بسم الله الرحمن الرحيم

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Energy Storage & Transmission

By

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Lecture (4)

Conversion of Energy

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Forms of Energy

Mechanical Energy

Electrical Energy

Light Energy

Thermal Energy

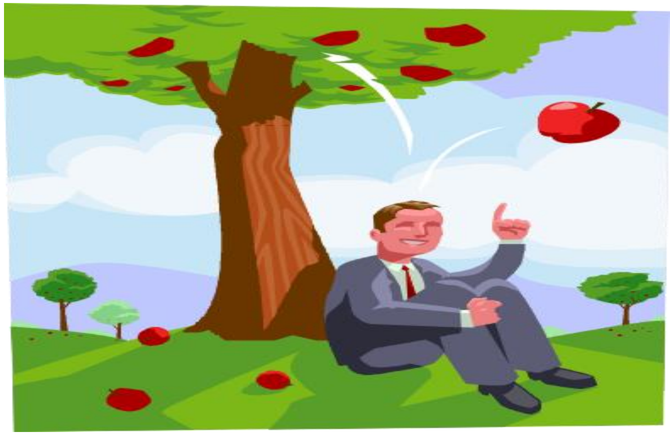
Sound Energy

1. Mechanical Energy

- The energy of movement. This energy includes both kinetic energy (motion) and potential (stored) energy.

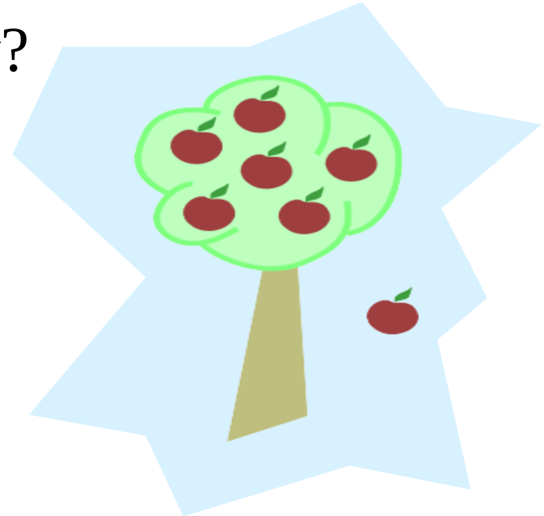
- Mechanical energy is due to the position and motion of the object.

- What happens to the mechanical energy of an apple as it falls from a tree?



- As the apple falls to the ground, its height decreases. Therefore, its Potential Energy decreases.

- The potential energy is not lost… it is converted into kinetic energy as the velocity of the apple increases.
- What happens to the mechanical energy?



2. Kinetic Energy

- It’s the energy an object has due to motion

Example

- A moving bowling ball has energy that causes the pins to fall .
- This energy is called kinetic energy.

The sky diver has kinetic energy

A ball kicked by a football player has a kinetic energy

Mass, Speed and Kinetic Energy

- All moving objects have kinetic energy.
- Not all moving objects have the same amount of kinetic energy.
- The amount of kinetic energy an object has depends on the mass and the speed of the object.
- Kinetic energy also depends on speed. The faster object has more speed and has more kinetic energy.

- Imagine those two rocks are rolling down the hillside with the same speed.
- Which one will have more kinetic energy?
- Which one will cause more damage if they hit something at the bottom?

- The larger rock could cause more damage because it has larger mass and has more kinetic energy than the smaller rock

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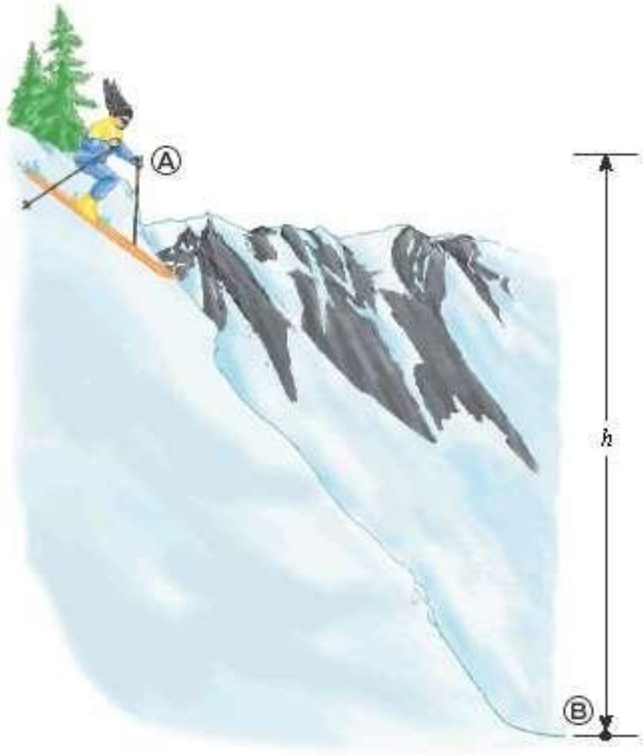
Transferring kinetic energy

- Kinetic energy could be transferred from one object to another when they collide.
- The bowling ball does not touch all the pins but it can knock them down with one roll.
- The bowling ball transfer the kinetic energy to few pins.
- The pins will transfer this kinetic energy to each other and knock them down.

- Gravity pulls the skater down the hill.

- If the skater was standing at the bottom of the hill, gravity wouldn't start her moving.

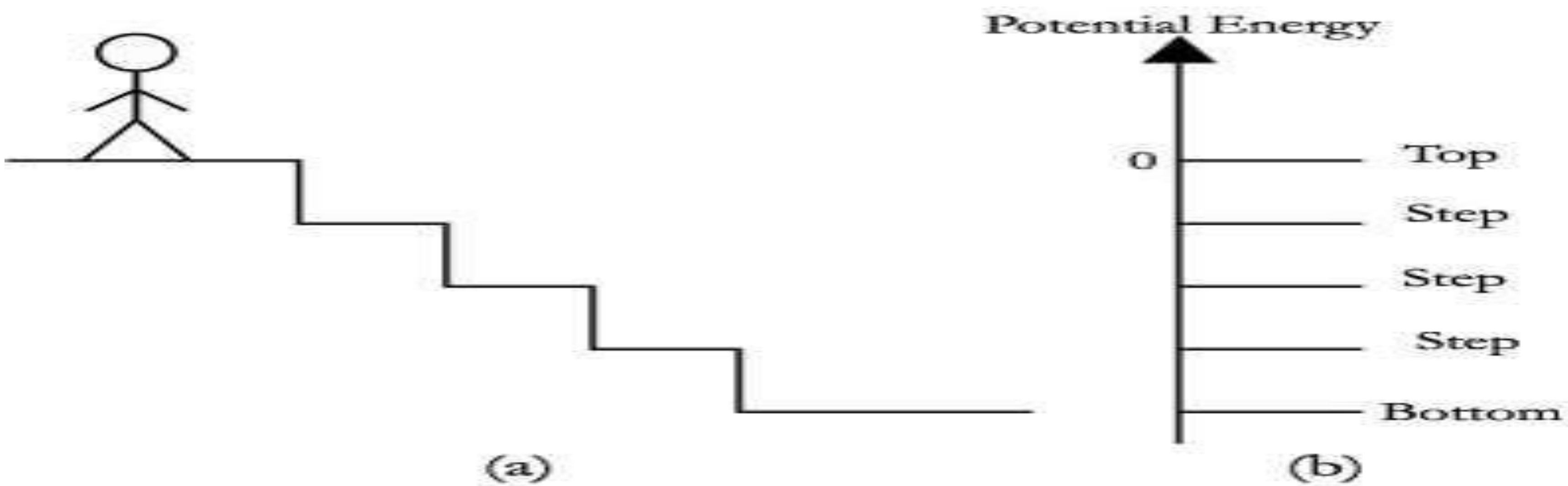
- When the skater is at the top of the hill, she has a form of energy called Potential energy.

