



What Do Light Bulbs Have to Do with Air Pollution?

This lesson is the second in a unit focusing on air quality and electricity production, provided by The Clean Air Campaign®. In the lesson, 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.
(Environmental Education)

<i>Education Committee</i>	<i>The Clean Air Campaign®</i>	<i>Fulton</i>	<i>EEinGEORGIA.org</i>
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Primary Learning Outcomes

What is the correlation between energy conservation and reduction of air pollution? Which type of light bulb (incandescent or compact fluorescent) uses the most energy therefore contributes most to the problem of air pollution caused by power plant emissions? How much electrical energy is used by a light bulb and which type of bulb is most energy-efficient? How much carbon dioxide (an air pollutant) is produced by generating power for incandescent vs. compact fluorescent light bulbs? How can I use mathematics to solve real-life questions about the cost-effectiveness, energy savings, and air pollution impact of different types of light bulbs?

Additional Learning Outcomes

What would be the impact of making changes in my own home, based on conclusions drawn from this lesson? Do my actions really matter, and how big a difference could I personally make in reducing air pollution?

Assessed GPS Standards:

Grade: 6

Science Standards:

S6E6b: Students will describe various sources of energy, and with their uses, and conservation.

- b. Identify renewable and nonrenewable resources.

S8P2c: Students will be familiar with the forms and transformations of energy.

- c. Compare and contrast the different forms of energy (heat, light, electricity, mechanical motion, sound) and their characteristics.

Math Standards:

M6P1 a-d: 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 a,c: Students will make connections among mathematical ideas and to other disciplines.

- a. Recognize and use connections among mathematical ideas.
- c. Recognize and apply mathematics in contexts outside of mathematics.

Non-Assessed GPS Standards:

Grade: 6

Science Standards:

S8CS4b: Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities utilizing safe laboratory procedures.

- b. Use appropriate tools and units for measuring objects and/or substances.

S8CS3c: Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.

- c. Apply the metric system to scientific investigations that include metric to metric conversions (i.e., centimeters to meters).

S6CS4c: Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.

- c. Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rates, and temperature, and choose appropriate units for reporting various quantities.

S6CS3b: Students will use computation and estimation skills necessary for analyzing data and following scientific explanations.

- b. Use metric input units (such as seconds, meters, or grams per milliliter) of scientific calculations to determine the proper unit for expressing the answer.

Math Standards:

M6N1g: Students will understand the meaning of the four arithmetic operations as related to positive rational numbers and will use these concepts to solve problems.

- g. Solve problems involving fractions, decimals, and percents.

Procedures/Activities

Step: 1 Duration: Teacher Preparation

Review of the Teacher Resource Manual

The Teacher Resource Manual provides background information on the lesson topic and other lesson resources that may be used to answer students' question and facilitate class discussions. Review all steps in this lesson prior to beginning so that you will know what to prepare in advance for your class. Be sure to collect all the items listed in the materials section, and to make transparencies and handouts (as attached throughout the lesson) ahead of time. Also, make approximately five copies of the two-page "Light Bulb Cards" handout attached at Step 4 and cut the cards apart prior to start of the lesson.

Note: This is the second lesson in the "Electricity and Air Pollution" unit, presented by The Clean Air Campaign. For best effect, complete lesson 1: "Air Pollution and Electrical Energy," before starting this lesson.

Web Resources for Step 1

Title: 6th Grade Teacher Resource Manual

URL: http://eeingorgia.org/content/ee/docs/6th_CAC_Manual.doc

Annotation: The Teacher's Resource Manual provides background information on the lesson topic and other resources which may be used to answer students' questions and facilitate class discussions.

Please review this manual thoroughly before beginning the lesson. Graphics courtesy of MicrosoftOffice clip art. Web sites listed in this document are also linked in the Web Resources section at this step.

Title: How Hydropower Works

URL: <http://people.howstuffworks.com/hydropower-plant1.htm>

Annotation: This Web site is hyper-linked in the 6th Grade Teacher Resource Manual attached at this step. The article and diagram tell “How Hydropower Works”. Click also on “Inside the Generator” to see how a water wheel is used to generate power. Then, for fun, click on “Hydropower Footwear” to see how a water wheel is used to generate power in a new invention. Relevant to Lesson 1.

