Energy for Keeps: Electricity and Renewable Energy Teacher Information

Grades: 5-8

Topic: Energy Basics

Owner: Energy for Keeps

This educational material is brought to you by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

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Dear Educator,

On this web page you will find:
1. A note for your students that includes safety warnings related to the activities
2. Classroom activities for grades 6 – 12, plus extensions and further suggestions
3. Content standards correlations for math, science, language arts and social studies
4. Other information including a template for a Scientific Method Form for students and additional information resources (slightly more extensive than those in the printed book)
5. A template for renewable energy bookmarks

Energy for Keeps is, by design, highly inclusive and multidisciplinary. In addition to the basics about renewable energy the book covers historical information, the physics involved in electricity generation, information about nonrenewable as well as renewable energy resources, environmental facts and considerations, and discussion of energy conservation and efficiency.

This book has been used successfully as a manual in teacher-training programs as well as in the classroom. If you plan to use this book in a teacher education program, we'd like to know about it. Perhaps we will be able to provide you with further support and suggestions — or get you in touch with others who have done a similar program. We also welcome inquiries about working with state education or energy departments, and with school districts, to distribute copies and provide teacher workshops.

We'd appreciate hearing from you about any aspect of *Energy for Keeps* — especially the activities: what worked well (or not), your successful adaptations, suggestions, etc. We invite you to call or write if you have new activity suggestions or if you are interested in the addition of — or possibly helping with development of — content standards correlations from your state.

Check our website — www.energyforkeeps.org — for links to other sites with quality activities about renewable energy or energy efficiency and conservation. If you know of any that we have not listed and that you recommend, please send us a note so we can consider adding to our list.

The staff of the Energy Education Group hopes you enjoy using *Energy for Keeps* and that it will prove valuable to you and your students.

Yours truly,

Marilyn Nemzer
Director
Energy Education Group

TO THE STUDENT

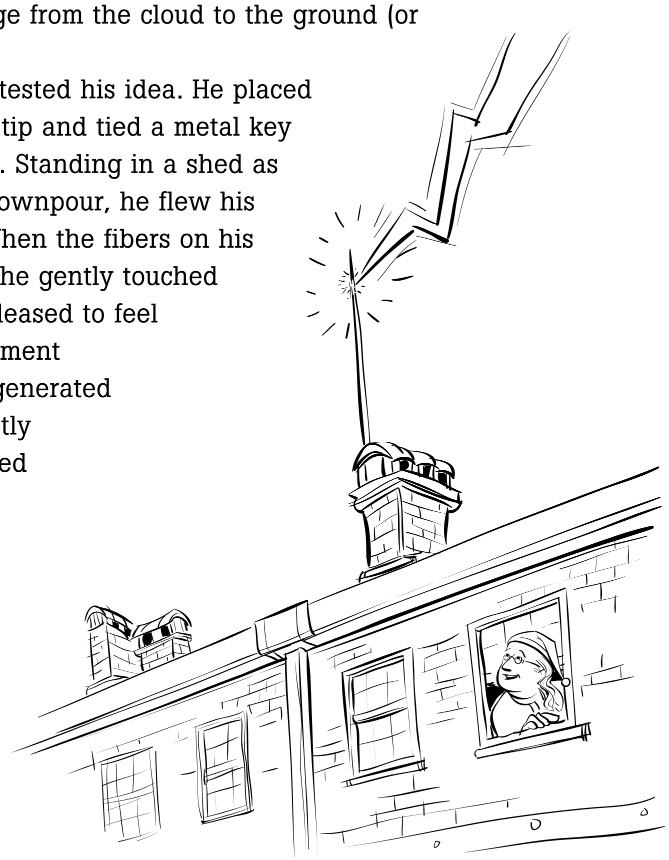
Benjamin Franklin is the mascot for this unit on energy. We chose him not just for his famous experiments with electricity, but also because he always sought — through hard work and ingenuity — to understand the world around him and to make a positive impact on it.

BENJAMIN FRANKLIN: 1706 – 1790

The best-known story about Ben Franklin is that he experimented with electricity by flying a kite in a raging lightning storm. In reality, he did not stand directly out in a storm, nor was he actually trying to have lightning strike his kite. One day in June of 1752, however, he did fly his kite while a storm was brewing, hoping to draw the "fire" (electrical charge) out of the clouds so that he could study it further.

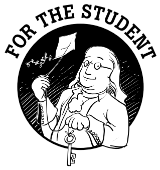
By this time, Ben had already been studying electricity. He had correctly proposed that the sparks resulting from what we now call static electricity — an object of great fascination at that time — were due to excess electrical charges building up in an object and then leaping, or discharging, to an object of lesser charge. He speculated that thunderclouds also could build up excess electrical charges and that lightning was the discharge from the cloud to the ground (or other object, such as a house).

So on that stormy day Ben tested his idea. He placed a metal wire on a kite's upper tip and tied a metal key to the bottom of the kite string. Standing in a shed as protection from the potential downpour, he flew his kite up into the dark clouds. When the fibers on his kite string began standing up, he gently touched the key and must have been pleased to feel an electrical charge. His experiment confirmed that thunderclouds generated static electricity. He also correctly concluded that lightning resulted from the build-up and discharge of excess electrical charges.



NEVER A DULL MOMENT

Life with Ben must have been pretty interesting. Imagine living with him while he was testing his new invention, the lightning rod. A metal rod on the roof attracted lightning, which traveled safely to the ground through a wire, sparing the house from fire. In one experiment, he threaded the wire right through the inside of his own house along the staircase banister. One stormy night the family awoke to the sound of bells clanging wildly. It turned out that Ben had attached metal bells to the wire along the banister, so that he would be alerted when electricity passed through to the ground.



Ben was not just an avidly curious scientist, but also a writer, a publisher, an inventor, a civic leader, and a statesman. He had his own print shop where he wrote and produced a newspaper and an annual almanac, among other publications. His many inventions include the lightning rod, the first bifocal glasses, the Franklin stove (a freestanding fireplace), and the odometer (which measures mileage). He began the nation's first lending library and the first fire department. He was Postmaster General of the American colonies. He contributed significantly to the writing of the Declaration of Independence and worked for the abolition of slavery. To top it off, his close diplomatic and scientific ties with Europe influenced France to support the colonial Americans during the Revolutionary War.

As you can see, Ben Franklin was a man who made many valuable contributions to science and society, contributions that we can appreciate to this day.

SAFETY PRECAUTIONS

- Always review all directions before beginning any project or scientific experiment.
- Use caution and take your time when cutting and assembling any project.
- Always work with or near other people. Report accidents or hazards to your teacher (or other adult) at once.
- If working with heat or open flames, long hair should be tied back and long sleeves rolled up. Wear safety goggles, if available. Learn the location of safety equipment and supplies. If a fire starts, react quickly but do not run, and do not panic. Always get adult help. A small fire can often be extinguished with a fire extinguisher, baking soda, sand, or a fire blanket (or even a rug). If a piece of your clothing catches on fire, immediately drop and roll. If any fire cannot be extinguished immediately, the entire class should always exit the room.

THE ENERGY TIMES

PLANNING OVERVIEW

SUBJECT AREAS:
Language Arts, Fine Arts, Earth Science, Environmental Science, Physical Science, History, Geography, Government

TIMING:
Preparation: 30 minutes
Activity: 3-5 45-minute class periods

Summary

Students investigate past and present energy use while developing their own historical newspaper.

Objectives

Students will:

- Recognize that energy use has evolved over time to meet the changing demands of society.
- Explain why energy use is a newsworthy topic.
- Conduct research on an historical period.
- Demonstrate skills needed to publish a special edition newspaper on energy.
- Evaluate their finished product, *The Energy Times.*

Materials

Student Handout: "*The Energy Times*: Getting Out the Newspaper"

"Energy Timeline" (in Appendix)

A variety of local, state, or national newspapers

Pens, pencils, marking pens, paper

Research materials including books, encyclopedias, Internet access, library references

Tape, rulers, rubber cement, glue sticks, scissors

Optional: Tabloid-sized paper (Rolls of newsprint are sometimes available from local newspapers.)

Optional: Computers and word-processing programs

Optional: Computer graphics programs

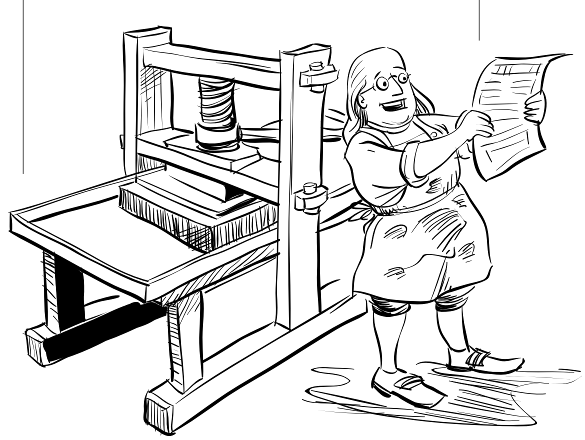
Optional: E-mail or web page software and Internet access

Making the Link

Energy affects our lives every day. In fact, there has never been a time in history when humans have not used energy. Energy use has always been a newsworthy topic, whether communicated by word of mouth, by stone tablet, or by the printed word.

The advent of practical ways to use electricity, along with the development of the internal combustion engine (such as that found in cars and trucks), brought an ease to our lives that most of us are not willing to give up. Our electrical devices and our cars are considered necessities of modern life.

Energy issues are frequently front page news. The resources we use to produce electricity and run our transportation have become very valuable commodities. The resulting problems associated with energy use (such as pollution, gasoline shortages, electrical blackouts) are also common topics of everyday life.



By studying the history of energy use, we can learn more about where we stand in the present, as well as how to plan our future.

Since energy use plays a significant role in our daily lives and in the global community, using this topic for the production of a newspaper should be an easy concept for students to grasp.

Teaching Notes

In this project the class will develop its own newspaper, *The Energy Times*, which will cover society at a chosen time in history. The focus will be on energy production and use, and will include newsworthy events and inventions as well as interviews and human interest stories.

Newspapers are collective efforts, which are excellent for developing interdisciplinary skills, including those of research, composition, word processing, hierarchical decision-making, organizing, proofreading, illustrating, and editing.

Information found in the Chapter 1 Discussion and the handouts, "*The Energy Times*: Getting Out the Newspaper" and the "Energy Timeline" will help guide the project.

Warm-up

After students have read the Discussion for Chapter 1, "A Brief History of Energy," ask them if there has ever been a time when humans have not used energy. Generate a discussion about what students know concerning energy use over time. During the discussion, make a list of various energy resources on the blackboard. Try to include as many resources as possible.

Ask students if there is ever a day in their lives when they don't use energy. If they were to create a newspaper about a day in their community, could the activities or events they describe have taken place without some form of energy use? Elicit students' views regarding pollution, transportation, space heating, and technological advances. Discuss our daily dependence on electricity (which usually only comes to mind if there is a power failure).

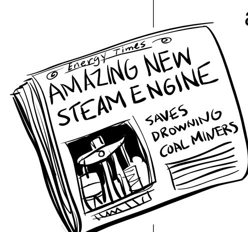
The Activity

1. Bring in some recent newspapers. Break students into informal groups and have each group scan a newspaper to identify and name the various sections.

2. As a class, generate a list of the different sections of the newspaper and what information each contains. After some discussion, distribute "Getting Out the Newspaper" and have students check to see what other sections might be included. Add these to the list. Tell students to keep this handout.

3. Explain that they, as a class, are going to develop their own newspaper with the theme of energy. Tell students that different groups will be responsible for various sections of this newspaper.

   Explain that their newspaper, *The Energy Times*, will not be like a daily newspaper, but will reflect a longer range of time and a particular historical period. However, it will be written as if the events were occurring in the present.



4. Discuss the different jobs involved in developing a newspaper. These include editors, reporters, photographers, artists, cartoonists, proofreaders, word processors, designers and printers. For those teachers who integrate technology into the classroom, please note the possibilities here for Internet research, word processing, design, creation and importing of graphics, and document layout.

5. Divide the class into working groups and have each group choose (or assign each group) a different section of the newspaper on which to work. Possible sections might include News and Features, Editorial, Entertainment and Leisure, Business, Sports, and Advertising.

6. Refer to the handout, "Getting Out the Newspaper" and make sure that everyone understands the jobs described. Then have each group select an editor, reporters, and any other jobs they think necessary to get the job done.

7. Hand out the "Energy Timeline" and allow groups some time to review it. Tell them to suggest a 50- to 100-year time period that they think would be most interesting to focus on as a class. Or you may wish to pick one yourself, (e.g., the era of the Industrial Revolution, which started in the early 1700s and continued to the mid-1800s).

8. Have groups brainstorm what kinds of articles, features, illustrations (or, when possible, scanned graphics) they could have in "their" section of the newspaper.

   For example, if the time period 1700–1750 is chosen, News/Features may have a description of T. Savery's steam engine being used to pump water from flooded coal mines. They might compose some interviews with coal miners and with Mr. Savery. The Entertainment/ Leisure section could have a feature on fashions made from fabric from the new textile mills. The editorial department might have a commentary on the terrible conditions in the coal mines or applaud the march of progress brought about by increased coal mining production. The business section might have a feature comparing the benefits of various waterwheel designs for factories.

   Assist each group in determining where to find the information it will need to write convincingly about its choices.

9. Give students a deadline for completing their sections. Allow class time for groups to work on research, composition, proofreading, and word processing. If possible, have each group save its work on a disk. If you have a scanner, groups may wish to scan in any illustrations or photographs they have found during their research. Editors should supervise the work, assisting in editing and proofreading as well as layout.

10. Have editors from each group assemble the newspaper. Have them refer to actual newspapers as a model for layout. They may be assisted by their group's word processor.

Wrap-up

As a class, share and evaluate the final product. You may wish to have each group present its section. Examine and discuss the various sections to see whether each reflects the theme of energy use during the selected time period. Elicit comments about the effect energy use had on lifestyle and the environment during the time period studied. Compare this to the effects energy use has had in other time periods, including the present.

Discuss the process of composing a newspaper. Compare the process of producing an "historical newspaper" with that of putting out a daily newspaper.

You might want to reproduce the newspaper in sufficient quantities to be given to other classes and taken home to family and friends. (If you are especially pleased with the product, you may wish to have your local newspaper printer publish your paper on newsprint.) If distributed beyond your classroom, you may wish to have a small student group gather feedback from others about the newspaper. This feedback could be used as part of the evaluation process.

Assessment

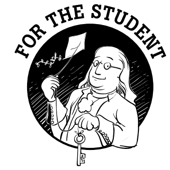
Have students:

- Explain why energy use is a "newsworthy" topic that affects all aspects of life at any given time.
- Demonstrate an understanding of how energy use has changed over time in order to meet the demands of progress.
- Recognize that energy use has come with a price.
- Work cooperatively to develop a section of a newspaper.
- Assume a specific task related to newspaper development.
- Evaluate the finished product.

Extensions

- Further integrate your newspaper with technology. For example, create a "paperless" product by posting your newspaper on a web page, sending it as an e-mail attachment, or copying it onto CDs to send to your "subscribers." Use PowerPoint or other presentation software to produce your newspaper.
- Brainstorm other time periods that could be covered in a future newspaper. Have each group compose its own newspaper, each representing different time periods. Compare and contrast the different time periods.
- Encourage students to read their daily newspapers and to look for energy-related topics. Have them bring in news clippings to share.

"*The Energy Times*," adapted from Project Wet, "Water: Read All About It."



THE ENERGY TIMES: Getting Out the Newspaper

Newspapers are designed to report on current events. Yet they can be considered journals that record history. They also are places where people can exchange ideas and points of view. An historical newspaper such as *The Energy Times* differs from a daily newspaper in that it is a fictionalized version of actual events from a specific time period.

Many people work together to produce a newspaper.

Reporters seek and gather information about events they are assigned to cover. Reporters write (and rewrite, if necessary) the "copy" (article, story, or column). Reporters tell who, what, when, where, why and how in an interesting, easy-to-read style. For a daily newspaper, reporters often conduct interviews to get their information. For *The Energy Times*, reporters can quote from imaginary interviews based on research.

Photographers record images that illustrate a story and capture the interest of the reader.

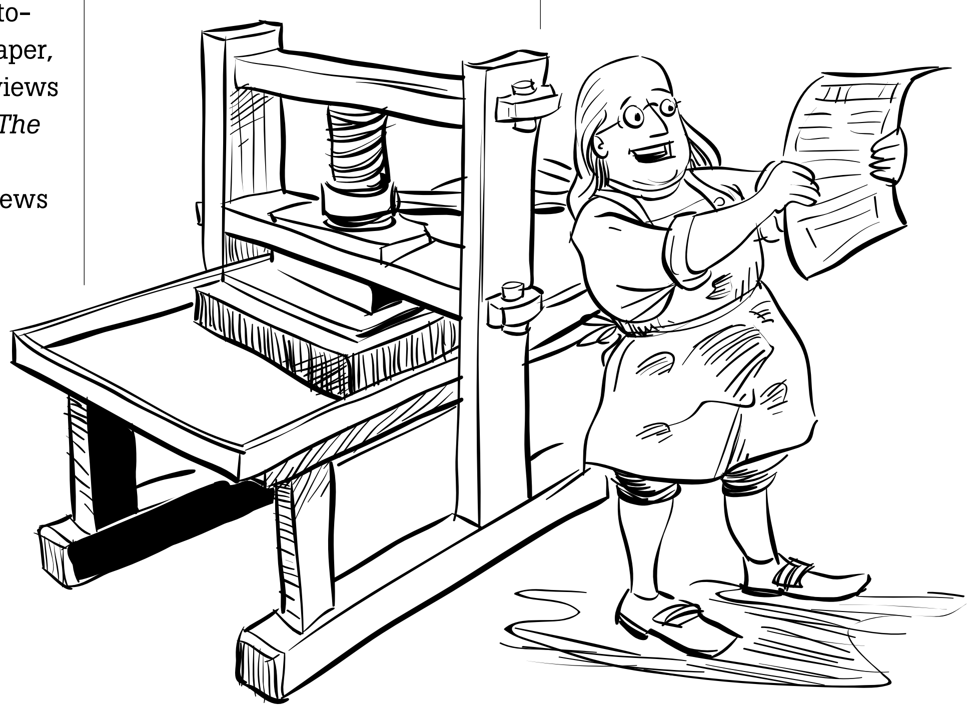
Graphic artists enhance a story and provide illustrations and images such as maps, charts, and graphs. For *The Energy Times*, graphic artists and photographers may also create illustrations or "photographs" using models with props and costumes. Actual photos and other images can be downloaded from the Internet or scanned from other public domain resources.

Editors determine, along with the rest of the staff, which stories to report and where to place them. They also review rough drafts and comment on additions or deletions that should be made. Editors for *The Energy Times* will also put the various sections together to complete the final product.

Managing editors or **page editors** lay out and arrange the stories in logical order. For *The Energy Times* the editors of each department assume this duty.

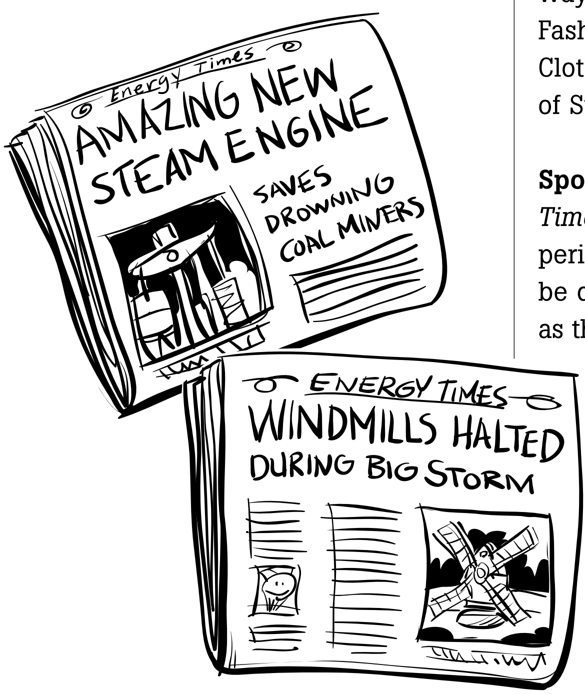
Proofreaders make detailed corrections on all written copy and graphics.

Ad managers decide which ads to use and where to place them in the paper. **Advertising copywriters** write ads, and graphic artists illustrate the ads.



Most newspapers are divided into sections.

News and Features. All the articles that the editor and staff feel are important are in this section. For *The Energy Times*, these stories will cover some aspect of life related to energy use. Some examples: "Amazing New Steam Engine Saves Drowning Coal Miners!" or "World's First Geothermal Electric Power Plant Opens."



Entertainment and Leisure. In this section, news and stories about society's leisure-time and recreational activities are found. In newspapers today, this category includes fashion, movies and television, music, art and community events. For *The Energy Times*, the time period that the class chooses will dictate the aspects of entertainment and leisure to be covered. Every attempt should be made to relate the stories to energy use in some way. Two examples: "New Fall Fashion From Factory-Woven Cloth" or "Exploring the Wonders of Steam-driven Ocean Travel."

Sports/Weather. For *The Energy Times*, depending on the time period, sports and weather may be difficult to research, especially as these subjects relate to energy. Some examples: "Stadium Lit With Modern Electric Power — More Nighttime Games Possible" or "Windmills Halted During Huge Storm." (If desired, this section may be eliminated for *The Energy Times*.)

Editorials. This section presents the opinions of the newspaper staff and contributing writers. Readers are also invited to respond with their own thoughts in the form of letters to the editor. For *The Energy Times*, students will assume the roles of editors, contributing writers, and readers, responding to hot-button energy issues of the time period chosen. Some examples: "New Factories Are Driving Hand Weavers Out of Business" or "New Steam Engine Steps Up March of Progress."

Advertising. Without people purchasing space for ads, most newspapers couldn't survive. The advertising department of *The Energy Times* can create ads that reflect all aspects of society at the time but should try to focus on those that relate to energy use. Two examples: "Don't Be the Last on Your Block to Buy the New Model T Ford" or "Feeling Under the Weather? A Visit to Saratoga Hot Springs Will Fix You Right Up!"

FOR THE TEACHER

GOING FOR A SPIN: Making a Model Steam Turbine

PLANNING OVERVIEW

SUBJECT AREAS:
Physical Science, Math, Language Arts

TIMING:
Preparation: 30-60 minutes
Activity: 1-2 45-minute class periods

Note: "Going for a Spin" and "Getting Current" are best done in conjunction with one another.

Summary

Students explore how various energy sources can be used to cause a turbine to rotate.

Objectives

Students will:

- Recognize how the force of wind, falling water, and expanding steam can be used to do work.
- Create a model of a turbine and cause it to spin using the forces of wind, falling water, and expanding steam.
- Create a steam device that simulates some of the conditions of a steam-driven power plant.
- Use the scientific method to write up their work, including hypothesizing and drawing conclusions.
- Assess the ability of the turbine model to actually generate electricity.
- Use diagrams and narratives to describe how their apparatus worked and why.
- Compare their models to an actual power plant.

Materials

Per student group:

2 aluminum pie pans

Metal funnel, 4 inches (10 cm) in diameter

Scissors

Compass (for drawing circles)

Ruler

Pencils

Several plastic straws (the long soda type is best, but regular sized straws can be used)

Push pins

Small, thin washer (optional)

Small cooking pot, no bigger than 5 or 6 inches (13–15 cm) in diameter

Student Handout, "Going for a Spin," pages 36–39

Copy of Chapter 2 Discussion, "Energy and Electricity"

Student Handout, "Scientific Method Form," page 185

For all groups to share at a "central station":

Hot plate(s) or other heat source(s)

Oven mitts

Source(s) of falling water, such as a faucet and sink, or a large jug or bottle of water and a bucket or tub

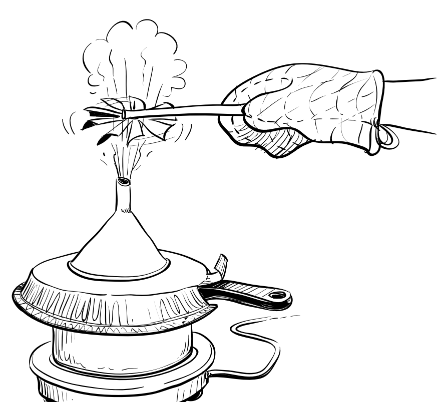
Towels for clean-up

Teaching Notes

Please review with your students all safety rules for working with heat and steam, particularly if you must use an open flame. Remind students to take care when cutting the aluminum pie plates.

This activity is intended for use in conjunction with the activity, "Getting Current." Each represents the two main functions of many typical power plants. However, each activity is designed to stand alone, if necessary.

