Battle of the Bulbs

Unit 3: Energy Production and Transmission

This lesson was adapted from the Ohio Energy Bike Project by Lyndon Anderson of Great River Energy. Materials required to conduct this lesson plan include the Energy Bike from the Ohio Energy Project.

Start-up Discussion

1. How have you used electricity today (energy associated with moving electrons)?

   Get answers from students: Lights, radio, TV, charge cell phones, alarm clock, computers, games, cooking, heating, dry grain, power tools, air conditioner, clothes washer & dryer, coffee maker, DVD player, curling iron, dishwasher, fan, grill, hair dryer, iron, microwave oven, oven, refrigerator, toaster, vacuum cleaner, water heater, freezer, etc.

2. How does electricity improve your standard of living?
3. What energy resources do we have in the world to generate electricity?

Terms to Know

- Coal: a fossil fuel in the form of a solid black rock
- Nuclear: energy resulting from fission, or the splitting of uranium atoms
- Natural gas: a colorless, odorless fossil fuel mostly made of methane
- Petroleum: a fossil fuel that is a thick black liquid
- Wind: energy from moving air
- Hydropower: energy produced by moving water
- Solar: energy from the rays of the sun
- Biomass: energy from burning plants, trash and organic matter

North Dakota Electricity

ND produces electricity from three primary energy sources. Ask students what the three resources are (coal-87 percent, hydropower-10 percent, wind-3 percent) Compare them to what Minnesota uses for resources (coal, nuclear, natural gas, wind, hydropower, biomass).

Procedure:

1. **Ask the students to define electricity.**
   a. Electricity is energy associated with moving electrons.
2. **Ask for a volunteer. Have the volunteer start pedaling at no more than 12 volts.**
   a. Once the volt meter reaches 12 volts, switch one fluorescent switch to the on position

b. Then, switch one LED switch to the on position
c. Then, switch one incandescent switch to the on position
d. Ask the rider to stop
e. Ask him or her to compare the amount of strength to light each bulb
f. The rider should indicate that the LED bulb was easier to light
g. If the rider can't tell the difference between the fluorescent or the LED, ask him to light up all four of those bulbs

3. **Define volts**
   a. Volts measure the difference in electric potential between two points of an electrical circuit.
   b. One analogy to volts might be water pressure. Think of a water faucet in your home, one that is shut off. There is a lot of water pressure in the pipe that is connected to the faucet. As a result, there is a lot of potential for water to come through the faucet.
   c. Volts measure the difference in electric potential between two points of an electric circuit, or the potential to develop a current across a conductor (or electric line)
4. **Define amps**
   a. Amps measure the amount of electric current.
   b. In the water analogy, the amps or current is the flow of the water out of the faucet, similar to the flow of electrons through the conductor.
   c. An increase in frequency in electrons passing through a certain point in the circuit per second represents an increase in amps, or electric current.
5. **Define watts**
   a. Watts measure electrical power.
   b. Watts can be determined by multiplying volts (electric potential) by amps (current). Volts x Amps = Watts

Next, we're going to figure out how many amps each bulb requires, and then we will figure out the watts.

6. **Ask for a volunteer to pedal the energy bike and light one of each of the various bulb types.**
   a. Adjust the rotary gauge switch to the 5 amp position for the fluorescent and incandescent bulb. For the LED, rotate the gauge selector switch to the 1 amp position.

b. Have the class determine which type of bulb requires more electricity to operate by reading the amp meter.
    i. Incandescent bulb = 4 amps
    ii. Fluorescent bulb = 1.25 amps
    iii. LED = 0.21 amps
c. Have a student read both the volt and amp meter. Calculate the power of each bulb using the equation.
    i. Volts x Amps = Watts
    ii. Incandescent bulb = 50 watts (12x4)
    iii. Fluorescent bulb = 15 watts (12x1.25)
    iv. LED bulb = 2.5 watts (12x.21)
d. Let's say we woke up tomorrow, and magically all light bulbs were placed with LEDs. What would be the impact at a power plant?

7. **Ask a volunteer to first light incandescent bulbs, then fluorescent bulbs then finally LED bulbs one. Do either 1 or 2 or 3 or 4 of each bulb (be consistent). This might work better if the rider has to do anywhere from 2‑4 bulbs.**
    a. Ask the students to determine which bulb(s) looks brighter. You may wish to turn off the lights to help the students compare the brightness of the bulbs.
        i. Often they will answer fluorescent; However, sometimes the LED bulb appears brighter when observed head‑on. If you look at the lumens for each bulb, and if the student pedals really fast for the incandescent bulbs, they will look very bright (but most don't pedal that fast).
        ii. Since the incandescent bulb requires more "leg power," it seems as if it should be brighter. If the extra power is not being converted into light, to what other form of energy is it being converted? (Answer: It is being converted to heat, or thermal energy.)
8. **While a student is pedaling, have volunteers put their hands near each of the three bulbs. Instruct the students to take their hands away as soon as they start to feel warm.**
    a. Which bulb feels warmest? (Answer: The incandescent feels warmest.)
    b. Ask the students to guess what percentage of energy goes into thermal energy for each bulb.

