NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
ACTIVITY : 2 HRS 30 MINS

Natural Gas: A Cleaner Energy Solution or Just Another Fossil Fuel?

Students read informational text about natural gas and compare and contrast its greenhouse gas emissions to those of other fossil fuels. They take positions to debate the question: *Should the United States expand its use of natural gas as an energy resource, using it as a "bridge fuel" to more sustainable energy practices in the future?* Students support their arguments with evidence from a systems-based analysis of the extraction, leakage, and combustion of fossil fuels.

GRADES

9 - 12+

SUBJECTS

Earth Science, English Language Arts, Experiential Learning, Geography, Human Geography

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9 PDFs, 1 Link

OVERVIEW

Students read informational text about natural gas and compare and contrast its greenhouse gas emissions to those of other fossil fuels. They take positions to debate the question: *Should the United States expand its use of natural gas as an energy resource, using it as a "bridge fuel" to more sustainable energy practices in the future?* Students support their arguments with evidence from a systems-based analysis of the extraction, leakage, and combustion of fossil fuels.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/natural-gas-cleaner-energy-solution-or-just-another-fossil-fuel/

DIRECTIONS

1. Activate students' prior knowledge about natural gas.

Distribute a KWL Chart to each student. Engage students in a whole class discussion about natural gas as an energy resource, including anything they may know about its origin, uses, extraction methods, global significance, and environmental impacts. Invite volunteers to share what they think they know and want to know. If students say something factually incorrect, don't correct them; instead, ask them to highlight that comment and return to it later to confirm or revise their thinking. Then give students enough time to complete columns 1 and 2 of the chart independently. Tell students they will return to the chart to complete column 3 at the end of this activity.

2. Introduce the term "bridge fuel" and its role in the energy conversation.

Introduce the concept of a bridge fuel. Elicit from students some common phrases that rely on the use of a bridge, such as bridge over troubled water, don't burn your bridges, or bridging a gap. Tell students that in the February 2014 State of the Union address, the president described natural gas as a "bridge fuel that can power our economy with less of the carbon pollution that causes climate change." Ask: *What do you think the president means by bridge fuel? What is the bridge connecting? How long do you think this type of bridge is meant to be?* Tell students that later in this activity they will debate the following question: *Should the United States expand its use of natural gas as an energy resource, using it as a "bridge fuel" to more sustainable energy practices in the future?*

3. Introduce the concept of systems model thinking.

Tell students that later in this activity they will take a position for or against the expansion of natural gas as an energy resource in the United States. Explain that in order to come to a fully supported opinion, they will need to take a systems model approach in their thinking. Introduce the concept of a systems based model by asking students to consider the following question: How do you determine which homework to complete first? What types of variables are involved in the decision? Guide students to recognize the influence one thing has on another and how things influence other things to change. Explain to students that energy decisions in the real world are complex. Economic, political, environmental, and social factors

are often all taken into consideration. To apply a systems perspective when considering a fossil fuel's impact on climate, one would investigate the emissions involved with extraction, transportation, and the combustion process in order to get a more in-depth understanding of the implications of the energy choice. Check for understanding. Ask: *Why is it important to look at the various stages from exploration, transportation, and combustion when considering an energy option as a "bridge fuel"?*

4. Have students listen to and discuss a podcast about natural gas.

Write the following questions on the board:

- What about natural gas worries scientists?
- What is a contentious issue among scientists studying natural gas?
- What does this contention indicate?

Ask students to consider the questions as they listen to a podcast. Stream the National Public Radio podcast "Natural Gas May Be Easier on Climate than Coal, Despite Methane Leaks." Replay the podcast, as needed. Ask:

- *What about natural gas worries scientists?* (Scientists are concerned about natural gas, or methane, leaks; methane is a greenhouse gas.)
- *What is a contentious issue among scientists studying natural gas?* (Scientists debate whether or not natural gas is easier on the atmosphere than coal due to production methods, as methane leaks could potentially cancel out the climate benefits of natural gas.)
- *What does this contention indicate?* (There is still considerable uncertainty about methane leakage and a need for greater analysis.)

5. Have students independently read the handout "Natural Gas: A Cleaner Energy Solution or Just Another Fossil Fuel?"

Distribute a copy of the reading passage and a copy of the Cornell Note Taking worksheet to each student. Tell students that they will later use evidence from the reading passage in a debate. Ask them to use the Cornell Note Taking worksheet to condense and organize notes as they read, including identifying any unfamiliar vocabulary. Give students adequate time to read the passage independently and take notes.

