

# **Marcellus Shale: Who Pays?**

Last updated: September 22, 2013

## **Background**

The Marcellus Shale is a large black shale deposit extending for 54,000 square miles (139,860 square kilometers) under Ohio, West Virginia, northwest Pennsylvania and southern New York (US Department of Energy). Although the shale appears at the surface in the northern Finger Lakes area, in Pennsylvania the shale can be as deep as 7000 feet (2134 meters) below the ground (Cornell University).

The Marcellus Shale deposit was formed 390 million years ago through sedimentary rock formation. During the process as sedimentary rock materials were deposited, microscopic organisms were occasionally stuck in the deposits. When these organisms decomposed, natural gas was left behind (Soeder and Kappel). Natural gas is primarily made up of methane (CH<sub>4</sub>) and other odorless, nontoxic hydrocarbons (US Department of Energy Alternative Fuels Data Center), and can be used to heat homes, as fuel for cooking, and potentially as an alternative fuel for vehicles (American Petroleum Institute). It is estimated that 489 trillion cubic feet of natural gas is contained by the entirety of the Marcellus Shale deposit, though it is unknown how much of that can be used commercially at this time. Currently, the state of New York only uses 1.1 trillion cubic feet of natural gas annually (New York State Department of Environmental Conservation).

Geologists have known about the presence of natural gas in the Marcellus Shale for many years now. However, they were only recently able to extract the natural gas from the deposits as a result of newly approved welling and drilling technologies: horizontal welling and hydraulic fracturing, or “fracking” (New York State Department of Energy Conservation). Drilling typically takes place at depths greater than 2000 feet (610 meters) (Cornell University). Horizontal wells are first drilled down vertically and then special tools are used to curve the well horizontally, drilling into the shale from the side. Using the same tools as vertical drilling, horizontal wells enable maximum contact with the shale rock while being able to drill multiple wells from the same location. Hydraulic fracturing involves pumping a fluid and a propping agent (such as sand) at a high pressure into the well to crack the shale and let the natural gas well to the top. The fluid is often mixed with a number of chemicals to prevent corrosion in the pipes and to make sure that the propping agent (also known as a proppant) stays in the shale fractures (New York State Department of Environmental Conservation). These chemicals have the potential to contaminate drinking water (US Environmental Protection Agency). Due to uncertainties associated with the science and engineering of these two processes, politicians are being increasingly forced to make decisions under high uncertainty about extracting natural gas from Marcellus Shale deposit.

## **Objective**

Students will be able to:

- Develop a working definition of a “bad incident,” know when one has occurred, and try to assign responsibility for the action
- Recognize that determining who is at fault isn’t always straightforward.
- Evaluate news sources in order to form an opinion.
- Explain and debate the positives and negatives associated with hydraulic fracturing.

**Materials Needed**

- Computer
- Projector
- Policy Question handouts
- Pro-industry and pro-environment news articles

**Safety Concerns**

- None

**Vocabulary**

- Marcellus shale: a large black shale deposit extending under Ohio, West Virginia, northwestern Pennsylvania, and southern New York.
- Energy: Energy that the plants and animals originally obtained from the sun is stored in the form of carbon in natural gas. Natural gas is combusted to generate electricity, enabling this stored energy to be transformed into usable power. Natural gas energy is considered nonrenewable

**Procedure**

<b>Time</b>	<b>Activity</b>	<b>Description</b>	<b>Supplies</b>
10	1. “Bad” incidents	Show two videos of when a “bad” incident occurred that must be paid for: <ul style="list-style-type: none"> <li>• Video of car accident: <a href="http://www.youtube.com/watch?v=i16nRG7Prac">http://www.youtube.com/watch?v=i16nRG7Prac</a></li> <li>• Video of demolition crew taking out the wrong building: <a href="http://www.youtube.com/watch?v=86wbxr_tqtq">http://www.youtube.com/watch?v=86wbxr_tqtq</a></li> </ul> After each video, ask the students questions such as: <ol style="list-style-type: none"> <li>1. Explain the “bad” that occurred?</li> <li>2. Who is responsible to pay?</li> </ol>	Computer, projector
10	2. Acid Mine	When it comes to the environment, the person responsible for the damage is less clear.	Computer, projector

