BUILDING SERVICES - II

CONCEPTUAL UNDERSTANDING &EXPLANATORY NOTES

UNIT – 1

FUNDAMENTAL PRINCIPLES OF ELECTRICITY

Since the end of the nineteenth century virtually all buildings are provided with electric lightings installation for use at night. With the advent of fluorescent lamp that is compatible with daylight, cheap to run and not emitting heat gain in buildings, it made possible to install electric lighting supplementing day light and in extreme cases provide the only source of light in a windowless environment.

SYLLABUS : Fundamentals principles of Electricity: Voltage, Amperage, Wattage, generation, and transmission of power, distribution in cities, HT and LT consumers, Transformers and load calculations, Single and three phase Connections , Indian Electricity rules, Types of Generators, UPS.

In this unit we are going learn many basic things, Fundamentals , rules etc.

FUNDAMENTAL PRINCIPLES OF ELECTRICITY: Basically there are 3 main fundamentals electrical energy, they are Electric Current, voltage, and resistance.

Current : is the directed flow of charge through a conductor.

Voltage : is the force that generates the current.

Resistance: is an opposition to current that is provided by the material, component, or circuit.

We are going to learn about the more principles of electricity in this unit, in deep and clearly. Before that , let's know some basics :

As we know Electric Current is represented in formulas by the letter **I** (For intensity). The intensity of current is determined by the amount of charge flowing per second. The greater the flow of charge per second, the more intense the current.

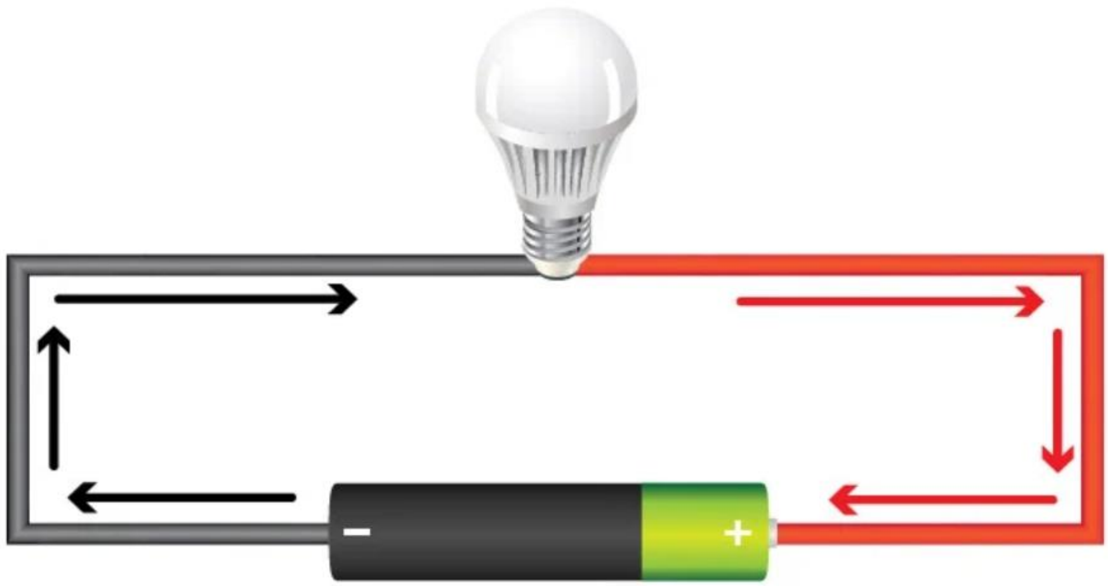
Coulomb © is used as the basic unit of charge One coulomb equals the total charge on 6.25×10^{18} electrons.

These are used in calculations.

VOLTAGE : Voltage is the pressure from an electrical circuit's power source that pushes charged electrons (current) through a conducting loop, enabling them to do work such as illuminating a light.

- In brief, **voltage = pressure**, and it is measured in **volts (V).**
- In electricity's early days, voltage was known as electromotive force (emf). This is why in equations such as **Ohm's Law**, voltage is represented by the symbol E.

Example of voltage in a simple direct current (dc) circuit:



- In this dc circuit, the switch is closed (turned ON).
- Voltage in the power source—the "potential difference" between the battery's two poles—is activated, creating pressure that forces electrons to flow as current out the battery's negative terminal.
- Current reaches the light, causing it to glow.
- Current returns to the power source.

Why measuring Voltage is useful ?

Voltage is a very important concept in operating a power system, and in talking about how the power system works. To understand how voltage influences power system operation, here are some of the key concepts:

- Electrical energy is carried through conducting material (such as power lines) by electrons. The transmission line's voltage measures how much potential energy each electron is carrying as it moves along the power line. In other words, voltage is the pressure that pushes current through the electrical supply chain.

- Electrical current measures how many electrons flow through a particular part of the supply chain in a given amount of time.
- Voltage combines with current to define how much power flows through the network.

Voltage is measured in volts (V) – from the 1.5 V battery in the TV remote, to the 230 V wires running from street poles to our houses. At the power system level, where much larger pressure keeps electricity flowing, voltage is measured in thousands of volts, or kilovolts (kV).

We use different voltage levels for different purposes. Generally, it is very high on the biggest power lines coming from large-scale generators or carrying electricity between states, and lower on the lines closer to our homes and businesses.

AMPERAGE : the strength of an electric current in amperes

The ampere or amp (Symbol: A) is the standard unit of electric current. An electric current of one amp is one coulomb per second.

