



Lesson 8: Light Bulbs and Energy Efficiency

Overview

Students begin to develop an understanding of energy efficiency and the importance of energy conservation by comparing different light bulbs. By comparing the amount of energy, heat, bulb life, and light output each bulb delivers, students learn that some bulbs provide the same light output using less electrical energy. The lesson culminates with a discussion about the broader impact of using energy wisely.

Teacher Background

A seemingly limitless amount of energy bombards planet Earth every day in the form of sunlight. Virtually all the energy we use originates from the sun. Sunlight contains an enormous amount of energy. Even with such an abundance of energy available from the sun, concerns about fiscal and environmental energy “costs” take center stage in our nation.

There are three key ideas in understanding the energy dilemmas facing our world:

- 1) energy is not created or destroyed,
- 2) energy changes from one form to another, and
- 3) in a transformation, some energy is given off as heat.

Energy comes in many different forms and energy changes from one form to another. By the time energy is delivered to us in a usable form, it has typically undergone several transformations. While energy doesn't disappear in nature, as it is transformed, it changes into forms that are sometimes not as readily available for its intended use and/or easily harnessed. This excerpt, from the National Academy of Sciences resource *What You Need to Know About Energy*, illustrates the energy transformation issue: “On a clear day, solar radiation (sunlight) reaches Earth with more than enough energy in a single square meter to illuminate five 60 watt light bulbs. IF all the sunlight could be captured and converted to electricity.... Imagine that the coal needed to illuminate an incandescent light bulb contains 100 units of energy when it enters the power plant. Only two units of that energy eventually light the bulb. The remaining 98 units are lost along the way, primarily as heat.” Herein lies the problem: IF all the sunlight could be captured and converted to the desired form (electricity)... and not “lost” as heat along the way.



Note: Electricity is measured in units of power called "watts." One watt is a fairly small amount of power. An average household incandescent light bulb may use 60-100 watts when it is on. A 100-watt light bulb would use 1000 watt-hours if left on for 10 hours. A kilowatt represents 1,000 watts. A kilowatt-hour (kWh) is equal to the energy of 1,000 watts working for one hour. Kilowatts and kilowatt-hours are useful for measuring amounts of energy used by large appliances or households. One megawatt is equal to 1,000 kilowatts, or 1,000,000 (1 million) watts. The numbers vary, but on average, one megawatt is enough electricity for 500-1,000 average households here in the US. (kidwind.org)

Even though students have not been formally introduced to the concept of energy transformations, they can develop a basic understanding of the idea that not all of the energy available (from a power plant, battery, fuel, etc.) gets used entirely for "desired effects." Some energy is used unintentionally in devices in ways that people can't control. To help develop an understanding of using energy efficiently, students spend some time at the beginning of this lesson thinking about the intended use and unintended use of energy in some familiar devices. This introduction helps lay the foundation for more formal concept development of transformations in the middle and high school grades, helps students understand some of the challenges involved in using energy efficiently, and gets students thinking critically about the kinds of devices that minimize or redirect "unintended" energy effects.

As students revisit the variety of ways electricity is generated and the number of steps involved in getting electric current to light our homes, schools, and businesses, it may be tempting to refer to the energy that gets transformed to heat or other undesired forms as "lost." One of the most basic principles of energy, known as the *Law of Conservation of Energy* or *First Law of Thermodynamics*, states that energy cannot be created or destroyed. Energy is never "lost" but rather it is transferred to other places and in other forms. Describing this energy as "lost" may confuse students as they work toward developing an understanding of these more sophisticated energy concepts in future grades. Additionally, students at this age typically confuse energy and energy sources, making it even more challenging to get around the thinking that energy is "lost." Batteries, food, and oil do in fact get "used up." However, the energy they contain does not disappear, but rather is changed into different forms. Students do not need to exit this lesson with a clear understanding of the Law of Conservation of Energy, but clarifying the use of the word "lost" will assist students in developing a more accurate understanding of energy. While these concepts are formally introduced to students in middle and high school, students in this grade span can begin developing an understanding of some of the precursory ideas.



So if energy is never “lost” why is it important to use energy efficiently? The problem is that Americans primarily use fossil fuels for energy. Our current rate of fossil fuel consumption presents a number of problems. We are depleting the Earth's finite amount of fossil fuels faster than it can ever be replenished. Coal, oil, and natural gas take millions of years to form deep within the earth. Because of this, fossil fuels are considered non-renewable energy sources.

