Lesson 6: People Have the Power!

Electricity Generation

Overview

Where does electricity that is used to light our homes, schools, and businesses come from? In this lesson, students investigate how electricity is generated on a wide scale basis. The major components of electric production: the turbine, the generator, and energy source are introduced in this lesson.

Teacher Background

Widespread distribution of electric light became a reality in the late 1800's in conjunction with the development of two key technologies—the invention of the incandescent light bulb by Thomas Edison and Nikola Tesla's invention of alternating current equipment (http://www.pbs.org/tesla/index.html). Initially, centralized power houses allowed homes and businesses a few blocks away in America's larger cities access to low voltage electricity. The desire for street lighting, power for trolleys, and lighting for businesses stimulated rapid development of power plants across the country. In 1882 Edison's Pearl Street Station was the first power station to be built. During this same year, the first hydroelectric power plant was constructed in Wisconsin along with eight others across the country. In the United States, the number of power plants generating electricity rose from 468 in 1889 to 1,807 in 1899. The evolution of wide scale electricity production has a fascinating history and is a prime example of science inquiry. The inventors who first experimented with the world of electricity experienced numerous trials and errors in developing wide scale systems, but their hard work, perseverance and dedication laid the foundation for wide scale electrical production used today.

During the late 1800's Maine began utilizing its beautiful and pristine rivers to produce hydroelectric power. Hydropower plants were built on the shores of the Androscoggin, Kennebec, Penobscot and Saco Rivers. In Portland, a steam-driven generator was built by the Consolidated Electric Light Company. In 1910, Maine's oldest electric company, Central Maine Power, was founded. Despite the growing expertise in producing power on a more wide scale basis, the infrastructure to support transmission of electricity over long distances limited the availability of power to many areas. It wasn't until the 1920s that the Rural Electrification Project, initiated by President Roosevelt's New Deal, began to extend electricity lines to rural parts of Maine. By 1950, 90% of American farmers

were able to access electricity, which transformed life on the farm, lit those homes, and was used for innumerable daily tasks of farm life.

Because electricity isn't a substance and it can't be bottled up or put into a pile, electricity must be generated from energy sources. Much large scale generation of electricity is accomplished using an old, but very successful, method that combines the use of a turbine, a generator, and an energy source. When coal or natural gas is the energy source used to generate electricity, the coal or natural gas is burned to heat water to produce steam which spins a turbine. The spinning of a turbine is an integral component in nearly all methods of wide scale electricity production. The turbine either spins coils of wire around stationary magnets or magnets are spun around coils of wire. The "spinning" sets in motion the flow of electricity. Electricity is delivered to homes, schools, and businesses through a series of power lines. When wind or water is the energy source used to generate electricity, the water is not heated to produce steam to turn a turbine. The force of wind turns the wind turbine and the force of water turns the water turbine.

In many parts of the United States, coal continues to be a dominant energy resource used for electricity production. Coal has been a top energy choice since the late 1800's. Alternative energy sources being explored in Maine include wind, biomass (plant and other once living material), solar, geothermal, and ocean tidal and wave. The resource *What You Need to Know about Energy* from the National Academies Press **http://www.nap.edu/** provides a more detail description of energy sources used in the generation of electricity. This material can be accessed online.

Key Ideas

- Electricity can be generated using a variety of energy sources.
- Presently, the majority of electricity generated uses some of the same methods used for over 100 years.
- Electricity generation most commonly involves a turbine and generator.
- Some energy sources are renewable and some energy sources are nonrenewable.

Lesson Goals

Students will:

- explore how electricity is generated.
- investigate several energy sources used in the generation of electricity.
- consider why different energy sources are used in the generation of electricity.
- be introduced to the idea that some energy sources are renewable and some energy sources are nonrenewable.

Vocabulary

circuit: a complete pathway or loop for electricity to travel (flow).

