



Air Pollution and Electrical Energy Production

This lesson is the first in a unit focusing on air quality and electricity. In this lesson, students will conduct Internet research to understand how the production of electricity contributes to the problem of air pollution and will locate and mark power plants on a map of Georgia. They will differentiate between renewable and nonrenewable energy sources and be able to give examples of each. Students will also explore hydropower as an alternative, renewable energy source, and construct a water wheel to investigate how water-driven turbines can be used to generate electricity. A Teacher Resource Manual, Power Point presentations, and other resources are included. (Environmental Education)

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

How does the production of electricity contribute to the problem of air pollution? What is the difference between renewable and nonrenewable energy resources and what are examples of each? What are the major energy sources used to produce electricity? How can I read and interpret bar graphs, pie charts, and other data displays to determine reliance on various types of energy production? How can water be used to generate electricity? How can I create a model that demonstrates the use of water as an alternative energy source?

Additional Learning Outcomes

How can I use the Internet to research the relationship between air pollution and various types of energy production?

Assessed GPS Standards:

Grade: 6

Science Standards:

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

- b. Identify renewable and nonrenewable resources

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

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

S8P5c: Students will recognize characteristics of gravity, electricity, and magnetism as major kinds of forces acting in nature.

- c. Investigate and explain that electric currents and magnets can exert force on each other.

Math Standards:

M6D1d: Students will pose questions, collect data, represent and analyze the data, and interpret results.

- d. Use tables and graphs to examine variation that occurs within a group and variation that occurs between groups.

Non-Assessed GPS Standards:

Grade: 6

Science Standards:

S6CS1: Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.

- a. Understand the importance of—and keep—honest, clear, and accurate records in science.
- b. Understand that hypotheses are valuable if they lead to fruitful investigations, even if the hypotheses turn out not to be completely accurate descriptions.

S6CS9: Students will investigate the features of the process of scientific inquiry.

- a. Scientific investigations are conducted for different reasons. They usually involve collecting evidence, reasoning, devising hypotheses, and formulating explanations.
- b. Scientists often collaborate to design research. To prevent bias, scientists conduct independent studies of the same questions.
- c. Accurate record keeping, data sharing, and replication of results are essential for maintaining an investigator's credibility with other scientists and society.
- d. Scientists use technology and mathematics to enhance the process of scientific inquiry.

- e. The ethics of science require that special care must be taken and used for human subjects and animals in scientific research. Scientists must adhere to the appropriate rules and guidelines when conducting research.

S8CS9: Students will understand the features of the process of scientific inquiry.

- a. Investigations are conducted for different reasons, which include exploring new phenomena, confirming previous results, testing how well a theory predicts, and comparing different theories.
- b. Scientific investigations usually involve collecting evidence, reasoning, devising hypotheses, and formulating explanations to make sense of collected evidence.
- c. Scientific experiments investigate the effect of one variable on another. All other variables are kept constant.
- d. Scientists often collaborate to design research. To prevent this bias, scientists conduct independent studies of the same questions.
- e. Accurate record keeping, data sharing, and replication of results are essential for maintaining an investigator's credibility with other scientists and society.
- f. Scientists use technology and mathematics to enhance the process of scientific inquiry.
- g. The ethics of science require that special care must be taken and used for human subjects and animals in scientific research. Scientists must adhere to the appropriate rules and guidelines when conducting research.

S8CS5b: Students will use the ideas of system, model, change, and scale in exploring scientific and technological matters.

- b. Understand that different models (such as physical replicas, pictures, and analogies) can be used to represent the same thing.

S8CS1: Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.

- a. Understand the importance of—and keep—honest, clear, and accurate records in science.
- b. Understand that hypotheses can be valuable even if they turn out not to be completely accurate.

Procedures/Activities

Step: 1 *Duration: Teacher Preparation*

Review the Teacher Resource Manual

The Teacher Resource Manual provides background information on the lesson

topic and lesson resources to answer student questions and facilitate class discussions. Review the Manual and all steps in this lesson prior to teaching it, so that you will know what to prepare in advance for your class. Be sure to collect all the items listed in the materials section, and to make transparencies and handouts (attached at Steps 3, 5, and 6) ahead of time.

Note: This lesson is the first in a unit focusing on air quality and electricity. Students will investigate ways in which energy production can contribute to the problem of air pollution. In the second lesson, titled “Light Bulbs and Air Pollution” they will determine the amount of carbon dioxide (CO₂) pollution produced in the process of generating electricity for various types of light bulbs. For more information, refer to the Teachers’ Resource Manual.

