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 in to the air.* The dust and smoke released into the air irritates people’s lungs and can *contribute to heath 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 at207.760.2556 or nchandler@mainepublic service.com.

Online References and Resources

Science in Focus: Energy Workshop 8.
http://www.learner.org/resources/series160.html#

Comparing Light Bulbs

Bulb Type	Watts	Observation of Light Output (bright/dim)	Light Output (Lumens)	Observation of Heat Output (hot/warm/cool)	Heat Output (temperature in °C)	Bulb Life (hours)
Incandescent	100					
Incandescent	25					
CFL	26					
LED	13					

Lesson 9: Bright Schools

Energy Knowledge in Action!

Overview

In this culminating lesson, students examine electric lighting used in their schools and determine if there are methods that can reduce the amount of energy being used for their schools' lighting.

Teacher Background

Schools spend more money on energy than on textbooks, computers, and other school supplies. Lighting accounts for approximately 15% of the total energy bill of educational institutions nationwide. (Source: US Department of Energy's Office of Energy Efficiency and Renewable Energy, 1999.) Older buildings, particularly those constructed before 1970, have high levels of illumination and may use outdated incandescent or fluorescent light fixtures. Sometimes even more modern buildings have inefficient lighting.

The majority of lighting in most schools is from florescent tubes. In order to operate, a fluorescent tube needs to have a ballast. The ballast regulates the electric current passing through the gas inside the florescent light bulb. There are two types of ballasts, magnetic and electronic. Magnetic ballasts have lights that flicker. Electronic ballasts are more energy-efficient than those powered by magnetic ballasts, and reduce eyestrain and other negative health effects caused by some older fluorescent lighting systems. Electronic ballasts use up to 30 percent less energy than magnetic ballasts.

Electricity is used to provide artificial lighting to various school areas such as classrooms, cafeterias, corridors, offices, sports fields, and parking areas. Maximizing the use of natural light and installing more energy efficient fluorescent lighting systems can significantly reduce energy costs. Turning off unnecessary lights and proper system maintenance can also make an impact on lighting costs for the school. Even the most efficient fluorescent system is not efficient if it is used indiscriminately.

Some schools have been designed to use natural lighting effectively, particularly in common spaces such as libraries, entryways, hallways, and cafeterias. In addition to making the best use of available natural light, newly constructed schools are often equipped with devices called lighting controls that turn lights on and off or dim lights. Photocells, timers, occupancy sensors, dimmer switches and other lighting technologies help reduce unnecessary energy use. State agencies in Maine provide support and guidance for school construction, not only to reduce the cost of energy, but also to reduce fossil fuel consumption and improve the environment in and outside schools.

Does turning off the lights when not in use or changing the type of light bulbs that are used to light schools, businesses, and homes really make a difference in reducing humans' impact on the planet? In March of 2007, in an effort to raise the awareness of the greatest contributor to global warming, coal-fired electricity, the entire city of Sydney Australia turned its lights off for one full hour. In this one-hour, 2.2 million people and over 2,100 businesses turned off their lights, reducing energy use by 10%. This is equivalent to taking 48,000 cars off the road! This bold act caught the attention of people across the planet and in 2008, 24 cities worldwide repeated this effort. (For more about this and future "Earthhour" events visit http://www.earthhour.org/) The message is clear: from turning off the lights when rooms are empty to replacing inefficient bulbs with more efficient versions and making the most of natural lighting whenever possible, simple changes collectively make a difference.

Students and many adults have great difficulty making sense of the complex connections between seemingly simple actions such as turning off lights when not in use and global climate change. While it is not expected that students understand all of the intricate details of this connection, it is important for students to understand that there is a connection and their efforts do make a difference. The above example of Sidney is a collective effort – students need to be convinced that single efforts make a difference.

