Lecture Notes

(Using Electric Energy)

Intro:

- household appliances convert electric energy to some other form, such as light, kinetic energy, sound, or thermal energy; when you turn on one of these appliances, you complete a circuit and begin converting electric energy

Energy Transfer In Electric Circuits:

- energy that is supplied to a circuit can be used in many different ways; Ex. a motor converts electric energy to mechanical energy, and a lamp changes electric energy into light

- not all of the energy delivered to a motor or a lamp ends up in a useful form, some of the electric energy is converted into thermal energy

- current moving through a resistor causes it to heat up because flowing electrons bump into the atoms in the resistor; these collisions increase the atoms' kinetic energy and, thus, the temperature of the resistor

- some devices are designed specifically to generate heat Ex. space heaters, hot plates, and the heating elements in a hair dryers

- these and other household appliances act like resistors when they are in a circuit; when charge, q, moves through a resistor, its potential difference is reduced by an amount, V.

- remember, electrical current is the symbol I and is the ratio of charge per unit time and is measured in amperes (A)

$$I = \frac{q}{t}$$

- this leads us to the following electric power relationship

$$P = I^2R$$

- thus, the power dissipated in a resistor is proportional both to the square of the current passing through it and to the resistance

- if you know V and R, but not I you can use the following relationship

$$P = \frac{V^2}{R}$$

- the power is the rate at which energy is converted from one form to another; energy is changed from electric to thermal energy, and the temperature of the resistor rises

- if power continues to be dissipated at a uniform rate, the following relationships may be used

$$E = Pt$$

$$E = I^2Rt$$

$$E = \left(\frac{V^2}{R}\right)t$$

Transmission of Electric Energy:

- energy often must be transmitted over long distances to reach homes and industries; a goal of power companies is to transmit energy with as little loss to thermal energy as possible

- thermal energy is produced at a rate represented by $P = I^2R$

- electrical engineers call this unwanted thermal energy the joule heating loss, or I^2R loss

- to reduce this loss, either the current, *I*, or the resistance, *R*, must be reduced; all wires have some resistance, even though their resistance is small

- the large wire used to carry electric current into a home has a resistance of 0.20 Ω/km

- this loss could be minimized by reducing the resistance

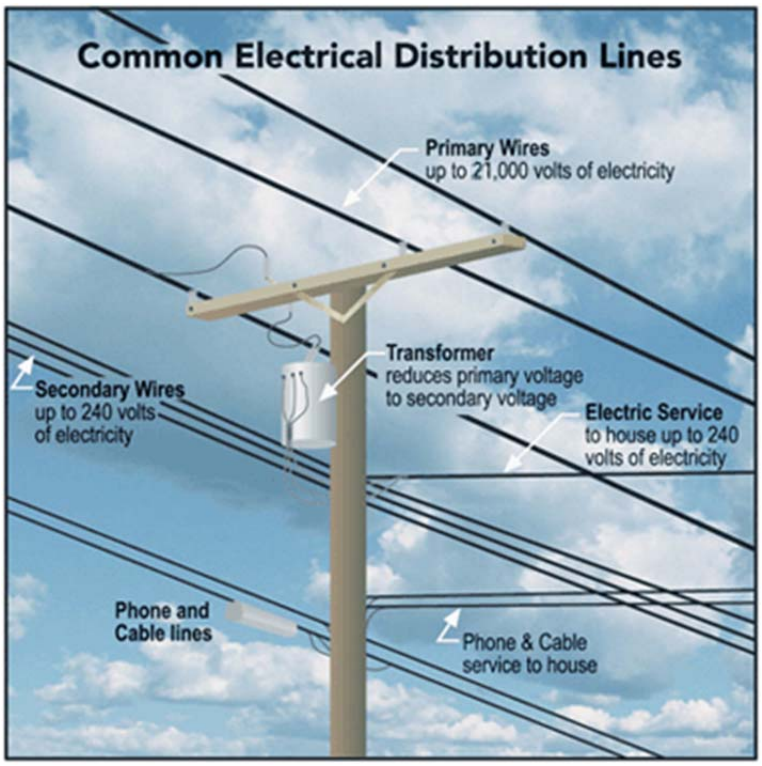
- cables of high conductivity and large diameter (and therefore low resistance) are available, but such cables are expensive and heavy