Title: The Clean Air Campaign Speakers Bureau

URL:

http://www.cleanaircampaign.com/index.php/cac/about_us/request_a_speaker

Annotation: This Web site is hyper-linked in the 6th Grade Teacher Resource Manual attached at this step. The Clean Air Campaign has a free speakers bureau. Teachers may want to arrange for a speaker during the week of lesson. Requests can be made online. Relevant to both Lessons 1 and 2.

Title: AQI Kids

URL: <http://www.epa.gov/airnow/aqikids>

Annotation: This kids’ Web site is hyper-linked in the 6th Grade Teacher Resource Manual attached at this step. It is sponsored by the United States Environmental Protection Agency and provides general information on air quality. The “What Can I Do?” link has great information on how to prevent or reduce pollution. Relevant to both Lessons 1 and 2.

Title: Watts, Kilo-Watts and Meter-Reading

URL: <http://www.gcse.com/energy.htm>

Annotation: This British Web site is hyper-linked in the 6th Grade Teacher Resource Manual attached at this step. It provides examples and background information on energy formulas, graphics for practice reading electric meters, and background information about energy. Recommended for teachers who would like to review the concepts and formulas presented in the Student Worksheet. Click on “Watt” and “Kilo-Watt” for relevant slide

presentations. (Optional: This web site could also be viewed by students on an Internet-connected computer, printed on transparencies to be shown on an overhead projector, or presented to the class with a scan converter and LCD projector or monitor). Relevant to Lesson 2.

Title: A Short History of Energy

URL:

http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=74

Annotation: This Web site is hyper-linked within the 6th Grade Teacher Resource Manual linked at this step. "A Short History of Energy" tells about sources of power historically used in this country. Check out links to other pages on this Web site from the Union of Concerned Scientists, such as "Coal vs. Wind Power" and "State Clean Energy Maps and Graphs." Relevant to Lesson 1.

Step: 2 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 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 the "Two Different Kinds of Bulbs" graphic (attached) as a PowerPoint slide or an overhead projector transparency. Tell students that although both types of bulbs contribute to air pollution, one type causes less than the other, simply because it uses less energy. 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.

Attachments for Step 2

Title: Two Different Kinds of Light Bulbs

FileName: [Two Different Kinds of Bulbs.ppt](#)

Description: This PowerPoint slide illustrates two types of bulbs: incandescent and compact fluorescent. Graphics from MicrosoftOffice. In the absence of actual light bulb specimens, arrange to show this image on a monitor or screen, or copy the graphic as a transparency and show it on an overhead projector.

Step: 3 Duration: 30 minutes

Distribute a copy of the handout: "Light Bulb Pollution Worksheet," (attached at this step) 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 Web resource linked below to show a presentation, or copy pages from as transparencies and show on an overhead projector. Also available at this Web site: graphics and directions for reading and interpreting electric meters.

Web Resources for Step 3

Title: Energy Formulas Explained

URL: <http://www.gcse.com/energy.htm>

Annotation: This Web site provides background information and examples regarding energy conversions and formulas; with graphics for practice reading electric meters. It is provided as an option for teachers who would like to review the concepts and formulas presented in the Student Worksheet. Click on “Watt” and “Kilo-Watt” for relevant slide presentations. (Meter reading activity is part of Kilo-Watt presentation).

Attachments for Step 3

Title: Light Bulb Pollution Worksheet

FileName: [Light Bulb Pollution Worksheet Final.doc](#)

Description: This student worksheet provides examples, background information and directions for conducting a cost-benefit analysis and CO₂ pollution-comparison for two types of light bulbs. Please distribute one to each student.

Title: Answer Key for Light Bulb Pollution Worksheet

FileName: [Light Bulb Pollution Worksheet Key Final.doc](#)

Description: The answer key is provided for teacher reference, while working problems in the Light Bulb Pollution Worksheet with the class.

Step: 4 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 (pollution) emitted during energy production for each bulb. Review the assumptions and formulas used in Step 3; that is, Energy Cost = \$0.075/ per kilowatt-hour (kWh) [or 7.5¢ 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.

Attachments for Step 4

Title: Light Bulb Cards

FileName: [Light Bulb Cards.doc](#)

Description: Copy and cut out cards prior to distribution. Each card represents either an incandescent or fluorescent bulb with a different wattage. Make at least three Light Bulb Cards for each pair of students, including at least one card with a compact fluorescent bulb and one card with an incandescent bulb. Graphics from MicrosoftOffice.