It can be easy for students and adults alike to become overwhelmed and even discouraged with the prospects of climate change. This lesson is designed to provide opportunities of empowerment for students. Care must be taken that the message of this lesson be delivered in a way that is empowering and not frightening to students. The idea of climate change and the role electricity production and usage plays in it is very abstract and can be difficult for students to grasp. This lesson isn't meant for students to thoroughly understand those ideas and connections. They simply aren't developmentally ready either intellectually or emotionally. But they are ready to study the fact relationship electricity production and usage and the changing climate. So what are teachers and students to do? It's as simple as turning out a light. Remember this powerful quote from an insightful person as you proceed through this lesson:

Never doubt that a small group of thoughtful committed citizens can change the world. Indeed, it is the only thing that ever has.

–Margaret Mead, *anthropologist*

Note: *Even after instruction about electricity production, students may have questions that stem from misconceptions such as:*

- *Does carbon dioxide come out of the lights when they are turned on? (No it doesn't. The carbon dioxide comes from the coal, oil, natural gas power plants that create the electricity but many students think the CO_2 comes right from the bulbs themselves).*
- *Is it true that it takes more energy to turn the lights on than to leave them on? (False. This belief comes from thinking about antiquated light bulbs. This is not true of light bulbs used today.)*

Key Ideas

- By modifying habits, people can reduce the amount of energy being used for lighting.
- By taking action, students can incorporate these simple habits to save energy at school.
- These actions are cumulative, important, and have an effect on our environment.

Lesson Goals

Students will:

- conduct a survey to determine how energy is used for lighting in school.
- make recommendations for reducing the amount of energy being used for lighting in school.
- recognize that everyone can contribute to using energy more responsibly by including simple habits like turning off a light when it is not needed.

Vocabulary

survey: a method of collecting information for the purpose of analysis of a particular issue.

Preparation

- Alert the principal, teachers, staff and custodian that students will be conducting a light survey of the school as part of their energy studies.
- Become familiar with different examples of light surveys. Numerous examples of light survey can be found online. Some to review are:

  XCEL Energy's School Light Survey
  http://www.energyclassroom.com/conservation.php

  Battle of the Bulbs Home Light Bulb Survey
  http://wattwatchers.org/Assets/kisp/incanvscfl.pdf

Materials

Item	Quantity
Scientist's Notebook	1 per student
Paper for drawing diagrams of school	1 per team
Clipboards	1 per team
Master Diagram of School	1 per team
Student Handout 9.1: Recommended Light Levels	1 per student
Light meter (optional)	1 per class

Time Required: 2-4 sessions

Connection to *Maine Learning Results: Parameters for Essential Instruction* and *Benchmarks for Science Literacy*

- 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

Teaching The Lesson

Engage

1 Present the scenario.

Present the following or a similar scenario to students:

The principal of our school knows that our class has been learning about how Energy Lights Maine and more specifically, how much energy is used to light our school. We have learned that lights use a lot of energy and, unfortunately, energy use in lights is not always efficient. Because we have been learning so much about energy with respect to lighting, the principal wondered if our class might have some suggestions as to how we might, as a school, reduce the amount of electricity used in our school for lighting?

Ask the class why the principal might be concerned about the school's energy use. This provides an opportunity to revisit the connection between energy use, conservation, and the environment. (See step 9 in Lesson 8.)

2 Brainstorm and share suggestions.

Allow students time to brainstorm and discuss their ideas in pairs or small groups, before facilitating a whole class discussion. It may be useful to chart their initial ideas on paper or a black/white-board.

3 Discuss developing a light survey.

During this discussion, guide students toward the idea that it may be beneficial to first determine the current amount of light use in the building. Knowing the current status of lighting in the school, including the different sources, number of lights, how many hours lights are on, etc. is valuable information because it can help determine the changes necessary and if energy is being saved in the future.

