RESOURCE LIBRARY
LESSON

What Are Our Energy Choices?

In this lesson, students explore the advantages and disadvantages of different energy sources for generating electricity. A particular focus is given to natural gas extracted from shale formations through the hydraulic fracturing process. At the end of the module, students will be able to compare the relative costs and benefits (abundance, ecological impacts, etc.) of different sources used for generating electricity.

GRADES

7 - 12+

SUBJECTS

Earth Science

CONTENTS

6 Activities, 1 Link

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The Concord Consortium

ACTIVITY 1: CONSTRUCTING AN ARGUMENT: ENERGY | 10 MINS

DIRECTIONS

Tell students that Activity 1 (Constructing an Argument) of the lesson What are our Energy Choices? introduces the structure of the scientific argumentation they will be asked to do in the rest of the lesson. Tell students that Activity 1 will give them practice with analyzing a data set and making a good scientific argument from the evidence. Encourage students to review the questions and example best answers provided in Activity 1 before starting on the current activity.

OBJECTIVES

Subjects & Disciplines

Learning Objectives

Students will:

- create a good scientific argument in the context of energy

Teaching Approach

- Inquiry-based learning

Teaching Methods

- Self-directed learning
- Self-paced learning
- Writing

Skills Summary

This activity targets the following skills:

- Critical Thinking Skills
  - Creating

National Standards, Principles, and Practices

Preparation

Background Information

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
claim	*verb*	to state as the truth.
coal	*noun*	dark, solid fossil fuel mined from the earth.
electricity	*noun*	set of physical phenomena associated with the presence and flow of electric charge.
energy	*noun*	capacity to do work.
evidence	*noun*	data that can be measured, observed, examined, and analyzed to support a conclusion.
hydroelectricity	*noun*	power generated by moving water converted to electricity. Also called hydroelectric energy or hydroelectric power.
megawatt hour	*noun*	equal to 1,000 kilowatt hours (Kwh), or 1,000 kilowatts of electricity used continuously for one hour. One megawatt-hour equals one million (1,000,000) watt-hours or 3,600,000,000 joules.
renewable energy	*noun*	energy obtained from sources that are virtually inexhaustible and replenish naturally over small time scales relative to the human life span.

FUNDER

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ACTIVITY 2: ELECTRICITY: SOURCES AND CHALLENGES | 45 MINS

DIRECTIONS

1. Activate students' prior knowledge about sources of electricity.

Show the pie charts in **U.S. Electricity Usage 2001-2011.** (In media carousel; click the download arrow lower right.) Tell students electricity in the United States is generated from many different sources. Ask:

- *How did the United States' usage of coal change between 2001 and 2011?* (Coal usage decreased.)
- *How did the United States' usage of nuclear power change between 2001 and 2011?* (Nuclear power usage stayed about the same.)
- *How did the United States' usage of natural gas change between 2001 and 2011?* (Natural gas usage increased.)

Inform students they will be exploring how electricity is produced in the 50 states.

2. Discuss the role of uncertainty in the scientific process.

State that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Show students the **Load Forecast** graphs. (In media carousel; click the download arrow lower right.) Let them know that in the graph they can see examples of scientists' uncertainty in forecasting electrical demand (load). Ask:

- *Did the scientists forecast the power demand exactly?* (No. The red line fluctuates above and below zero, showing that sometimes, the forecast load was higher than the actual load and sometimes the forecast load was lower than the actual load.)

- *Why do you think scientists did not accurately predict the forecast load?* (Student answers will vary. One reason actual load could have been higher is if the temperature was higher or lower than forecast. This could lead people to use more or less air conditioning or heat than was forecast.)

Tell students they will be asked questions about the certainty of their predictions and they will need to think about what scientific data is available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Have students launch the Electricity: Sources and Challenges interactive.

Provide students with the link to the Electricity: Sources and Challenges interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer work stations. Tell students they will be working through a series of pages of data with questions related to the data. Ask students to work through the interactive in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 2 in the **What Are Our Energy Choices?** lesson.

4. Discuss the issues.
After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *How is electricity generated from coal, natural gas, and biomass?* (The coal, natural gas, and biomass are burned. The energy trapped in their chemical bonds is turned into heat energy. The heat energy is used to heat water to steam. The steam is used to spin a turbine, turning the heat energy into mechanical energy. The spinning turbine magnets generate an electrical current in the wires around the turbine. The electrical energy travels through the power lines to homes and businesses.)

- *What energy transformations happen once electricity arrives at your home?* (The electrical energy is transformed into heat energy [electric space heaters, toasters, electric ovens], light energy [lighting], sound energy [radios], and mechanical energy [fans].)

- *Why isn't electricity demand constant?* (There are fluctuations in electricity demand because people use electricity for heating and cooling purposes. Air conditioners and heating are not used equally across all months of the year. Even on a daily basis, electricity demand is not constant. Less electricity is used at night when most people are sleeping.)

