Final Report

Shale Gas Outlook for Great Lakes and Ohio River Basin States: Production, Production Facilities, Products, and Methods of Delivery

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Executive Summary

Background and Purpose

The emergence and rapid growth of the shale gas industry in the Northeastern U.S. raises questions regarding Great Lakes and inland waterways system transportation demand, and on U.S. Army Corps of Engineers responsibilities for those systems. The hydraulic fracturing process (fracking), when applied to Marcellus and Utica formation shale, produces natural gas in large quantities and at low prices. Fracking has created an entirely new industry since 2007, and that industry is still developing rapidly.

The purpose of this report is to:

- Broaden the Corps' understanding of shale gas development in the Great Lakes and Ohio River basins
- Analyze the initial implications for increased use of inland waterways (specifically the Ohio River System and the Great Lakes) by the shale gas industry.

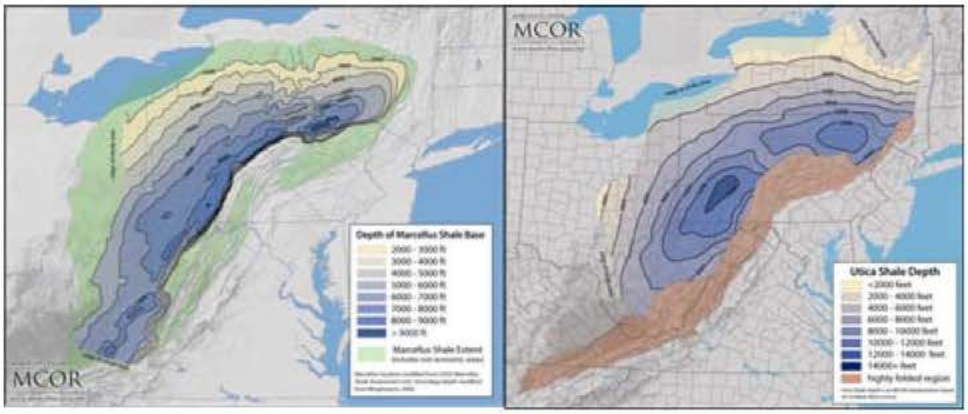
The study focused shale gas production in the Marcellus and Utica formations in the Northeast (Figure 1) and on Ohio River transportation for three reasons:

- The Marcellus/Utica shale plays are very large. The Marcellus formation has become the largest shale gas producing formation in the United States.
- Expanded natural gas supplies have driven prices down, and as a result the Marcellus and Utica are the only Northeastern shale plays that are producing profitably recoverable gas at this time. Current production rates are estimated at 7-10 billion cubic feet/day (Bcfd).
- A review of Corps traffic data did not show identifiable movement of shale gas industry commodities on the Great Lakes. This is likely due in large part to New York State's current moratorium on hydraulic fracturing.

The Marcellus/Utica regions produce both "Dry" and "Wet" natural gas. Natural gas originating in the Marcellus formation in Northeastern Pennsylvania near Williamsport is primarily methane. This is known as "dry gas" and does not require further processing prior to commercial use by residential, commercial, and industrial customers.

Natural gas originating in the Utica formation and the western portion of the Marcellus region near Pittsburgh is "wet." "Wet" gas includes natural gas liquids (NGLs) which must be processed and removed leaving dry gas. Natural gas liquids are very valuable byproducts; propane is one example.

Figure 1: Utica and Marcellus Geological Formations Location and Depth



U.S. Energy and Natural Gas Overview

Natural gas is an important and growing element of U.S. energy supply, accounting for about a 27% of the total. Natural gas use is about 26 quadrillion BTU annually or 70 billion cubic feet per day (Bcfd) and is distributed between demand sectors as illustrated in Table 1.

Table 1: Natural Gas Consumption-2012[1]

Demand Sector	*Billion Cubic Feet*	*Natural Gas Share*
Electric Power	9,137	36%
Industrial	8,492	33%
Residential	4,177	16%
Commercial	2,905	11%
Transportation	746	3%
Total	**25,457**	**100%**

Source EIA

The market has responded to the lower price and environmental advantages of natural gas, as evidenced by the increased natural gas share of consumption and increased replacement of coal-fired electrical power plants with plants that burn natural gas.

The estimated size of shale gas reserves is very controversial. The Marcellus wells are so new that estimates are based on unproven assumptions regarding typical well life and prospective production rates. Sources generally agree, however, that Marcellus/Utica is the largest single U.S. source of shale gas. Marcellus/Utica production is expected to pass 10 Bcfd in 2013 and make the Northeast self-sufficient in natural gas at 12 Bcfd soon thereafter.

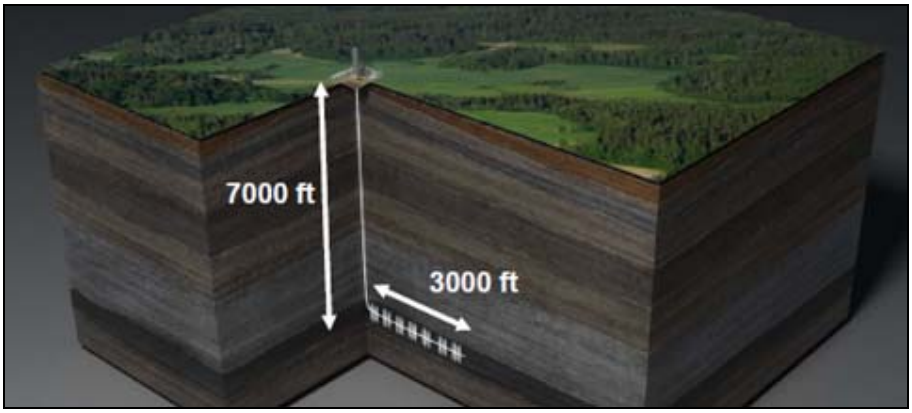
The ultimate development pace of this resource is highly uncertain because the long term regulatory climate for gas development is also highly uncertain. States currently regulate development in very different ways; New York has a statewide moratorium on drilling while Pennsylvania has actively promoted development and has issued over 10,000 well drilling permits. Other affected states have policies between these two extremes.

Shale Gas Wells

The wells are the basic components of shale gas production infrastructure. Well development drives logistics requirements and transportation demand to bring the materials needed to construct the well and to transport the raw gas for processing. The 2012 EIA Annual Energy Outlook forecast the eventual need for more than 100,000 Marcellus/Utica gas wells.

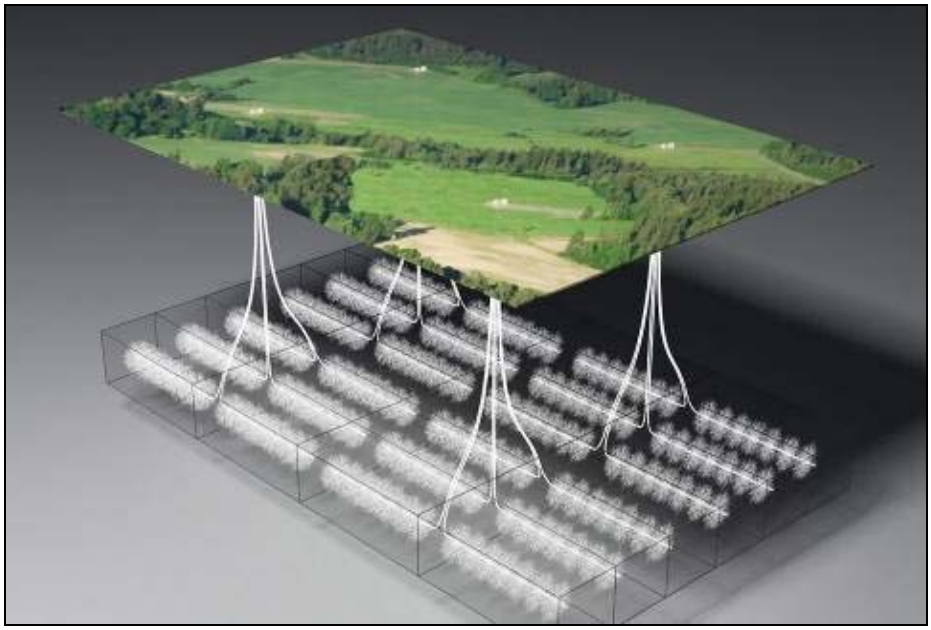
Shale wells are typically drilled around the clock for 15 to 30 days at a cost of $5 to $6 million per well. The well is drilled vertically to a level slightly above the shale Figure 2. The drill is then turned sideways and pushes horizontally as much as 5,000 feet into the formation.

Figure 2: Typical Marcellus Formation Shale Gas Well



This drilling process may be undertaken multiple times from a single well drilling pad, which allows for the extraction of larger quantities while minimizing surface disruption. One surface pad may cover several wells and tap the available gas over hundreds of acres, as illustrated in Figure 3. The average Pennsylvania Marcellus well pad covers 2.8 wells. In one case, a well pad covers 20 wells.

Figure 3: Multiple Wells per Drilling Pad[2]



Wells are cased and cemented from the surface. The horizontal portions of the well casing are then perforated using small explosive charges. Fracturing fluids (water, sand, chemicals) are then injected into the well under controlled high pressure to fracture the strata. Sand or ceramic beads (proppants) in the fluid keep the fractures open. Natural gas and wastewater flow from the fractures and into the well.

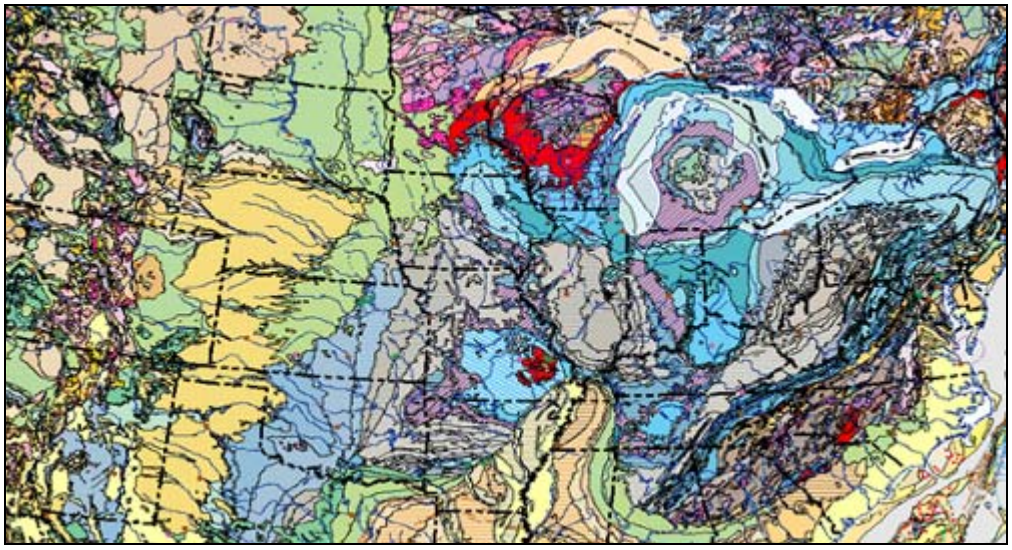
Tioga's estimate of *current* Marcellus/Utica region drilling activity is 200 wells per month. Permitting activity is very strong, however, despite low gas prices and a shortage of pipeline capacity. Tioga therefore believes the medium-term average will be higher, approximately 250 wells per month or 3,000 wells per year. At this rate about 30 years will be required to develop the Marcellus and Utica formations completely.

Inbound Commodities, Transportation, and Facilities

The major inbound flows include water, frac sand, pipe, cement, chemicals, and aggregate.

- **Water.** An average Marcellus horizontal deep shale gas well requires an average of 5.6 million gallons of water.[3] Water is obtained locally, usually using trucks. Some pipelines are used.
- **Frac Sand.** Each well requires between 2,500 and 4,000 tons of sand; this report uses 3,500 tons as a planning figure.[4] The primary sources of fracking ("frac") sand are quarries in Wisconsin, Minnesota, and Missouri, and on the Illinois River near Ottawa, Illinois, as illustrated in red in Figure 4. The frac sand moves by rail or barge to terminals in the Marcellus region for delivery to well sites. For barges to compete, quarries need to be within 40 miles of a navigable waterway.

Figure 4: Major Sources of Frac Sand



Source: USGS

- **Pipe.** Pipe is required for the well infrastructure and for outbound natural gas. A typical well requires about 20 truckloads of pipe[5]. Increased demand has led to expanded steel mills and pipe production, primarily in Ohio.

- **Cement.** Cement is usually obtained from a local source and transported to the well site by truck. A typical well requires 125 tons of cement. The cement may be moved to the distribution point by barge.[6]
- **Chemicals.** About 8 truckloads of various chemicals are moved to each well from a diverse set of origins.
- **Aggregate.** A typical well requires about 5,000 tons of aggregates to produce the well pad. Aggregate is typically sourced locally and delivered by truck.[7]

Transportation and Logistics. Thus far, logistics support for booming Marcellus gas drilling activity has been almost exclusively by rail and truck. The logistics system appears to be evolving, with inventory moving toward distribution centers and transload facilities near the drilling activity. Suppliers and distributors with access to both rail and waterway transport are seeking lower rates via rail-barge competition.

Outbound Commodities, Transportation, and Facilities

The major outbound commodities are dry gas, wet gas, natural gas liquids, and wastewater

- **Dry Natural Gas.** Consumer quality dry or processed natural gas is typically moved by pipeline. Current construction is focused on bringing shale gas to large Northeastern cities.
- **Wet Natural Gas.** Wet natural gas typically moves by pipeline to processing plants near the drilling sites. From these plants consumer-quality gas enters the pipeline system for distribution.
- **Natural Gas Liquids.** Natural gas liquids (NGLs) are the other product of wet gas plants and may include ethane, propane, butane, isobutane, and natural gasoline. NGLs may be moved to customers by pipeline, truck, or rail. Some barge movements of NGLs from the Northeast to the Gulf have been made in advance of new pipeline construction. Further pipeline capacity is planned to move NGLs to Philadelphia for marine transshipment, as well as to Canada and the Gulf Coast for further processing.
- **Wastewater.** Shale gas wells generate large volumes of flowback wastewater. Wastewater is transported by truck to water to treatment plants in Northeast Pennsylvania or to deep wells in Ohio and Western Pennsylvania. Planned Ohio River wastewater barge operations are being presently held up by a Coast Guard regulatory process.

Affected Industries

Due to the abundant supply of natural gas, there is a significant current price advantage for industries using either large amounts of energy or natural gas as a feedstock.

- **Ethylene.** Abundant, low cost ethane has stimulated a 33% expansion in ethylene production capacity. Ethylene is a critical component in the Plastics and Chemicals industries. A large number of facilities have been planned on the Gulf Coast. A large new plant on the Ohio River near Monaca, PA will need river access for barge movements of oversized project cargo.

- **Steel.** At current prices the first stage of steel production can be performed at a 20% cost savings by using natural gas instead of coal. As a result the steel industry is considering a new generation of plants that use natural gas.[8] One is currently under construction in Convent, LA. At least four other similar facilities, including locations in Ohio and Minnesota, are in planning as of early 2013.

- **Vehicle Fuels** Transportation is the most significant and uncertain aspect of future natural gas demand. Vehicles currently use only .14% of natural gas production, and natural gas fuels only about 0.05% of the nation's highway vehicles. Major efforts are underway to dramatically increase that share.

  Forty percent of new garbage trucks and 25 percent of new buses in the U.S. can run on natural gas.[9] The lack of a national natural gas fueling network is a major barrier holding back implementation.

  Further, "Gas to liquids" (GTL) plants convert natural gas to ordinary liquid fuel. This option avoids the practical issues surrounding the introduction of a new type of vehicle fuel. A South African company is planning to build a plant in Louisiana, Shell is considering a plant on the Gulf Coast,[10] and two smaller GTL facilities have been announced in the Marcellus region.

- **Fertilizer.** Natural gas is the critical element in the production of nitrogen fertilizers. In 2007, 90% of the cost of fertilizer was natural gas, which is used both as a fuel and a feedstock. Virtually all the corn planted in the United States depends on nitrogen fertilizers, and thus on natural gas.

LNG Exports

There is serious interest in increased LNG exports driven by the current global price differentials. The U.S. both imports and exports natural gas via pipeline to Mexico and Canada, but more marine LNG export capacity is required for overseas exports. The Sabine Pass LNG terminals in Texas is the only facility in the continental U.S. currently permitted to export LNG to both free-trade and non-free-trade countries. As of September 2012, 18 U.S. companies had applied for permits to construct liquefaction facilities at existing LNG import terminals or build new facilities.[11] There is a debate in the United States regarding the wisdom of exporting large quantities of natural gas. A recent report by NERA Economic Consulting found that the U.S. could gain net economic benefits from LNG exports, but that the high cost of liquefaction and transportation constrains the ability of U.S. suppliers to meet global markets in the long term.[12]

Confidence Level

As noted earlier there is a high degree of uncertainty regarding the future shale gas development.