Numerous examples of light survey can be found online.
Some to review are:

XCEL Energy's School Light Survey
http://www.energyclassroom.com/conservation.php

Battle of the Bulbs Home Light Bulb Survey
http://wattwatchers.org/Assets/kisp/incanvscfl.pdf

Note: *Alternately, students could develop and carry out a light survey of one common room in the school, such as the library or cafeteria, or specific area or wing of the school, as practice or in lieu of conducting an entire school light survey.*

4 Assist students in creating a light survey.

Create a simple, easy to follow master diagram of the school or create one as a class the day before the students conduct their survey. Label classrooms, offices, hallways, restrooms, libraries, gymnasiums, cafeterias and other common areas and non-classrooms on the master diagram. Make photocopies of the labeled diagrams. Students will initially record their data directly on these diagrams. Students should consider including the following information in the diagram:

- location surveyed (room number or name)
- number of lights
- type of lights
- number of light switches in each room and each common area as well as the number and location of each light fixture that goes with each switch.
- number of hours lights are on (copies of the school schedule may help in gathering and estimating this information. Suggest students (that they may want to) talk to the custodian to get a more accurate picture of when lights are turned on and off each day.)
- if it is a sunny day or not
- (optional) readings from light meter(s).

Explore

5 Carry out light survey.

Divide the class into small groups or teams. Pair each team with an adult volunteer and assign each team to an equal number of classrooms, common areas, and non-classrooms to survey. Give each team a clipboard with a diagram of the school attached. Guide the students through the school and conduct the survey. Record the type of lighting, number of light fixtures, and on/off switches in each area. Make note of any light fixtures that can be turned off during the course of the day. Alternatively, have teams of students schedule convenient appointment times with individual classroom teachers, perhaps visiting these teachers during a break or planning period. This approach may give students a chance to interview each classroom teacher and office employee.

> **Note:** *If you have a light meter, review its use. Also review the Recommended Light Levels sheet that accompanies this lesson (Lesson 9) and use the light meter to determine light levels with lights on and with lights off for each area visited and record that information.*

6 Create a class chart.

After students return with their surveys, work as a class to create a class data collection chart. Each student group records the light information gathered from the school survey. Information on the class data chart should include all the information recorded on each diagram.

Reflect And Discuss

7 Bring lesson to a close.

Review and analyze data. Make recommendations. Have students review the data they collected in their survey. Ask students to respond in their notebooks to the following prompt(s):

- Write a short summary that describes what you found out about light use through your survey.
- List three things that you would recommend to the principal, classroom teacher, and students to reduce the amount of energy that is used in our school for lighting.

Discuss the findings and brainstorm ways to conserve energy. Draw up a list of recommendations to present to the school administration and the energy manager.

8 Develop and present plan to school.

Ask students to develop a plan that will encourage everyone in the school to be more aware of the issues related to energy use for lighting. Students' plans can be as simple or as elaborate as time and abilities permit. Action ideas that students might want to try include:

- Setting up an energy patrol by contacting MEEP. *The Maine Energy Education Program* (MEEP) will provide guidance in setting up a daily monitoring activity known as an *Energy Patrol*. Energy Patrols are aimed at empowering students and helping students and teachers remember to save electricity. Students simply tour the school during lunch or recess to make sure lights and computer monitors are not left on while not in use. MEEP may be contacted through their website: http://www.meepnews.org/

- Create "doorknob reminders" that could be placed on classroom doorknobs to remind them to turn out the lights when they are not needed.
- Create posters for the hallways throughout the school.
- Create a multimedia presentation that can be played over televisions located in common areas.
- Conduct a follow up investigation using light meters to determine if the recommended light levels could be attained by using natural or alternative lighting.
- Calculate/estimate financial savings of switching to more efficient lighting (ex: CFLs or LEDs)

Extensions

Student may:

- examine how new lighting technologies are used in schools, businesses and homes.
- read articles about or "tour" (virtual or otherwise) a school that has incorporated new lighting technologies.
- conduct a similar activity at home to see how lights are used there. Check for devices that control lights such as sensors or timers.
- talk with an energy auditor and/or weatherization specialist.
- take an online quiz about climate change http://news.bbc.co.uk/cbbcnews/hi/specials/climate_change/default.stm
- design an energy-efficient school.
- learn how to read an electric meter. MEEP and MPS are available to assist students and teachers in Maine.