The turbine model in this activity is not powerful enough to generate electricity, but it will successfully show students how different energy sources cause a turbine to spin. In "Getting Current" students will demonstrate how electricity is produced using electromagnetism. Though the two activities cannot be "connected" to produce electricity using the turbine model, students should be able to make a mental link between the two devices.



If you wish to do a more complicated project that shows a student-made turbine causing a generator to produce electricity, see the Tennessee Valley Authority materials listed in the Teacher Resources section of the Appendix.

Important Note: There are many different scientific method formats. The one suggested here is very basic and you may prefer to use your own format. If your students are not familiar with the steps of the scientific method, then you may wish to explain the method further.

Warm-up

Ask students if they have tried to wade across a rushing river or into ocean waves. Perhaps some have stood near a large waterfall. Ask students to describe these experiences. Have students connect the force of moving water with the idea of using it to do work.

Next ask students about the power of steam. It may be more difficult for kids to picture how steam can be forceful enough to make something move. Have students relate their experiences with steam (steamy showers, tea kettle, geyser, or natural steam vent). Students may think of steam as a wispy vapor that is not very powerful.

Review Chapter 2, especially the idea that we can produce and harness steam in a particular way that makes it very forceful — enough to spin a turbine that can be used to do work.

Tell students that in this activity they will be exploring how we use wind, water, and steam to turn turbines. Remind students that in the generation of electricity, the sole purpose of making a turbine rotate is to spin a generator.

The Activity

1. Gather the necessary materials and set up your classroom to accommodate the activity. Refer to the Student Activity page for the specific procedure. Develop a plan for use of a "central station," if needed.

2. Use the Chapter 2 Discussion information to discuss turbines and the various ways we can cause them to turn (wind, water, and steam).

3. Explain to students that power plant turbines are highly engineered devices that are designed to make the best use of the force of wind, water, or steam. In this activity, students make very simple turbines that will spin when blown on ("wind"), placed under falling water or held up to the homemade steam device.

   Remind students that most power plants today use steam to spin their turbines, and review how steam-driven power plants work. Emphasize that in order for the steam at a power plant to hit the turbine with enough force, it must be confined, creating high-pressure steam, and then released through a small opening, bursting out and expanding at great velocity.

4. Distribute copies of the Student Activity page for "Going for a Spin" and review the procedure. Organize student groups and give out all needed materials. Explain, if needed, that some materials are shared and that groups will be taking turns using the heat source at the "central station."

5. Once students have had a chance to look over the directions for constructing the turbine model and the steam device, and have a general idea of what they both look like, go over the instructions for using the Scientific Method Form on page 185.

6. Once finished with all three tests of the model turbine, tell students to write up the activity. Have students stay in their groups for discussion and support, but ask each individual to write up his or her own description. Consult Student pages 36–39 for exact directions.

Wrap-up

Gather the entire class together and have groups share their experiences with their turbines and the three different energy sources. Discuss ways they adapted the turbine model to make it work best. Talk about whether the angle of the blades or the distance from the resource needed to be adjusted for different energy sources and why.

Have students share their predictions regarding whether the turbine model could actually produce electricity. Ask if they changed their predictions after working with the model. Discuss why they thought the turbine in this activity is being called a "model."

Relate the use of their "wind" and water to turn their turbine models to the use of actual wind and water resources for the production of electricity. Explain that in this unit they will be learning about the many interesting ways we can use different energy resources to produce electricity without having to burn fuels. Remind students that there are also ways to produce electricity without using a turbine at all, such as with solar (photovoltaic) cells or hydrogen fuel cells, but that in this activity we are concentrating on turbines — the most common method in use today.

Ask students to explain why the steam device worked the way it did. (In the steam device, the steam is confined in a small space and so is constrained from expanding in all directions. This creates high-pressure steam that forces its way out through the small opening of the funnel. When it bursts out of the small opening of the funnel, it rises and expands with great force.)

Ask groups how far from the opening they held their turbines to get the most spin. Guide the discussion to the idea that the expanding steam hits the blades of the turbine, causing them to turn. There is a certain point above the opening where the most expansion occurs, thus causing the most spin.

Next, review the various ways we can produce steam to turn a turbine. Direct the discussion beyond burning fossil fuels (the most common way). Points to include are the use of fuels such as biomass (students may first think of wood, but explain that there are many other types of biomass), of steam that comes directly from the earth (geothermal), and of the sun's heat to boil water (as in the process of solar thermal).

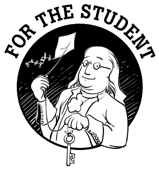
If any students have completed the extra credit, have them share their descriptions. To carry this further, you might facilitate the building and testing of any of these student designs, or suggest it as extra credit homework, or as a science fair project.

Assessment

Students will have had the opportunity to:

- Create and test a model of a turbine as well as a steam-producing device.
- Draw conclusions regarding the use of wind, water, and steam as energy sources.
- Use the scientific method, including hypothesizing and drawing conclusions.
- Relate turbine models being driven by various energy sources to an actual power plant.
- (Optional) Suggest a "home-made" turbine design that would be useful for generating a small amount of electricity.

Permission was granted by the Tennessee Valley Authority to adapt portions of their junior high curriculum unit, "The Energy Sourcebook," for use in this activity.



GOING FOR A SPIN: Making a Model Steam Turbine

In this activity you will demonstrate how different energy sources can be used to spin a turbine. Remember that the sole purpose of spinning a turbine at a power plant is to rotate an electrical generator. The turbine in this activity is not strong enough to operate an electrical generator; however, you can still experience how the force of wind, water, and steam are used to make a turbine spin.

You will also be constructing a device that produces steam in a manner similar to that used at a steam-driven power plant. You will recall from the Chapter 2 Discussion that the actual steam production technology at a power plant is extremely sophisticated and produces steam at very high pressures. However, this activity works well enough to get the point across.

Be sure to review all the safety instructions found in the Student Preface before you begin this activity.

Materials

Per student group:

2 aluminum pie pans

Metal funnel, 4 inches (10 cm) in diameter

Scissors

Compass (for drawing circles)

Ruler

Pencils

Several plastic straws (the long soda type is best, but regular sized straws can be used)

Push pins

Small, thin washer (optional)

Small cooking pot, no bigger than 5 or 6 inches (13–15 cm) in diameter

Copy of Student Activity, "Going for a Spin"

Copy of Chapter 2 Discussion, Energy and Electricity

Copy of "Scientific Method Form," page 185

For all groups to share at a "central station":

Hot plate(s) or other heat source(s)

Oven mitts

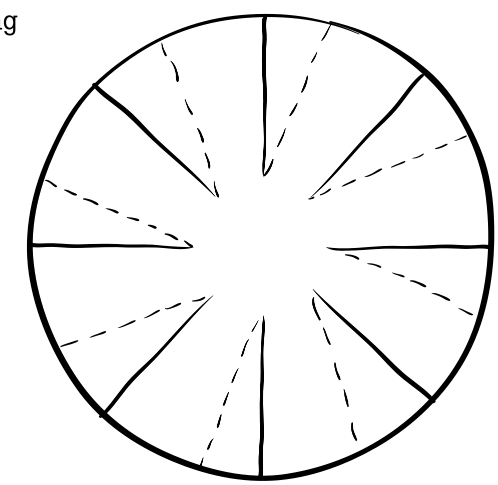
Source(s) of falling water, such as a faucet and sink, or a large jug or bottle of water and a bucket or tub

Towels for clean-up

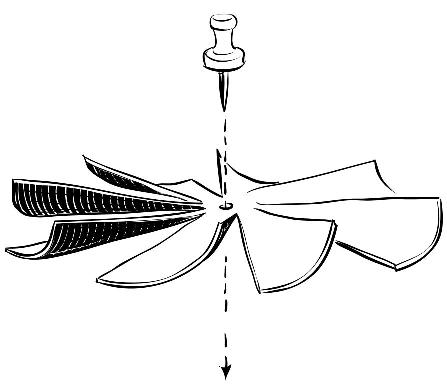
Procedure

THE TURBINE

1. Using your compass, measure and draw a 3.5 inch (approximately 8 cm) diameter circle with a pencil on one of the aluminum pie plates. Divide the circle into halves, then fourths, then eighths (marking the divisions by drawing your pencil down the straight edge of the ruler). As shown in the diagram, cut the circle into 8 blades by cutting along the 8 divisions on the solid lines, to within ¾ inch (2 cm) of the center. Make sure not to cut all the way to the center.

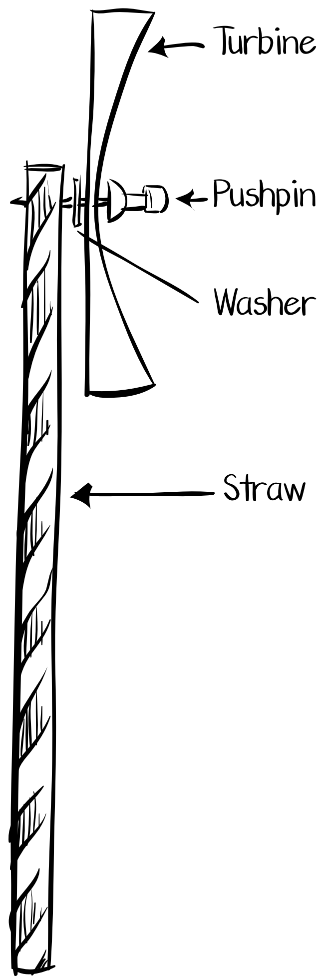


2. Taking each blade, bend one side gently up (along the dashed lines) so that all blades are curved up the same direction. (Pick a direction, such as clockwise, and stick to it all the way around). Don't overwork the blades at this point. You may need to make adjustments to the bend of the blades when you start using your turbine.



3. Using a push pin, attach the turbine to a straw at one end (illustration at right). Leave space (or insert washer, if needed) between the straw and the turbine, so it spins freely.

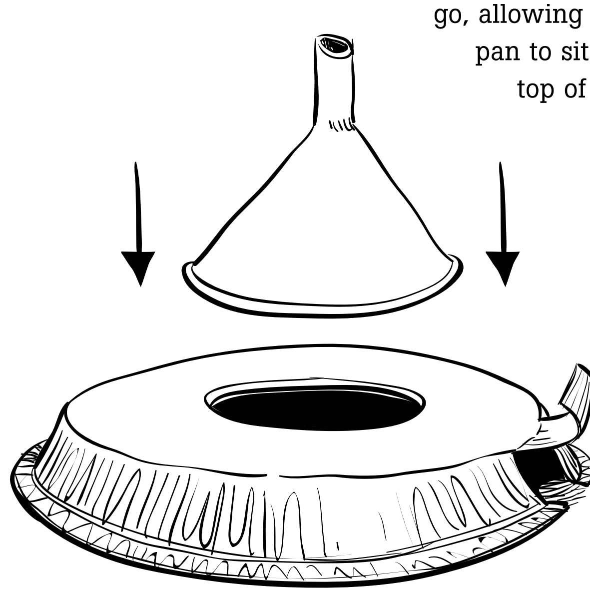
4. Next, construct your steam device (illustration at right), so that you will be ready when it's your turn to use the heat source(s) at the "central station."



THE STEAM DEVICE

1. Trace the circumference of the funnel onto the center of one of the aluminum pie pans. Using scissors, poke a hole in the center of the pan. Cut from the center out toward the edge of the traced circle, but stop about ¼ inch (almost 1 cm) from the circle itself. The line you traced is where the funnel will sit on the pie pan. The hole you are cutting must be smaller than this, so cut the circle about 1/4 inch (almost 1 cm) inside from the traced circle. This way your funnel will sit on the pie pan without falling through and will cover the gap so that steam won't escape.

2. If necessary, cut a place on the edge of the pie pan where the cooking pot handle will go, allowing the pie pan to sit level on top of the pot.



THE SCIENTIFIC METHOD FORM

Before testing your turbine model and steam device, complete Steps 1 through 3 that follow. Remember that each student should do his or her own write-up, though you are doing the experiment in a group.

1. You will be using the Scientific Method Form provided with this activity unless your teacher tells you to use a different experiment write-up form.

2. For the Research section, unless your teacher indicates otherwise, you may summarize what you have learned from reading and discussing Chapter 2 about power plant turbines. Be sure to credit this book as the source of information.

3. For the Hypothesis, you should address the following:

   a. Predict how well your turbine model will perform using the three "resources": water, "wind" (your breath), and steam. For example, will the shape of the blades and/or their angle in relationship to the force of the resource affect the turbine's performance? When using steam, will it matter how far you hold the turbine from the opening that releases the steam? Will there be an optimal amount of "wind" to get the best spin? Does it matter how far the water falls or at what angle you hold the turbine blades in the stream of water?

   b. Predict whether you think this particular turbine model would actually be able to produce a small amount of electricity if it were connected to a small generator.

4. As you work on constructing and testing your devices using the directions in "Testing the Turbine (see page 39)," fill out the Procedure and Data sections of the form.

   Since the directions are lengthy, be sure to summarize them for the Procedure.

   For the Data sections, draw pictures showing your turbine using the three different resources (wind, water, steam). Make notes about how the turbine performed using different variations, such as varying heights of water, varying "wind" speeds and distances from your mouth when blowing, different angles of holding the blades, and alterations to the shape of the blades.

   For the steam test, be sure to include the height at which your turbine spun the fastest.

5. For the Conclusion portion of the form:

   a. Compare the actual performance of the turbine to your predictions (hypothesis) regarding how the turbine worked with each resource. Make any other comments on what you learned while doing the tests, based on your notes from the Data section. Comment on why the authors have been referring to the turbine as a "model."

   b. Reassess your thinking in your original prediction as to whether the turbine could actually generate electricity.

TESTING THE TURBINE

1. Test your turbine by blowing on it, to simulate the energy of wind. Gently make adjustments to the turbine blades to get the most spin. Try varying the distance from your mouth or the force of your breath.

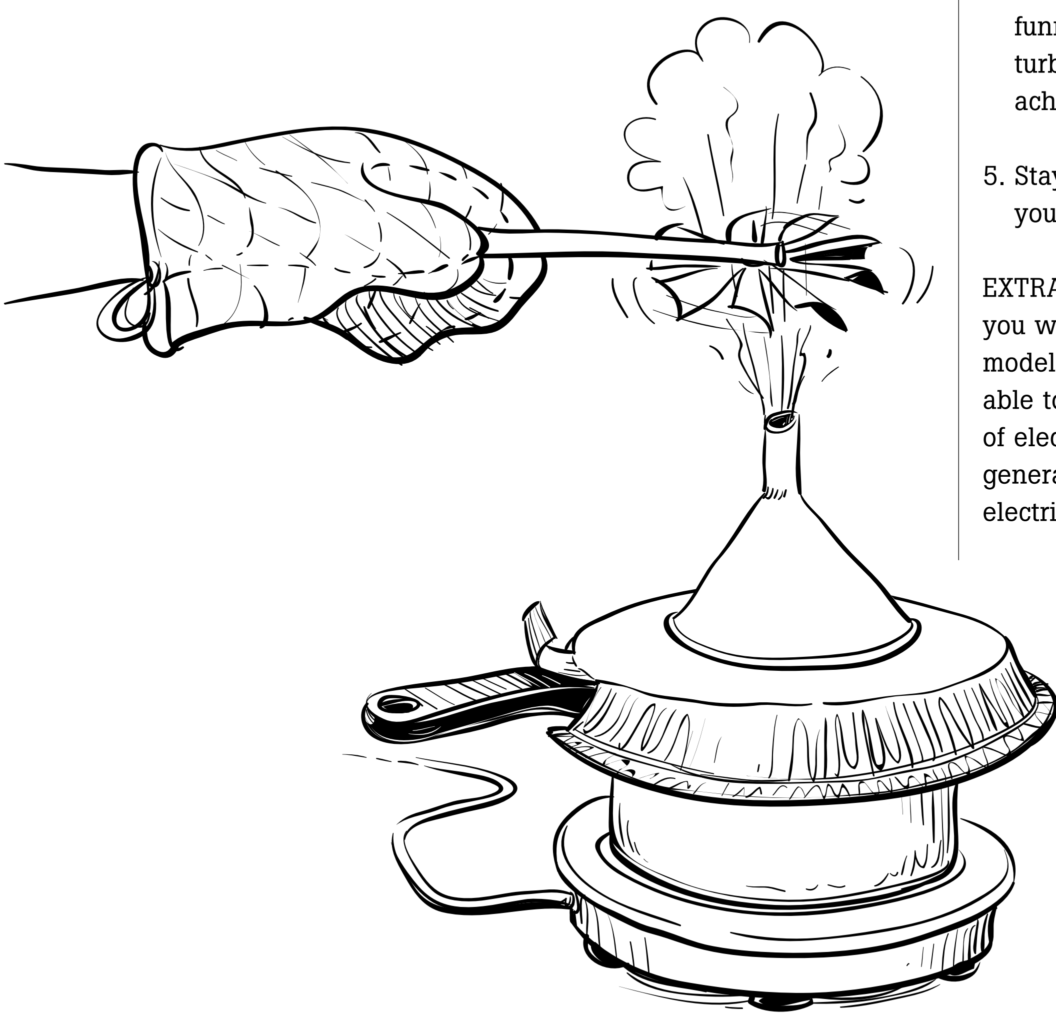
2. Test your turbine with a stream of falling water, making any needed adjustments for optimum spin. See how fast you can get the turbine to spin. Try varying amounts of falling water and varying heights from which the water falls before it hits the turbine.

3. Test your turbine using steam. Using the heat source, fill the cooking pot ¼ full of water and bring to a boil. Wearing oven mitts, place your steam device on top of the pan. Make sure that the funnel fully covers the opening in the middle of the pie plate. Steam should be issuing only from the funnel opening.

4. Wearing an oven mitt, hold your turbine "face" down over (but not directly on) the funnel opening. Remove the turbine and gently adjust its blades, if needed, to ensure optimum spin. Hold the turbine over the funnel opening again and raise and lower it slowly to see at which height it will spin fastest. Using the ruler, make an estimated measurement of the height from the funnel opening at which your turbine's top speed was achieved.

5. Stay in your groups to finish your experiment write-ups.

EXTRA CREDIT: Describe how you would design a turbine model that would actually be able to generate a small amount of electricity using a very small generator. If it worked, what electrical apparatus could it run?



GETTING CURRENT:
Generating Electricity Using a Magnet

PLANNING OVERVIEW

SUBJECT AREAS:
Physical Science, Math, Language Arts

TIMING:
Preparation: 30 minutes
Activity: 1-2 45-minute class periods

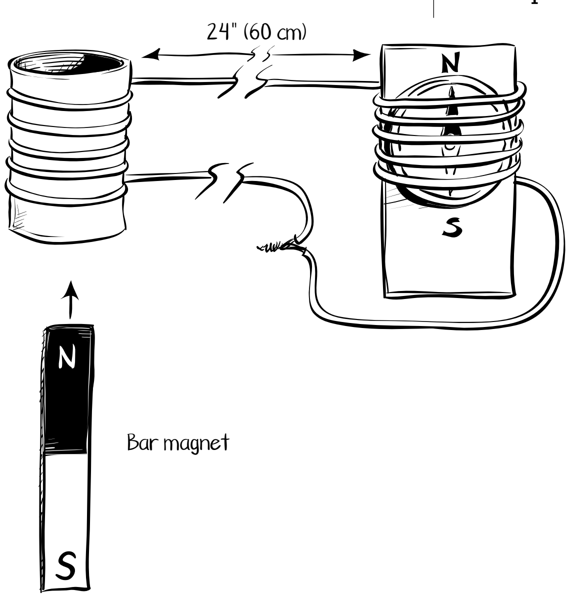
Summary

Students investigate how generators produce electricity by using electromagnetism.

Objectives

Students will:

- Hypothesize what will happen and why when a bar magnet is passed in various ways through coils of wire.
- Construct and use a model that demonstrates the actions of an electricity generator.
- Prepare a brief summary of the activity, including a description of the set-up and what occurred when it was tested.
- Draw a conclusion comparing their hypotheses to what was observed in the activity.
- Compare their models to an actual electricity generator.
- Propose explanations relating magnetism and electricity.
- Recognize that the main reason for making an electrical turbine spin is to turn a generator.
- Compare both models to an actual power plant turbine and generator (if "Going for a Spin" was also done).



Model generator

Materials for Warm-up

(Optional)

Iron filings

Stiff paper

Strong bar magnet

Materials for Student Activity

Per student group:

Student handout: "Getting Current"

Copy of Chapter 2 Discussion, Energy and Electricity

A directional compass

A strong bar magnet with north and south poles

13 feet (4 m) insulated copper wire

Cardboard toilet paper tube

Transparent tape (optional)

At least one for the entire class:

Wire stripper/cutter

Teaching Notes

Ensure that students understand that the activity setup is just a demonstration of the idea that moving a conductive wire in a magnetic field can create an electrical current. The setup in this activity does not look like a power plant generator, but both use coiled wire and strong magnets. The model works using the same principle.

Remind students to keep magnets away from computer disks, audio or video tapes, etc.

Since this activity is a simple demonstration, the full scientific method outline is not called for here. Rather, certain key elements of the method are used, including hypothesizing, describing the activity, gathering data, and drawing conclusions.

If students have trouble with their models, have them try making more coils. If this doesn't produce an electric current (move the compass dial), you may need stronger magnets.

Items in the materials list can be found at hardware, electronics, or school supply stores. You can also order them from a science supplier such as Sargent-Welch, Edmund Scientific, or Nasco Science. If you can't find iron filings, show the magnetic field illustration (also in the student handout) to your students. Discuss it using information in the Warm-up section, or have students view a video or CD-ROM that discusses magnetic fields.

Warm-up (Optional)

If you were able to find some iron filings, try this with your students: Place a stiff piece of paper over a bar magnet that is resting on a flat surface. Sprinkle some iron filings on the piece of paper. Ask students to observe what happens. The interesting pattern that results is due to the magnetic field surrounding the magnet.

Explain that any magnetic field is actually invisible to us. The iron filings are lining up in reaction to the magnetic field, and show the lines of magnetic force — the "attraction" that occurs between the two opposite poles (north and south) of the magnet. The lines of force in a magnetic field travel from north to south — much the same way electric current flows from negative to positive (opposite charges attract).

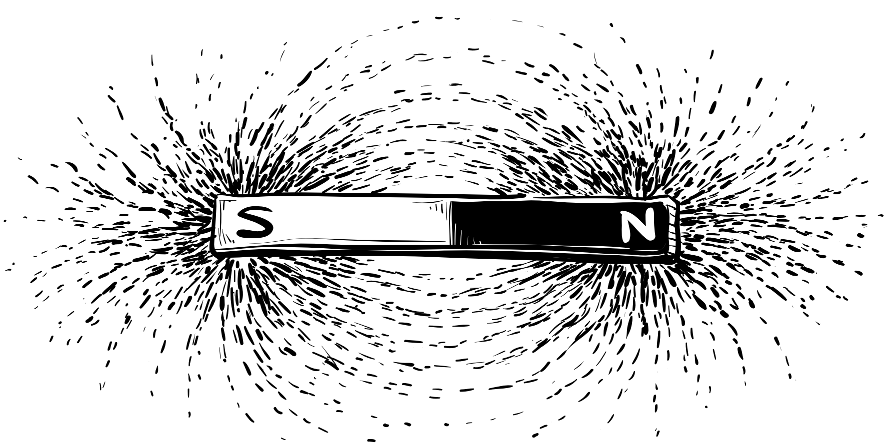
In this activity, the magnetic field of the bar magnet interacts with electrons in a wire to create an electrical current.

Note: Students may ask what causes magnetism in the first place. Tell students that until recently, the cause of magnetism was not well understood. In fact, not long ago, the *Encyclopedia Britannica* stated: "Few subjects in science are more difficult to understand than magnetism." Recently scientists have begun to unlock magnetism's mysteries, but the answers are very complex, having to do with "spin" of electrons on their own axis as they buzz around the nucleus of an atom.