Step: 5 Duration: 20 minutes

Review calculations with the entire class and call on students to post their results on a poster board or large chart pad, in the format suggested by the attachment below (“Light Bulb Comparison Chart”). See “Light Bulb Comparison Chart Key,” also attached at this step, 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).

Attachments for Step 5

Title: Answer Key for Light Bulb Comparison Chart

FileName: [Light Bulb Comparison Chart Key.doc](#)

Description: Answer Key for Light Bulb Comparison Chart Worksheet. Graphics from Microsoft Office.

Title: Light Bulb Comparison Chart

FileName: [Light Bulb Comparison Chart Worksheet.doc](#)

Description: This worksheet contains a chart with blanks for student-teams to fill in data. Graphics from Microsoft Office.

Step: 6 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 necessary). 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 3. 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 s/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 attached checklist can be used as a student worksheet for the homework activity and also as a scoring rubric after the activity is completed.

Attachments for Step 6

Title: Home Light Bulb Audit Report with Scoring Rubric

FileName: [Home Light Bulb Audit Report & Scoring Rubric.doc](#)

Description: Student Worksheet for Home Light Bulb Audit Report, including Scoring Rubric. Graphics from Microsoft Office.

Step: 7 Duration: 15 minutes

Debriefing

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

Step: 8 Duration: Feedback

The Clean Air Campaign is pleased to provide standards-based air quality lesson plans for 4th through 8th grades. Please offer your feedback after implementing

this lesson plan, as there is no substitute for real classroom experience. Send teacher name, school name and address, grade level, lesson name, comments or suggestions, and the number of students who completed the lesson to: mail@cleanaircampaign.com. Each teacher who responds will receive a Clean Air Campaign goody bag as a 'thank you.'

Materials and Equipment

1. Calculator (one per student)
2. Light Bulb Cards (prepared from handout attached at step 4- three cards per team of two)
3. two types of light bulbs: incandescent and compact fluorescent (one each, per class) or
(optional) substitute "Two Different Kinds of Bulbs" PowerPoint slide (attached at step 2)
4. Light Bulb Comparison Chart enlarged on poster board or chart pad (attached at step 5)
5. Light Bulb Comparison Chart Key (attached at step 5- one for teacher)
6. Light Bulb Pollution Worksheet (attached at step 3- one per student)
7. Light Bulb Pollution Worksheet Key (attached at step 3-one for teacher)
8. optional (for use if actual light bulbs unavailable) Computer and LCD projector/TV hook-up or transparency and overhead projector for PowerPoint slide attached at step 2.

Total Duration

1 hour, 45 minutes; plus two or more evenings for homework assignment

Technology Connection

The teacher will use an LCD projector or TV hookup and the attached PowerPoint slide to show students the Two Different Kinds of Bulbs illustration (optional: please use only if no actual bulbs are available). The teacher may use a scan converter and television monitor to display one or more optional presentations from the web site linked at step 3.

Assessment

The homework assignment described in step 6 will assess student knowledge and ability to apply lesson concepts. A Scoring Rubric is included as a part of the Home Light Bulb Audit worksheet, attached at Step 6.

Extension

Remediation

Accommodation

For students with exceptional needs, what changes can be made in instruction and teaching delivery to enhance student participation and learning? Each area below is a direct link to general classroom accommodations.

[Non-readers](#) [Physical Impairments](#) [Sensory Impairments](#)
[Attention/Behavior](#) [Gifted](#)

Each disability below is a direct link to general classroom accommodations specific for that disability.

[Autism](#)

[Deaf - Blind](#)

[Deaf/Hard of Hearing](#)

[Emotional and Behavioral Disorder](#)

[Mild Intellectual Disability](#)

[Orthopedic Impairment](#)

Other Health Impairments:

[Attention Deficit Disorder/Attention Deficit Hyperactivity Disorder](#)

[Tourette Syndrome](#)

[Significant Development Delay](#)

[Specific Learning Disability](#)

[Speech - Language Impairment](#)

[Traumatic Brain Injury](#)

[Visual Impairment](#)

Modification

For students with significant disabilities, what changes can be made in instruction and teaching delivery to allow students to participate in classroom instruction while working on IEP objectives and off grade level GPS standards. Below are suggested modifications correlated to the procedures of this lesson plan.