👉Now, doubt raises, how **amperage** is different from **voltage** ?

Voltage and amperage are two measures of electrical current or flow of electrons. Voltage is a measure of the pressure that allows electrons to flow, while amperage is a measure of the volume of electrons.

Amps = watts/volts : Since power is defined as the product of current and voltage, the ampere can alternatively be expressed in terms of the other units using the relationship I = P/V, and thus 1 A = 1 W/V.

WATTAGE : an amount of electrical power expressed in watts.

A watt (W) is a unit of measurement of power. Watts therefore refer to the power of your device. Examples: an incandescent lamp has a power of 60 W. your microwave oven has a maximum power of 900 W.

- 1 kilowatt (kW) = 1,000 watts (W)

- 1 megawatt (MW) = 1,000 kilowatts (kW)
- 1 gigawatt (GW) = 1,000 megawatts (MW)

The formula for calculating wattage is: W (joules per second) = V (joules per coulomb) x A (coulombs per second) where W is watts, V is volts, and A is amperes of current. Simply **W= V x A** (since A = W/V)

In practical terms, wattage is the power produced or used per second(time).

So here, we got to know about voltage, Wattage, Amperage and how they are related with a formula. Now we are going to learn about Generation, and power supply in to the cities and further details.

GENERATION , TRANSMISSION AND DISTRIBUTION IN CITIES:

Generation of Electricity: Electricity generation is the process of generating electric power from sources of primary energy.

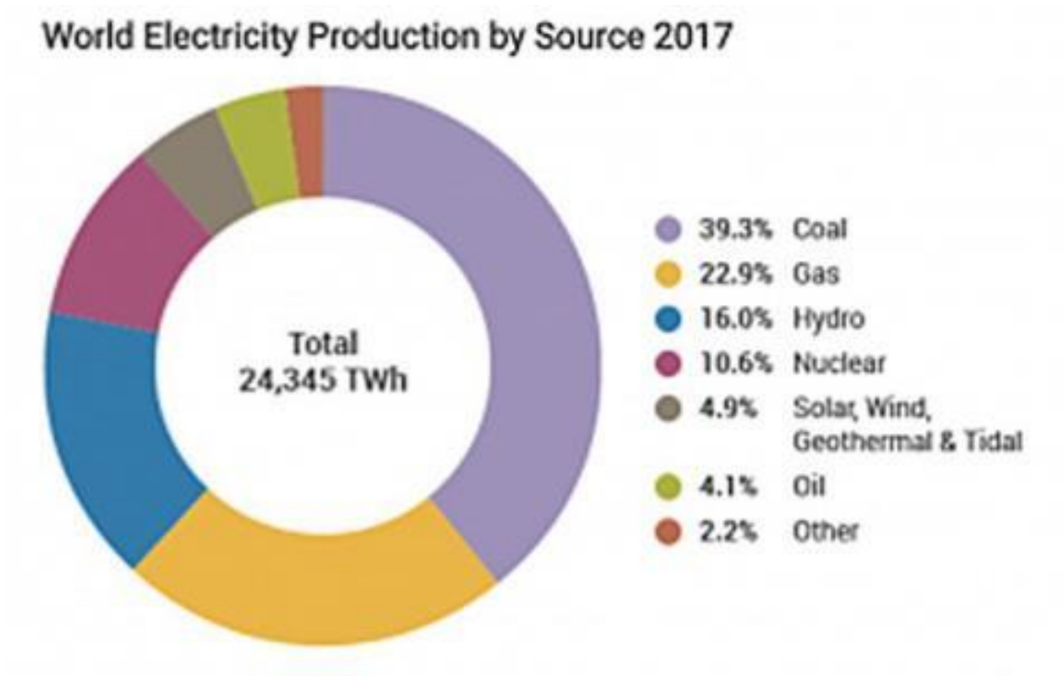
- For utilities in the electric power industry, it is the stage prior to its delivery to end users (transmission, distribution, etc.) or its storage.
- A characteristic of electricity is that it is not freely available in nature in large amounts, so it must be "produced" (that is, transforming other forms of energy to electricity).
- Production is carried out in power stations (also called "power plants").

How the electricity is generated?

- Electricity is most often generated at a power plant by electromechanical generators, primarily driven by heat engines fueled by combustion or nuclear fission but also by other means such as the kinetic energy of flowing water and wind.
- Other energy sources include solar photovoltaics and geothermal power.

Sources of electricity : Solar Energy, Wind energy, Geothermal Energy, Hydrogen Energy, Coal , natural gas , petroleum etc.

Hydroelectric power is the best source of electricity, using the potential energy of rivers, is by far the best-established means of electricity generation from renewable sources.



Methods of Generation :

Several fundamental methods exist to convert other forms of energy into electrical energy.

Generators: Electric generators transform kinetic energy into electricity. This is the most used form for generating electricity and is based on Faraday's law. It can be seen experimentally by rotating a magnet within closed loops of conducting material (e.g. copper wire).

Electrochemistry: Electrochemistry is the direct transformation of chemical energy into electricity, as in a battery. Electrochemical electricity generation is important in portable and mobile applications. Currently, most electrochemical power comes from batteries.

Photovoltaic effect : The photovoltaic effect is the transformation of light into electrical energy, as in solar cells. Photovoltaic panels convert sunlight directly to DC electricity. Power inverters can then convert that to AC electricity if needed.

Now the electricity is transmitted to transformers and consumers, Electricity is delivered to consumers through a complex network. Electricity is generated at power plants and moves through a complex system, sometimes called the grid, of electricity substations, transformers, and power lines that connect electricity producers and consumers.