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

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

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

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

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

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

Preparation

- Prepare *PowerSleuth* student puzzle sets and a large class puzzle set. Prepare a picture set of power generation methods (power plants).
- Consider that a variety of student groupings are used for the puzzle activity. Because of this it is suggested that groupings be chosen prior to the start of this lesson. Initially, students work in pairs to complete one of four puzzles: coal, wind, natural gas, or water (hydro). After each pair completes their puzzle, it is suggested that they be paired with another group in the following way: students with a coal puzzle are paired with students with a wind puzzle; students with a natural gas puzzle are paired with students with a water (hydro) puzzle. In last part of the activity, all pairs that started with the coal puzzle will work together, and likewise for the wind, water, and natural gas pairs. The terms renewable and nonrenewable energy sources are introduced in Step 6 in this lesson.
- Set up LCD projector, speakers, and computer with internet access or arrange for use of computer lab. Preview website: http://www.energyclassroom.com/powerplanttour.php and those listed in the extension section of this lesson.
- Preview the book *My Light* by Molly Bang. Review the caveats in using this book.

Materials

Item	Quantity
Picture Set of Power Generation Methods (Plants, etc.)	1 set per class
Teacher Resource 6.1: *PowerSleuth* Student Puzzles http://www.powersleuth.org/teacher/energy-lights/lesson6-overview	1 set per pair
Teacher Resource 6.2: *PowerSleuth* Puzzle Descriptions	1 set per class
Teacher Resource 6.3: *PowerSleuth* Class Puzzle	1 set per class
Scientist's Notebook	1 per student
Computer, LCD projector, speakers, internet connection	1 per class
My Light by Molly Bang	1 per class

Time Required: 1-2 sessions

Connection to *Benchmarks for Science Literacy*

- The sun is the main source of energy for people and they use it in various ways. The energy in fossil fuels such as natural gas and coal comes from the sun indirectly, because the fuels come from plants that grew long ago. BSL 8C(3-5) b
- Electrical energy can be produced from a variety of energy sources... Moreover, electricity is used to distribute energy quickly and conveniently to distant locations. BSL 8C (6-8) d

Teaching The Lesson

Engage

1 Review electrical hazards.

Open the lesson by briefly reviewing some of the electrical safety ideas from Lesson 5, perhaps using students' safety messages to seed the discussion. Remind students that there are two types of dangers associated with electricity:

1) People are conductors and if they become part of the electric current pathway, they complete the circuit and current will flow through them. If the current is strong enough it can cause serious injury or death.
2) Having too much current can cause things to overheat and start fires. This is why exposed wiring and short circuits are electrical hazards.

2 Introduce the idea of large scale production of electricity.

Briefly remind students that they have primarily explored light emitting devices powered by batteries. Ask students to describe the energy source and the electrical pathway found in a simple circuit and flashlight. The idea is to remind students that the simple circuits they made and the flashlights they examined were powered by batteries. These devices emitted light because they had an energy source (a battery) and a complete pathway (wires) for electric current to travel.

Pose the following to students and allow discussion after each:

When you turn on a light at home or at school, where do you think the electricity comes from? What's the source? What is the pathway?
Students may or may not have answers for these questions. Accept students' answers.

Hold up a battery and/or flick on/off a light switch and inquire:

Is there an enormous battery somewhere that people plug into to get electricity to light their homes and businesses?

Students may suggest that electricity comes from a power plant. If they don't, guide them to the idea of a power plant as producing our electricity. If students do mention a power plant, ask them what they think happens in a power plant or how the power in the plant gets to homes, businesses, and schools.

Explore

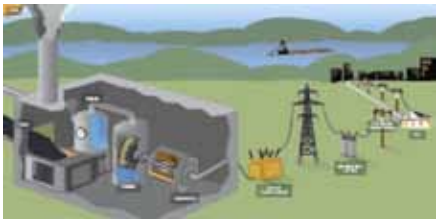
3 Introduce the use of energy sources in the generation of electricity.

Show students the pictures of power generation methods. These pictures can be found at: http://www.powersleuth.org/teacher/energy-lights/lesson6-overview

Explain to students that power plants are in some ways similar to the batteries used in the simple circuits and flashlights they examined earlier. Just like batteries, power plants use an energy source to get electric current moving through wires. Major differences between power plants and batteries are: the kind of energy source they use to generate electricity, the way electricity is transmitted (over much greater distances and in complex networks), and the amount of electricity that can be carried.