	Damage	<ol style="list-style-type: none"> <li>1. Show the map of bituminous coal in Pennsylvania (Enviro Sci Inquiry). <a href="http://www.ei.lehigh.edu/envirosci/enviroissue/amd/links/Pa_project_s.html%3e">http://www.ei.lehigh.edu/envirosci/enviroissue/amd/links/Pa_project_s.html%3e</a>.</li> <li>2. Show video of acid mine drainage flow near Altoona, Pennsylvania.             <ol style="list-style-type: none"> <li>a. Link: <a href="http://www.youtube.com/watch?v=ii-7pPtZilo">http://www.youtube.com/watch?v=ii-7pPtZilo</a></li> <li>b. Mention that water flowing from this hole is toxic and, when it flows into a nearby stream, everything the water touches will be killed.</li> </ol> </li> <li>3. Ask the students questions such as:             <ol style="list-style-type: none"> <li>a. Who is responsible for the damage caused by the acid mine damage?</li> <li>b. How does one put a cost on the damage?</li> <li>c. What are some reasons this is different than the car accident?</li> <li>d. What if the person who dug the mine has no money and cannot pay for damage?</li> <li>e. What if the problem cannot be fixed?</li> </ol> </li> </ol>	
10	3. Mr. Sanderson Case	<ol style="list-style-type: none"> <li>1. Introduce the students to the Mr. Sanderson case: <i>He was a homeowner who sued a coal company in the 1870's after acid mine drainage ruined the water in a stream on his property. Pennsylvania's Supreme Court ruled that the damage was a necessary evil of coal mining.</i></li> <li>2. Ask the students questions about the case such as:             <ol style="list-style-type: none"> <li>a. Provide reasons why the Supreme Court may have ruled this way, even when Mr. Sanderson clearly had his property damaged.</li> <li>b. Explain the different sides of the problem.</li> </ol> </li> <li>3. Describe the Supreme Court's actual reasoning for ruling the way that it did: <i>If coal mine operators were required to fix the problem, they would have to charge more for coal. If coal costs more, people would have to pay more for electricity. The impacts would be felt by a larger number of people if the coal company had to fix the problem.</i></li> <li>4. Ask the students questions such as:             <ol style="list-style-type: none"> <li>a. Are you satisfied with that reasoning?</li> <li>b. Should Mr. Sanderson not be compensated for the damage to his property just because cheaper coal is good for the economy?</li> </ol> </li> </ol>	
10	4. Connection to Marcellus Shale	<ol style="list-style-type: none"> <li>1. Ask the students questions to gauge their current knowledge about Marcellus Shale such as:             <ol style="list-style-type: none"> <li>a. How many of you have heard or read anything about Marcellus Shale?</li> <li>b. What have you heard?</li> </ol> </li> <li>2. Show a map of the Marcellus Shale (<a href="#">Pennsylvania Center for the Books</a>).</li> <li>3. Give a brief background summary on the Marcellus Shale, either in a</li> </ol>	Computer, projector, Background handout (optional)

		<p>handout or verbally (see Background section).</p> <p>4. Show a video demonstrating how horizontal drilling and hydraulic fracturing work. Link:  <a href="http://www.askchesapeake.com/Video/Pages/information.aspx">http://www.askchesapeake.com/Video/Pages/information.aspx</a></p>	
	5. Activity	<ol style="list-style-type: none"> <li>1. Break students into smaller groups (2-3 groups total).</li> <li>2. Give each group of students a paper with policy specific questions, such as:             <ol style="list-style-type: none"> <li>a. Should we allow drillers to dump wastewater in rivers?</li> </ol> </li> <li>3. Give groups brief quotes / headlines taken directly from newspapers regarding the relevant issues. One group will have a pro-industry slant and the other a pro-environment slant.</li> <li>4. After a brief period of discussion, invite students to come together and share their results.             <ol style="list-style-type: none"> <li>a. It is expected that the pro environmental group will have a different response than the pro industry group.</li> <li>b. Encourage the students to get involved in the issues they care about, because the environmental issues left unaddressed will ultimately be their financial responsibility in the future, but they will not receive any of the benefit.</li> </ol> </li> </ol>	Policy question handouts, pro-industry and pro-environment news articles