Connection to Maine Agencies

MEEP (Maine Energy Education Program) has an *Energy Patrol* (4th to 8th grade) Activity focusing on the question: *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.

MEEP also has *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.A MEEP representative will come to interested schools, free of charge, to guide this activity. The MEEP website is http://www.meepnews.org/classroomactivities

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

Lesson modified from:

http://www.earthcarecanada.com/EarthCARE_Program/Lessons/4_light_detective.pdf

Recommended Light Levels

Below is a list of recommended illumination levels for school locations in footcandles.

From the National Energy Education Development Project (NEED)'s Learning and Conserving Teacher Guide and Student Guide (2004) www.need.org

Area	Footcandles	Type of Lighting
Classrooms – general	50-75	fluorescent
Classrooms – art	50-75	fluorescent
Classrooms – computer	50-75	fluorescent (indirect)
Classrooms – drafting	75-100	fluorescent
Classrooms – sewing	75-100	fluorescent (task lighting)
Labs – general	50-75	fluorescent
Labs –demonstration	100-150	fluorescent (task lighting)
Auditorium seating areas	10-15	fluorescent
Auditorium concerts on stage	50-75	fluorescent
Kitchens	50-75	fluorescent
Cahiers	20-30	fluorescent (task lighting)
Dishwashing areas	20-30	fluorescent
Dining areas	10-20	fluorescent
Corridors and stairwells – elementary	10-15	fluorescent
Corridors and stairwells – middle	20-30	fluorescent
Corridors and stairwells – high	20-30	fluorescent
Gymnasiums	20-30	metal halide / fluorescent
Media Centers	50-75	fluorescent
Offices	75-100	fluorescent
Teacher workrooms	30-50	fluorescent
Conference rooms	30-50	fluorescent
Washrooms	20-30	fluorescent
Building exteriors and parking lots	1-2	sodium / metal halide

Master Materials Checklist

✓	Quantity	Item	Lesson(s)
❑	1	Materials to make classroom dark	1
❑	1	Small light such as a flashlight or book light	1
❑	1	*Raven A Trickster Tale from the Pacific Northwest* by Gerald McDermott	1
❑	1 per group	Teacher Resource 1.1: *Early Light* Card Set	1
❑	1	Chart paper, markers, tape	1,2,4,5,8
❑	1 per student	Scientists' Notebook	1-9
❑	1 per student	Student Handout 1.1: Blank Light Card template	1
❑	1	Wire stripper	2,3
❑	1	Teacher Resource: 2.1: Simple Circuit Configurations	2
❑	1 per group	Flashlight with batteries	2,5
❑	1 per student (have spare materials on hand)	Basic Circuit Kit: • Wire, 22-gauge, insulated (1 12" piece, stripped) • D battery • Incandescent flashlight bulb (replacement type)	2,3,5
❑	1 set per group	An assortment (4-6 different styles) of incandescent light bulbs (e.g. flashlight bulbs, holiday replacement bulbs, decorative flame or teardrop shaped bulbs, etc. Avoid bulbs with frosted or colored glass.	3
❑	1 per set of bulbs	Tray or boxes (for distribution of bulbs and to prevent bulbs from accidental breakage)	3,5
❑	1 per student	Hand lens	3
❑	1 per student	Safety goggles	3
❑	1 set per group	Colored pencils	3,5
❑	1	Access to LCD projector, laptop, speakers, internet	3,6,7
❑	1 set per pair (have spare materials on hand)	Supplementary circuit components: • Bulb holder (some bulb holders may require a Philips head screwdriver) • Battery holder • 2 additional 12" pieces of wire, stripped	3,4