- *What sources are used to generate electricity in your state?* (Answers will vary. Use the interactive **Electricity Generation Sources in the United States** to explore electricity generation sources in your state and others from 2001 to 2011.)

- *How do you think electricity generation will change in the future?* (Answers will vary. Renewable energy sources may increase. Fossil fuel sources may decrease. Nuclear power may decrease. There are many uncertainties about the energy landscape for the future.)

TipTeacher Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the What Are Our Energy Choices? lesson. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Alternative Assessment

1. Check students' comprehension by asking them the following questions:

- What energy conversions happen to generate electricity from coal?
- What energy conversions happen in your home?
- How did electricity generation change in the United States from 2001 to 2011?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

Learning Objectives

Students will:

- explain how energy is converted from one form to another in the generation of electricity
- describe how electricity generation sources in the United States changed from 2001 to 2011

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- Critical Thinking Skills

    - Analyzing
    - Evaluating
    - Understanding
- Science and Engineering Practices
    - Analyzing and interpreting data
    - Asking questions (for science) and defining problems (for engineering)
    - Constructing explanations (for science) and designing solutions (for engineering)
    - Engaging in argument from evidence
    - Obtaining, evaluating, and communicating information
    - Using mathematics and computational thinking

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard E-2:**
Understandings about science and technology
• **(5-8) Standard F-5:**
Science and technology in society
• **(5-8) Standard G-1:**
Science as a human endeavor
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard B-5:**
Conservation of energy and increase in disorder
• **(9-12) Standard D-1:**
Energy in the earth system
• **(9-12) Standard E-1:**
Abilities of technological design
• **(9-12) Standard E-2:**
Understandings about science and technology

• **(9-12) Standard F-3**:
Natural resources
• **(9-12) Standard F-6**:
Science and technology in local, national, and global challenges
• **(9-12) Standard G-1**:
Science as a human endeavor

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.9-10.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.3

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3**:
Research and Information Fluency
• **Standard 4**:
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

- **Crosscutting Concept 1:**
Patterns
- **Crosscutting Concept 3:**
Scale, proportion, and quantity
- **Crosscutting Concept 5:**
Energy and matter: Flows, cycles, and conservation
- **Crosscutting Concept 7:**
Stability and change
- **HS. Earth and Human Activity:**
HS-ESS3-2. Evaluating competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- **Science and Engineering Practice 1:**
Asking questions and defining problems
- **Science and Engineering Practice 4:**
Analyzing and interpreting data
- **Science and Engineering Practice 5:**
Using mathematics and computational thinking
- **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
- **Science and Engineering Practice 7:**
Engaging in argument from evidence
- **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information.

Preparation

BACKGROUND & VOCABULARY

Background Information

Electricity is generated from many different sources. Most methods of generating electricity involve water. Coal, natural gas, biomass, and oil are burned to generate heat. The chemical energy stored in the bonds is turned into heat energy. Nuclear power heats water as a result of atomic decay. The heat energy is used to heat water, which is turned to steam, which turns turbines. Thus, the heat energy is turned into mechanical energy. The mechanical energy spins the turbines, and the spinning action of the copper wire generates electricity. Thus, the chemical energy in the bonds of coal, natural gas, biomass, and oil and the nuclear energy in uranium is turned into heat energy, mechanical energy, and finally electrical energy that can flow through power wires into houses to do work. In the house, the electrical energy is transformed again to power electrical devices.

In hydropower and wind operations, the water and wind turn the turbine directly—a transformation of mechanical energy into electrical energy as the spinning turbine generates electricity. Solar energy can be used to generate electricity in two different ways. One way involves heating water to spin a turbine. The other way, commonly seen on rooftops, involves direct generation of electricity. The solar energy moves electrons on a silicon panel, turning light energy into electrical energy in a single step.

The demand for electricity has increased. More people around the world are gaining access to electricity. The energy sources for electricity generation in the United States changed between 2001 and 2011. The amount of natural gas used to generate electricity has increased, while coal use has declined. More renewable energy sources are being used. What sources will generate electricity in the future?

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
consumption	*noun*	process of using goods and services.
electricity	*noun*	set of physical phenomena associated with the presence and flow of electric charge.
kilowatt-hour	*noun*	(kWh) unit of energy equal to 1,000 watt hours.

Term	Part of Speech	Definition
megawatt hour	*noun*	equal to 1,000 kilowatt hours (Kwh), or 1,000 kilowatts of electricity used continuously for one hour. One megawatt-hour equals one million (1,000,000) watt-hours or 3,600,000,000 joules.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
renewable resource	*noun*	resource that can replenish itself at a similar rate to its use by people.