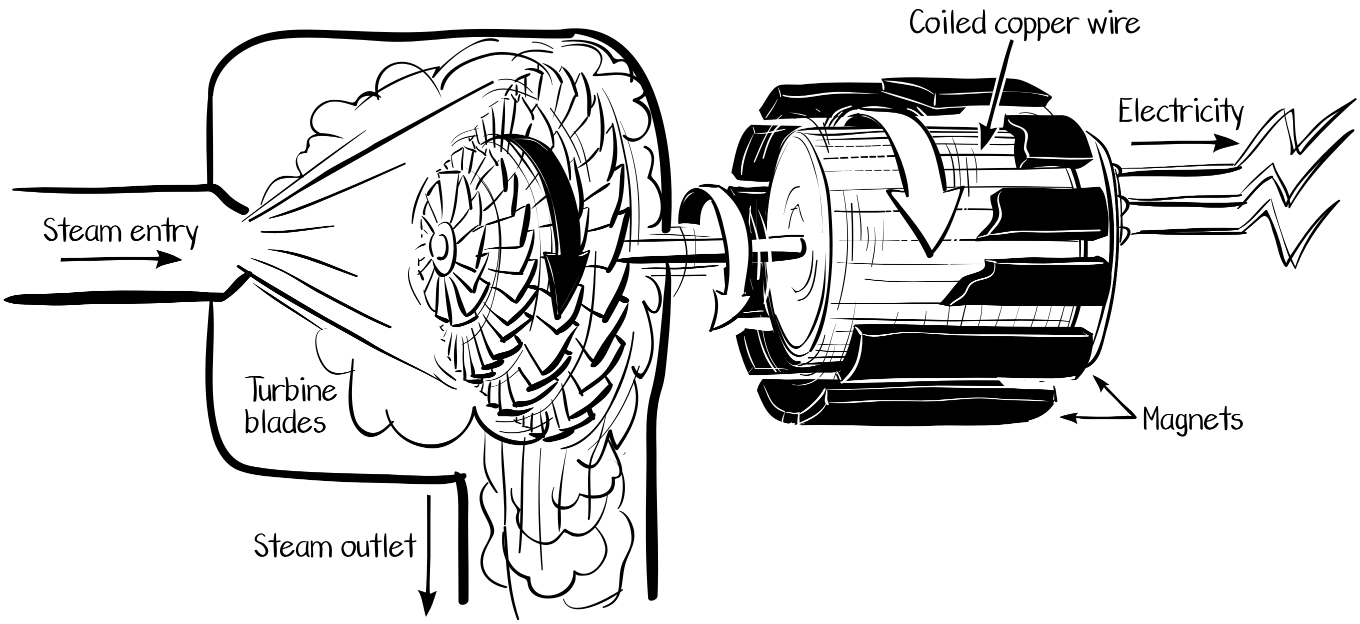
The Activity

1. Gather the necessary materials and set up your classroom to accommodate the activity. Refer to the Student Activity page for the specific procedure.

2. Use the Chapter 2 Discussion to talk about how a power plant generator works. Using the graphic of the typical steam-driven power plant on page 29, discuss how the power plant turbine provides the spinning force that turns the generator. While this diagram does not show the inner workings of the generator, it does illustrate the interconnection of the turbine and the generator.



Iron filings showing magnetic fields



Inside a turbine generator

3. Next direct the students' attention to illustration, "Inside a turbine generator" (also in the student handout). Explain that in generators the rapid spinning of wire coils between the two poles of strong magnets produces an electrical current.

4. Point out that in most power plant turbines the wire coils are moving and the magnets are stationary. However, it can work the other way around. We can move a magnet in and out of wire coils (as demonstrated in this activity) and still generate an electric current.

5. Review with the class the outline they must prepare to write-up the activity. The specific directions for doing so are found in the Student Handout for this activity. Tell students that they will be working in groups to do the activity, but each will do his or her own write-up.

6. Organize students into groups. Pass out materials and copies of the Student Activity pages.

7. Have students look over the activity directions, then reflect on what they've learned so far about generators and electromagnetism. Then ask them to fill in the Hypothesis portion of their outline (see page 45). Explain that they need to predict what they think will happen when they do the activity and why.

8. Have students create and test their own model generators. Allow time for them to also do their activity write-ups. Remind them that the background information they need to help explain how their experiment works was included in your discussion of this activity, and is also found both in the Chapter 2 Discussion, as well as in their student handout, "Getting Current."

9. Have the class get together after groups have tested their model generators and have done their write-ups. Ask students to use what they've learned from studying Chapter 2 and their experiences with both activities to write a brief narrative, on separate paper, comparing both the turbine model and the generator model to an actual power plant turbine and generator. If you did do "Going for a Spin," then have students explain how their generator model compares to an actual power plant generator.

Wrap-up

Call the class together to discuss their findings. Ask students to explain why they think generators work the way they do.

Ensure that students are able to make the connection between electricity and magnetism and have a general understanding of electromagnetism.

Next conduct a discussion connecting this activity (and that of "Going for a Spin" if you have done it as well) to an actual power plant that uses turbines and generators.

Referring back to the Warm-up, remind students that magnets create a magnetic field around them. This field causes electrons to move in the conductive wires that are spun inside the magnetic field. If these wires are connected in a complete pathway, or circuit, an electric current will then course through the wires.

Explain that the compass in their activity set-up serves as a "galvanometer," a device that indicates electric current. The very small current produced by the passing of the magnet through the coils of wire causes the compass needle (which is magnetized) to turn aside, or deflect. This is a property of electromagnetism.

Extension

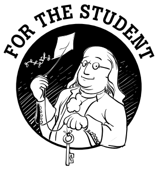
As a follow-up, students may also wish to look up power plant generators in reference books or on the Internet to learn more about how they work. Other interesting topics to pursue are the electromagnetic force and the history of the compass (this one may appeal to both history and science buffs alike).

Assessment

Students will have had the opportunity to:

- Create and test a model generator.
- Prepare a write-up of the activity, including using hypothesis, description, and conclusion.
- Develop an activity write-up that includes diagrams and labels and tells why the activity worked the way it did based on what they have learned about electricity and magnetism.
- Produce a brief narrative description comparing an actual power plant generator to their turbine models from the first activity and their generator models from the second activity.

Permission was granted by the Tennessee Valley Authority to adapt portions of their junior high curriculum unit, "The Energy Sourcebook" for use in this activity.



GETTING CURRENT: Generating Electricity Using a Magnet

Generators use magnets and wire coils to produce electricity. The electricity is produced by the rapid rotation of wire coils between the two poles of strong magnets (or the spinning of magnets surrounded by wire coils). Turbines — driven by a force such as pressurized steam, moving water, or forceful wind — provide the spinning power.

Magnets are surrounded by a magnetic field that can cause electrons to move in wires turning inside this field. If these wires are conductive (allowing electrons to flow easily), and if they are connected in a complete pathway (called a circuit), an electric current will then run through those wires.

While most generators operate by rapidly turning wire coils inside the two poles of a magnet, it also works the other way around — we can move a magnet in and out of wire coils to generate an electric current. In this activity, you will demonstrate this concept using a compass (which has a magnetized pointer that acts as a current detector) to show that electricity has been produced.

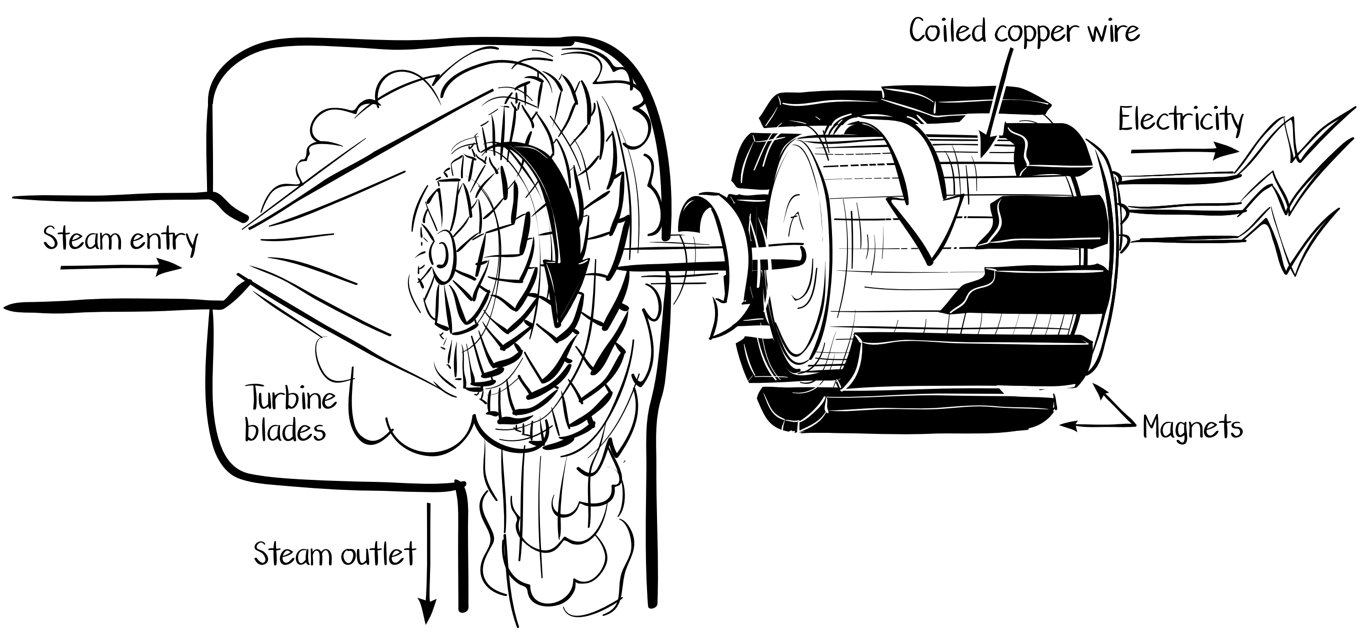
Materials

Per student group:

- A compass
- A strong bar magnet with north and south poles
- 13 feet (4 m) insulated copper wire
- Cardboard toilet paper tube
- Transparent tape (optional)

At least one for the entire class:

- Wire stripper/cutter



Inside a turbine generator

Prepare Write-up Outline

Make an outline, leaving room to write in each section, using the format below. Be sure to title your paper and include name, group name or number, and date.

1. Hypothesis. Predict what will happen.

2. Activity Description/Data. Describe the set-up and what happened when you tried all the variations suggested.

3. Conclusion. Revisit your hypothesis. Tell whether or not it was correct, and why.

Next, review what you have learned so far about generators and electromagnetism, and study the directions for the activity. Based on this information, pose a hypothesis predicting how you think the generator model will work and why.

When everyone in your group has completed his or her hypothesis, move on to the Procedure.

Procedure

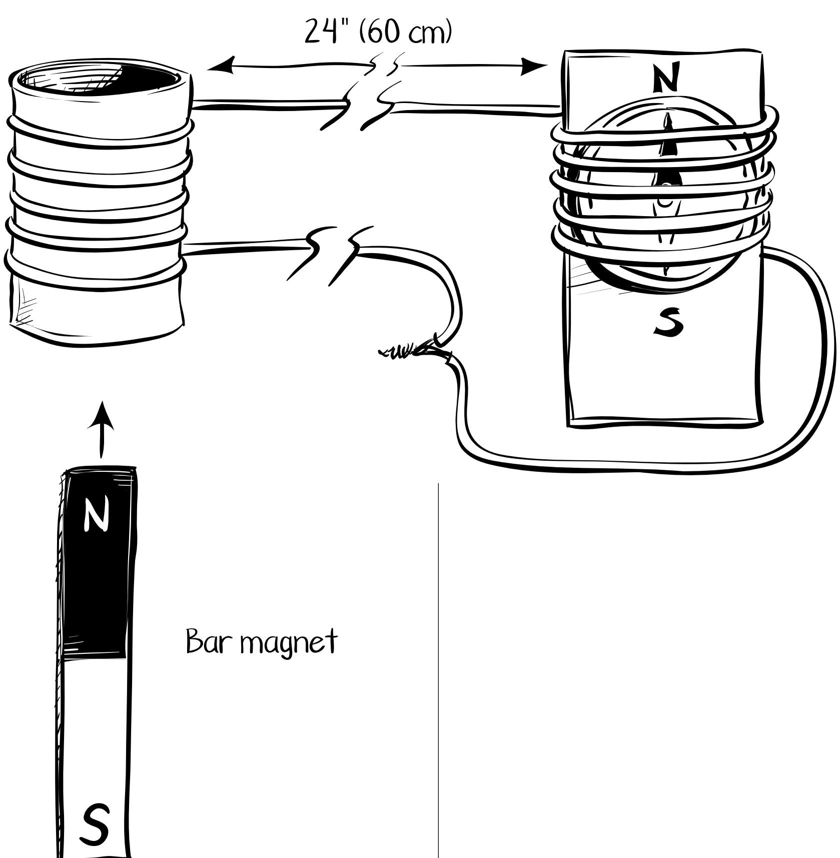
1. Remove about ¾ inch (2 cm) of insulation from each end of the wire.

2. Wrap one end of the wire around the compass five times as shown. Be sure to position the compass so that the needle is directly underneath the wire wrapped around it. CAUTION: Ends of wire are sharp.

3. Extend the other end of the wire out about 24 inches (about 60 cm) from the compass and then wind the remaining length around the cardboard tube five times. The bar magnet will pass through these coils.

4. Run the remainder of the wire back to the compass. Twist the two exposed ends of the wire together. If desired, secure the wire to the compass with transparent tape.

5. Have one group member pass the magnet back and forth through the coils. If nothing happens disconnect one side of the wire and add more coils to the tube, then reconnect. Keep the compass at least 20 inches (50 cm) from the magnet so that the magnet itself does not cause the needle of the compass to be deflected.



Model generator

6. Other group members should watch the compass closely to observe and record what happens.

7. Change the direction of the magnet by inserting it from the opposite end of the tube. Observe and record what happens. Next turn the magnet around (inserting the other pole first). Observe and record what happens.

8. Stay in your groups to finish writing up your activity. Group members should share insights and give each other support, but each person should write his or her own.

   Include your three observations based on the three different ways you tested the model. Using the Chapter 2 Discussion, your classroom instruction, and the information on this worksheet, explain why the compass reacted the way it did in your conclusion.

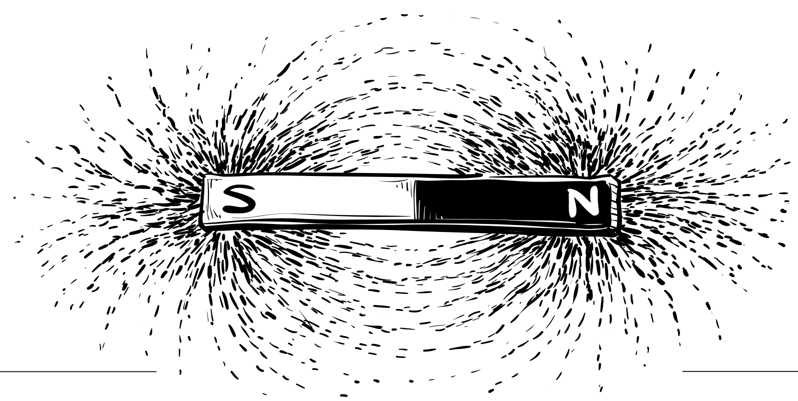
9. Be prepared to discuss your findings with the class.

UNLOCKING SOME OF MAGNETISM'S MYSTERIES

Although we can't see magnetism, we've all seen its effects. We know that magnets have a force that can attract certain materials (or another magnet). The force of a magnet can also cause another magnet to move away. We use magnetic forces everyday, from refrigerator magnets holding up memos to magnetic poles in common devices such as motors and telephones.

Most of us are also familiar with the terms north pole and south pole. This is something you usually can find marked on a bar magnet. (The labels north and south pole are arbitrary names given by scientists who first studied magnetism.) All magnets have north and south poles — no matter what shape they are. Magnets have the most force at the poles. However, magnetic lines of force actually extend all around the magnet, creating a magnetic field.

Scientists are still exploring what causes these lines of magnetic force. They do know that most atoms actually act like microscopic magnets, each with its own tiny north and south pole. When atoms are all jumbled up — as they are in most materials — we don't notice the atoms' magnetic force. But, in certain materials (mostly some metals), the atoms all line up, creating a collective north pole at one end and a south pole at the other. This results in magnetism at each pole strong enough to attract a material such as iron.



WATT'S MY LINE?

PLANNING OVERVIEW

SUBJECT AREAS:
Physics, Chemistry, Language Arts

TIMING:
Preparation: 30 minutes
Activity: 4–5 45-minute class periods

Summary

Students demonstrate their understanding of how we use energy resources to produce electricity by giving presentations and participating in a unique game of cooperative charades.

Objectives

Students will:

- Identify major energy resources
- Demonstrate how electricity-generating technologies work
- Compare the advantages and disadvantages of various energy resources

Materials

Nine sets of copies of Chapter 2 and Chapter 3 Discussions (including the introductory pages and all of the resource sections of Chapter 3)

Student Handout: "Electric Power Technologies," one for each student, plus one for teacher to cut up prior to playing the charades game

Hat or other container in which to place the slips of paper naming the power technologies

Presentation materials: These will vary, but may include poster board, markers; video equipment, overhead projector and transparencies; computer presentation software such as PowerPoint® (often bundled with Microsoft Office®), Kid Pix®, Hyper Studio®, or Inspiration®.

Optional: Materials for making props such as paper cups, plates, plastic utensils, string, paper, tape, markers, yard sticks, paper clips, small Slinkies®, springs, used paper towel tubes, and so on.

Optional: Other reference materials on energy resources and their uses; Internet access

Making the Link

Many of us don't think much about where our electricity comes from or how much of it we consume (that is, until there's a power outage!). It would be ideal if teachers could take their classes to visit power plants to see how electrical technologies work and to learn firsthand what resources they use for energy. Because such opportunities aren't typically available, this activity brings electrical technologies to "life" right in the classroom.

Many different energy resources and the electrical generation technologies that use them have been discussed in the previous sections. In studying these in more depth, students may come to recognize the value of using more than one energy resource for electricity, as well as the advantages of using more renewable energy resources.

The Activity

PART ONE

1. Before beginning this activity, divide your students into nine study groups. If you have not yet given students copies of the Chapter 2 and Chapter 3 Discussion sections (including the introductory pages and all the resource sections), do so — one set to each group.

2. Tell students that each group will prepare and give a presentation on one of the energy resources and how it is used to generate electricity. Explain that following the presentations the class will be playing a game of cooperative charades pantomiming a technology that makes use of one of these resources.

3. Review the Sidebar from Chapter 2 Discussion, "What is Energy?" and the section "Understanding Electrical Terms." Emphasize that energy can change, or convert, from one kind to another. In the second part of the activity, students will be showing how energy changes from one type to another (such as from mechanical energy to electrical energy. Discuss that the term "watt," is a measurement of power, specifically the rate of heat flow or of the flow of electricity. It is named after James Watt, an inventor whose experiments resulted in significant improvements to the power of steam engines during the Industrial Revolution.

4. Assign an energy resource to each group. Explain that groups will be studying the information about their resources and then preparing a presentation to give to the rest of the class. Show them the materials that you wish them to use for preparing these presentations. If you have extra references (including Internet access), then point these out as well. Remind students that their presentations need to be very clear, so that the class will be adequately prepared to later play the game of charades.

5. Set a deadline and let groups go to work.

6. When the deadline arrives, have groups give their presentations to the rest of the class. Allow for a question and answer period following each presentation, if time allows.

PART TWO

1. Next, prepare to play the game "Watt's My Line?". Cut up one copy of the handout, "Electric Power Technologies" so that you have one type of system on its own slip of paper. Place all of these slips into a hat or other container.

2. Ask your class if anyone has ever played Charades, Pictionary, or Cranium. Ask for examples of how they had to pantomime something for the other players. Next, explain to your class that they will be playing a pantomime energy game, "Watt's My Line?". Students will be trying to guess what "line" of electrical work is being depicted.

3. Explain that if they get a technology for which there are several different types of systems (such as for Solar Thermal, where there are Solar Dish-Engines, Parabolic Troughs, and Central Towers) they get to decide which one specifically they wish to depict.

4. To show their technology, each group needs to use pantomime. All members of a group must participate in their group's role-play. Group members may speak, make sound effects, and use props, but may not use words that reveal the electrical technology being depicted. Show students the materials you have available for props.

   You may wish to give an illustration before students begin preparing their pantomime. For example, to depict a storage hydropower plant, one student might be the water, another the dam and the penstock (channel through which the water falls), another the turbine, another the generator, and still another the tailrace through which the water spills out to the river below the dam. Sound effects (gurgling, whooshing, humming, etc.) and props will enhance the pantomime and add to the fun.

5. Place your class back into their study groups. Now have each group draw a slip from the hat. Remind groups not to reveal what their technology is. Tell them that they may use the Discussion sections and any other reference materials provided to them, as well as what they learned from the student presentations, to figure out how to portray their energy technology in an interactive group charade.

   Some students may have to take on more than one role in the pantomime if the groups are small. You may also wish to arrange for groups to work outside or far enough away from each other (or as homework) so that their work remains a "secret."

6. Set a time limit and let groups go to work. When the time limit is up, have groups act out their "power pantomime." You may wish to have students put away their reference materials, but allow them to keep a copy of the handout, "Electric Power Technologies," to help guess what is being depicted. Before the class begins, decide how the viewers will guess (raising hands, calling out, etc.). Then proceed to play "Watt's My Line?"

Wrap-up

Lead a class discussion comparing the different energy resources and their technologies. Explore the benefits and disadvantages of each resource, referring to the Consideration sections for each resource, if you'd like.

Assessment

Students will have had the opportunity to:

- Work cooperatively in research groups to produce energy resource presentations.
- Portray and guess the various types of electricity-producing technologies in a game of cooperative charades.
- Compare and contrast the different energy resources and their technologies and discuss their use in a responsible energy plan.

FOR THE STUDENT

ELECTRIC POWER TECHNOLOGIES

Biomass Power Plant

Geothermal Flash Steam Power Plant

Geothermal Dry Steam Power Plant

Geothermal Binary Power Plant

Hydropower: Run-of-River System

Hydropower: Storage (Impoundment) System

Ocean: Marine Current System

Ocean: Wave Energy System

Ocean Thermal Energy Conversion (OTEC)

Solar: Photovoltaic (PV) System

Solar Thermal: Concentrating Solar Power System (CSP)

Wind: Stand-alone Turbine

Wind Farm

Hydrogen Fuel Cell

Fossil Fuel Power Plant

Nuclear Fission Power Plant

GRIME SCENE INVESTIGATION

PLANNING OVERVIEW

SUBJECT AREAS:
Language Arts, Ecology, Environmental Science, Government, Math

TIMING:
Preparation: 30 minutes
Activity: 3-5 45-minute class periods; some students will spend extra time outside of class

Summary

Students form detective agencies to gather evidence regarding air pollution in their own community.

Objectives

Students will:

- Identify particulate matter as an air pollutant.
- Identify energy sources that don't contribute to particulate (and other) air pollution.
- Design and build particulate matter collection devices.
- Develop hypotheses predicting the amount of particulate deposition found at each experiment site.
- Measure the rate at which different sources deposit particulate matter in a given locale.
- Identify possible sources of deposited particulate matter in a specific area.
- Prepare a class master list of experiment procedures and results.
- Prepare experiment write-ups, using the scientific method.
- Draw conclusions regarding particulate pollution in a certain area.
- Prepare summary reports based on the entire class's findings.
- Optional: Conduct extension activities regarding other types of air pollution.

Materials

For warm-up demonstration:

Small mirror

Paraffin wax candle and candleholder

Matches

Tongs and oven mitt

For activity, per group:

Copy of "Air Pollution's Heavy Hitters," page 137

Optional: Copy of Scientific Method Form, page 185

Particulate Chart, page 152

Wax pencil or other means to mark glass slides

Glass microscope slides (minimum of two per group)

Petroleum jelly or double-sided tape

Clean jar lids and plastic wrap or petri dishes in which to place slides

Maps of your city or area

Information on industries in your area from the chamber of commerce (optional)

Entire class:

Microscopes, handheld microscopes, or hand lenses. (Each detective group should examine the particle samples under the same magnification, or use the same type of magnifying lenses.)

Other materials for devices to protect particulate matter collection slides, including sturdy dowels or other posts, empty coffee cans, cardboard boxes, aluminum pie plates, foil, Superglue, nails/hammer, and so forth

Optional: Other materials for extension activities (see Extensions, page 151)

Making the Link

Sometimes it's hard for students (and even adults!) to picture that the air around them, while invisible, is actually full of many different substances, an excess of which may be bad for their health and for the environment.

This may be especially true for students who don't live in an obviously hazy or smoggy urban area. These students may be surprised to find that their air contains contaminants (such as those from farming, logging, or a factory miles away, whose pollutants are carried by wind). Those who live in congested, urban areas will more easily recognize the effects of smog, smoke, or other pollutants.

While it is difficult to measure the gases in the air with ordinary classroom or science lab equipment, we can measure some of the materials released into the air from human activities. These released materials are tiny solid and liquid particles called particulate matter that become suspended in the air.

It is normal to have some particulates in the air (as from volcanic eruptions, forest fires, dust, and pollens). In fact, without some airborne particles, we wouldn't have rain. However, humans have been producing an excessive amount of particulates from combustion of fuels, contributing to poor air quality. As discussed in "Energy and the Environment," the reaction that occurs when we burn fuels for energy is one that releases different types of gases and small solid particles. Certain other industries also put extra substances into the air.