6. Have a whole-class discussion about the reading passage.

Encourage students to refer to their Cornell Note Taking worksheets as you discuss the following questions:

- *What is combustion? Describe the process of combustion for a fossil fuel.*
- *Compare and contrast the combustion of natural gas, petroleum, and coal.*
- *How do different fossil fuels compare based on CO_2 emissions?*
- *How can we determine which fossil fuel results in less pollution?*
- *Explain the difference between methane and carbon dioxide, both chemically and as it relates to their potential to impact global climate.*
- *How do different fossil fuels compare based on energy output?*
- *How do the environmental costs of fossil fuels compare from a systems model perspective?*

7. Review the debate topic and model creating a position statement.

Tell students that next they will write a position statement to prepare for a debate of the following question: *Should the United States expand its use of natural gas as an energy resource, using it as a bridge fuel to more sustainable energy practices in the future?* Answer any questions students may have about the debate topic. Stress that students must craft a one- to two-sentence position statement that clearly and succinctly expresses their position. They should then expand the statement, using facts from their reading to support their position. Use the Sample Position Statement to model the thought process involved in determining possible positions on a topic, generating supporting reasons for those positions, and then crafting a solid position statement. Emphasize that position statements must be arguable. This means that an argument could be made for or against the statement. A statement of known fact is not a position statement. Model a few good and poor examples of position statements for students. Briefly model how to expand a supporting reason into a paragraph with factual evidence.

8. Have students write a position statement.

Distribute the Position Statement Rubric and review it with students. Divide the class into roughly half and assign each team as “for” or “against” natural gas as a bridge fuel. Have students work independently to craft a position statement. Distribute a copy of the Decision

Matrix to each student and have each write his or her position statement in the box labeled "Choice."

9. Have students formulate arguments from evidence in preparation for the debate.

Have students use their Cornell Note Taking charts to complete the pros, cons, and decision portion of the Decision Matrix. Encourage students to revisit column 2 of their KWL charts (What I Want to Know) to look for their own answers as debate preparation.

10. Break students into small groups to engage in a peer review process.

Break students into small groups that include positions both "for" and "against." Have each student read the position statement of every other student in the group silently. Ask each student to take notes on their peers' statements, specifically looking for strengths and weaknesses. Students pass the work around until everyone has read everyone else's argument. Then have groups openly discuss and provide constructive criticism on the arguments they read.

11. Have students re-group in two large teams and prepare for the debate.

Distribute several copies of the Debate Rubric and Moderator Questions to each group. Have teams work together to draft opening statements based on the moderator questions.

12. Have students engage in a class debate.

Have the two groups—for and against—debate the topic. Make sure students back up any statements with factual information from the reading. Students should be prepared to answer questions during or after the debate. They should be able to discuss the various sides to the issue and explain their position. Likewise, the opposite side should be prepared to ask good questions—questions that call for the other side to clarify points and defend their position.

13. Have students complete their KWL Charts from Step 1.

After the debate, have students return to their KWL charts and independently complete column 3. Encourage them to revisit columns 1 and 2 and annotate where they confirmed or revised their thinking.

Modification

Instead of a whole class debate, you may choose to have students conduct mini debates in small groups of three. Have students self-select roles: pro, con, and moderator. Have them switch roles at timed intervals, so each student plays each role in order to experience the debate from all sides.

Modification

Have students complete Step 3 as homework. If possible, encourage them to reference additional sources of information, including the National Geographic encyclopedic entry for natural gas and the video "How Hydraulic Fracturing Works."

Informal Assessment

There are multiple opportunities for assessment in this activity:

- Have students use their completed KWL charts to perform self-assessments.
- Expand the peer review process in step 8. Allow students to grade each other using the Position Statement Rubric. This both familiarizes them with the rubric and allows them to take an active role in the evaluation process.
- Assess group work using the Position Statement Rubric and Debate Rubric.

Extending the Learning

Have students investigate the concept of "cost of switching" or "inertia" in an energy system. Ask students to think about the bridge metaphor inherent in the term "bridge fuel" and discuss how long they think it will take for society to reach the other end of the energy "bridge." Have small groups of students work together to complete the chart and rationale in Part 1 of the worksheet Energy Mix Scenarios. Then have them enter their scenarios in the interactive You Have the Power to complete Part 2. Next, have students predict the energy

mix scenario for their town and check their predictions in Part 3. Finally, regroup for a whole class discussion about how students' perceive the possibility of a future energy system that is based on renewable energy resources.