Transmission of electricity : Electrical transmission is the process of delivering generated electricity - usually over long distances - to the distribution grid located in populated areas.

- An important part of this process includes transformers which are used to increase voltage levels to make long distance transmission feasible.
- The electrical transmission system combined with power plants, distribution systems, and sub-stations to form what is known as the electrical grid.
- The grid meets society's electricity needs, and is what gets the electrical power from its generation to its end use.
- Since power plants are most often located outside of densely populated areas, the transmission system must be fairly large.

How Electricity is transmitted : Electricity is transmitted through **Power lines or transmitted lines** , Usually, this electricity is alternating current so step-up transformers can increase the voltage. This increased voltage allows efficient transmission for 500 kilometers or less. There are 3 types of lines:

👈 High voltage power lines are used for the transmission of electricity over long distances.

- **Overhead lines** are very high voltage, between 100 kV and 800 kV, and do the majority of long distance transmission. They must be high voltage in order to minimize power losses to resistance.
- **Underground lines** are used to transport power through populated areas, underwater, or pretty much anywhere that overhead lines can't be used. They are less common than overhead lines due to heat-related losses and higher cost.
- **Sub transmission lines** carry lower voltages (26 kV – 69 kV) to distribution stations, and can be overhead or underground.

Distribution in Cities: Electric power distribution is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2 kV and 35 kV with the use of transformers.

Primary distribution lines carry this medium voltage power to distribution transformers located near the customer's premises. Distribution transformers again lower the voltage to the utilization voltage used by lighting, industrial equipment and household appliances. Often several customers are supplied from one transformer through secondary distribution lines.

Commercial and residential customers are connected to the secondary distribution lines through service drops. Customers demanding a much larger amount of power may be connected directly to the primary distribution level or the sub transmission level.

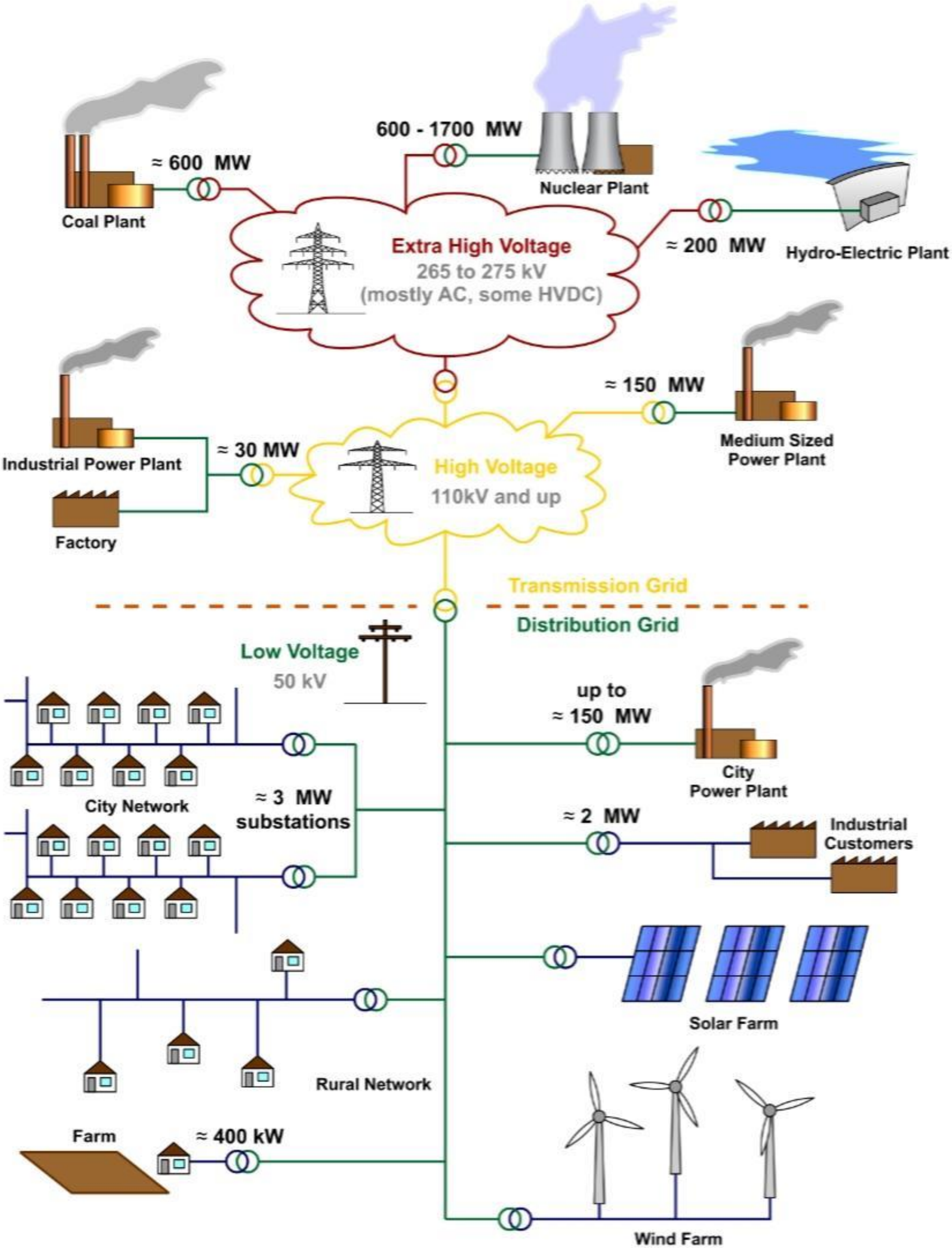
The transition from transmission to distribution happens in a power substation, which has the following functions:

- Circuit breakers and switches enable the substation to be disconnected from the transmission grid or for distribution lines to be disconnected.
- Transformers step down transmission voltages, 35 kV or more, down to primary distribution voltages. These are medium voltage circuits, usually 600–35000 V.
- From the transformer, power goes to the busbar that can split the distribution power off in multiple directions. The bus distributes power to distribution lines, which fan out to customers.

