EE-101

Çankaya University

Engineering Faculty

Electrical Electronics Engineering Department

week 10

Topic Outline :
Fundamentals of Distribution Systems

1. Fundamentals of Distribution Systems

we introduce the basic configurations and characteristics of distribution including primary and secondary distribution

Ancient Discoveries and Early Theories

1. Ancient Times: The earliest understanding of electricity dates back to ancient civilizations. The Greeks discovered that rubbing amber with fur produced static electricity.

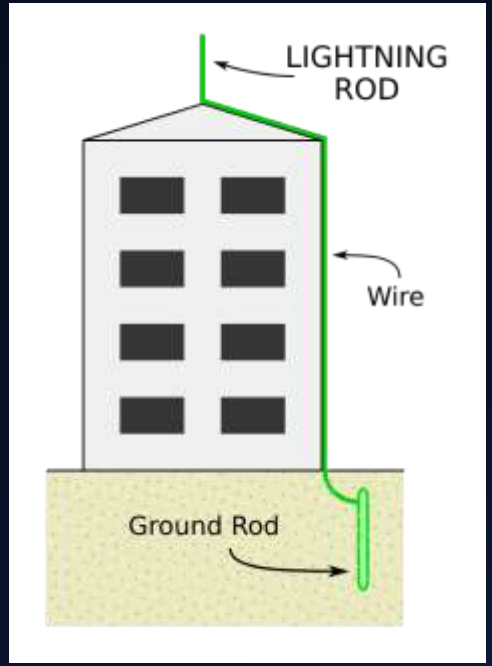
The word Electricity comes from the Greek and Latin words for "amber [kehribar]".

2. 1600s: In the early modern era, William Gilbert, an English scientist, coined the term "electricity" and distinguished between magnetism and static electricity.

The Age of Enlightenment and Early Experimentation

3. 1700s: The 18th century , scientists Benjamin Franklin discovered that lightning and thunder are the results of charges, invented the lightning rod.

- His desire to protect buildings from lightning strikes, cause fires and damage.
- a method to safely direct the electrical energy of a lightning strike away from structures.
- **Concept and Design**
- **Principle of Operation**: Franklin proposed that lightning was essentially a large-scale electrical discharge and could be attracted to a conductive rod placed on top of a building. The rod would conduct the electrical charge safely into the ground, thereby preventing damage to the structure.
- **Structure**: The lightning rod is a metal rod (typically made of copper or iron) that is mounted on the highest point of a building or structure. It is connected to the ground via a wire, which allows the electrical charge from a lightning strike to be safely dissipated into the earth.



2 Kinds of Electric Charge

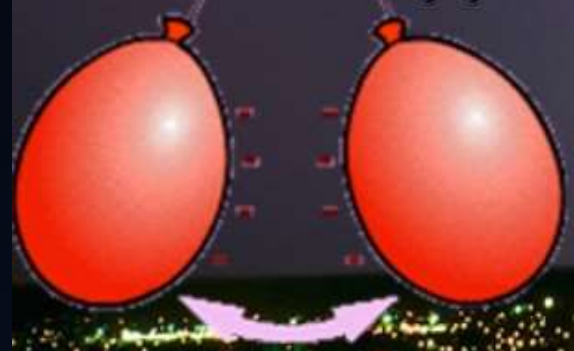
- Both were named by Ben Franklin

1. Positive charge (+)

2. Negative Charge (-)

→ Like charges **repel**

→ Opposite charges **attract**



2 like charges repel

4. 1800s: The **19th century** was a period of **rapid advancement** in electrical science and technology:

- **Alessandro Volta (1800)**: Invented the voltaic pile, the first chemical battery, which provided a steady current of electricity. This was the first practical source of electric power
- alternating disks of zinc and copper sandwiching a pasteboard or leather moistened with brine or vinegar.
- The disks were placed on a wooden base and supported by three glass rods.
- Each three-disk unit functioned as a single electric cell that produced a current due to an **electrochemical reaction in which zinc loses electrons and copper gains them.**

