DRAFT Lightbox Demonstration – Overview for Teachers

First, check out this video for a quick overview: www.youtube.com/watch?v=BovQ3RcMglw&t=7s.

After watching the video, if you want step-by-step instructions with additional detail, follow along below!

When using the lightbox, we typically have students fill out and analyze the table below and come to their own conclusion about which is the most efficient lightbulb. They might already know the answer, but we emphasize the importance of examining data in order to know for sure.

What you'll need:

- Lightbox and power cord
- Lightbulbs (incandescent, CFL, and LED)
- Associated lightbulb boxes
- Infrared camera
- Light meter
- Chalkboard, dry-erase board, etc.

Optional items:

- Box of 10 incandescent lightbulbs + one box of LEDs (Part 2)
- Bag of charcoal (What's a kilowatt hour?)

Part 1: Determining which bulb is the most efficient (step-by-step instructions)

Light bulb type	Lumens	Watts	Efficacy (lumens/watt) *	Footcandles	Temperature (°F)
Incandescent					
CFL					
LED					

** Efficacy is the ability of the light bulb to produce the desired result (i.e. to create light). It's a similar concept to efficiency.*

1. Have the table above already drawn on the board before starting the activity.
2. Ask students if they know what kind of lightbulbs they have in their home. You can then ask why they think their parents/guardians purchased that specific type. You want them to bring up the idea of efficiency, cost, etc.
3. Now ask students, "OK, so why do we buy light bulbs?" It seems simple, but sometimes it takes some coaxing. The answer we're looking for: light!
4. Next ask the students what they think efficiency means. You might eventually need to explain the difference between conservation and efficiency. For example, choosing to walk to school instead of drive is an example of energy conservation. Choosing to drive a small car vs. a big truck is an example of energy efficiency. In other words, efficiency is doing the same action, but doing it using less resources. When it comes to light, we want ***"The most amount of light, for the least amount of energy."*** Have them repeat this "mantra" several times during the demonstration.
5. Now tell students that you're not going to tell them which light bulb is the most efficient, you want them to figure that out on their own, using data they collect themselves. Ask for four volunteers:
    a. **Scribe**. This student fills out the table that has already been drawn on the chalkboard, dry erase board, etc.
    b. **Watt meter reader.** The watt meter is built into the lightbox. The watt meter reader tells the scribe how much power each lightbulb is using.
    c. **Light meter reader.** This student places the light meter on the table directly underneath each lightbulb (you can encourage them to line up the white "half-globe" of the light meter under each bulb, so that it's very consistent). Once the light level has mostly leveled out (the number will always be changing slightly), the student should tell this number to the scribe. Make sure to remind this student the CFL usually takes 30 seconds to one minute to get to near full brightness.
    d. **Infrared camera user.** First, make sure the student puts the strap around her or his wrist and remind them to be careful with the camera, as it's expensive ($500). This student should use the infrared camera to measure the temperature of each lightbulb. The incandescent bulb

can get up to 350°F, so remind the students to be careful! The number on the top left of the camera screen shows the temperature in the "bulls eye" area. The scale on the right-hand side of the screen shows the lowest and highest temperature the camera is currently reading; this might be the easiest way for students to identify the hottest temperature. After measuring the incandescent light bulb temperature, you might want to put a binder, book, piece of paper in between the incandescent light bulb and the others, so the camera doesn't pick up the residual heat from this bulb.

6. If you want, encourage all students to come closer as the volunteers work together to fill out the table. After the students have filled out the Watts, Footcandles, and Temperature columns, all volunteers except the scribe can sit down.
7. Now ask students to examine the information on the lightbulb boxes. You can tell them the manufacturers have to do testing to verify all that information. Have them find the "lumens" on each box and then fill out that column.
8. Ask students how they think they can calculate the efficacy (answer: divide the lumens by the watts)
9. Once the "Efficacy" column is filled out, emphasize how much difference there is between the lightbulb types. For example, "For each watt of energy you put into that lightbulb, you get X lumens!"
10. Now ask why they think the incandescent bulb is so inefficient. Answer: heat.
11. Share this fact: "The incandescent lightbulb is only 10% efficient. 90% of the energy that goes into that bulb is lost as heat. And why do we buy lightbulbs?"[1] Answer: light
12. If you plan to end the activity here, provide an overview of what efficiency means (the most amount of light, for the least amount of energy) and encourage students to think about efficiency in other areas of their lives besides lightbulbs. Otherwise, move on to Part 2