Burning fossil fuels also presents an environmental problem. As fossil fuels are burned, carbon dioxide gas and particulate matter is released into the air. Carbon dioxide builds up in the atmosphere creating a blanket that traps heat. Scientists believe that the excessive buildup of “greenhouse” gases like carbon dioxide is the primary cause of global warming. Elevated amounts of particulate matter in the air contribute to health problems, such as asthma, and contribute to acid rain and global warming. Smog is the direct result of the dust and smoke released into the air as a result of burning fossil fuels.

Students have undoubtedly heard terms such as energy-efficient, global warming, greenhouse gases, and climate change. **Be advised that the topic of climate change and global warming is disturbing to many students.** Consider following the recommendations outlined in the Edutopia article *“Truth and Consequences: Teaching Global Warming Doesn't Have to Spell 'Doom'”* as this subject matter is breached. The article suggests that being selective and honest in what is shared, focusing conversations on positive things that are happening, and giving students something easy they can do to make a difference will reduce students' fears. (Visit <http://www.edutopia.org/global-warming-fear> to read the article in its entirety.) This lesson was designed with those recommendations in mind.

Comparing light bulbs provides a concrete way to engage upper elementary students in a complex topic – the need for energy efficiency. Whether at home or in school, all students can take action by monitoring their light usage and/or by replacing incandescent light bulbs with more efficient versions.



Key Ideas

- Not all the energy that a device uses gets used in the way that people intend. As energy moves from place to place, it always produces heat, which is often an undesired effect.
- Things that are energy-efficient use less energy to do the same task. Energy-efficient devices minimize or redirect unintended energy effects.
- Using energy responsibly is something everyone can and should do.





Lesson Goals

Students will:

- develop an understanding of energy-efficiency and the importance of energy conservation.
- discover that some devices do the same job but use less energy to do so.
- recognize that there are many factors to consider when deciding how to use energy responsibly.

Vocabulary

CFL (compact florescent lamp): smaller spiral shaped fluorescent light bulbs that emit light as electricity interacts with gases and a coating on the inside of the bulb.

energy efficient: the amount of energy in a device used for the intended purpose compared to the amount of energy that is transferred into an unintended purpose.

LED (light emitting diode): a source of lighting that is long-lasting, hard to break, and energy efficient,

lumen: the light emitted by a light source.

incandescent light bulb: a source of light that emits light as an electric current is passed through a thin filament which glows with intense heat.

nonrenewable resource: resource that does not replenish as part of natural ecological cycles.

renewable resource: a resource that replenishes as part of natural ecological cycles.

watt: unit of power that is used to measure electricity

Preparation

- Set up the desk lamps in a central location.
- Practice the demonstration.

Safety

An adult will demonstrate the heat comparison for the different bulbs. Review the safe handling of CFLs. In the event of accidental breakage, follow the U.S. Environmental Protection Agency's recommendations for clean up and safe disposal outlined at:

<http://www.epa.gov/mercury/spills/>

Materials

Item	Quantity
Packaged CFL light bulb (prop)	1 per class
Packaging from 25 and 100 watt incandescent light bulbs, and 26 watt compact florescent (optional: 13 watt LED packaging if using)	1 set per group
Desk lamps (access to electrical outlets and/or power strip)	2-3 per class
Incandescent light bulb 100 watt	1 per class
Incandescent light bulb 25 watt	1 per class
Compact florescent light bulb 26 watt	1 per class
LED 13 watt (optional)	1 per class
Thermometer	1 per class
Scientist's Notebook	1 per student
Chart paper and markers (optional)	1
Extension cord	1
Student Handout 8.1: Comparing Light Bulbs	1 per student

Note: The materials for this lesson can be modified as incandescent light bulbs become more difficult to obtain and as LEDs become increasingly available and affordable. Select bulbs that have similar light output (lumens) but different wattages to compare. For example, a 26 watt CFL, 100 watt incandescent, and a 13 watt LED all have a light output of approximately 1600 lumens.



Time Required: 2 sessions

Connection to Maine Learning Results: Parameters for Essential Instruction (MLR) and Benchmarks for Science Literacy (BSL)

- Some people try to reduce the amount of fuels they use in order to conserve resources, reduce pollution, or to save money. BSL 8C/E4 (3-5)
- Explain that natural resources are limited and that reusing, recycling, and reducing materials and using renewable resources is important. MLR C3 (3-5) c
- Give examples of changes in the environment caused by natural or man-made influences. MLR C3 (3-5) b
- Explain how scientific and technological information can help people make safe and healthy decisions. MLR C3 (3-5) a



Teaching The Lesson

Engage

1 Initiate thinking about “energy efficiency.”

Initiate students' thinking about “energy efficiency” by holding up a packaged CFL light bulb and saying aloud to the students: *This package states that it contains energy-efficient light bulbs. Where have you heard the term “energy-efficient” before and what do you think it means?* (Most likely students will have heard of this term. Students may suggest certain cars, appliances, fuels, etc. are energy-efficient, or they may suggest habits related to energy efficiency.)