- **Changing Magnetic Field**: Faraday discovered that a constant magnetic field did not induce a current; only a changing magnetic field did.
- **Induced Voltage**: He also found that the magnitude of the induced current depended on how quickly the magnetic field changed, not just on the strength of the field.
- **Faraday's Law of Induction**: Faraday's work led to the formulation of Faraday's Law of Electromagnetic Induction, which states that the electromotive force (EMF) induced in a circuit is proportional to the rate of change of the magnetic flux through the circuit

$$\varepsilon = -N \frac{\Delta \phi_M}{\Delta t}$$

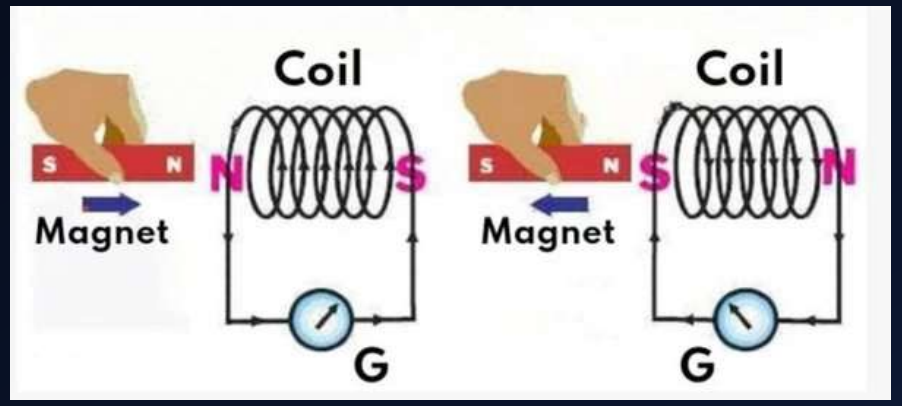
Faraday's Law

N = number of loops

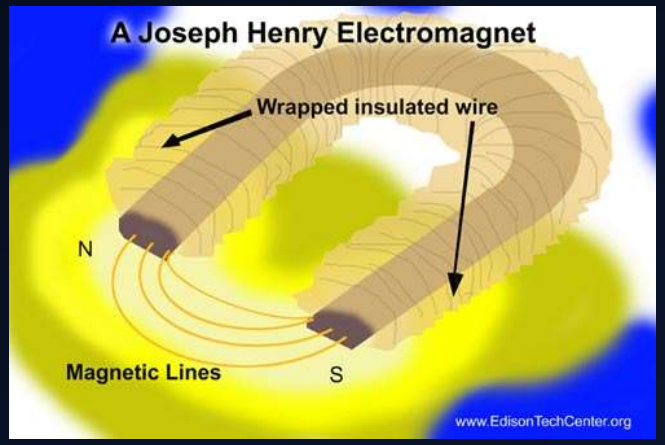
$\Delta \phi_M$ = change in magnetic flux

Δt = change in time

ε = induced voltage (also known as emf)



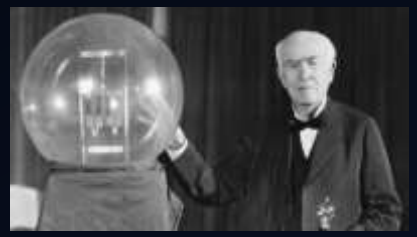
- **Joseph Henry (1830s-1840s):** His work on electromagnetism and self-induction contributed to the development of the electric transformer and other technologies.



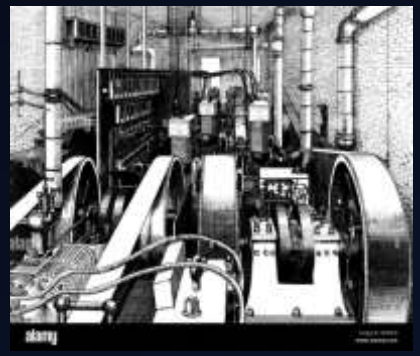
The Birth of the Electric Power Industry

5. 1870s-1880s: The practical application of electric power began to take shape.

