# Primer

House Appropriations Committee (D)

JOE MARKOSEK, DEMOCRATIC CHAIRMAN

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# Marcellus Shale Development in Pennsylvania

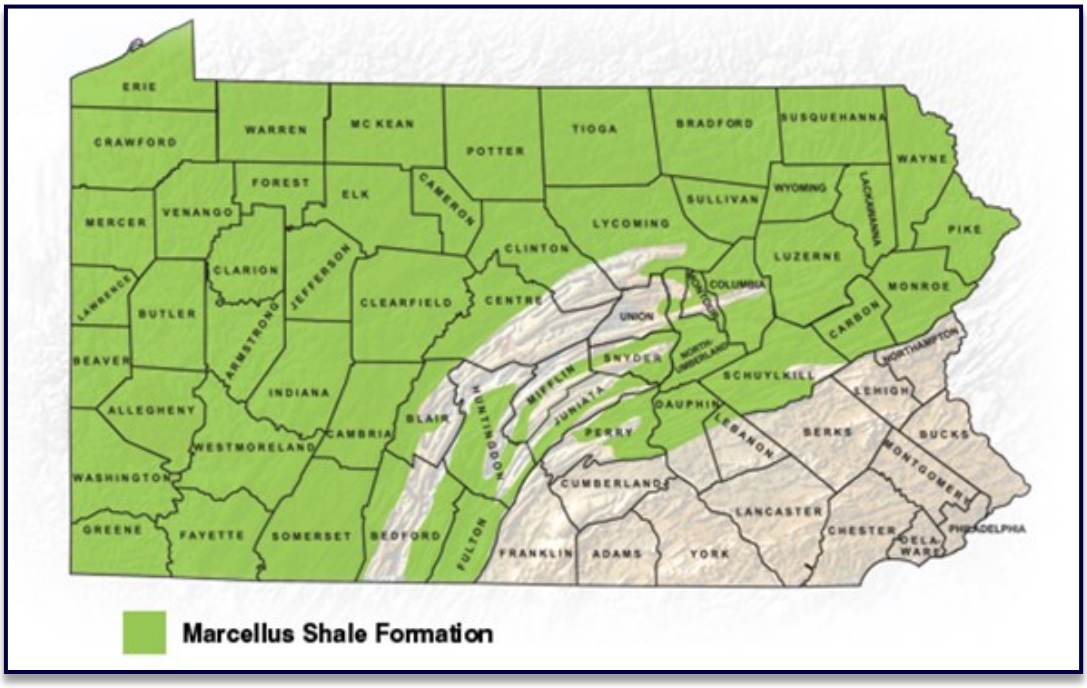
The Marcellus Shale is a gas-rich rock formation that underlies more than three-quarters of Pennsylvania. Geographically, the Marcellus Shale is the largest shale basin in the United States and, potentially, one of the largest in the world.[1] Estimates of the amount of natural gas in the Marcellus Shale have evolved as drilling and research continue, ranging from 84 trillion to 500 trillion cubic feet.

Geologists and petroleum engineers have long known about the Marcellus Shale gas deposits. However, it was not until recent improvements in three-dimensional imaging, horizontal drilling, and hydraulic rock fracturing (fracking) technologies revealed how economically viable it was to extract the gas. The sharp increase in natural gas production has sparked a number of concerns about the environmental impact of the fracking process, the most appropriate regulations to oversee the industry, and what financial return is owed to Pennsylvania citizens for the recovery of this valuable resource.

## Geology and Background

Typically, deeper and thicker layers of shale contain more gas. The geology of the Pennsylvania Marcellus Shale formation suggests that areas in the southwest, north central and northeastern regions contain the deepest and thickest shale, thus explaining why the greatest concentrations of drilling activity and production can be found in these regions.

Relative to other shale gas plays in the U.S., the Energy Information Administration says the Marcellus Shale has 5.5 times more gas resources than the next biggest shale gas play: the Haynesville formation (75 tcf) under Texas and Louisiana. “Play” is a gas and oil industry term used to reference a geographic area targeted for exploration.



## Natural Gas Production and Its Uses

Natural gas is a combustible mixture of hydrocarbons that occurs naturally below the earth's surface. Typically, natural gas is comprised of between 70-90 percent methane – and is considered 'dry' gas when it is almost pure methane. Alternatively, 'wet' natural gas describes a mixture that includes other hydrocarbon gases, such as ethane, propane, and butane. Like other fossil fuels, natural gas formed as a result of organic tissue being buried by layers of sediment before decomposing. Heat and pressure applied over the course of millions of years transformed the trapped organic matter into natural gas.