After conducting this activity students may have a heightened sense of what is in the air they breathe every day. The study may also provide motivation for action regarding what they learn. (An action plan activity is included in Chapter 5, "Energy Policy and Management.")

Teaching Notes

Acting as detective teams, students will attempt to identify possible sources of airborne particulate matter by collecting samples. An increased rate of deposit in the vicinity of, for example, a local factory or fossil-fuel power plant may point to it as a possible source of particulate pollution. Students can then conduct further research, such as contacting the Environmental Protection Agency, your local air quality board, or other organizations that may have information to substantiate their hypotheses.

If time and resources are limited, consider conducting the Adaptation or one of the Extension investigations as an alternative to this activity. You may also choose to do a data exchange with other classes to share and compare your findings.

Warm-up

Use this quick demonstration to show how byproducts are often created when we burn something. Light the candle. Wearing an oven mitt, grasp the mirror at one corner with the tongs. Hold it over (not in) the candle flame for about five seconds. Take the mirror away and show it to your students. They should see a dark sooty residue on the mirror.

Ask what the sooty residue might be. Guide the discussion to the idea that whenever something is burned, a chemical reaction called combustion occurs. Combustion refers to the chemical combination of certain materials with oxygen and the release of energy.

When we burn a paraffin candle, heat, light, and some byproducts are given off. (The byproducts occur because the combustion reaction is incomplete. With complete combustion the only products, besides energy, are water and carbon dioxide. Complete combustion is rare and occurs only under specially controlled circumstances.) These byproducts show up as the residue on the mirror. In large quantities they are considered pollutants.

If any students have been camping, they can also relate this demonstration to the soot they see inside the lantern of a used kerosene lamp. Kerosene is a form of fossil fuel, as is the paraffin commonly used to make candles.

Explain to students that they will be investigating industries that may add to particulate pollution in their area. They will also identify industries that may not contribute to this type of pollution.

The Activity

STAGE ONE

1. Go over the background information in the "Energy and the Environment" Discussion section with your students. Review the chart on page 137, (Air Pollution's Heavy Hitters). Ensure that students have a clear understanding of "particulate matter."

2. Post a map of your community and, if possible, display literature from your chamber of commerce on local industries. (For this activity, the term "industries" includes any place of work, including retail businesses, service industries, manufacturing firms, repair firms, high-tech companies, home offices, and academic institutions.)

   Use the map and the business literature, along with your class's general knowledge of the community, to brainstorm a list of the possible industry sources of particulates in your locale. Make another list of industries that students think might generate little or no particulate pollution. One of these sites could certainly be your school.

3. Next, ask students to identify the industries to which they personally have safe and easy access. This could include places where their parents, other relatives, or friends work or attend classes. Narrow these down to those industries that seem the most likely to grant permission to set up experiment stations.

   As a class, compare each of these places to the lists made in Step 2. From this comparison, make a list of six to eight places (depending on how many groups you have) to contact. Remember that some of these should be suspected generators of particulate matter and others should not.

4. As a class, compose and send a letter (or e-mail) to the general manager of each of these industries or businesses, explaining the purpose of the project and asking permission for specific students (or their adult contact) to set up an experiment station on the firm's premises. Be sure to mention the connection — parent, neighbor, etc. — that the student has at that industry. A copy of this letter should be sent to each student who has a connection, as well as to the connections themselves.

   Keep your lists from Step 2 handy, so that your class can select another potential site if any of your inquiries results in a negative answer.

5. While waiting for answers to the inquiries, divide your class into teams.

   It is optimal to have at least six teams, even if there are only two or three students on a team. The more research sites, the better. Explain that each team is to form a "detective agency." Their assignment: to identify some industries in your area that may be particulate matter polluters, as well as some that may not be.

   You might allow time for each team to develop a name for its agency, as well as a pseudonym for each detective participant.

FOR THE TEACHER

The student who has the connection at a potential experiment station site could be the team leader.

If some of the teams do not have a specific connection, or if one of the selected industries denies the request, assist these groups in selecting and contacting another potential experiment station from the lists developed in Step 2. As an alternate, use public property, skipping the permission process.

6. Make a master list to organize and collect experiment designs and results. When your initial inquiries are answered in the affirmative, place in the far-left column the names of the industries that have agreed to participate. Write the student team names and team members in the next column. Highlight the team member with the industry connection. Allow for other columns to show information such as the number of slides placed and the particulate count for each. (See example below.)

   Assist students in following up with industries that don't respond to your first inquiry.

7. As a class, decide how many slides will be left at each location. The more slides, the more accurate the data. Make sure that each team plans to leave the same number of slides.

8. Show the class the materials you have available for each group to make protective set-ups to safeguard their collection slides for one week. Have each group draw up a plan that will use these materials, plus any others they think of that are reasonable to acquire (e.g., Sam's mom is the manager of a shipping company and always brings home discarded, but usable, packing materials).

   You may wish to give students an example of a protective device: An uncovered empty coffee can could be attached, using hammer and nails, to the top of a pole inserted into the ground. The collection slides could be placed inside the can to prevent their being disturbed.

   Once completed, have each group present their plans to the rest of the class. After discussing the merits of each, have the class vote on the best (and most feasible) plan. Then all the groups will construct the same protective devices. Groups might wish to make a separate protective set-up for each different slide. If so, all groups should do so.

   Make arrangements to acquire any additional materials and make a copy of the chosen plan for each group. Allow time for groups to construct their devices.

10. Assist students in making arrangements to take these devices to the selected experiment sites. Remind students that once the collection devices are set up, the covers are removed.

Experiment Site	Adult Contact	Team	Number of Slides Placed	Particulate Count

11. Pass out a copy of the Particulate Chart, page 152, to each group and explain that when they retrieve their devices they will be comparing the amount of particulates left on their collectors to the amounts on the chart. Explain that the chart shows an approximate amount of particles per square inch (which can be recalculated in centimeters).

For the write-up of this experiment, you can have students use the Scientific Method Form on page 185 of the Appendix or have them use one of your own. Pass out copies to your students. Review your expectations for each category.

Explain that, though they will be working in groups, each student will fill out his or her own write-up.

Have each student develop a hypothesis predicting how much particulate matter he or she thinks will be deposited at the team's site, based on an average taken from all of their group's collection devices.

STAGE TWO

1. After seven days, the collection devices are retrieved and brought to class. Ask students to cover them, taking care that nothing touches the slides' surfaces.

2. Each team then carefully examines its slides with a microscope or hand lens. Ask students to make a list of what they think the particles may be and to draw what they see. Have them compare their drawings to the Particulate Chart on page 152 and estimate the amount of particulate matter collected on each slide. Have them calculate the average number of particles deposited at their site. Explain that the rate of deposit is this amount per the time period (in this case, seven days).

3. Have student groups finish the write-up of their findings using their scientific method form. For the Research portion, students can cite the Chapter 4 and your classroom discussion (You may wish to have students do other research as well.) For the Procedure section, you can ask them to briefly summarize the steps they took. For the Data section, students should identify their test site and list the count of particulates for each slide. You may also wish to have them draw a picture of what they see on each slide. Then the average of all slides should be listed. For the Conclusion, each student will be revisiting his or her Hypothesis, saying whether it was correct or not, and explaining why.

Wrap-up

Have each team report its findings to the class, using their write-ups. Record the results on the master list. As a class, identify the experiment site that produced the most particulates and the possible types of particulates found. Discuss how this compared to their original suspicions. What results did they find for the suspected nonpolluters? Were there any surprises? Where could particulate matter be coming from at what was thought to be a clean site?

Ask each group to write a brief summary of the entire class's findings, drawing conclusions based on all the evidence gathered.

Each group should also write a thank-you letter to the establishment that allowed an experiment to be set up on its premises.

As a class, talk about how more extensive tests could be conducted to determine if the suspect is the actual source of the pollution. Additionally, your class may wish to contact your local air quality board or the U.S. Environmental Protection Agency (EPA) to see if they have data that might corroborate student findings.

Assessment

Students will have had the opportunity to:

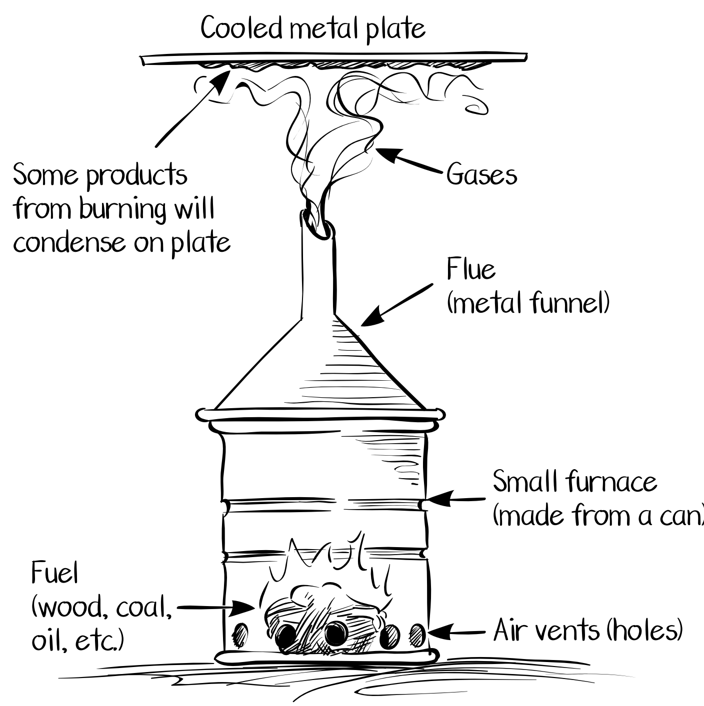
- Select experiment sites and ask permission to test for particulate matter pollution.
- Develop hypotheses predicting the amount of particulates deposited at various test sites.
- Design and build particulate matter collection devices.
- Measure the rate at which particulate matter is deposited in a specific locale.
- Develop a class master list of experiment procedures and results.
- Compose experiment write-ups using the standard scientific method.
- Prepare summary reports.

Adaptation

If your students aren't able to go into the field to collect samples, you may wish to simulate the conditions that produce particulates. Under controlled circumstances, burn wood, other dried biomass, paraffin candles, charcoal, or use a kerosene lantern and compare the particles gathered to those collected in a cleaner location in your room or lab.

In this case, you may wish to make a simple furnace using an inverted metal funnel on top of an empty can. Use a cooled metal plate or mirror as your collection device. Set the furnace on a noncombustible surface and provide adequate ventilation. Follow all safety rules for working around heat and flames. Wear goggles and have a bucket of sand, a fire extinguisher, or a fire blanket handy. Place the charcoal, wood, candle, or dried biomass directly in the can, ignite it, and use tongs and an oven mitt to hold the cooled metal plate or mirror over a funnel to collect particles. The kerosene lantern can be lighted and the collection device held directly over its chimney.

You may be able to examine the particulates using a hand lens or handheld microscope and compare them to the Particulate Chart on page 152. Relate your findings to possible sources of particulates in your community.



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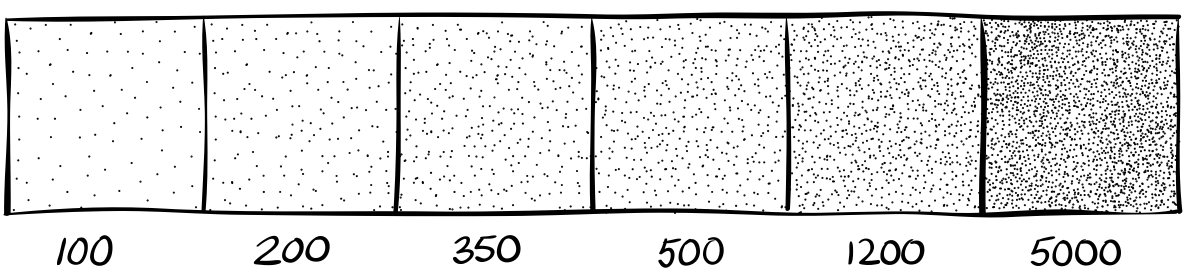
Extensions

- Research the feasibility of an electric utility company that uses fossil fuels (or other heavy polluter such as a charcoal production plant) switching to cleaner energy sources that don't contribute to particulate matter pollution. If one of your test sites was a heavy particulate polluter, discuss diplomatic ways to share your findings with the owners, along with suggestions for alternatives.
- Discuss the idea that some of the evidence may have blown in from another source. Consider ways to verify that the particles collected actually came from the source identified.
- Contact the EPA or local air quality board for information about how scientists determine and quantify levels of various air pollutants.
- Learn more about how industries try to control air pollution.
- If your specific situation allows, plan a day when everyone in your class, or even in the entire school, gets to school without burning fossil fuels. Suggest that students (as well as teachers and staff!) walk or ride a non-fossil fuel-powered vehicle (bike, electric scooter, skateboard, or an electric train or bus). For safety, and depending on the age of your students, encourage students to travel with a buddy, in small groups, or with an adult.
- Devise demonstrations to show relationships between the greenhouse effect and global warming, using simple materials such as a small clear box, two thermometers, and an incandescent lamp or sunlamp. Bring the two thermometers to the same temperature by placing them under the lamp for a few minutes. Place one thermometer under the clear covered container and the other in the open, both under the lamp. List the beginning temperature, then the temperature of each thermometer for every minute thereafter.

  Make a chart or graph of the results. Relate findings to information in the previous section on global warming. Note: Explain to students that other factors also affect the temperature readings inside and outside a greenhouse. The warming inside a greenhouse also results from the isolation of the inside air from the outside world, so the heat cannot escape. Additionally, the outside thermometer is being air cooled, while the inside one is not.) Even so, this demonstration is a fun and simple way to bring a big concept down to classroom size.
- Explore the effects of a household acid on ordinary materials, and compare them to the effects of acid precipitation. Obtain things to test (such as hard-boiled eggs, leaves, chicken bones), two clean glass jars, water, and vinegar. Place the same amount of a test item in each jar. Cover one with water and the other with the same amount of vinegar. Label the jars; cover and leave for several hours or days. Check at regular intervals and make notes of your observations. Try testing other items. Relate your findings to what you have learned about acid precipitation.

GRIME SCENE INVESTIGATION

PARTICULATE CHART



Number of particles per square inch

FOR THE TEACHER

Renewable Energy Action Project: WHAT'S IN *YOUR* ENERGY PORTFOLIO?

PLANNING OVERVIEW

PLANNING OVERVIEW
Environmental Science, Ecology, Government, Math, Fine Arts, Language Arts

TIMING
Preparation: 1 hour
Activity: Will vary depending on several factors, including size of survey group and scope of research. Estimated minimum: 5 45-minute class periods

Summary

Students will survey adult attitudes in their own community in order to raise student and public awareness about the use of renewable energy for the generation of electricity.

Objectives

Students will:

- Develop hypotheses regarding the possible outcomes of the class investigation.
- Determine the potential for renewable resources in their region.
- Ascertain which energy resources their local power provider(s) are currently using to produce electricity.
- Develop and conduct a renewable energy survey to assess the knowledge and attitudes of a selected target audience of adults.
- Collate survey information and interpret results.
- Prepare a summary paper of their findings, including suggestions for further action.
- Compare the actual investigation results to their earlier predictions (hypotheses).
- Formulate a conclusion and reflect on the changes in their reasoning based on the investigation findings.
- Present their findings to various audiences.
- (Extension) Report findings to a wider audience and/or conduct a vigorous public information campaign.

Materials

Per student:

Information logs. Report folders with 5–10 sheets of lined binder paper. You may also wish to copy Chapters 3, 4, and 5 Discussion sections and relevant information from the Appendix for each log.

Student handouts. Investigation Task List, Report Task List, Survey, and Cover Letter

Per survey participant:

Cover letter

Survey

Final report

Thank-you letter

General materials:

Information from electricity bills, city hall, and chamber of commerce regarding all electricity providers in your area; other resource materials such as phone books

Letter-writing materials

9″ x 12″ mailing envelopes: enough for entire survey group

Other envelopes to enclose with survey: enough for entire survey group

Paper or tag board for classroom charts

Optional: Computer with printer and Internet access

Optional: Report materials: poster board, markers; overhead projector and transparencies; presentation software such as PowerPoint®, Kid Pix®, Hyper Studio®, or Inspiration®

Making the Link

Students may ask: "If renewable energy is so great, why isn't it already more widely used?" Now that they've gotten this far in this unit, your students will easily recognize renewable energy resources all around them. Perhaps they live in an area that is very windy or sunny. Their town may be located by a seashore with strong wave action, a roaring river, or an active geothermal area. It certainly can be puzzling why we aren't making greater use of this abundant energy.

Many reasons may be cited regarding the challenges renewable energy has faced over the years, some of which will be addressed in this activity. However, perhaps one of the most important challenges today has been a lack of public awareness regarding how our electricity is produced. Many people are still not aware of the variety of resources available for the production of the electricity we use everyday.

In this activity, students have an opportunity to survey key adults in their own lives, to present a report to them and to others, and to inform them of the renewable energy options available to them right in their own communities.

Teaching Notes

Though rigorous, activities of this type are well worth tackling with your students.

There are a number of educationally sound justifications for doing so. This activity cultivates essential critical thinking strategies. Also, class work that moves into a "real-world" context is an effective and engaging type of learning. Working cooperatively with a variety of people is a skill that not only enhances learning, but will also serve students well as future citizens. Further, students will feel empowered, not just by their own involvement, but also by the involvement of the adults who show interest in this project.

A number of skills practiced in this activity are hallmarked in the National Science Education Standards & Benchmarks for Scientific Literacy. These standards support the importance of students being able to look at and analyze evidence, deduce a conclusion, and develop an interpretation or opinion based on evidence.

When working with the results from the survey, prepare students for the fact that the survey findings may not come out the way they'd anticipated. Emphasize the importance of reporting their findings honestly and accurately.

Remind students that, when giving presentations (see Wrap-Up, page 171), it is imperative that they act maturely and keep their cool in order to be convincing. Some people may simply have no interest in the subject. Others may consider energy use and the environment to be controversial "hot button" topics. Prepare your students for the fact that a few people may ask pointed questions or behave in a confrontational manner. Remind students that they must always be professional and polite. If they don't know an answer to a question, suggest that they get back to that person with sources of information or an answer to his or her question. Make sure that students get, with permission, contact information (phone number, e-mail, address).

Warm-up

Your students may be surprised to learn just how much of a difference they can make in the way things are run in the adult world. Share the following narrative, "Students Making a Difference," which shows how one teacher and a group of students made such a difference.

Students Making a Difference
When an environmental science teacher joined the staff of a Massachusetts high school in 1990, she found a neglected solar array right behind the school. She learned that the dozens of solar panels had been installed there as part of a U.S. government study on solar energy in 1981. At the time solar PV was very expensive, but the federal government policy regarding renewables was very supportive. Then, because of changes in policy in the late 1980s, support for the project was withdrawn.

The teacher decided that this "backyard" opportunity for educating students about renewable energy was just too good to miss. So, along with the original project developer, she launched a student-based lobbying campaign. They worked hard to convince the federal government to resume funding the project.

The teacher and students were very successful. Public funding was renewed in1994 to restore the array and keep it running. To top it off, this project also supported what was to become a nationally recognized renewable energy education program.

Interestingly, when repairs were finally made on the array, engineers discovered that only 7 out of 3,200 solar modules had failed. They found that the array had been quietly generating electricity in spite of the lack of maintenance and the harsh New England weather. Now kept in tip-top shape, it will continue to supply both energy and education for many more years to come.

This story is just one of many examples of teachers and students affecting energy policy and management.

In the following venture, students will conduct a public information survey of adults in the community about electricity sources and report the findings. This research might raise awareness that could eventually result in some real changes in the way electricity is produced and used in their own area.

The Activity

STAGE ONE: **Setting the Scene**

1. Distribute an Information Log to each student (*See Materials*). Explain to students that they will be using these logs to record plans and information. Remind them to always date each entry. You may wish to have students place a title on the front cover, such as "Renewable Energy Action Project."

2. Divide your class into groups of 3-5 students. These will be their action groups for the duration of this activity.

3. Ask each group to consider the reasons why renewable energy has not been more actively used in our country (at least not until very recently). Ask them to brainstorm and list on scratch paper what they perceive these challenges to be.

   Have each group share its ideas with the rest of the class. As they do, make a master list on large chart paper. Label the list with a title such as "Barriers to Use of Renewable Energy."

   Students might list the following barriers:

- Many people may not understand about the "hidden costs" of producing energy with resources such as fossil fuels, so they may perceive that renewable energy technologies are expensive.
- People may hear that it takes a long time to make up for an investment in renewables with the savings they realize on their energy bills.
- Some renewable resources are "intermittent;" they can only be used at certain times (e.g. solar, wind).
- There are some concerns about wildlife safety with certain renewable energy technologies (e.g. wind turbines, hydropower dams).

- Some people object to power plants in their cities, rural areas, or favorite forests.
- Some government policies — whether local, state, or federal — haven't always supported renewables, or have only supported a select few.

4. Explain to students that you would like to add other challenges to the list: first, public awareness; and second, lack of "choice." Write these on the Barriers master list. Discuss the first challenge, noting that electricity customers may not be aware of the renewable energy technologies now available to us.

   For the second challenge, discuss that the electricity providers may not offer a "green energy" or renewable "customer choice" program. Once aware, adults may begin to question why their power suppliers aren't offering renewable choices. Some may even start urging their power providers to add more renewable options. Additionally, these adults may have already considered adding renewable energy technologies to their own places of work or at their homes.

5. Ask students to copy the Barriers list into their logs.

6. Tell students that they will be doing an action project to determine attitudes and raise awareness about renewables in your community. This project will be done in stages. Students will determine the policies of your power provider(s) regarding renewable energy. They will learn what the potential is in your region for various resources. They will conduct a survey on renewable energy, with the target group being their parents, teachers at the school, and other adults in their lives. They will collate, assess, and present their findings. If their findings reveal a strong interest in renewable energy, a ripple effect of interest and demand could result in eventual changes in the use of renewable resources in your area.

7. Have students get back into their groups and give their group a name. You might suggest that they choose energy-related names, such as Kilowatt Kids or The Transmitters, etc.

STAGE TWO: **Investigation**

1. Use a large piece of chart paper on which to place an "Investigation Action Plan." On the page opposite is an example matrix that can be placed on the chart. Adapt this to suit your individual situation.

2. Distribute the student handout "Investigation Task List" to each student and review its contents with your class. Have students place this handout in their "Information Logs."

3. As a class, read over and discuss the various tasks, then decide which groups will be in charge of which tasks. If there is more than one power provider in your area, then assign a different group to each one. Note the name of each provider on the master chart alongside the assigned group's name. You will most likely assign each group to more than one task. Establish target dates for the completion of each task. Place all this information on the chart. Remind groups to use their "Information Logs" as the organizer for all their work on this project.

4. Pass out the sample survey and cover letter. As a class, read through each of these

Investigation Action Plan

Task	Who's in Charge	Action	Target Date	Results
Determine power providers' portfolio				
Assess local energy resource potential				
Investigate future plans for renewables				
Determine survey participants				
Analyze and adapt survey				
Analyze and adapt cover letter				
Prepare and deliver surveys				
Collect and record completed surveys				

and discuss any suggested changes. The group(s) assigned to make these changes should take notes during these discussions.

5. Have groups meet to discuss their assigned tasks, using the handout, "Investigation Task List" (page 174). Assist groups in determining how they will go about gathering and writing up their information or making changes to existing documents (e.g., survey or cover letter).

6. Ask student groups to discuss what they think their investigation will reveal, based on what they presently know about their community. Do they predict that their power provider is or isn't already using renewable energy? What types of energy resources might be available in their region? What attitudes and knowledge about energy use will their survey uncover?

   After some discussion as a group, have each student write his or her predictions in his or her log. Ask each student to form a hypothesis regarding the possible outcomes of the class investigation.

   Call the class together and ask students to share their hypotheses and to explain the reasoning behind their choices.

7. Allow time in future class periods for student groups to work together on their appointed tasks. If needed, allow time, too, for students to do any required research, or perhaps assign as part of their homework.

8. Make enough copies of the final Cover Letter and Survey for your survey participant group, plus extras for use in collating responses. Have students (or classroom volunteer) prepare self-addressed envelopes by placing the school address in the "To" position of the envelope. Place these along with the cover letters and surveys into the clasp envelopes. Have students deliver packets to their own survey participants. To avoid duplication, decide who will deliver surveys to adults at your school and to other parties such as district personnel.