<u>Edison’s direct current (DC) system was an early method of electricity distribution.</u>



6. 1890s: The "War of Currents" between Edison’s DC system and Nikola Tesla and George Westinghouse’s alternating current (AC) system was a pivotal moment.



AC power, being more efficient for long-distance transmission, eventually won out.

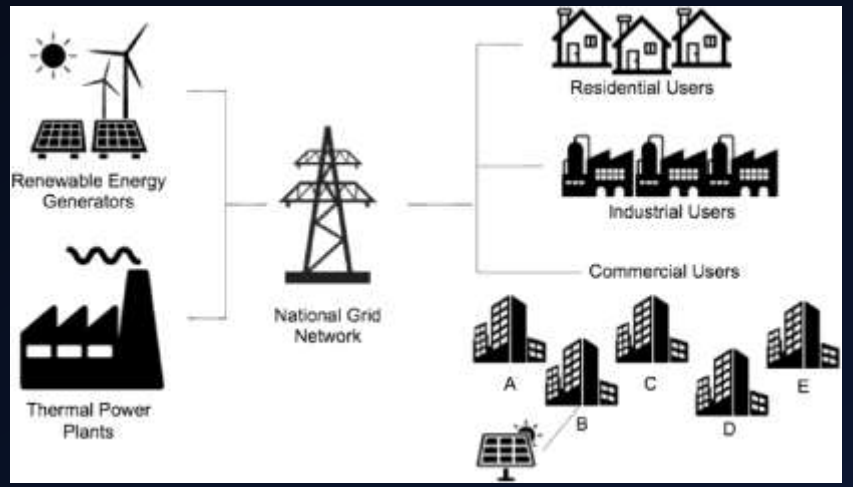
Tesla’s AC system allowed for the development of a nationwide power grid.

Expansion and Technological Advancements

7. Early 20th Century: The electric power industry expanded rapidly with the development of large-scale power plants and the establishment of **a national electrical grid**. Hydroelectric power became a significant source of electricity, with large projects like the Hoover Dam harnessing the power of water for energy.

Hoover Dam

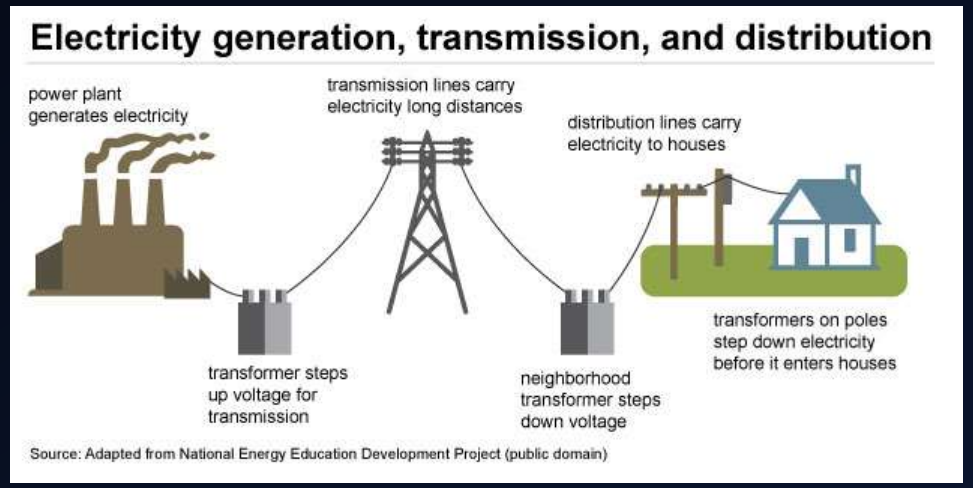
The first commercial nuclear power plant