FUNDER

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PARTNER

The Concord Consortium

ACTIVITY 3: EXTRACTING GAS FROM SHALE | 45 MINS

DIRECTIONS

1. **Activate students' prior knowledge about natural gas.**

Tell students the United States has produced natural gas commercially for over 100 years. Show the **Natural Gas Gross Withdrawals and Production Graph.** (In media carousel; click the download arrow lower right.) Ask:

- *How has the production of natural gas changed since 1950?* (Production of natural gas has increased since 1950.)

- *From where has the most recent increase in natural gas come?* (The most recent increase in natural gas production has come from shale gas resources. See the yellow line on the graph.)

Share with students that recent technologies have made it possible to extract natural gas from deep underground shale formations. Let students know they will be using models to explore how natural gas is released from shale.

2. Discuss the role of uncertainty in the scientific process.

Introduce students to the idea that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Show the **Geologic Cross-Section of Ohio and Pennsylvania**. Tell students the Marcellus Shale contains natural gas. They can see examples of scientists' uncertainty in knowing how deep or how thick the shale layers are in some areas. Ask your students to think about these questions, based on the cross-section of Marcellus Shale.

- *Is it possible to drill at the same depth to reach the Marcellus Shale?* (No. The Marcellus Shale is buried at different depths, depending on the location. The Marcellus is deeper in Pennsylvania than it is in Ohio.)

- *How do you think scientists know where to drill to reach the shale layer?* (Student answers will vary. One way to know where to drill is to drill many different test wells to figure out the shape of the underlying shale layer.)

Tell students they will be asked questions about the certainty of their predictions and to think about what scientific data is available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model they may have seen, such as forecasting the weather. The **NOAA Weather Forecast Model** provides a good example. Reinforce the fact that scientists use models to predict the locations and quantity of natural gas deposits. Tell students that:

- geophysicists use physical characteristics, such as magnetic and gravitational properties, to guess the type and shape of subsurface rocks.
- scientists use technologies to model and visualize layers below the surface that they cannot see.
- scientists test their models by drilling and sampling.

4. Have students launch the Extracting Gas from Shale interactive.

Provide students with the link to the Extracting Gas from Shale interactive. Divide students into groups of two or three, with two being the ideal grouping for sharing computer work stations. Inform students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Let students know that this is Activity 3 of the **What Are Our Energy Choices?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *How does natural-gas filled shale form?* (In deep oceans, organic material falls to the bottom and is compressed by the weight of the water and other sediments on top of it. Eventually, the organic material starts to decay into oil and natural gas. This happens at great pressures and temperatures, which come about as the rock is buried deeper and deeper underground.)

For the next questions, show **Model 1: Hydraulic Fracturing**.

- *Why doesn't shale release its natural gas without being fractured?* (Natural gas doesn't flow easily out of the shale because it is not very permeable. The fracturing process increases the permeability of the shale so natural gas can flow out.)

- *What happens to the water that is used during the hydraulic fracturing process?* (Water is pumped underground to fracture the shale. Then some of it returns to the surface, where it is stored in pools above ground.)

- *Can you predict the shape of a shale formation from a single point?* (It is not possible to predict the shape of a shale formation with just a single point. The shale formation may be inclined or declined from a single point, or it may be thicker or thinner. It is possible for the shale formation to be discontinuous if there was an isolated geologic uplift.)

- *Why does the natural gas output of a well decline over time?* (The natural gas output declines over time because the gas that was in the shale is removed. It takes more time to generate more natural gas than it does to remove it from the shale.)

TipTeacher Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the What Are Our Energy Choices? lesson. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking them the following questions:

- How is shale formed?
- Why does some shale contain oil and/or natural gas while other shales do not?
- Why does shale have to be fractured to release the trapped natural gas?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

Learning Objectives

Students will:

- describe how oil and natural gas are formed
- describe how geologists find the shales with oil and/or natural gas resources
- explain why shale needs to be fractured to release natural gas

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard F-1:**
Personal health
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard F-1:**
Personal and community health

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

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• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3:**
Research and Information Fluency

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

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1:**
Patterns

• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction

• **Crosscutting Concept 3:**
Scale, proportion, and quantity

• **Crosscutting Concept 4:**
Systems and system models

• **Crosscutting Concept 5:**
Energy and matter: Flows, cycles, and conservation

• **Crosscutting Concept 6:**
Structure and function

• **Crosscutting Concept 7:**
Stability and change

• **HS. Earth and Human Activity:**
HS-ESS3-2. Evaluating competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

- **Science and Engineering Practice 1:**
Asking questions and defining problems
- **Science and Engineering Practice 2:**
Developing and using models
- **Science and Engineering Practice 4:**
Analyzing and interpreting data
- **Science and Engineering Practice 5:**
Using mathematics and computational thinking
- **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
- **Science and Engineering Practice 7:**
Engaging in argument from evidence
- **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information.

