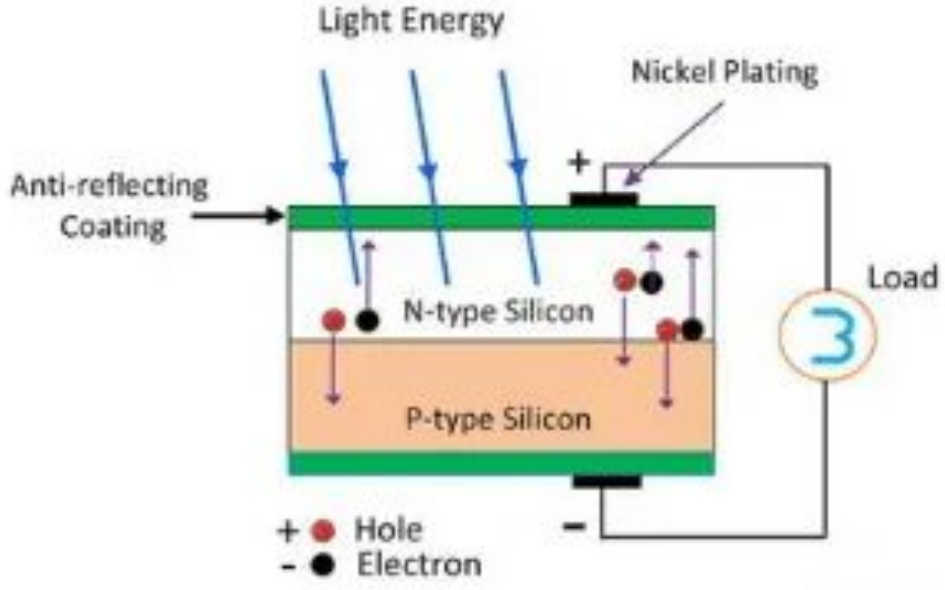
Geothermal energy

Solar energy

Tidal energy

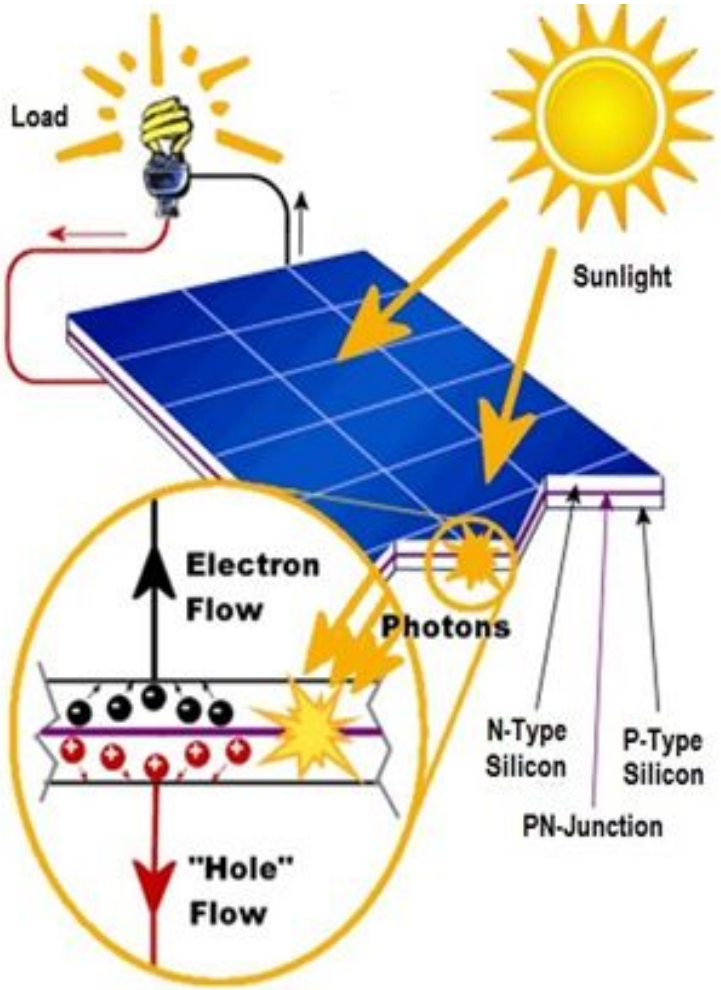
Solar Photovoltaic system

A **solar cell** (also known as a photovoltaic cell or PV cell) is defined as an electrical device that converts light energy into electrical energy through the photovoltaic effect. A solar cell is basically a p-n junction diode. Solar cells are a form of photoelectric cell, defined as a device whose electrical characteristics – such as current, voltage, or resistance – vary when exposed to light.