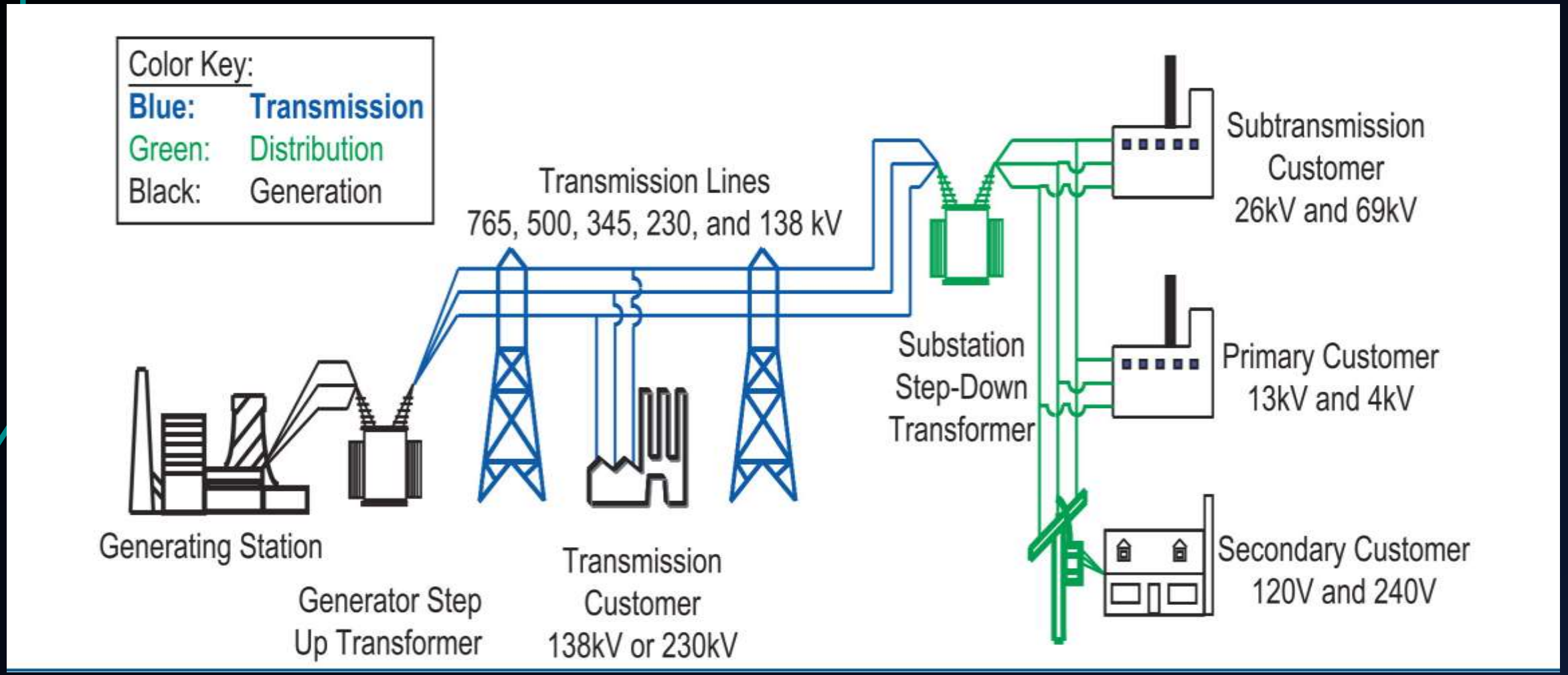


The History of Electric Power Transmission

Transmission vs. Distribution

- **Transmission**: High-voltage lines transport electricity over long distances from power plants to substations. The high voltage reduces energy loss during transit.
- **Distribution**: After electricity reaches substations, it is stepped down to lower voltages suitable for end users through distribution networks.