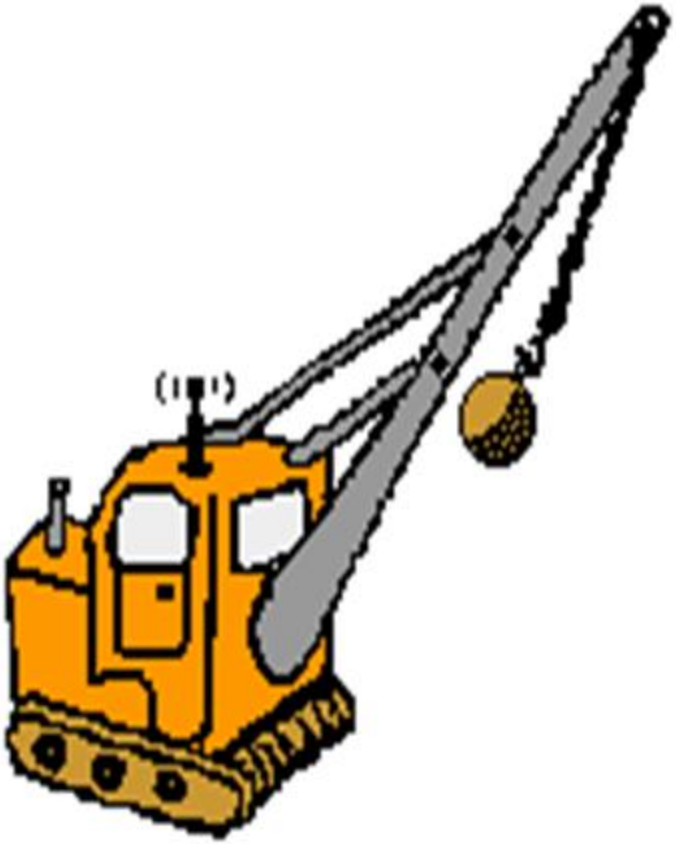


3. Potential Energy

- It's the energy that is stored because of an object's position.

- The Higher an object is lifted above earth, the greater is it's potential energy.





The massive ball of a demolition machine and the stretched bow possesses stored energy of position – potential energy.

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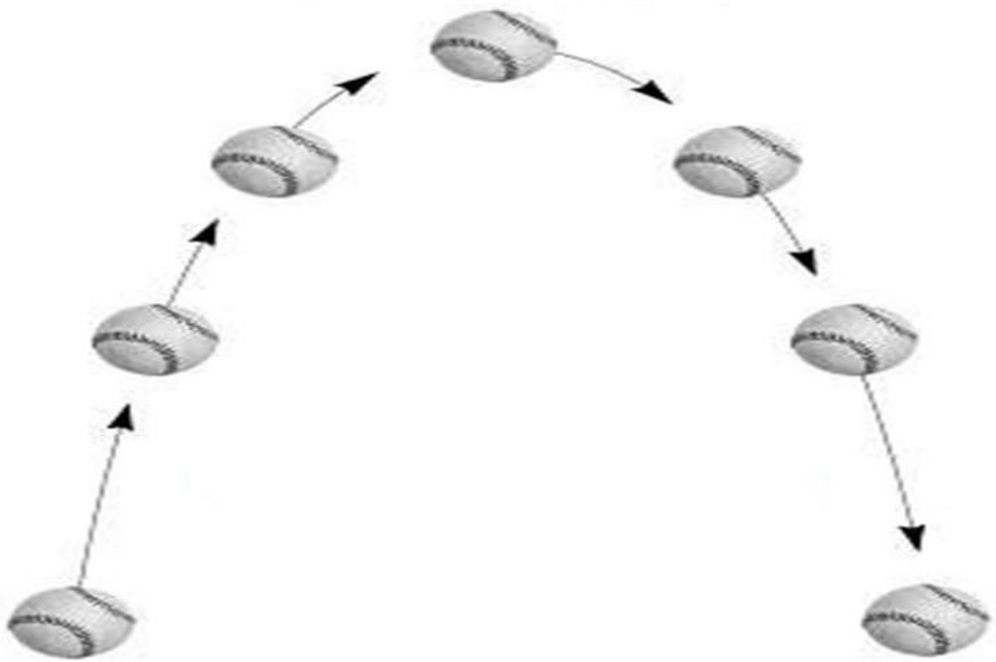
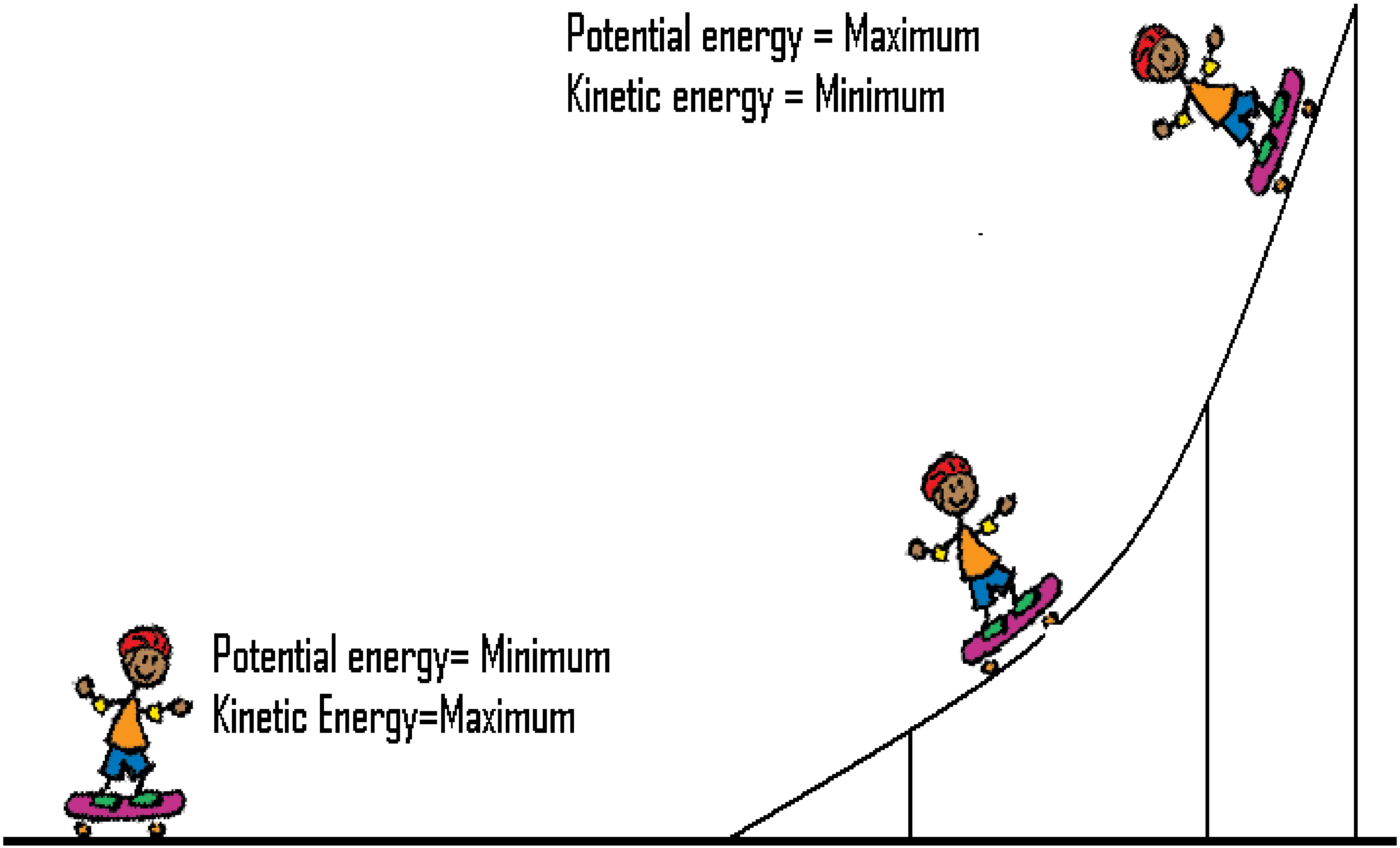
Converting potential and kinetic energy