- **Regulatory Climate.** The long-term regulatory climate is highly uncertain. Fundamentally, the nation lacks consensus regarding development of natural gas, which is a relatively clean-burning fossil fuel, as a long-term energy source. At present each state is finding its own course regarding the promotion and regulation of oil and gas development and frac sand mining. The federal government has taken only small steps toward regulation of hydraulic fracturing. The EPA launched a long-term assessment of the risks and dimensions of shale gas drilling in 2011, but will not be issuing a draft report until 2014.

- **Long-term Demand.** Long-term demand levels are uncertain. Current demand is about 70 Bcfd, which is primarily from the residential, industrial, commercial, and electric power sectors. Current low natural gas prices are stimulating conversion in all sectors, now including transportation. In addition, current market conditions will support significant export activity.
- **Long-term Supply.** Long-term Marcellus/Utica supply levels are uncertain. At present, in Pennsylvania counties in the Marcellus region, the current extraction footprint is less than 3% of the region. While experts agree that the Marcellus/Utica region is the most significant gas play, there is considerable disagreement among experts as to just how much gas is actually available.
- **Fracking Technology.** Fracking is a new and evolving technology. The number of wells being drilled from each well pad and the horizontal breadth of wells are both increasing. Supply chain planning factors based on consumption per well will likely change in the future. The amount of gas produced per well or per dollar invested can also be expected to increase.
- **Supply Chain Practices.** The price of natural gas is low and economic returns are thin at present, which is forcing a rapid evolution in supply chains. The initial boom was supported primarily by trucks, with rail cars serving as forward storage of frac sand, but this past logistics practice does not appear viable in the long term. A more likely future appears to be the establishment of logistics platforms served by truck, rail, and sometimes barge in the Marcellus/Utica areas, where frac sand and other drilling products can be forward deployed and warehoused. The point of sale for these commodities appears to be moving closer to the drilling activity, but the result of that business strategy is by no means assured. As a result, a stable transportation market with a stable barge, truck, and rail market shares has yet to emerge.

Implications

The Marcellus/Utica region shale gas industry development is far from mature. This Corps inquiry is well out in front of events and the details of future development are inherently uncertain at this point.

While there is little impact on Ohio River cargo flows at this time, there may be significant impact in the future--depending upon the ultimate resolution of open logistics, environmental, and regulatory questions. Given the political status quo, Tioga expects:

- The trend toward increasing use of existing Ohio River barge terminals to serve the oil and gas industry will continue.
- Ohio River traffic related to the oil and gas industry will increase, led by increasing frac sand and cement movements. The absolute volume is difficult to forecast at this time, but could exceed a million tons per year.
- The Coast Guard will ultimately permit waste water to be transported by barge short distances on the Ohio. Commodities of much greater hazard are regularly transported by barge currently.

Introduction

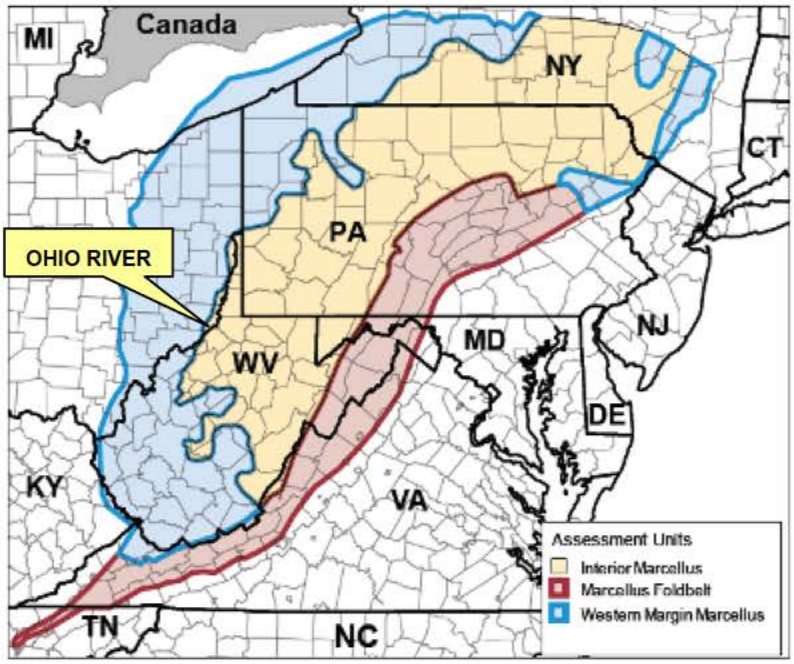
In the Northeastern United States, hydraulic fracturing (fracking) of shale formations has created an entirely new industry since 2007, and that industry and its logistics channels are still developing rapidly. The hydraulic fracturing process produces natural gas in large quantities and low prices.

The emergence and rapid growth of this industry raises questions about its potential impact on transportation demand on the Great Lakes and Inland Waterways systems, and on U.S. Army Corps of Engineers responsibilities for those systems.

The purpose of this report is to broaden the Corps' understanding of how the shale gas industry is developing in the Great Lakes and Ohio River basins, and to gain an initial outlook for use of inland waterways (specifically the Ohio River System and the Great Lakes) by the gas industry. The report will illustrate that this Corps inquiry is well out in front of this shale gas industry development in the Marcellus/Utica region, which is far from mature.

The study focused on transportation on the Ohio River and shale production the Marcellus and the more recently identified Utica functions in the Northeast (Figure 5) for three reasons.

Figure 5: Marcellus Assessment Units



First, the Marcellus/Utica shale plays are very large. The Marcellus formation has become the largest shale gas producing formation in the United States. Second, copious gas supplies have driven prices down and as a result the Marcellus and Utica are the only Northeastern shale plays that are producing profitably recoverable gas at this time. Current production rates are estimated at 7-10 billion cubic feet/day (Bcfd). Third, a review of Corps traffic data did not show identifiable movement of shale gas industry commodities on the Great Lakes.

I. U.S. Energy and Natural Gas Overview

This chapter discusses the U.S. energy industry and the natural gas industry in general terms, both from a national and regional perspective. The chapter discusses the factors driving natural gas demand, supply, and price. The chapter also provides an overview of the natural gas industry in the nation and study region.

U.S. Energy Demand

In 2010 the United States consumed over 95 quadrillion British Thermal Units (BTUs) of primary energy. This energy heats and lights homes and businesses; fuels transportation of all types; and powers industrial production. Demand for this energy is typically categorized by type of use as follows:

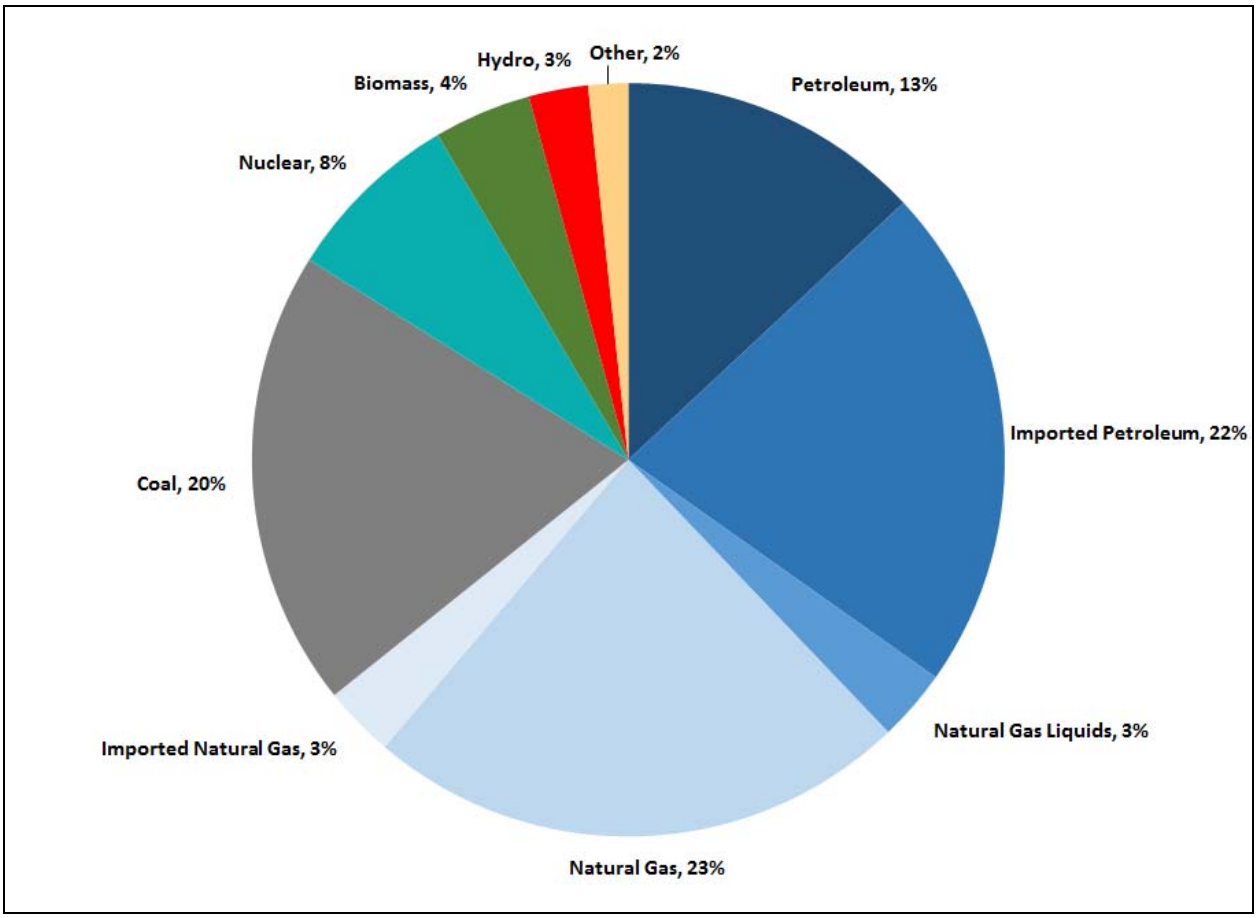
- **Residential.** Energy used in living quarters for private households constitutes the residential demand sector. In 2012 this sector consumed 5.9 quadrillion BTU. Natural gas and electricity are the most important sources of energy for this sector.
- **Commercial.** Energy used in private and public service-providing facilities constitutes the commercial sector. This sector includes businesses, public buildings, churches, etc. In 2012 this sector consumed 3.7 quadrillion BTU. Electricity and natural gas are also the most important sources of energy for this sector.
- **Industrial.** Energy used in facilities that produce, process, or assemble goods constitutes the industrial sector. In 2012 this sector consumed 20.4 quadrillion BTU. Natural gas and petroleum are the most important sources of energy for this sector.
- **Transportation.** The transportation sector includes energy used to move passengers and freight. In 2012 this sector consumed over 26.6 quadrillion BTU. Petroleum is by far the most important source of energy for this sector.
- **Electrical Power.** Coal and natural gas are the most important sources of electrical power generation. In 2012 the U.S. used over 38.3 quadrillion BTU of electricity.

U.S. Energy Supply

In 2012 the U.S. produced 79 quadrillion BTU of energy, imported another 27 quadrillion BTU, and exported 11 quadrillion BTU. Domestic energy consumption was 95 quadrillion BTU. U.S. consumption peaked in 2007 and has declined approximately 6% over the past five years.

The U.S. relies on several sources to produce the energy required. Natural gas is a very important component, accounting for about 29% of the total supply. The energy supply situation in 2012 is illustrated in Figure 6.

Figure 6: 2012 U.S Energy Sources (Production plus Imports)



Net of exports the U.S. produced 83% of the energy that it consumed in 2012. This share has been increasing recently due to the reduction of both natural gas and petroleum imports.

Natural Gas Demand

Natural gas currently contributes significantly to all demand sectors except transportation. Natural gas is growing in importance generally, most importantly in the production of electricity. 2012 consumption data are presented in Table 1.

- Energy demand is highly seasonal, with the most pronounced peak associated with winter heating needs for residential and commercial customers. This peak creates the need for natural gas storage facilities to serve season demand.
- Power production experiences both a heating and cooling peak.
- The most important driver of increasing natural gas demand is power production.
- Industrial demand is relatively stable over the period.
- Transportation demand for natural gas is very low. The most important current transportation use of natural gas is to power natural gas pipelines.

A key feature of the growth of natural gas demand over the past five years is the substitution of gas for coal in power generation. Figure 7 shows current trends for the three most important sources of electricity and illustrates the substitution of natural gas for coal. Together the three sources provide 87% of U.S. electrical power[13]. The use of coal is on a downward trend while the share of natural gas is rising. The share of nuclear power is roughly stable.

Figure 7: Electric Power Generation by Source

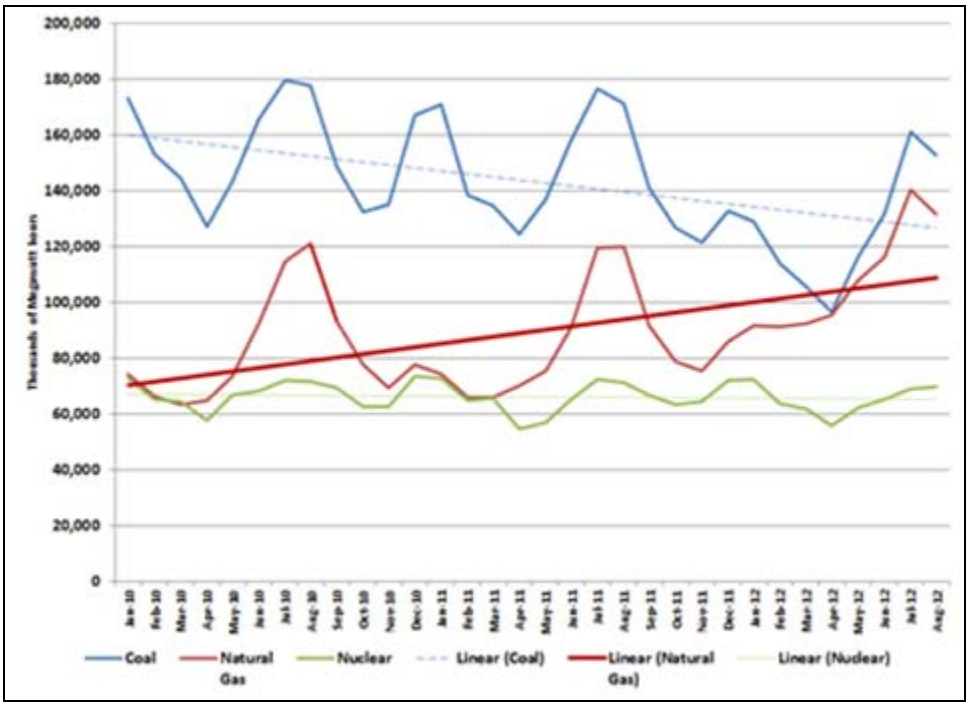
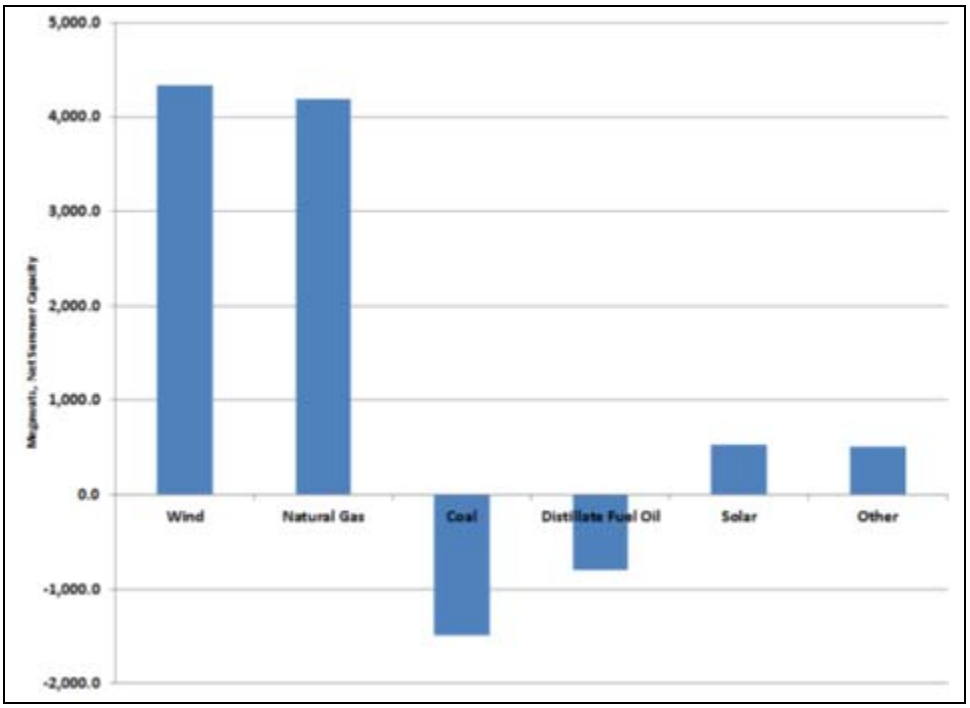


Figure 8[14] further illustrates the substitution by presenting the changes that have occurred in the first three quarters of 2012. The largest new power plants commissioned in 2012 are fueled by coal, natural gas, and wind. The largest decommissioned plants were fueled by coal and oil. Ten smaller natural gas plants were also decommissioned. The net result is less reliance on coal and a greater reliance on natural gas and wind resources.