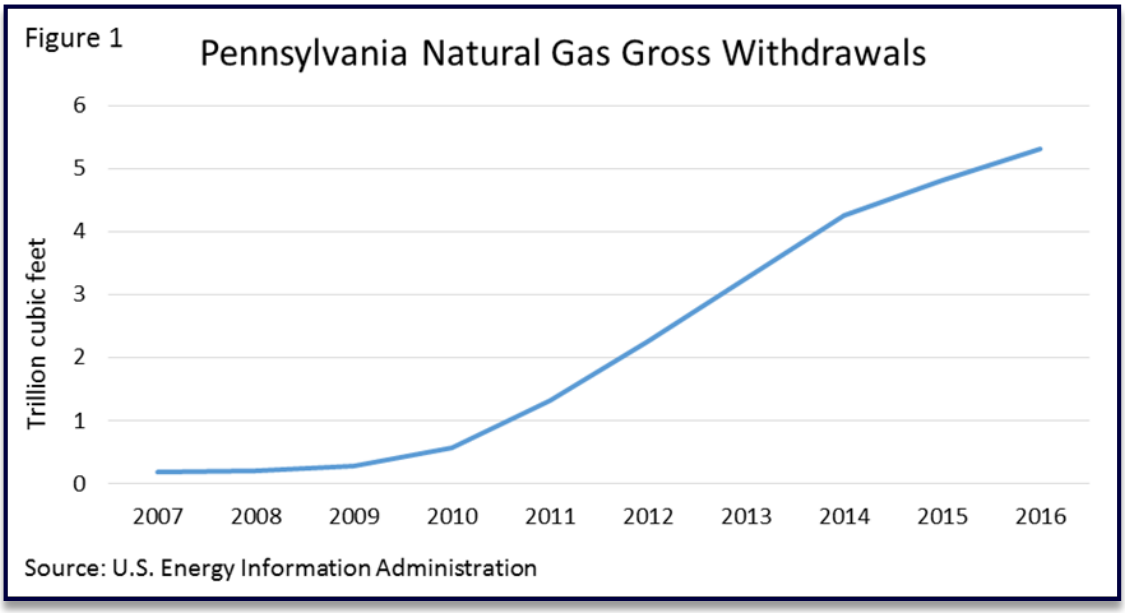
The development of new technology to reach natural gas in an economically viable manner led to a sharp increase in production (Figure 1). As prices dropped, natural gas became a more appealing and competitive energy source. According to the U.S. Energy Information Administration natural gas-fired electricity generation began to surpass coal-fired generation as the leading energy source in 2016. However, coal is expected to rebound in 2017 as natural gas prices begin to rise once more. In 2015 alone, Pennsylvania produced 4.6 trillion cubic feet of natural gas, enough to power more than 62 million U.S. households annually.[2]

Natural gas is a vital and growing part of the United States' energy portfolio and has many residential, commercial, and industrial applications. It can be used in household cooking and heating or commercially to heat offices, schools, or hospitals. Natural gas is also used industrially in food processing and metals preheating. Ethane, butane, and propane are extracted from natural gas and individually used in the manufacturing of chemicals and other products. Additionally, natural gas is increasingly being used as an alternative fuel in the transportation sector.

The widespread usage of natural gas as an energy source has also been seen as relatively more environmentally friendly than coal. Coal, when burned, is considered to be one of the largest emitters of carbon dioxide (CO2), which an overwhelming majority of scientists argue is a contributor to harmful global warming. Anthracite coal emits 111 more pounds of CO2 per million British thermal units (Btu) than natural gas.

Natural gas has been considered as a useful alternative and energy source as the United States (either in whole or as collaborations of cities) works towards national and international goals to reduce the carbon output of its energy portfolio. However, natural gas does raise concerns related to the methane emissions associated with its production. Methane does not last as long in the atmosphere, but is far more potent as a heat-trapping gas.