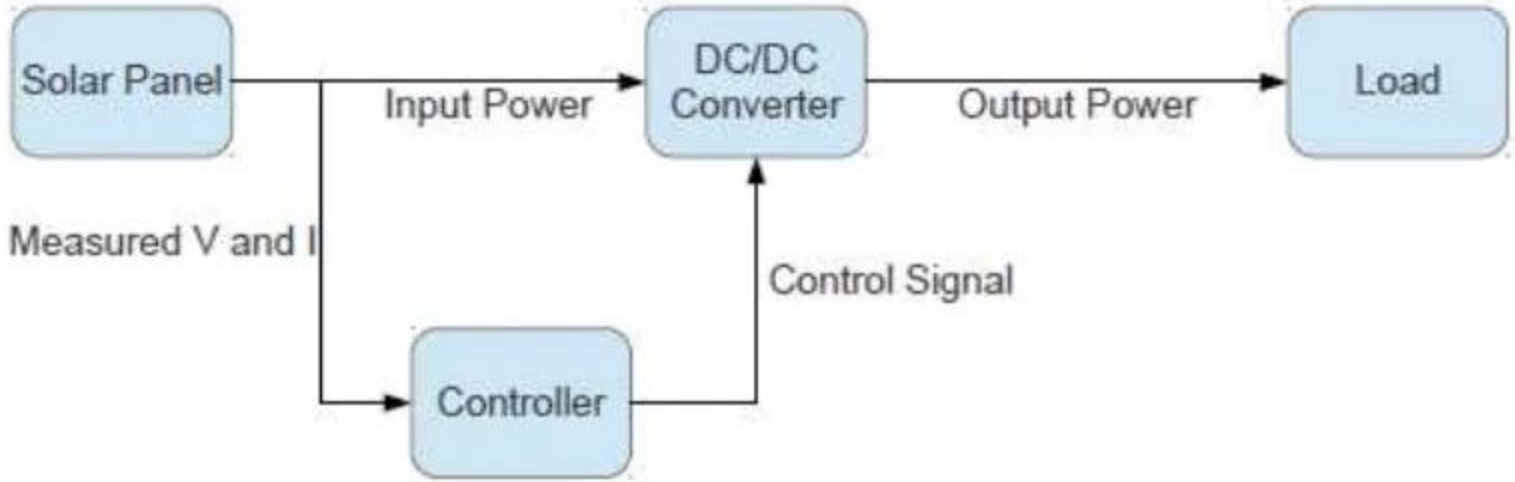


- Solar cells, a type of semiconductor device that efficiently absorbs solar radiation and converts it into electrical energy, are also known as photovoltaic cells because of their **photo-voltaic effect** using various potential barriers.

- A photovoltaic cell is also called a solar cell. It is a semiconductor device which converts sunlight into DC power using the photoelectric effect. Practically, all solar cells are photodiodes made of semiconductor material like silicon.

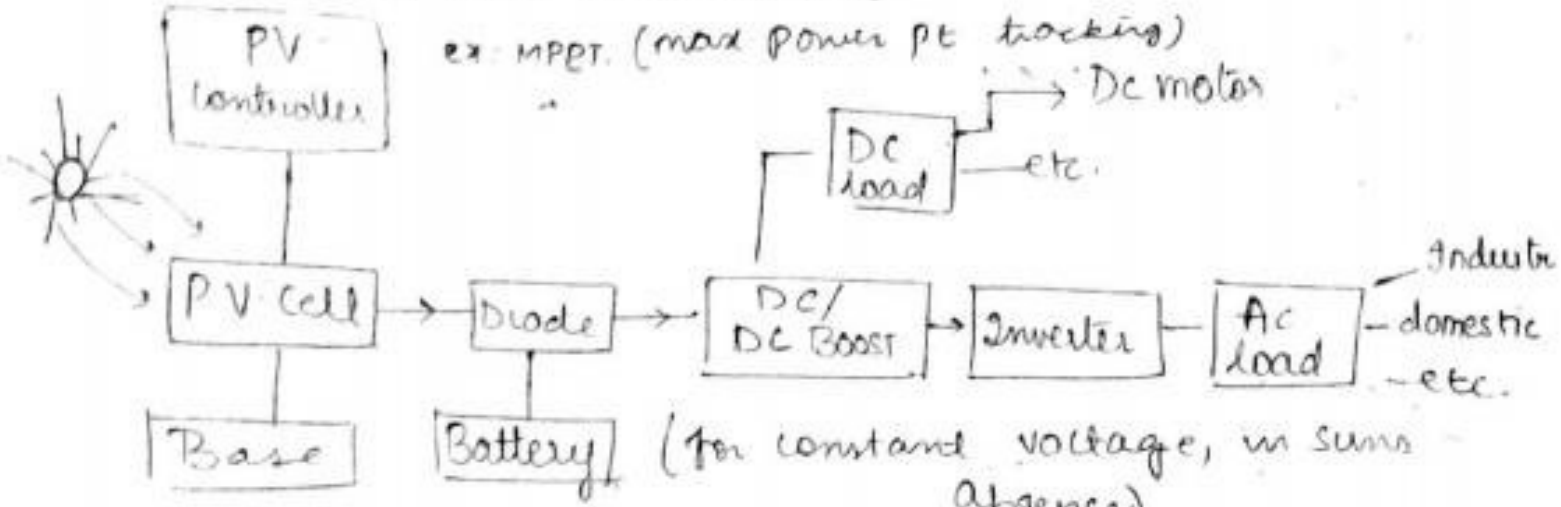


System Modeling

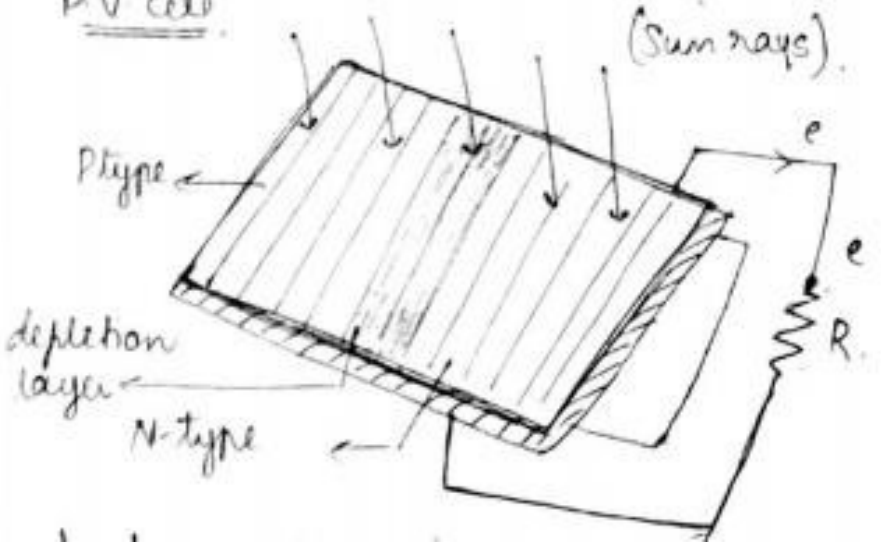


PV → P Si N type semiconductor combination.