- because the loss of energy is also proportional to the square of the current in the conductors, it is even more important to keep the current in the transmission lines low

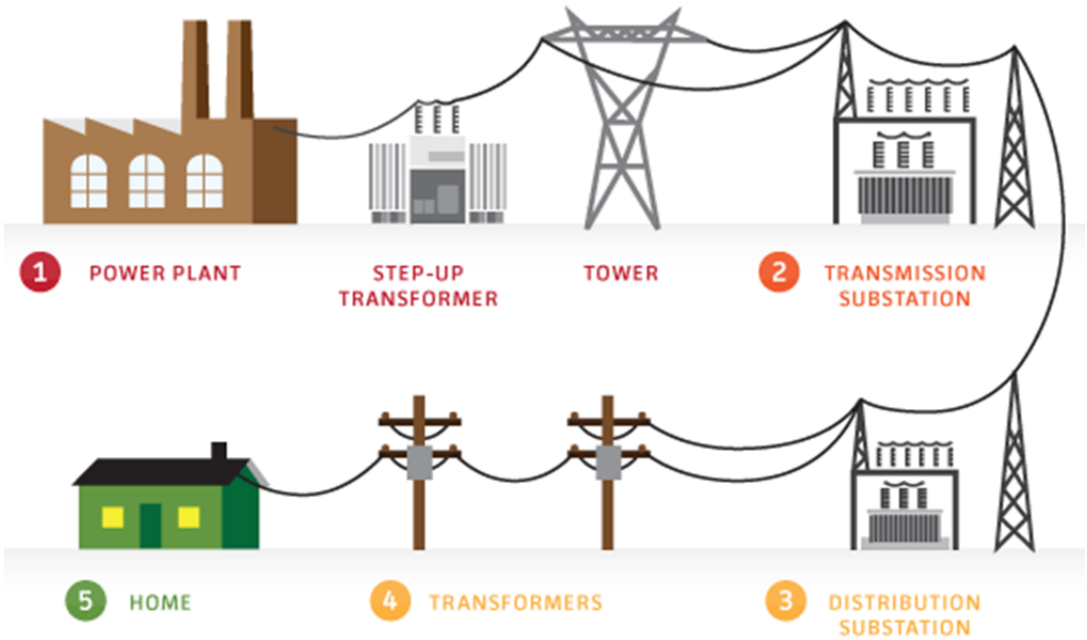
- current is reduced without the power being reduced by an increase in the voltage; some long-distance lines use voltages of more than 500,000 V

- long-distance transmission lines always operate at voltages much higher than household voltages in order to reduce I^2R loss

- the output voltage from the generating plant is reduced upon arrival at electric substations to 2400 V, and again to 240 V or 120 V before being used in homes



Electric Power Generation Summary:



1. Power plants generate electricity a step-up transformer, which raises the voltage level and sends the electricity to transmission lines; transmission lines are noticeable by the tall transmission towers that support them
2. Transmission lines carry high-voltage power to transmission substations; transmission substations contain transformers that lower the voltage of electricity and distribute it between lower-voltage lines; a transmission substation can serve tens of thousands of customers
3. Distribution substations further lower the voltage of electricity and distribute the power to cities and towns through main lines, which serve hundreds of customers
4. Branch lines carry lower voltage power to clusters of homes and businesses, and are supported by wood poles
5. Service drop lines serve single customers; the voltage from a branch line is lowered through a transformer at the pole that connects to your home or business through the service drop line.

North American Electric Reliability Corporation Interconnections