Summarize students' comments by saying: *What does “energy-efficiency” mean?* Post the follow focus question on the board and ask students to do a quick write in their notebooks:

- *What makes something “energy efficient?”* and
- *How would you describe an energy-efficient light bulb?* (It may be helpful to ask students to think about the characteristics of an energy-efficient light bulb and/or why a light bulb would get labeled as being “energy-efficient”?)



2 Create working definition of energy efficiency.

After students have a few minutes to capture their thoughts in their quick write, develop a working definition of “energy-efficient” that is reflective of their quick write thinking. Students will revisit and revise their working definition of “energy-efficient” later in the lesson.

3 Develop idea of using energy for desired effects.

Ask students what “job” is being performed by a light bulb? In other words, what is it that we want the energy used for when we turn on a light bulb? (We want the energy to produce light.) Explain to students that not all of the energy that a device uses gets used in the way we want. (Note: In any transformation, heat is **always** given off. Students will investigate the heat given off by different bulbs later in this lesson.)

To illustrate this point, ask students to think about the way energy is used in common household devices. Begin with the following example:

- How do people want the energy in a device to be used and how is all the energy in the device used? For example, when a vacuum cleaner uses energy, what is it that people want to use energy to do? (People want to use energy to remove/suck up dirt.)
- What else does the vacuum do that we don't necessarily want it to do? (Energy in a vacuum also produces sound and heat, which is an undesired use of energy in that device).

Note: The prompt “What other ways is energy used in a vacuum cleaner?” may need to be rephrased if students do not readily equate energy with the sound or heat it also produces. Because the focus of this module is light and electricity, students may not be familiar with other forms of energy such as sound or motion/mechanical. The emphasis here is to recognize that energy is not expended exclusively on desirable effects in devices rather than correctly identifying other forms of energy.

Discuss the other examples summarized in the chart below and ask students to suggest other examples.

Note: The goal is to introduce students to the idea that there are many forms of energy, and as energy is transformed from one form to another, it is sometimes transformed into forms that are less desirable or unusable. It is not expected that students understand energy transformations at this grade span. The main idea is to help students develop an understanding of the challenges of using energy efficiently and to set the stage for formally investigating energy transformations in middle school.



Example of Human-made Device	Intended or Desired Effect	Unintended effect(s)
Vacuum cleaner	Remove dirt	Emits sound and heat
Hand-held video game, TV, computer	Light and sound	Emits heat
Electric mixer, blender	Motion (blends/chops foods)	Emits sound and heat
Drill, pencil sharpener	Motion	Emits sound and heat
Automobile	Motion	Emits sound and heat
(Toaster) oven or stovetop	Heat (cook) food	Emits light
Light bulb	Emit light	Emits heat

Explore

4 Determine relevant information.

Set the stage for an investigation comparing light bulbs by asking students the following:

- *How do we know if one light bulb is more efficient than another light bulb?*
- *What should be considered when comparing light bulbs?*

As students suggest what should be considered when comparing light bulbs, make a list of their ideas on the board or on chart paper. Make certain that students have included the following in their list:

- Amount of light produced (lumens)
- Amount of energy a light bulb uses (watts)
- Amount of heat the bulb gives off
- Length of time the light bulb lasts ("life")

Note: *Students may want to add "how much the bulb costs" in this list. Acknowledge that cost is a big concern and that this aspect will be considered later in the lesson. For now, the focus is on comparing energy use and cost is indirectly related. Some students may also suggest "environmental impact." You may or may not want to include this on the list at this point, depending on whether the impact is tied to energy use and whether the student can articulate the connection at this point. Perhaps the best solution is to include these suggestions on the list and explain to the class that these are important considerations that will be examined later in the lesson.*



5 Determine how to collect information.

Provide each group of students with packaging from an incandescent light bulb and a compact florescent light bulb.

Note: *This lesson may be modified to include LEDs. Refer to the explanation in the materials section.*

Ask students to examine the information on the light bulb packages, making note of the information that can be found on the packaging and noting terms that are unfamiliar to them. Clarify the following:

- **Lumens:** a measure of the amount of light produced
- **Watts:** the amount of energy per second a light bulb uses
- **Life:** the average amount of time a light bulb will last, measured in hours

Suggest to students that the packaging provides a lot of valuable information (refer to list generated earlier in step 4) that can be used to compare light bulbs but that the packaging doesn't provide all of the information needed to compare bulbs thoroughly. Ask students for suggestions as to how the amount of heat a bulb gives off can be safely measured. Suggest to students that a thermometer could be used to measure how much heat is given off as each bulb is used in a lamp.