Urban distribution is mainly underground, sometimes in common utility ducts. Rural distribution is mostly above ground with utility poles, and suburban distribution is a mix.

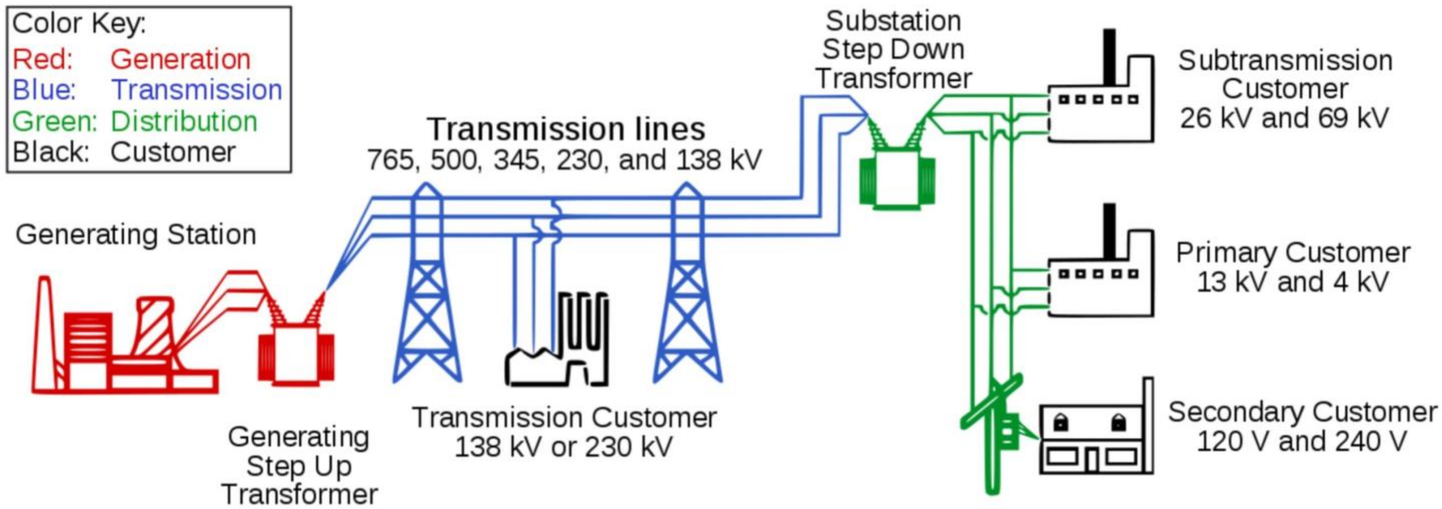
Closer to the customer, a distribution transformer steps the primary distribution power down to a low-voltage secondary circuit, usually 120/240 V in the US for residential customers.

The power comes to the customer via a service drop and an electricity meter. The final circuit in an urban system may be less than 15 meters (50 ft.), but may be over 91 meters (300 ft.) for a rural customer.



Coal Plant
≈ 600 MW
600 - 1700 MW
Nuclear Plant
≈ 200 MW
Hydro-Electric Plant
Extra High Voltage
265 to 275 kV
(mostly AC, some HVDC)
Industrial Power Plant
Factory
≈ 30 MW
High Voltage
110kV and up
≈ 150 MW
Medium Sized
Power Plant
Transmission Grid
Distribution Grid
Low Voltage
50 kV
up to
≈ 150 MW
City
Power Plant
City Network
≈ 3 MW
substations
≈ 2 MW
Industrial
Customers
Solar Farm
Rural Network
Farm
≈ 400 kW
Wind Farm

The process of Generation and transmission in one diagram :