Figure 8: Net Changes in U.S. Power Generation (Sep 2012 YTD)



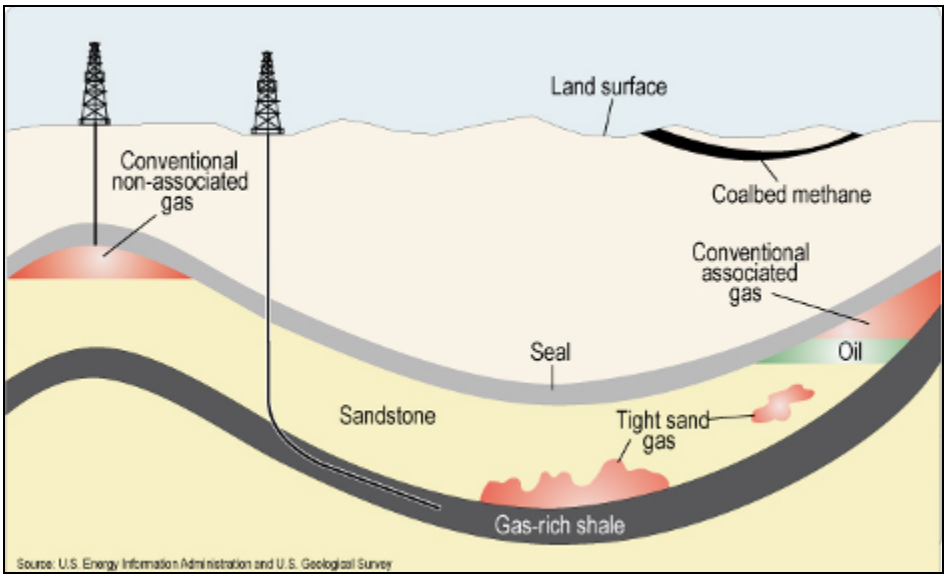
Natural Gas Supply

Geology of Natural Gas[15]

As illustrated in Figure 9, the U.S. Geological Survey and Energy Information Agency (EIA) categorizes the sources of natural gas as follows:

- Gas-rich shale is the source rock for many types of natural gas resources and is the primary subject of this report. Until the combination of horizontal drilling and hydraulic fracturing (fracking) it was not economically viable to recover natural gas directly from shale.
- Coal-bed methane is generated during the transformation of organic material to coal.
- "Tight gas" occurs when gas originating from shale migrates upward and is trapped in a sandstone formation.
- "Associated" conventional gas accumulates in conjunction with petroleum.
- "Non-associated" conventional gas accumulates in conjunction with gas-rich shale. Gas migrates upward but is trapped by an impermeable layer.

Figure 9: Geology of Natural Gas Resources



The fracking process was developed during a long period of experimentation (1981-1999) by George Mitchell (Mitchell Energy & Development) who then used the innovation to exploit the gas the Barnett formation in Texas in the first decade of the 21st century.

While shale has many pores and therefore the ability to store gas, it is not permeable. The gas cannot flow because there are no connections between the pores. By using water and sand under pressure the shale can be fractured, creating the connections that permit the gas to flow to the surface. Conventional vertical drilling permits only limited access to the shale layer while horizontal drilling permits economic access.

Natural Gas Reserves

EIA estimates technically recoverable (proved and unproved) reserves of all types of natural gas at 2,203 trillion cubic feet[16] (Tcf). This is a substantial reserve; as presented earlier in Table 1. Consumption in 2012 was 25.5 Tcf. Unproved shale gas reserve estimates are part of that estimate and are source of serious current debate. EIA's 2012 national estimate is 482 Tcf of shale gas with 141 Tcf being attributed to the Marcellus region. This 2012 EIA estimate is seriously at odds with Penn State University, industry, and EIA's own 2011 forecast, which estimated the Marcellus reserves alone at over 400 Tcf.[17]

Figure 10 illustrates the location of gas reserves. In the northeastern United States the shallowest and least valuable shale is in the Devonian formation; the middle, richest level is the Marcellus formation; and deeper still is the Utica formation. USGS recently issued its initial estimate of Utica reserves at 38 Tcf.

Figure 10: Shale Gas "Plays" in the Lower 48 States[18]

As a practical matter the Marcellus wells are new enough that all public estimates are based on unproven assumptions regarding typical well life and prospective production rates. Both the estimates and the fracking process can be expected to become more refined with time. Sources generally agree, however, that Marcellus/Utica is the largest single source of shale gas in the United States.

Northeastern Shale Gas Geology

The Penn State University's Marcellus Center for Outreach and Research (MCOR)[19] has been active in mapping the Marcellus and Utica regions. In central Pennsylvania the Marcellus shale is more than a mile underground and the Utica shale may be more than a mile below the Marcellus. Both formations are much nearer the surface in New York and Ohio.

As illustrated in Figure 11 and Figure 12 the formations tend to be thicker where they are deeper. The Marcellus varies in thickness between 5 feet and 350 feet in thickness while the Utica can be as thick as 500 feet.

Figure 11: Utica and Marcellus Geological Formations Depth

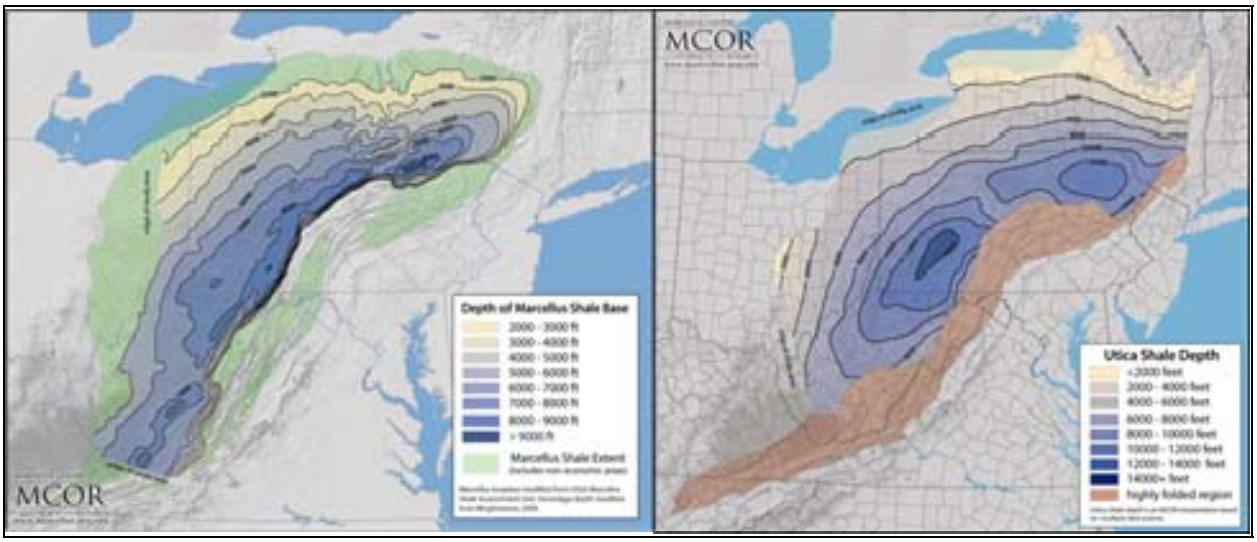
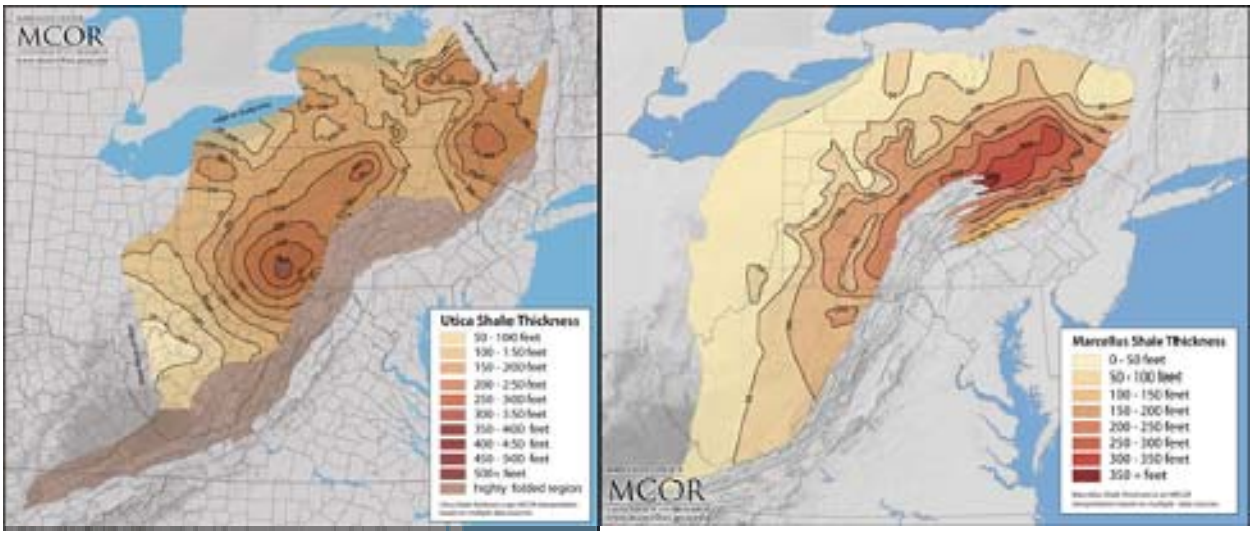


Figure 12: Utica and Marcellus Geological Formations Thickness

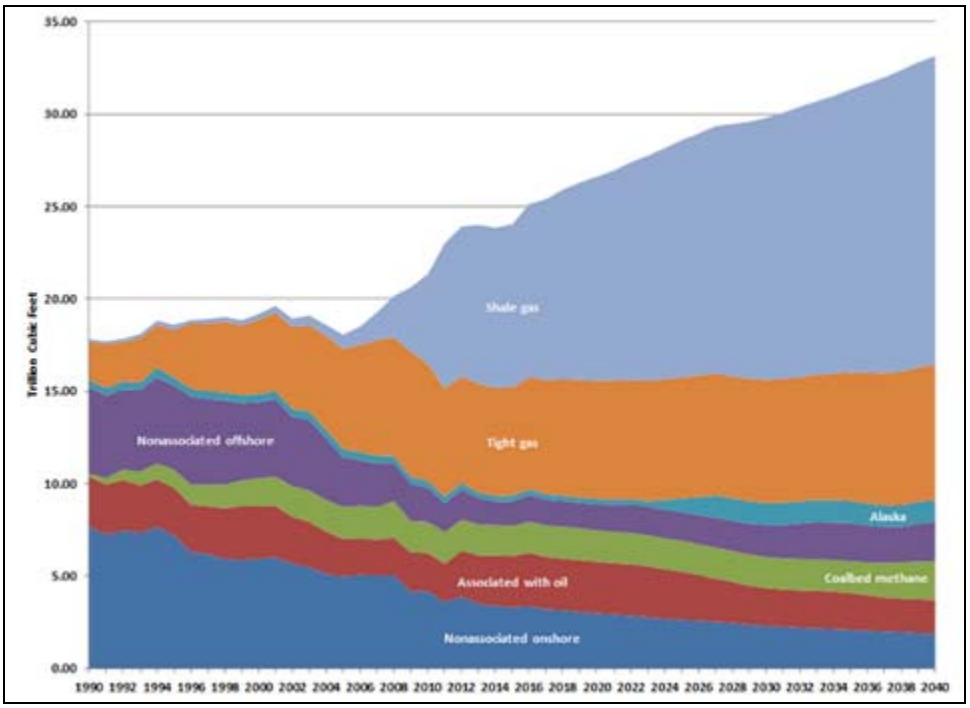


Natural gas originating in the western portion of the region is "wet". "Wet gas" includes natural gas liquids which must be processed and removed leaving "dry gas", the natural gas supplied to customers. Natural gas liquids are valuable byproducts; propane is one example. Natural gas originating in Northeastern Pennsylvania is already dry gas and does not require further processing. Dry gas is primarily methane.

Natural Gas Production

Figure 13[20] shows natural gas production from 1990 and includes the EIA's current forecast through 2035. The chart illustrates the impact that the combination of horizontal drilling and hydraulic fracturing has already had (and is expected to make) on natural gas production. In a very short period, shale gas has become the largest source of natural gas for the U.S. market. The EIA expects shale gas to grow in importance in the next two decades to account for about half of natural gas production by 2037.

Figure 13: Natural Gas Production 1990-2040, Shale Gas is 50% of Total by 2037



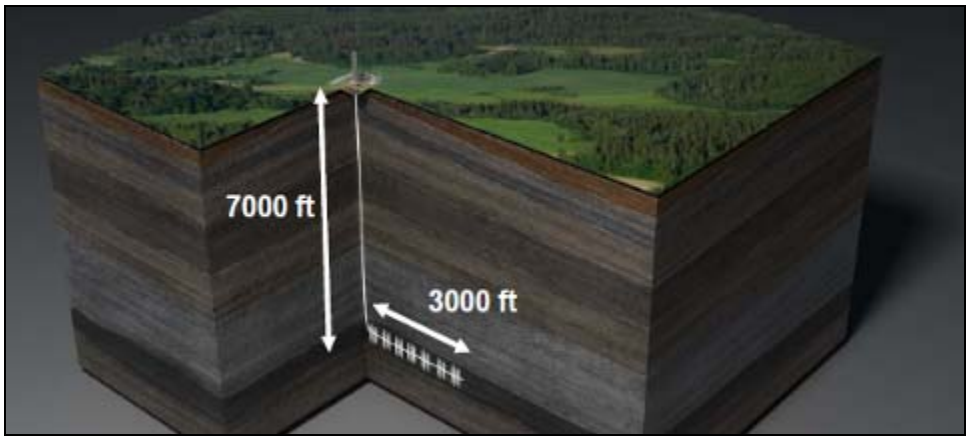
The Fracking Process[21]

Hydraulic fracturing is a conceptually simple process of breaking up underground shale formations to release natural gas. In practice, however, neither the process nor its logistics implications are simple.

The initial step in the process is for the property owner to lease his mineral rights to a driller/producer. The lease is typically time-limited and includes a one-time payment and royalty payments that vary based on the value of the well's production. Landowners are also compensated for the use of additional land for pipelines and related facilities.

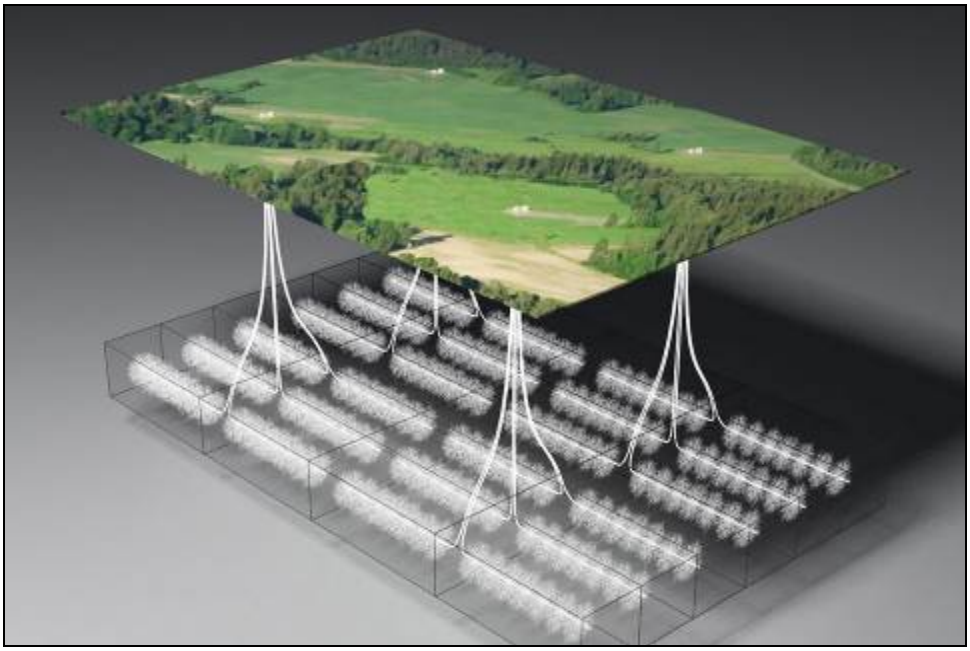
Once the process starts, shale wells are typically drilled around the clock for 15 to 30 days at a cost of $5 to $6 million per well. A typical Marcellus well site is illustrated in Figure 14 below.