9. As surveys are returned, have the group assigned to collecting and checking them off do this on the "Survey Participant Chart." You will want to keep the surveys in a safe place until students are ready to process the information.

STAGE THREE:
Collation and Interpretation

1. When the surveys are returned, it is time to collate the information.

   Divide the survey responses among the groups. Have students tally up each question's results, using the extra blank copies of the survey. Decide who will prepare a final master copy with a total of all responses.

   Using a blank master copy of the survey, "tic marks" are placed by each response. Then these tic marks are totaled. Any written comments are copied down beside their respective questions or on the blank sheets to be attached to the tally sheet.

2. Make a copy of the final collated results for each student. Have them place these in their logs. Have students examine and discuss these results in their groups.

3. Then call the class together. Ask each group what their general impressions of the results are and what they think the results may mean. Explain that when they are doing this, they are "interpreting" the results.

   These interpretations reflect the overall trends that you and your class see based on the responses to the survey questions. For example, in one case, your class might learn that your local power provider does not have a diverse energy portfolio that includes renewable energy resources, though your research shows that there are several such resource choices available in your area. Your survey findings might show that the majority of the participants are quite interested in having the option to get electricity from renewable energy resources and may be willing to pay a bit more for such choices. In this case, students may reasonably interpret the results to indicate that there is an indicator of community interest in further use of renewable energy sources.

   In another instance, what may seem like a lack of community interest may actually be lack of knowledge. Certain questions are indicators of this lack. Perhaps the survey participants (and most likely other community members) need more information regarding the benefits of using renewable energy and the great strides renewable energy technologies have taken in recent years. Or perhaps you may learn that your region has few renewable resources.

4. On large chart paper, make a master list of your class's general interpretations of the survey results. Have students copy these into their logs.

STAGE FOUR: **The Report**

1. On a large piece of chart paper, create another action plan matrix, this time for developing your final report. As before, place the task list vertically on the left side and place the following on the top horizontal: Group Name(s), Action, and Target Date.

2. Distribute the student handout, "Report Task List." Explain that they will be developing a report of their findings. It will have four sections (see "Task List"). A group will be assigned to each section. Another group will need to develop a thank-you letter to participants. The report and the thank-you letter will also need to be typed, copy-edited, and revised.

3. Encourage students to make charts and graphs displaying their numerical information (by hand or using presentation software). Once written, have different groups proof and edit each other's sections of the report, as well as the thank-you letter.

4. Decide how the report and thank-you letter will be typed up. Make enough copies for each survey participant who requested one, plus one for each student. Have students place their copies in their logs.

5. Have students individually review their original hypotheses and compare them to the actual findings of the class report. Ask them to reflect, in writing, on the reasons for their previous understandings and how they have now changed. Then, ask them to write up their own conclusion based on the investigation findings.

   Have groups get together to discuss their conclusions and how they may or may not differ from their original hypotheses. Have them share things that were surprises. For example, was it a surprise that their power provider is (or isn't) already using renewable energy. Maybe they didn't realize that a certain type of energy resource is so widely available in their region. Or, perhaps they thought that the adults surveyed would know more than they do about energy use.

   Bring the entire class together and ask a spokesperson from each group to give a general summary of their group's exchange. Invite further class discussion about any interesting points that may arise and make notes of any items for future class or individual investigations.

6. Send a copy of the report (with contact information for inquiries) to your local newspaper, your community government, and chamber of commerce. Make sure that your local power provider(s) receives a copy. Discuss with your students how inquiries arising from this distribution will be handled.

7. Educators for the Environment would be very pleased to receive a copy of your students' report along with any information you'd like to share about the outcome of this activity.

   Please send to: Educators for the Environment, 664 Hilary Drive, Tiburon, CA 94920, or, if electronically produced, to energyforkeeps@aol.com.

Wrap-up

Prepare a presentation in which your class will tell an audience about its findings and its recommendations. As a class, choose selected portions of the report to give orally or use in a visual format. You might consider presentation software, overheads, or other visuals such as charts and posters. Discuss the students' purpose in giving the report. For example, do they wish to persuade consumers, such as their parents, to ask their utility to use more renewable resources? Would they like your school board to consider installing solar panels on school buildings or to provide information to the school's power provider about diversifying its energy resource portfolio? Whatever the purpose or audience, steer students away from making strident demands.

If charts and other visuals are to be made or presentation software (see Materials) will be used, assign various sections to different groups.

Determine who will deliver the presentation. It might be a representative from each student action group.

First practice the presentation by giving it to another class at your school, or to an audience of the parents of your class. Invite your district's school board members to attend. Afterwards entertain questions. Based on the audience response, revise your presentation.

If the students' presentation is impressive, consider inviting a local power provider to send a representative to visit. In preparation, have students meet in their groups to discuss their opinions about the provider's policies. Then have the class meet to share and discuss each group's opinions. Make a class decision about the purpose of giving their presentation to the power provider. Will it be to applaud their efforts, to raise their awareness, or possibly to encourage a policy change?

Discuss the nature of persuasion and the different ways to promote one's point of view without being demanding. Once the presentation has been given, allow the representative time to digest and pass the information on to his colleagues. Then encourage follow-up contacts. Ideally, class members might continue an ongoing dialogue with the company. The results in the long run could be quite positive.

Assessment

Students will have had the opportunity to:

- Organize and maintain an information log.
- Do research concerning the potential for and attitudes about use of renewable resources for electricity in their community.
- Collate and interpret survey results.
- Develop a summary report of research findings and recommendations.
- Formulate hypotheses and conclusions regarding anticipated and actual investigation results.
- Prepare and deliver a presentation of findings.

Extensions

- Publish results to a wider audience. Contact regional TV and radio stations. Ask for display space in your community's library. Send a copy of your report to your federal and state officials.
- Contact established organizations that may share a common purpose. Share your report findings with them. Discuss the possibility of a working together to develop a more extensive public information campaign on renewable energy.

Additional Culminating Activity Suggestions

Civics Simulations. Have your class simulate a civics decision-making process. Here are two ideas, which you can adapt to meet your specific educational goals:

1. Your class might establish a "town council," made up of five or six students with various assumed identities. The rest of the class can act out the roles of various citizen groups who want their form of energy resource to be used for a proposed power plant in their community. Be sure to include all the resources that would apply to your area (including fossil fuels and nuclear). Groups can meet to prepare for the town council, and appoint a representative to speak for their group at the meeting. Consider having "representatives" of renewable

energy power providers, an oil company, a nuclear power facility, environmentalist groups, home owners, business owners, college professors and students, people who will be living right near the plant, and so on.

While these groups are meeting, the town council can meet to establish whether future power needs can be generated in the region or must be purchased from elsewhere, what they perceive the needs of the community might be, and some guidelines for the council meeting discussion.

Students can make up their own names and identities, or you can develop some and pass them out randomly. Invite a member of your local town/city council to come and advise students about the town/city council decision-making process, or, if possible, have your class (or representatives from your class) attend a town/city council meeting.

2. If you have been studying state or national government, you can adapt the above activity by changing it to a state or federal legislative "hearing" on energy. Each student (or small group with a spokesperson) would be a member of Congress testifying before the rest of his or her peers, advocating a particular type of resource to be supported by Congress to meet future energy needs.

   Once all have testified, then the entire "Congress" would vote on a 10 to 20-year energy plan (or whatever). One or two students may wish to assume the Congressional leadership role to moderate the discussion.

   Not only will students need to study their energy resource in preparing for the hearing, they will also need to learn how the governing body they are simulating conducts its meetings. You may wish to watch a broadcast of a Congressional hearing or invite your local representative to advise the class.

Forecast the Future. Assign a different energy resource to each student group. Ask them to brainstorm what they think the future would be like if that resource replaced fossil fuels as the most widely used energy resource. Select a time period such as 50 or 100 years in the future.

Have them consider all aspects of an industrial society: agriculture, transportation, factories, high tech businesses, service industries, schools and universities, recreation, national parks and wilderness areas, and so forth. What would cities and towns be like? How about air and water quality? What about the value of open space and having an enjoyable view? What role do they picture the government having?

Have groups develop a method to present their forecasts to the rest of the class. You might consider offering these choices: poster with report; play, puppet show, or "news hour broadcast;" computer presentation; travel log or travel brochure.

Ecological Footprints. Explore the idea of Ecological footprints more extensively. One way to do this is by going online. Students can compute their own "eco footprint" and learn how to shrink it by visiting the "Redefining Progress: Sustainability Program" website (see page 213).

What's in Your Energy Portfolio? INVESTIGATION TASK LIST

Assess Local Energy Resource Potential

Find out what energy resources are abundant in your local area. For many resources there is information available online. Several good places to start are the U.S. Department of Energy, your state's energy department, and possibly your local power provider.

Review Local Power Providers' Energy Portfolios

First, learn who your local power providers are (there may be only one in some cases). Then investigate their energy portfolios. Find out what percentage of the total electricity produced is coming from each renewable source (if any). Disclosure regulations in many areas should make this information readily available. With some power providers, this information will be online. Otherwise, call or write to ask their community relations department.

Investigate Future Plans for Renewables

Contact each power provider's community relations department. If they aren't currently using any renewables, ask what their plans are for adding renewables in the future. If they are already using renewables, ask them what their plans are for adding more, if possible. Get specific information regarding which types and what percentage of the total electricity produced they estimate each will be.

Ask their community relations department what they consider the barriers to more extensive use of renewables to be. Urge them to be specific. Use your list of "Barriers" to assist in the conversation. Remember to be courteous!

Determine Survey Group

Each student should list people he or she knows and trusts in the community who may be willing to participate in the survey. The group assigned this task should then gather all these names from each student and create a master list of participants. Additionally, the class should add other key adults to this list, including your school's administrator(s), office manager, teachers, librarian, custodian, as well as school district personnel. This list of survey participants should be posted. The group assigned this task is responsible for making sure that enough cover letters and surveys are copied. They are also responsible for following up to see that most (or all, if possible) of the surveys are returned (see below) and are checked off on the list.

Develop or Adapt Survey

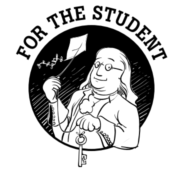
A sample survey is provided. You may want to use it as it stands or adapt it. Or, your class may wish to create one entirely on your own, based on your individual circumstances. Your teacher should conduct a class discussion to brainstorm any changes to the sample survey. Your group should take notes of these suggestions and then make the changes to the survey.

Analyze and Adapt Cover Letter

Your teacher will conduct a class discussion regarding ideas for revising the sample cover letter. Your group should take notes during this discussion, then make the needed changes to the letter.

Collect and Check Off Surveys

See "Determine Survey Group" above. Once the surveys are checked off, give them to your teacher.



REPORT TASK LIST

SECTION ONE: **Our Area's Energy Resource Potential.** This section reports on findings regarding your region's potential for various energy resources.

SECTION TWO: **What's in Our Power Provider's (Providers') Energy Portfolio(s)?** This section reports your findings regarding what energy resources your local power providers are currently using to produce electricity, along with whether they offer a "green energy" or other customer choice program.

SECTION THREE: **Survey Findings.** This section reports the findings and interpretations of your survey.

SECTION FOUR: **Summary and Recommendations.** This section includes a summary, as well as recommendations for further action. The recommendations should be based on the opinions of all the groups.

Edit Report. Several or all groups should help proof and edit the report, with the teacher and/or volunteer's guidance.

Thank-you Letter. This letter should contain a thank-you to the participant, a recap of the investigation's purpose, a very brief overall summary of what is found in the report, and possibly a paragraph stating future hopes and expectations of the class.

Type Report. You may want to have an adult or high school/ college student volunteer to type the report in order to save time.

Prepare and Deliver Report and Letter. Stuff clasp envelopes with the thank-you letter and report; each student delivers to his or her own key adults; mail, or otherwise arrange to deliver, the remainder to those who requested the report.

COVER LETTER

(Date)

(School address)

Dear Survey Participant,

______ grade students from ______________ class at ______________ School, ______________ District, have been studying the use of renewable energy. We have explored the many interesting choices available in different locations for the production of electricity.

We are now conducting a study on electricity production and energy use in our local community. We are investigating the potential for using renewable energy resources in this region. We are also learning what energy resources our local power providers are using to produce electricity. We have explored what the possible barriers, or challenges, have been to a more extensive use of renewable energy sources in our area.

We would like to learn community attitudes about renewable energy and are asking you to take a few minutes to fill out this survey. The questions are about:

- Your general feelings about the quality of life in our community.
- What you think is important regarding electricity production and energy use in our community.
- What you already know about the renewable energy choices we do have available.
- Whether you think it is important to be using more renewable energy for the production of electricity and what you would be willing to change in order for this to happen.

We are gathering and collating this information in order to gain an overall impression of adult awareness of and interest in these issues. Your individual responses will be completely anonymous.

The information from this survey will be collated with other respondents' answers and used as part of a report on energy production and use in our community. You will be sent a copy of our final report if you wish.

We plan to present our findings to various audiences, including fellow students and teachers, as well as school board members. We also might deliver a presentation to one of our local power providers.

Please return this survey to ______________ class, ______________ School, by ______________.
(date)
A self-addressed return envelope is enclosed for your convenience.

Thanks so much for helping us with this project,

Sincerely,

(Name of class)
(Name of school)

Your ZIP code: ____________________

SURVEY:
Renewable Resources for Electricity in our Region

A ABOUT QUALITY OF LIFE IN OUR COMMUNITY

Using the scale shown below, please indicate your answer to questions 1–4 by circling one of the letter abbreviations.

VS = Very satisfied
S = Satisfied
N = Not sure
D = Dissatisfied
ED = Extremely dissatisfied

1. How satisfied are you with the overall quality of life in our community?	VS	S	N	D	ED
2. How satisfied are you with each of the following conditions of our community?					
a. Physical environment (Consider, for example, parks/wilderness/open space vs. areas of buildings and pavement.)	VS	S	N	D	ED
b. Air quality	VS	S	N	D	ED
c. Water quality	VS	S	N	D	ED
d. Economic conditions	VS	S	N	D	ED
e. Cleanliness	VS	S	N	D	ED
3. Our government representatives are responsive and proactive about reducing air pollution.	VS	S	N	D	ED
4. I am happy with our community's waste management program.	VS	S	N	D	ED

Check the statements that apply to the following question.

5. Our community's waste management program includes these features:

- ☐ Green waste (yard waste) is collected in a separate container and placed at our curbside.
- ☐ Recyclables (paper, newspaper, glass and plastic containers, plastic bags, aluminum foil, Styrofoam, etc.) are collected altogether in one container and placed at our curbside.
- ☐ We separate our recyclables by type and place them at our curbside.
- ☐ We separate our recyclables by type and take them to a recycling center.
- ☐ We collect and place our garbage in a separate container at the curbside
- ☐ None of the above. Describe ____

B ABOUT RENEWABLE ENERGY IN GENERAL

Place a check mark by as many answers as you feel apply to the following question.

6. The following energy resources are considered to be renewable resources:

- ☐ Coal
- ☐ Oil
- ☐ Natural Gas
- ☐ Nuclear energy
- ☐ Biomass
- ☐ Solar energy
- ☐ Wind energy
- ☐ Geothermal energy
- ☐ Storage-type (dam) hydropower
- ☐ Run-of-river hydropower
- ☐ Hydrogen
- ☐ Wave energy
- ☐ Tidal energy
- ☐ Not sure

Using the scale shown below, please indicate your answers to statements 7–9 by circling one of the following letter abbreviations.

SA = Strongly agree
A = Agree
N = Not sure
D = Disagree
SD = Strongly disagree

7. Renewable resources are generally environmentally friendly.	SA	A	N	D	SD
8. It is important to produce electricity with locally available, renewable resources so that we can be more energy independent.	SA	A	N	D	SD
9. It is important to protect the environment and our health by reducing the amount of polluting resources we use for energy.	SA	A	N	D	SD

C ABOUT ELECTRICITY PRODUCTION IN MY REGION

Check the box beside each answer you feel applies to the following three questions.

10. The electricity we are using in our region is currently being produced with the following resources:

- ☐ Coal
- ☐ Oil
- ☐ Natural gas
- ☐ Nuclear energy
- ☐ Biomass
- ☐ Solar energy
- ☐ Wind energy
- ☐ Geothermal energy
- ☐ Storage-type (dam) hydropower
- ☐ Run-of-river hydropower
- ☐ Hydrogen fuel (for example, hydrogen fuel cells)
- ☐ Wave energy
- ☐ Tidal energy
- ☐ Not sure

11. In our region, we have the potential for, but aren't necessarily using, the following energy resources to produce electricity:

- ☐ Coal
- ☐ Oil
- ☐ Natural gas
- ☐ Nuclear energy
- ☐ Biomass
- ☐ Solar energy
- ☐ Wind energy
- ☐ Geothermal energy
- ☐ Storage-type (dam) hydropower
- ☐ Run-of-river hydropower
- ☐ Hydrogen (for example, hydrogen fuel cells)
- ☐ Wave energy
- ☐ Tidal energy
- ☐ Not sure

12. Renewable resources provide about what percentage of electricity in the United States? (*Check one.*)

- ☐ 2 percent
- ☐ 5 percent
- ☐ 10 percent
- ☐ 15 percent
- ☐ 25 percent
- ☐ 50 percent or more
- ☐ Not sure

Using the scale below, indicate your answer to statements 13 – 17 by circling one of the following letter abbreviations:

SA = Strongly agree
A = Agree
N = Not sure
D = Disagree
SD = Strongly disagree

13. Our region has an adequate supply of electricity.	SA	A	N	D	SD
14. Our electricity is reasonably priced.	SA	A	N	D	SD
15. My local power provider(s) offers me a "green energy" option. In other words, I can choose to get some of my electricity from clean and/or renewable energy sources.	SA	A	N	D	SD
16. Although my local power provider(s) does not offer a green energy program, I would like to be offered more choices of how my electricity is produced.	SA	A	N	D	SD
17. I would be willing to pay a bit more on my energy bill for an option to get some or all of my electricity from renewable energy.	SA	A	N	D	SD

D ABOUT SAVING AND PRODUCING RENEWABLE ELECTRICITY AT MY HOME AND WORKPLACE

My Home

18. According to my electricity bill, last month, which is the month of ____________________________ , our household used ___________ kilowatt-hours (kWhr) of electricity.

Using the scale below, indicate your answer to each statement by circling one of the following letter abbreviations:

SA = Strongly agree
A = Agree
N = Not sure
D = Disagree
SD = Strongly disagree

Please answer the questions in this section whether you are a homeowner or not. If you aren't, answer them as you would if you did own your home or as they may apply to the place you occupy (apartment, student housing, shared rental home, etc.).

19. We are willing to pay more for energy efficient lightbulbs and appliances such as Energy Star appliances. SA A N D SD

20. My household would be interested in producing some of our own electricity with a renewable energy system (such as solar panels). SA A N D SD

21. If you agreed to Item 20, then list the renewable energy systems you would be most likely to use:

____ ☐

____ ☐

22. We already have a renewable energy electrical generation system installed at our home. SA A N D SD

If you agreed to Item 22 above, then please answer the following three items. If not, then skip to Item 27.

23. List the type of renewable energy system(s) you have installed at your home:

____ ☐

____ ☐

24. We are participating in a "net metering" plan, in which we have remained connected to the electrical grid and can sell any excess electricity that we generate back to our utility. SA A N D SD

25. We are satisfied with our renewable energy electrical generation system. SA A N D SD

26. Why or why not? ____

____ ☐

My Workplace

27. My work associates and I may be interested in producing some of our own electricity with a renewable energy system installed at our workplace. SA A N D SD

28. If you agreed to Item 27, then list the one(s) you would be most likely to use:

______________________________ ☐

______________________________ ☐

29. A renewable energy electrical generation system is already installed at my workplace. SA A N D SD

If you agreed with Item 29, then please answer the following three items.

30. List the type of renewable energy system(s) you have installed at your workplace:

______________________________ ☐

______________________________ ☐

31. My workplace is participating in a "net metering" plan, in which we have remained connected to the electrical grid and can sell any excess electricity that we generate back to our utility. SA A N D SD

32. People at my workplace are satisfied with its renewable energy electrical generation system(s). SA A N D SD

33. Why or why not? ______________________________

______________________________ ☐

E ABOUT OUR HOUSEHOLD (OPTIONAL)

34. Including yourself, how many of your household members are in the following age categories. (*Write the number of people for each category.*)

____ Birth to 5 years old

____ 6–17

____ 18–64

____ 65 or older

35. How long have you lived in our community? ____ years

36. Why did you come to our community? (*Check as many as apply.*)

☐ Born here
☐ Employment
☐ Health reasons
☐ Friends/Relatives here
☐ Physical environment
☐ Reputation
☐ Geographic location
☐ To live in a bigger city
☐ To live in a smaller city
☐ Other ______________________________

37. Is your workplace or school in another community? ☐ Yes ☐ No

For the following question, check as many as apply.

38. To get to work or school, do you:

☐ Drive ☐ Take public transportation

☐ Walk ☐ Bicycle

39. What is your main occupation? ______________________________

____

40. Do you own or manage a business in our local area? ☐ Yes ☐ No

41. Are you involved in the civic government of our community? ☐ Yes ☐ No

42. If you answered yes to the above question, please describe your involvement:

______________________________ ☐

______________________________ ☐

43. Please remember to enter your ZIP code on the first page of this survey. Thank you.

44. If you would like to receive a summary report of our findings, please complete the following:

Name: ______________________________

Address: ______________________________

____

E-mail (optional): ______________________________

Energy for Keeps: Electricity from Renewable Energy

Biomass

Geothermal

Hydropower

Ocean

Solar

Wind

If made from renewables: Hydrogen

www.energyforkeeps.org

www.energyquest.ca.gov

www.eere.energy.gov

Energy for Keeps: Electricity from Renewable Energy
Biomass
Geothermal
Hydropower
Ocean
Solar
Wind
If made from renewables: Hydrogen
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STANDARDS CORRELATIONS

CALIFORNIA CONTENT STANDARDS

- This unit has been correlated to all the California Content Standards that are applicable to the unit's content. As of this publication date, the correlation has been done for grades 6-8. Correlations for grades 9-12, when completed, will be posted on the Educators for the Environment website, www.energyforkeeps.org. They will also be included in future editions of this unit.
- The California Content Standards Correlation has been organized by chapter and by grade level. The Standards listed include topics covered anywhere in the chapter, including the discussion section and the accompanying activity(ies). The exception to this is Chapter 3, where you will find the standards correlations broken down into subcategories by energy source.
- Here you will find an Overview for each chapter. On our website, energyforkeeps.org, you will find the complete wording of each standard to which that chapter applies, as well as corrections or additions to the overviews.
- The actual content standards for each discipline have unique organization and numbering systems. We have copied them exactly as they appear in the state documents (see California Department of Education website: www.cde.ca.gov/standards).

NATIONAL SCIENCE STANDARDS

Following the Overviews of the California Content Standards you will find a matrix showing an overview of National Science Standards to which this unit applies. A double asterisk (**) indicates that that Standard is addressed in this unit.