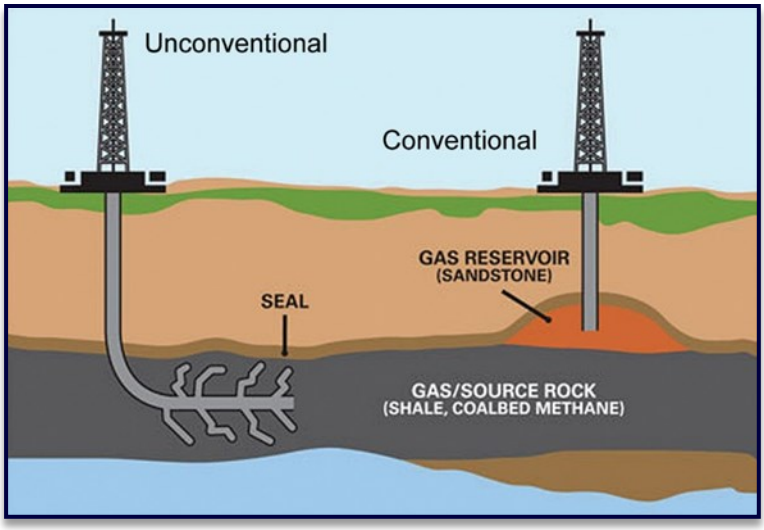
Figure 1




## Unconventional vs. Conventional Wells

Conventional and unconventional well operators use advanced subsurface imaging technology to locate commercial quantities of gas prior to setting up a well. Conventional wells are drilled where gas flows in low pressure areas as a result of highly porous and permeable rock. Here, drillers simply bore into a pocket of gas to extract the resource.

Unconventional formations, like the Marcellus Shale, are different -- a sedimentary rock formation characterized by very low permeability. In the Marcellus Shale, gas is stored within the pores of the rock but is unable to flow or collect in larger pockets of gas, making it an unconventional resource. This geographic reality requires operators in the Marcellus Shale to extract the embedded gas using a process called hydraulic fracturing.




Source: https://www.croftsystems.net/oil-gas-blog/conventional-vs.-unconventional

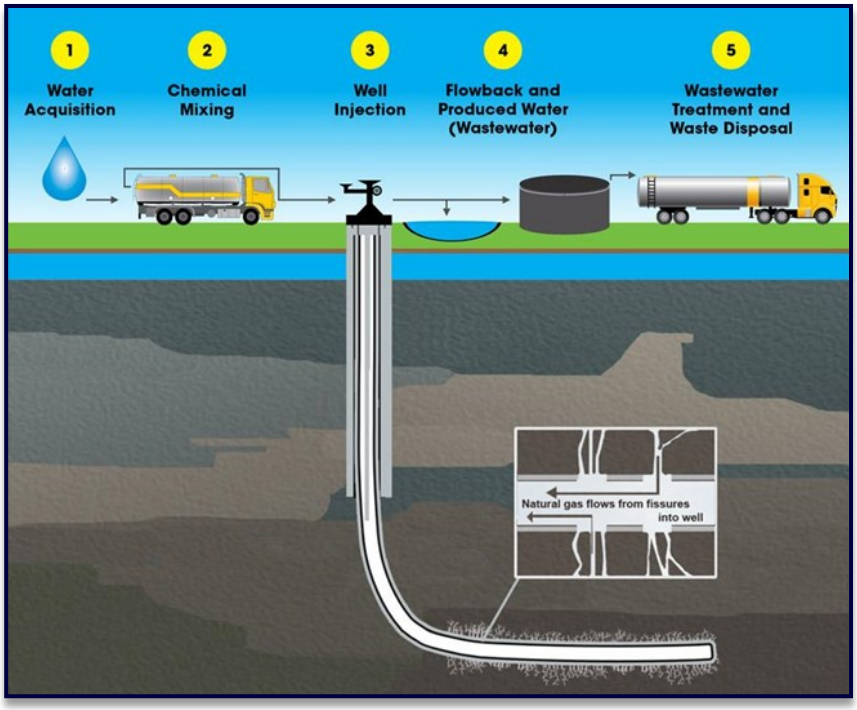
## Hydraulic Rock Fracturing

Fracking -- or horizontal, high-volume, slickwater hydraulic rock fracturing -- is the process of pumping water mixed with sand and chemicals into the rock at high pressure until the rock cracks and releases natural gas. This process includes drilling a vertical shaft to within several hundred feet of the shale. From there, the drill bit is directed sideways to reach a range of fractures. These horizontal shafts can be drilled in several directions from a single vertical well shaft. Next, a charge is set at the end of the well bore. The charge starts the fracture of the shale formation. A mixture of water, chemicals, and sand is then pumped under high pressure to further break rock formations and expand and hold open the fractures, allowing the natural gas trapped in the shale to flow to the well head.