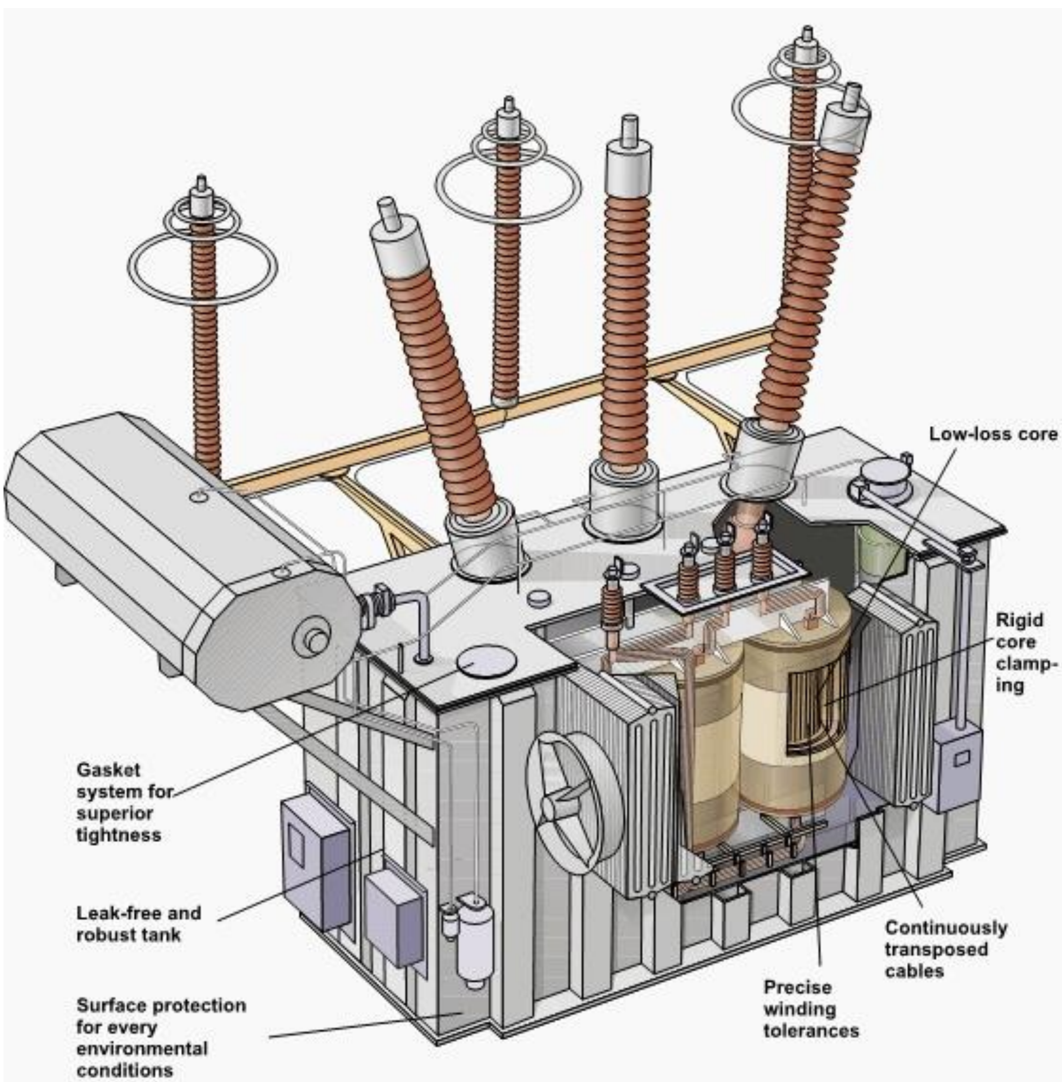
In simple words , this can be explained the power/Electricity is generated at Generator or Generating step up Transformers (Red) and transmitted through the huge power lines (Blue) to Transformer , where the current is converted from one voltage to other (Green) and through the transformers it will be supplied to consumers (Black) as per the demand.

<u>HT and LT Consumers</u> : HT(High tension) supply is applicable for bulk power purchasers who need 11 kilo-Volts or above. Most small consumers of electricity like individual houses, shops, small offices and smaller manufacturing units get their electricity on LT(Low Tension) connection.

- In some states, a residential complex can benefit from lower rates if electricity is taken at bulk HT tariff. Internally the complex can provide electricity to its residents through the common supply.
- Aluminum and copper are the most used conductors for LT and HT cables. Both LT and HT cables have insulation layers to protect the cables from external elements. LT cables use materials like PVC while HT cables normally use cross-linked polyethylene (XLPE).
- LT cables are mostly used in industries like power stations, power distribution, and railways that require a maximum of 1100V. On the other hand, HT cables are normally used in power distribution or transmission with a range above 1100V.

<u>TRANSFORMER</u> : A transformer is a passive component that transfers electrical energy from one electrical circuit to another circuit, or multiple circuits.

- Today, they are designed to use AC supply, which means that fluctuation in supply voltage is impacted by the fluctuation in the current.
- So, an increase in current will bring about an increase in the voltage and vice versa.
- Transformers help improve safety and efficiency of power systems by raising and lowering voltage levels as and when needed.
- They are used in a wide range of residential and industrial applications, primarily and perhaps most importantly in the distribution and regulation of power across long distances.



How does a transformer work – Working principle : click on the given link ☞ YouTube/Redirect-Transformer ☜ To watch the video.

Types of Transformers :

On basis of Design:

- CORE TYPE TRANSFORMER: This transformer features two horizontal sections with two vertical limbs and a rectangular core with a magnetic circuit. Cylindrical coils (HV and LV) are placed on the central limb of the core type transformer.
- SHELL TYPE TRANSFORMER : shell type transformer has a double magnetic circuit and a central limb with two outer limbs.

On basis of supply :

- SET UP TRANSFORMER: This type is determined by the number of turns of wire. So, if the secondary set has a greater number of turns than the primary side, it means that the voltage will correspond to that, which forms the base of a step up transformer.
- STEP DOWN TRANSFORMER: This type is typically used for stepping down the level of voltage in the power transmission and distribution network and so its mechanism is the exact opposite of a step up transformer.

On basis of use :

- POWER TRANSFORMER: Typically used to transmit electricity and has a high rating.
- DISTRIBUTION TRANSFORMER: This electrical transformer has a comparatively lower rating and is used to distribute electricity.
- INSTRUMENTAL TRANSFORMER : This electrical transformer is further sub-categorized into current and potential transformers.

On basis of cooling :

- SELF COOLED OIL FILLED : This type is generally employed in small transformers of up to 3 MVA and is it designed to cool itself by the surrounding air flow.