PV converts heat to electricity



PV cell



→ to block unwanted discharge → diode.

→ avalanche of e^- occurs.

heat → radiation → movement of e^- from breaking layer

controller - allows PV to change its alignment for high intensity

diode: allow supply to flow via panel to battery.

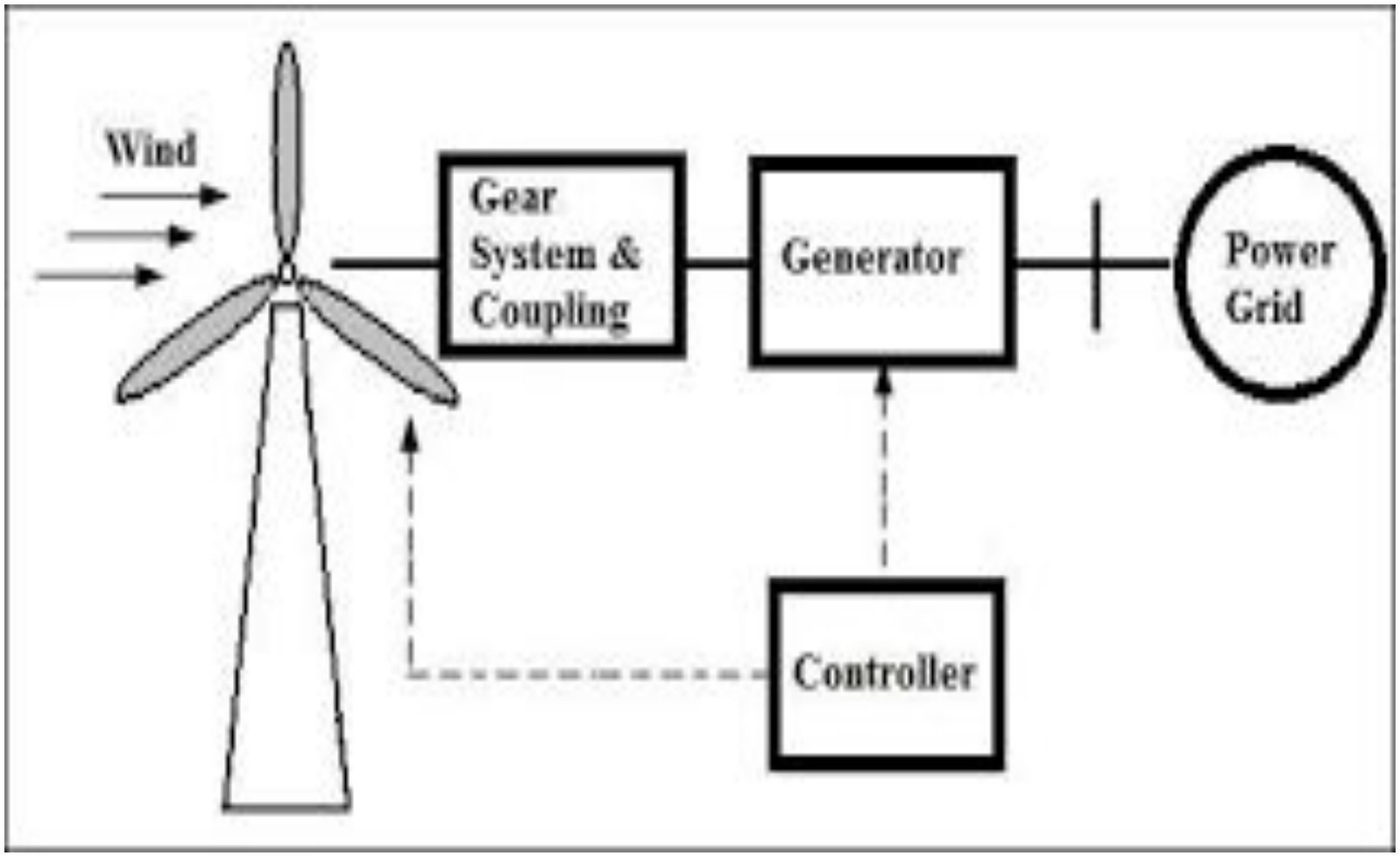
battery: storage & supply

boost: converts DC to strong DC supply

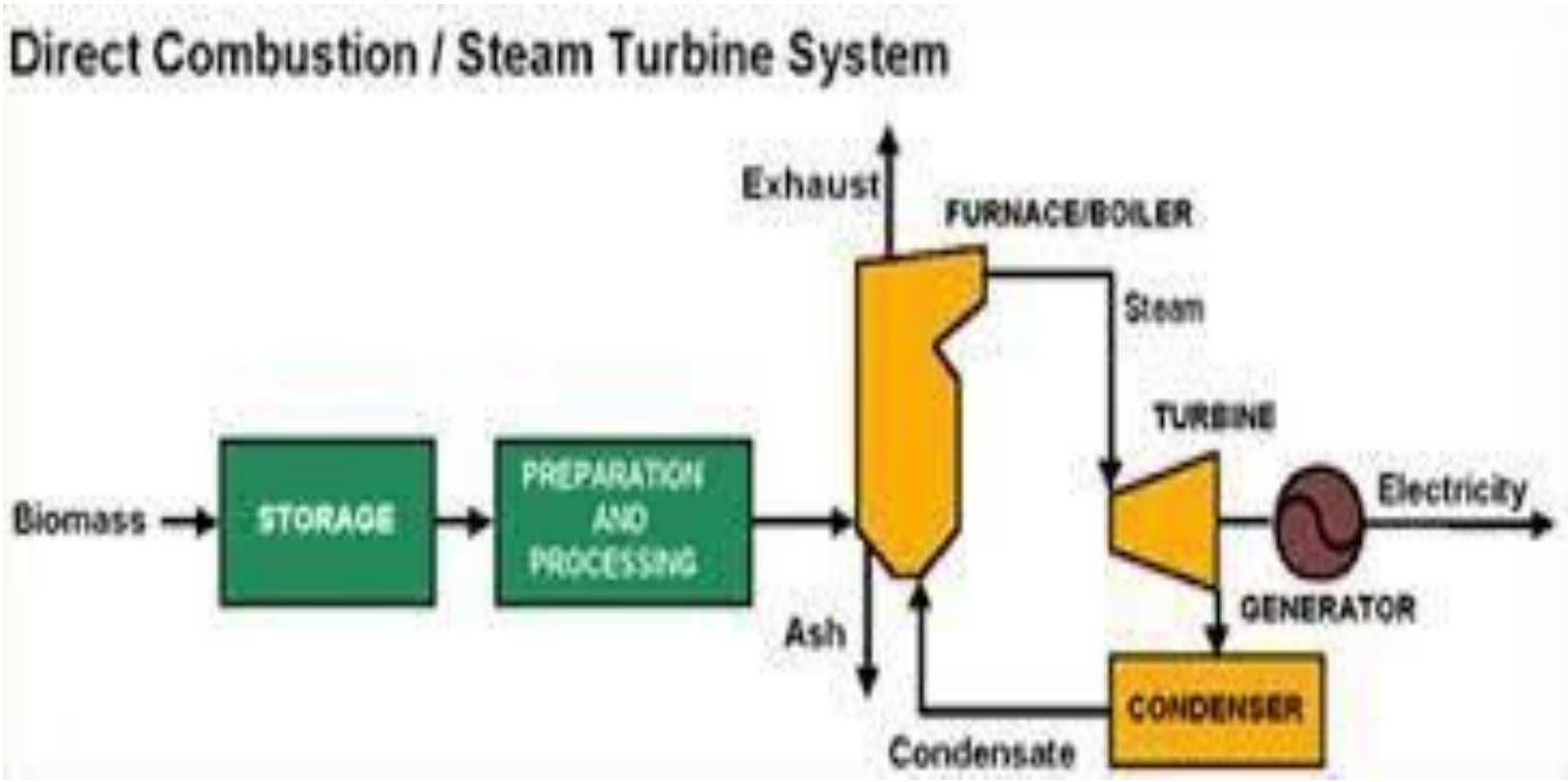
Inverter: DC to AC.

→ radiation → PV → DC → boost → DC load
↓ battery
↳ inverter → AC load:

Solar Photovoltaic system


Wind
Gear
System &
Coupling
Generator
Power
Grid
Controller

Biogas is a gaseous mixture generated during anearobic digestion processes using waste water, solid waste (e.g. at landfills), organic waste, and other sources of biomass



Tidal wave energy:

- Tidal energy technologies harvest energy from the seas.The potential of tidal wave energy becomes higher in certain regions by local effects such as shelving, funnelling, reflection and resonance.
- India is surrounded by sea on three sides, its potential to harness tidal energy is significant.