Max potential energy, Min kinetic energy



Max kinetic energy, Min potential energy



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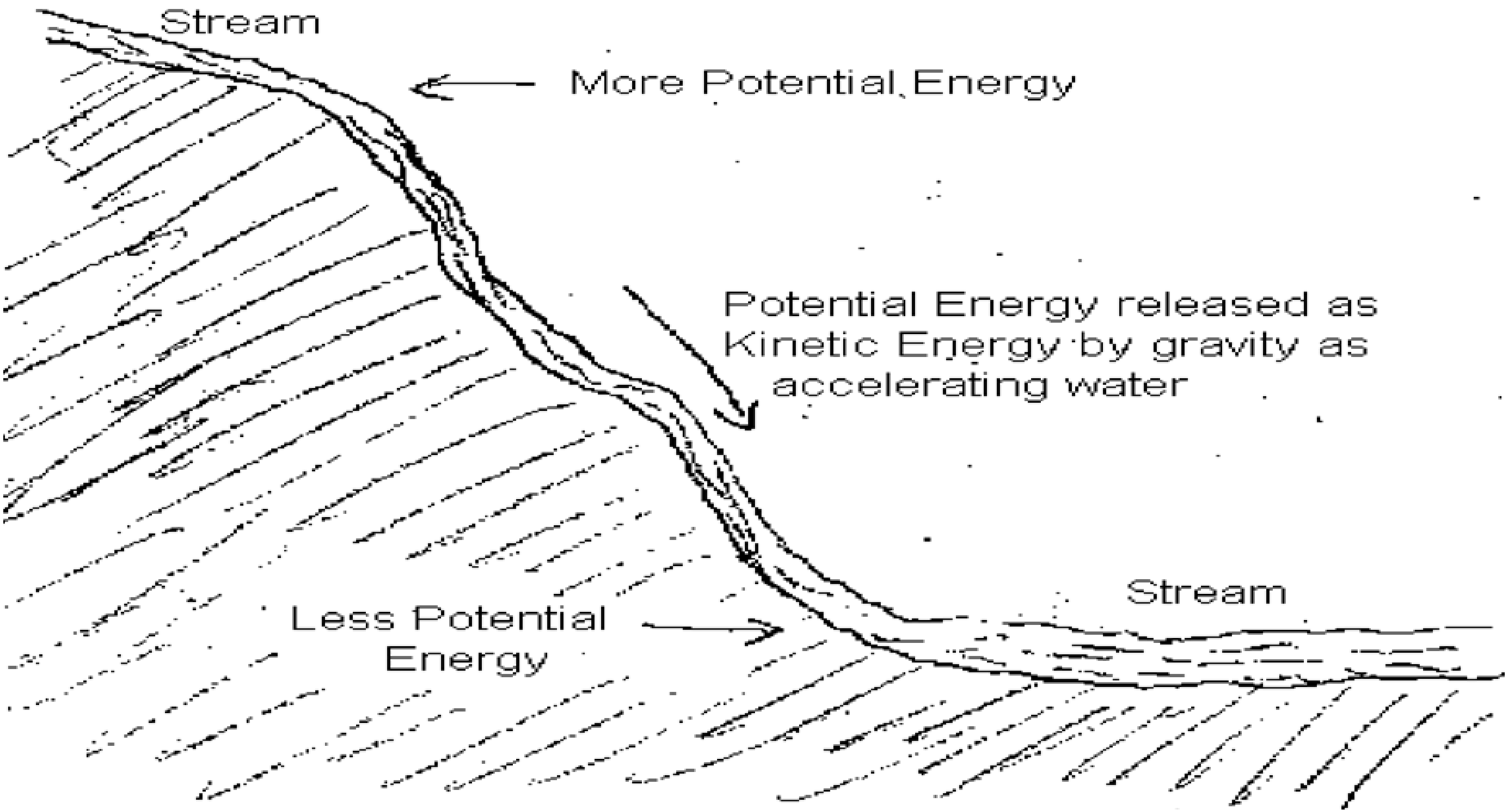
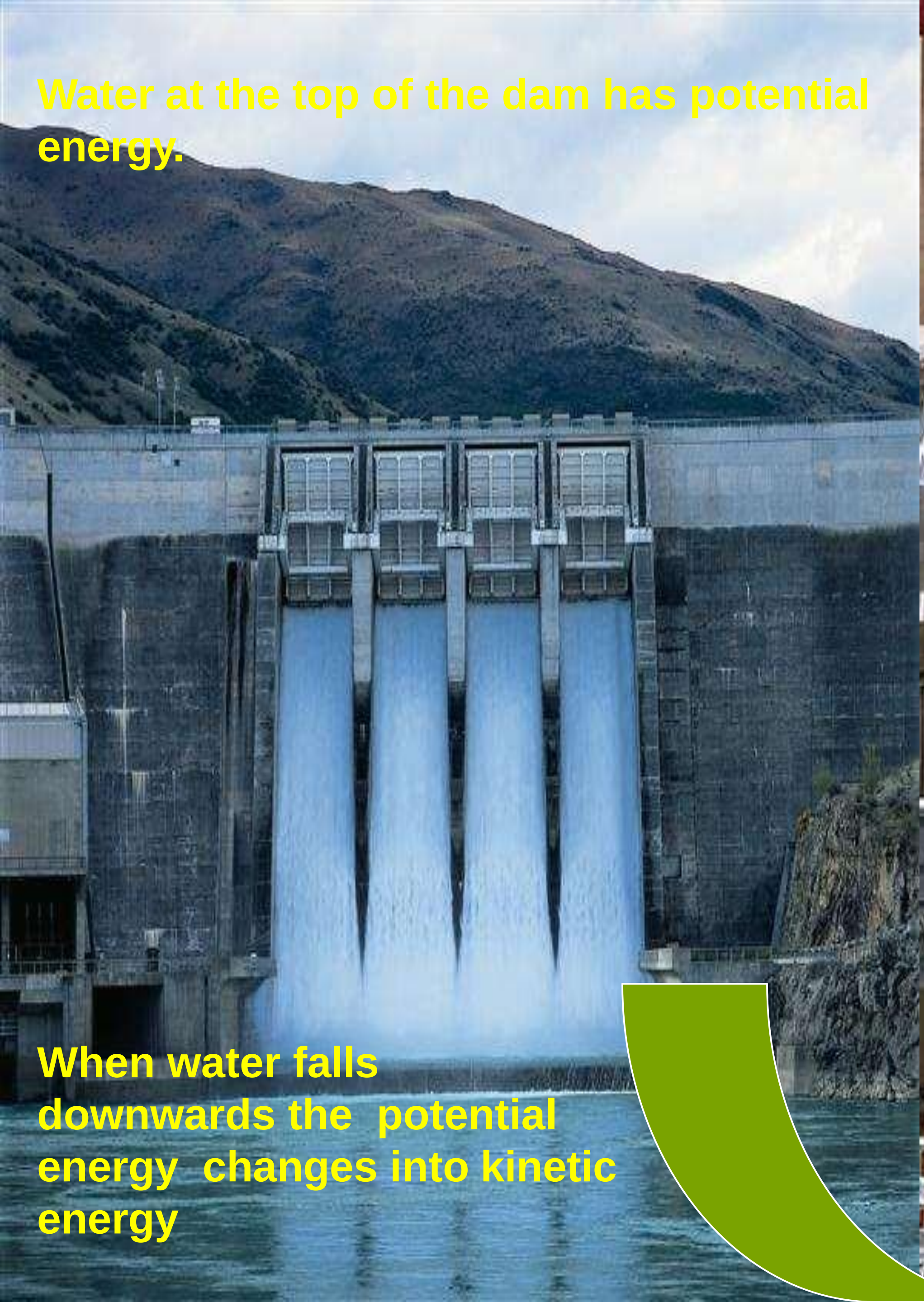
Energy changes in falling water