- WATER COOLED OIL FILLED : This type of electrical transformer employs a heat exchanger to facilitate the transfer of the heat from the oil to the cooling water.
- AIR COOLED (AIR BLAST) TRANSFORMER : In this type of transformer, the heat that is generated is cooled with the help of blowers and fans that force the circulation of air on the windings and the core.

Main characteristics of transformers :

All transformers share some common features regardless of their type:

- The frequency of input and output power is the same
- All transformers make use of electromagnetic induction laws
- The primary and secondary coils are devoid of electrical connection (except for auto transformers). The transfer of power is through magnetic flux.
- The losses that do occur in transformers are smaller than those in other electrical devices, and include:

  ☞Copper loss (electrical power lost in the heat created by circulation of currents around the copper windings, considered the heaviest loss in transformers)

  ☞ Core loss (eddy current and hysteresis losses, caused by lagging of magnetic molecules in response to the alternating magnetic flux within the core)

Uses of Electrical transformer:

The major uses of an electrical transformer include:

- Raising or lowering the voltage level in the circuit of an AC.
- Increasing or decreasing the value of an inductor or capacitor in an AC circuit.
- Preventing the passage of DC from one circuit to another.
- Stepping up the voltage level at the site of power generation before the transmission and distribution can take place.

Common applications of an electrical transformer include pumping stations, railways, industries, commercial establishments, windmills and power generation units.

Load calculations: The electrical load is the calculation of how much power is required to run everything that consumes electricity in your home. When making significant electrical additions to a home, everything that will use electricity to run is calculated to find the electrical load.

- The electrical load of a house determines many things, including the amperage of your electrical panel.
- Finding the electrical load is an important part of determining whether you need to change your electrical service, as it will tell you if the power supplied to your home (amps) isn't enough for your electricity use.
- Changing the electrical load of your house also indicates a change in your energy bill.
- For example, if you get a new HVAC system that doesn't use as much electricity, your electrical load and your energy bill will be lower.

Calculation : You can calculate how many amps your home needs using the following steps:

- Add the wattage capacity of all general lighting circuits and the wattage rating of all of your plug-in outlet circuits.
- Add together the wattage rating of all of your permanent appliances (washer/dryer, dishwasher, water heater, etc.).
- Subtract 10,000 watts from the sum of all these, and multiply the result by 0.4 (40%). Then add 10,000 watts back in.
- Compare the wattage of your air conditioner and furnace. Since you only use one at a time, add only the larger wattage rating to your equation.
- Divide the resulting number of watts by volts (most homes use 220 volts) to get the number of amps, or the electrical load.

☞Calculating an Electrical Load in a Simple Circuit:

Let Power = Voltage x Current (P=VI).

Let Current = Voltage/Resistance (I=V/R).

Apply Kirchhoff's Second Law, that the sum of the voltages around a circuit is zero. Conclude that the load voltage around the simple circuit must be 9 volts. Calculate that the load voltage is evenly distributed across each of the resistors, since they have equal resistance, and that the voltage over each must be 4.5 volts (or -4.5 for purposes of Kirchhoff's Law).

Calculate I=V/R (current calculation), so that I=4.5/330=13.6mA (milliamps). Calculate P=VI=9*.0136=.1224 Watts. Note that all the load characteristics (Voltage, Resistance, Current, and Power) are now known. Be safe and choose resistors rated at .5 Watts.

SINGLE AND THREE PHASE CONNECTIONS :

What is single phase power ?

Single-phase power simultaneously changes the supply voltage of an AC power by a system. More often, single-phase power is known as "residential voltage," since it is that most homes use.

☞In the distribution of power, a single-phase uses the phase and neutral wires. Phase wire carries the current load, while the neutral wire provides a path where the current returns.

☞It creates a single sine wave (low voltage). The common voltage for a single-phase power starts at 230V. Also, its frequency approximates to 50Hz.

Advantages of single phase power:

- Single-Phase Power generates electricity to residential homes and domestic supplies, since most appliances require only a small amount of power to function, including fans, heaters, television, refrigerator, and lights.
- The design and operation are plain and ordinary. It has a lightweight and compact unit, which the current through the line will be less when the transmission of voltage is high.
- Due to the reduction of I2R, the current is low. Meaning, single-phase power ensures the unit to operate at optimum with an increased efficiency of its transmission.
- Single-phase power is best to use with fractional, or lower horsepower units up to 5 HP.

Disadvantages of using Single-Phase Power:

- Small single-phase motors need an additional circuitry such as Motor Starters (similar to starter capacitors in fans and pumps), since its single-phase supply is insufficient for an initial start-up.
- Industrial motors require heavy electronic loads. Ergo, it cannot run on a single-phase supply.

What is three phase Power ?

Three-phase power provides three alternating currents, with three separate electric services. Each leg of alternating current reaches a maximum voltage, only separated by 1/3 of the time in a full cycle.

- In other words, the power output of a three-phase power remains to be constant, and it never drops into zero.
- In a three-phase power supply, it requires four wires, namely one neutral wire and three-conductor wires. These three conductor wires are 120-degree distant from each other. Also, each AC Power Signal is 1200 out of phase with each other.
- Moreover, there are two types of circuit configurations in a three-phase power supply, such as the Delta and the Star. The Delta Configuration requires no neutral wire and only all high voltage systems use it; while, Star Configuration requires a neutral wire and a ground wire.