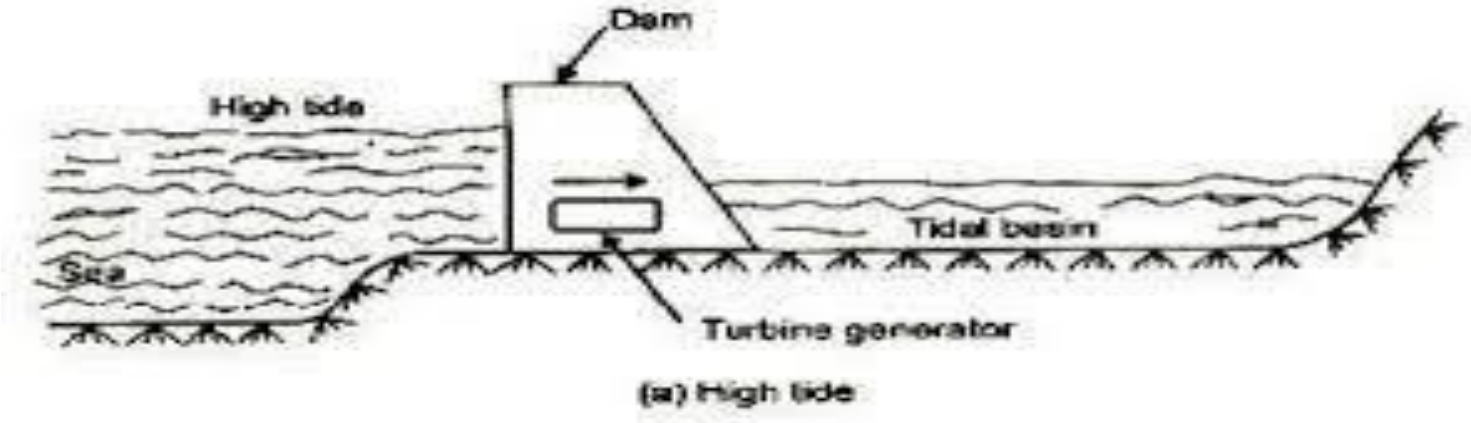


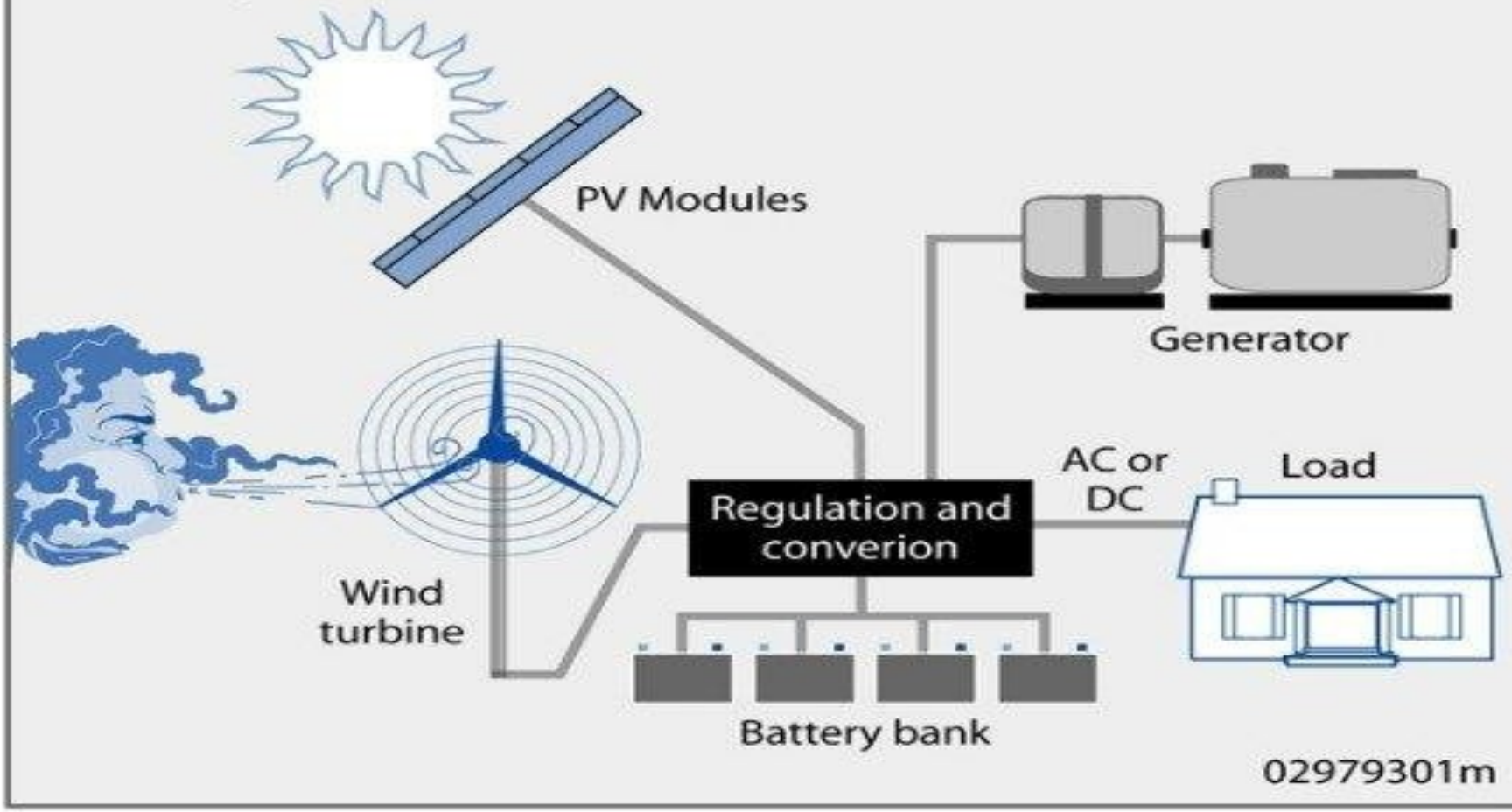
Figure: High tide

Geothermal energy

