



What Do Light Bulbs Have to Do with Air Pollution?

Grade 6, Science and Math

Length of Lesson:

2 – 2 ½ hours

This attachment includes the Light Bulb Pollution Worksheet (to be copied and distributed to each student) and a corresponding Answer Key for use in the class activity at Step 3; the Light Bulb cards to be cut apart and distributed to students at Step 4; and the Light Bulb Comparison Chart to be enlarged and used to record student results at Step 5. A Light Bulb Comparison Chart Key is also provided, with correct answers in red.

Georgia Performance Standards:

S6E5 Students will investigate the scientific view of how the earth's surface is formed.

j. Describe methods for conserving natural resources such as water, soil, and air.

M6P1 Students will solve problems (using appropriate technology).

- a. Build new mathematical knowledge through problem solving.
- b. Solve problems that arise in mathematics and in other contexts.
- c. Apply and adapt a variety of appropriate strategies to solve problems.
- d. Monitor and reflect on the process of mathematical problem solving.

M6P4 Students will make connections among mathematical ideas and to other disciplines.

c. Recognize and apply mathematics in contexts outside of mathematics.

National Standards:

[NAAEE](#) Guidelines for Excellence in Environmental Education
Strand 2.4 Human/Environment Interactions

Focus:

In the lesson, sixth grade students will investigate how the act of conserving energy by using certain types of light bulbs can reduce air pollution, in cases where fossil fuels produce electricity for the bulb. Based on a known relationship between power production and



emissions of carbon dioxide (CO₂), students will learn how to calculate the amount of CO₂ air pollution emitted, when energy is produced to power each type of light bulb. Students will also investigate other issues associated with use of compact fluorescent bulbs, including bulb recycling.

Materials:

- Calculator (one per student)
- Light Bulb Cards (prepared from handout attached at step four - three cards per team of two)
- Two types of light bulbs: incandescent and compact fluorescent (one each, per class)
- Light Bulb Comparison Chart enlarged on board or chart (attached: for use at step five)
- Light Bulb Comparison Chart Key (attached: for use at step five - one for teacher)
- Light Bulb Pollution Worksheet (attached: for use at step three - one per student)
- Light Bulb Pollution Worksheet Key (attached: for use at step three - one for teacher)

Procedure:

Step One: Teacher Preparation

Be sure to collect all the items listed in the Materials section, and to make transparencies and handouts (attached below) in advance. Also, make approximately five copies of the two-page "Light Bulb Cards" handout attached at Step Four and cut the cards apart prior to start of the lesson.

Step Two: Duration: 10 minutes

Explain to students that electrical equipment and appliances in their households contribute to air pollution, if the electricity in their homes comes from a fossil fuel (such as coal-fired power plants). Show the class two types of light bulbs: incandescent and compact fluorescent. If no bulbs are available, show this graphic (<http://www.cityofseattle.net/light/publications/connections/2000-2001/Bulbs.jpg>) of various compact fluorescent bulbs and this image (<http://media.canada.com/b17a5268-e809-4db2-a84b-06fc4c00d03e/bulb800500.jpg>) of a CF and incandescent bulb side by side. Tell students that although both CF and incandescent bulbs contribute to air pollution, one type of bulb causes fewer power plant



emissions, simply because it requires less energy to produce light. Let students know that they are going to conduct a cost-benefit analysis to figure out which type of bulb produces the most light for the least amount of energy (and lowest cost) in the long run. Finally, students will conduct a pollution comparison study for each type of light bulb. This study will help them determine which type of bulb is better for the environment.

Step Three: Duration - 30 minutes

Distribute a copy of the handout: "Light Bulb Pollution Worksheet" (attached in "Student Handout") to each student. Read and discuss the background information in this handout with the entire class. Review formulas for calculations. Note: The amount of air pollution related to the energy consumption of a particular light bulb is described as: $(1.37\text{lbs CO}_2/\text{kWh}) \times (\text{lamp wattage, in kW}) \times (\text{bulb life, in hours})$. The formula for the "life cycle cost" of a light bulb is given as: $(\text{purchase price of bulb @ } \$0.75 \text{ for incandescent or } \$6 \text{ for CF}) + [(\text{cost of energy, in kWh @ } \$0.075 \text{ per kWh}) \times (\text{bulb life, in hours}) \times (\text{bulb wattage, in kW})]$. Work through the calculations in the data table with the entire class. (This is not intended to be an individual assignment). An answer key is provided to assist the teacher. Have students record the calculations in the "Show your work" section, to save as reference for an upcoming homework assignment. If further explanation of the relationship between power and energy, or of kilowatts and kilowatt-hours is needed for student understanding of the formulas in this hand-out, feel free to use the Watts, Kilowatts, and Meter-Reading Web site (<http://www.gcse.com/energy.html>) to show one of several short tutorials on an interactive whiteboard, or copy pages from the Web site as transparencies and show on an overhead projector. Also available at this Web site: graphics and directions for reading and interpreting electric meters.

Step Four: Duration - 30 minutes

Divide students into pairs. Distribute at least three Light Bulb Cards to each pair. (Each pair of students should have at least one card with a compact fluorescent bulb and one card with an incandescent bulb). Tell students to calculate the "lifespan cost" and the mass of carbon dioxide (a type of pollution) emitted during energy production for each bulb. Review the assumptions and formulas used in Step Three; that is, Energy Cost = $\$0.075/\text{per kilowatt-hour (kWh)}$ [or $7.5\text{¢ per kiloWatt-hour}$]; Incandescent bulb purchase price = $\$0.75$, Compact



Fluorescent (CF) bulb purchase price = \$6.00, and in Georgia, 1.37 lbs of carbon dioxide emitted per kWh. In order to do a fair comparison of incandescent and compact fluorescent bulbs, have students calculate costs and air pollution impact of each type of bulb for a period of 10,000 hours. You may assume that a single CF bulb will last that long, but that each incandescent bulb will only last 1,000 hours. Ask the class how many 1,000-hour incandescent bulbs would be needed to last as long as one CF bulb (10), and remind students to use this information in their calculations. Allow students time to do the calculations for the cards they have drawn.