Color Key:
Blue: Transmission
Green: Distribution
Black: Generation
Transmission Lines
765, 500, 345, 230, and 138 kV
Subtransmission
Customer
26kV and 69kV
Substation
Step-Down
Transformer
Primary Customer
13kV and 4kV
Secondary Customer
120V and 240V
Generating Station
Generator Step
Up Transformer
Transmission
Customer
138kV or 230kV

a. Substations

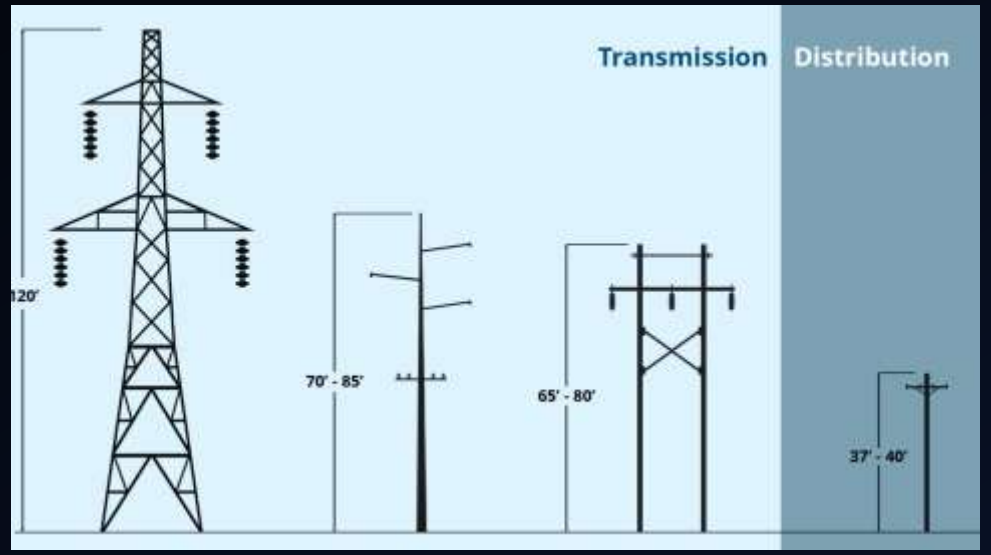
- Substations are critical facilities where high-voltage electricity is converted to lower voltages suitable for distribution.
- They house transformers, circuit breakers, and other equipment to manage the flow of electricity.

b. Transformers

- Transformers are devices used to change the voltage level of electricity. They step down high voltages from transmission lines to lower voltages used in distribution networks.