OBJECTIVES

Subjects & Disciplines

Earth Science

- English Language Arts
- Experiential Learning

Geography

- Human Geography

Learning Objectives

Students will:

- differentiate fossil fuels based on energy and carbon output characteristics
- compare environmental costs of different hydrocarbon fuel types from a system model to help fully discuss the value and impact of a fuel source
- analyze informational, scientific text about natural gas
- paraphrase data about natural gas
- explain the difference between methane and carbon dioxide, both chemically and as they relate to global warming
- formulate a position and write a position statement on natural gas as a bridge fuel
- construct arguments for or against natural gas as a bridge fuel supported by evidence
- debate natural gas as a bridge fuel and support positions with factual information

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Information organization

- Reading
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
  - Life and Career Skills
    - Social and Cross-Cultural Skills
- 21st Century Themes
  - Environmental Literacy
  - Financial, Economic, Business, and Entrepreneurial Literacy
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Evaluating
  - Understanding
- Science and Engineering Practices
  - Analyzing and interpreting data
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

ENERGY LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

• **Fundamental Concept 1.7:**
Many different units are used to quantify energy.

- **Fundamental Concept 2.7:**

The effects of changes in Earth's energy system are often not immediately apparent.

- **Fundamental Concept 4.2:**

Human use of energy is subject to limits and constraints.

- **Fundamental Concept 4.4:**

Humans transport energy from place to place.

- **Fundamental Concept 4.5:**

Humans generate electricity in multiple ways.

- **Fundamental Concept 5.1:**

Decisions concerning the use of energy resources are made at many levels.

- **Fundamental Concept 5.3:**

Energy decisions can be made using a systems-based approach.

- **Fundamental Concept 5.4:**

Energy decisions are influenced by economic factors.

- **Fundamental Concept 5.6:**

Energy decisions are influenced by environmental factors.

- **Fundamental Concept 6.1:**

Conservation of energy has two very different meanings.

- **Fundamental Concept 7.3:**

Environmental quality is impacted by energy choices.

NATIONAL COUNCIL FOR SOCIAL STUDIES CURRICULUM STANDARDS

- **Theme 7:**

Production, Distribution, and Consumption

NATIONAL GEOGRAPHY STANDARDS

- **Standard 14:**

How human actions modify the physical environment

- **Standard 16:**

The changes that occur in the meaning, use, distribution, and importance of resources

NATIONAL SCIENCE EDUCATION STANDARDS

- **(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

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Integration of Knowledge and Ideas, RST.9-10.7
• **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.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.2
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4
• **Speaking and Listening Standards 6-12:**
Comprehension and Collaboration, SL.11-12.2
• **Speaking and Listening Standards 6-12:**
Comprehension and Collaboration, SL.9-10.1
• **Speaking and Listening Standards 6-12:**
Presentation of Knowledge and Ideas, SL.9-10.4
• **Speaking and Listening Standards 6-12:**
Comprehension and Collaboration, SL.9-10.2
• **Speaking and Listening Standards 6-12:**
Comprehension and Collaboration, SL.9-10.3
• **Speaking and Listening Standards 6-12:**
Presentation of Knowledge and Ideas, SL.11-12.4
• **Speaking and Listening Standards 6-12:**
Comprehension and Collaboration, SL.11-12.3
• **Speaking and Listening Standards 6-12:**
Comprehension and Collaboration, SL.11-12.1

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- Paper
- Pencils

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per classroom, Speakers

PHYSICAL SPACE

- Classroom

GROUPING

- Large-group instruction
- Small-group instruction

OTHER NOTES

Ideally, students will complete this activity in two or three 50-minute classroom sessions.

BACKGROUND & VOCABULARY

Background Information

In 2012, 68% of the electricity generated in the United States came from fossil fuels and 30% came from natural gas. The largest consumer of natural gas was the electric power sector, followed by the industrial sector, residential sector, and commercial sector.

According to the U.S. EPA, of the total energy consumed in the United States, close to 40% is for the generation of electricity. As such, electricity consumption represents a significant portion of consumers' environmental footprint.

In addition to greenhouse gas emissions, environmental impacts of fossil fuels can include:

- Direct harm to the environment from the mining process of each resource
- Possible impacts resulting from the transportation of the resources
- The release of particulate matter by burning coal and oil, which has a human health impact
- Emissions of sulfur dioxide and mercury compounds from burning natural gas
- Release of carbon dioxide, sulfur dioxide, nitrogen oxides, and mercury compounds when coal is burned
- Additional emissions generated by mining, cleaning, and transporting coal to a power plant
- The creation of solid waste, called ash. Ash is composed primarily of metal oxides and alkali created by the burning of coal (while the burning of natural gas produces virtually no solid waste)
- Water pollution during the extraction process, during transport of fuels and due to spills, or illegal dumping of associated waste products created during the entire extraction process.