Preparation

BACKGROUND & VOCABULARY

Background Information

Geologists find oil and natural gas deposits by reading the history in the rocks. Oil and natural gas are formed when organic material is compacted and heated over long periods of time. Water and other sediments over the organic material can provide a lot of pressure to pack the layer. Under certain circumstances the layer can eventually produce oil and gas. Therefore, geologists look for specific rock types and geologic formations in areas that were once covered by large bodies of water such as ancient seas or lagoons.

Sedimentary rocks are formed when many layers of sediments are compacted together; most sedimentary rocks form under large bodies of water. Since Earth's continents are continually moving and areas that were once covered by water may no longer be covered by water, geologists look for sedimentary rocks with high organic matter content.

Shale is a tightly packed sedimentary rock. The shale is very porous, but it is not very permeable. This allows the shale to hold a lot of oil/natural gas but makes it difficult to remove those energy sources. Recent technologies have made it possible to extract the oil and natural gas trapped in deep shale formations.

Hydraulic fracturing increases the permeability of the shale by forcing open the natural cracks in the shale. Water or other fluids, such as propane, are pumped into wells, cracking open the natural fissures in the rock. The fractures are kept open by use of proppants, such as sand.

Prior Knowledge

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Recommended Prior Activities

- Electricity: Sources and Challenges

Vocabulary

Term	Part of Speech	Definition
hydraulic fracturing	*noun*	process usually used to extract oil and natural gas in which rocks are fractured by injecting water, chemicals, and sand at high pressure. Also called fracking.
methane	*noun*	chemical compound that is the basic ingredient of natural gas.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
natural gas	*noun*	type of fossil fuel made up mostly of the gas methane.
permeable	*adjective*	allowing liquid and gases to pass through.
porosity	*noun*	the ratio of the volume of all the pores, or holes, in an object and the object's total mass.
shale	*noun*	type of sedimentary rock.

FUNDER

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PARTNER

ACTIVITY 4: EVALUATING NATURAL GAS | 45 MINS

DIRECTIONS

1. Activate students' prior knowledge about the environmental effects of extracting energy resources.

Tell students that all electricity-generating sources have an effect on the environment. Ask:

- *What kinds of effects can the extraction and use of the energy resources have on the environment?* (Resource extraction can affect air, water, and land resources. These resources can be contaminated [e.g., oil spills]. Resource extraction could make it impossible to use the land for other purposes [surface mining, drilling pads, windmills, solar panels]. Fossil fuel resources can pollute the atmosphere. [Burning of fossil fuels releases CO_2 and methane is released during extraction of natural gas.] Disposing of waste can contaminate land and groundwater.)

Let students know that in this activity they will explore the costs and benefits of using shale gas as an electricity-generating resource.

2. Discuss the role of uncertainty in the scientific process.

Tell students science is a process of learning how the world works and scientists do not know the “right” answers when they start to investigate a question. Show the **Geologic Cross-Section of Ohio and Pennsylvania.** The Marcellus Shale contains natural gas. Students can see examples of scientists' uncertainty in knowing how deep and how thick the shale layers are in some areas. Ask:

- *Is it possible to drill at the same depth to reach the Marcellus Shale?* (No. The Marcellus Shale is buried at different depths, depending on the location. The Marcellus is deeper in Pennsylvania than it is in Ohio.)
- *How do you think scientists know where to drill to reach the shale layer?* (Student answers will vary. One way to know where to drill is to drill many different test wells to figure out the shape of the underlying shale layer.)
- *Is it possible to know exactly how hydraulic fracturing will affect the layers?* (No, it is not possible to know exactly how hydraulic fracturing will affect the layers. Scientists can predict how the layers might respond based on data from similar layers, but the geology can vary from location to location even in the same rock formation.)

Let students know they will be asked questions about the certainty of their predictions and they will need to think about what scientific data is available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model they may have seen, such as forecasting the weather. The **NOAA Weather Forecast Model** provides a good example. Tell students scientists use models to predict the locations and quantity of natural gas deposits, as well as to determine how hydraulic fracturing will affect underground water supplies.

4. Have students launch the Evaluating Natural Gas interactive.

Provide students with the link to the Evaluating Natural Gas interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer workstations. Tell students they will be working through a series of pages of models with questions related to the models. Ask them to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 4 of the **What Are Our Energy Choices?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *Is there an advantage for natural gas over coal?* (There could be an advantage for natural gas over coal. Natural gas emits fewer greenhouse gases when it is burned. But methane is also a powerful greenhouse gas, so if the natural gas well leaks, it could have no advantage over coal.)
- *How does drilling for natural gas affect the land?* (Land in the area needs to be cleared for the drilling pad. There is a lot of impact on the land during the drilling process with all of the equipment that needs to be present. In addition, there typically are a lot of wells in any given drilling area. But after the wells are drilled and fractured, there is only a small drilling pad area left on the land. Most of the effects of natural gas drilling happen under the ground.)

For the next questions, show **Model 3: Hydraulic Fracturing**.