Figure 14: Average Marcellus Well



The well is drilled vertically to a level slightly above the shale. The drill is then turned and pushes horizontally as much as 5,000 feet into the formation. This drilling process may be undertaken multiple times from a single well, which allows for the extraction of larger quantities while minimizing surface disruption. One surface well may tap the available gas over hundreds of acres, as illustrated in Figure 15 below.

Figure 15: Multiple Wells per Drilling Pad[22]



Wells are cased and cemented from the surface through the groundwater strata to form a barrier between the wellbore and the ground water. An important environmental concern is that if this step is not completed properly, drinking water may be contaminated.

The next step is to perforate the horizontal portions of the well casing using small explosive charges.

Fracturing fluids (water, sand, chemicals) are then injected into the well under controlled high pressure. Sand or ceramic beads (proppants) in the fluid open the fractures and keep them open. Chemical additives compose less than 1% of the injected fluid. Their job is to avert microorganism growth, prevent corrosion of metal pipes, and maintain fluid viscosity. Friction-reducing additives are also included in the fluid. For some time the composition of the fracking fluid was considered by the drillers to be a trade secret. As this was a source of conflict with environmental groups this information is now publicly available.

Once natural gas is flowing from the well, gathering pipelines move the gas to distribution points (dry gas) or processing plants (wet gas).

Marcellus Natural Gas Production Estimates

Natural Gas

A recent FBR Capital Markets report[23] asserted that the pace of Marcellus production over the next few years will be tied to the pace of pipeline construction. The report estimated Northeast natural gas demand at 12 Bcfd and forecast that the region would enjoy supply/demand balance by 2015. The same report contained the following production estimates:

- Northeastern Marcellus production:
  - 3.1 Bcfd during 4Q 2011
  - 8.8 Bcfd by 2016
- Southwestern Marcellus production:
  - 1.6 Bcfd during 4Q 2011
  - 5.2 Bcfd by 2016

The report went on to include an estimate of 2020 Marcellus production at 18 Bcfd. Utica gas, which appears to show a large additional potential from nearly the same geography as the Southwestern Marcellus, was not included in this analysis. In the report, 4Q 2012 combined production is estimated at 7.1 Bcfd.

Range Resources generally corroborates this estimate. The firm stated in its first quarter 2013 earnings call the "Marcellus is producing close to 9 Bcf equivalent per day and is now the largest-producing gas field in the U.S. and still growing."[24] It seems reasonable to expect production beyond 10 Bcfd in 2013.

Natural Gas Liquids

Regional natural gas liquid (NGL) production is a similar story. The Marcellus/Utica region produced 40,000 barrels/day (Bbld) of NGLs in 2011. Continued development in the Wet Marcellus and Utica regions coupled with the development of natural gas processing facilities will permit a significant increase in regional NGL production. BENTEK expects NGL production to increase to roughly 480,000 Bbld by the end of 2017.[25]

Ethane is currently not being recovered in the region. There are a number of projects in progress to address this problem.

- By mid-2013 50,000–65,000 Bbld of ethane will be exported to Canadian petrochemical facilities in Sarnia, Ontario, through MarkWest/Sunoco's Mariner West pipeline project.
- By mid-2014 70,000 Bbld of ethane and propane will be moving to Sunoco's export marine terminal at Marcus Hook on the Delaware River via the Mariner West pipeline project. The project includes a 45-mile pipeline to deliver ethane from MarkWest's Houston, Pennsylvania, fractionator.
- By early 2014 the ATEX pipeline will have the capacity to transport up to 190,000 Bbld from the Northeast region to Texas.

While current prices have slowed Northeastern Pennsylvania drilling activity recently, there is a backlog of wells which are yet to be connected to the pipeline network. Several of these projects are due for completion prior to the 2012-13 heating season.

Natural Gas Prices

Figure 16[26] illustrates the long term price trend for natural gas. After peaking in 2008, natural gas prices have dropped dramatically due to increasing shale gas supply.

Figure 16: Natural Gas Prices 2000-2012 at Wellhead with Trend Line

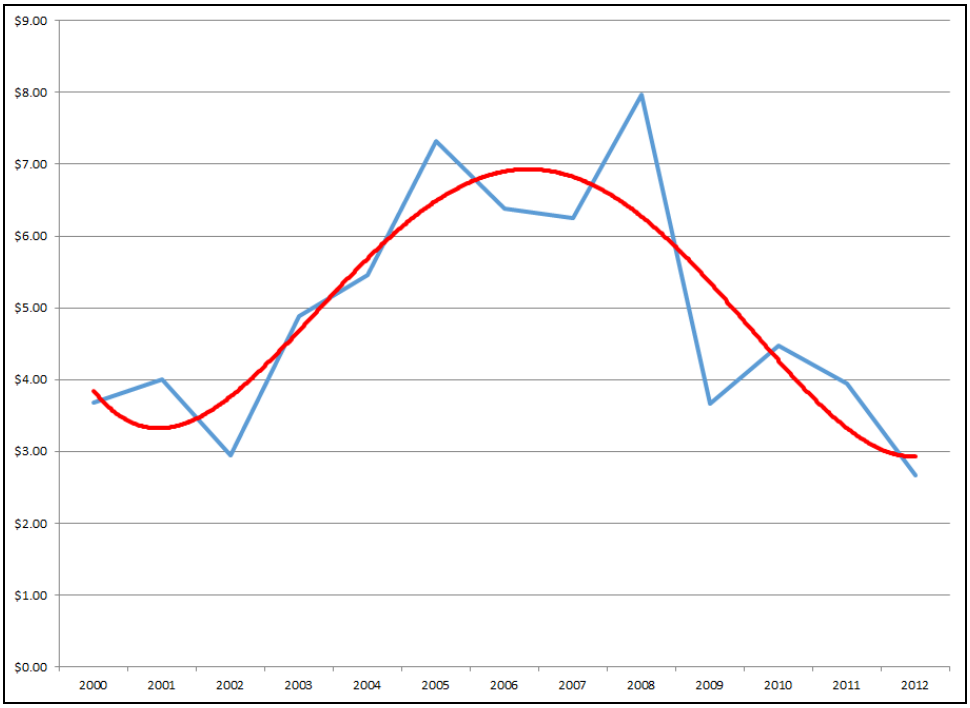
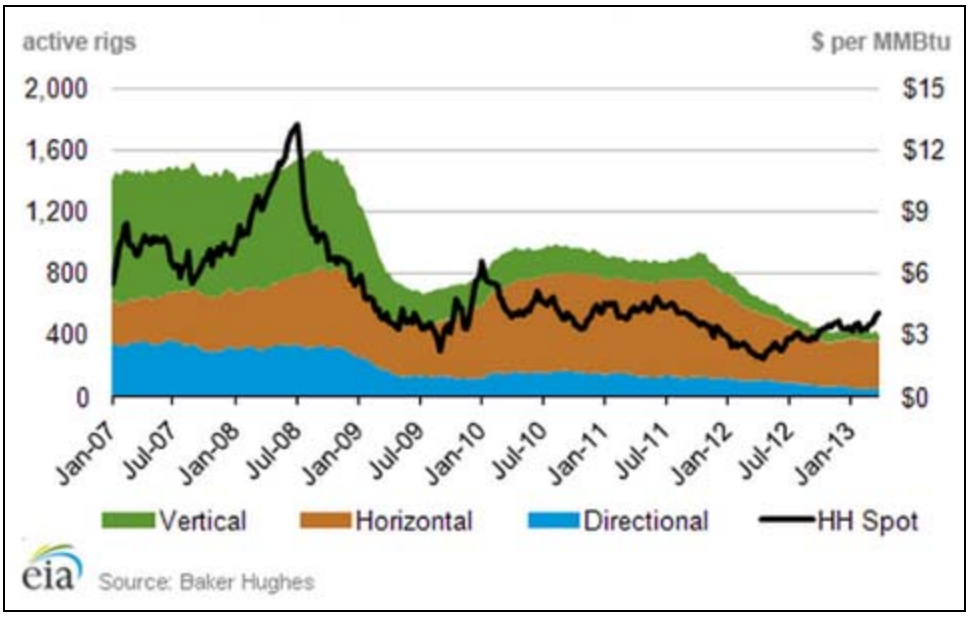


Figure 17[27] illustrates the more immediate trend and shows that:

- The price of natural gas is typically presented as the spot price at the Henry Hub in Louisiana. That price peaked in 2008 above $12 per million BTU. The price has subsequently declined and has remained relatively low since 2010.
- The "rig count" is the count of drilling rigs assigned to new natural gas drilling. This has declined with the price of gas as would be expected.
- What is unexpected is that the decline in drilling activity has not produced a significant increase in gas prices. This is largely due to the higher yield of horizontal wells, and the associated near elimination of new vertical and directional wells.

Figure 17: Weekly Natural Gas Rig Count and Average Spot Henry Hub Price 2007-Jan 2013



Low prices have presented a financial challenge for gas producers. Standard and Poor's recently estimated the internal rate of return based on a long term gas price of $3.50 per million BTU. They estimated a return of over 30% for NGL-rich wet Marcellus gas typically produced in Southwestern Pennsylvania, West Virginia and Ohio, while dry gas Marcellus wells in Northeastern Pennsylvania returned over 10% long term. The only other domestic gas play to produce a return in excess of 10% at a long term price of $3.50 per million BTU is the liquids-rich Eagle Ford play in Texas.[28]

It seems reasonable to draw two conclusions:

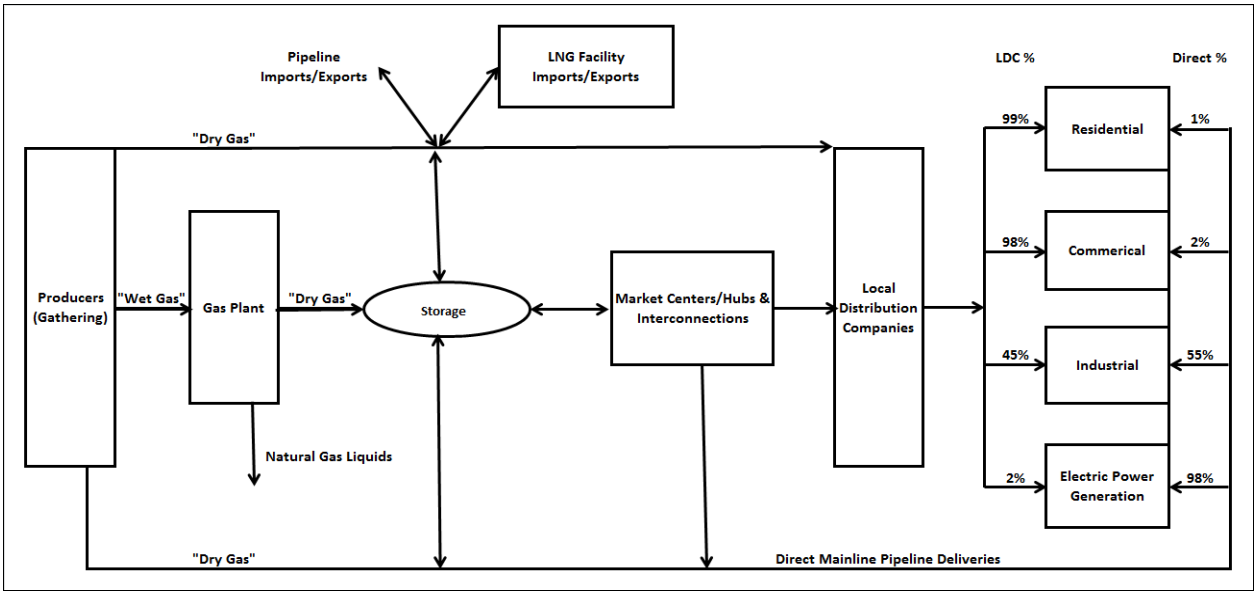
- In the future, the equilibrium price of natural gas will likely stabilize at over $3.50 per million BTU. Prices have increased gradually since mid 2012.
- The Marcellus portion of the natural gas industry is the low-cost provider relative to other U.S. natural gas sources.

Natural Gas Industry Structure[29]

The following section covers the structure of the natural gas industry by first describing natural gas marketing and distribution and then focusing in greater detail on the types of firms involved.

Figure 18[30] illustrates how natural gas is distributed from producers to end users.

Figure 18: Natural Gas Distribution Segments



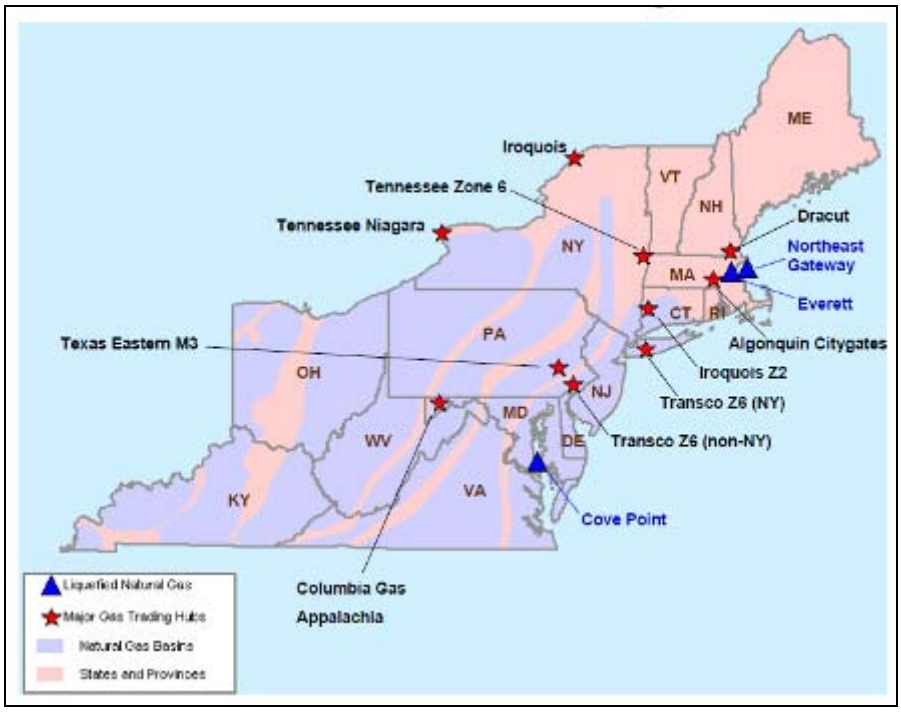
The dry gas typical of Northeastern Pennsylvanian production does not need to be processed at a gas plant and may move via pipeline directly to customers. The first sale of the gas is not regulated, in that a producer may sell gas directly to a local distributor or an end user.

The wet gas typical of the western portions of the Marcellus region must be processed at a gas plant to remove the natural gas liquids, which are marketed separately. The primary output of this process is dry gas, which is marketed as described above.

Figure 18 also shows that most residential and commercial customers obtain natural gas from a local distribution company while most industrial and electric power companies receive natural gas directly from a producer or marketer. In either case the gas may be moved to storage before being sold to an end user.

Because the first sale of the gas is unregulated, a natural gas market has developed. This activity is represented in Figure 18 by the block titled "Market Centers/Hubs & Interconnects." In its simplest form gas marketers purchase and hold gas for resale at a trading hub. Figure 19 shows the trading hubs in the Northeastern United States[31]. There is an associated active futures market which expects the price of gas to increase with time and currently places the 2014 price of gas over $4.00 per million BTU, which is good news for producers.