Additional concerns exist around the exploration of natural gas fields. Methane has a higher global warming potential than carbon dioxide. Methane leakage could eliminate the benefits of switching to natural gas, but more studies need to be done to confirm the rate of leakage. Another concern is reported increased seismic activity associated with the hydraulic fracturing process for natural gas extraction. Additionally the chemicals used in the hydraulic fracturing process have undergone scrutiny for their potential environmental impact to aquifers, lakes, and streams.

Prior Knowledge

["the process of global warming and the role greenhouse gases play","chemical formulas and balanced chemical equations","states of matter","ability to read and interpret data charts","ratios and percentages","Energy Literacy Principles 1.1, 1.2, 1.3, 1.4, 2.6, 3.6, 4.1, 4.3, 4.7, 5.2, 6.3, 6.4, 7.1"]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition

Term	Part of Speech	Definition
balanced equation	*noun*	chemical equation in which there are equal numbers of each type of atom on each side of the equation.
bridge fuel	*noun*	fuel that will power society with the least environmental cost while we deploy non-polluting, renewable energy.
British Thermal Unit (BTU)	*noun*	amount of heat or energy required to raise the temperature of one pound of water by one degree Fahrenheit, or 251.997 calories.
byproduct	*noun*	substance that is created by the production of another material.
carbon emission	*noun*	carbon compound (such as carbon dioxide) released into the atmosphere, often through human activity such as the burning of fossil fuels such as coal or gas.
climate change	*noun*	gradual changes in all the interconnected weather elements on our planet.
combustion	*noun*	burning, or the process of a substance reacting with oxygen to produce heat and light.
consumption	*noun*	process of using goods and services.
dry natural gas	*noun*	natural gas that is almost pure methane, having had most of the other common hydrocarbons (ethane, butane, propane, pentane) removed. Dry natural gas comes from a reservoir that does not also have large amounts of liquid petroleum.
electrical energy	*noun*	energy made available by a flow of electrical charge, through a conductor. Electrical energy is measured in Joules.
electrical energy	*noun*	energy associated with the changes between atomic particles (electrons).
emission	*noun*	discharge or release.
energy	*noun*	capacity to do work.
energy consumption	*noun*	use of power, usually defined as power produced by human beings in plants run on electricity, fossil fuels, or nuclear fission.
fossil fuel	*noun*	coal, oil, or natural gas. Fossil fuels formed from the remains of ancient plants and animals.
fugitive	*noun, adjective*	escaped from the law or another restriction.
global warming	*noun*	increase in the average temperature of the Earth's air and oceans.

Term	Part of Speech	Definition
Global Warming Potential (GWP)	*noun*	measure of how much a given amount of greenhouse gas is estimated to contribute to global warming, relative to the same amount of carbon dioxide.
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.
hydrocarbon	*noun*	chemical compound made entirely of the elements hydrogen and carbon.
impurity	*noun*	minute substance that differs from the chemical composition of the main compound in which it is found.
megawatt	*noun*	unit of electrical power equal to one million watts.
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.
natural gas	*noun*	type of fossil fuel made up mostly of the gas methane.
potent	*adjective*	very powerful.
steam turbine	*noun*	machine driven by the movement of steam passing over blades or rotors.
turbine	*noun*	machine that captures the energy of a moving fluid, such as air or water.
wet natural gas	*noun*	natural gas that includes common hydrocarbons (ethane, butane, propane, pentane) other than methane. Wet natural gas comes from a reservoir that also has large amounts of liquid petroleum.

For Further Exploration

Articles & Profiles

- AAAS: Science Journal—Methane Leaks from North American Natural Gas Systems

Websites

- U.S. Energy Information Administration: Electricity—Electric Power Monthly

- U.S. Energy Information Administration: Today in Energy—Year-to-date natural gas use for electric power generation
- U.S. Energy Information Administration: Emissions of Greenhouse Gases in the U.S.
- U.S. Energy Information Administration: U.S. Energy-Related Carbon Dioxide Emissions
- U.S. Environmental Protection Agency: Natural Gas
- U.S. Environmental Protection Agency: How does electricity affect the environment?
- NaturalGas.org: Natural Gas and the Environment—Emissions from the Combustion of Natural Gas