Incandescent bulb energy	90 percent thermal energy	10 percent radiant energy
Fluorescent bulb energy	60 percent thermal energy	40 percent radiant energy
LED bulb energy	10 percent thermal energy	90 percent radiant energy

9. **Which bulb is most energy efficient and cost effective?**
   a. *Hours*
      i. Incandescent bulbs – 900 hours
      ii. Fluorescent bulbs – 10,000 hours
      iii. LEDs – 50,000 hours (5.7 years if left on all the time)
   b. *Cost*
      i. Incandescent bulbs ‑ $0.50 for the 12 volt versions
      ii. Fluorescent bulbs ‑ $8 to $18 for the 12 volt versions
      iii. LEDs ‑ $20 to $90 for the 12 volt versions
   c. *Watts*
      i. Incandescent bulbs – 50 watts
      ii. Fluorescent bulbs – 15 watts (produce 940 lumens)
      iii. LEDs – 2.5 watts (equivalent to about a 45 watt incandescent from head on with decreasing lumens provided as the angle of view decreases), makes them good for direct, focused applications.
10. **Show an LED without the bulb to the class. Then, use the bike to light up that LED.**
   a. *LEDs – general information*
      i. The bulb remains cool after hours of operation.
      ii. They are 100 percent recyclable and contain no mercury.
      iii. They require over 90 percent less energy and last up to 30 to 50 times longer.
      iv. They are 100 percent recyclable.
   b. *If they are so good, why are they so costly?*
      i. The technology is new and still developing.
      ii. Few people use them (economies of scale).
11. **At current electricity prices, when will a bulb pay for itself?**
   a. Let's start with incandescent bulbs.
      i. Incandescent bulbs are being phased out in the United States except for special applications. New efficiency and labeling standards passed in 2007 took effect on

January 1, 2012, and the phase out of the traditional incandescent bulbs started in 2012 with the 100-watt bulb. The phase out of the 75-watt bulb will begin in January 2013, followed by the departure of its 60- watt and 40-watt counterparts.

ii. At current electricity prices, a compact fluorescent bulb is expected to pay for itself in only 1.7 years, a few years sooner than its more efficient LED counterpart.

12. **Let's say we woke up tomorrow, and magically, all bulbs were replaced with LEDs. What would be the environmental benefits of using LED bulbs over fluorescent bulbs?**
    a. Power plants would not have to burn as much coal, reducing air emissions and conserving nonrenewable resources.
    b. There is less of a need for air conditioners to remove the heat output from the light bulbs.
    c. The bulbs last longer, therefore you throw fewer bulbs away and conserve landfill space.
    d. 100 percent recyclable and no mercury in landfills.

The Bulbs

INCANDESCENT LIGHT BULBS

- The filament of an incandescent bulb is a resistive element, similar to the wires in a toaster.
- The filament is a tungsten wire wound in a tight coil. Tungsten has a very high melting point.
- It glows much more brightly than heating elements.
- Due to a filament's high temperature, inert gasses such as argon are placed inside the bulb to prevent the wire from burning.
- Incandescence is the emission of a glowing white light by an intensely heated material.

FLUORESCENT LIGHT BULBS

- A fluorescent bulb has a glass tube, whose inner surface has a phosphor coating.
- In compact fluorescent bulbs, the tube is folded back on itself.
- The tube is filled with argon gas and a small amount of mercury vapor.
- At the end of each tub are electrodes that emit electrons when heated by an electric current.
- When electrons strike the mercury vapor, the mercury atoms emit rays of ultraviolet (UV) light.
- When these invisible UV rays strike the phosphor coating, the phosphor atoms emit visible light.
- The conversion of one type of light into another is known as fluorescence.

LED LIGHT BULBS

- An LED emits light from a piece of solid matter --- a semiconductor.
- Stated very simply, an LED produces light when electrons move around within its semiconductor structure.
- A semiconductor is made of a positively charged and a negatively charged component. The positive layer has "holes" -- openings for electrons; the negative layer has free electrons floating around in it. When an electric charge strikes the semiconductor, it activates the flow of electrons from the negative to the positive layer. Those excited electrons emit light as they flow into the positively charged holes.