Water at the top of the dam has potential energy.

When water falls downwards the potential energy changes into kinetic energy

The kinetic energy in the moving water spins the generators and that’ll produce electrical energy

KE & PE

- In many situations, there is a conversion between potential and kinetic energy.
- The total amount of potential and kinetic energy in a system is called the mechanical energy

Mechanical energy = PE + KE

- The mechanical energy does not change because the loss in potential energy is simply transferred into kinetic energy.
- The energy in the system remains constant!!

4. Electrical Energy

- A form of energy that is produced when electrons move from one place to another place.

- Electrical energy is the movement of elections. Lightning and static electricity are examples of electrical energy that occur naturally. Science hasn't found a way to use natural forms of electrical energy, like lightning.

- Instead, we use different energy sources to create electrical energy by using generators and turbines

5. Nuclear Energy

- Nuclear energy is the energy stored in the nucleus of an atom.

- Nuclear energy is unusual in that it can give off energy in the form of light or heat, but it is the change in the atom's makeup that produces the energy. Submarines, power plants, and smoke detectors all use nuclear energy.

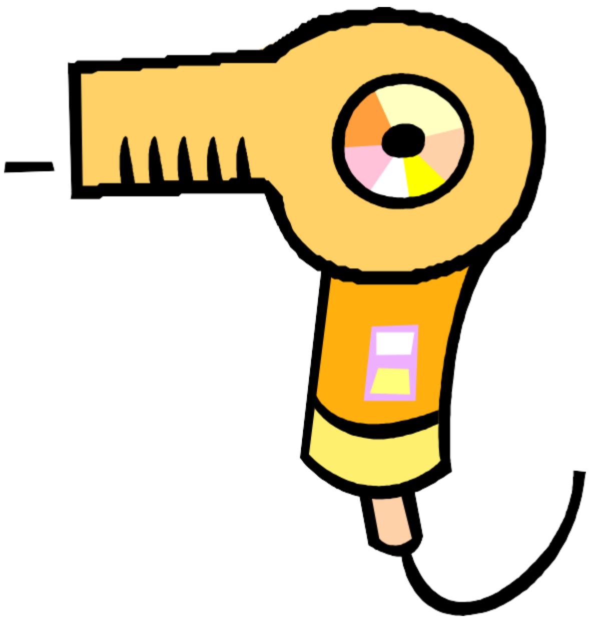
- Nuclear power plants use uranium, a radioactive element, to create electricity.

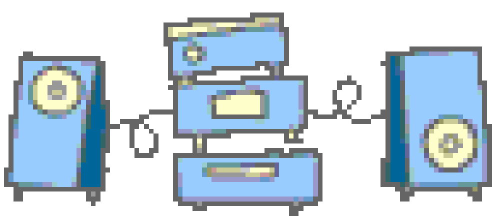
Changing Forms of Energy

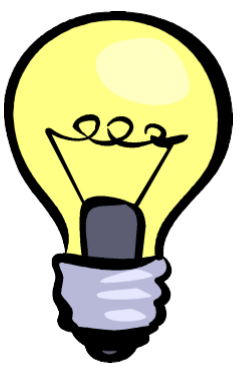
- Energy is most noticeable as it transforms from one type to another.

- What are some examples of transforming electrical energy?

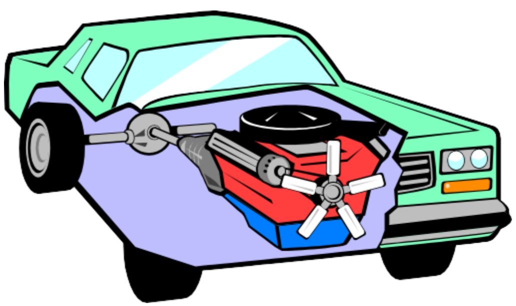
1. A lightbulb
2. A hair dryer







- An example of transforming chemical energy is a car engine.
- Chemical potential energy in gasoline is transformed into kinetic energy of the car as it moves!!



6. Magnetic Energy

- Magnetic energy is the attraction of objects made of iron. Medical equipment, compass, refrigerator magnets are all examples of magnetic energy.

- Any type of energy source that uses a generator in the process to make electricity uses magnetic energy.

7. Light Energy

- A form of energy that travels in waves and can move through empty space where there is no air.

8. Thermal Energy

- The energy of moving particles in a substance; also called heat energy.

- Thermal energy is the internal energy in substances-the vibration and movement of atoms and molecules within substance.

- Thermal energy is created in the movement of atoms.

- Boiling water, burning wood, and rubbing your hands together really fast are all examples of heat energy. Geothermal and passive solar are sources of heat energy, but biomass (a type of chemical energy) can be burned to produce heat energy.

9. Sound Energy

- A form of energy produced by vibrating objects.
- Sound energy is the movement molecules in the air that produces vibrations. Alarms, music, speech, ultrasound medical equipment all use sound energy.
- The electrical energy records the sound using magnetic tape. Speakers read the magnetic tape and change it back into sound.

10.Chemical Energy

- Chemical energy is the energy stored in the bonds of atoms and molecules. This a form of potential energy until the bonds are broken.

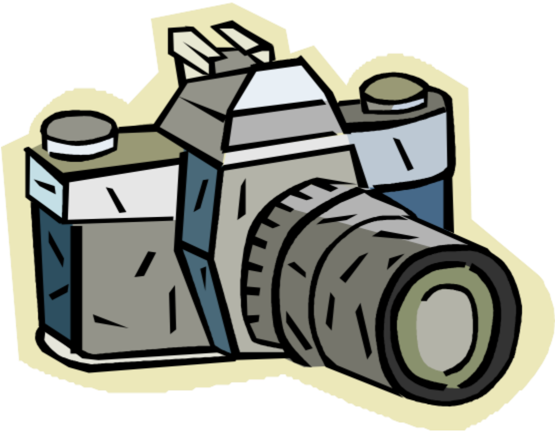
- Fossil fuels and biomass store chemical energy. Products that contain chemical energy include: baking soda, and a match.

- Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

The Law of Conservation of Energy

- The Law of Conservation of Energy states that energy cannot be created or destroyed.

- The big picture… the total energy in the universe remains constant.



Energy in your body

- Even the energy converted in your body follows the law of conservation of energy.

- Chemical potential energy is transferred to kinetic energy that allows your body to move!!

Energy is transformed... not destroyed!!