Chapter 1: A Brief History of Energy

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension – Structural Features 2.1–2.4
1.0 Writing Strategies 1.1–1.6
2.0 Writing Applications 2.1–2.3
1.0 Listening and Speaking Strategies 1.1–1.7
HISTORY AND SOCIAL SCIENCE
6.1 #1
SCIENCE
Heat/Thermal Energy 3a–d
Energy in the Earth System 4a
Resources 6a–c

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension – Structural Features 2.1–2.4
1.0 Writing Strategies 1.1–1.7
2.0 Writing Applications 2.3–2.5
1.0 Written and Oral English Language Conventions 1.1–1.7
1.0 Listening and Speaking Strategies 1.1–1.8
2.0 Speaking Applications 2.3
HISTORY AND SOCIAL SCIENCE
7.8 #4 and #5
7.10 #1– #3

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension – Structural Features of Informational Materials 2.1–2.4
1.0 Writing Strategies 1.1–1.6
2.0 Writing Applications 2.3–2.5
1.0 Listening and Speaking Strategies 1.1–1.7
2.0 Speaking Applications 2.1 and 2.3
HISTORY AND SOCIAL SCIENCE
Standard 8.12 #1 and #9

Chapter 2: Energy and Electricity

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing: Organization and Focus 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.5
1.0 Listening and Speaking Strategies 1.4–1.7
2.0 Speaking Applications 2.4a–d and 2.5a–b
MATH
Reinforcement of learned (prior) skills, use of compass and ruler to create pieces needed to complete the activity
SCIENCE
Heat/Thermal Energy 3a–d
Resources 6a–c
Investigation and Experimentation 7b–d

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing Strategies 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.7
1.0 Listening and Speaking Strategies 1.1–1.6
MATH
Reinforcement of learned (prior) skills, use of compass and ruler to create pieces needed to complete the activity
SCIENCE
Investigation and Experimentation 7a–e

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing Strategies 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.6
1.0 Listening and Speaking Strategies 1.1–1.7
MATH
Reinforcement of learned (prior) skills, use of compass and ruler to create pieces needed to complete the activity
SCIENCE
Structure of Matter 3a
Reactions 5d
Investigation and Experimentation 9a–c

Chapter 3: Energy Sources for Electricity Generation Chapter Overview

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing: Organization and Focus 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.5
2.0 Speaking Applications 2.4–2.5
MATH
Reinforcement of learned (prior) skills, e.g. understanding percentages and pie graphs
SCIENCE
Plate Tectonics and Earth's Structure 1a–c, e, f
Shaping Earth's Surface 2a–c
Heat/Thermal Energy 3a–d
Energy in the Earth System 4a–e
Ecology 5a, b
Resources 6a–c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding percentages and pie graphs
SCIENCE
Earth and Life History 4a–f
Physical Principles in Living Systems 6a, e, f
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding percentages and pie graphs
SCIENCE
Structure of Matter 3a, d
Reactions 5a, c, d
Chemistry of Living Systems 6a, b
Density and Buoyancy 8a
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Biomass

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1-2.4
SCIENCE
Heat/Thermal Energy 3a-d
Energy in the Earth System 4a-e
Ecology 5a, b
Resources 6a-c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1-2.4
SCIENCE
Physical Principles in Living Systems 6a, e, f
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

SCIENCE
Reactions 5a, c, d
Structure of Matter 3a, d
Chemistry of Living Systems 6a, b
Density and Buoyancy 8a
Investigation and Experimentation 9a-c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Geothermal

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Plate Tectonics and Earth's Structure 1a–c, e, f
Shaping Earth's Surface 2c
Heat/Thermal Energy 3a–d
Energy in the Earth System 4a–e
Resources 6a–c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Earth and Life History 4a–f
Physical Principles in Living Systems 6a, e, f
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Density and Buoyancy 8a
Structure of Matter 3c, d
Reactions 5c, d
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Hydropower

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Shaping Earth's Surface 2a–c
Energy in the Earth System 4a, d, e
Resources 6a–b
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Shaping Earth's Surface 2a–c
Energy in the Earth System 4a, d, e
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Density and Buoyancy 8a
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Ocean

GRADE 6

ENGLISH LANGUAGE ARTS

2.0 Reading Comprehension 2.1–2.4

MATH

Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.

SCIENCE

Plate Tectonics and Earth's Structure 1a, c
Shaping Earth's Surface 2c
Heat/Thermal Energy 3a, c, d
Energy in the Earth System 4a, d, e
Resources 6a–b

GOVERNMENT

Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS

2.0 Reading Comprehension 2.1–2.4

MATH

Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.

SCIENCE

Earth and Life History 4a

GOVERNMENT

Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS

2.0 Reading Comprehension 2.1–2.4

MATH

Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.

SCIENCE

Density and Buoyancy 8a
Motion 1b–e
Forces 2a–e

GOVERNMENT

Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Solar

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Heat/Thermal Energy 3a, c, d
Energy in the Earth System 4a, b, d, e
Ecology 5 a,b
Resources 6 a–c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Physical Principles in Living Systems 6a, e, f
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
SCIENCE
Reactions 5a, c, d
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Wind

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. measurement, the metric system, and place value.
SCIENCE
Plate Tectonics and Earth's Structure 1a–c, e, f
Shaping Earth's Surface 2a–c
Heat/Thermal Energy 3a, c, d
Energy in the Earth System 4a–e
Resources 6 a–c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of temperature, measurement, the metric system, and place value.
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. measurement, the metric system, and place value.
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Hydrogen

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
SCIENCE
Heat/Thermal Energy 3a–d
Energy in the Earth System 4a–e
Ecology 5a, b
Resources 6a–c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
SCIENCE
Physical Principles in Living Systems 6a, e, f
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
SCIENCE
Structure of Matter 3a, d
Reactions 5a, c, d
Chemistry of Living Systems 6a, b
Density and Buoyancy 8a
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Fossil Fuels

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of measurement, the metric system, and place value.
SCIENCE
Plate Tectonics and Earth's Structure 1a–c, e, f
Shaping Earth's Surface 2a–c
Heat/Thermal Energy 3a–d
Energy in the Earth System 4a–e
Ecology 5a, b
Resources 6a–c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of measurement, the metric system, and place value.
SCIENCE
Earth and Life History 4a–f
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
MATH
Reinforcement of learned (prior) skills, e.g. understanding of measurement, the metric system, and place value.
SCIENCE
Structure of Matter 3a, d
Reactions 5a, c, d
Chemistry of Living Systems 6a, b
Density and Buoyancy 8a
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation Nuclear

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
SCIENCE
Heat/Thermal Energy 3a–d
Resources 6a–c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
SCIENCE
Structure of Matter 3a, d
Reactions 5a, c, d
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation
Watt's My Line?

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing: Organization and Focus 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.5
1.0 Listening and Speaking Strategies 1.4–1.7
2.0 Speaking Applications 2.4–2.5

MATH
Reinforcement of learned (prior) skills or introduction to new ideas, e.g. understanding of pie graphs and charts, measurement, percentages, the metric system, temperature, place value.
Measurement and Geometry 1.0–1.3

SCIENCE
Plate Tectonics and Earth's Structure 1a–c, e, f
Shaping Earth's Surface 2a–c
Heat/Thermal Energy 3a–d
Energy in the Earth System 4a–e
Ecology 5a, b
Resources 6a–c
Investigation and Experimentation b–d

GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing: Organization and Focus 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.7
1.0 Listening and Speaking Strategies 1.1–1.6

MATH
Reinforcement of learned (prior) skills or introduction to new ideas, e.g. understanding of pie graphs and charts, measurement, percentages, the metric system, temperature, place value.

SCIENCE
Earth and Life History 4a–f
Physical Principles in Living Systems 6a, e, f
Investigation and Experimentation 7a–e

GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 3: Energy Sources for Electricity Generation
Watt's My Line? (continued)

GRADE 8

ENGLISH LANGUAGE ARTS

2.0 Reading Comprehension 2.1–2.4

1.0 Writing Strategies 1.1–1.3

1.0 Written and Oral English Language Conventions 1.1–1.6

1.0 Listening and Speaking Strategies 1.1–1.7

MATH

Reinforcement of learned (prior) skills or introduction to new ideas, e.g. understanding of pie graphs and charts, measurement, percentages, the metric system, temperature, place value.

SCIENCE

Structure of Matter 3a, d

Reactions 5a, c, d

Chemistry of Living Systems 6a, b

Density and Buoyancy 8a

Investigation and Experimentation 9a-c

GOVERNMENT

Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 4: Energy, Health, and the Environment

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1-2.4
1.0 Writing Strategies 1.1-1.3
1.0 Written and Oral English Language Conventions 1.1-1.5
1.0 Listening and Speaking Strategies 1.4-1.7
2.0 Speaking Applications 2.4-2.5
MATH
Reinforcement of learned (prior) skills, e.g. estimating and averaging as well as creation of graphs to display information
SCIENCE
Heat/Thermal Energy 3a-d
Resources 6a-c
Investigation and Experimentation 7b-d

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1-2.4
1.0 Writing Strategies 1.1-1.3
1.0 Written and Oral English Language Conventions 1.1-1.7
1.0 Listening and Speaking Strategies 1.1-1.6
MATH
Reinforcement of learned (prior) skills, e.g. estimating and averaging as well as creation of graphs to display information
SCIENCE
Investigation and Experimentation 7a-e

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1-2.4
1.0 Writing Strategies 1.1-1.3
1.0 Written and Oral English Language Conventions 1.1-1.6
1.0 Listening and Speaking Strategies 1.1-1.7
MATH
Reinforcement of learned (prior) skills, e.g. estimating and averaging as well as creation of graphs to display information
SCIENCE
Reactions 5d
Investigation and Experimentation 9a-c
Structure of Matter 3a, 5d

Chapter 5: Energy Policy and Management

GRADE 6

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing: Organization and Focus 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.5
1.0 Listening and Speaking Strategies 1.4–1.7
2.0 Speaking Applications 2.4–2.5
MATH
Reinforcement of learned (prior) skills, e.g. estimating and averaging as well as creation of graphs to display information
SCIENCE
Plate Tectonics and Earth's Structure 1a–c, e, f
Shaping Earth's Surface 2a–c
Heat/Thermal Energy 3a–d
Energy in the Earth System 4a–e
Ecology 5a, b
Resources 6a–c
Investigation and Experimentation 7b–d
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

GRADE 7

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing Strategies 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.7
1.0 Listening and Speaking Strategies 1.1–1.6
MATH
Reinforcement of learned (prior) skills, e.g. estimating and averaging as well as creation of graphs to display information
SCIENCE
Earth and Life History 4a–f
Physical Principles in Living Systems 6a, e, f
Investigation and Experimentation 7a–e
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

Chapter 5: Energy Policy and Management (continued)

GRADE 8

ENGLISH LANGUAGE ARTS
2.0 Reading Comprehension 2.1–2.4
1.0 Writing Strategies 1.1–1.3
1.0 Written and Oral English Language Conventions 1.1–1.6
1.0 Listening and Speaking Strategies 1.1–1.7
MATH
Reinforcement of learned (prior) skills, e.g. estimating and averaging as well as creation of graphs to display information
SCIENCE
Structure of Matter 3a, d
Reactions 5a, c, d
Chemistry of Living Systems 6a, b
Density and Buoyancy 8a
Investigation and Experimentation 9a–c
GOVERNMENT
Understanding of regulatory agencies and laws that govern production of environmental pollution.

NATIONAL SCIENCE CONTENT STANDARDS GRADES 5-8 Standards followed by a double asterisk are addressed in part by the activities within *Energy for Keeps: Electricity from Renewable Energy*.			
Unifying Concepts and Processes ■ Systems, order, and organization** ■ Evidence, models, and explanation** ■ Change, constancy, and measurement** ■ Evolution and equilibrium** ■ Form and Function**	**Science as Inquiry** ■ Abilities necessary to do scientific inquiry** ■ Understandings about scientific inquiry**	**Physical Science** ■ Properties and changes of properties in matter** ■ Motion and forces** ■ Transfer of energy**	**Life Science** ■ Structure and function in living systems** ■ Reproduction and heredity ■ Regulation and behavior ■ Populations and ecosystems ■ Diversity and adaptations of organisms
Earth and Space Science ■ Structure of the earth system** ■ Earth's history** ■ Earth in the solar system	**Science and Technology** ■ Abilities of technological design** ■ Understandings about science and technology**	**Science in Personal and Social Perspectives** ■ Personal health ■ Populations, resources, and environments** ■ Natural hazards** ■ Risks and benefits** ■ Science technology in society**	**History and Nature of Science** ■ Science as a human endeavor** ■ Nature of science ■ History of science**

Appendix Table of Contents

SCIENTIFIC METHOD FORM

Attach extra pages as needed for any of the steps listed below.

Name:

Group:

Activity:

Date:

1. Research

2. Hypothesis

3. Procedure

4. Data

5. Conclusions

ENERGY TIMELINE

4 million B.C.
First known use of tools in East Africa (muscle power)

460,000 B.C.
World's earliest known use of fire in area now known as China

10,000 B.C.
Asphaltum from natural oil seeps used for variety of purposes on America's Pacific coast

9000 B.C.
Farming begins in the Middle East and elsewhere; people begin permanent villages

6500 B.C.
Metalworking with copper begins in Middle East

3500 B.C.
Sails on boats used on the Nile in Egypt (wind power)

3200 B.C.
Wheels used in Urak, Iraq

3000 B.C.
First recorded use of crude oil, in Mesopotamia

2000 B.C.
Chinese use crude oil for home heating

1500 B.C.
Hittites (Asia Minor) first produce wrought iron

1500 B.C.
Fire-starting kits carried in Europe

1500 B.C.
People around the world use hot springs for bathing, healing, recreation, cooking, heating

1000 B.C.
Iron becomes commonly used metal throughout Mediterranean

750 B.C.
Ironworking reaches Europe

500 B.C.
Magnetic properties of lodestone (type of iron) described by Thales of Miletus in Greece

500 B.C.
Iron plow share first used in Europe, making plowing much faster (muscle power)

500 B.C.
Passive solar energy used in Greek homes

200 B.C.
Coal mining in China

50 A.D.
Hero of Alexandria invents first steam engine (not put to productive use)

50
Romans perfect glass windows (solar)

100
Greeks invent waterwheel

300
Natural gas drilling in China

644
First windmill with a vertical axis, recorded in Iran

700
Iron smelting introduced in Spain

1060
Possibly world's first city-wide space-heating project using geothermal built at Paquimé, Mexico

1088
Water-powered mechanical clock made by Han Kung-Lien of China

1100
Oil wells drilled in Europe and the Mediterranean

1100
Windmills introduced in Europe

1200
Coal mining begins in England

1320
Germans improve blast furnace, advancing the process of iron smelting and casting

1322
French village pipes water from hot springs for home heating

1400
Blast furnace introduced in Holland, enabling the first production of cast iron in Europe

1510
Leonardo da Vinci designs the precursor of the water-driven turbine

1582
First waterworks using waterwheels founded in London

1615
Use of coal for heating in England increases, owing to rising timber costs

1680
Mills driven by waterpower in common use throughout Europe

1688
Large sheets of glass used for windows in France (solar)

1690
Widespread use of coal begins in Europe due to wood depletion

1695
Frenchman G. Buffon uses mirrors to concentrate sunlight to burn wood and melt lead

1698
Englishman T. Savery develops steam engine to pump water out of flooded coal mines

1700
Textile mills and other factories driven by waterpower throughout Europe

1700
Greenhouses using glass windows become popular (solar)

1705
T. Newcomen, England, invents first practical steam engine

ENERGY TIMELINE (continued)

1709
Iron smelting process using coke developed by A. Darby, England; coal demand increases

1712
Piston-operated steam engine built by T. Newcomen

1746
B. Franklin conducts research that will later result in clearer understanding of electricity

1748
First American commercial coal production in Virginia

1752
B. Franklin's kite experiment verifies nature of static electricity; leads to invention of lightning rod

1757
First public gas streetlights in the American colonies light Philadelphia

1769
Improved steam engine patented by J. Watt, England

1770
Spinning jenny patented by J. Hargreaves helps automate manufacturing

1782
J. Watt invents rotary steam engine; soon to have widespread use in factories

1785
Textile plant in England is the first to be powered by steam

1790
First working United States cotton mill

1792
British engineer W. Murdock invents "town gas"

1800
A. Volta produces the first electricity from a wet-cell battery

1800
Several French towns use geothermal energy for space heating

1800
Hot springs resorts flourish throughout United States, Europe, and Asia

1803
Robert Fulton builds first steam-powered boat

1804
R. Trevithick invents and operates first steam locomotive on a track

1807
Commercial paddle-wheel steamship cargo service begins in New York

1807
First public street lighting using town gas occurs in London

1814
First practical steam locomotive invented by G. Stephenson

1818
First steamship (*Savannah*) crosses the Atlantic

1820
Ampere, Faraday, and Sturgeon experiment with electromagnetism

1821
M. Faraday, England, demonstrates that electricity can produce motion

1821
First U.S. natural gas well drilled in Fredonia, New York

1825
First steam train passenger service offered in England

1830
Steam-driven cars common in London

1831
Joseph Henry perfects electric motor

1831
M. Faraday invents dynamo, one of the first electric generators

1839
Englishman W. Grove builds first fuel cell

1859
First petroleum oil well in America drilled in Pennsylvania

1860
First internal combustion engine built by E. Lenoir, Belgium

1860
The Geysers, California, opens resort for therapeutic hot spring bathing

1861
French scientist A. Mouchot patents world's first solar steam engine

1868
First modern focusing solar power plant heats water for steam engine in Algiers

1870
Z. Gramme perfects dynamo, making it the first workable electrical generator

1874
Power plant in England burns garbage for electrical production (biomass energy)

1876
N. Otto perfects first practical internal-combustion engine (later used in autos)

1876
California's first "commercial" oil well drilled near Newhall, California

1878
T. Edison develops method to transfer electricity for common use

ENERGY TIMELINE (continued)

1879
T. Edison makes incandescent electric light practical

1881
J. d'Arsonval originates idea of using ocean as energy source

1882
Electric power stations go on-line in London and New York

1884
C. Parson develops first practical steam turbine electricity generator

1885
C. Benz develops the first working motorcar powered by gasoline

1886
Swede J. Ericsson invents first parabolic trough solar energy collector

1886
Up to 50 small hydropower plants generate electricity in America

1887
Stockton becomes first California city supplied with natural gas sent through pipelines

1888
First wind machine for electricity built in America

1890
Electricity begins to replace use of natural gas for lighting

1890
First dependable electric motor cars developed in France and Great Britain

1891
U.S. inventor C. Kemp patents first commerical solar water heater

1891
Huge hydroelectric power stations built in Frankfurt, Germany and Niagara Falls, U.S.

1891
Tessla coil invented, producing first high-voltage electricity

1891
First long distance electrical lines completed in Germany

1892
P. LaCour, Denmark, designs efficient machine that generates electricity from wind

1893
First Ford gasoline buggy driven by inventor, H. Ford

1894
Texas oil discovered while drilling for water

1894
Pneumatic (air-filled) tires introduced in France by A. and E. Michelin

1896
First U.S. offshore oil wells (built on wooden piers) drilled near Summerland, California

1896
Niagara Falls hydropower plant sends first long distance electricity in U.S.

1897
C. Parsons outruns every ship in the water with his steam-driven boat

1897
30 percent of homes in Pasadena, California, use Kemp's solar water heaters

1898
Garbage burned specifically for energy in New York (biomass energy)

1900
Power plants driven by hydropower or fossil fuels dot the U.S.

1900
Calistoga, California, hosts over 30 hot springs resorts

1904
Electricity generated from geothermal steam in Larderello, Italy

1905
A. Einstein publishes relativity theory, revolutionizing understanding of energy

1908
First cheap, mass-produced car, the Model T, is available

1910
Coal accounts for three-fourths of all fuel used in United States

1916
Einstein's unifying theory interrelates mass, energy, magnetism, electricity, and light

1918
Denmark produces electricity from over 100 wind generators

1920
Midwest farms in U.S. widely use wind turbines for electricity

1920
Decade begins with oil and gas shortages in California

1928
More than 3 million American families own two cars

1929
After major discoveries, decade ends with surplus of oil and gas in California

1930
Iceland begins to work on large-scale geothermal district heating project

1930
Solar water heaters supply hot water to homes throughout Miami, Florida

ENERGY TIMELINE (continued)

1930
Propeller-type wind generators perfected by M. Jacobs in use all around U.S.

1932
Francis Bacon, Great Britain, develops first successful fuel cell

1935
Rural electrification brings power to remote areas in U.S.; replaces most wind turbines

1936
America's Hoover Dam (for hydropower) completed

1939
Europeans O. Hahn, and L. Meitner unveil process of nuclear fission for energy

1940
First U.S. superhighway opens in Pennsylvania

1941
Almost 60,000 solar water heaters in use in Florida

1942
E. Fermi, using Einstein's theories, produces first controlled nuclear chain reaction in the U.S.

1943
132 MW produced from geothermal fields, Larderello, Italy

1944
U.S. National System of Interstate Highways established

1945
First nuclear bomb detonated in New Mexico

1945
5,000 U.S. homes have television sets

1947
Diesel-electric trains replace steam locomotives in U.S.

1948
One million U.S. homes have television sets

1950
Work-saving appliances and tools use increasing amounts of energy

1952
First U.S. hydrogen bomb detonated with 700 times force of fission bomb

1954
First solar cells used for electric generation developed in U.S.

1954
First Russian nuclear power plant opens

1954
Advanced European steel-manufacturing method introduced in Detroit

1954
First fuel cells used in NASA space program

1955
First U.S. town powered by nuclear energy in Idaho

1958
First major offshore oil-drilling platform built in the Pacific Ocean near Summerland, California

1960
Commercial electricity first produced from geothermal energy at "The Geysers," in California

1960
Environmental concerns increasingly relate to energy use and pollution

1960
German U. Huttrer perfects electrical wind turbine design, later adopted in U.S.

1963
First commercial nuclear power plant opens in New Jersey

1965
Historic electrical blackout in northeastern North America

1966
Partial meltdown at nuclear power plant in Detroit

1966
La Rance tidal power plant built at the Rance estuary in France

1967
First microwave for home use introduced

1968
78 million U.S. homes have television sets

1969
France begins large district-heating projects with geothermal energy

1970
First Earth Day signals worldwide concern about environmental damage

1970
Solar water heating well established in Israel, Japan, Australia

1971
P. McCabe, Great Britain, and M. McCormick, U.S., began development of first wave energy system

1973
Oil embargo opens up new era of electricity produced from renewable sources in U.S.

1973
Japan begins experiments with Ocean Thermal Energy Conversion (OTEC)

1974
J. Lindmayer, U.S., develops silicon photovoltaic cell for harnessing solar power

1977
Solar panels installed on the White House

ENERGY TIMELINE (continued)

1978
Public Utility Regulatory Policies Act, PURPA, encourages small and renewable power producers

1979
Partial meltdown of nuclear reactor at Three Mile Island, Pennsylvania

1979
Experimental OTEC project begins producing electricity in Hawaii

1980
Europe and Asia invest widely in generation of electricity from wind power

1980
Nuclear power generates more electricity than oil in U.S.

1980
Large, powerful wind generators emerge as result of fuel shortages

1982
Solar One in southern California proves that solar thermal power for electricity is feasible

1983
Three out of every four power plants in U.S. burn fossil fuels

1983
World's largest hydroelectric power plant opens in Brazil/Paraguay

1983
First solar thermal "trough" power plan opens in southern California

1984
Large scale biomass power plant opens in Vermont

1986
Worst nuclear meltdown with nuclear fallout occurs at Chernobyl, Ukraine

1990
More than half of world's wind-generated electricity produced in California

1992
6,000 MW of electricity being generated from geothermal in 21 countries

1992
World's top electricity-generating countries are U.S., Canada, Brazil, Russia, and China

1993
Nuclear power provides about one-fifth of U.S. electricity

1997
Hydropower now produces only 10 percent of U.S. electricity

1999
U.S. consumption of petroleum reaches all-time high, more than half for transportation

2000
Injection of wastewater into The Geysers geothermal reservoir boosts electricity production

2000
Renewable energy technologies gain wider acceptance in many parts of world, including U.S.

2000
Utility deregulation in some U.S. states results in ups and downs in opening up the energy production market

2000
Electricity generation produces almost 40 percent of all carbon dioxide emissions in U.S.

2000
State-of-the-art, multi-megawatt wind turbines replacing older models in U.S. and Europe

2000
State-of-the-art waste-to-energy biomass power plants throughout U.S. resolve some pollution and landfill capacity concerns

2000
Solar technology gains popularity in U.S.

2000
Run-of-river hydropower plants produce electricity without disturbing stream flow in many parts of the world

2000
Marine current and wave energy systems gain wider acceptance

2000
Renewable resources contribute 9 percent of electricity in U.S. and 18 percent globally

2000
Nuclear energy provides 20 percent of all U.S. electricity

2000
Fossil fuels (coal, oil, gas) provide 71 percent of all electricity production in U.S.

2000
99 percent of U.S. households have a color television

Note: Suggestions for the Energy Timeline are always welcome. Please send them to energyforkeeps@aol.com.