- *How can drilling for natural gas affect the aquifer?* (Drilling for natural gas can affect the aquifer because water is needed to fracture the wells. The aquifer can be contaminated if there is a casing failure or if the water storage pool on the surface leaks.)

- *Is there a difference between using water and using propane to fracture the well?* (A propane fractured well does not have the potential to contaminate the aquifer with leakage from the water storage pool.)

- *Can you predict when a leak will happen in the casing or in the water storage pool?* (In this model, there is no way to predict when there will be a leak. In the real world, there are tests that can be run to determine if the casing will leak, but the tests are not 100 percent accurate; nothing can predict the future with absolute certainty.)

TipTeacher Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the What Are Our Energy Choices? lesson. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking them the following questions:

- How can the water table be contaminated by shale gas extraction?
- What precautions can be taken to prevent groundwater contamination?
- What are some benefits of extracting shale gas for electricity generation?

2. Use the answer key to check students' answers on embedded assessments

OBJECTIVES

Subjects & Disciplines

Earth Science

Learning Objectives

Students will:

- explain how groundwater could be contaminated by the extraction of shale gas
- describe some precautions that can be taken to prevent groundwater contamination during the extraction of shale gas
- describe some benefits of using shale gas over coal for generating electricity

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes

- Environmental Literacy
- Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard E-2:**
Understandings about science and technology
• **(5-8) Standard F-2:**
Populations, resources, and environments
• **(5-8) Standard F-3:**
Natural hazards
• **(5-8) Standard G-2:**
Nature of science
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard D-1:**
Energy in the earth system
• **(9-12) Standard E-1:**
Abilities of technological design
• **(9-12) Standard E-2:**
Understandings about science and technology
• **(9-12) Standard F-1:**
Personal and community health
• **(9-12) Standard F-3:**
Natural resources

• **(9-12) Standard F-5**:
Natural and human-induced hazards
• **(9-12) Standard F-6**:
Science and technology in local, national, and global challenges
• **(9-12) Standard G-2**:
Nature of scientific knowledge

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.9-10.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.1

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3**:
Research and Information Fluency
• **Standard 4**:
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1:**
Patterns
• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 3:**
Scale, proportion, and quantity
• **Crosscutting Concept 4:**
Systems and system models
• **Crosscutting Concept 5:**
Energy and matter: Flows, cycles, and conservation
• **Crosscutting Concept 6:**
Structure and function
• **Crosscutting Concept 7:**
Stability and change
• **HS. Earth and Human Activity:**
HS-ESS3-2. Evaluating competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
• **Science and Engineering Practice 1:**
Asking questions and defining problems
• **Science and Engineering Practice 2:**
Developing and using models
• **Science and Engineering Practice 3:**
Planning and carrying out investigations
• **Science and Engineering Practice 4:**
Analyzing and interpreting data
• **Science and Engineering Practice 5:**
Using mathematics and computational thinking
• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
• **Science and Engineering Practice 7:**
Engaging in argument from evidence
• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information.

Preparation

BACKGROUND & VOCABULARY

Background Information

The extraction of natural gas from shale has the potential to contaminate groundwater. The casings around the pipe could leak, releasing methane into the aquifer. The pool of waste fluid from hydraulic fracturing could leak, releasing contaminated water into the aquifer. Beyond the effects on groundwater quality, using water to hydraulically fracture natural gas wells could lead to a shortage of water, depending on the area's climate. There are other negative environmental effects involved with extracting shale gas—from releasing greenhouse gases into the atmosphere to releasing volatile organic compounds that can result in smog and poor air quality.

But there are also benefits to using natural gas for generating electricity. Natural gas is abundant and inexpensive, and it releases fewer greenhouse gases into the atmosphere than burning coal. Extracting natural gas has less impact on human health than mining for coal or nuclear fuels. Each electricity-generating resource has environmental costs, and each has benefits.

Prior Knowledge

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Recommended Prior Activities

- Electricity: Sources and Challenges
- Extracting Gas from Shale

Vocabulary

Term	Part of Speech	Definition
casing	*noun*	material on the outside of a substance, usually there to protect the material inside.
energy resource	*noun*	source of energy found in nature that has not been subject to any human-induced energy transfers or transformations; for example, oil, coal, gas, wind, or sunlight.

Term	Part of Speech	Definition
hydraulic fracturing	*noun*	process usually used to extract oil and natural gas in which rocks are fractured by injecting water, chemicals, and sand at high pressure. Also called fracking.
methane	*noun*	chemical compound that is the basic ingredient of natural gas.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
natural gas	*noun*	type of fossil fuel made up mostly of the gas methane.
shale	*noun*	type of sedimentary rock.