The standard frack fluid (a.k.a. "slickwater") used in hydraulic rock fracturing in the Marcellus region consists of 92 percent water, 6 percent sand, and 2 percent chemical blend. The chemical blend usually includes hydrochloric acid (HCL), friction reducers, acid inhibitors, biocides, and other additives. During fracking operations, more than 4 million gallons of water are needed to fracture the shale in a single Marcellus well, so approximately 80,000 gallons of chemical blend is applied in the process. Other known chemical compounds found in slickwater include benzene, toluene, ethylbenzene and xylene. Drilling companies generally consider their specific slickwater mixture to be a trade secret.

At the outset of the natural gas boom, drillers would send fracking wastewater to public treatment plants, which generally were not equipped to handle this material. In 2011, DEP called on the industry to voluntarily cease this process. In early 2016, the Environmental Protection Agency formally banned the practice. The oil and gas industry uses injection wells or private treatment facilities to dispose of wastewater. During busier periods of drilling, water is often reused in other wells.

The amount of returned flow-back can range from between 0 to 30 percent of what is pumped into the well, with some reported cases of nearly 70 percent returned. This water can contain the mixture pumped into the ground and other naturally occurring minerals found in the strata of drilled earth. These minerals can include naturally radioactive rock that must be handled appropriately. Flow-back must be reused, recycled or collected and treated at an authorized wastewater treatment facility.




Source: Environmental Protection Agency

## Regulation of Marcellus Shale Drilling

Federal, state and affected municipal governments oversee the development and production of natural gas resources from the Marcellus Shale play. Oil and gas exploration is regulated under the state's oil and gas laws including the Oil and Gas Act, Coal and Gas Resource Coordination Act, and Oil and Gas Conservation Law, as well as the environmental protection laws that include the Clean Streams Law, the Dam Safety and Encroachments Act, the Solid Waste Management Act, the Air Pollution Control Act, the Storage Tank and Spill Prevention Act, the Waste Transportation Safety Act, the Water Resources Planning Act, and others.

The Pennsylvania Department of Environmental Protection is generally considered the lead state agency in the regulation of the state's natural gas industry as it is responsible for enforcing the Oil and Gas Act. The Oil and Gas Act establishes environmental controls and resource management for development of crude oil and natural gas and requires all new wells to receive a permit from the commonwealth before drilling. It also requires the registration of any existing well not previously permitted, and establishes bonding requirements for wells.

### Act 13 of 2012

In response to the burgeoning natural gas industry, the General Assembly amended the Oil and Gas Act with Act 13 of 2012, which consolidated the act into Title 58 and created six new chapters of law. Act 13 led to a number of large-scale changes to natural gas drilling and environmental oversight, and it enacted an impact fee on unconventional gas wells, created new funds and allocated revenues for environmental objectives and programs. It also established detailed setbacks and other public health safeguards for natural gas drilling activities, granted powers to the state Public Utility Commission to collect and distribute receipts from the impact fee, and provided programs to research and develop new sources for natural gas use.

Act 13 has been disparaged for not going far enough to ensure the responsible production of natural gas in Pennsylvania, and the protection of critical natural resources such as clean air and pure water. The law has also been criticized for failing to enact an extraction tax on natural gas and instead relying on an optional, low-rate impact fee. The law has been subject to litigation and, in 2013, the Pennsylvania Supreme Court struck down sections relating to state-mandated zoning rules, waivers for water setback requirements, and certain powers granted to the PUC. More detailed information on Act 13 and its role in regulating the natural gas industry can be found in the HACD companion piece, Act 13 Primer.

To drill a new Marcellus Shale natural gas well in Pennsylvania, an operator must obtain a well permit from DEP and post a bond. The bond is a financial incentive to ensure that the operator will adequately perform the drilling operations, address any water supply problems the drilling activity may cause, reclaim the well site, and properly plug the well upon abandonment.

Prior to 2012, companies paid $2,500 per well or $25,000 for a blanket bond to plug wells. Act 13 amended the Oil and Gas Act to increase bond fees that had not been changed since 1984.

A 2011 study conducted by Carnegie Mellon University found that, on average, it could cost $100,000 or more to plug an abandoned Marcellus Shale gas well. Even though the bonding fees were increased under Act 13, they only cover a fraction of the cost to plug a well.

