NATIONAL GEOGRAPHIC

Activity
APPLY

For Educator

The Role of Water in the Generation of Electricity

What role does water play in the generation of electricity?

For the complete activity with media resources, visit:
http://www.connectenergyed.org/education/activity/role-water-generation-electricity/

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PROGRAM

CONNECT! TRANSFORM THE FUTURE

DIRECTIONS

1. Activate students' prior knowledge about freshwater.

Ask students to describe what freshwater is. Accept all responses and generate a working definition of freshwater. Explain that students will watch a brief video about freshwater. Provide them with the following focus questions for the video: *Why is freshwater important? What are some ways we use freshwater? What are some concerns about our use of freshwater?* Show the National Geographic video "Why Care About Water?" and discuss the video using the focus questions.

2. Have students predict and identify areas of water scarcity.

Divide students into small groups—each with access to a computer—and direct them to the MapMaker Interactive. Starting with a basic world map, have students explore the information available in the interactive map and adjust the map to show information they think could affect freshwater availability, such as rainfall and climate zones. Have groups predict which areas in the world are likely to experience freshwater scarcity, stress, or vulnerability and use the drawing tools in the MapMaker Interactive to indicate their predictions. Have groups present their predictions to the class and briefly explain their rationale. Project the provided Freshwater Availability map and have each group compare the areas of scarcity, stress, and vulnerability to their predictions. Have students identify where the United States falls on the scale.

3. Introduce students to the role of water in the generation of electricity.

Navigate to the provided USGS Total Water Use in the United States webpage and display the Total Water Use by Category of Use graph (note that you will need to scroll down to see this graph). Have students identify the largest categories of water use and how much water they use daily. Point out the water use for mining, which is also necessary for generating electricity from fossil fuels. Read the information about water use in the generation of electricity located under the graph. Emphasize that irrigation is a more significant use of water even though more

water is used in the generation of electricity, because much of the water used in thermoelectric power plants is returned to its source. Write the terms *use* and *consumption* on the board. Ask students to define these terms and explain how they are different. Ask students to give examples of each from their daily lives to illustrate the difference; for example, the use of a rag for cleaning up spilled milk versus the consumption of a paper towel to clean it up. Ask students for ideas about how water is used in the generation of electricity. Point out that water is used in a variety of ways depending on the energy resource being used to generate the electricity. Explain that in the case of fossil fuels, water is used both in the extraction of energy resources and in converting those resources to electricity. Explain that students will read about how water is used to generate electricity from several types of energy resources.

4. Have students read the handout The Role of Water in the Generation of Electricity.

Distribute the reading and the Charting Water Use in Electricity Generation worksheet. Have students read the handout and take notes using the worksheet. When students have finished, discuss the reading as a class. Ask different students to summarize the role of water in converting various energy resources to electricity. Encourage students to ask any questions they may have about the processes described in the reading. Then ask students to identify:

- energy resources that consume the most water to generate electricity
- energy resources that use the most and least amounts of water to generate electricity

Finally, ask students to think about water that is used and then returned to a lake, river, or reservoir. Ask: *What are some problems that can be caused by this process, even though most of the water is returned to the source?*

5. Divide students into six groups and present them with the problem scenarios.

Distribute the Water Use for Electricity Scenarios and the Water Use for Electricity Rubric. Review the scenarios with students and explain that each group will research one of these scenarios and make a recommendation about whether or not the energy resource is appropriate for the region, based on water availability/needs for the energy resource. Review the specific project requirements listed on the Water Use for Electricity Scenarios handout and review the rubric with students. Allow groups time to research their scenarios using the provided links and to develop their recommendations.

6. Have each group present its recommendation to the class.

Have each group present, and allow time following each presentation for students to ask questions of the presenters. After all groups have presented, discuss the activity as a class. Ask: *How might an increase in energy use around the world affect the supply of freshwater? What are some steps that can be taken to protect freshwater supplies as energy use increases?*

7. Assess students' understanding of the role water plays in the generation of electricity.

Have each student select two energy resources and write a brief comparison of the role of water in the generation of electricity from the two resources.

MODIFICATION

Depending on your class size, you can divide students into more than six groups and assign the same problem scenario to multiple groups. If you do this, have groups covering the same scenario present their recommendations side-by-side and compare them.

INFORMAL ASSESSMENT

Use the Water Use for Electricity Rubric to assess groups' recommendations for the water use scenarios. Use the Comparing Water Use in Electricity Generation Answer Key to assess students' comparisons of how water is used in generating electricity from two energy resources.

EXTENDING THE LEARNING

Have students investigate water use in generating electricity used in their local area. Have them create a display that includes a map showing which bodies of water are affected.

OBJECTIVES

SUBJECTS & DISCIPLINES

- Geography
  - Human Geography
- Language Arts
  - Reading
- Science
  - Earth science
  - Physical sciences

LEARNING OBJECTIVES

Students will:

- explain and describe the broader impacts of energy choices as they relate to water resources
- compare and contrast how water is used to produce electricity from different renewable and nonrenewable energy resources
- explain and describe the importance of water to humans' quality of life and to the production of electricity
- use data to make region-specific energy decisions
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- use data to make region-specific energy decisions

TEACHING APPROACH

- Learning-for-use

TEACHING METHODS

- Cooperative learning
- Discussions
- Reading
- Research
- Writing

SKILLS SUMMARY

This activity targets the following skills:

21st Century Student Outcomes

Learning and Innovation Skills

- Communication and Collaboration
- Critical Thinking and Problem Solving

Critical Thinking Skills

- Analyzing
- Applying
- Evaluating

Geographic Skills

- Analyzing Geographic Information
- Answering Geographic Questions

Science and Engineering Practices

- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

NATIONAL STANDARDS, PRINCIPLES, AND PRACTICES

Energy Literacy Essential Principles and Fundamental Concepts

• Fundamental Concept 4.7: Different sources of energy and the different ways energy can be transformed, transported, and stored each have different benefits and drawbacks.