The total amount of Energy stays the same

Transmission
&
Distribution
&
Consumption

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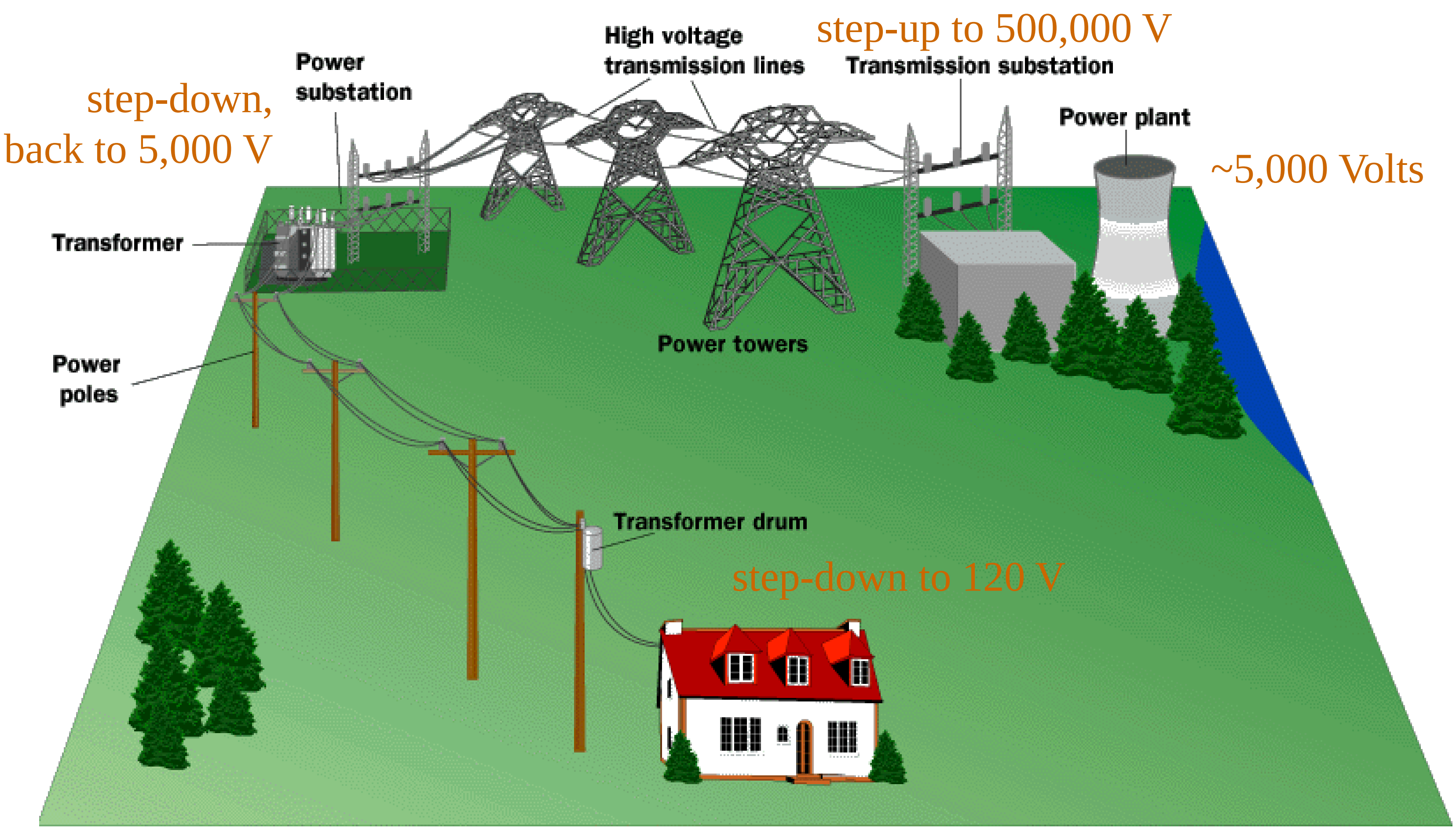
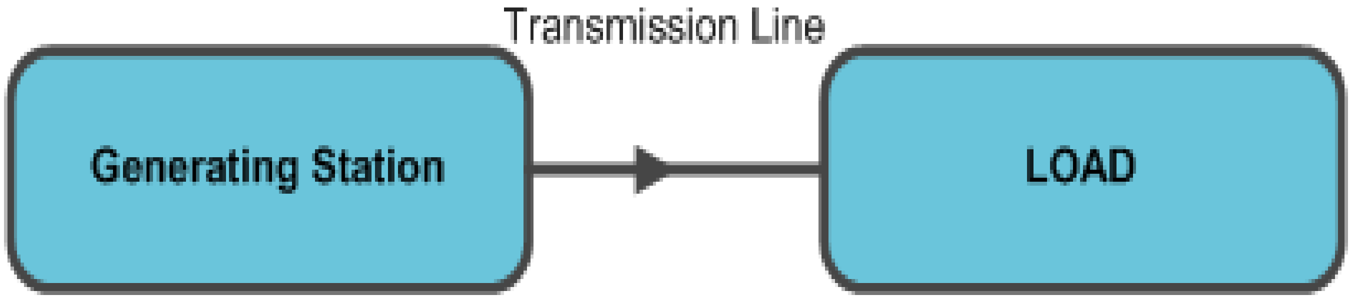
Concept of Energy Transmission



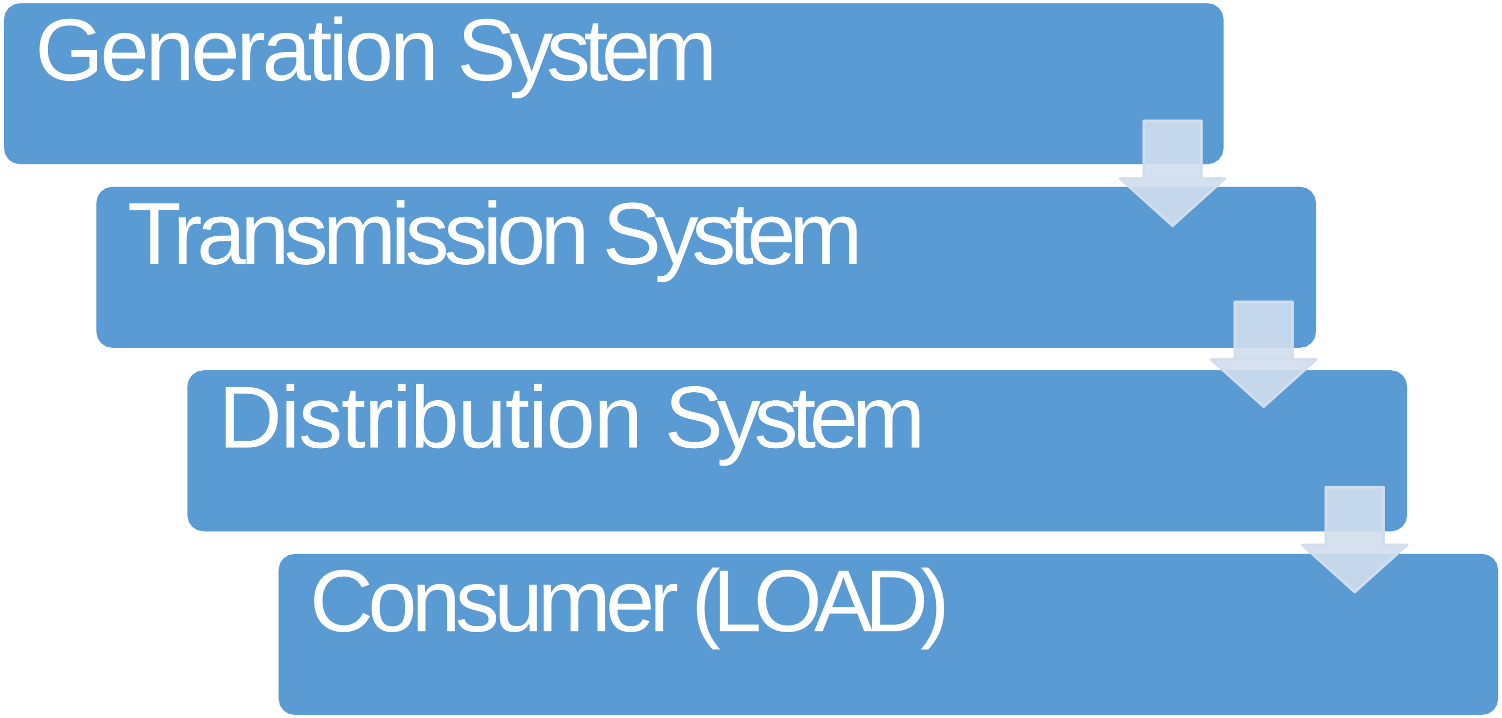
Purpose of Electrical Transmission System