### Additional Regulation, authorized by Act 13 of 2012

An ongoing point of conflict in the regulation of Pennsylvania's natural gas industry centers on conventional versus unconventional wells. While some argue the two differ in the method by which the gas is retrieved, the commonwealth defines wells by the depth of the operations and permeability of the reservoirs, not by the method of retrieval.

The commonwealth's definition of a well became problematic when the Environmental Quality Board began to develop regulations for natural gas production, which was required by Act 13 of 2012. The EQB promulgated regulations for both types of wells and the conventional industry objected, citing the differences in how they operated compared with unconventional drillers in the Marcellus Shale.

The disagreement prompted the General Assembly, through Act 126 of 2014, to compel the EQB to separate proposed regulations for the conventional industry. In response, the EQB bifurcated the regulations, establishing, in Title 58 of Pennsylvania Unconsolidated Statutes, a distinct chapter for conventional regulations (Chapter 78) and unconventional regulations (Chapter 78a).

Despite the separation and industry-specific tailoring of regulations, and approval of the regulations by the Independent Regulatory Review Commission, or IRRC, the conventional industry and members of the General Assembly felt the EQB did not properly separate the regulations. In response, Gov. Wolf's administration and the General Assembly agreed to proceed with regulations for the unconventional industry and not abandon the rule package altogether. All parties said they would continue working on regulations for the conventional industry.

The final rules adopted by the EQB for unconventional gas wells (Chapter 78a regulations) included standards for well development impoundments, onsite wastewater processing, site restoration, reporting and remediating spills and releases, water supply replacement standards, and identification and monitoring of wells proximal to hydraulic fracturing activities.[3]

## Drilling on State-owned Lands

According to the Department of Conservation and Natural Resources, approximately 1.5 million acres of state forest are underlain by the Marcellus Shale formation. Forty-four percent, or 673,000 acres, are available for gas development.[4]

Surface and mineral rights are sold separately under Pennsylvania law. The commonwealth owns roughly 85 percent of the mineral rights in state forests, but it does not own the subsurface rights for roughly 287,000 acres.

When the natural gas industry began to grow, drilling on state park and forest lands where mineral rights could be acquired became desirable. After serious questions about the safety of fracking and drilling activities were raised, Gov. Ed Rendell, in 2010, ordered a moratorium on the further leasing of state lands owned and managed by DCNR (Executive Order 2010-05). Policies also enacted under Rendell require DCNR to perform an environmental-impact analysis before drilling can occur in state forests and parklands where the state does not own the mineral rights.

In 2011, Gov. Tom Corbett repealed the environmental-impact analysis requirement and eventually overturned Rendell's moratorium. Seeking to further foster the natural gas industry in the commonwealth, Corbett issued an executive order in 2014 opening state parks and forests to additional natural gas leasing, so long as the leases did not result in additional surface disturbance. The governor also anticipated $95 million in additional revenue for the 2014/15 budget as a result of this expanded leasing. However, the Pennsylvania Environmental Defense Foundation filed a lawsuit against the Corbett Administration for using oil and gas revenues for purposes other than those prescribed by Act 256 of 1955 and, more broadly, the environmental rights amendment to the Pennsylvania Constitution (Article I, Section 27). The litigation compelled the Corbett administration to put the expanded leasing plan on hold until the PA Commonwealth Court ruled on the matter.

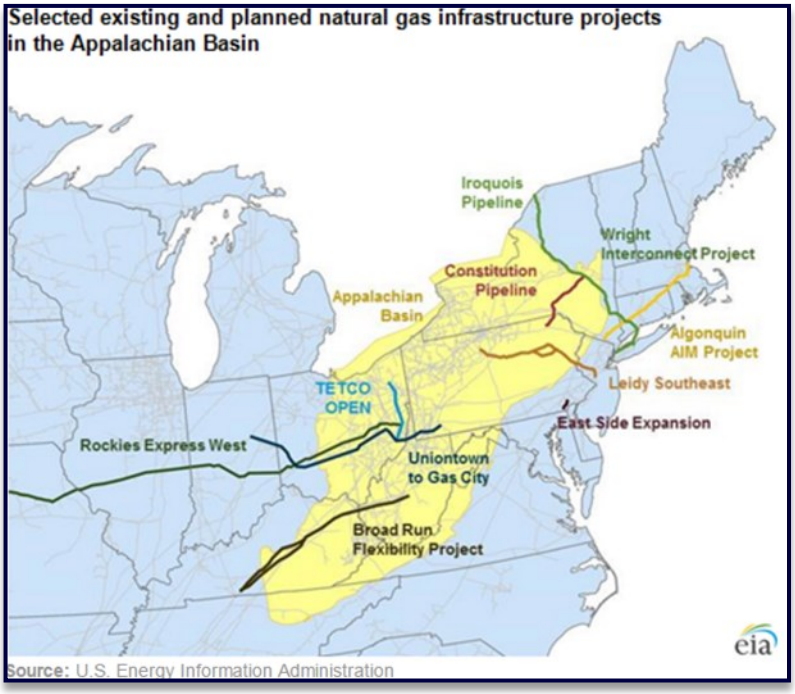
In January 2015, Commonwealth Court found that public revenues collected from oil and gas leases were not required to be spent on environmental goals. However, this protracted court challenge complicated the governor's leasing plan and the anticipated revenue did not materialize. The Environmental Defense Foundation appealed the decision to the state Supreme Court and, in June 2017, it reversed the lower court ruling and clarified the commonwealth as a trustee of the public natural resources.