Figure 19: Northeastern Natural Gas Marketing Region



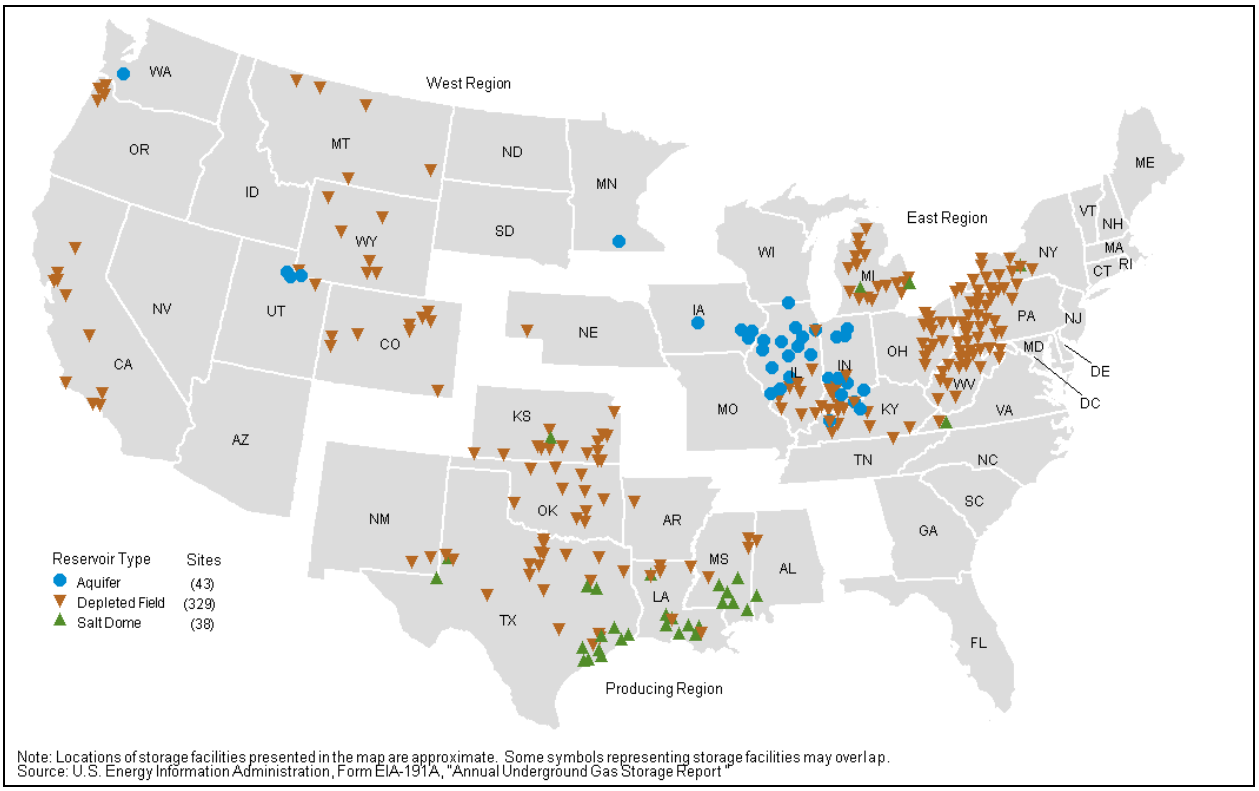
Natural Gas Industry Firms

Local Distribution Companies. There are about 1,200 natural gas distribution companies in the U.S., with ownership of over 1.2 million miles of distribution pipe. Many of these companies maintain economically regulated monopoly status over their distribution region.

Pipelines. Gas typically moves from wells to consumers in an interconnected, continuous series of pipes extending for 1.54 million miles. There are about 160 pipeline companies in the United States, operating over 300,000 miles of interstate and intrastate distribution pipelines. The Federal Energy Regulation Commission (FERC) is responsible for economic regulation of interstate distribution pipelines, which function as common carriers. Prices, entry, and expansion are regulated. Marcellus shale development has significantly changed the demand for distribution pipeline transportation; several new pipeline facilities are planned, under construction, or newly commissioned.

Storage. There are about 123 natural gas storage operators in the United States, which control over 400 underground storage facilities as illustrated in Figure 20[32]. These facilities have a storage capacity of over 4 Tcf of natural gas. Gas can be withdrawn from this system at the rate of over 88 Bcfd.

Figure 20: Lower 48 Natural Gas Storage Facilities by Type (December 31, 2011)



Processors. There are over 530 natural gas processing plants in the United States. They process natural gas and extract natural gas liquids. Several of these facilities are being constructed currently in the liquids-rich natural gas portion of the Marcellus located in Southwestern Pennsylvania, Ohio, and West Virginia.

Producers. There are several thousand firms producing natural gas in the United States. These range from very large firms and operations that are integrated throughout all aspects of the oil and gas industry to small one- to two-person operations. Table 2 presents a list of the largest Marcellus Producers, as understood by Standard and Poor's, including an estimate of production and number of Marcellus acres for which the firm has mineral rights.[33]

Table 2: Top 15 Marcellus Production Companies

Company	4Q11 Marcellus natural gas production estimate (Million cubic feet per day)	Company % of total production	Marcellus net acres, 1Q 12
Chesapeake Energy Corp.	450-910	13	1,780,000
Talisman Energy, Inc.	429-622	20	217,000
Range Resources Corp.	534-375	60	900,000
Cabot Oil & Gas Corp.	460-300	50	188,000
EQT Corp.	233-269	47	532,000
Royal Dutch Shell PLC	213	1	650,000
Anadarko Petroleum Corp	328-193	5	260,000
Chevron Corp.	140	1	714,000
Southwestern Energy Corp.	126	9	187,000
National Fuel Gas Corp.	129-124	62	745,000
Exxon Mobil Corp.	103	1	660,000
Consol Energy Inc.	173-70	16	361,000
EOG Resources Inc.	79-40	2	210,000
Exco Resources Inc.	75-40	7	140,000
Rex Energy Corp.	46-35	71	69,700

Chesapeake Energy Corporation is the most active driller of new wells in the U.S and is an example of how the large drillers vertically integrate their operations in the oil and gas industry. Chesapeake describes its operations as *"discovering and developing unconventional natural gas and oil fields onshore in the U.S. The company has also vertically integrated its operations and owns substantial marketing, midstream and oilfield services businesses directly and indirectly through its subsidiaries."* These subsidiaries include:

- Chesapeake Energy Marketing Inc., which provides "commodity price structuring, contract administration and nomination services for Chesapeake Energy Corporation and its partners."
- Chesapeake Midstream Development, L.P., which "owns, operates, develops, and constructs oil and gas fields and pipelines."
- Chesapeake Oilfield Services Holdings, L.L.C, which "manages several oilfield services companies that help produce natural gas and oil in the United States."

Environmental Issues

As with any extraction process, fracking raises environmental concerns whose resolution could slow or limit production growth. One set of environmental concerns is associated with the unwelcome release of natural gas into the water supply. Other water quality issues include potential adverse impacts on drinking water, concerns about water withdrawal from local sources, and issues regarding treatment and disposal of wastewater. Air quality issues include release of unburned gas into the atmosphere.

Wells are tested using a flaring process, and plugged while equipment is put in place to allow the well to move to the production phase. The flaring process releases potent greenhouse gasses into the atmosphere to an extent that the environmental advantage of natural gas over coal may be called into question.

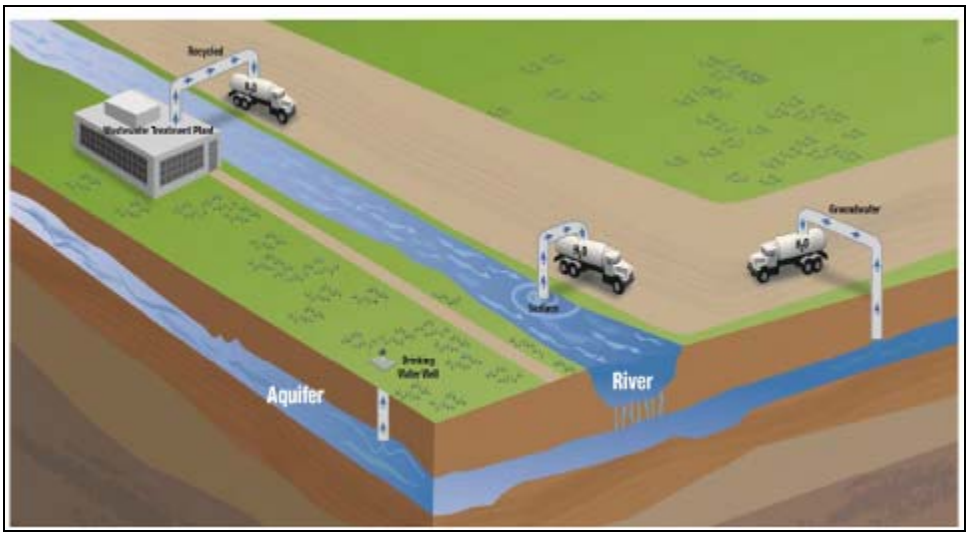
Water is currently the key element in fracking fluid. In Pennsylvania roughly 65% of the water used for shale drilling comes from rivers, creeks, and lakes. The other 35% is purchased from municipalities by drilling companies. The Commonwealth's Department of Environmental Protection (DEP) and the various River Basin Commissions regulate and establish fees for water use. In order to obtain a permit, drilling companies must identify the planned water sources, specify anticipated impacts, and provide waste-water treatment and storage plans.

Water is transported by truck from a withdrawal point or conveyed through a water pipeline to a well location. About 10% to 30% of the water used in the fracking process returns to the surface with the extracted gas. This "flowback" water contains salts and other naturally occurring elements as well as trace concentrations of fracking chemicals. Flowback water is stored temporarily on site and then (1) reused to fracture additional wells, (2) hauled off site for treatment, or (3) disposed of in underground injection wells.

Public response to environmental concerns is a key driver of the pace of future development. The notable differences between New York State and the Commonwealth of Pennsylvania's approaches illustrate the matter. Pennsylvania is generally pro-development, albeit with aggressive oversight, and approximately 10,000 wells have been permitted since 2007.[34] New York imposed a complete moratorium on shale gas drilling in 2008, pending completion of an environmental review due later this year.

The Environmental Protection Agency, at the request of congress, is conducting a study "to better understand any potential impacts of hydraulic fracturing on drinking water and ground water. The scope of the research includes the full lifespan of water in hydraulic fracturing, from acquisition of the water, through the mixing of chemicals and actual fracturing, to the post-fracturing stage, including the management of water flowback and ultimate water treatment and disposal."[35] On December 21, 2012, EPA issued a preliminary progress report. The work is to be completed by 2014. Figure 21 illustrates concerns regarding the large volume of fresh water that is being used in the fracking process.

Figure 21: EPA Study Questions Potential Impacts of Large Volume Water Withdrawals



Penn State Public Broadcasting has identified the three most common occurrences in which water pollution results from shale gas drilling.[36]

- Storm water containing silt and debris may run off the drilling site and into local waterways. This violation of permit plans is commonly cited by the DEP.
- Chemical-laden fluids, gasoline, or diesel fuels may spill or leak and seep into the ground surrounding a drill pad, or flow into nearby fields and streams. While there are a number of ongoing investigations of reported spills, to date there are no substantiated cases of these fluids entering the groundwater supply.
- Methane migration may occur due to faulty cementing procedures. In 2010 PA DEP fined Chesapeake Energy more than $1 million for improper well casing and cementing. Poor workmanship permitted natural gas from non-shale shallow gas formations to migrate into groundwater and contaminate 16 families' drinking water supplies. DEP documented cases of this type of migration in at least 5 Pennsylvania counties in 2011.

The area that is highly technical and controversial is gas seepage from deep underground caused by fracking. Both the extent and the cause of gas seepage are unclear, in part because gas seepage also occurs for other reasons.

Existing water wells provide a conduit for the naturally occurring gas in the aquifer to be released and surface seepage incidents have been reported in the region since the 1600s.[37] The New York Times recently reported a USGS study that showed 9 percent of groundwater samples taken from more than 200 wells in New York State between 1999 and 2011 showed levels of methane that were high enough to warrant further monitoring or steps "to avoid possible explosive conditions."[38] Also a recent industry study in Susquehanna County in Northeast Pennsylvania showed 78% of water wells tested in advance of nearby drilling have detectable levels of naturally occurring methane.[39]

Response by Environmental Organizations

Environmental groups are divided on strategic questions related to natural gas, carbon emissions, and global warming. On one hand, natural gas has important environmental advantages over coal and oil in that it releases less carbon when burned. On the other hand, low-cost natural gas holds the potential to delay transition to cleaner forms of energy. This controversy within the environmental community regarding fracking for shale gas is illustrated by the positions of the Sierra Club and the Environmental Defense Fund.

Environmental Defense Fund (EDF). EDF recognizes natural gas's advantage over coal and oil when burned. Its position is that natural gas can ease the transition to a low-carbon economy, which it views as essential to succeed in the fight against catastrophic global warming. The EDF is working with the industry to ensure that gas is developed in a way that minimizes leaks of methane and protects the environment. Recent EDF studies have focused on harm from leaks in the system, which EDF believes to be correctable. The associated release of carbon could neutralize natural gas's benefits. EDF President Fred Krupp stated, *"It is crucial for industry, regulators and the environmental community to work together to make sure every molecule of natural gas is produced as safely and responsibly as possible. Unfortunately, the industry's response too often has been to argue that hydraulic fracturing can't possibly cause any problems. That kind of denial erodes public trust. That's why EDF is grateful to the industry leaders who are working with us to solve these problems."*[40]

Sierra Club. The Sierra Club initially shared the EDF's view of shale gas but has recently reversed its position and is now opposed to natural gas development as it rejects the immediate environmental advantages of natural gas in favor of a longer-term energy solution involving renewable energy sources. The position was stated by Sierra Club's President as follows: "*Fossil fuels have no part in America's energy future – coal, oil, and natural gas are literally poisoning us. The emergence of natural gas as a significant part of our energy mix is particularly frightening because it dangerously postpones investment in clean energy at a time when we should be doubling down on wind, solar, and energy efficiency.*"[41]

The Sierra Club's program is called "Beyond Natural Gas" and consists of four major platforms:

- Close industry loopholes. The Sierra Club views ending natural gas loopholes as vital in the fight to achieve a clean energy future. (The loopholes referred to by the Sierra Club include exemptions from certain provisions of the Clean Water Act and the Safe Drinking Water Act enjoyed by the fracking industry.)
- Clean up drilling. The Sierra Club is working to correct air and water quality problems and clean up the industry.
- Stop LNG exports. The Sierra Club intends to block all LNG export facilities.
- Protect parks. The Sierra Club will work to defend these lands and ensure the most stringent safeguards are put in place.

II. Shale Gas Wells

Well Drilling Activity

The wells are the basic component of shale gas production infrastructure. Well development drives logistics requirements and transportation demand to bring the materials needed to construct the well and to take away the raw gas for processing. Figure 22 shows a typical Marcellus well pad during the drilling process. The site is typically served by a light duty country road. The well pad has been constructed to support the heavy equipment required for the development.

A Marcellus well costs about $6 million to drill. About $1.5 million consists of motor carrier costs in bringing 3-5 million gallons of water to the well site.[42] The well also requires an estimated 3,500 tons of frac sand,[43] steel pipe, cement, and construction materials.

Figure 22: Shale Gas Well Pad with Drilling Rig

Drilling Locations

Marcellus/Utica drilling activity has been centered in two areas. The dry Marcellus region is in Northeastern Pennsylvania in the northern tier of counties northwest of Scranton and bordering on New York State. The wet Marcellus/Utica region is located in the areas of Ohio, West Virginia, and Southwestern Pennsylvania near Pittsburgh, as illustrated in Figure 23 through Figure 25.