Web Resources for Step 1

Title: 6th Grade Teacher Resource Manual

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

Annotation: The Teacher Resource Manual provides background information on the lesson topic and other lesson resources. Please review this information. The Web sites listed below are linked in the Teacher Resource Manual.

Title: How Hydropower Works

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

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

Title: The Clean Air Campaign Speakers Bureau

URL:

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

Annotation: The Clean Air Campaign has a free speakers bureau. Teachers may want to arrange for a speaker during the week of lesson. Requests can be made online. Relevant to both Lessons 1 and 2.

Title: Environmental Education in Georgia

URL: <http://www.eeingeorgia.org>

Annotation: This Web site is hyper-linked in the 6th Grade Teacher Resource Manual attached at this step. Additional lessons on environmental education can be accessed from this Web site.

Title: AQI Kids

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

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

Title: Watts, Kilo-Watts and Meter-Reading

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

Annotation: This British Web site is hyper-linked in the 6th Grade Teacher Resource Manual attached at this step. It provides examples and background information on energy formulas, graphics for practice reading electric meters, and background information about energy. Recommended for teachers who would like to review the concepts and formulas presented in the Student Worksheet. Click on "Watt" and "Kilo-Watt" for relevant slide presentations. (Optional: This web site could also be viewed by students on an Internet-connected computer, printed on transparencies to be shown on an overhead projector, or presented to the class with a scan converter and LCD projector or monitor). Relevant to Lesson 2.

Title: A Short History of Energy

URL:

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

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

Title: Hydropower- Water Science for Schools

URL: <http://www.ga.usgs.gov/edu/hyhowworks.html>

Annotation: This Web site is hyper-linked in the 6th Grade Teacher Resource Manual attached at this step. USGS' "Water Science for Schools" Web site explains how hydrological power generation works, with an animated diagram. Links are provided to other information about hydro power. Relevant to Lesson 1.

Step: 2 Duration: 10 minutes

Ask students to recount how they use electricity from the moment they wake up until the time they go to bed. List their responses on the board. (e.g. Students might say that they cook with electricity, have a ceiling fan, use electricity to cool

or heat their homes, shower with warm water from an electric water heater, use electricity to pump water from a well, read by lamp light, etc.). Tell students that using electricity can increase air pollution, if the electricity is produced from fossil fuels. Let the class know that they will examine ways in which electrical energy is produced and learn how electrical energy production contributes to air pollution.

Step: 3 Duration: 30 minutes

Divide the class into teams of two. Distribute a copy of the "Student Worksheet on Energy Resources" handout (attached below) to each team. Have students work with partners to complete the Worksheet, using the attached Web resources. Each team of students will need access to an Internet-connected computer to complete this activity. Each individual will complete a separate worksheet.

Web Resources for Step 3

Title: Power Plant Air Pollution Locator

URL: <http://cta.policy.net/dirtypower/>

Annotation: A link to this Web site is provided in the Student Worksheet. This interactive site, which contains state maps and air pollution emission information derived from the Environmental Protection Agency, is presented by Clear the Air's National Campaign against Dirty Power. (Students should be aware that the Web site is hosted by an advocacy group which attempts to influence public policy on air quality. Reference to the Web site is made for informational purposes only. The opinions expressed therein are solely those of Clear the Air, and do not represent The Clean Air Campaign, an educational non-profit organization, nor Georgia Learning Connections).

Title: How Hydropower Works

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

Annotation: This Web site features articles and diagram regarding "How Hydropower Works." In the first article, "The Power of Water," click on the link in the paragraph about turbines, to see how a water wheel serves as a turbine. Next, click on "Inside the Generator" from the table of contents, at the top of the page to see a turbine animation and photos. Then, for fun, click on "Hydropower Footwear" from the table of contents, to see how a water wheel is used to generate power in a new invention.

Title: Green Technology

URL: <http://www.greentechnolog.com/>

Annotation: This Web site is linked within the Student Worksheet. It provides information on strategies for preventing or reducing air pollution.

Title: EIA Energy Kids' Page

URL: <http://www.eia.doe.gov/kids/energyfacts/index.html>

Annotation: This Web site is linked within the Student Worksheet. It provides entertaining information about energy, with clickable links for details on renewable and non-renewable energy sources.