FUNDER

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1220756. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

PARTNER

The Concord Consortium

ACTIVITY 5: EVALUATING OTHER ENERGY SOURCES | 45 MINS

DIRECTIONS

1. Activate students' prior knowledge about the environmental effects of extracting energy resources.

Introduce students to the idea that all electricity-generating sources have an effect on the environment. Ask:

- *What kinds of effects do different energy sources have on the environment?* (Resource extraction can affect air, water, and land resources. These resources can be contaminated [e.g., oil spills]. Resource extraction could make it impossible to use the land for other purposes [surface mining, drilling pads, windmills, solar panels]. Fossil fuel resources can pollute the atmosphere. Disposing waste can contaminate land and groundwater [natural gas, nuclear].)

Tell students that in this activity they will explore the costs and benefits of using different resources for electricity generation.

2. Discuss the role of uncertainty in the scientific process.

Discuss the concept that science is a process of learning how the world works and scientists do not know the “right” answers when they start to investigate a question. Tell students about the theory “tragedy of the commons," where "individuals, acting independently and rationally according to each one's self-interest, behave contrary to the whole group's long-term best interests by depleting some common resource." For example, a common area is used for grazing cows; each person grazes all of their cattle there, and eventually, the grass is all gone. Ask:

- *Could the people have predicted that the cattle would eat all of the grass?* (It is difficult for them to have predicted that everyone would take maximum advantage of the common resource.)

- *Do you think it is possible to know in advance how much of a resource there is?* (Student answers will vary. There are ways of measuring approximate amounts of resources, but it has not been very predictive in the past [i.e. the continuing idea that we will run out of oil in a certain year, and the fact that new resources keep being discovered].)

- *Do you think it is possible to know in advance how humans use of a resource will affect the environment?* (Student answers will vary. There are some effects that are known, and there are others that are unknown. Some risks are bigger than others.)

Tell students they will be asked questions about the certainty of their predictions and they will need to think about what scientific data is available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Have students launch the Evaluating Other Energy Sources interactive.

Provide students with the link to the Evaluating Other Energy Sources interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer work stations. Tell students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students that this is Activity 5 of the **What Are Our Energy Choices?** lesson.

4. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *Which electricity-generating sources have the lowest effect on global warming?* (Energy sources that don't emit greenhouse gases have the lowest effect on global warming. These include solar, wind, geothermal, and nuclear power.)
- *Which electricity-generating sources have effects on the water supply?* (Many electricity-generating sources have an effect on the water supply. Hydroelectric dams keep water dammed up, preventing its flow downstream. Water is used in coal, natural gas, and nuclear plants to make steam to turn the turbines. Wind and solar resources do not use water directly.)
- *What is the effect of renewable energy sources (hydroelectric, solar, and wind) on land resources?* (The renewable energy sources take up a lot of land. They are not as energy dense as fossil fuels or nuclear fuels.)

- *Which electricity-generating source is most abundant in your area?* (Answers will vary. Refer the slideshow on **page 3 of the activity** to discuss the relative abundance of electricity-generating sources in your area.)

TipTeacher Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the What Are Our Energy Choices? lesson. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking them the following questions:

- Why is the location of a resource important in its usefulness as an electricity-generating source?
- Why is the abundance of a resource important in its usefulness as an electricity-generating source?
- Which electricity-generating sources emit greenhouse gases?
- What are the benefits of using renewable resources for electricity generation?
- What effects do different electricity-generating sources have on water supply and quality?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

Learning Objectives

Students will:

- describe the effects of different electricity-generating sources on water supply quantity and quality
- describe the effects of different electricity-generating sources on air quality
- describe the effects of different electricity-generating sources on local habitats
- compare the abundance of different electricity-generating sources in a given area
- compare the energy density (how much energy per unit of area) of different electricity-generating sources

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy

- Learning and Innovation Skills
  - Critical Thinking and Problem Solving
- 21st Century Themes
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard E-1:**
Abilities of technological design
• **(5-8) Standard E-2:**
Understandings about science and technology
• **(5-8) Standard F-1:**
Personal health
• **(5-8) Standard F-3:**
Natural hazards
• **(5-8) Standard F-4:**
Risks and benefits
• **(5-8) Standard F-5:**
Science and technology in society
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard D-1:**
Energy in the earth system
• **(9-12) Standard E-1:**
Abilities of technological design

• **(9-12) Standard E-2**:
Understandings about science and technology
• **(9-12) Standard F-1**:
Personal and community health
• **(9-12) Standard F-3**:
Natural resources
• **(9-12) Standard F-4**:
Environmental quality
• **(9-12) Standard F-6**:
Science and technology in local, national, and global challenges
• **(9-12) Standard G-2**:
Nature of scientific knowledge

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.9-10.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3**:

Research and Information Fluency

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

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1**:
Patterns

• **Crosscutting Concept 2**:
Cause and effect: Mechanism and prediction

• **Crosscutting Concept 3**:
Scale, proportion, and quantity

• **Crosscutting Concept 7**:
Stability and change

• **HS. Earth and Human Activity**:
HS-ESS3-2. Evaluating competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

• **Science and Engineering Practice 1**:
Asking questions and defining problems

• **Science and Engineering Practice 4**:
Analyzing and interpreting data

• **Science and Engineering Practice 5**:
Using mathematics and computational thinking

• **Science and Engineering Practice 6**:
Constructing explanations and designing solutions

• **Science and Engineering Practice 7**:
Engaging in argument from evidence

• **Science and Engineering Practice 8**:
Obtaining, evaluating, and communicating information.