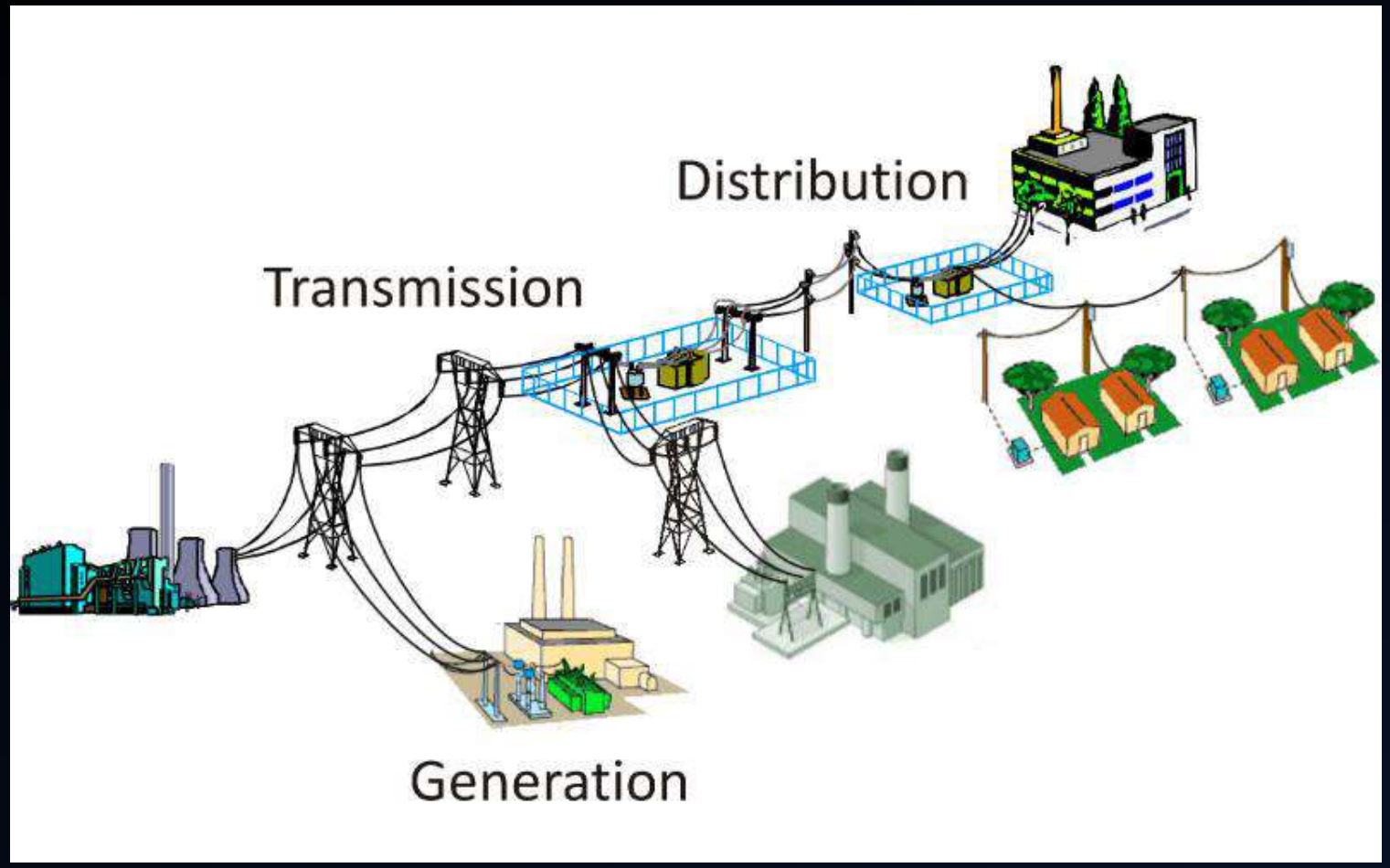
c. Distribution Lines

- These are the lower-voltage lines that carry electricity from substations to consumers. They can be divided into:
- **Primary Distribution Lines**: Carry electricity at voltages typically ranging from 4kV to 35kV.
- **Secondary Distribution Lines**: Distribute electricity at lower voltages (typically 120V to 480V) to homes and businesses.



d. Circuit Breakers and Switches

- These devices control and protect the distribution system by interrupting the flow of electricity in case of faults or maintenance needs.
- They help isolate problems and ensure reliable operation.



Electrical power system has three major sections

- generation: source of power
- transmission and distribution : transmits power
- end user/load: consumes power