**Additional Resources**

**Reputable:**

Enviro Sci Inquiry – Abandoned Coal Mine Drainage Projects in Pennsylvania

"AMD: PA projects." *Enviro Sci Inquiry*. Lehigh University, n.d. Web. 3 Jul 2013.

<[http://www.ei.lehigh.edu/envirosci/enviroissue/amd/links/Pa\\_projects.html](http://www.ei.lehigh.edu/envirosci/enviroissue/amd/links/Pa_projects.html)>.

The Enviro Sci Inquiry page discusses the negative impacts of coal mines in Pennsylvania, particularly related to damages from coal mine drainage. Teachers looking to highlight an environmental issue aside from those related to Marcellus Shale could look here to get a brief introduction to a potential topic.

EPA Hydraulic Fracturing Diagram

"EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources." *US Environmental Protection Agency*. United States Environmental Protection Agency, 22 May 2013. Web. 5 Jun 2013.

<<http://www2.epa.gov/hfstudy>>.

The EPA diagram shows each step of hydraulic fracturing process, where each step is accompanied with a picture and a description of what could go wrong such that the water would be contaminated. The diagram could be a good resource for teachers who want to visually show the process of “fracking” or for those who want to begin a debate on whether or not “fracking” should occur.

### Pennsylvania's Buried Treasure – Marcellus Shale

Grant, Stephen. "Pennsylvania's Buried Treasure." *The Pennsylvania Center for the Book*. Pennsylvania State University, n.d. Web. 27 Jun 2013.

<<http://pabook.libraries.psu.edu/palitmap/Marcellus.html>>.

The Pennsylvania Center for the Book gives basic background information about Marcellus Shale, and provides sources to the links that they used. Teachers looking for a quick read about Marcellus Shale and teachers looking for more useful sources would both do well to look here.

### Marcellus Shale Gas Play Map

"Marcellus Shale Gas Play, Appalachian Basin." *US Energy Information Administration*. US Energy Information Administration, n.d. Web. 5 Jun 2013.

<[http://www.eia.gov/oil\\_gas/rpd/shaleusa5.pdf](http://www.eia.gov/oil_gas/rpd/shaleusa5.pdf)>.

This site shows a map of the extent of the Marcellus Shale, as well what is pure Marcellus Shale and what is Marcellus Shale mixed with another formation. The map makes for a good visual to show the large amount of area the shale covers.

### EPA Natural Gas Summary

"Natural Gas." *US Environmental Protection Agency*. United States

Environmental Protection Agency, 30 Apr 2013. Web. 13 Jun 2013.

<<http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html>>.

This EPA page gives a summary on what natural gas is, what natural gas is used for, and how it's used to generate power. If a teacher wanted to get a better background on the natural gas aspect of Marcellus Shale, this would be a good place to start looking.

### EPA Region 3 Mid-Atlantic States Oil and Gas Development

"Oil and Gas Development." *US Environmental Protection Agency*. United States

Environmental Protection Agency, 30 May 2013. Web. 31 May 2013.

<[http://www.epa.gov/region3/marcellus\\_shale/](http://www.epa.gov/region3/marcellus_shale/)>.

The EPA website for Mid-Atlantic Oil and Gas Development gives a brief background about what the Marcellus Shale Formation is, and what the EPA has done in relation to the Marcellus Shale. Teachers looking for extensive policy examples and government files will find that here.

### US Shale Gas Overview

"Review of Emerging Resources: US Shale Gas and Shale Oil Plays." *US Energy*

*Information Administration*. US Energy Information Administration, 8 Jul 2011.