GLOSSARY

A

acid precipitation (acid rain): any precipitation that primarily contains damaging sulfuric and nitric acids; may harm and/or destroy natural land or water habitats and corrode human structures including roads, buildings, and bridges

active solar: any system for collecting, storing, and releasing solar energy that requires an outside source of energy to operate system equipment, such as fans or pumps

A.D.: any year after the birth of Jesus Christ; from the Latin, *anno Domini*, meaning "in the year of our Lord;" from 20 B.C. to 50 A.D. is 70 years

alloy: a mixture of different metals; for example, bronze, a mix of copper and tin; some alloys include metals mixed with non-metals (e.g., some kinds of steel are made of several metals plus carbon, a non-metal)

alternating current (AC): an electric current that reverses direction at regular intervals; caused by an alternating electromotive force (the force that produces en electric current)

alternative energy: an older term, the use of which is diminishing, as renewable energy becomes better known and more widely accepted; once defined as a source of energy other than fossil fuels, hydropower, or nuclear

alternator: an electric generator that produces alternating current

ampere (amp): a measure of the amount of current, or electrons, flowing in a wire over time; one ampere = 6.25×10^{18} electrons per second

anaerobic digestion: the breakdown of organic materials by bacteria in the absence of oxygen; results in the production of gases, primarily methane and carbon dioxide; occurs naturally or can be caused to occur under controlled conditions

anemometer: a device for measuring wind speed

anode: the positively charged electrode in an electrical circuit or in an electrochemical reaction

aquafarming: the cultivation of fish and other water-dwelling organisms under controlled conditions

array: in general, a symmetrical arrangement of a large group, as in rows; in solar energy, usually refers to an arrangement of a large group of photovoltaic (solar) panels or mirrors

atom: the smallest particle of an element that retains the chemical properties of that element; composed of protons, neutrons, and electrons

B

balance of trade: the difference in value over a period of time between a country's imports and exports

barrage: an artificial obstruction, such as a dam or an irrigation channel, built in a river or other waterway to increase depth or divert flow

baseload power: the amount of power needed to supply the minimum anticipated demand for electricity at any given time

B.C.: any year before the birth of Jesus Christ; from 20 B.C. to 50 A.D. is 70 years

binary power plant: geothermal power plant that uses a heat exchanger to transfer heat to a second (binary means two) liquid that flashes to vapor and drives a turbine-generator

biomass: anything that is, or was once, alive; organic material

blackout: the loss of electricity, caused intentionally or by an electrical power failure

blast furnace: a furnace in which the combustion of a fuel is intensified using blasts of air or pure oxygen

brine: water containing large amounts of salts, particularly sodium chloride

brownout: a reduction in electric power; may be the result of a shortage or mechanical failure, or may be intentional in response to excessive consumer demand

GLOSSARY (continued)

byproduct: something produced in the making of something else; a secondary product produced from the production of a primary product

C

capacity: in electricity generation, the maximum electrical output that a turbine or turbines in a power plant are rated (by the manufacturer) to generate

carbon cycle: the chemical cycle in which the element carbon naturally circulates in various forms throughout the living and nonliving systems of the earth over time

carbon monoxide: a gaseous molecule composed of one atom of carbon and one atom of oxygen; is highly toxic to animals and humans

carbon sink: components of the global ecosystem that store carbon; includes all plants, the ocean, old-growth forest floor litter (duff), soils, fossil fuels, and certain minerals such as limestone

carbon-based compound: element whose atomic structure causes it to join with a variety of other elements, forming the basis of many different compounds; the basis of all living things, as well as for fossil fuels (hydrocarbons) and many other substances, including diamonds and graphite

cathode: the negatively charged electrode in an electrical circuit or in an electrochemical reaction

centigrade (C): also Celsius; the temperature scale that registers the sea-level boiling point of water as 100° and the freezing point as 0°

central receiving tower: a concentrating solar power technology; a tall structure with a top section that contains a liquid, such as molten salt, water, or liquid metal, that has a high heat capacity; this liquid is heated by the reflection of solar energy from concentrating mirrors aimed at the tower's focal point

chain reaction: in physics, a method of releasing energy from the atom in a multistage nuclear reaction, in which the release of neutrons from the splitting of one atom leads to the splitting of others

charcoal: a material containing large quantities of carbon, formed by heating wood or other organic material in the absence of air

Clean Air Act (CAA): federal law designed to protect public health by setting standards and enforcement regulations regarding polluting air emissions from energy production and other human activities

cogeneration: the process of doing work utilizing two forms of energy, usually thermal (heat) energy and electrical energy, both produced simultaneously from one source

coke: a fuel that burns very hot; used primarily in metal production; produced by removing mainly the sulfur (which makes iron brittle when smelted) from coal

combined cycle power plant: power plant in which two different turbines — most commonly a gas turbine accompanied by a steam turbine — work in succession to produce electricity; most gas-fired power plants are combined cycle plants

combustion: the process of burning, which is a chemical change requiring the presence of oxygen that results in the production of heat and light

complete circuit: a complete and circular path for an electric current to follow as it moves through wires and electrical devices

compound: substance made of two or more elements that are bonded together chemically

concentrating solar power: any of the solar energy systems (solar dish engines, parabolic troughs, and central receiving towers) that focus, or concentrate, the energy of the sun for energy production or storage

condenser: a device that uses a cooling process to cause a vapor to condense to a liquid

conduction: the transmission of electric charge or heat through a conductor

conductor: in electricity, a substance or medium that conducts, or transmits, an electric charge; in thermal energy, a medium that allows the movement of heat through it

GLOSSARY (continued)

conservation: the controlled use and systematic protection of natural resources such as water, minerals, forests, and soil; also, the practice of avoiding and reducing waste, as in the production of or use of electricity

containment vessel: at a nuclear power plant, a large structure that houses the reactor core, its radiation shield, and the reactor core's maintenance equipment; the containment vessel is surrounded by an outer concrete building designed to prevent the escape of radiation in the event of an internal power plant accident or by an external event such as an airplane crash

control rod: in a nuclear power plant, a long rod made of material that absorbs neutrons; a number of these are inserted amidst the fuel rods in the reactor core; control rods are raised and lowered as needed to control the nuclear chain reaction, and thus the amount of heat energy produced

controller: in a wind turbine, a computerized device that receives information from all the sensors on the turbine (including anemometers, blade positions, temperatures, fault conditions, loads, vibration etc.) and uses this information to determine how to control all the various devices on a turbine

crude oil: unprocessed oil (petroleum) that varies in color and in thickness (viscosity); contains many different compounds, which can be separated and used for a variety of products, including energy fuels such as gasoline, heating oil, and butane

crust: in geology, the relatively thin, outermost rock layer of the earth

D

decompose: to become broken down into basic components or elements; to rot

deflect: to cause to turn aside

demand: in electrical power, the amount of electricity needed at any given time, based on the amount being used by all electrical devices connected to the power supply through the power grid

dense (density): the amount of mass, or matter, that is in a given volume of something; e.g., the molecules of a substance that is very dense are packed very closely together

deplete: to use up or consume

direct current (DC): an electric current that flows only in one direction

direct use geothermal: systems that use geothermal resources directly for heat energy rather than for producing electricity; includes space heating, greenhouse and fish farm operations, bathing and swimming at health spas, and industrial applications such as food and timber drying

disclosure: the act or process of revealing or uncovering; in energy management, the ready provision of information by a power provider regarding which energy resources are being used to produce electricity

distributed generation: supplying on-site electricity using small generating units; can be comprised of similar systems or a variety of different system types; distributed generation is used to manage peak loads, to add extra power for a region without having to build a large power plant, to provide electricity for remote locations or for a vital industry such as a hospital that needs power at all times, even when grid power is unavailable

dry steam power plant: geothermal power plant that uses steam directly from a steam-filled geothermal reservoir

dynamo: an electric generator that usually produces direct current

E

ebb: to fall away or recede

ecological: pertaining to the science of the relationships between organisms and their environments

ecosystem: the community of all organisms living in an area and their interactions with the physical environment; an exchange of materials between the living and non-living parts

GLOSSARY (continued)

electric current: the flow of charged particles through a conductive material

electrical energy: the energy of electrical charges, usually electrons in motion

electrochemical: the interaction of electrical and chemical phenomena

electrode: a solid electric conductor, such as a piece of metal, through which an electric current enters or leaves a solution containing an electrolyte; also, a collector or emitter of electric charge, such as found in a fuel cell

electrolysis: chemical reaction caused by passing an electric current through a liquid containing an electrolyte, resulting in the break down of the liquid's molecules; the electrolysis of water releases hydrogen and oxygen

electrolyte: a chemical compound which, when molten or dissolved, usually in water, will conduct an electric current; an electrolyte solution

electromagnetic spectrum: radiated energy waves as described in terms of their wavelengths and frequencies, including gamma rays, X-rays, ultraviolet, visible light, infrared radiation, microwaves, radar, television, and radio; the sun is the largest natural source of electromagnetic radiation

electromagnetism: the study of the relationship between magnetism and electricity; the phenomena of producing electricity using magnetism and vice versa

electron: a negatively charged component of an atom; exists outside of and surrounding the atom's nucleus; can either be free or bound to a nucleus

element: the simplest possible chemical, made up of its own particular kind of atom; most elements occur naturally, though some have also been made artificially

encroach: to advance beyond usual or proper limits

energy conservation: the planned management of energy resources and energy use in order to prevent waste and to ensure future availability

energy conversion (transformation): the process of changing energy from one form to another

energy farm: a farm that grows plants specifically as biomass energy crops

estuary: a river mouth broadening into the sea; if undisturbed, estuaries are very fertile and provide habitat for a variety of wildlife

exempt: excused or released from a requirement

F

Fahrenheit (F): the temperature scale that registers the sea-level boiling point of water as 212°F and the freezing point as 32°F

fissionable: in nuclear power, an unstable element that is capable of being split; in a nuclear power plant, fissionable material — primarily one form of uranium (U-235) — is used to produce a nuclear chain reaction

fissure: in geology, an extensive crack, break, or fracture in rock

fixed-speed wind turbine: a wind turbine that always turns at the same speed, regardless of how fast the wind is blowing; the machinery of a fixed-speed wind turbine is simpler than that in a variable-speed turbine

flash power plant: a geothermal power plant that uses a process in which geothermal water is converted to steam to drive a turbine

fossil fuels: coal, oil, natural gas, and products made from them; fossil fuels are the remains of once-living (organic) plants and animals formed underground and subjected to intense heat and pressure over millions of years; have high concentrations of carbon and hydrogen and can be burned, producing energy as well as polluting emissions

fuel rod: at a nuclear power plant, pellets of uranium (U-235) that are arranged in long rods, which are collected together into bundles and placed in the reactor core

fumarole: steam and gas, venting from the earth's crust

GLOSSARY (continued)

G

gas turbine: power plant turbine that is driven by a continuous blast of hot gas from the combustion of natural gas combined with high-pressure air

gasification: the process of converting into or becoming a gas

generator: a machine that transforms (converts) mechanical energy into electrical energy

geothermal reservoir (hydrothermal aquifer): a large volume of underground water saturating (filling) porous and permeable rock, superheated by the hot rock and hot magma nearby

geothermal: the heat of the earth's interior; the earth's natural heat emanating from its core outward and from the radioactive decay of certain elements in the crust

global climate change: long-lasting changes in Earth's weather patterns and systems, resulting in dramatic, possibly harmful, changes in habitats and ecosystems worldwide; is thought by many researchers to be caused by the overall (global) warming of the planet, resulting from an excess of greenhouse gases in the atmosphere

green energy: any energy source considered to be environmentally friendly; commonly associated with renewable energy sources, but also sometimes used when referring to nonrenewable sources that produce few pollutants

green pricing: offering customers the choice of paying additional fees on their utility bill in order to support the production of renewable energy; in some cases some, or all, of the electricity that these customers actually receive has been produced by renewable energy sources; in others, renewable generation elsewhere is paid for by green pricing

green waste: yard trimmings (usually leaves, grass clippings, and tree and bush trimmings) that are collected in specially designated containers and used for various purposes, including as a source of biomass energy

greenhouse effect: the trapping of heat energy from the sun in Earth's atmosphere, notably by water vapor and greenhouse gases such as carbon dioxide, nitrous oxide, and methane; the resulting heat energy warms the planet's surface

greenhouse gas: any gas in the atmosphere that contributes to the greenhouse effect

grid: the interconnected system that distributes electricity, including power plant(s), transmission and distribution lines, towers, substations, and transformers

groundwater: water that collects underground, mostly from surface water that has seeped down through cracks and pores in rock

H

habitat: the place that is natural for the life and growth of an organism

head: in hydropower, the distance that water falls before it hits a turbine generator

heat (thermal) energy: the energy that flows from one body to another because of a temperature difference between them; the effects of heat energy result from the motion of molecules

heat engine: any device that converts heat energy into mechanical energy; typical heat engines include steam engines, steam and gas turbines, internal combustion (vehicle) engines, and Stirling engine

heat exchanger: device used to transfer thermal (heat) energy from a liquid flowing on one side of a barrier to a liquid flowing on the other side

heliostat: an instrument in which a mirror is automatically moved so that it reflects sunlight in a constant direction

high and low tide: the rise and fall of the earth's oceans, caused mainly by gravitational forces of the moon and the sun

horsepower: originally the power exerted by a horse when pulling; now, a unit of power equal to 745.7 watts per minute

GLOSSARY (continued)

hot dry rock: a potential source of heat energy within the earth's crust; a geothermal resource created when hot but impermeable (does not allow water to pass through) underground rock structures are fractured to allow infiltration of water, thus creating an artificial geothermal reservoir

hydrocarbon: any compound made up of hydrogen and carbon; will combine with oxygen when burned, producing heat energy; includes all the fossil fuels

hydrogen gas: colorless, combustible gas that can be used as an energy source; does not occur naturally by itself, and must be separated from another substance, such as from water, biomass, or a fossil fuel

hydrogen sulfide: a gas with a disagreeable odor, frequently dissolved in geothermal waters in small amounts; toxic at high concentrations

hydropower: methods of producing electricity using the energy of rapidly flowing or falling water

I

impoundment: a structure which allows the accumulation and storage of water in a reservoir; a dam placed across a river

incandescent light bulb: a glass bulb of inert gas (gas that is not readily reactive) that emits visible light as a result of passing electricity through a filament found inside the bulb, causing it to heat and glow

indirect (hidden) costs: the costs of producing a product (including electricity) that are not directly accounted for by an industry or utility, but are borne by other sectors of society

Industrial Revolution: the shift to large-scale factory production brought about by the extensive use of machinery, often driven by steam engines; generally thought to occur between the 1750s to the mid to late 1800s; resulted in dramatic social, environmental, and economic changes

industrial: the practice of making goods; often implies the production of large quantities of manufactured items, as found in factories

infrared: heat radiation; part of the electromagnetic spectrum radiated from the sun and other hot objects

internal combustion engine: an engine, used primarily in vehicles, in which fuel is burned within the engine itself, rather than fuel being burned in an external furnace, as in a steam engine

J

jet stream: a narrow belt of westerly winds found at high altitude that can reach speeds of up to 230mph (370 km/h)

K

kilowatt: 1,000 watts

kilowatt-hour: the energy expended when 1,000 watts of electrical power are used for one hour

M

magma: hot, thick, molten rock found beneath the earth's surface; formed mainly in the mantle; some estimate its temperature to reach over 2,100°F (1,200°C)

magnetic field: a condition found in the region around a magnet or an electric current where a detectable magnetic force is found at every point in the region and where there are distinguishable magnetic poles

mantle: the zone of the earth below the crust and above the core, primarily filled with a mixture of molten and solid rock

manufacture: to make a finished product, often using large-scale industrial operations

marine (ocean) current: movement of ocean water: either two-way (tidal) or one-way (like the Gulf Stream)

mass: in physics, the measure of the quantity of matter that an object or body contains

mass-produce: to manufacture in large quantities, often using assembly lines

GLOSSARY (continued)

mechanical energy: the energy of an object as represented by its movement, position, or both

medieval: relating to a period in European history, usually between ancient cultures and the Renaissance (A.D. 476 to 1453), during which scientific and philosophical innovations were often suppressed

megawatt: 1,000 kilowatts

methane gas: an odorless, colorless, combustible gas that can be used as an energy source; the primary component of natural gas and a source for hydrogen gas

microbe: a microorganism; microscopic life form

modular: designed with standardized equipment and dimensions designed for flexible arrangement and the ability to add more units

module: in solar energy, a group of photovoltaic (solar) cells wired together into a single unit that can be grouped in any combination with other modules; in geothermal, a turbine-generator unit

mud pot: a type of hot spring containing boiling mud

multi-megawatt turbine: very tall wind turbine with huge blades that catch the faster wind speeds found higher from the ground; ones most commonly used can generate between 1–2.5 megawatts of electricity; more advanced designs may produce up to 5 megawatts

N

nacelle: in a wind turbine, a covered housing that protects the gear box, high– and low–speed shafts, generator, controller, and brake

NASA: the National Aeronautics and Space Administration; United States' space exploration agency; many scientific and technological advances that originated at NASA have been introduced into other industries

negative charge: one of two kinds of electric charge, the kind carried by an electron (a positive charge is carried by a proton)

net metering: a program offered by power producers that encourages grid-connected consumers to generate some or all of their own electricity using specific, usually renewable, resources; in many cases, this type of program allows the consumer's meter to turn backwards when they are producing more power than they are using, and some utilities will pay the consumer for the net excess power generated

neutron: an electrically neutral subatomic particle

nitric acid: a transparent, colorless to yellowish, corrosive substance; one of the components of acid precipitation

nitrogen oxides: gases formed mainly from nitrogen and oxygen; one of the damaging components of acid precipitation

nonrenewable energy: energy sources that do not regenerate themselves in a useful amount of time, including fossil fuels and nuclear fuels

nuclear fission: a reaction in which an atomic nucleus is split into fragments, releasing large quantities of energy

nuclear fuels: minerals, such as uranium, from which energy is liberated by a nuclear reaction or by radioactive decay

nuclear fusion: a reaction in which nuclei are combined (fused) to form a more massive nucleus, accompanied by the release of energy

nucleus: the positively charged central region of an atom (plural: nuclei)

O

Ocean Thermal Energy Conversion (OTEC): ocean energy technology that produces electricity — sometimes along with clean drinking water — by taking advantage of the temperature difference between warm surface ocean water and cold water from the ocean depths

oil refinery: factory where crude oil is separated into various components and cleaned to remove some impurities

GLOSSARY (continued)

oil rig: large collection of machines, hoists, and power equipment, established on land or on platforms or barges in open water; used to drill down into oil reserves found in underground rock

old-growth forest: forest having a mature ecosystem, including presence of old woody plants (mainly trees), and the wildlife and smaller plants associated with them; typically old-growth forest floors are made up of "duff," a rich layer of debris, decomposing matter, and leaves

one-way marine currents: deep oceanic currents that result from varying conditions of ocean water including differences in temperature and water density

organic decay: the breakdown of organic matter as a result of bacterial or fungal action; rot

organic: derived from living organisms

oscillating: to swing back and forth with a steady, uninterrupted rhythm

ozone: a highly reactive molecule made of three atoms of oxygen; high in the atmosphere ozone forms a protective layer that filters out harmful ultraviolet radiation; is formed at the earth's surface as a harmful component of photochemical smog

P

parabolic: a curved geometric shape based on the parabola; when radiant energy, such as sunlight, hits a parabolic surface and is reflected back, all the reflected radiant waves pass through one area of space in front of the parabolic surface known as the focus; in solar energy, parabolic surfaces, such as parabolic mirrors, are used to concentrate radiant waves from the sun

parabolic trough: a concentrating solar power technology that utilizes a long, trough-shaped parabolic reflector to focus the sun's energy onto a pipe that contains a liquid that boils to produce steam

particulates: solid particles and liquid droplets suspended in the air, including smoke, soot, dust, and ash

passive solar: techniques using the structure of a building for heating or cooling that require no collectors, pumps, or other devices; examples include large, south-facing windows to allow solar energy in to warm the house, or awnings to block solar radiation to cool the house

peak load: the time(s) of day when consumers demand (use) the most electricity

peaking power: the electricity demand, or need, that exceeds the amount of baseload power available at any given time

penstock: a conduit or pipe that carries water from a storage reservoir or from upriver to a turbine

photochemical smog: a complex mixture of air pollutants, produced in the lower atmosphere by the reaction of hydrogen and nitrogen oxides when exposed to sunlight; is unsightly, damages vegetation, and leads to eye and respiratory ailments in animals and humans

photon: tiny bundles of electromagnetic radiation that move rapidly from one place to another at the speed of light; sometimes considered a flow of particles; the sun emits huge quantities of photons

photovoltaic: refers to the ability to convert photons into electrical energy; photons are used to dislodge electrons from atoms of silicon or other materials, causing them to migrate, producing an electric current

policy: a plan or general set of guidelines that reflects a particular set of values and influences specific actions and decisions

porous: able to hold water in spaces within rock

positive charge: one of two kinds of electric charge, the kind carried by a proton

proton: a positively charged subatomic particle found in all nuclei

pumped storage: a system of generating electricity using water pumped from a lower reservoir to a higher storage site and later released to fall back to the lower reservoir when electricity is needed; used as a method of "storing" energy; generally, surplus electric power is used to lift the water when demand is low

GLOSSARY (continued)

R

radiant energy: energy transmitted in the form of rays, waves, or particles

radioactive: emitting radiation, either from unstable (fissionable) nuclei or from a nuclear chain reaction

reactive: an element or compound that tends to participate readily in chemical reaction

reactor core: in a nuclear power plant, the contained assembly of fuel rods, around which a liquid or gas flows in pipes to remove the resulting heat energy

rebate: return of a percentage of the cost of an item

regenerate: to renew the supply of something, such as an energy resource

renewable energy: any energy resource that can be used without being exhausted

Renewable Portfolio Standards: a set of standards, adopted by a government, designed to ensure that a certain percentage of various renewable energy resources be included in the portfolio (assorted collection) of its power providers or sources

resistance: opposition to the passage of electric current, causing electric energy to be transformed into heat

rotor: the rotating part (the blades and hub) of an electrical or mechanical device

run-of-river (diversion): hydropower system that produces electricity while still maintaining the natural or near-natural flow of a river (as opposed to creating an impoundment to hold the river back to form a reservoir); most run-of-river systems divert some of the water through an electrical powerhouse and then return it to the river

S

scrubber: an apparatus used to remove impurities from gaseous emissions

silicon: one of the most abundant elements on Earth; always occurs in combination with other elements; high heat is required to isolate it; widely used in products such as glass, ceramics, computer microchips, and solar photovoltaic cells

sluice: an artificial channel for conducting water

smelt: to melt ore (rock containing valuable minerals, especially metals) in order to separate the metal from the rock

solar cell: a photovoltaic device that converts solar energy into electrical energy using an electrochemical reaction in which electrons are caused to move, creating an electrical current

solar dish engine: a concentrating solar power technology that uses either one large, dish-shaped parabolic mirror, or a group of these mirrors, to concentrate the thermal (heat) energy of solar radiation onto a receiver; a heat engine in the receiver converts the concentrated heat into mechanical energy to drive an electrical generator

solar energy: the radiant energy from the sun received by the earth

solar panel: a group of around 10 solar, or photovoltaic, modules (see solar cell) that are assembled together into a panel

spent fuel: fissionable material left over from a nuclear reaction; spent nuclear fuel is still radioactive, therefore toxic; classified as hazardous waste, and must be handled and stored properly for safety

stand-alone wind turbine: a wind turbine that is not part of a wind farm; most commonly used in remote or rural locations, and is often not connected to the electrical grid

static electricity: an accumulation of electric charge (as opposed to the movement of electric charge known as electric current); imbalance between positive and negative charges

steam reforming: a form of fuel processing often used to produce hydrogen gas, frequently from natural gas or biomass; uses a special process involving heat and a catalyst (substance that increases the rate of a chemical reaction without being consumed in the process)

GLOSSARY (continued)

Stirling engine: an engine that has a sealed chamber where heat is focused on one side, causing the air inside to expand and push down on a piston; as the piston moves, air flows to the cold side of the engine where it is cooled; a second piston pushes the cooled air back to the hot side

strait: a narrow channel joining two larger bodies of water

subatomic particle: any of various units of matter below the size of an atom, including neutrons, protons, and electrons

substation: in electrical transmission, the location of the transformer equipment that decreases the voltage of electric current after it has traveled through high-voltage transmission lines

sulfur oxides: pungent, colorless gases formed mainly by the combustion of fossil fuels; considered a major air pollutant

sulfuric acid: a colorless to dark brown, highly corrosive, dense liquid; sulfur oxide dissolved in water

sustainable: a process, system, or technology that does not deplete resources or cause environmental damage and thus lasts indefinitely; a school of thought that advocates preserving meaningful choices, such as of energy resources, for future generations

synthetic: not natural; the combination (synthesis) of materials to form a product that may or may not occur naturally

system efficiency: input (of energy or work) versus output (of energy or work) of a system, often expressed as a ratio (energy in divided by energy out); theoretically, the ratio is never one-to-one

T

tailrace: the part below a water wheel or water turbine through which the used (spent) water flows

tectonic plates: the large sections of the earth's crust that are slowly moving over the mantle; the plates interact with one another at their boundaries, causing a variety of geologic phenomena including earthquake and volcanic activity

telegraph: apparatus historically used to communicate Morse code at a distance over a wire using electrical impulses

temperate zone: a region with a moderate climate, characterized by being neither too hot nor too cold

terrain: the surface features of an area of land

textile: cloth, especially that manufactured by weaving or knitting

thermal energy: see heat energy

tidal currents: the two-directional, in and out and up and down movements of the ocean along coastlines

tidal fence: an ocean energy technology that uses a long, connected series of underwater turbines that utilize the tides to produce electricity

tidal power plant: marine current energy technology that uses the mechanical energy of ocean tides to produce electricity; traditional tidal systems situate turbines in a barrage (dam) through which the tides come in and out; newer designs use free-standing, generally submerged, turbines located at or near shorelines

town gas: gas (composed mainly of hydrogen) that is manufactured from raw materials such as coal, coke, or oil; is distinguished from natural gas, which occurs naturally in underground deposits; during the 1800s town gas was widely distributed through pipelines to many cities and towns in Europe and America for light and heat

transformer: device used to "step-up" (increase) or "step-down" (decrease) the voltage of electric current

transmission lines: long distance wires through which high-voltage electricity travels

transmit: to send from one place to another

turbine: bladed, wheel-like device caused to spin by the force of pressurized steam or gas, wind, or moving water; used in electricity production to drive an electrical generator

GLOSSARY (continued)

U

U.S. Environmental Protection Agency (EPA): a federal agency of the United States whose mission is to protect the nation's natural environment; establishes and enforces regulations through a network of regional offices

ultraviolet: radiant waves that are part of the electromagnetic spectrum; are invisible to the human eye; solar ultraviolet radiation comes in several wavelengths, one of which is harmful to biological life, but most of which is absorbed by upper atmospheric ozone layer

unburned hydrocarbons: air pollutants that come from the incomplete combustion of fossil fuels and from the evaporation of petroleum fuels, industrial solvents, painting and dry cleaning chemicals

uranium: a heavy, silvery-white metallic element that is radioactive and toxic; exists in 14 different forms, or isotopes; is extracted from ores for use in research, nuclear fuels, and nuclear weapons

V

vaporize: to convert into a vapor, the gaseous state of a substance

variable-speed wind turbine: turbine that can respond to wind speed changes to take advantage of a wide range of energy production from wind

voltage: the measure of the electrical force that "pushes," or drives, an electric current

W

wastewater: the collective discharge from toilets, sinks, showers, washing machines, storm-sewers, etc.; can be cleaned, or "treated," to remove most of the toxic components and then used for purposes other than consumption by animals or humans

water cycle: the natural process of the movement of Earth's water as it evaporates from bodies of water, condenses, precipitates (rains, sleets, hails, snows) and returns to those bodies of water, in a continuous cycle

watt: the rate of electrical current flow, when one ampere is driven, or "pushed," by one volt

watt-hour: the energy expended when one watt of electrical power is used for an hour

Wave Energy Conversion Systems (WECS): any of a variety of ocean energy systems that employ the moving (mechanical) energy of waves to produce electricity; can be located along shorelines or in the open sea.

wet-cell battery: a battery, or "cell," in which an electrochemical reaction occurs in an electrolyte

wetland: a lowland area, such as a marsh, swamp, or estuary, that is saturated with moisture; provides a rich habitat for wildlife; absorbs heavy metals and filters out toxins, releases oxygen into the air while removing carbon dioxide and other greenhouse gases; provides flood control and is a significant factor in the recharge of groundwater

wind farm: a cluster of wind turbines located in areas with reliably favorable wind speeds, such as on high windy mountain passes or gusty open plains; can also be situated on farms or ranches alongside other uses such as crop-growing or ranching

ADDITIONAL INFORMATION RESOURCES

There is a wealth of information available on all aspects of energy use. Space constraints limited what we could include here. However, many of the sources listed below include great website links and suggestions for additional materials. And check our website (www.energyforkeeps.org) occasionally for more postings of educational resources.