Title: Electricity Info Cards

URL: <http://www.eia.doe.gov/neic/brochure/elecinfocard.html>

Annotation: This EPA Web site is linked within the Student Worksheet. "Electricity Info Cards" provide data, charts and graphs to illustrate electrical energy production capacity by type of resource; electrical energy actually generated by type of resource; electric power industry emissions (air pollution discharges); amount and cost of fossil fuels consumed to make electricity; who buys electrical power in this country, and changes in the cost of electricity over a 40 year period.

Title: History of Hydropower

URL: <http://www.energyquest.ca.gov/story/chapter12.html>

Annotation: This Energy Quest Web site is linked within the Student Worksheet. Chapter 12 provides an illustrated history of hydropower, from water wheels and grist mills to turbines and hydroelectric dams.

Title: Renewable Energy vs. Fossil Fuels

URL: <http://www.energyquest.ca.gov/story/chapter17.html>

Annotation: This Energy Quest Web site is linked within the Student Worksheet. Chapter 17 provides a thorough comparison of the pros and cons of each source of renewable and non-renewable energy.

Title: Word IQ Article on Hydroelectricity

URL:

http://www.wordiq.com/definition/Hydroelectricity#Advantages_and_disadvantages

Annotation: This Web site is linked within the Student Worksheet. The section on hydropower explains how it works, as well as its benefits and limitations.

Attachments for Step 3

Title: Student Worksheet on Energy Resources

FileName: [Student Worksheet on Energy Resources, Final.doc](#)

Description: Students will use this worksheet to record their research on nonrenewable and renewable energy resources, define the term "fossil fuel," and identify some of the air pollutants which can be caused by electrical energy production. Web links are provided in this document, to facilitate student research. All the Web sites which

are linked in the document are listed in the Web Resources section at this step. Data represented in pie chart used with permission from the United States Energy Information Administration.

Step: 4 Duration: 15 minutes

Discuss responses to the worksheet completed in Step 3 with the entire class. Use the Answer Key attached at this step. Make sure students understand that nonrenewable energy resources cannot be replaced in a human timescale. On a large sheet of paper or poster board divided into two columns, list the types of renewable and nonrenewable energy resources used to produce electrical energy. (Consider uranium, used for nuclear power generation, to be nonrenewable). Post this list in the classroom.

Web Resources for Step 4

Title: U.S Department of Energy: Energy Efficiency and Renewable Energy Change

URL: <http://www.eere.energy.gov/>

Annotation: For extension Activity #1. Click on the links in the Energy Information Portal. The links to information for consumers and kids have great activities and information for classroom use.

Attachments for Step 4

Title: Answer Key to Student Worksheet FileName: [Answer Key for Student Worksheet.doc](#)

Description: Answer Key for the Student Worksheet, which is attached at previous step.

Step: 5 Duration: 15 minutes

Show the Power Point slide, "Sources of Energy for Electricity in Georgia," to the class. (Because text and numbers appear small when the slide is viewed on a computer monitor, this slide may be made into a transparency prior to the class, and shown on an overhead projector). Ask students to look at Figure 1 and identify the major source of nonrenewable energy, based on industry capability to generate electricity in Georgia (coal). Ask students what percentage of Georgia's electricity would be produced by coal, if all types of power plants were functioning at capacity (59.2%)? What percentage of Georgia's electricity would be produced by all nonrenewable sources combined, if every power plant were functioning at capacity (83%)? Notes: Assume "other" represents renewable energy sources. Nuclear power plants use uranium to generate power. Uranium is considered a

nonrenewable source of energy.

Challenge students to analyze the difference between the data in Figure 1 and that in Figure 2. (Figure 1 is based on industry capabilities; Figure 2 is based on actual power generation). Now, ask students how much power in Georgia is actually generated by coal (64.2%)? How much is actually generated by nonrenewable sources (95.1%)? How much is actually generated by hydropower (2.3%)?

Direct students to work in teams of two again. Give each team a map of Georgia showing cities. (Maps may be downloaded or ordered from Georgia Department of Transportation, linked below, or obtained for free at tourist information centers). Also give each team three different markers or crayons and the "Power Plants in Georgia" handout. Have students make a key and then mark the locations of these power plants on the map, using one color for plants using nonrenewable fossil fuels, another color for hydroelectric power plants, and a third color for nuclear power plants. Note the locations of the power plants nearest to you, and the type of energy they use to generate electricity.