6 Organize data.

Before allowing students to begin collecting the relevant information about each type of light bulb in their notebooks, suggest that they think about and develop a way to organize the information they are collecting. Alternately, show students how to set up a data table or provide students with a copy of the data table included in this lesson.

7 Conduct the demonstration and investigation.

Explain to students that an adult will help them measure the amount of heat given off by each bulb. If a parent volunteer or other adult is not available to assist groups, the teacher can carry out this part as a demonstration following this procedure:

- Place an incandescent bulb in a lamp and turn it on. Ask students to observe the light that is produced. (Students could measure the light output using a light meter if available).
- Hold a thermometer six inches above the bulb for one minute and record the temperature. (A student volunteer may read the temperature as long as it is emphasized that the student should not get too close to the bulb or touch the bulb. Consider allowing students to carefully hold their hands a few inches away from the bulb to get a sense of the heat the bulb produces.) Turn the bulb off and let the bulb cool.
- Remove the incandescent bulb, place another bulb in the lamp and turn it on.
- Observe light output and record temperature as before.
- Repeat with remaining bulbs.

Provide each group of students with the packaging for each of the light bulbs used in the demonstration. Have students examine the packaging and record the relevant data in their notebooks.



Reflect And Discuss

8 Analyze results and draw conclusion.

Instruct students in their small groups to review the data they collected. Post the follow up questions and ask students to use the data they collected in their notebooks to support their answers (back with evidence).

- *What were the differences in the amount of light the bulbs produced?* (The amount of light that a bulb produces varies. When comparing incandescent bulbs of higher wattage to incandescent bulbs of lower wattage, bulb with higher wattages are brighter. CFLs emit the same number of lumens using fewer watts than incandescent bulbs.)
- *How did the bulbs compare in heat production?* (Incandescent bulbs produce much greater amounts of heat than CFLs.)
- *Which bulb is more energy-efficient? What evidence do you have?* (The CFL packaging states that CFLs have a longer life than a comparable incandescent bulb. This, however, varies somewhat from manufacturer to manufacturer.)

9 Relate findings to the importance of energy efficiency.

After students have reviewed their findings and discussed the follow up questions in small groups, engage students in a class discussion about light bulbs and energy efficiency. Begin the discussion by allowing each group to briefly share which bulb they considered to be more energy-efficient and what evidence they can offer to support their answer. As the discussion about energy-efficient light bulbs progresses, ask students to address the following:

- *Why is it important to use devices, including light bulbs that are energy-efficient?*

As the importance of energy efficiency is discussed, revisit some of the earlier ideas students have encountered in this module, especially ones about how energy is produced on a wide-scale basis and what is required (a source, pathway) to light a bulb. Incorporate the following talking points (it may be helpful to list each of these points on the blackboard or on chart paper for students to reference later):

- **Using light bulbs that are energy-efficient means using less energy to do the same “job.”** Students should have noticed that the 25 watt CFL gives off the *same light output* (lumens) as the 100 watt incandescent bulb *using less energy*. The 100 watt incandescent bulb produces much more heat and has a shorter bulb life.



- **Using less energy means that our energy resources will last longer.** Ask students to recall the kinds of fuels used for wide-scale electricity production. The majority are fossil fuels (coal, oil, natural gas). *The amount of fossil fuels on Earth is limited* because these fuels are the *fossilized remains* of dead plants and animals that have been exposed to heat and pressure in the Earth's crust over hundreds of millions of years. Fossil fuels take millions of years to form. Once they are used up, they are lost to us. Fossil fuels are called “non-renewable” forms of energy because they take too long to be replenished.
- **Using fewer fossil fuels means that we can reduce the impact on the planet.** When fossil fuels are burned to produce steam in power plants, gases are released that can harm the environment. Some of these gases, called greenhouse gases, collect and act like a blanket, trapping heat. As more and more of these gases collect, the blanket becomes thicker and if it becomes too thick the Earth's temperature will increase. This increase in temperature can lead to some serious problems for Earth including drought, melting of ice caps, extreme weather, flooding, loss of crops, etc. This phenomenon is referred to as global warming. *Decreasing the amount of fossil fuels burned means that fewer harmful gases are released into the air that contribute to climate change.*
- **Using fewer fossil fuels means producing less harmful pollution.** *When fossil fuels are burned tiny particles are released into the air.* The dust and smoke released into the air irritates people's lungs and can contribute to health problems, such as asthma. Students may have seen smog, a brownish-yellow haze in the air, caused by tiny particles combining with gases in the air. Acid rain occurs when pollutants combine with precipitation. It has harmful effects on the environment and man-made structures.
- **Using energy-efficient light bulbs saves money!** Students may be interested in conducting a follow up activity to determine the cost of using each type of light bulb. Assist students in devising a fair way to compare cost. (ex: Cost/hours of light bulb life)