Figure 23: Marcellus/Utica Well Locations[34] - Pennsylvania

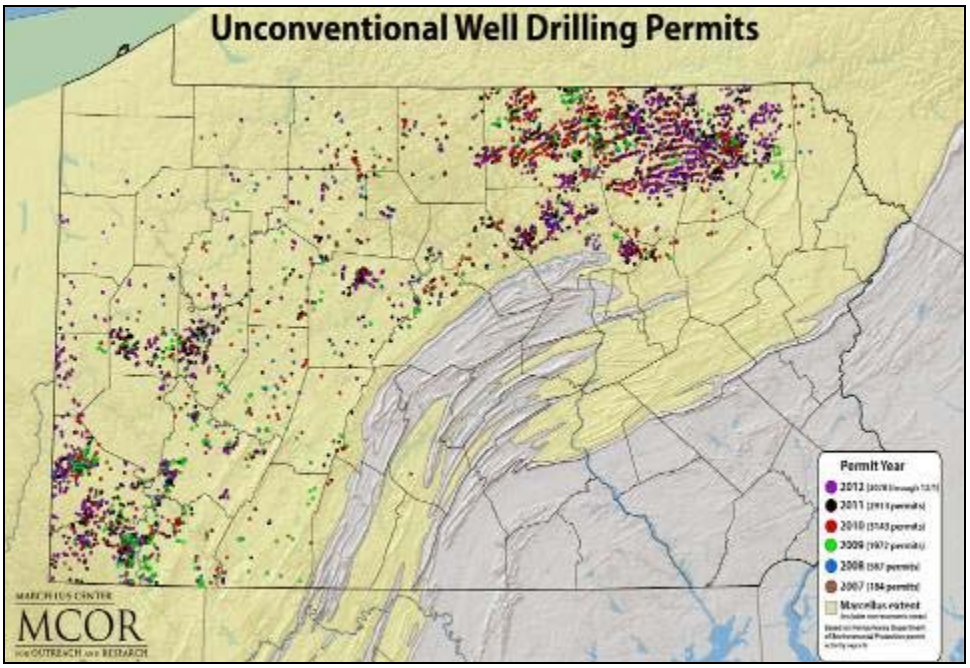


Figure 24: Marcellus/Utica Well Locations[44] - West Virginia

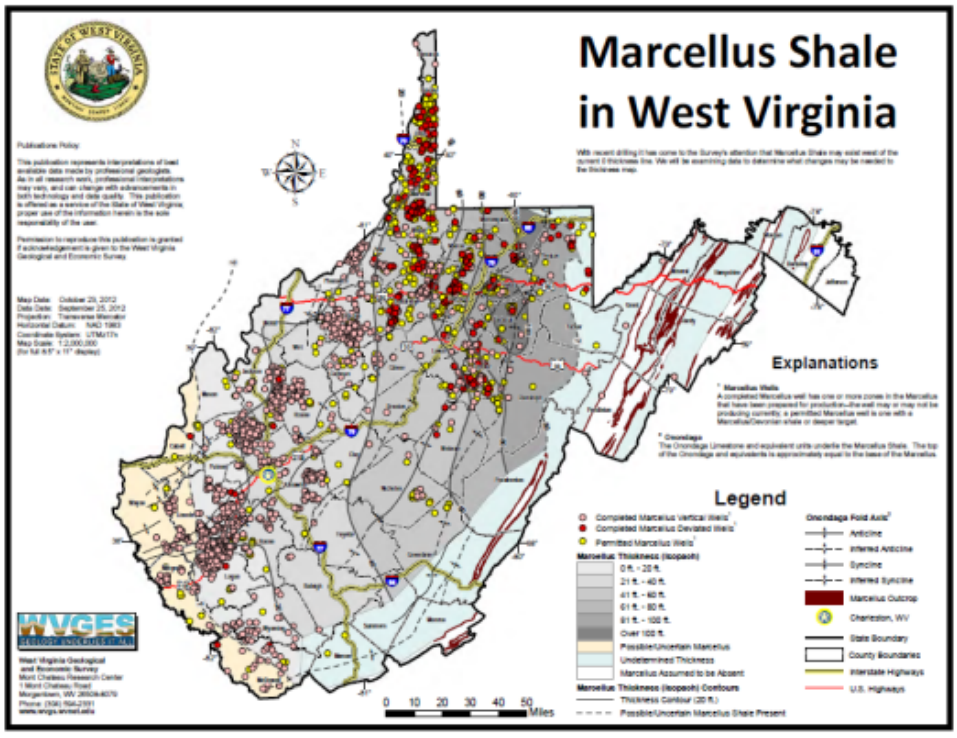
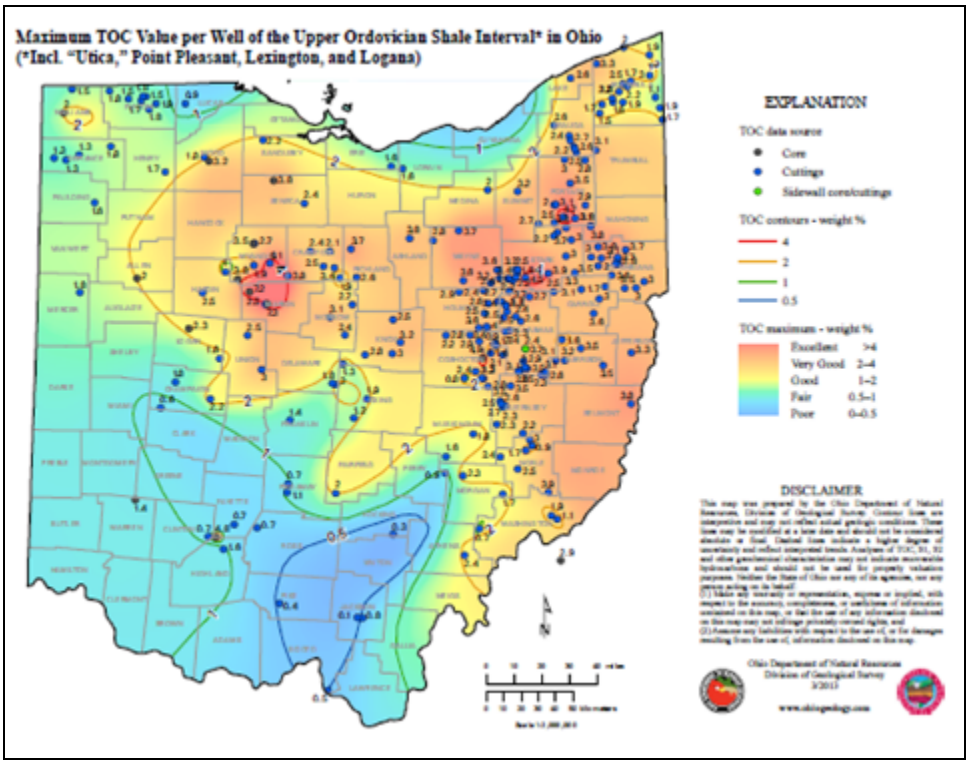


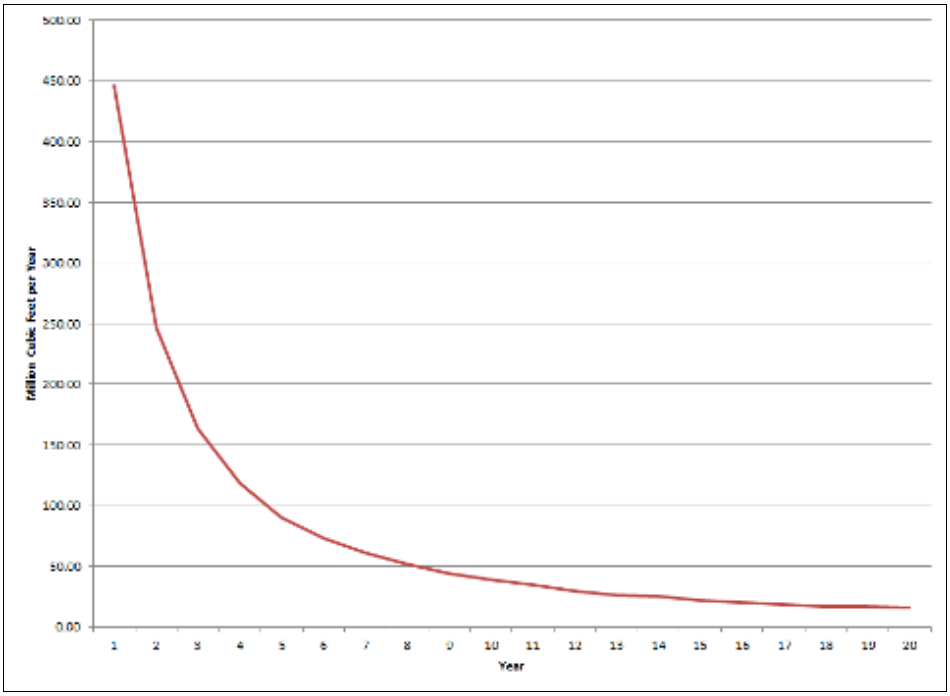
Figure 25: Marcellus/Utica Well Locations[45] - Ohio



Well Depletion

The EIA estimates that nearly 65 percent of the well's estimated ultimate recovery (EUR) is produced in the first four years, as illustrated in Figure 26.[46]

Figure 26: Marcellus Well Estimated Average Production Profile



EIA's forecast for gas reserves in the region is derived from an assumption regarding the average production of each well:

- 1.56 billion cubic feet for a Marcellus well
- 1.13 billion cubic feet for a Utica Well

These numbers can be expected to become more accurate with time.

The result is that once an equilibrium production point has been achieved in the region, new wells must be drilled each year to maintain production levels. Over time, the number of new wells drilled each year will be adjusted to reflect anticipated market conditions.

Marcellus/Utica Wells Forecast

The 2012 EIA Annual Energy Outlook forecasts the eventual need for more than 100,000 Marcellus and Utica gas wells[47]. As a result, it is anticipated that exploitation of this resource will be a multi-decade effort, the precise dimensions of which are as yet undetermined.

The estimate is derived from the following assumptions:

- The Marcellus region covers 104,067 square miles over several states, as previously illustrated in Figure 26.
- About 5 wells are required per square mile, and 18% of the area is suitable for drilling.
- 90,216 Marcellus wells would thus be required to cover the Marcellus region.
- There are about 16,590 square miles in the Utica region.
- An average of 4 wells are required per square mile in the 21% of the area suitable for drilling.
- 13,936 Utica wells would thus be required to cover the Utica region.

The combined total would be 104,152 wells. However, most of the Marcellus area remains untested. The EIA forecast therefore contains the following important caveat: "The estimation of Marcellus shale gas resources is highly uncertain, given both the short production history of current producing wells and the concentration of most producing wells in two small areas, Northeast Pennsylvania and Southwest Pennsylvania/Northern West Virginia."[48] As these are all very uncertain numbers, this analysis will use 100,000 as the number of Marcellus/Utica wells that will ultimately be required.

Tioga's estimate of current Marcellus/Utica region drilling activity is 200 wells per month based on the current drilling rig count. As of December 14, 2012, 123 gas drilling rigs were working in the Marcellus/Utica region. This figure is down from 142 working on that date in 2011.[49] It takes 15–30 days to complete an average well. These observations imply that the current level of effort will produce 120–240 wells per month. This number is also consistent with a total of 2,382 wells

drilled in Pennsylvania in 2012. About 57% of these wells were unconventional fracking wells (i.e., involved horizontal drilling).

Because gas prices are low and pipeline capacity is not yet in place, Tioga believes the future rate of drilling will be higher. Tioga's current estimate of medium-term Marcellus/Utica activity is approximately 250 wells per month. This estimate is based on the rate of drilling permits issued, which is an indicator of the industry's intentions. Some 2,954 permits were issued in Pennsylvania in 2012 for unconventional, horizontal wells alone. Ohio and West Virginia issued 452 and 471 permits for unconventional wells during the same period. This estimate of 250 wells per month or 3,000 wells per year was used to forecast related cargo flows.[50]

There is a trend toward drilling more wells from each drilling pad. In the long term this trend will alter the inbound commodity mix for each well. Commodities used for pad construction, such as concrete, will not grow as fast as commodities used for operating the wells, such as frac sand and water.

III. Inbound Commodities, Facilities, and Transportation

Inbound Commodities

This chapter discusses the cargo flows and associated transportation services necessary to support the well drilling activity. The process involves bringing large amounts of water, sand, pipe, and cement to mostly rural well locations. The major inbound logistics flows and related facilities are as follows.

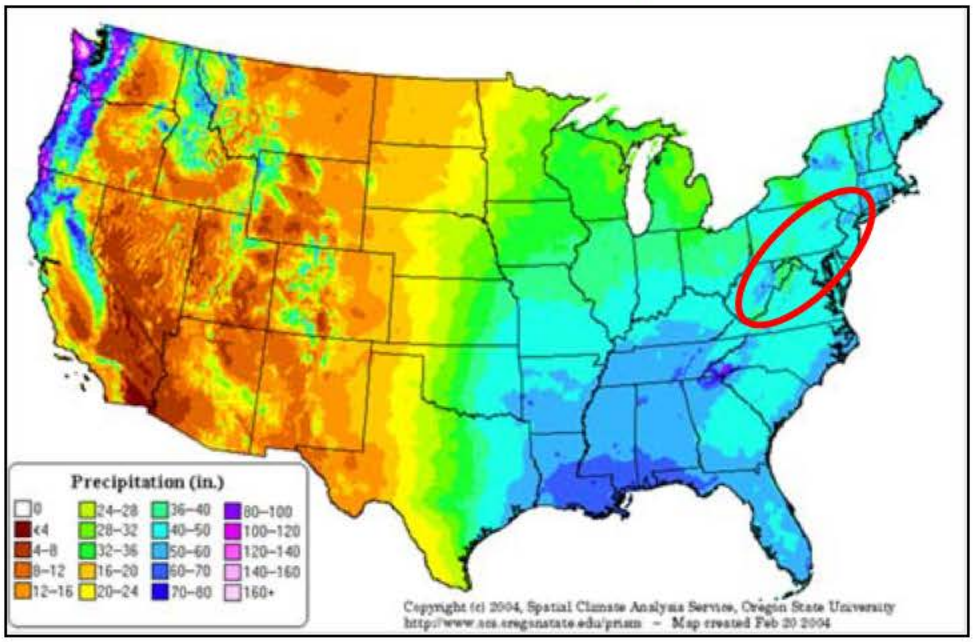
- **Water.** Driller Chesapeake Energy reports that an average Marcellus horizontal deep shale gas well requires of 5.6 million gallons of water per well to drill and fracture.[51] This water is obtained locally, most often using trucks on local roads or highway. In some cases pipelines have been developed to reach the well sites.
- **Cement.** Cement is typically obtained from a local source or distribution point and transported to the well site by truck. A typical well requires 125 tons of cement. The cement may be moved to the distribution point by barge.[52]
- **Sand.** The amount of sand required per well is variously reported at between 2,500 and 4,000 tons. This report assumes U.S. Silica's 3,500 tons per Marcellus well as a planning figure.[53] Sand has been moving almost exclusively by rail to transload facilities near the well sites for final delivery by truck. There appears to be an opportunity for barges to gain a meaningful share of this market.
- **Pipe.** Pipe is required for both for the well infrastructure and for the gathering pipeline that moves the raw gas downstream. A typical well will require about 20 truckloads of pipe (Figure 27)[54].
- **Chemicals.** About 8 truckloads of various chemicals are moved to each well from a diverse set of origins.
- **Aggregate.** A typical well requires about 5,000 tons of aggregates to produce the well pad. This is typically sourced locally and delivered by truck.[55]

Figure 27: Oil Country Tubular Goods (OCTG) Pipe Shipment by Truck

Water

Water, the key ingredient in the fracking process, is relatively plentiful in the Marcellus/Utica region where average rainfall averages at least 35 to 45 inches per year.

Figure 28: U.S. Annual Precipitation (1971-2000)



In Pennsylvania roughly 65% of the water used for shale drilling comes from rivers, creeks, and lakes. The other 35% is purchased from municipalities. The Commonwealth of Pennsylvania's Department of Environmental Protection (DEP) and the various River Basin Commissions regulate and establish fees for water use. To obtain a permit, drilling companies must identify the planned water sources, specify anticipated impacts, and provide waste-water treatment and storage plans. Water is transported by truck from a withdrawal point or conveyed through a water pipeline to a well location.

Proppants/Fracking Sand

Proppants

Proppants are used in oil and gas fracking to hold the fractures created by the process open, permitting gas to flow to the wellhead. There are three types of proppant in wide use at this time. In 2011, 77% of the market was met by "frac sand" (most of which is northern white alpha quartz), 13% of the market was met by resin-coated frac sand, and 9% by ceramic proppants. Ceramic proppants are typically sourced in Asia.

Frac sand is a high-purity sand with very durable and very round grains of specific sizes. Frac sand is a highly specialized, crush-resistant material. More expensive ceramics or resin-coated sand are used where fracking pressures are required to be higher than sand alone can endure. Figure 29 below illustrates the difference between frac sand (on the right) and a typical sand of similar grain size (on the left). Notice how the frac sand has a very uniform grain size, rounded

grain shapes, and a uniform composition. Northern white alpha quartz sand is a very strong material that is highly resistant to fracturing under very high pressures.