- The purpose of the electric transmission system is the efficient interconnection of the electric energy producing power plants or generating stations with the loads.

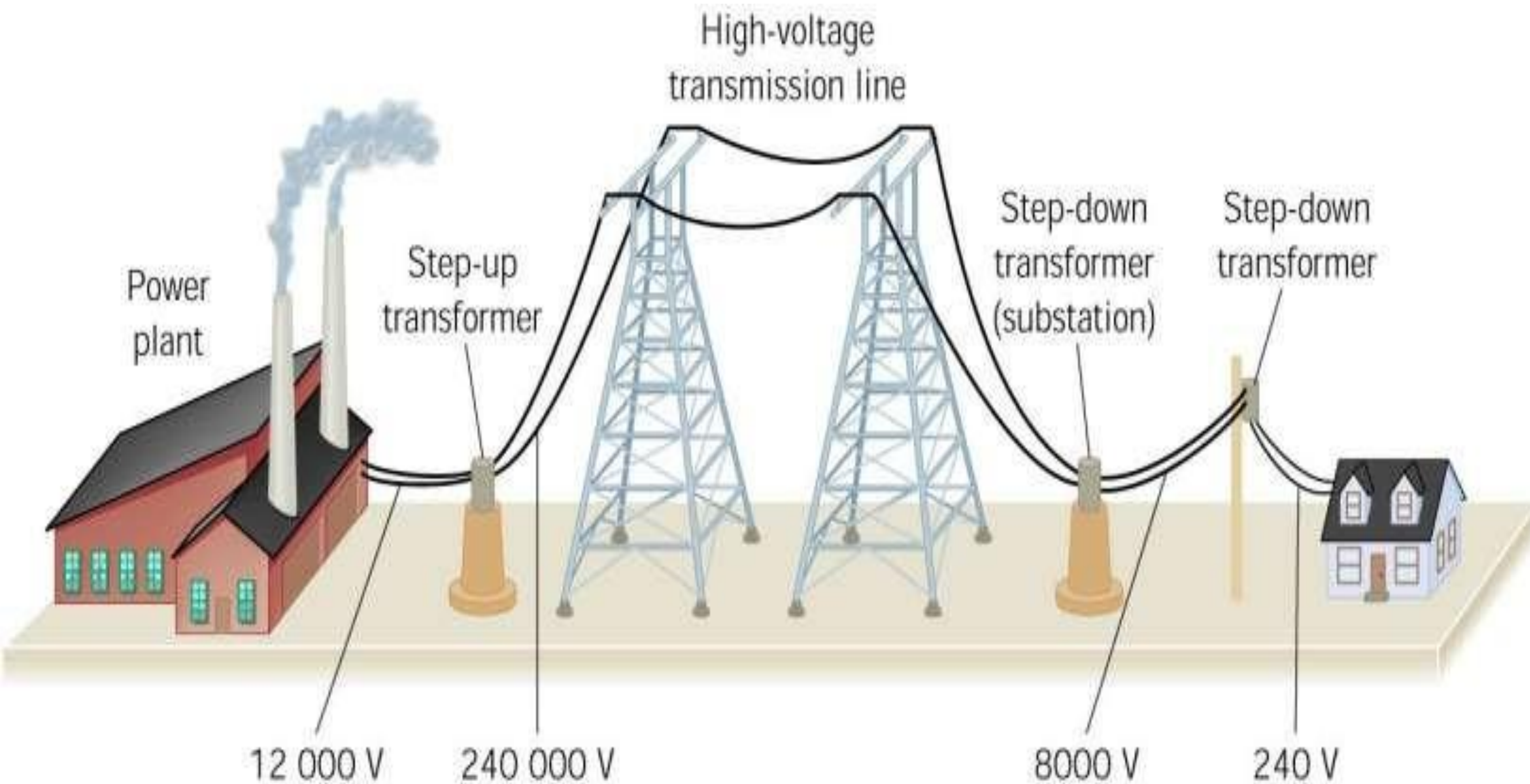


Main Parts of Power System

Four main parts :



Simplified Diagram of Power System



2. Transmission System

Basic idea of Transmission

- The huge amount of power generated in a power station (hundreds of MW) is to be transported over a long distance (hundreds of kilometers) to load centers to cater power to consumers with the help of transmission line and transmission towers.

- To give an idea, let us consider a generating station producing 120 MW power and we want to transmit it over a large distance.
- Let the voltage generated (line to line) at the alternator be 10 kV. Then to transmit 120 MW of power at 10 kV, current in the transmission line can be easily calculated by:
- For 3-phase

$$I = \frac{P}{\sqrt{3}\, V_L\, cos\,\theta} \quad \text{where } \cos\theta \text{ is the power factor}$$

$$= \frac{120\times 10^6}{\sqrt{3}\times 10\times 10^3\times 0.8}$$

$$\therefore I = 8660 \text{ A}$$

- if transmission voltage were chosen to be 400 kV, current value in the line would have been only 261.5 A.

- Standard transmission voltages used are 132 kV or 220 kV or 400 kV or 765 kV depending upon how long the transmission lines are.

- after the generator we must have a step up transformer to change the generated voltage (say 10 kV) to desired transmission voltage (say 400 kV) before transmitting it over the transmission lines.