Part 2: Examining life-cycle cost (step-by-step instructions)

1. Show the box of the incandescent and LED lightbulbs to the students. Tell them the box of LEDs cost $10 and the incandescent bulbs was $3. Now ask them which box they would purchase if they knew nothing else about the lightbulbs and had none of the data they just collected.
2. Tell the students most people would purchase the incandescent lightbulbs due to cost. But are incandescent bulbs really cheaper? Let's take a closer look.
3. Ask students to examine the boxes for the incandescent and LED light bulbs (skip the CFLs) and determine how long each should last. Based on 3 hrs/day, the LEDs last 10 years and the incandescent bulbs last 0.9 years. Now tell the students to round the 0.9 years up to 1 year and ask how many incandescent bulbs it would take to last as long as an LED. Answer: 10.
4. For a great visual effect, now set out all 10 boxes of incandescent bulbs and one box of LEDs. Ask the students how much the bulbs would now cost ($3/box * 10 boxes = $30 vs. the $10 for LEDs) and which is cheaper.
5. Remind students that only considers the initial cost and not how much less the LEDs cost to operate.

Part 3 (older students):

Calculations that involve cancelling units

What's a kilowatt hour?

If you want to use the lightbox to demonstrate how each of us is personally responsible for the environmental impact of our actions, you can show the bag of charcoal to the students. Tell them while coal is different from charcoal, this is a good visual example. It takes about three pounds of coal to produce one kilowatt-hour (kWh) of electricity.

One kilowatt-hour of electricity is enough to power ten 100-Watt lightbulbs for one hour.

Here's the math:

[1] *Data source: https://www.mrsec.psu.edu/content/light-bulb-efficiency*

$$\frac{100\ Watts}{lightbulb} \times 10\ lightbulbs \times \frac{1\ kilowatt\ (kW)}{1000\ Watts} \times 1\ hour = 1\ kilowatt - hour\ (kWh)$$

Follow-on Activities:

1. Coal:

Since the light box has an outlet and power meter, have students bring in an electrical item of their choice (alternatively, you can use electrical items from the school). Plug in each item individually to determine its power draw in watts, then use the conversion factor above to convert the watts to kW. Have the students estimate how long they use each item, either in minutes or hours (if they use minutes, they'll have to convert the minutes to hours) to convert to kWh. You can use the three pounds/kWh to determine how many pounds of coal they are personally responsible for when using their electrical items.

PUT IN EQUATION EXAMPLE (Hair dryer; Xbox, etc)

Discussion: How much would it take renewable energy sources to produce the same amount of electricity? What are the advantages and disadvantages?

2. Pollutants:

Using the Environmental Protection Agency's Emission & Generation Resource Integrated Database (eGRID) at https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid, you can determine the amount of air pollutants (nitrogen oxides, sulfur oxides, carbon dioxide, methane, and nitrous oxide) for each kWh. Note the eGRID reports in lb/MWh, so the students will have to convert from kWh to MwH.

Using the Pollution Prevention Greenhouse Gas Calculator at https://www.epa.gov/p2/pollution-prevention-tools-and-calculators, have the students calculate the greenhouse gas emissions from each of the electrical items.

Using the EPA's Greenhouse Gas Equivalencies Calculator at https://www.epa.gov/p2/pollution-prevention-tools-and-calculators, have the students calculate the greenhouse gas equivalencies for each electrical item.