Master Materials Checklist *(continued)*

✓	Quantity	Item	Lesson(s)
❑	1 set per pair	Switch components: • index card • 2 brad fasteners • 2 metal #1 paper clips	3
❑	1	Teacher Resource 3.1: Incandescent light bulb diagram	3
❑	1	Teacher Resource 3.2: Desk lamp diagram	3
❑	1 per group	Desk lamp (prop/optional)	3,5,8
❑	1 per group	Extension cord	3,5,7,8
❑	1 per student	Student Handout 3.1: The Light Bulb Problem	3
❑	1	Roll of heavy duty aluminum foil (for foil strips)	4
❑	1 set per group	A variety of miscellaneous familiar items for students to test the conductivity of, such as: • Glass (marble) • Styrofoam • Plastic (bag, spoon, lid, straw • Wax (birthday candles) • Ceramic mug • Rubber (erasers, stoppers) • Chalk • Sharpened pencil • Chenille stick • Various metal objects (old keys, paper clips, penny, quarter, brass fastener, bolt, screw, nail, washer, spoon, soup or soft drink can) • Lemon juice • Salt water	4
❑	1 per student	Student Handout 4.1 (optional): Conductors and Insulators	4
❑	1 per class	Micro ammeter (optional)	4
❑	1 per student	Electrical Hazards Handout (online from http://www.dolceta.eu/malta/Mod4/IMG/pdf/TB_FINAL_Secondary_Resource_10-12_Worksheets_1-3_REV.pdf)	5
❑	1 set per group	Safety Signs examples (optional)	5
❑	1 per student	Poster or large sheets of paper	5

Master Materials Checklist *(continued)*

✓	Quantity	Item	Lesson(s)
❏	1	Picture set of power generation methods (sample Power Point on www.powersleuth.org)	6
❏	1 set per pair	Teacher Resource 6.1: *PowerSleuth* student puzzles with Teacher Resource 6.2: *PowerSleuth* Puzzle Descriptions (at www.powersleuth.org)	6
❏	1 set per class	Teacher Resource 6.3: *PowerSleuth* class puzzle (at www.powersleuth.org)	6,7
❏	1	*My Light* by Molly Bang	6
❏	1 set for teacher demonstation, assembled in advance.	Model steam turbine materials: • 4 disposable metal pie pans • lightweight metal washer (approx. ½ inch) • heat resistant (metal) funnel • electric hot plate • extension cord • 3 prong adapter • oven mitt • unsharpened pencil • push pin • safety goggles	7
❏	1 class set	A variety of pinwheel making materials such as: • Heavy duty aluminum foil • Index cards (4 "X 6") • File folders • Wax paper • Plastic bags • Tissue paper, etc.	7
❏	1	Blow dryer	7
❏	1 per pair	Plastic straws	7
❏	1 per pair	Push pins	7
❏	1 per pair	Unsharpened pencils	7
❏	1 per pair	Washers	7
❏	Enough for class	String	7
❏	1 per pair	Small paper cups (3 ounce)	7
❏	1 set per class	Tape, glue, scissors	7

Master Materials Checklist *(continued)*

✓	Quantity	Item	Lesson(s)
☐	Approx. 100	Pennies	7
☐	1	Store-bought pinwheel	7
☐	Various amounts	Miscellaneous materials such as: wax coated hanger wire, dental floss, paper (different weights), plastic 2 L soda bottles, etc. (optional)	7
☐	1	Digital camera (optional)	7
☐	1	Pinwheel template	7
☐	1	Packaged CFL (prop)	8
☐	1 set per group	Packaging from 25 and 100 watt incandescent light bulbs and 26 watt CFL (optional: 13 watt LED packaging)	8
☐	1	Incandescent light bulb 100 watt	8
☐	1	Incandescent light bulb 25 watt	8
☐	1	CFL 26 watt	8
☐	1	LED 13 watt (optional)	8
☐	1	Thermometer	8
☐	1 per student	Student Handout 8.1 (optional): Comparing Light Bulbs	8
☐	1 per student	Student Handout 9.1 (optional): Recommended Light Levels	9
☐	1 per class	Light meter (optional)	9
☐	1 per pair	Master diagram of school	9
☐	1 per team	Clipboards	9