Generation

Solar Power

Fuel Cell Power

Wind Power

Geothermal Power

Hydro Power

Biomass Power

Transmission

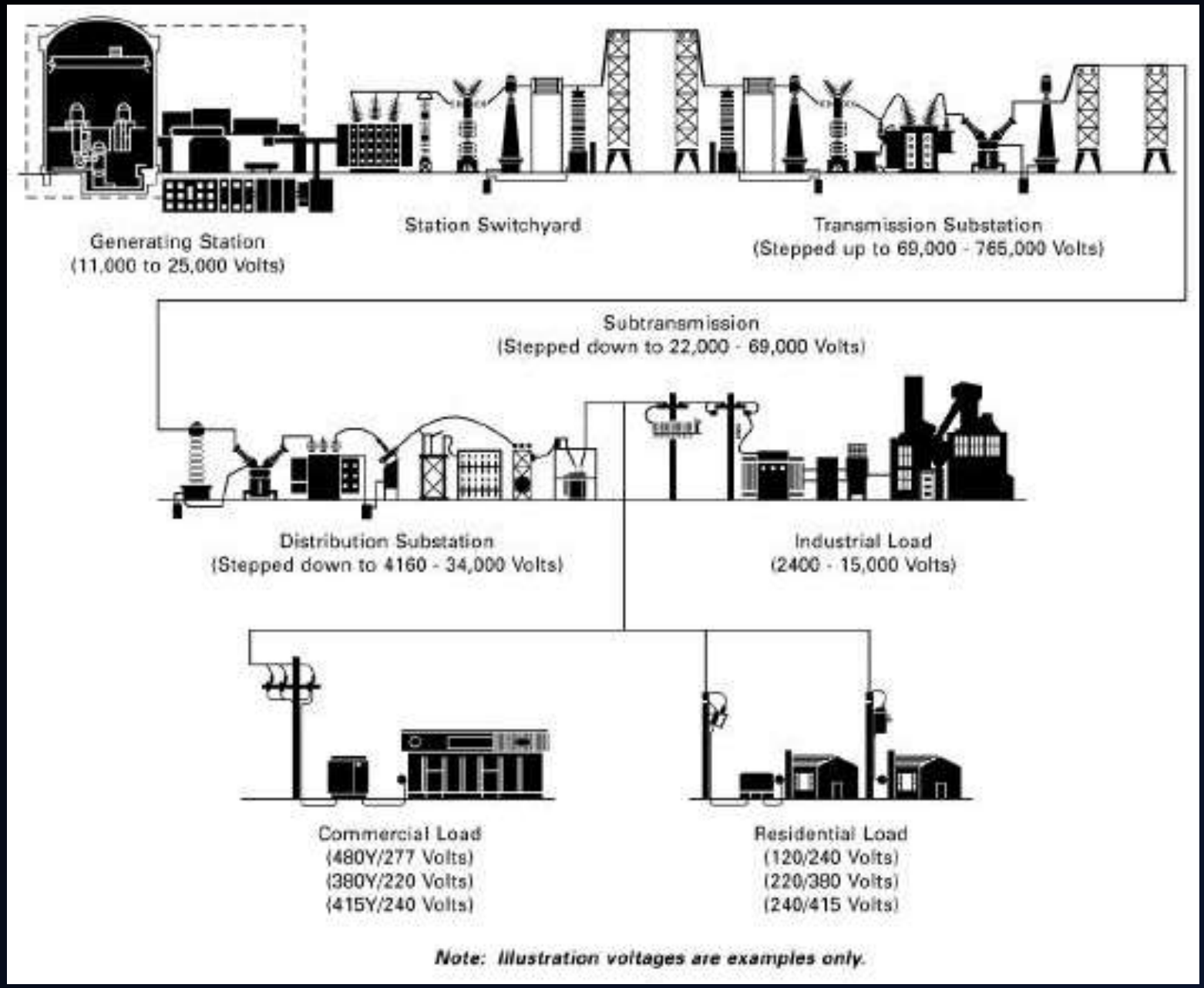
Transmission Lines

Substation

Distribution

Overhead Lines

Underground Cables



SIMPLE ELECTRIC DISTRIBUTION SYSTEM

STEP 1: The flow of electricity begins at the utility company where it is created at the **generating station.**