• Fundamental Concept 5.6: Energy decisions are influenced by environmental factors.

• Fundamental Concept 7.3: Environmental quality is impacted by energy choices.

IRA/NCTE Standards for the English Language Arts

• Standard 7: Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

National Geography Standards

• Standard 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

• Standard 14: How human actions modify the physical environment

Common Core State Standards for English Language Arts & Literacy

• Writing Standards 6-12: Text Types and Purposes, W.6.2

ISTE Standards for Students (ISTE Standards*S)

• Standard 4: Critical Thinking, Problem Solving, and Decision Making

PREPARATION

WHAT YOU'LL NEED

Materials You Provide

- Paper
- Pencils

Required Technology

- Internet Access: Required
- Tech Setup: 1 computer per small group, Projector, Speakers

Physical Space

- Classroom
- Computer lab

Grouping

- Large-group instruction

Other Notes

The topic of water use in the generation of electricity is a complex one. Be sure to keep students focused on central issues during their investigations and avoid more complicated aspects such as toxicology and chemistry.

BACKGROUND & VOCABULARY

BACKGROUND INFORMATION

Most electricity in the United States is generated from thermoelectric power plants. These plants use a variety of energy resources to generate heat to turn water into steam. That steam is then used to power turbines, which turn the coils in generators to generate electricity. A variety of renewable and nonrenewable energy resources can be used to create steam, including coal, oil, natural gas, biomass, geothermal energy, and solar energy. The amount of water needed in the process of generating electricity depends greatly on the type of resource and on the process used. Some processes require the use of water, which is eventually returned to its source. Some also consume water, which is lost to contamination or evaporation. For example, burning fossil fuels or biomass can use between 300 and 20,000 gallons of water per megawatt-hour (MWh) of electricity generated and can consume between 300 and 480 gallon per MWh. Solar-thermal troughs can use 760–920 gallons per MWh and consume a similar amount.The use of water also consumes electricity. For example, much of the water consumed in Las Vegas comes from far away and has to be pumped great distances, which requires electricity. In most places there is a significant amount of electricity “embedded” in every gallon of water. Agriculture is another significant use of freshwater. Though the water used for irrigation is eventually returned to its source through evaporation and transpiration, the process may be more energy intensive because of the proximity to the place where it is being used and the treatment required for use. Water that is used for both agriculture and in the process of generating electricity must often be treated before being returned to the source to make it safe for humans and animals to drink and use.

PRIOR KNOWLEDGE

- Energy Literacy Principle 1: Energy is a physical quantity that follows precise natural laws.
- Energy Literacy Principle 2: Physical processes on Earth are the result of energy flow through the Earth system.
- Energy Literacy Principle 3: Biological processes depend on energy flow through the Earth system.

RECOMMENDED PRIOR ACTIVITIES

- None

VOCABULARY

Term	Part of Speech	Definition
climate	*noun*	all weather conditions for a given location over a period of time.
electricity	*noun*	set of physical phenomena associated with the presence and flow of electric charge.
extraction	*noun*	process by which natural resources are extracted and removed from the earth.
fossil fuel	*noun*	coal, oil, or natural gas. Fossil fuels formed from the remains of ancient plants and animals.
freshwater	*noun*	water that is not salty.
geothermal energy	*noun*	heat energy generated within the Earth.
hydroelectric power	*noun*	the rate of producing, transferring, or using hydroelectric energy, often measured in kW or mW.
irrigation	*noun*	watering land, usually for agriculture, by artificial means.
mining	*noun*	process of extracting ore from the Earth.
non-renewable energy	*noun*	energy resources that are exhaustible relative to the human life span, such as gas, coal, or petroleum.
photovoltaic	*adjective*	able to convert solar radiation to electrical energy.
problem scenario	*noun*	hypothetical challenge that requires critical thinking and decision-making to solve.
renewable energy	*noun*	energy obtained from sources that are virtually inexhaustible and replenish naturally over small time scales relative to the human life span.
thermoelectric power plant	*adjective*	power plant that uses a temperature difference between two materials to generate electricity.
turbine	*noun*	machine that captures the energy of a moving fluid, such as air or water.
water consumption	*noun*	water used in electricity generation that cannot be recycled or reused.
water scarcity	*noun*	situation when the amount of water available does not meet the amount of water needed or wanted by a population.
water stress	*noun*	situation faced by a nation or community when the amount of available water is less than 1,700 cubic meters per person.
water use	*noun*	water used in electricity generation that can be recycled and reused.
water vulnerability	*noun*	threats to the supply of freshwater such as aquifer depletion, contamination from human and natural sources, and the effects of climate variability and change.

FOR FURTHER EXPLORATION

Articles & Profiles

- ABC News: ‘New’ Energy Sources Hard on Water Supply

Interactives

- National Geographic Environment: Freshwater—Water Footprint Calculator
- National Geographic Environment: Freshwater—The Hidden Water We Use

Websites

- Union of Concerned Scientists: How It Works—Water for Electricity
- U.S. EPA: Water Resource Use
- USGS: Thermoelectric Power Water Use
- Rocky Mountain Institute: Efficiency and Distributed Resources—Solutions at the confluence of energy and water

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