Web Resources for Step 5

Title: Online Maps from Georgia Department of Transportation

URL: <http://gis.state.ga.us/emaps/dotmaps/>

Annotation: Maps of Georgia can be viewed using Adobe Acrobat Reader or downloaded and opened using a Zip utility. Information about ordering printed State of Georgia maps is also available on this Web page. Note: It is also possible to obtain a free classroom set of state maps from many tourist information and welcome centers.

Attachments for Step 5

Title: Power Plants in Georgia FileName: [Power Plants in Georgia.doc](#)

Description: This table provides names, locations, and the types of some power plants in Georgia.

Title: Sources of Energy for Electricity in Georgia FileName: [Sources of Energy for Electricity in Georgia.ppt](#)

Description: Pie charts showing electrical generating capability by energy source, in Georgia and actual electrical generation by energy source, in Georgia. Graphics used by permission from the United States Energy Information Administration. Print this slide on a transparency if it is preferable to show it to the class using an overhead projector.

Step: 6 Duration: 5 minutes

Show and discuss a short PowerPoint presentation, "Electricity and Air Pollution" (attached below). If no projection source is available, the slides can be made into transparencies for an overhead projector, prior to beginning this step. Students should be able to conclude that most power plants in Georgia use nonrenewable energy resources, such as coal, and produce air pollutants. On the other hand, renewable-energy resources such as hydropower produce little or no air pollution. Vehicle emissions contribute significantly to air pollution, especially in urban areas. However, the amount of nitrogen oxides produced by power plants in Georgia each year is the equivalent of that produced by 20 million cars. The amount of sulfur dioxide emissions from Georgia power plants is equivalent to that which would be produced by five times the number of diesel trucks and buses that are currently operating in the United States. (Sources of information: *New York Times* and U.S. Energy Information Administration)

Attachments for Step 6

Title: Electricity and Air Pollution

FileName: [Electricity and Air Pollution.ppt](#)

Description: This presentation identifies major air pollutants from fossil fuel power plants, and their corresponding health effects.

Sources of information: United States Energy Information Administration and Environmental Protection Agency. Graphics from Microsoft Clip Art.

Step: 7 Duration: 45 minutes for building the water wheel model OR 3 hours 45 minutes for the more complicated hydroelectric generator model.

Students should return to teams of two to construct a simple water wheel or hydroelectric generator, depending on which model the teacher prefers. (Alternative: Building water wheel models may be assigned as individual homework). Plans for constructing these models can be found on the Web sites linked below. The teacher may wish to prepare the generator model in advance as a demonstration, rather than a student project, due to complexity and time required.

Web Resources for Step 7

Title: Sustainable Energy Ireland

URL: <http://www.irish-energy.ie/index.asp?locID=391&docID=-1>

Annotation: This Web site features a plan explaining how to construct a simple, working water wheel from cardboard. Students should make this model.

Title: Small Scale Hydroelectric Generator

URL: http://www.re-energy.ca/t-i_waterbuild-1.shtml

Annotation: This Web site contains downloadable project directions for constructing the optional model: a micro-hydroelectric generator which actually produces enough power for a light bulb. The project is complex and may require adult supervisions for certain activities. Acrobat Reader required for link to directions.

Step: 8 Duration: 15 minutes

Debriefing: Review the big ideas from this lesson in a class discussion. Students may say that:

- energy must be used to generate electrical power.
- nonrenewable energy sources are limited and should be conserved because they cannot be replaced in our lifetimes.
- fossil fuels such as coal, gas, and oil are examples of nonrenewable energy sources.
- nonrenewable energy sources, including fossil fuels, typically produce more pollution than renewable energy sources.
- air pollution is produced when power plants burn fuels to generate electricity, and can be somewhat mitigated if steps are taken to reduce or clean emissions or limit consumption.
- key pollutants are sulfur dioxide, mercury, carbon dioxide, nitrogen oxides and particulate matter.
- in Georgia, the vast majority of electricity is produced using coal.
- in Georgia, hydropower is the major renewable energy source used (3%).
- especially in urban areas, vehicle emissions also contribute to air pollution.

Step: 9 Duration: Teacher Feedback

The Clean Air Campaign is pleased to provide standards-based air quality lesson plans for 4th through 8th grades. Please offer your feedback after implementing this lesson plan, as there is no substitute for real classroom experience. Send teacher name, school name and address, grade level, lesson name, comments or suggestions, and the number of students who completed the lesson to schools@cleanaircampaign.com. Each teacher who responds will receive a Clean Air Campaign goody bag as a 'thank you.'