Tie the P2 GHG calculator to the eGrid columns

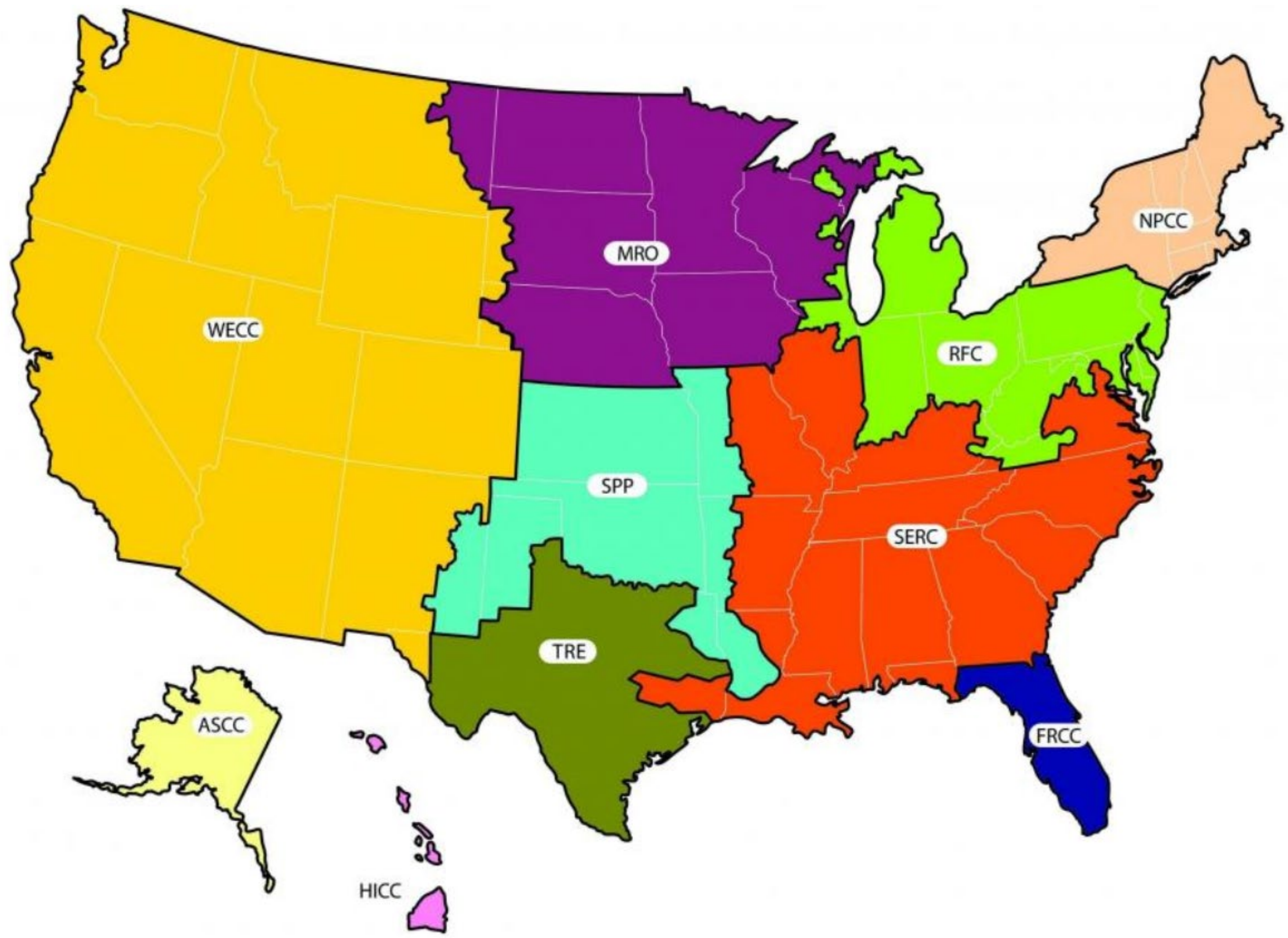
Discuss the different in baseload vs. non-baseload and how different types of fuel sources can impact those.

3. State generation:

Kansas belongs to the Southwest Power Pool for electricity generation, https://www.spp.org/. Using the graphic below and tab NRL16 from eGRID, have the students compare the air emissions from each region. For each region, have the students identify the primary source for power generation. How does the source impact the air emissions?

For air pollutants and GHG, find the NEED curriculum and find out what they address. Make Kansas specific.

FERC regions; compare SPP to other regions and discuss why some regions are "cleaner." How can SPP reduce its emissions associated with energy production?



This is a representational map; many of the boundaries shown on this map are approximate because they are based on companies, not on strictly geographical boundaries.
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