In January 2015, Gov. Wolf signed Executive Order 2015-03 to reinstate an absolute moratorium on additional leasing of state park and forest land for natural gas development.

## Pipeline Infrastructure and Continued Industry Growth

Natural gas production from the Marcellus shale and Utica shale plays has had a significant impact on national energy trends. According to the U.S. Energy Information Administration, with combined growth of 12 billion cubic feet of natural gas per day since 2011, these shale plays account for 89 percent of total U.S. growth in natural gas production.[5] One of the most pressing concerns for the industry has been insufficient infrastructure growth in the northeast, to move natural gas to other export locations.

Recognizing the need for responsible development of natural gas infrastructure, Gov. Wolf convened a Pipeline Infrastructure Task Force. This diverse group of stakeholders identified top recommendations for how best to expand pipelines in Pennsylvania, while taking into consideration the complex and interrelated environmental and community issues associated with developing this infrastructure. The map below displays some existing and planned natural gas infrastructure projects across Pennsylvania, and in the broader Marcellus Shale region.




Some notable pipeline projects in Pennsylvania include:

- Atlantic Sunrise, which will move through 10 counties across the commonwealth as it carries gas from northeast Pennsylvania to markets in the Mid-Atlantic and southeast United States;
- Constitution Pipeline, which will span 124 miles in length and move gas from Susquehanna County into New York;
- Leidy Southeast Expansion Project, an addition to the Williams' Transco pipeline, moves gas through Luzerne, Lycoming, Monroe and Columbia counties, and into New Jersey;
- Mariner East 1 and Mariner East 2 Pipelines, which were repurposed to carry gas across 14 counties in southern Pennsylvania;
- Mountaineer Xpress, in southwestern Pennsylvania, will carry gas through parts of West Virginia and Ohio; and
- PennEast Pipeline, which will cover 114 miles in eastern Pennsylvania and New Jersey, and is a partnership among a group of energy companies.

As an indication of predicted future growth, Shell Chemical Appalachia announced in 2016 that it was moving forward with plans to build a multi-billion dollar ethane cracker plant in Beaver County. The plant, which will break down oil and gas into smaller molecules to create ethylene that can be used for plastics manufacturing, is expected to create 6,000 construction jobs and 600 permanent jobs when operational. Other states in the Marcellus Shale region have also been building infrastructure to foster the growth of the natural gas industry, such as the Dominion Cover Point Liquefied Natural Gas (LNG) Plant under construction in Maryland.

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[1]Considine, T. J., Watson, R., & Blumsack, S. (2010). The economic impacts of the Pennsylvania Marcellus shale natural gas play: an update. *The Pennsylvania State University, Department of Energy and Mineral Engineering*. http://marcelluscoalition.org/wp-content/uploads/2010/05/PA-Marcellus-Updated-Economic-Impacts-5.24.10.3.pdf

[2]DEP 2015 Oil and Gas Annual Report - http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-113887/8000-RE-DEP4621.pdf

[3]PA Bulletin – Environmental Protection Performance Standards at Oil and Gas Well Sites -- http://www.pabulletin.com/secure/data/vol46/46-41/1757.html

[4]DCNR Shale Gas Monitoring Report, April 2014 - http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20029147.pdf

[5]U.S. Energy Information Administration - New pipeline projects increase Northeast natural gas takeaway capacity - https://www.eia.gov/todayinenergy/detail.cfm?id=24732