4 Distribute PowerSleuth Puzzles.

Give pairs of students a PowerSleuth puzzle set. Puzzle pieces can be downloaded with or without puzzle lines from http://www.powersleuth.org/teacher/energy-lights/lesson6-overview Puzzles include: coal, natural gas, wind, water (hydro) and are the focus of this exploration. To have an even distribution of puzzles, divide up the class so each puzzle is equally represented. For example, 2 sets of coal, 2 sets of water (hydro), etc.



Coal

Solar

Hydro

Natural Gas

Wind

Direct student pairs to work cooperatively to put the pieces of the puzzle in order using the descriptions provided. As pairs finish their puzzles, partner coal students with wind students, and natural gas students with water students. This encourages a discussion about the different types of energy sources used in the generation of electricity.

> **Note:** *Assembling the puzzles will not be, nor is it intended to be a difficult task for students at this grade level. The puzzle format is a tactile alternative to reviewing diagrams of various power generation methods and serves as a springboard for discussion.*

Reflect And Discuss 

5 Compare and discuss findings.

Bring students back together as a large group. Ask students to think about the different *PowerSleuth* puzzles they examined and discussed. Ask for a volunteer to share their group's puzzle solution by posting up the class size *PowerSleuth* puzzle pieces on the wall. After the pieces are displayed, poll the class using thumbs up (agreement with the puzzle order) or thumbs down (disagreement with the puzzle order). If there is disagreement, provide an opportunity for students to comment about their disagreement. Explain to students that after all four puzzles have been posted and polled, an opportunity will be provided to change the order of their pieces if new ideas arise.

Once all puzzles have been posted and polled, provide one more opportunity for students to discuss and agree on the puzzle pieces. For this final discussion, group all coal puzzle students together. Do the same for natural gas, water (hydro), and wind. If a group would like to change the order of their group's posted puzzle, they may do so. This is an opportunity to listen to students' thinking and ask guiding questions that direct the group's thinking. The intent of this activity is to familiarize students with the common steps involved in the generation of electricity as opposed to memorizing the sequence.

In a large group, explore the following points by asking questions such as:

- *What parts or "pieces" did your puzzles have in common?* (energy source, pathway, turbine, generator)
- *What if one of the parts was removed?*
- *What parts were different?* (energy source)
- *Why do you think these parts (energy sources) are different?*

6 Introduce terms renewable nonrenewable resource.

Ask students if they have ever heard of energy sources referred to as "renewable" and "nonrenewable." Explain to students that one way the power puzzles differ is in their use of different kinds of energy sources. Nonrenewable energy sources are those that cannot be replaced in a practical amount of time, making their amount limited to what is what is on the Earth right now. Fossil fuels (such as coal, petroleum, and natural gas) take millions of years to form. Renewable energy sources are those that can renew themselves or be replenished by natural processes. Energy from the sun, wind, and water are examples of renewable energy sources.

Optional: Follow this discussion by taking the virtual power plant tour found at:
http://www.energyclassroom.com/powerplanttour.php

This could be done as a whole class activity or individually if sufficient computers and headphones are available. Students could also tour a power plant in their area, but be aware that visits to such facilities may be challenging to arrange due to new security measures set in place after 9/11.

7 Introduce the sun connection.

Post the large sun puzzle piece in front of the coal, wind, water (hydro), and natural gas sequences. Ask students what they think about the addition and position of this extra piece. Allow student to share a few of their ideas. Prepare to read the book *My Light* by Molly Bang. Tell students that while the book is being read aloud, they are to think about the extra puzzle piece and its connection to the generation of electricity. Read the book aloud. At the conclusion of reading *My Light*, ask students to share their thoughts on the sun's connection.

8 Bring lesson to a close.

Ask students to reflect on their understanding of how electricity is generated as well as renewable and nonrenewable resources from this lesson by responding in writing to the following sentence frames in their notebooks:

- *Today I learned…*
- *I wonder…*
- *Questions I have now are…*

Review student's entries to determine if students have grasped the key ideas of the lesson. Make note of students' wonderings and questions for the purpose of addressing these in future lessons.

