NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
ACTIVITY : 45 MINS

Evaluating Natural Gas

Students use an interactive computational model and real-world data to evaluate the environmental impact of extracting natural gas to generate electricity. Students explore some of the relative benefits of natural gas and some of the potential environmental costs of extracting natural gas.

GRADES

7 - 12+

SUBJECTS

Earth Science

CONTENTS

1 Image, 3 Links

OVERVIEW

Students use an interactive computational model and real-world data to evaluate the environmental impact of extracting natural gas to generate electricity. Students explore some of the relative benefits of natural gas and some of the potential environmental costs of extracting natural gas.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/evaluating-natural-gas/

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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 $CO2$ 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

What You'll Need

MATERIALS YOU PROVIDE

- Computers with Internet connection

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per pair, 1 computer per small group, Interactive whiteboard, Projector

PHYSICAL SPACE

- Classroom
- Computer lab
- Media Center/Library

GROUPING

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction
- Small-group work

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.
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.

For Further Exploration

Articles & Profiles

- National Geographic Magazine: Bakken Shale Oil
- National Geographic: Daily News: Breaking Fuel From the Rock

Reference

- National Geographic Encyclopedic Entry: natural gas
- National Geographic Encyclopedic Entry: oil shale

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