Preparation

BACKGROUND & VOCABULARY

Background Information

Every electricity-generating resource has costs and benefits. All electricity-generating sources have negative effects on the environment. Each electricity-generating source has some benefits. Resources can be compared based on their geographical abundance, energy density, effects on water quality, effects on air quality, and the amount of land needed for extraction and generation.

Prior Knowledge

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Recommended Prior Activities

- Electricity: Sources and Challenges
- Evaluating Natural Gas
- Extracting Gas from Shale

Vocabulary

Term	Part of Speech	Definition
biomass	*noun*	living organisms, and the energy contained within them.
fossil fuel	*noun*	coal, oil, or natural gas. Fossil fuels formed from the remains of ancient plants and animals.
global warming	*noun*	increase in the average temperature of the Earth's air and oceans.
greenhouse gas	*noun*	gas in the atmosphere, such as carbon dioxide, methane, water vapor, and ozone, that absorbs solar heat reflected by the surface of the Earth, warming the atmosphere.
habitat	*noun*	environment where an organism lives throughout the year or for shorter periods of time.
hydroelectric energy	*noun*	energy generated by moving water converted to electricity. Also known as hydroelectricity.
methane	*noun*	chemical compound that is the basic ingredient of natural gas.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
natural gas	*noun*	type of fossil fuel made up mostly of the gas methane.

Term	Part of Speech	Definition
non-renewable energy	*noun*	energy resources that are exhaustible relative to the human life span, such as gas, coal, or petroleum.
renewable energy	*noun*	energy obtained from sources that are virtually inexhaustible and replenish naturally over small time scales relative to the human life span.

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PARTNER

The Concord Consortium

ACTIVITY 6: ENERGY EFFICIENCY | 45 MINS

DIRECTIONS

1. Activate students' prior knowledge about the energy efficiency.

Show the **Electricity Flow Graph**. (In the media carousel; click the download arrow lower right.) Tell students that not all of the electricity that is generated makes it to homes and businesses. Ask:

- *How much of the electricity is lost?* (According to the graph, 26.03 quadrillion BTUs go to conversion losses. The blue lines show the proportion of each generating source that is lost during energy conversion.)

- *Where does the lost energy go?* (Converting between different forms of energy is not efficient. The "lost" energy goes to heat.)

- *How do you think the amount of electricity losses can be minimized?* (Answers will vary. The number of conversions between different types of energy can be minimized. The waste heat can be recovered to make more electricity or to heat homes and businesses.)
- *Why are there transmission and delivery losses from the generated electricity?* (Resistance in the wires can reduce the efficiency of transmission. At the power plants, the voltage is increased to transmit electricity over long distances. Nearer to consumers, the voltage is decreased. Transformers are not 10 percent efficient at up-converting and down-converting voltages.)

2. Discuss the role of uncertainty in the scientific process.

Tell students science is a process of learning how the world works and scientists do not know the “right” answers when they start to investigate a question. In science, sources of uncertainty arise for a variety of reasons: Natural systems are inherently variable, measuring things comes with uncertainty, and predicting the future is arguably imperfect. Talk to students about the theory “tragedy of the commons,” where "individuals, acting independently and rationally according to each one's self-interest, behave contrary to the whole group's long-term best interests by depleting some common resource." For example, a common area is used for grazing cows; each person grazes all of their cattle there, and eventually, the grass is all gone. Ask:

- *Could the people have predicted that the cattle would eat all of the grass?* (It is difficult for them to have predicted that everyone would take maximum advantage of the common resource.)
- *Do you think it is possible to know in advance how much energy you need?* (Student answers will vary. There are ratings on electrical devices that tell the maximum amount of electricity used. You can make predictions about how long you will need to use each device.)

Tell students they will be asked questions about the certainty of their predictions and they will need to think about what scientific data is available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Have students launch the Energy Efficiency interactive.

Provide students with the link to the Energy Efficiency interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer workstations. Tell students they will be working through a series of pages of models with questions related to the models and encourage them to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 6 of **What Are Our Energy Choices?** lesson.

4. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions. Ask:

- *During what season is electricity usage the highest?* (Summer usage is highest because of air conditioner use.)
- *How could people use electricity more efficiently in the summer?* (They could insulate their homes and businesses so that cooling losses are minimized. They could prevent solar gain by closing shades during the day. They could keep the thermostat set higher to reduce the load on the air conditioner. They could use fans instead of air conditioners.)
- *How can your school be made more efficient?* (Answers will vary. Insulation, using electricity only when clearly needed, and unplugging unused devices could make a building more efficient.)
- *How does energy efficiency affect the electrical grid?* (If energy is used more efficiently, less energy will be needed. This lowers the stress on the electrical grid, and less electricity needs to be generated.)