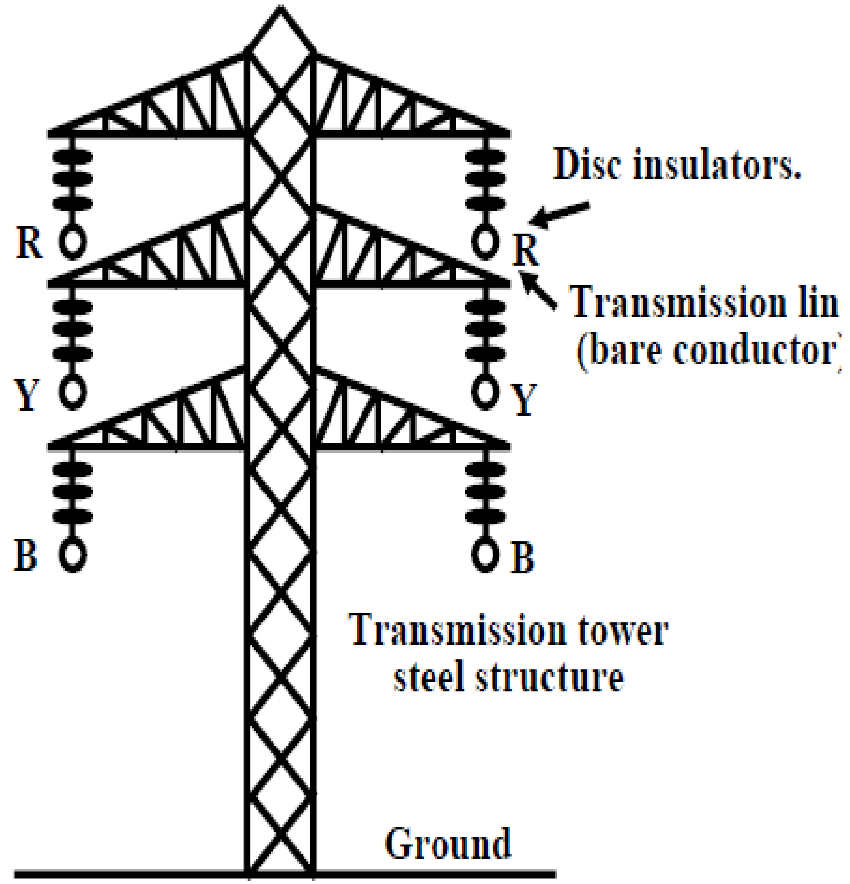
Main Parts of Transmission Line

A. **Conductor.**

B. **Earth wire.**

C. **Insulator.**

D. **Transmission Tower.**



Transmission tower

Design Methodology

- Gather preliminary line design data and available climatic data.
- Select reliability level in terms of return period of design.
- Calculate climatic loading on components.
- Calculate loads related to safety during construction and maintenance.
- Select appropriate correction factors, if applicable, to the design components such as use factor, strength factors related to numbers of components, quality control, and the characteristic strength.
- Design the components for the above loads and strength.

Selection of Transmission Voltage

- Standard Voltage: 66,110,132, 220, 400 KV

- Tolerances - ±10% up to 220 KV & ±5% for 400 KV

- Selection Criterion of Economic Voltage

1. Quantum of power to be evacuated
2. Length of line
3. Voltage regulation
4. Power loss in Transmission
5. Initial and operating cost

Voltage level in a power system

Transmission level:

400 kV, 230 kV, 220 kV, 132 kV, 110 kV, 66 kV

Primary distribution level:

33 kV, 22 kV, 15 kV, 11 kV, 6.6 kV, 3.3 kV, 2.2 kV

Secondary distribution level:

400 V (line to line) 230 V (phase)

Transmission Line

i. Overhead transmission line.

ii. Underground transmission line.

I. Overhead transmission line

- An overhead power line is a structure used in electric power transmission and distribution to transmit electrical energy along large distances.
- It consists of one or more conductors (commonly multiples of three) suspended by towers or poles.
- Since most of the insulation is provided by air, overhead power lines are generally the lowest-cost method of power transmission for large quantities of electric energy.

II. Underground transmission line

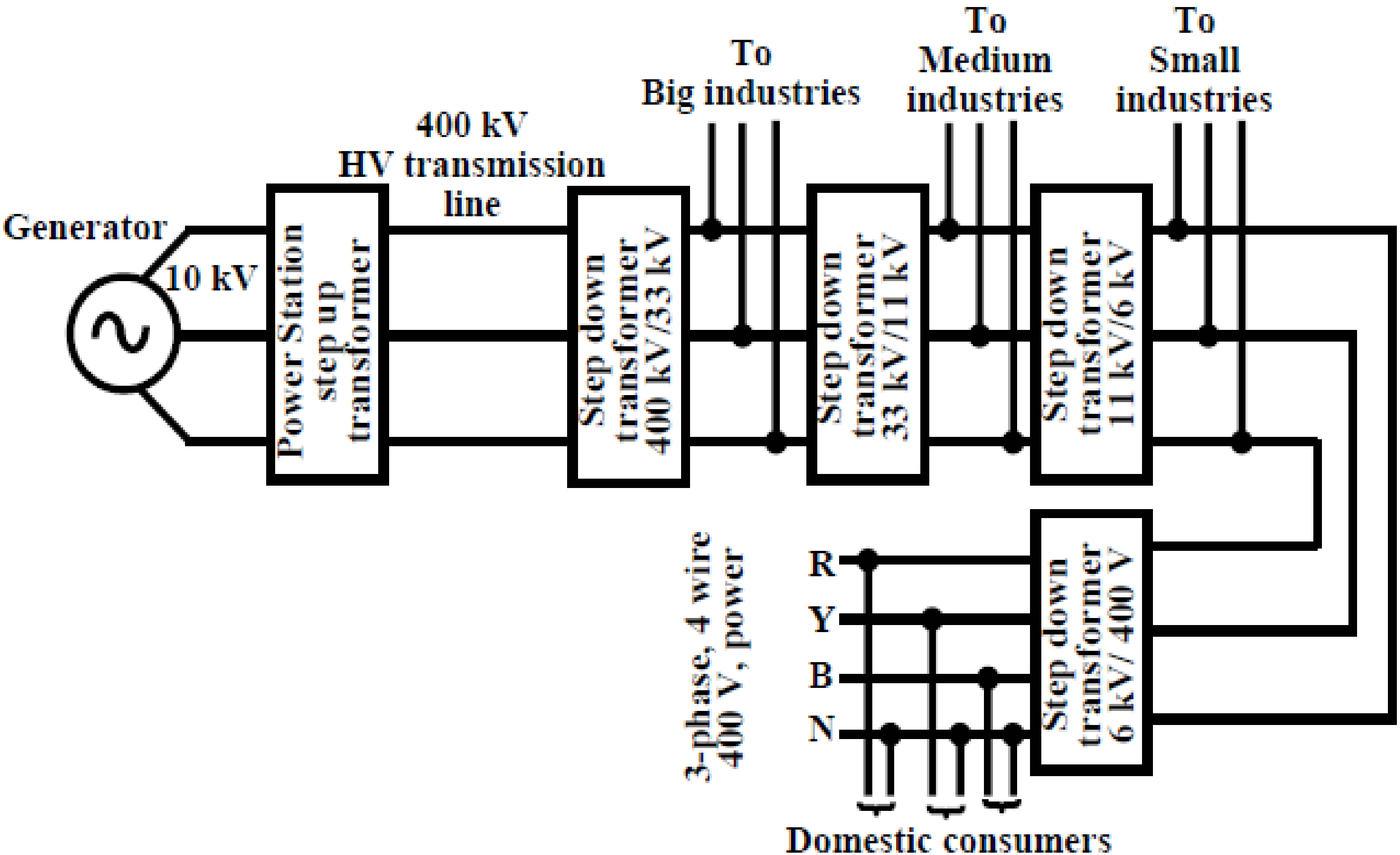
- Undergrounding is the replacement of overhead cables providing electrical power or telecommunications, with underground cables.
- This is typically performed for fire prevention and to make the power lines less susceptible to outages during high wind thunderstorms or heavy snow or ice storms.
- Undergrounding can increase the initial costs of electric power transmission and distribution but may decrease operational costs over the lifetime of the cables.