Web. 5 Jun 2013. <<http://www.eia.gov/analysis/studies/usshalegas/>>.

This site gives a background on US Shale from a broader point of view. The history of using shale is discussed, as well as a report on how much natural gas is available in the US. Teachers interested in learning to what shale is used for in general could look here.

**Opinion / Newspaper:**

**Conventional Resources vs. Unconventional Resources**

"Conventional & Unconventional." *Canadian Association of Petroleum Producers*.

Canadian Association of Petroleum Producers, n.d. Web. 14 Jun 2013.

<<http://www.capp.ca/CANADAINDUSTRY/NATURALGAS/CONVENTIONAL-UNCONVENTIONAL/Pages/default.asp&xgt;>>.

The page on conventional and unconventional resources gives further explanation into why the Marcellus Shale was unable to be drilled previously. If a teacher is looking to explain the need for hydraulic fracturing, explaining the difference between the two types of resources might be a good start.

**Marcellus Formation - Wikipedia**

Anon, . "Marcellus Formation ." *Wikipedia*. Wikipedia - The Free Encyclopedia, 10 May 2013. Web. 31 May 2013. <[http://en.wikipedia.org/wiki/Marcellus\\_Formation](http://en.wikipedia.org/wiki/Marcellus_Formation)>.

The Wikipedia page on Marcellus Shale gives an extensive summary on the Marcellus Shale formation, focusing primarily on where its located and the economic implications of drilling for natural gas in the shale. Teachers may be interested in the citations made by the Wikipedia page; with over 170 sources, it may be a great place to start looking for addition reputable sites and books.

**Marcellus Shale Coalition**

"Marcellus Shale Coalition." *Marcellus Shale Coalition*. Marcellus Shale Coalition, n.d. Web. 31 May 2013. <<http://marcelluscoalition.org/>>.

The Marcellus Shale Coalition (MSC) offers information to policy-makers, the media, and other people in the public eye looking to know more about the benefits of natural gas production and use. The website provides its own description of the process of obtaining natural gas as well as outside literature. Though the MSC clearly takes a positive stance on natural gas production, the literature section may serve as a good resource for teachers looking to learn more.

**Pittsburgh Post-Gazette**

"Pipeline from the Pittsburgh Post-Gazette." *Pipeline: your source for Marcellus Shale coverage & community*. Pittsburgh Post-Gazette, 2 Jun 2013. Web. 5 Jun 2013. <<http://pipeline.post-gazette.com/>>.

The Pipeline subsection of the Pittsburgh Post-Gazette is dedicated to showing new articles and stories related to the Marcellus Shale Formation. If teachers are looking for a

current events update to share with their students about the Marcellus Shale formation, this would be a good place to start.

**Other**

Video - Car accident - <http://www.youtube.com/watch?v=i16nRG7Prac>

Video - Demolition crew taking out the wrong building - [http://www.youtube.com/watch?v=86wbxr\\_tqtq](http://www.youtube.com/watch?v=86wbxr_tqtq)

Video - Acid mine drainage flow near Altoona, Pennsylvania - <http://www.youtube.com/watch?v=ii-7pPtZilo>

Video - How horizontal drilling and hydraulic fracturing work - <http://www.askchesapeake.com/Video/Pages/information.aspx>

Webinar links

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Lesson idea from Austin Mitchell; final product compiled by Sabrina Larkin on behalf of the Leonard Gelfand Center for Service Learning and Outreach.

**Funding Sources**

Portions of this work were supported by a) the Leonard Gelfand Center for Service Learning and Outreach, and b) the Center for Climate and Energy Decision Making (SES-0949710) through a cooperative agreement between the National Science Foundation and Carnegie Mellon University.

**Next Generation Science Standards Alignment**

HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Crosscutting Concept: Cause and Effect

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Crosscutting Concept: Stability and Change (Feedback)

Connections: HS-LS2, HS-LS4