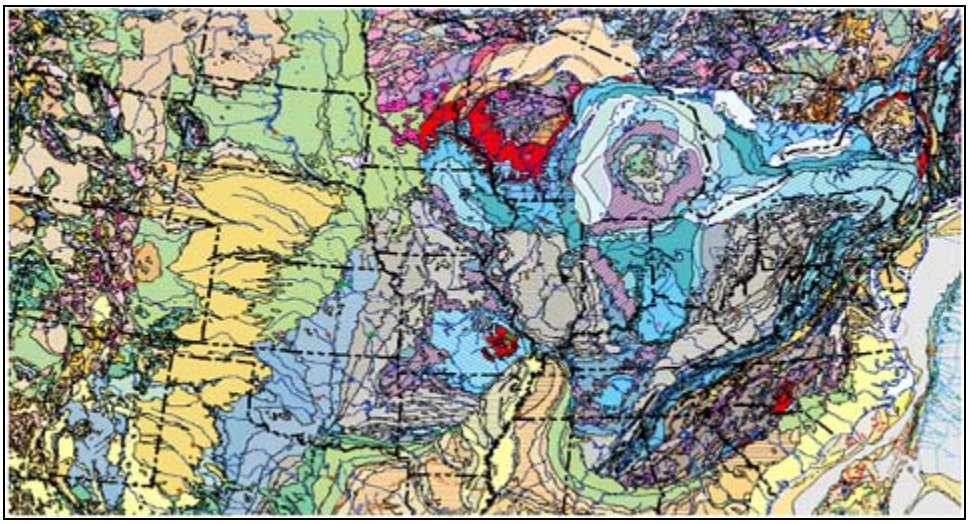
Figure 29: Frac Sand vs. Regular Sand

Photo © BanksPhotos, iStockphoto.

Frac Sand Mines

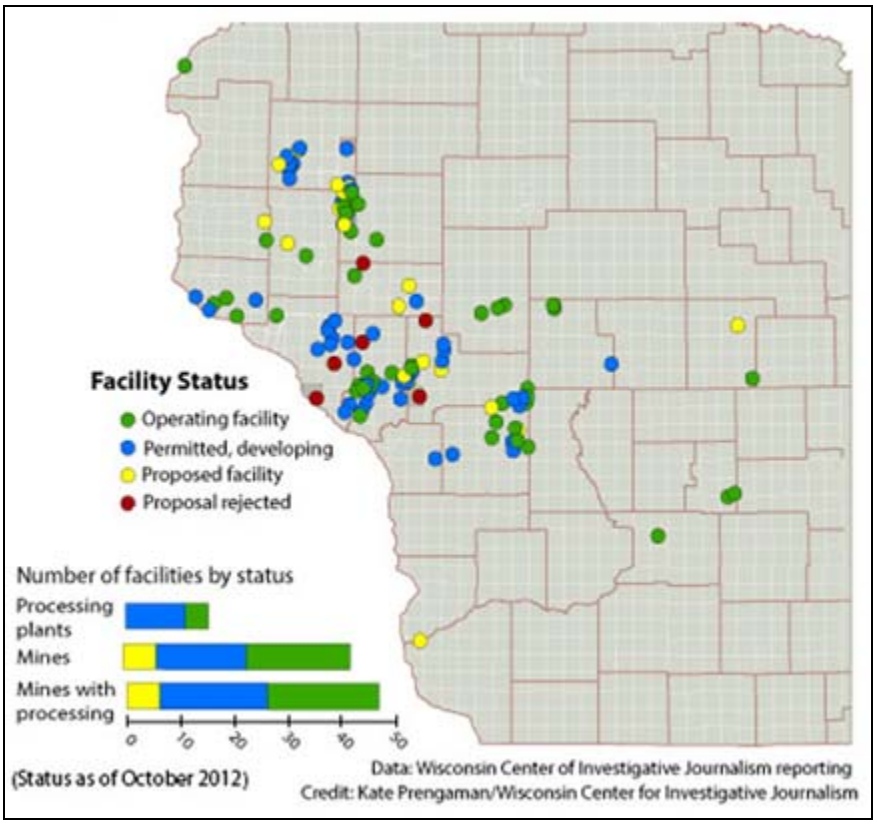
The primary sources of high quality frac sand are quarries located in the upper Midwest, primarily Wisconsin, Minnesota, and Missouri. Another very large source of frac sand is located in a small, but prolific pocket on the Illinois River near Ottawa, Illinois, as illustrated in red on Figure 30.

Figure 30: Major Sources of Frac Sand



Source: USGS

Figure 31: Wisconsin Frac Sand Industry



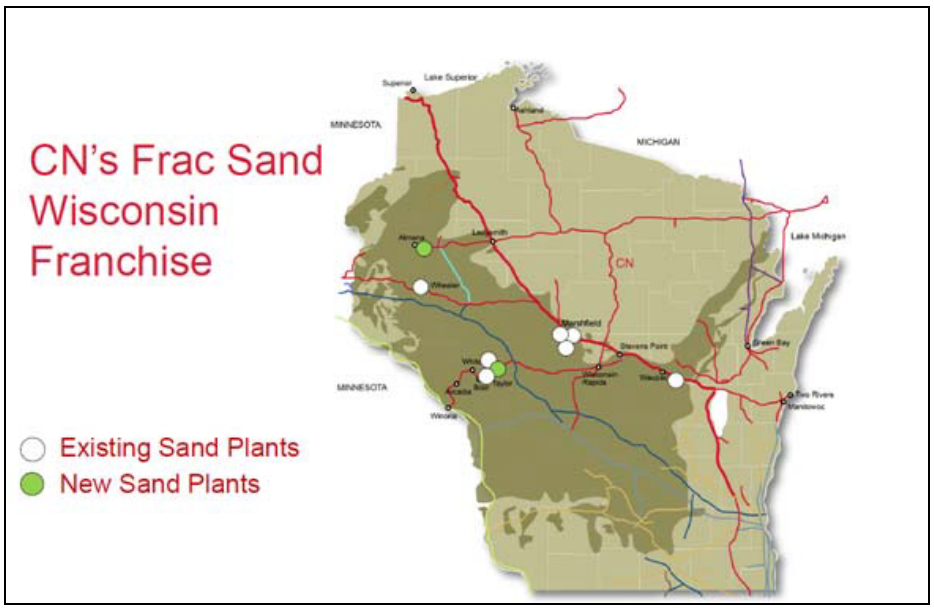
In Wisconsin alone, mines with the capacity of 14.1 million tons/year are under construction and mines with an additional capacity of 11.5 million tons/year are permitted or proposed. These numbers stand in contrast to current production, which is 28.5 million tons annually, implying that the industry is presently being overbuilt.

From these Midwestern sources the frac sand moves by rail or barge to transfer terminals in the Marcellus region, where sand is inventoried for short notice delivery to well sites.

Frac Sand Rail Facilities and Equipment

Frac sand is moving in large volume, primarily by rail, from the Upper Midwest to North Dakota, Northeast Pennsylvania, Appalachia (Southeast PA, WV, OH), the South Central U.S. (TX, OK, LA), and Western Canada. The railroads see oil and gas industry movements as the strategic replacement for declining coal business and they have responded to the increased demand for sand transportation by developing (with their partners) numerous transload terminals in origin and destination areas. The railroads have also invested in track rehabilitation and upgrades necessary to serve the sand trains. Canadian National (CN) is particularly well positioned in Wisconsin to originate frac sand shipments, as illustrated in Figure 32.

Figure 32: CN's Frac Sand Wisconsin Franchise



CN's Barron Subdivision restoration is one of the largest rail frac sand infrastructure projects in the nation. CN and Superior Silica Sands made a multi-year agreement to move frac sand from a new 85-acre sand processing facility near Poskin, Wisconsin. The sand facility has the capacity to produce 2.4 million tons per year. CN is spending $35 million to restore rail service on nearly 40 miles of track west of Ladysmith, Wisconsin. CN is also upgrading its track between Winona, Minnesota, and Whitehall, Wisconsin, to support frac sand movements. This upgrade is likely to increase competition for barge loading operations in Winona, Minnesota. In the shale gas production areas, transload facilities must be located near the well sites with easy access to highways.

In the Marcellus/Utica region the transload facilities unload the rail cars, store a range of products (the most important of which is frac sand), and then transfer products to tractor trailers. Figure 33 illustrates a typical rail-served transload facility.

Figure 33: Wellsboro & Corning Railroad PA Transload Facility

Norfolk Southern Railway (NS) moved more than 3 million tons of frac sand into the Marcellus and Utica region in 2011. By mid-2011, NS had connections with 57 terminals on its own lines or with its shortline partners. NS has refurbished and modified about 1,000 covered hopper cars,

upgraded track, added employees, and increased locomotive power in the region.[56] CSX is the other rail carrier in the Marcellus Region. CSX frac sand carloads increased to more than 12,000 in 2011.[57]

The small-cube covered hopper rail car fleet (Figure 34) used for frac sand now stands at about 83,000 cars, and a frac sand car shortage that existed in 2011 has been addressed. Most of the new rail cars are owned by shippers, short lines, and leasing companies. Almost 18,000 small-cube covered hopper cars were ordered between June 2010 and June 2011. Those cars have been delivered and the production backlog addressed, as illustrated in Figure 35.

Figure 34: Small Cube Covered Hopper

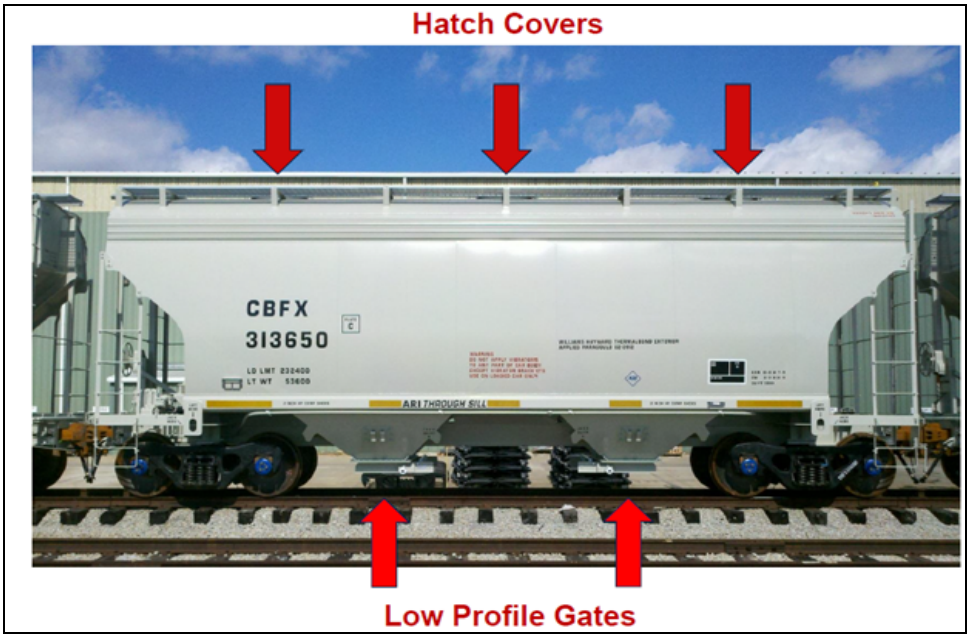
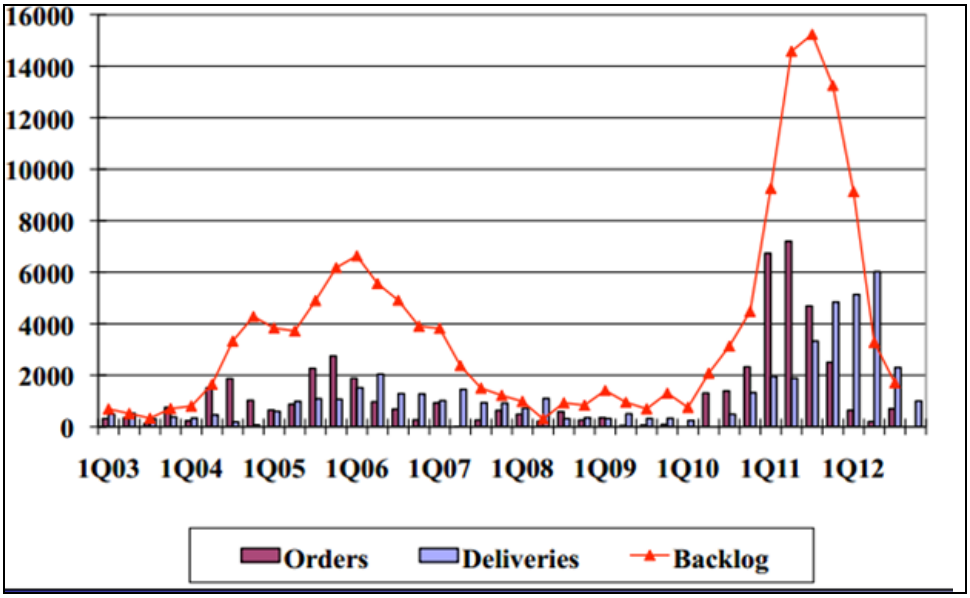


Figure 35: Small Cube Covered Hopper Car Production[58]



Steel Pipe

Domestic Production

The shale gas industry requires steel pipe in large quantities, both for the wells and for the pipelines needed for gas collection and transportation. Increased demand has stimulated several projects that expand regional steel production capacity. For example:

- In October 2012, United States Steel opened a $100 million, 325,000 square-foot mill at its Lorain plant to manufacture steel pipe for the drilling industry.
- Timkin Company is constructing a $200 million, 83,000 square-foot addition to its existing plant in Canton, Ohio.
- Vallourec & Mannesmann recently produced their first tubular steel pipe at its new $650 million, 1.1 million square-foot steel pipe mill in Youngstown, Ohio, and are building a separate 200,000 square-foot mill nearby to thread the pipe.[59]
- In 2011 Republic Steel announced plans to invest $85.2 million in a new furnace in Lorain, OH. The new operation will employ 450 people.[60]
- TMK Steel started manufacturing steel fittings and connectors for steel pipe in Brookfield, OH in 2010. The firm is producing two lines of threaded fittings and connectors with over 70 employees and is considering installing a third production line to meet demand.[61]
- U.S. Steel remains a major supplier to the industry from its Mon Valley Works near Pittsburgh.

Marine Imports

Seamless Steel Pipe. About half the seamless pipe used in the oil and gas industry is imported. This high quality pipe is also known as Oil Country Tubular Goods (OCTG) and is used in well construction. About 76% is imported through Houston. Other ports with significant seamless pipe import volume include Detroit, Los Angeles, and Philadelphia. While some of this pipe could move by barge to the Marcellus/Utica region, USACE inland waterway data for 2010 showed no evidence of this type of movement.

Line Pipe. In this context, line pipe is used to construct pipelines. Houston and New Orleans are the major receivers of line pipe, with over half the imports in those districts. Other Customs districts with significant line pipe import volume include Detroit, Los Angeles, and Laredo. North Dakota's Baken oil field also receives a significant volume of line pipe imports. That volume is spread between several Customs districts, including Great Lakes districts such as Duluth.

Marcellus/Utica Region Logistics

The shale gas industry logistics system appears to be evolving in the direction of minimizing of transportation costs. For fracking water supply, this trend is reflected in the development of water pipelines. Concurrently, supply chains for other commodities are evolving with the sale point and the maintenance of inventory moving toward distribution centers or transload facilities

near the drilling activity. This emphasis on reduced logistics costs is likely a prerequisite for an increase in barge market share, particularly as the Ohio River borders the rapidly developing Wet Marcellus and Utica development zones.

US Silica, Unimin, Fairmont, and Preferred are reported to be the major firms currently supplying frac sand to the Marcellus region. Interviews conducted in late 2012 with sand firms produced the following information:

- Unimin is the largest U.S. supplier of fracking sand overall and ships exclusively by rail due to the location of its mines.
- U.S. Silica has four transload terminals that serve the Marcellus shale region. Three are barge and rail served: East Liverpool, Ohio, and Rook, Pennsylvania, on the Ohio River; and Fairmont, West Virginia, on the Monongahela River. The fourth terminal is at Renovo, Pennsylvania and is exclusively rail-served.
- The Santrol division of Fairmont Minerals is developing a barge terminal at Tiltonsville, OH, to be completed in mid-2013.
- Preferred has made one test shipment by barge to the Pittsburgh area and expects to make more.
- Mississippi Sand has mines in Missouri and primarily serves southern points. When serving the Marcellus region, Mississippi Sand uses a barge terminal in Marietta, Ohio.

These rail- and barge-served facilities mainly use brownfield development sites or remodel existing bulk terminals as necessary to support frac sand and other commodities. For example, in October 2012, S.H. Bell and U.S. Silica announced an agreement in which U.S. Silica will use Bell's facility to maintain inventory and advance the sale point of its products closer to the market. Bells East Liverpool Terminal (Figure 36) opened in 1963 and is described by Bell as a storage, transfer, and warehousing facility capable of processing, crushing, screening, and packaging of materials.[62]

Figure 36: U.S. Silica/SH Bell E. Liverpool, OH Facility

Suppliers and distributors with access to both rail and waterway transport are seeking to use a combination of both to secure lower rates via rail-barge competition. For the Wet Marcellus and

Utica gas drilling activity, the purveyors of those commodities that perceive commercial advantages in using the Ohio River and inland waterway system appear to be finding sufficient developable existing bulk terminals and brownfield development sites served by both barge and rail.