Transmission Line Models and Calculations

- Classification of transmission lines according to line length:
- Short transmission line $\leq$ 80 Km
- Medium transmission line 80 : 240 Km
- Long transmission line $\geq$ 240 Km

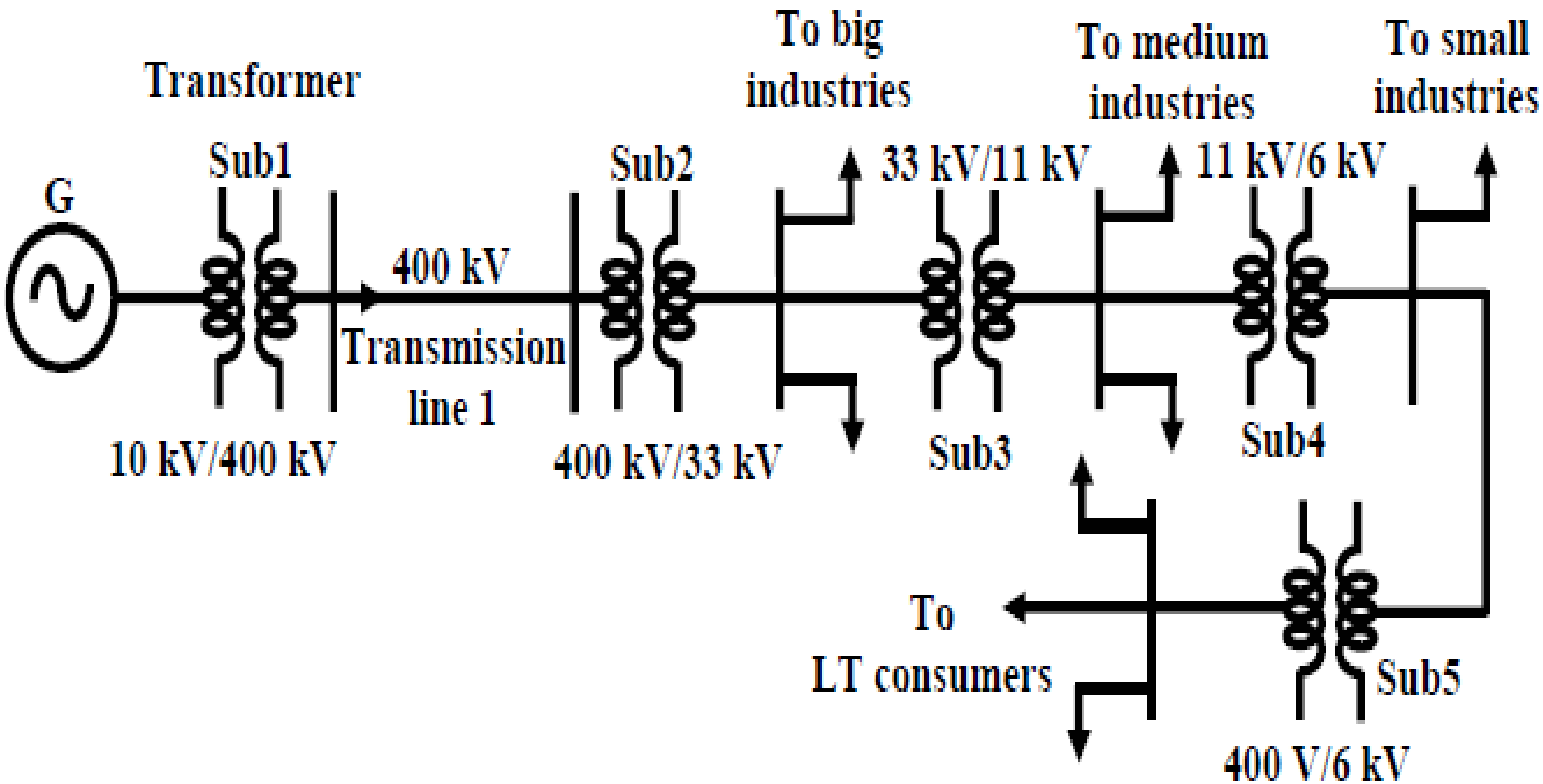
Substations

- Substations are the places where the level of voltage undergoes change with the help of transformers.
- Apart from transformers a substation will house switches (circuit breakers), meters, relays for protection and other control equipment.
- a big substation will receive power through incoming lines at some voltage changes level of voltage using a transformer and then directs it out wards through outgoing lines.
- At the lowest voltage level of 400 V, generally 3-phase, 4-wire system is adopted for domestic connections.
- The fourth wire is called the neutral wire (N).



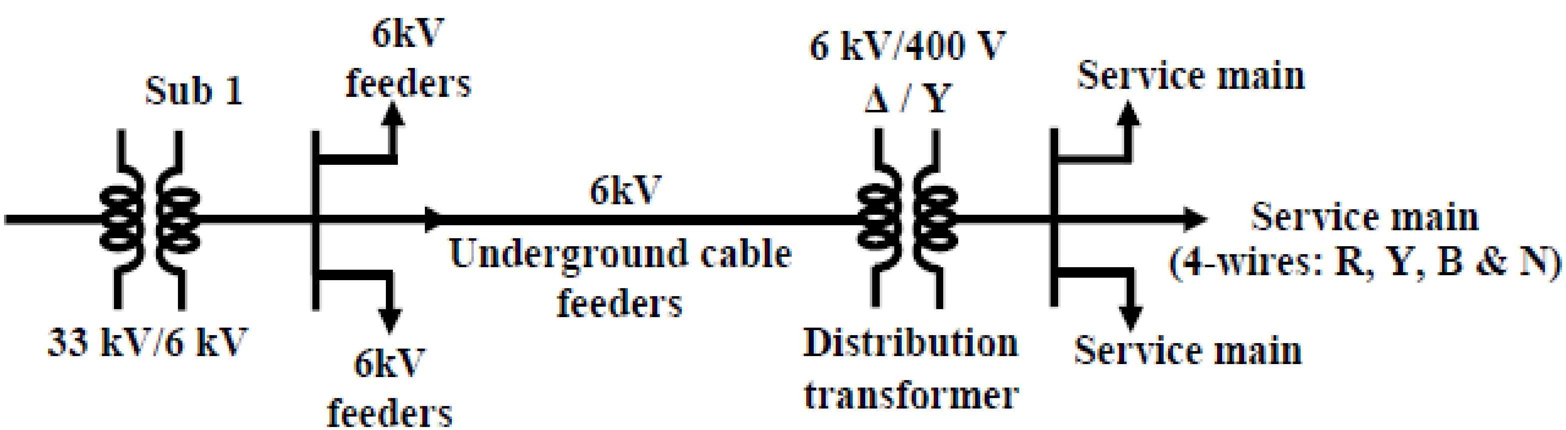
Typical voltage levels in a power system.

Single line representation of power system



3. Distribution System

- The loads of a big city are primarily residential complexes, offices, schools, hotels, street lighting etc. These types of consumers are called LT (low tension) consumers.
- LT consumers are to be supplied with single phase, 220 V, 50 Hz. this is achieved in the substation receiving power at 33 kV.



Typical Power distribution scheme.

- Power receive at a 33 kV substation is first stepped down to 6 kV and with the help of under ground cables (called feeder lines).
- power flow is directed to different directions of the city. At the last level, step down transformers are used to step down the voltage form 6 kV to 400 V.
- These transformers are called distribution transformers with 400 V, star connected secondary.
- From the secondary of these transformers 4 terminals (R, Y, B and N) come out.
- the neutral taken out from the common point of star connected secondary.
- Voltage between any two phases (i.e., R-Y, Y-B and B-R) is 400 V and between any phase and neutral is 240 V(=400/√3 .

4. Consumer

- At the load centers voltage level should be brought down at suitable values for supplying different types of consumers.
- Consumers may be:

1. **Big industries**, such as steel plants.
2. medium and small industries.
3. offices and domestic consumers.

- Electricity is purchased by different consumers at different voltage level.