Advantages of using three phase power:

- Run larger loads easily. Commercial and Industrial loads prefer a three-phase power supply since it requires more heavy electronic loads.
- Do not require any starters to three-phase motors used in big industries, since it has sufficient phase difference to supply initial torque for the motor to start.
- Three-phase power supply requires less conducting materials to transmit and distribute electrical power. Hence, it becomes more economical when it speaks about costs.
- As the number of phases increases in the system, the DC voltage of a three-phased power becomes smoother and more advantageous.

Disadvantages of using three phase Power:

- Since the system voltage is quite high, the three-phase power supplies and motors maintain a high cost of insulation. Insulation depends on the voltage of the unit, while its size of the wire depends on the current.
- Three-phase power units cannot handle overload. Meaning, when it results in damage, the cost of repair is higher since changing individual components is expensive.

What are the differences between Single-Phase Power and Three-Phase Power?

Required Wirings on Power Supply

- In a single-phase power supply, it only requires two wires, namely Phase and Neutral. On the other hand, a three-phase power supply only works through three wires, including three-conductor wires and a neutral wire.
- Thus, the costs of cabling and total installation are both reduced when you deliver three-phase power directly to your server cabinets.

Voltages : In a single-phase power supply, it only suffices to 230V, whereas a three-phase power supply maximizes up to 415V.

Its place of utility : Residential homes usually utilize lower power supply, requiring less quantity of power to function your mobile devices and home appliances. In contrast, commercial and industrial companies require heavier electronic load. Hence, it utilizes a three-phase power supply to function.

Efficiency : A single-phase power cannot start by themselves, requiring external devices such as Motor Startups. As its opposite, a three-phase power can start by itself without requiring any external devices. Also, it can even reverse the directions of two conductors.

Applications:

A single-phase power supply generates a lower amount of electricity to support homes and non-industrial businesses, whereas a three-phase power supplies power grids, data centers, aircraft, shipboard, and other electronic loads larger than 1,000 watts.

INDIAN ELECTRICITY RULES :

It is very essential to follow the safety precaution while carry out the electrical installations and commissioning work so some of the Important Indian Electricity Rules are given below.

Indian Electricity Rule no. 54: A supplier shall not permit the voltage at the point of commencement of supply to vary from the declared voltage.

- In case of low & medium voltage, the variation not more than by 6%.
- In case of High voltage by 6% in the higher side and 9% in lower side.
- In case of Extra high voltage by 10% in the higher side and 12.5% in lower side.

Indian Electricity Rule no. 55: Declared frequency of A.C supply to consumer to vary from the declared frequency by more than 3%.

Indian Electricity Rule no. 56: Stipulates that the supplier may affix one or more seals to meters and cutouts and no person other than the supplier shall break any such seal.

Indian Electricity Rule no. 57: Stipulates the provision to ensure correctness of meters, maximum demand indicators and other apparatus on consumers premises.

Indian Electricity Rule no. 58: It states the point of commencement of supply" The point of commencement of supply of an energy to a consumer shall be deemed to be the point at the incoming terminal of cutouts installed by the consumer under rule no.50.

Indian Electricity Rule no. 59: Provides precautions to be taken against failure of supply and notice of failures to be given.

Indian Electricity Rule no. 76: Stipulates maximum stresses "factor of safety"

- For metal supports= 1.5
- For mechanically processed concrete support= 2.0
- For hand moulded concrete support= 2.5
- For wood support= 3.0
- Minimum factor of safety for stay wires, ground wires or bearer wires shall be= 2.5
- Minimum factor of safety for conductor= 2.0

Safety Factor = (Ultimate Stress/ Actual Stress)

Indian Electricity Rule no. 77: Minimum ground clearances as per IE- 1956

Voltage in kV To ground in Metre

- 132 6.10
- 220 7.0
- 400 8.84
- 800 12.40

Overhead lines along the street (parallel to the street) & across the street/ road 

Voltage Level	**Ground clearances in meter**(along the street)	**Ground clearances in meter(across the street)**
Low and Medium Voltage	5.5	5.8
High Voltage	5.8	6.1
Extra High Voltage	5.8 + add 0.3 meter for every additional 33 kV	6.1 + add 0.3 meter for every additional 33 kV

Overhead lines without across or along the street/ road

Voltage Level in kV	**Ground clearances in meter**
Low/medium/HT Line up to 11 kV, if bare conductor	4.6
Low/medium/HT Line up to 11 kV, if insulated conductor	4.0
Above 11 kV Line	5.2
Above 33 kV Line	5.8 + add 0.3 meter for every additional 33 kV

Voltage level in kV	**Clearances in meter**
Low and Medium voltage	1.2
High Voltage up to 11 kV	1.8
High Voltage above 11 kV	2.5
Extra High Voltage line	3.0

Indian Electricity Rule no. 78:

Clearances between Trolley/Tram and Conductors

Indian Electricity Rule no. 79: Clearances for roof, open balcony, Verandah roof and lean to roof.

Line passes through	**Clearances in meters.**
Line passes over building vertical clearances	2.5
Line passes adjustments of buildings horizontal clearances	1.2
For pitched roof	
Line passes over building vertical clearances	2.5
Line passes adjustments of buildings horizontal clearances	1.25

Indian Electricity Rule no. 85: Stipulates maximum interval between supports, all conductor shall be attached to supports at intervals not exceeding the safe limit based on ultimate tensile strength of the conductor and the factor of safety prescribed in Rule No.-76.

TYPES OF GENERATORS : There is a variety of generators available for commercial purchase, some of which are specially designed for households while others are meant for industrial purposes.