Energy Lights Maine

Master List of Student Handouts and Teacher Resources

Lesson 1

Teacher Resource 1.1: *Early Light* Cards

Student Handout 1.1: Blank Light Card Template

Lesson 2

Teacher Resource 2.1: Simple Circuit Configurations

Lesson 3

Teacher Resource 3.1: Incandescent Light Bulb Diagram

Teacher Resource 3.2: Desk Lamp Diagram

Student Handout 3.1: The Light Bulb Problem

Lesson 4

Student Handout 4.1: Conductors and Insulators

Lesson 5

Electrical Hazards Handout from http://www.dolceta.eu/malta/Mod4/IMG/pdf/TB_FINAL_Secondary_Resource_10-12_Worksheets_1-3_REV.pdf

Lesson 6

Teacher Resource 6.1: *PowerSleuth* Puzzles www.powersleuth.org

Teacher Resource 6.2: *PowerSleuth* Puzzle Descriptions

Teacher Resource 6.3: *PowerSleuth* Class Puzzle www.powersleuth.org

Lesson 7

No auxilliary materials

Lesson 8

Student Handout 8.1: Comparing Light Bulbs

Lesson 9

Student Handout 9.1: Recommended Light Levels

Lessons 1-9

Teacher Resource: Scientist's Notebook Cover

PowerSleuth
Maine Energy Education Curriculum

Energy Lights Maine

Scientist's Notebook

Scientist: ______________________________

Energy Lights Maine

Glossary

circuit: a complete pathway or loop through which electricity travels. (Lesson 2, 3, 6)

closed circuit: a complete pathway or loop that allows electricity to travel. (Lesson 3)

compact fluorescent lamp (CFL): smaller spiral shaped fluorescent light bulbs that emit light as electricity interacts with gases and a coating on the inside of the bulb. (Lesson 8)

conductor: a material through which electric current readily flows. (Lesson 4)

electrocute: to kill by electric shock. (Lesson 5)

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. (Lesson 8)

energy source: a material such as coal, gas, oil, or wood used in the generation of electricity. (Lesson 6)

filament: a thin thread of metal, often made of tungsten, that becomes very hot and emits light as an electric current passes through it. (Lesson 3)

fuel: a substance that can be burned to provide heat or power. (Lesson 1)

generator: a device that converts mechanical energy into electrical energy usually by passing magnets through an electric field
(electromagnetic induction). (Lesson 6)

hazard: something that is dangerous and can cause harm or serious injury or death. (Lesson 5)

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. (Lesson 3, 8)

insulator: a material through which electric current does not readily flow. (Lesson 4)

light emitting diode (LED): source of lighting that is long-lasting, hard to break, and energy efficient. (Lesson 8)

lumen: the light emitted by a light source. (Lesson 8)

myth: typically a traditional story of an event that serves to explain a practice, belief, or natural phenomenon. (Lesson 2)

nonrenewable resource: resource that do not replenish as part of natural ecological cycles. (Lesson 6, 8)

open circuit: an incomplete pathway or loop that interrupts the flow of electricity. (Lesson 3)

pathway (electrical): the course that electric current follows; most typically a wire. (Lesson 6)

renewable resource: a resource that replenish as part of natural ecological cycles. (Lesson 6, 8)

short circuit: allows electric current to flow along a path other than the one intended. (Lesson 5)

survey: a method of collecting information for the purpose of analysis of a particular issue. (Lesson 9)

switch: a device that allows circuit to be connected and disconnected. (Lesson 3)

system: a set of interacting parts that work together to form a unified whole. (Lesson 3)

turbine: a device made up of a series of blades that is turned by a fluid (gas or liquid) and as it turns, converts mechanical energy into electrical energy. (Lesson 6,7)

watt: a unit of power that is used to measure electricity. (Lesson 8)

Energy Lights Maine

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Notes

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