Materials and Equipment

1. Student Worksheet on Energy Resources (one per student)
2. Large sheet of paper or poster board (one per class)
3. Map of Georgia, with cities (per team of two)
4. Markers, in three contrasting colors (per team of two)
5. Transparency of Sources of Electricity in Georgia
6. Computer with Internet access (per team of two)

7. Overhead projector, if transparencies are used in lieu of PowerPoint presentations.
8. Computer with PowerPoint software and LCD projector or TV hook-up (if available)

For Simple Water Wheel (all materials per team of two):

9. Mathematical compass
10. Metric ruler
11. Roll of tape
12. Cardboard, approximately 9"x12"
13. Water source – faucet or pitcher of water
14. Scissors

For constructing Hydroelectric Generator (optional)- see materials list in Web resource linked at Step 7

Total Duration

90 minutes plus 45 minutes for water wheel model (or 3 hours 45 minutes for generator model)

Technology Connection

The teacher will use a scan converter and TV hookup (or LCD projector) to show the PowerPoint presentations which provide an overview of energy sources, fossil fuel power plant air pollutants and their related health effects. As an alternative, transparencies may be made from the PowerPoint slides for use on an overhead projector. Students will use Internet-connected computers to conduct research, complete Worksheets, and obtain directions for model-building.

Assessment

A scoring rubric is provided, to assess student work products including the worksheet, model, and demonstration. Graphics from Microsoft Office.

Title: Scoring Rubric for Air Pollution and Electrical Energy Production. FileName: [Scoring Rubric for Air Pollution & Electrical Energy Production.doc](#)

Description: This rubric assigns point values for student work products completed during the lesson.

Extension

1. Have students research and prepare a report on other forms of renewable energy being used for electrical power production around the country. The U.S. Department of Energy has a good Flash movie about wind power and information about how families can generate their own clean electricity (see Web resources below). Also, a PBS lesson plan on wind power is provided via a link below. Note:

While wind power is being used to generate electricity in several places around the country and internationally, it is not a significant source of power generation in Georgia.

2. The U.S. Department of Energy sponsors a National Junior Solar Sprint (JSS) Program. The program is a classroom-based, hands-on educational program for middle grades students. Student teams apply math, science, and creativity to construct model solar-powered cars. They race these cars in competitions hosted within their schools or within their states or regions. See the JSS link below for more information.

3. Arrange a tour for students to one of the hydropower plants in Georgia.

Web Resources

Title: U.S. Department of Energy: Wind and other Sources of Clean Electricity

URL:

http://www1.eere.energy.gov/windandhydro/wind_how.html#inside

Annotation: For Extension Activity #1. Click on “How a Wind Turbine Works” to view a Flash movie about harnessing wind to generate electric power. At this Web site, see also Making Your Own Clean Electricity and Short Cuts to Technology Information.

Title: Flash Player

URL: <http://www.macromedia.com/software/flashplayer/>

Annotation: For Extension Activity #1: The Macromedia Flash player is available for free from the URL above, and must be installed on your computer in order for you to view the Department of Energy Flash movies.

Title: JSS: National Junior Solar Sprint Site

URL: http://www.nrel.gov/education/jss_hfc.html

Annotation: For Extension Activity #2: This page contains a wealth of information on an interesting solar car racing event. It also provides many good suggestions for classroom activities.

Title: Wind Power Lesson

URL: <http://www.pbs.org/now/classroom/wind.html>

Annotation: For Extension Activity #1: This PBS site features a lesson plan (complete with the necessary supplementary materials) on how wind is harnessed to generate electric power.

Title: Educational Tours of Southern Company Power Plants
URL:

<http://www.southernco.com/learningpower/tours.asp?mnuOpc o=soco&mnuType=lp&mnultem=oc>

Annotation: For Extension Activity #4: Consult this Web site to arrange a class tour of a power plant near your school.

Remediation

Accommodation

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

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

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

[Autism](#)

[Deaf - Blind](#)

[Deaf/Hard of Hearing](#)

[Emotional and Behavioral Disorder](#)

[Mild Intellectual Disability](#)

[Orthopedic Impairment](#)

Other Health Impairments:

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

[Tourette Syndrome](#)

[Significant Development Delay](#)

[Specific Learning Disability](#)

[Speech - Language Impairment](#)

[Traumatic Brain Injury](#)

[Visual Impairment](#)

Modification

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