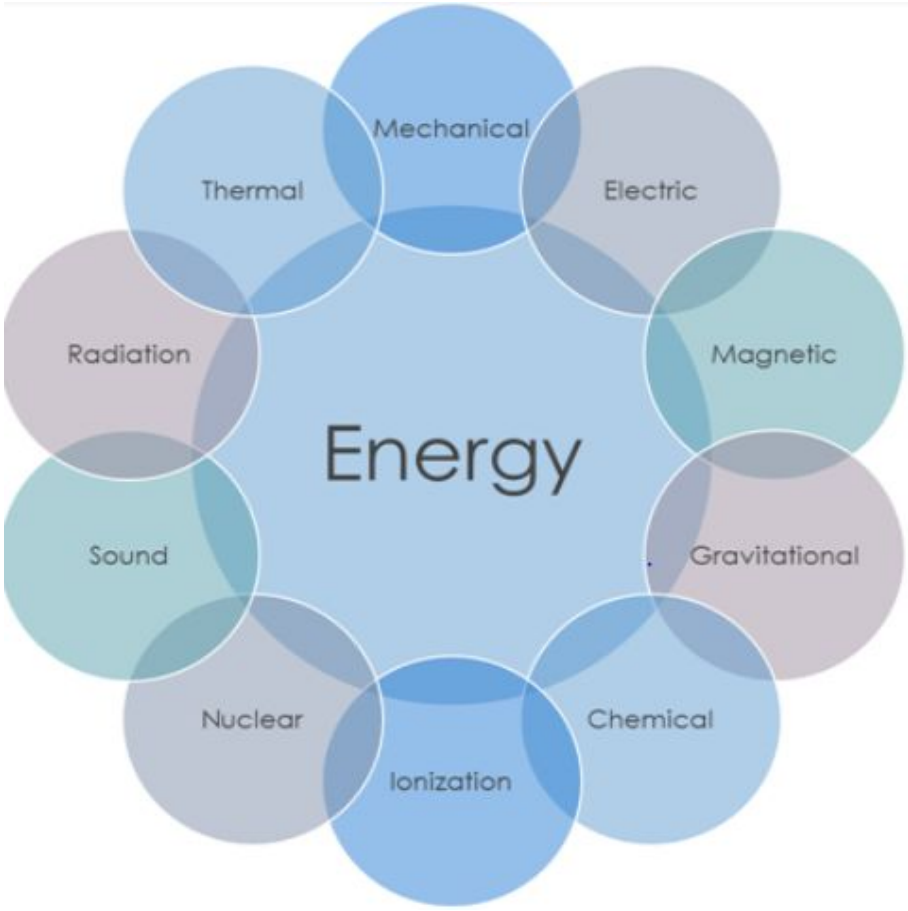
- *Geothermal energy is thermal energy generated and stored in the Earth*.