GENERAL

Organizations and Websites

Acorn Naturalists
800-422-8886
www.acornnaturalists.com

Books and other teaching materials on many topics including environmental education, outdoor education, science inquiry, interpreting cultural and natural resources, "GEMS" ("Great Explorations in Math and Science"), earth science, ecology, plant and animal studies, and the ocean.

Alliance to Save Energy
202-857-0666
www.ase.org

Advocacy organization promoting energy efficiency; energy efficiency programs, including "Energy Science Fair," "Green Schools," "New School Construction," and "Downloadable Educator Lesson Plans;" links for teachers and students.

Ask an Energy Expert
1-800-DOE-3732
www.eere.energy.gov/askanenergyexpert

A division of U.S. DOE Office of Energy Efficiency and Renewable Energy; answers questions ranging from how to make your school more energy efficient to specifics on the use of renewable energy.

Bonneville Power Administration (BPA)
800-282-3713
www.bpa.gov

"Resources for Teachers" includes curriculum units, booklets, activities, posters, videos, films; kids site. General information on water, hydroelectricity, energy conservation, electric safety, resource planning and BPA history; links for other information.

California Energy Commission (CEC)
General: 916-654-4287

CEC Renewable Energy and
Consumer Energy Efficiency Information
Toll Free in California: 1-800-555-7794
Outside California: 916-654-4058
www.energy.ca.gov

Consumer Energy Center Website; information about energy efficiency, energy statistics, and renewable energy; rebate information news releases; programs include energy efficiency, renewable energy development, alternative fuel vehicles. Highly recommended kids website: "Energy Quest."

California Energy Commission Kids Site: Energy Quest
www.energyquest.ca.gov

"Timeline of Energy History," "The Energy Story" (all aspects of energy and energy resources, including all the renewables), games, energy terms, "How Things Work," science projects, "Ask Professor Questor," teacher and parent resources.

California Mineral Education Foundation
916-655-1050
www.calmineraled.org

Charitable education corporation developed to provide mineral education programs for K-12 teachers. Covers wide variety of geological topics, as well as mining and processing of minerals. Curriculum materials, educational programs, grants, and extensive links.

Center for Energy Efficiency and Renewable Technologies (CEERT)
916-442-7785
www.ceert.org

Based in Sacramento, public interest coalition working towards policy change and public education regarding the use of sustainable, environmentally sound methods to meet California's energy needs. Up-to-date information on renewable energy technologies, energy efficiency, and energy policy.

ADDITIONAL INFORMATION RESOURCES (continued)

Chelsea Green: Books for Sustainable Living
800-639-4099
www.chelseagreen.com

Wide range of sustainable living books and some videos on topics such as energy-efficient homes, stand-alone renewable energy systems, ecological architectural design, and renewable energy.

Energy Ant: DOE Kids Zone
www.eia.doe.gov/kids

Energy history, articles on various energy topics, "What is Energy," "Kids Corner," "Energy Quiz," teacher resources, links.

The Franklin Institute Science Museum
214-448-1200
www.fi.edu

Museum online resource; science history; energy information; online study unit topics include wind, plate tectonics, oceans; links to many other resources; "Community Science Action Guides" include global warming, fossil fuel depletion, nuclear energy, energy resources, and visual animations of energy at work.

How Stuff Works
www.howstuffworks.com

Reliable information source on just about every topic, including many specific energy-related topics.

National Energy Education Development (NEED)
703-257-1117
www.need.org

Partner with U.S. DOE's Rebuild America and "Energy Smart Schools." Information about energy resources, including how their use impacts the environment; K-12 curriculum material including hands-on activities about the science of energy, electricity, efficiency and conservation; training and professional development; photo gallery.

National Energy Foundation
801-908-5800
www.nef1.org

Information about renewable energy, efficiency, and conservation. Materials catalog, NEF Academy for professional development, Energy Action Programs (energy awareness and energy management for schools, community, home), student programs include "Academy of Energy," "Fueling the Future," and "Igniting Creative Energy;" links to many energy-related topics for teachers and for students.

National Renewable Energy Laboratory (NREL)
303-275-3000
www.nrel.gov/education

U.S. DOE's laboratory for renewable energy and energy efficiency research and development; general information on state-of-the-art renewable energy technologies; Office of Education Program provides renewable energy and energy efficiency curriculum, activities, projects; student competitions; teacher training, including direct access to current renewable energy research.

National Science Resources Center
Smithsonian Institution/The National Academies
www.si.edu/nsrc

Many educational resources on all topics, including energy; publications; science newsletter; links to many resources; science curriculum units for both middle school and K-6.

National Science Teachers Association
World of Energy
www.nsta.org/Energy

Library of energy resources; interactive decision making simulation; energy facts and figures.
The Science Store has many resources including curriculum units on electricity, magnetism, chemistry, geology, and oceanography. Interdisciplinary titles include "American History Through Earth Science," "Reinvent the Wheel" (stories behind key inventions with hands-on science activities), "Mixing it Up: Integrated, Interdisciplinary Intriguing Science," and "The New Science Literacy: Using Language Skills to Help Students." Links to recommended energy education sites.

ADDITIONAL INFORMATION RESOURCES (continued)

Northeast Sustainable Energy Association
413-774-6051
www.nesea.org

Education section provides interdisciplinary K-12 curriculum materials on energy, transportation, and the environment, links, other educator materials, access to "Junior Solar Sprint Model Solar Car Competition," links to "Information on Clean Energy," and "Green Buildings."

NOVA Science in the News
Australian Academy of Science
www.science.org.au/nova

Up-to-date linked information on various science topics, geared for high school level; categories include environment, physical sciences, and technology; includes links to such topics as climate, electromagnetism, and plate tectonics.

Renewable Energy Policy Project (REPP)
www.crest.org

Information on renewable energy; energy and the environment, efficiency, and policy issues; Library archives; "Global Energy Marketplace," e-mail newsletter; up to date news; recent trends.

Renewable Energy Project Kits
Pembina Institute, Canada
www.re-energy.ca

Provides background information on selected renewable energy resources (including wind, hydropower, solar, biomass) then includes detailed directions for building your own working model related to those energy resources; each resource section includes links to other information sources.

Renewable Energy World
www.jxj.com/magsandj/rew

Website containing many articles from magazine of same title; global coverage of state-of-the-art renewable energy projects and policy issues; information is rather technical, but students can skim for general information; one of the best sources for up-to-date information; check to see if it will give you free subscription to the print-version magazine.

Sustainable Energy Coalition
202-293-2898
www.sustainableenergy.org

Advocacy organization that promotes federal support for energy efficiency and renewable energy technologies; members include Union of Concerned Scientists, American Wind Association, National Hydropower Association and many others; energy facts and statistics; energy policy information; links to many energy experts.

Tennessee Valley Authority Kids Site
www.tvakids.com

Information on protecting the environment, making electricity, "Green Power," electrical safety, TVA history; teacher resources include a K-12 renewable energy curriculum and "Energy Sourcebooks" with teacher guides and energy education activities.

Union of Concerned Scientists
National Headquarters
Phone: 617-547-5552
West Coast Office
Phone: 510-843-1872
www.ucsusa.org

Partnership of scientists and citizens for scientific analysis, policy development and citizen advocacy promoting practical and sustainable environmental solutions in many areas including energy use and pollution; programs include support for renewable energy development and policies.

U.S. Department of Energy (DOE)
Energy Information Administration
202-586-8800
www.eia.doe.gov

Ask an Expert; Energy data, analyses, forecasts, and publications about specific energy resources, as well as general publications such as "Monthly Energy Review," the "Annual Energy Review," the "Short-Term Energy Outlook," and the "Annual Energy Outlook."

ADDITIONAL INFORMATION RESOURCES (continued)

U.S. Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy
202-586-9220
www.eere.energy.gov

Kids site: Dr. E's Energy Lab; "Ask an Energy Expert;" portals to related U.S. DOE offices, as well as to many other programs related to energy efficiency and renewable energy; energy education programs include energy curriculum, science projects and activities, student competitions, and student resources; oversees "EnergySmart Schools" and "Rebuild America" programs.

Books

Brennan, Richard P. **Dictionary of Scientific Literacy**. New York: John Wiley and Sons, Inc, 1992.

Brower, Michael. **Cool Energy: Renewable Solutions to Environmental Problems**. Cambridge, MA: The MIT Press, 1998. (teacher reference only)

Challoner, Jack. **Eyewitness Science: Energy**. London: Dorling Kindersley, 1993.

Christensen, John W. **Global Science**. Dubuque, IA: Kendall/Hunt Publishing Co., 2000.

Christianson, Gale E. **Greenhouse: The 200-year Story of Global Warming**. New York: Penguin Books, 1999. (teacher reference only)

Farndon, John. **Dictionary of the Earth**. London: Dorling Kindersley, 1994.

Macaulay, David. **The New Way Things Work**. Boston: Houghton Mifflin Company, 1998.

Technologies and Sustainable Living. White River Junction, Vermont: Chelsea Green Publishing Co., 2001. (catalog for ordering various products, plus general information)

Science Supply Houses

Carolina Science and Math
800-334-5551
www.carolina.com
Edmund Scientifics
800-728-6999
scientificsonline.com

Nasco Science
800-558-9595
www.nascofa.com

CHAPTER 1: ENERGY HISTORY

California Energy Commission
Energy Time Machine
www.energyquest.ca.gov/time machine

Extensive timeline of energy history from the dawn of history to present day.

Celebrating California's Sesquicentennial with 150 Years of Energy Pictures
California Energy Commission
www.energy.ca.gov/photos

Virtual photo gallery with images of California energy use over last 150 years.

Milestones in the History of Energy and Its Uses
EIA Energy Ant Kids Site
www.eia.doe.gov/kids/milestones

Traces significant events in the history of energy; links to "Pioneers in Energy" and "Energy in the United States, 1635-2000."

Newspapers in Education
515-823-3501
www.abqtrib.com/nie

Offers resources such as "Creating a Classroom Newspaper" and "Science in the News." These and other specific newspaper-related resources are offered through this Albuquerque Tribune NIE website. NIE products are also offered through a number of other newspaper websites; products vary from site to site.

ADDITIONAL INFORMATION RESOURCES (continued)

Pacific Northwest Newspaper Association
206-632-7913
www.pnna.com

Trade association that provides support for use of the newspaper in the classroom, among other projects. Go to Hot Links and look for the "Newspapers in Education" links to various newspaper and educational sites.

Visions of Power
Image Galleries
Smithsonian Institution
americanhistory.si.edu/csr/powering/visions

Virtual gallery with energy images, historical images, and electric power ads of yesterday.

See General category for more history info.

Books

Grun, Bernard. **The Timetables of History**. New York; Simon and Schuster, 1991.

James, Peter and Nick Thorpe. **Ancient Inventions**. New York: Ballantine Books, 1994.

Ochoa, George and Melinda Corey. **The Timeline Book of Science**. New York: Ballantine Books, 1995.

Platt, Richard. **Smithsonian Visual Timeline of Inventions**. London: Dorling Kindersley, 1994.

CHAPTER 2: ELECTRICITY

Electricity and Magnetism Learning Resources
Exploratorium Teacher Institute, San Francisco, CA
www.exploratorium.edu/ti/resources/electricityand magnetism

Resources selected by the Exploratorium's Teacher Institute and Information Resources staff; dozens of print publications, video resources, and internet links.

Electricity Online
ThinkQuest
www.thinkquest.org

Explores the physics, practical applications, and history of electricity in an interactive, online format.

See General category beginning on page 205 for more resources on electricity.

CHAPTER 3: BIOMASS

California Biomass Energy Alliance
805-386-4343
www.calbiomass.org

General biomass information; specific information on California biomass power plants; ask an expert; links.

National Renewable Energy Laboratory (NREL)
Clean Energy Basics
About Biomass Energy
www.nrel.gov/clean energy/bioenergy

Information about state-of-the-art biomass technologies; general information on using biomass for energy.

U.S. Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy
Biopower Division
www.eere.energy.gov/biopower

Information on all aspects of using biomass for energy; links to related organizations and information sources; library; photo gallery.

CHAPTER 3: GEOTHERMAL

Geo-Heat Center
Oregon Institute of Technology
541-885-1750
geoheat.oit.edu

General information on geothermal energy, especially its use at lower temperatures; where geothermal resources are located and being used; access to experts; links to other information sources.

ADDITIONAL INFORMATION RESOURCES (continued)

Geothermal Education Office
415-435-4574
800-866-4436
geothermal.marin.org

Provides educational materials on all aspects of geothermal energy; products include geothermal curriculum unit, videos, maps; links to other resources; access to experts; outstanding website with great "Introduction to Geothermal" slide show.

Books

Ford, Brent. **Project Earth Science: Geology**. Arlington VA: National Science Teachers Association, 1998.

Duffield, Wendell and Sass, John. **Geothermal Energy — Clean Power from the Earth's Heat**. Circular 1249. U.S. Department of the Interior and U.S. Geological Servey, 2003.
(This report and any updates to it are available at http://geopubs.wr.usgs.gov/circular/c1249/

CHAPTER 3: HYDROPOWER

Bonneville Power Administration (BPA)
See page 205.

Bureau of Reclamation Power Program Hydropower Information
www.usbr.gov/power

Topics covered include history of hydropower in the United States; background information on hydropower, major hydropower producers; links to other sources of information; educational materials for K-8, including "Nature of Water Power."

Foundation for Water and Energy Education
800-279-6375
www.fwee.org

Many educational materials on hydropower; information on all aspects of hydropower including environmental impacts.

National Hydropower Association
202-682-1700
www.hydro.org

Advocacy organization promoting the widespread use of hydropower; access to basic hydropower information.

U.S. Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy
Hydropower Division
www.eere.energy.gov/RE/hydropower

Information on all aspects of hydropower; links to other hydropower resources and organizations.

CHAPTER 3: OCEAN

Ocean Energy
CEC Site
www.energy.ca.gov/development/oceanenergy

Basic information on ocean energy and extensive links to government and industry sites.

Ocean Thermal Energy Conversion Fact Sheet
Natural Energy Laboratory of Hawaii Authority
www.hawaii.gov/dbedt/ert/otec

Explanation of OTEC; links to other OTEC reports and other sites with OTEC information.

Practical Ocean Energy Management Systems (POEMS)
619-224-6732
www.poemsinc.org

Advocacy organization dedicated to educating the general public about ocean energy; portal to many different resources related to ocean energy.

U.S. Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy
Ocean Topics
www.eere.energy.gov/RE/ocean

Information on all aspects of ocean energy and links to other ocean energy sites.

ADDITIONAL INFORMATION RESOURCES (continued)

CHAPTER 3: SOLAR

American Solar Energy Society
303-443-3130
www.ases.org

Advocacy organization promoting widespread use of solar energy; information on all aspects of solar energy; magazine: *Solar Today*; Solar Guide Fact Base; publications; educational materials: videos, slides, activities.

Florida Solar Energy Center Teacher Resources
www.fsec.ucf.edu/ed/teachers

Information on all aspects of solar energy; student contests such as Junior Solar Sprint and Hydrogen Sprint; offers many teaching resources including units on energy in general, solar energy, alternative fuels, and environmental issues; links to many other resources.

Project Sol
Arizona Public Service (APS)
http://projectsol.aps.com

A solar education site developed by APS (an Arizona power supplier); topics include energy from the sun, electrical energy, inside PV systems, power for the future; solar data; virtual tour of a photovoltaic cell.

U.S. Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy
Roofus' Solar and Efficient Neighborhood
www.eere.energy.gov/roofus

Interactive website for kids covering various topics, including solar energy and energy efficiency; teacher resources.

CHAPTER 3: WIND

American Wind Energy Association
202-383-2500
www.awea.org

Advocacy organization promoting widespread use of wind energy; information on all aspects of wind energy; online bookstore; "Wind Energy Weekly" covers wind industry, global climate change, and energy policy; resource library; information on specific wind energy projects.

U.S. Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy
Wind Energy Program
www.eere.energy.gov/wind

Information on wind energy basics, including how wind turbines work; wind turbine research, and wind energy projects; links to other organizations; resources for teachers and students; photo gallery.

Wind Energy Resource Atlas of the United States
National Renewable Energy Laboratory
http://rredc.nrel.gov/wind/pubs/atlas

Atlas showing the quality of wind energy resources in various parts of the United States.

CHAPTER 3: HYDROGEN

Fuel Cell Store
303-237-3834
www.fuelcellstore.com

Fuel cell products for classroom and for the general public; products include fuel cell demonstration kits, fuel cell systems and accessories; resources for students and teachers, including fuel cell experiments, books, posters, and videos.

National Hydrogen Association
202-223-5547
www.hydrogenus.org

Advocacy organization promoting the widespread use of hydrogen fuel; basic information on hydrogen fuel; resources for students and educators.

Schatz Energy Research Center
707-826-4345
www.humboldt.edu/~serc

Working in affiliation with Humboldt State University's Environmental Resources Engineering program, develops and promotes renewable energy technologies, especially hydrogen fuel cells, zero emission vehicles, and solar hydrogen power systems; information on all aspects of hydrogen and fuel cells; educational materials; links to other related resources.

ADDITIONAL INFORMATION RESOURCES (continued)

CHAPTER 3: FOSSIL FUELS

Petroleum Education
Paleontological Research Institution
607-273-6623
www.priweb.org/ed

"From the Ground Up: The World of Oil" covers all aspects of oil including geology basics, oil history, hydrocarbon systems, daily uses of oil; links to other energy resources.

U.S. Department of Energy (DOE)
Fossil Energy Division
www.fe.doe.gov

Extensive information on all aspects of fossil fuel production and use in the United States and globally; recent fossil fuel news items; clean coal and natural gas technologies; "For Students" section.

CHAPTER 3: NUCLEAR

Nuclear Energy Institute
202-739-8000
www.nei.org

Advocacy organization promoting the use of nuclear energy; information on nuclear technologies; public policy issues; nuclear data; library; "NEI Science Club," teachers and kids site that includes games, information, curricular materials, links.

U.S. Department of Energy (DOE)
Office of Nuclear Energy, Science and Technology
www.ne.doe.gov

Information on all aspects of nuclear energy; nuclear power research; space and defense power programs; nuclear facilities management; nuclear fuel supply security; public information; video: "Splitting Atoms: An Electrifying Experience."

CHAPTER 4: ENERGY, HEALTH, AND THE ENVIRONMENT

Earth Island Institute
415-788-3666
www.earthisland.org

Institute researching and promoting a wide variety of projects on conservation, preservation, and restoration both nationally and globally; "Earth Island Journal," many publications; news and citizen action alerts; information on starting your own action project.

National Oceanic and Atmospheric Administration
202-482-6090
www.noaa.gov

Researches and disseminates information on all aspects of climate, weather, and the oceans; weather forecasting satellite imagery; ocean exploration; fisheries; climate research; air quality; coastal services; undersea laboratory; library and archives; photo library.

See General and Chapter 5 categories for more resources on the environment.

Books

Gutnik, Martin J. **Ecology**. New York: Franklin Watts, Inc., 1984.

Ranger Rick's NatureScope: Pollution — Problems and Solutions. New York: Learning Triangle Press (for National Wildlife Federation), 1998.

Pollock, Steve. **Eyewitness: Ecology**. London: Dorling Kindersley, 2000.

CHAPTER 5: ENERGY POLICY AND MANAGEMENT

Alliance to Save Energy
(*see page 205)*

ADDITIONAL INFORMATION RESOURCES (continued)

American Council for an Energy-efficient Economy
202-429-2248
www.aceee.org

Organization dedicated to advancing energy efficiency; advises on and provides educational information on energy policy, energy efficient buildings, industry, transportation; publications and other consumer information. Look for "Consumer Guide to Home Energy Savings."

Astronomy Picture of the Day (APOD)
National Aeronautics Space Administration
http://antwrp.gsfc.nasa.gov/apod/ap001127.html

Satellite composite photo taken Nov. 27, 2000, shows "Earth at Night": highlights developed or populated areas of the earth's surface; can be used for topics of discussion such as cultural geography and the differences in resource consumption between developed and developing nations.

Cleaner and Greener
Leonardo Academy, Madison, WI
877-977-9277
www.cleanerandgreener.org

Interdisciplinary program to improve the environment through education, analysis, consumer programs, and public policy initiatives; energy efficiency information; K-12 resources; emissions calculators; reports on greenhouse gases, green energy programs.

Redefining Progress: Sustainability Program
510-444-3041
www.rprogress.org/programs/sustainability

Partnership of organizations dedicated to sustainability; calculate your own ecological footprint; ecological footprint concepts and methods; sustainability education resources; publications; links to other sustainability sites.

Rocky Mountain Institute
970-927-3851
www.rmi.org

Investigates and fosters sustainable social, economic, and environmental practices; information on energy, climate, water, transportation, energy efficient buildings; Kids site; educational materials; newsletter, bookstore.

Union of Concerned Scientists
See page 207.

U.S. Environmental Protection Agency (EPA)
www.epa.gov

Federal government health and environment regulatory agency; information on many topics including laws and regulations, environmental management, health topics, pollution prevention, economics, compliance and enforcement; educational resources; extensive Global Warming Site, including Kids site and educator materials and information.

Worldwatch Institute Resource Center
202-452-1999
www.worldwatch.org

Independent research organization advocating environmental sustainability; resource center topics include energy resources, climate change, transportation pollution, biodiversity, food, population, and water issues; publications and news alerts.

See General category for more resources on sustainability and energy management/policy.