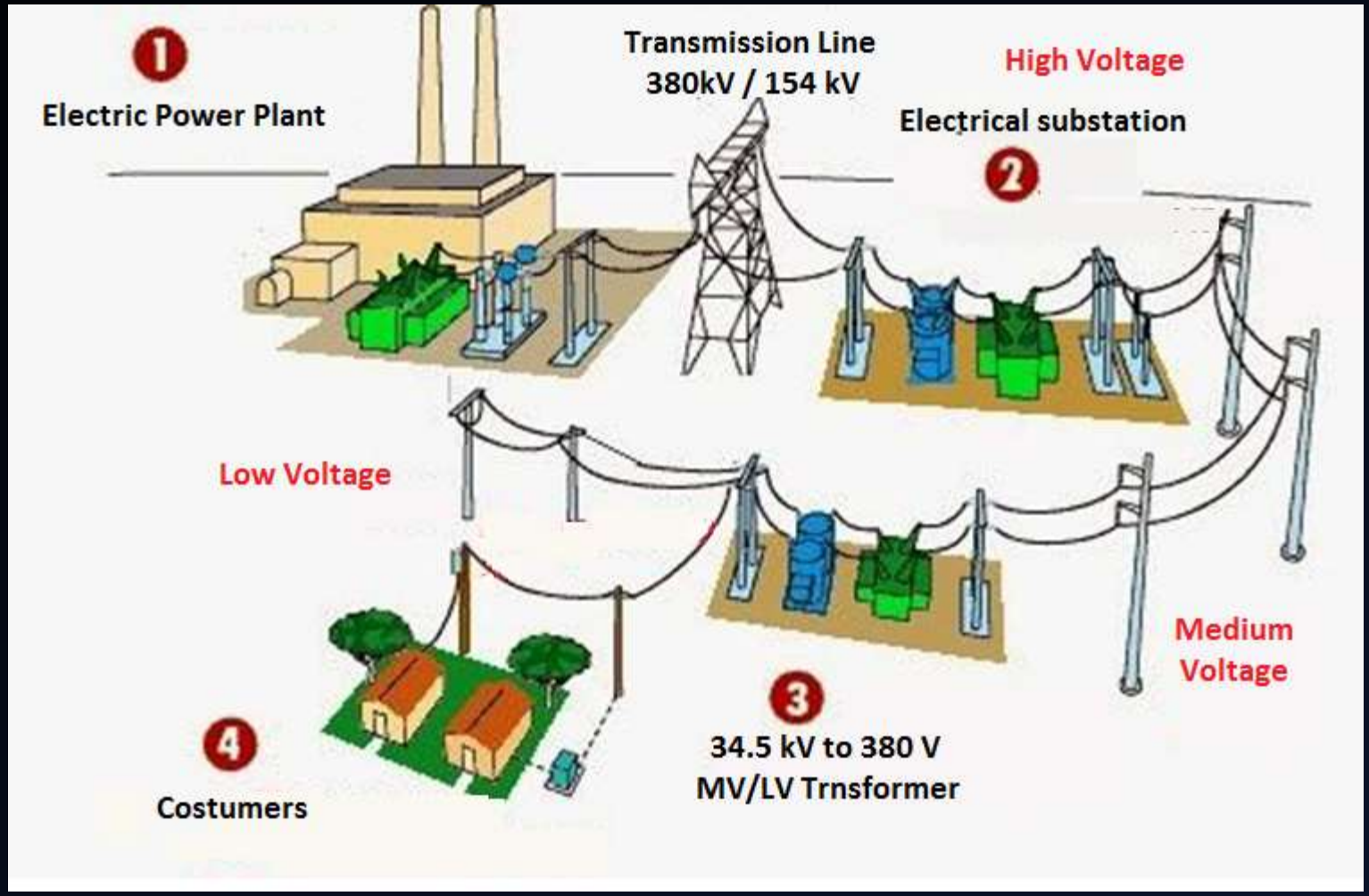
STEP 2: The **voltage** is then stepped up (increased) by a **generator transformer**. This is done to minimize the cable size and electrical losses.

STEP 3: The **Transmission Substation**, increases the voltage by a *step-up **t**ransformer*. The voltage increase depends on the distance it will go and the type of facilities it will ultimately supply. The power is then distributed in multiple directions to the proper **subtransmission station**.

STEP 4: The subtransmission station is located closer to its end customer and as a result the voltage is decreased by a *step-down transformer***.**

STEP 5: The electricity is then sent to the **Distribution Substation** where the voltage is stepped down by the Step-Down Transformers to useful voltages. The power is then distributed to homes and facilities.

STEP 6: At or near each home and facility there are transformers that adjust the voltages down to the proper level for use. For example a large industrial plant will receive voltage level from 2400 – 15,000 volts.


1
Electric Power Plant
Transmission Line
380kV / 154 kV
High Voltage
Electrical substation
2
Low Voltage
Medium
Voltage
3
34.5 kV to 380 V
MV/LV Trnsformer
4
Costumers