Step Five: Duration - 20 minutes

Review calculations with the entire class and call on students to post their results on a whiteboard, interactive whiteboard, a poster board or large chart pad, in the format suggested by the attachment ("Light Bulb Comparison Chart"). See "Light Bulb Comparison Chart Key," also attached, for answers. Ask students, based on all the data, which bulbs cause the least amount of air pollution? (compact fluorescent) Discuss responses with the class. Ask students what bulbs they would use if they were trying to save the most energy (compact fluorescent); to save the most money; (compact fluorescent) to reduce air pollution? (compact fluorescent).

Step Six: Duration: Homework assignment - two or more evenings
Tell students that they are going to conduct an audit of light bulbs in their bedrooms, as a homework assignment. Have students count the number, wattage and type (incandescent or compact fluorescent) of at least two light bulbs in the bedroom (using bulbs in an additional room, if there is only one bulb in bedroom). Tell students to calculate the light bulb lifespan cost and analyze the air pollution impact of each bulb, referring to the formulas and examples provided in the Light Bulb Pollution Worksheet distributed at Step Three. Students should then total the light bulb lifespan costs and total the air pollution impacts of all the light bulbs in the room.

Next, each student should think of at least one specific change she/he could make to save energy on lighting in the room, and calculate the difference this change would make, in terms of air pollution impact. The Light Bulb Audit and Scoring Rubric, included in the attached "Student Handout," can be used as a worksheet for the homework activity and also as a scoring guide after the activity is completed.



Step Seven: Debriefing and Optional Essay, Duration: 30 - 60 minutes

To debrief the lesson, have students tell about the actions they proposed to save energy and to reduce CO₂ emissions from power plants (referring to last step of Home Light Bulb Audit homework assignment) and tally the results. Total the value of all students' energy savings; and total the amounts by which all the corresponding CO₂ emissions would be reduced, to determine the impact of actions proposed by the whole class. Discuss the collective power of individual actions to save energy and reduce air pollution.

If compact fluorescent (and regular fluorescent) bulbs are so good for the environment, ask students to brainstorm why they are not more widely used. (Possible answers: resistance to change, lack of awareness of benefits, lack of availability of CF bulbs, lack of variety of CF bulbs such as dimmables and three-ways, dissatisfaction with light hue, difficulty fitting CF bulbs in certain fixtures and lamps, greater initial cost than incandescents, waiting to use stockpile of incandescent bulbs before switching to CFs, certain temperature and humidity levels required for CF bulbs to operate, disposal and clean-up issues related to mercury contents). Display and review information from the EnergyStar Web site

(http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf) about mercury in CF bulbs, on an interactive whiteboard (or make and distribute hand-outs; or copy Web pages on transparencies and show on overhead projector).

Review recommended clean-up methods for broken CF bulbs. Emphasize avoiding direct contact with mercury and the importance of avoiding vacuuming, because vacuum cleaners exhaust tiny droplets of mercury in the air, creating a greater safety hazard. Note that some authorities go beyond the recommendations on this Web site and suggest that if a CF bulb breaks on carpet, especially in a child's bedroom, the carpet should be removed and disposed of as hazardous waste by a professional clean-up crew. Also note that unbroken CF bulbs must be carefully disposed of at special locations (such as Home Depot and Ikea stores). Point out the chart and text regarding how CF bulbs reduce overall mercury emissions into the air, relative to the amount of mercury that would be released by coal-fired power plants to produce energy for incandescent bulbs. Ask students if they can identify the health effects and environmental impacts of mercury.



Display the Earth 911 Web site (<http://earth911.com/hazardous/mercury/mercury-and-the-environment/>) for more information on how mercury affects people and wildlife, as well as how to recycle items containing mercury.

Tell the class that some countries have already banned incandescent light bulbs and that other countries are considering such legislation. Ask students to express their opinions about the advisability of such legislation, taking into consideration what they know about incandescent and CF bulbs. (There is no "right" answer to this issue. Allow free discussion). Ask students to think of ways to improve the safety of CF light bulbs. (Possible answers: decrease the amount of mercury in the bulbs, increase the number of disposal sites, cover bulb with an unbreakable outer shell). In addition to or instead of using CF bulbs, ask what actions students and their families can take to conserve energy and reduce the amount of air pollution produced by power plants. (Possible answers: replace old appliances with energy-saving models, replace old thermostats with programmable ones, generate power by using methods other than burning fossil fuels, develop new technologies for more efficient lighting ~ such as L.E.D. bulbs ~ which do not contain mercury). Sum up by pointing out the benefits of CF bulbs (energy conservation relative to incandescent bulbs, reduced CO₂ and mercury air pollution from power plants) vs. the unintended consequences of their use (possible safety hazards and disposal issues). As an optional closing activity, ask students to write a persuasive essay on the topic of whether incandescent bulbs should be banned.

Assessment:

The homework assignment described in step six will assess student knowledge and ability to apply lesson concepts.

Follow-Up:

After you have taught this lesson plan, please tell the Clean Air Schools program about your efforts in a brief, 60-second online survey at CleanAirCampaign.org. The information you provide is invaluable in helping this non-profit education program direct its resources to improving these lesson plans and creating new materials for your students. Thanks!