Hybrid Power Systems

Combine multiple sources to deliver non-intermittent electric power



Introduction to Energy Storage



✔ Energy storage systems have been in use for a very long time, for diverse applications.

✔Quantitative property held by an object or a system that can be consumed to perform work or convert the form of energy.

✔retention of anything, whether physical or virtual, for (possible) usage in the future.

(i) Portable electronics **(ii) Uninterruptible Power Supplies (UPS)**

(iii) Energy offset for renewable energy

Overview of Battery

- Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components: an anode (the ‘+' side), a cathode (the ‘-' side), and some kind of electrolyte (a substance that chemically reacts with the anode and cathode).

Types:

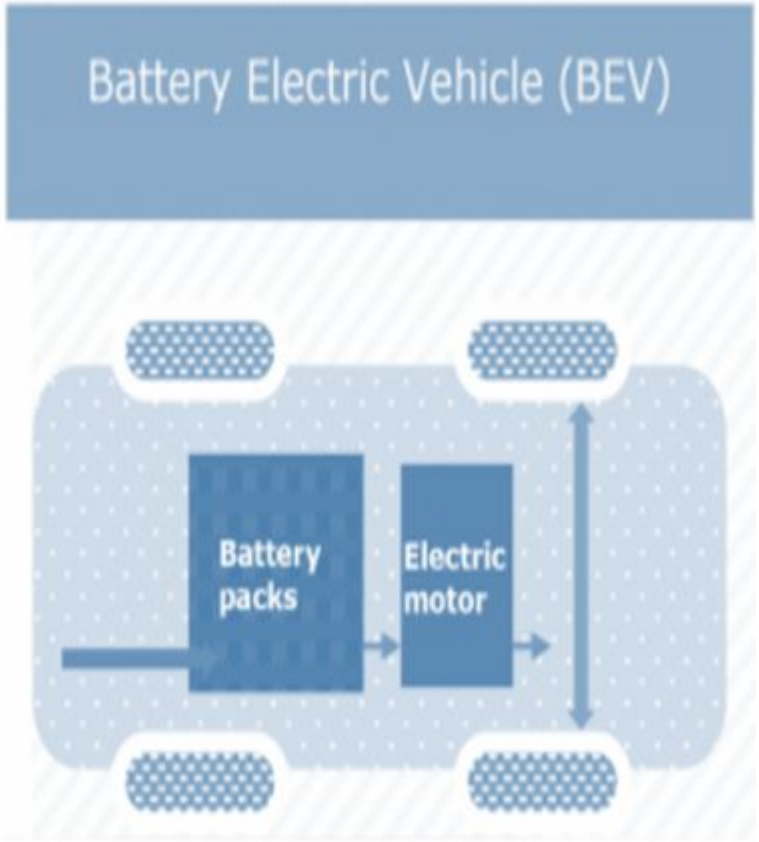
1. **Lead acid**
2. **Nickel cadmium**
3. **Nickel metal hydride**
4. **Lithium ion**
5. **Sodium sulfur**
6. **Redox flow**

Fuel cell technologies

The fuel cell technology is a clean technology with low chemical pollution and is a chemical engineering way of producing energy based on electrochemical energy conversion of chemical energy of hydrogen and oxygen into electricity and heat which produces only water as the by product.

