

# **Natural gas and Pennsylvania's future**

June 27, 2013

## **Background**

Natural gas is a fossil fuel primarily made up of methane (CH<sub>4</sub>) and other odorless, nontoxic hydrocarbons (US Department of Energy Alternative Fuels Data Center). It can be used to heat homes, as fuel for cooking, and potentially as an alternative fuel for vehicles (American Petroleum Institute). Natural gas is formed when buried plants and animals are exposed to high pressures and temperatures over thousands of years. The carbon in the natural gas comes from solar energy once stored in the plants and animals. Methane (natural gas) and oxygen react to form carbon dioxide and water. This combustion process is used to generate electricity and transform the stored energy into power (Natural Gas - United States Environmental Protection Agency).

Natural gas can be extracted from both conventional and unconventional deposits. Conventional resources typically include free gas trapped in small porous zones in naturally occurring rock formations. Looking for and extracting conventional gas has been the priority of the oil and gas industry for the past 100 years. Unconventional resources typically include tight gas, gas hydrates, and shale gas, and are generally more difficult to extract than conventional resources (Canadian Association of Petroleum Producers).

Geologists have known about the presence of natural gas in the Marcellus Shale for many years now. However, because shale gas is an unconventional resource, they were only recently able to extract the natural gas from the deposits. This extraction is the result of new 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 (The Hydraulic Fracturing Water Cycle - 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:

- Explain the role natural gas in their lives.
- Define what a hydrocarbon is and where it is found.
- Describe the difference between conventional and unconventional gas reservoirs.
- Explain why we frack and what it could mean for the future of Pennsylvania.

**Materials Needed**

- Computer
- Projector
- Cups
- Straw
- Sponges; clean, new
- Juice
- A piece of shale (optional)

**Safety Concerns**

- None.

**Vocabulary**

- Marcellus shale: a large black shale deposit extending under Ohio, West Virginia, northeastern 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
- Hydrocarbons: any compound containing only hydrogen and carbon. Hydrocarbons are the chief components in petroleum and natural gas.

**Procedure**

<b>Time</b>	<b>Activity</b>	<b>Description</b>	<b>Supplies</b>
10	1. Introduction	Begin discussion with students about natural gas. Suggested questions include: <ul style="list-style-type: none"><li>• What do you know about natural gas?</li><li>• How might you be using it in your life?</li><li>• How much natural gas do you use to shower?</li></ul>	Computer, projector

10	2. Teach base concepts of methane and other hydrocarbons	Include: <ul style="list-style-type: none"> <li>• Basic chemistry and combustion</li> <li>• Notes on how it is easy to move and use</li> <li>• Video clip:  <a href="http://www.youtube.com/watch?v=UY8DAIHkkw8">http://www.youtube.com/watch?v=UY8DAIHkkw8</a> </li> </ul>	Computer, projector
10	3. Where does natural gas come from and how did it get there?	Use visual aids to discuss with students. Include: <ul style="list-style-type: none"> <li>• <a href="#">Decomposition of organic material</a> (Te Kura a-Tuhi)</li> <li>• <a href="#">Conventional reservoirs versus unconventional reservoirs</a> (Canadian Association of Petroleum Producers)</li> <li>• A piece of shale (optional)</li> </ul>	Computer, projector, piece of shale (optional)
10	4. Why do we need to frack the shale?	<ol style="list-style-type: none"> <li>1) Pass out two cups to each student. One cup will have a sponge in it.</li> <li>2) Fill both cups with juice and give each student a straw to drink juice from cup.</li> <li>3) The juice from the cup with the sponge will be more difficult to 'extract.'</li> </ol> <p>Describe how natural gas is extracted from shale...</p> <ul style="list-style-type: none"> <li>• Show video of the process:  <a href="http://www.youtube.com/watch?v=WF3_gFTCN7A">http://www.youtube.com/watch?v=WF3_gFTCN7A</a> </li> <li>• Answer questions to make sure students have basic understanding of the process</li> </ul>	Computer, projector, cups, straw, sponges, juice
10	5. General discussion/	Discuss follow up concepts. Include: <ul style="list-style-type: none"> <li>• Do you know if Pennsylvania has a lot of shale? What have you heard?</li> <li>• Risks and opportunities of developing shale.</li> </ul>	Computer, projector
10	6. Conclusion	Discuss: <ul style="list-style-type: none"> <li>• The role of hydrocarbons in Pennsylvania's past and future.</li> <li>• What does this mean to students?</li> <li>• What can students do?</li> </ul>	

### Additional Resources

#### **Reputable:**

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.

#### 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.

#### Decomposition Diagram

"Horticulture - HT1032." *Science Horticulture*. Te Kura a-Tuhi: The Correspondence School. Web. 13 Jun 2013.

<[http://www.tekura.school.nz/departments/horticulture/ht106\\_p3.html](http://www.tekura.school.nz/departments/horticulture/ht106_p3.html)>.

This page briefly discusses organic and inorganic resources. It also provides interactive diagrams at the end to test readers on the information that was previously discussed.

Teachers looking to focus more on organic and inorganic matter could look here for both content and activities.

#### 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 - Base concepts of methane and other hydrocarbons -

<http://www.youtube.com/watch?v=UY8DAIHkkw8>

Video - How natural gas is extracted from shale -

[http://www.youtube.com/watch?v=WF3\\_gFTCN7A](http://www.youtube.com/watch?v=WF3_gFTCN7A)

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**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

HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.