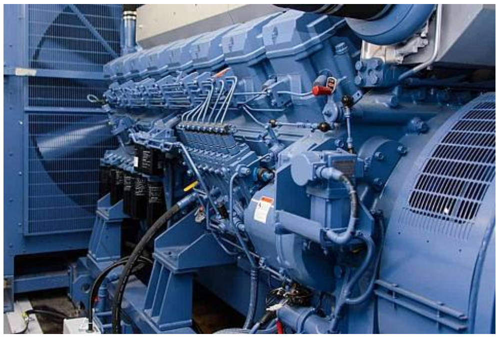
These are some of the most common and popular types of generators, and each of them has their own unique and specific features, qualities, uses, advantage, and disadvantages.

1. **Diesel Generators :** Also known as diesel genset, diesel generators run through diesel fuel which is one of the least flammable of all the fuel sources.
    - This generator uses a combination of a diesel engine with an electric generator in order to produce electrical energy.
    - They are highly durable and have a long life.
    - They are really easy to start, even in cold environments.

2. **Natural Gas Generators :** This is one of the most efficient and widely used means of generating power and electricity.
    - Natural gas generators work in a very similar fashion to other types of generators.
    - The best thing about natural gas is that it can be stored very easily in above or below ground tanks, which makes these generators highly durable.
    - They run very quietly and cause very little disturbance.
    - They burn cleanly without producing a lot of waste.
3. **Gasoline Generators :** Also called 'gas generators,' these are probably the most common among all types of generators.
    - The main reason behind their commonness and popularity is that they are powered with the help of gas, and gasoline is always readily available.
    - These generators are also towards the more reasonable end of the price spectrum, which places them at the low-end of the cost scale.
    - These generators are usually available in small sizes, which make them highly portable.
    - They are very easy on the pocket.
    - They are extremely portable, which means you can easily move them around as per your needs.
    - They produce relatively high emissions.
4. **Standby Generators :** Also known as "backup generators" or "emergency power systems," standby generators are an electrical system that operates automatically.
    - These generators may run on diesel or gas, and they have a large external tank that lasts them for at least 48 hours before the need arises to refuel them.
    - Some common uses of standby generators include safety systems in elevators, fire protection systems, standby lighting, and life and medical support equipment.
    - They ensure seamless switching between systems, which means that you don't have anything to worry about when the power goes out.

- They guarantee a continuous flow of power, which is very useful when you need a permanent fix for power shortage.
- They can be really costly, especially when you need one to run your entire

5. **Portable Generators** : These are mainly powered by gas or diesel and are an excellent option for producing temporary electrical power.
    - Some of their key characteristics include the use of a combustion engine that helps produce and conduct electricity.
    - They can also be used in remote sites and have enough power to run televisions, freezers, and refrigerators.
    - They are the cheapest option available and are easy on the pocket.
    - They cannot be operated inside a home or a garage.
6. **Solar Generators:** These generators are extremely interesting, considering how they use the radiating energy of the sun for power.
    - Solar power is undeniably one of the simplest forms of energy that can be found around us.
    - Solar generators primarily work by using solar panels to help capture the energy from the sun.
    - This energy is then used to charge a battery in the generator.
    - The charge stored in this battery is then used to produce electricity.
    - Since most appliances in today's time use alternating current, the inverter in the solar generator first changes the power into this type of current before its full extraction.
    - The one important thing to know about solar generators is the amount of time they require to fully charge. A full recharge for these generators is almost eight hours of direct sunlight.
7. **Inverter Generators:** Generators have always been referred to as loud and bulky electrical tools; however, with the invention of inverter generators, that perception has greatly changed.
    - These generators use an engine that is connected to an alternator, as a result of which, it produces AC (alternating current) power.
    - This AC power is then converted into DC (direct current) power by these generators with the help of a rectifier.



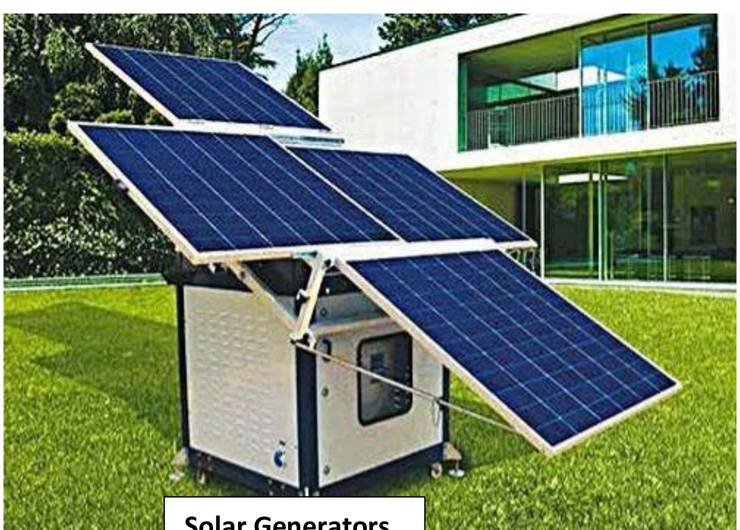
Diesel Generator

Natural gas generators

Gasoline Generators

Standby Generators.

Portable generators



Solar Generators

Inverter Generators

UPS (Uninterrupted Power Supply) : A device that provides battery backup when the electrical power fails or drops to an unacceptable voltage level.

- Small UPS systems provide power for a few minutes; enough to power down the computer in an orderly manner, while larger systems have enough battery for several hours.
- UPS systems can be set up to alert file servers to shut down in an orderly manner when an outage has occurred, and the batteries are running out.

END OF UNIT 1