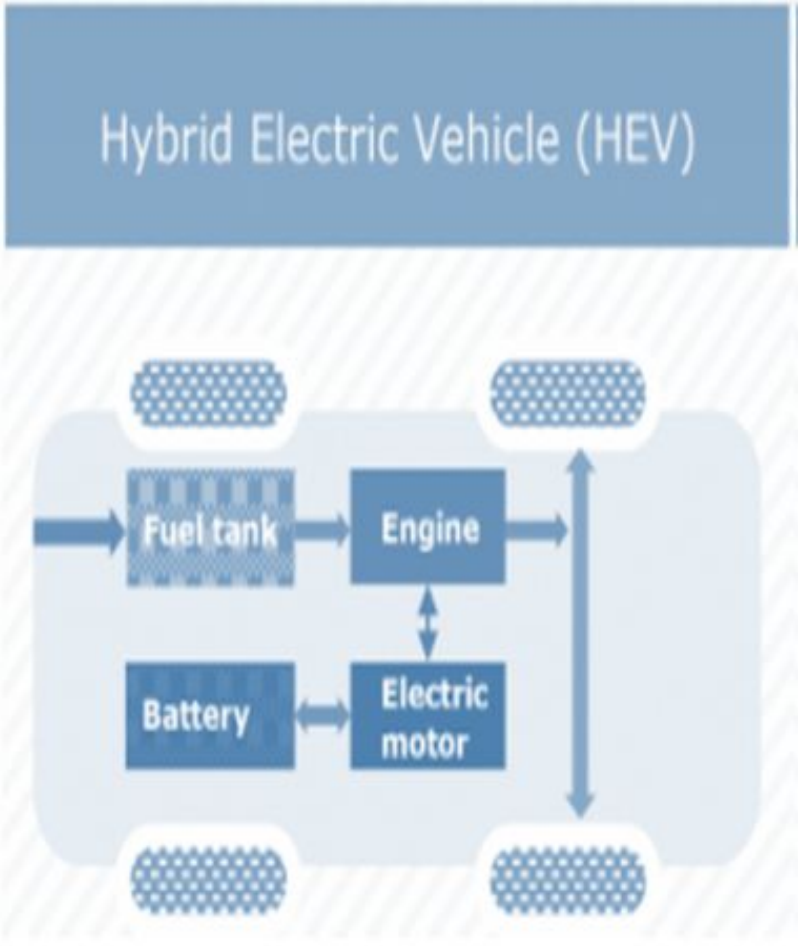
Types of EVS

(i) BEV (Battery Electric Vehicle)



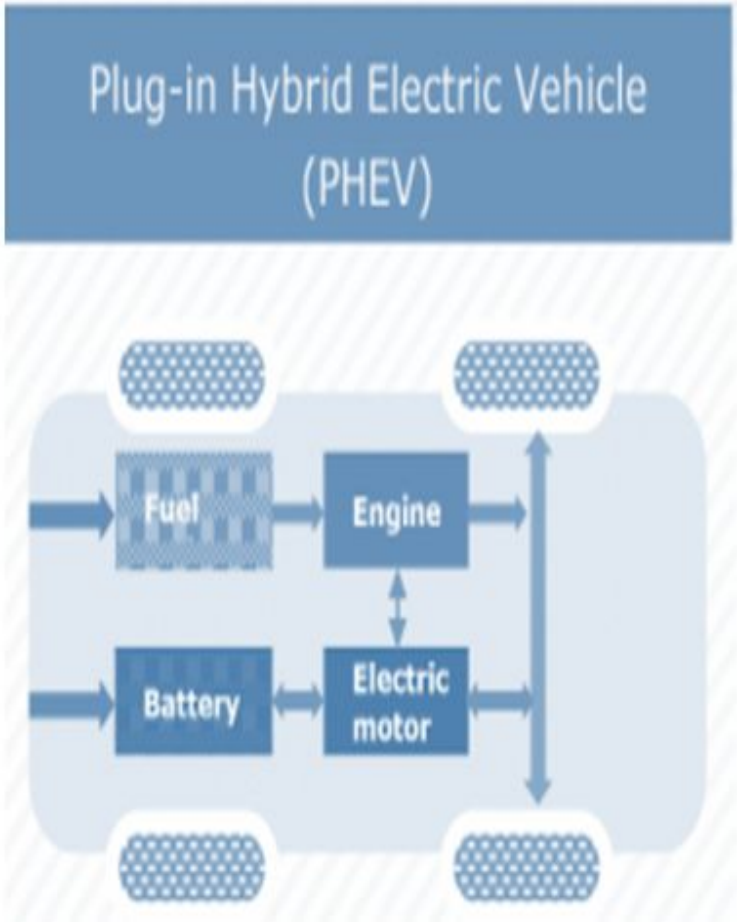
- EVs run on battery power without an internal combustion engine's assistance, they can run much faster on a single charge than hybrid vehicles.
- They're also known as battery electric vehicles, or BEVs. That's what distinguishes them from hybrids that run on battery power with assistance from internal combustion engines

(ii) HEV (Hybrid Electric Vehicle)



- HEVs run on both an internal combustion engine and an electric motor that uses energy stored in a battery. Unlike most electric vehicles, however, HEV drivers charge their batteries via regenerative braking.
- Regenerative braking stores the kinetic energy used to stop the car to charge its battery and help the internal combustion engine accelerate the vehicle.