Revisit students' earlier definition of “energy-efficient” and ask if they want to make any changes to their definition. Guide students toward a definition that includes the idea that something is considered more energy-efficient when it uses less energy to perform a certain job. A suitable definition should include the idea if something is energy-efficient, it uses energy in the most productive way to achieve the desired effects with as little waste as possible.



10 Bring lesson to a close.

Discuss the following question:

- *If CFLs (and/or LEDs) are more energy-efficient and last longer, then why doesn't everyone use them?*

Ask students to think about why everyone does not use the most energy-efficient devices available, such as CFLs or LEDs? Give students a few moments to talk with the person next to them about their ideas before opening up the conversation to the whole group. Students may offer the following ideas:

- Many energy-efficient devices such as CFLs and LEDs often have higher upfront costs than other devices.
- Some energy-efficient devices are hard to find locally.
- Some energy-efficient devices cannot be used in the same places as other devices. (Ex: CFLs are often recommended for indoor use only.)
- People do not know about energy-efficient devices such as CFLs or LEDs.
- Some energy-efficient devices such as CFLs contain small amounts of harmful substances and have to be recycled rather than thrown away. (Note: CFLs do contain a small amount of mercury which is toxic. CFL packaging identifies hazards and specifies handling and disposal procedures. For more information visit: <http://www.epa.gov/mercury/spills/index.htm#fluorescent>.)
- Some people may think that using energy-efficient devices doesn't really make a difference.
- Some people may think that using energy-efficient devices is "not cool."



11 (Optional) Share energy-efficient learnings knowledge with others.

As a culminating exercise, ask students to select one or more of the talking points outlined in step 9 about energy efficiency to share in one of the following ways:

- Create a short skit, poster, song that highlights an energy-efficient concept. Share these with classmates and/or other classes.
- Design a postcard with a picture and greeting that captures an energy-efficient learning concept. Send it to a student at another school, family member, or friend.

Extensions

Student may:

- visit Energy Star “Choose a Light” interactive guide to learn more about how to make the right lighting decisions for the task at hand. (The link to the Guide is on the right hand side of the webpage). http://www.energyfederation.org/efficiencymaine/default.php/cPath/39_3042_2376
- expand their comparison of different types of light bulbs to include costs.
- write a short persuasive paragraph or develop a poster explaining which types of bulbs are most energy efficient. The writing and/or poster can be shared with the school community to convince those making bulb purchases to use the recommended bulbs.
- conduct a survey to find out where they see energy efficient bulbs being used. For example, energy efficient are being used in many more facilities, including in airports and lighthouses and for holiday lighting.
- search local newspapers, magazines, and the Internet for articles about energy-efficient lighting devices or technological advances in energy efficiency. Write a summary of their finding to share with others by posting these in a public place.

Connection to Maine Agencies

MEEP (Maine Energy Education Program) has several activities related to this lesson and will come to interested schools, free of charge. The MEEP website is <http://www.meepnews.org/classroomactivities>

- **Energy Patrol (4th to 8th grade):** Are lights left on when they are not being used? The energy patrol tours the school and rewards the classroom that does the best job saving electricity with a week's care of a toy armadillo, an emerging symbol for climate change.
- **Light Meter/Lighting Survey:** Students learn how to use a light meter and inventory the light levels in their school to see if any areas are over-lit.
- **Kill A Watt:** Students learn how to use a Kill A Watt meter and use it to find phantom loads and inefficient appliances at school and/or home.
- **Home Lighting Inventory:** Students take an inventory of the lighting in their homes – number of fixtures, types of bulbs, and how long the lights are used per day - to see what impact lighting has on their electricity consumption.



For schools in Aroostook County, a Maine Public Service (MPS) representative will come to interested schools, free of charge, to guide and support concepts developed in this lesson. A description of programs is available at www.mainepublicservice.com. Click on the education section of the site. To schedule a visit contact Nancy Chandler at 207.760.2556 or nchandler@mainepublicservice.com.

Online References and Resources

Science in Focus: Energy Workshop 8.

<http://www.learner.org/resources/series160.html#>