Extensions

Student may:

- explore the hand-crank generator flashlights. *How are these similar to and different from how electricity is generated in a power plant?*
- read Joanna Cole's *The Magic School Bus* and the *Electric Field Trip.* **Caution:** This book discusses electricity in terms of electrons, which is above the sophistication level for students in this grade span.
- explore emergency home generators and/or security lights in public buildings.
- research the historical basis for power plant locations. (History and Social Studies in locating where power plants are located).
- take a virtual walk through a hydroelectric power plant at: **http://www.fwee.org/walktour**
- read Science News for Kids article: entitled "Weaving with Light" Oct. 17, 2007; found online at: **http://www.sciencenewsforkids.org/articles/20071017/Feature1.asp**
- write a persuasive essay or editorial about renewable and non-renewable resources.
- graph a bar graph showing the distribution of energy sources that generate Maine's electricity. Note: Residential electric bills provide this information.
- create a Maine map showing the power plants responsible for Maine's electricity.
- find the closest energy source to home. Investigate whether the community that they live in has a dam (or mill) or other energy source that has been used or is currently being used to generate electricity.
- debate the pros and cons of "The Flooding of Flagstaff." Ask students to view the 2½ minute clip describing the flooding of Flagstaff, Maine in 1949. Have students discuss what they would do if faced with a similar dilemma today. **http://windowsonmaine.library.umaine.edu/fullrecord.aspx?objectId=9-35** **Note:** The clip above is part of a longer video (approximately 27 minutes) called "Power Lines" that describes the development of early wide scale distribution of electricity to Maine homes. **http://windowsonmaine.library.umaine.edu/fullrecord.aspx?objectId=9-204**
- research the connection between the *Furbish lousewort* and the Dickey-Lincoln dam and discuss Congress' 1986 decision.
- interview parents and/or grandparents or talk with others in the community about "log drives." *What are they? What connection do they have with Maine and energy? Do they still occur today?*

Connection to Maine Agencies

MEEP (Maine Energy Education Program) has a *Great Energy Debate Game (4th to 12th grade)*. What are the pros and cons of renewable versus nonrenewable resources? Do you have any preconceptions as to which energy sources is the best? In this debate, students take on the real world challenge of convincing others that one energy source is the best. A MEEP representative and will come to interested schools, free of charge, to guide this activity.

MEEP also has a Coal-fired Power Plant Activity. Students learn how electricity is made in a power plant and discuss the pros and cons of using coal. They then discover alternative ways to spin a turbine to run a generator. A MEEP representative and 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@mainepublic service.com.

A note about *My Light* by Molly Bang

Children's literature can be used in science to engage students, guide scientific inquiry, and aid in scientific comprehension of concepts. *My Light* by Molly Bang uses simple poetic phrases and engaging artwork to describe how flipping a switch is related to the Sun. The book describes various ways electricity is generated, presenting Earth's energy story in an interconnected and subtly comprehensive way. However, there are some issues that need to be mentioned, as this book is used to some degree to supplement content.

- The book is written in the first person which anthropomorphizes the Sun. (The Sun is the "narrator.") Most students should be able to recognize that the Sun is not a living thing even though it is given human qualities in the story.
- Text that reads "Tiny drops of warm water rise and form clouds" and on the following page "The clouds cool down" is misleading. Water vapor rises. Clouds are formed when water vapor in the air cools and condenses.
- The text that accompanies the hydroelectric dam is incomplete. The water moves the turbine. The turbine turns a magnet that is surrounded by coils of wire. This causes electricity to flow.

- "Green plants catch my light and use my energy to help build leaves and stems" is misleading text and may perpetuate the common misconception that plants make their food out of light. Light is not a substance. Plants use light energy during photosynthesis to convert water and carbon dioxide into sugars.
- Oil is not mentioned in the book.

These points are made as cautions, not to discourage the use of the book.

Consider visiting the book's companion website:
http://www.mollybang.com/mylight.html

Online References and Resources

Life and Legacy Inside the Lab: Tesla – Master of Lighting
http://www.pbs.org/tesla/index.html