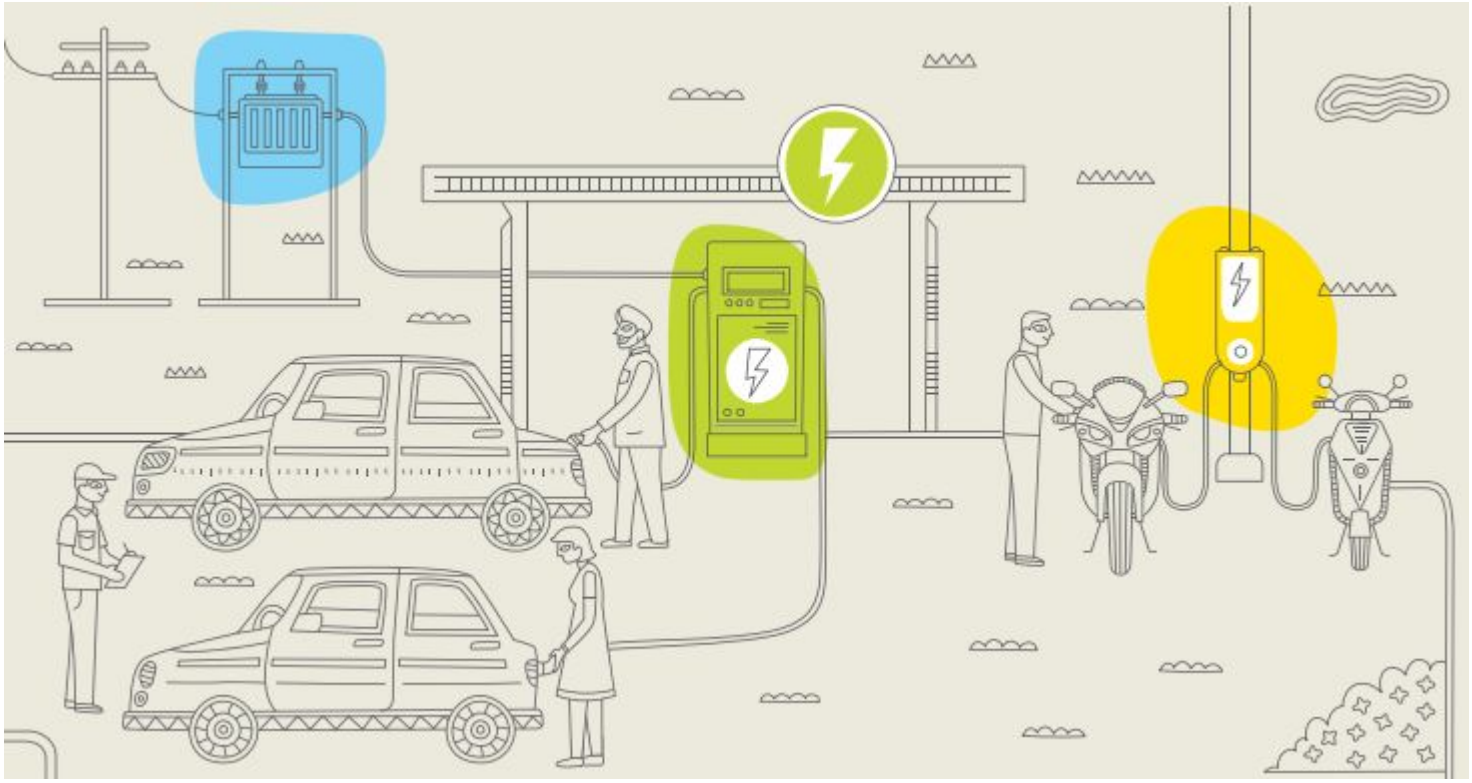
(iii) PHEV (Plug in Hybrid Electric Vehicle)



- PHEVs expand on the concept of the standard hybrid vehicle. They have both an internal combustion engine and a battery-powered electric motor. This allows the battery to store enough power to feed the electric motor and in turn decrease your gas usage by as much as 60 percent.
- This can save you time and money at the gas pump. PHEVs can travel up to 40 miles on electric power alone, rather than a couple of miles with a standard hybrid vehicle.

EV Charging station

- EV charging points are primarily defined by the power (in kW) they can produce and therefore what speed they are capable of charging an EV. While connector types are also a key issue, most EVs are equipped with two or more cables to allow the use of chargers with different connector outlets.



CHARGE POINT TYPES

(i) Slow charging (up to 3kW)

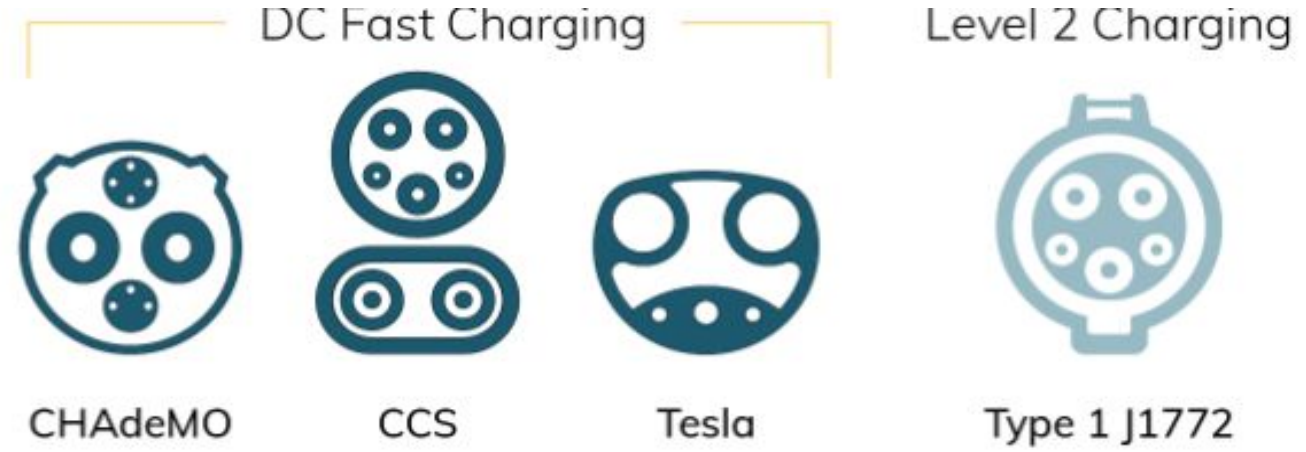
(ii) Fast charging (7-22kW)

(iii) Rapid chargers (43-50kW)

4 categories:

- ❑ **The Process**
- ❑ **Time**
- ❑ **Price**
- ❑ **EVs are better for the environment**

4 Types of Connectors



CHAdeMO	CCS	Tesla	Type 1 J1772
'Charge de Move' Nissan, Toyota, and Mitsubishi	Combined Charging System (all EVs except Tesla)	Only Tesla	DC Fast Charging all EVs except Tesla