- *Is it better for the environment to put solar panels on your roof or be more energy efficient?* (Energy efficiency is better than solar panels on your roof. Solar panels are intermittent, so you still need to rely on the electrical grid to provide a steady supply of electricity.)

- *What do you think the energy mix for electricity generation will be in the future?* (Answers will vary. Students should back up their answers with reasons for why the energy mix would change.)

TipTeacher Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the What Are Our Energy Choices? lesson. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking them the following questions:

- How can electricity losses be minimized?
- How can buildings be made more energy efficient?
- What can you do to avoid needing to build new power plants in your state?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

Learning Objectives

Students will:

- describe why useful energy is lost during energy conversions
- describe how buildings can be made more energy efficient
- explain how energy conservation can reduce the environmental impact of resource extraction

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes

    - Environmental Literacy
    - Global Awareness
- Critical Thinking Skills
    - Analyzing
    - Evaluating
    - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard B-3:**
Transfer of energy
• **(5-8) Standard E-1:**
Abilities of technological design
• **(5-8) Standard E-2:**
Understandings about science and technology
• **(5-8) Standard F-1:**
Personal health
• **(5-8) Standard F-3:**
Natural hazards
• **(5-8) Standard F-5:**
Science and technology in society
• **(5-8) Standard G-2:**
Nature of science
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard B-3:**
Chemical reactions
• **(9-12) Standard D-1:**
Energy in the earth system

• **(9-12) Standard E-1**:
Abilities of technological design
• **(9-12) Standard E-2**:
Understandings about science and technology
• **(9-12) Standard F-3**:
Natural resources
• **(9-12) Standard F-5**:
Natural and human-induced hazards
• **(9-12) Standard F-6**:
Science and technology in local, national, and global challenges
• **(9-12) Standard G-2**:
Nature of scientific knowledge

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literature 6-12**:
Key Ideas and Details, RL.9-10.3
• **Reading Standards for Literature 6-12**:
Craft and Structure, RL.9-10.4

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3**:

Research and Information Fluency

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

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1:**
Patterns

• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction

• **Crosscutting Concept 3:**
Scale, proportion, and quantity

• **Crosscutting Concept 7:**
Stability and change

• **HS. Earth and Human Activity:**
HS-ESS3-2. Evaluating competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

• **Science and Engineering Practice 1:**
Asking questions and defining problems

• **Science and Engineering Practice 4:**
Analyzing and interpreting data

• **Science and Engineering Practice 5:**
Using mathematics and computational thinking

• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions

• **Science and Engineering Practice 7:**
Engaging in argument from evidence

• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information.

Preparation

BACKGROUND & VOCABULARY

Background Information

The demand for electricity has increased. More people around the world are gaining access to electricity. Electricity is generated from many different sources. All electricity-generating sources have negative effects on the environment and human health. Using less electricity and using electricity more efficiently can minimize the negative effects of resource extraction and generation on the environment and human health.

Much of the generated electricity is lost before it can ever do any useful work. These losses are called conversion losses. In addition to the losses inherent in converting between different forms of energy, much of the energy is lost during transmission. Generating electricity closer to where it will be used reduces the amount of transmission losses.

Using more efficient electrical devices ensures that more of the electricity is used for useful purposes, rather than being lost as waste heat. One notable example is in lighting; incandescent bulbs get very hot when they are on. LED lighting remains cool to the touch. This is because the LEDs are more efficient at providing light. The incandescent bulbs provide light, but a large amount of the electricity used to operate them is "lost" as heat energy—electricity that was not able to be used for the primary purpose of providing light.

Prior Knowledge

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Recommended Prior Activities

- Electricity: Sources and Challenges
- Evaluating Natural Gas
- Evaluating Other Energy Sources
- Extracting Gas from Shale

Vocabulary

Term	Part of Speech	Definition
conservation	*noun*	management of a natural resource to prevent exploitation, destruction, or neglect.

Term	Part of Speech	Definition
efficient	*adjective*	performing a task with skill and minimal waste.
electricity	*noun*	set of physical phenomena associated with the presence and flow of electric charge.
energy consumption	*noun*	use of power, usually defined as power produced by human beings in plants run on electricity, fossil fuels, or nuclear fission.
kilowatt-hour	*noun*	(kWh) unit of energy equal to 1,000 watt hours.
megawatt hour	*noun*	equal to 1,000 kilowatt hours (Kwh), or 1,000 kilowatts of electricity used continuously for one hour. One megawatt-hour equals one million (1,000,000) watt-hours or 3,600,000,000 joules.
renewable resource	*noun*	resource that can replenish itself at a similar rate to its use by people.

FUNDER

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