Highway Infrastructure

Most of the drilling activity occurs in rural areas. Water, sand, chemicals, concrete, and building materials are moved to drilling sites by highway, raising major issues regarding road wear and condition. Road wear was a serious problem in Pennsylvania in early the drilling activity, but it now has become a non-issue due to proactive work by drillers to address road conditions before drilling begins and impact fees paid to local governments.

It appears that the road wear problem will not be repeated in the Utica sections of Ohio, which require road use agreements before drilling can begin. An example is the recent reparation and upgrading of Jefferson County, Ohio, roads at the expense of the oil and gas industry[63] at a cost of $4.5 million.

IV. Outbound Commodities, Facilities, and Transportation

Outbound Commodities

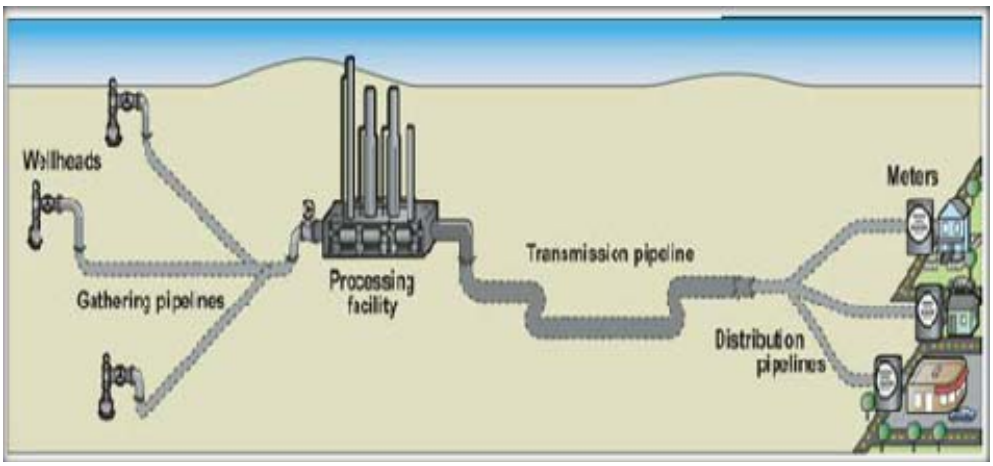
This chapter discusses the cargo flows and associated transportation services necessary to take gas and waste water away from well locations. The major outbound logistics flows from the well site include:

- **Dry Natural Gas.** Consumer quality natural gas is typically moved by pipeline. About half the new regulated pipeline construction in the U.S. is in Pennsylvania, and gas production is currently limited by the ability of the pipeline system to carry the gas to market.
- **Wet Natural Gas.** Raw natural gas is typically moved by gathering pipeline to processing plants near the drilling sites. From these plants consumer-quality dry gas enters the pipeline system for distribution.
- **Natural Gas Liquids.** NGLs are the other product of this process and they may be moved to customers by pipeline or rail. Some movements from the North East to the Gulf have been made by barge in advance of the completion of new pipeline.
- **Wastewater.** Shale gas wells also generate large volumes of flowback wastewater. Wastewater is currently transported by truck, with transloading to barge being held up by a Coast Guard regulatory process. Trucks are moving the water to treatment plants in Northeast Pennsylvania, and to deep wells in Ohio and Western Pennsylvania. One experimental technology promises to economically treat flowback water on site through a solar powered evaporation process.

Natural Gas Pipelines

Natural gas typically moves from wells to consumers in an interconnected network of pipelines, as illustrated in Figure 37. There are about 160 pipeline companies in the United States, operating over 300,000 miles of interstate and intrastate distribution pipelines. Marcellus shale development has significantly changed the character of demand for distribution pipeline transportation in the Northeast. Several new pipeline facilities of all categories are planned, under construction, or newly commissioned.

Figure 37: Production, Gathering, & Transmission Diagram



Source: Pipeline & Hazardous Material Safety Administration

One example is Kinder Morgan Energy Partners' project to expand its Tennessee Gas Pipeline. The expansion runs from the heart of the dry Marcellus region in Bradford County, PA to the Mahwah, NJ Meter Station in the New York metropolitan area (Figure 38). The Tennessee Gas Pipeline connects with the Algonquin Gas Transmission Line at Mahwah. The Algonquin Line delivers natural gas to New England.

Figure 38: Tennessee Pipeline, Northeast Upgrade Project

Tennessee Pipeline will upgrade its existing 24-inch diameter pipeline by constructing an adjacent 30-inch diameter pipeline. The work is being done in two phases: the 300 Line Project, which was approved in 2010; and the North East Upgrade Project, which was approved in December 2012. Together, these will add about 1 Bcfd of new transportation capacity serving the northeastern population centers. The Northeast Upgrade Project is expected to cost approximately $400 million, with a majority of the capital spending occurring in 2013.

In addition to these large interstate transmission system projects, there is a companion effort to develop local gathering lines. Natural gas gathering lines are typically 8 to 30 inches in diameter, constructed of steel, and have cathodic protection applied to the exterior to protect the structural integrity and guard against corrosion. Line pressures for transporting unconventional natural gas from the wellhead can range from 70 to 1,100 pounds per square inch (psi). Pipelines are generally buried between three to five feet below the surface, or deeper if an operator is boring underneath roadways, rail lines, or waterways. The right of way width is negotiated with the landowner but is typically between 50 to 75 feet wide and generally must remain clear of obstructions.

As of October 1, 2012, about 2,536 miles of gathering pipelines serving shale gas wells have been developed in Pennsylvania.[64] Since 2010, more than half of the federal applications for new pipelines involved Pennsylvania. In late 2012, Reuters published a list of Marcellus-region transmission pipeline projects with anticipated project completions in 2012 and 2013, as presented in Table 4.

Table 3: Transmission Pipeline Projects Anticipated in 2012 & 2013

Project	Operator	Capacity Mcf/d	State	Startup Date
Inergy Marc 1 Hub Line	Inergy Midstream	555	PA	Nov 2012
Ellisburg to Craigs	Dominion Transmission	150	PA	Nov 2012
Tetco Team 2012	Texas Eastern	200	PA	Late 2012
Northeast Supply Diversification Project	Tennessee Gas Pipeline	250	PA/NY	Nov 2012
Station 230C Project	Tennessee Gas Pipeline	320	PA/NY	Nov 2012
Line N Expansion	National Fuel Gas Supply Corp	150	PA	Nov 2012
Northeast Expansion Project	Dominion Transmission	200	PA	Nov 2012
Northern Access Expansion Project	National Fuel Gas Supply Corp	320	PA/NY	Fall 2012
Marcellus Expansion Phase	Equitrans	800	WV/PA	Late 2012
Northeast	Williams	100	PA/NJ	Late 2012
MPP Pipeline	Tennesee Gas Pipeline	100	PA	2013
Northeast Supply	Transcontinental Gas	250	PA	2013
Sabinsville to Morrisville	Dominion Transmission	92	PA	2013
TETCO Team 2013 Expansion	Texas Eastern	500	PA	2013
Tioga Area Expansion	Dominion Transmission	270	PA	2013
Dominion Keystone Pipeline	Dominion Transmission	500	PA	2013
Northeast Supply Link	Transcontinental Gas	250	PA/NJ/NY	2013
Northeast Upgrade	Tennessee Gas Pipeline	636	PA/NJ	2013

Source: Reuters – October 15, 2012

Natural Gas Processing Facilities

Wet Gas Processing

Natural gas wells in the Western Marcellus and Utica regions produce wet natural gas. In addition to methane the raw gas typically includes ethane and varying amounts of heavier components. The raw gas must be processed to produce pipeline quality dry natural gas (primarily methane) and other valuable products including:

- Ethane, which is used primarily as feedstock in the production of ethylene, one of the basic building blocks for a wide range of plastics and other chemical products.

- Propane, which is used for heating, engine and industrial fuels, agricultural burning and drying, and as a petrochemical feedstock for the production of ethylene and propylene.
- Butane, which is mainly used for gasoline blending, as a fuel gas either alone or in a mixture with propane, and as a feedstock for the manufacture of ethylene and butadiene, a key ingredient of synthetic rubber.
- Isobutane, which is primarily used by refiners to enhance the octane content of motor gasoline.
- Natural gasoline, which is principally used as a motor gasoline blend stock or petrochemical feedstock.

Each of these hydrocarbons has a distinctive weight, boiling point, vapor pressure, etc. Natural gas processing plants remove and separate individual hydrocarbons using these differences in physical properties. These plants are typically located near the wells.

The oil and gas industry has announced plans to expand natural gas processing capacity in the Marcellus region by 3.8 Bcfd by 2015.[65] One example, illustrated in Figure 39, is the Dominion Resource's recent $500 million processing plant in Marshall County, West Virginia. The construction effort employed 900 workers to construct a facility that will process 0.2 Bcfd and employ 40–45 regular employees.[66]

Figure 39: West Virginia Gas Processing Plant under Construction

Once NGLs have been isolated, they are separated from one another by fractionation – boiling off of individual hydrocarbons one by one. Fractionation systems are typically either an integral part of a gas processing plant or a ''central fractionator'' many miles from the primary

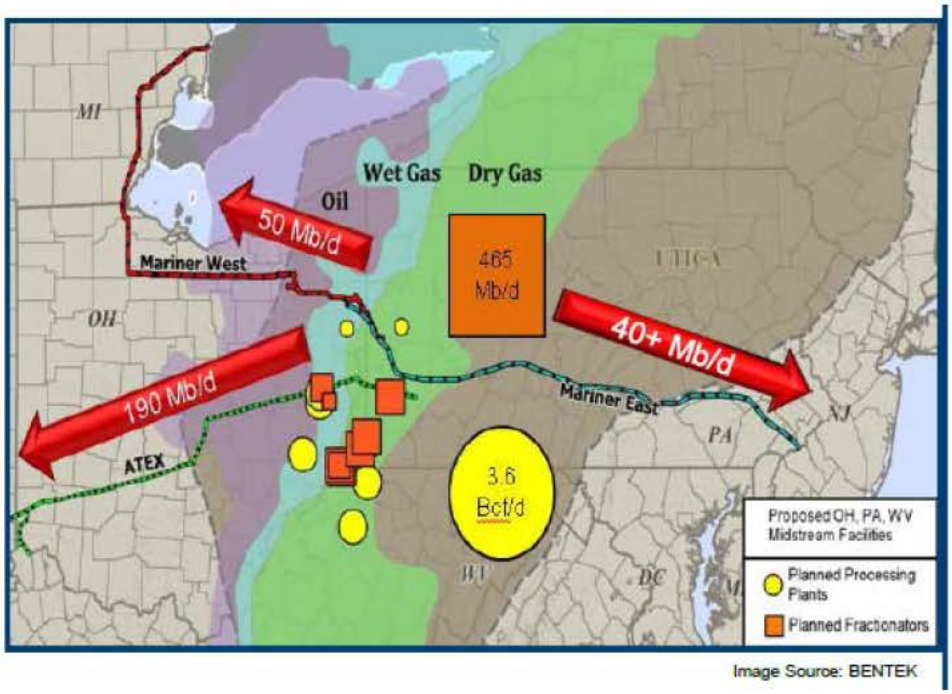
production and processing facility. A central fractionator may receive mixed streams of NGLs from many processing plants. Marcellus/Utica Fractionation plant expansions for 2012-2014 are listed in Table 4.

Table 4: Announced Marcellus/Utica Fractionation Plants

Owner/Operator	*Location*	*Initial/Expansion capacity (.000 barrels/day)*	*In-Service*
Williams	Marshall, WV (Moundsville I)	12.5	2Q12
Williams	Marshall, WV (Moundsville II)	30	4Q12
Dominion Transmission	Marshall, WV	36	4Q12
Chesapeake/M3/EV Energy	Harrison, OH	90	2Q13
MarkWest Liberty Midstream	Washington, PA	38	2Q13
MarkWest Liberty Midstream	Marshall, WV	38	2Q13
Williams	Marshall, WV (Ft. Beeler)	30	3Q13
Dominion Transmission	Marshall, WV	23	3Q13
Williams	Marshall, WV (Moundsville III)	30	4Q13
MarkWest Utica	Harrison, OH	60	4Q13
MarkWest Utica	Harrison, OH	40	1Q14
MarkWest Liberty Midstream	Marshall, WV	38	2Q14
Williams	Marshall, WV (Ft. Wetzel)	20	TBD

Figure 40 illustrates mid-2012 plans to develop gas processing plants in the Western Marcellus/Utica region that can process raw gas at the rate of 3.6 Bcfd and produce 465 million barrels of NGLs daily. It further illustrates the development of pipeline capacity planned to move a portion of that production to Philadelphia for marine transshipment as well as Canada and the Gulf Coast for further processing.

Figure 40: Marcellus/Utica Midstream Plans



Wastewater

Roughly 10% to 30% of the water used in the fracking process returns to the surface with the extracted gas. This "flowback" water contains salts and other naturally occurring elements as well as trace concentrations of fracking chemicals. Flowback water is stored temporarily on site and then (1) reused to fracture additional wells; (2) hauled off site for treatment; (3) disposed of in deep underground injection wells; or (4) processed at the well site.

Deep injection wells are the traditional means of disposing of flowback water. These facilities are drilled into porous formations of limestone or sandstone well below the water table. In Ohio these wells are about 4,000 feet deep. As of mid-November, Ohio had 179 injection wells for disposal of fluids created during hydraulic fracturing.[67]

Because the geology that supports deep injection wells is not typically available in the Northeastern Marcellus region, most flowback water from that region is reused or treated. This requirement to treat the water is leading to the development of state of the art regional water treatment facilities.

The original example is Eureka Resources' Williamsport, Pennsylvania wastewater treatment plant, which is the only facility currently treating Marcellus wastewater that meets or exceeds the Pennsylvania Department of Environmental Protection's standards for discharge directly into the state's rivers or streams. Eureka Resources is presently constructing a more advanced wastewater treatment facility in Standing Stone Township in Bradford County, Pennsylvania. Eureka will use a concentrated brine crystallizer to separate the valuable byproducts from the flowback liquid and leave water that is useable at future well sites. The project is expected to be completed in third quarter of 2013.[68]

Figure 41: Epiphany Solar Wastewater Treatment System

A number of firms are working to develop technology to purify flowback water at the well site. One such firm is Epiphany Solar Water Systems. Epiphany is perhaps the farthest along in development of this technology. Its system, which was initially designed to purify water in regions of the world lacking available electricity, uses concentrated solar power to flash distill

waste water into distilled water and salt – both of which can be reused. Most of the component parts are low-cost, easily available, off-the-shelf items. Consol Energy has invested $500,000 in Epiphany, and one of its gas wells in Greene County Pennsylvania, is piloting the solar-powered water purification system.[69]

V. Induced Industry Facilities

Overview

Due to the abundant supply in the United States, the domestic price of natural gas has become uncoupled from the price of petroleum. The result is a significant current cost advantage for natural gas users. Industries that use natural gas as a feedstock are advantaged as are those manufacturing industries with greatest reliance on energy. Long term maintenance of this advantage is a prerequisite for the commercial success of firms presently making heavy, long term investment in domestic U.S. industry, some of which are highlighted in this chapter.

Ethane and Ethane Cracking Plants

Ethane, one component of Marcellus shale gas, is typically worth much more than an equivalent volume of methane gas. A problem is that there is no facility in the northeast United States to "crack" the ethane to produce ethylene, which is a prime feedstock for the plastics industry. The nearest cracker is in Sarnia, Ontario, and the greatest demand is on U.S. Gulf Coast.

As a result most Marcellus ethane remains in the natural gas residue stream, or is blended with leaner, low-BTU dry gas to meet pipeline specifications. Blending is increasingly economically inefficient and impractical as wet gas production is growing rapidly.

The obvious solution is to move the ethane to the demand locations, and industry is responding by constructing the pipeline projects listed in Table 5. These pipelines will move the ethane to Sarnia, Ontario and the Gulf Coast for processing as well as to Marcus Hook, Pennsylvania for export.

Table 5: Announced Marcellus/Utica Ethane Pipelines

Owner/Operator	Pipeline	Direction (from-to)	Initial Capacity (000 b/d)	Distance (miles)	In-Service
Mark West	Mariner West	Marcellus to Sarnia, ON	50	350	3Q 2013
Enterprise	ATEX Express	Marcellus/Utica to Mont Belvieu, TX	125	369	1Q 2014
Sunoco Logistics	Mariner East	Marcellus to Marcus Hook, PA	65	300	2Q 2014

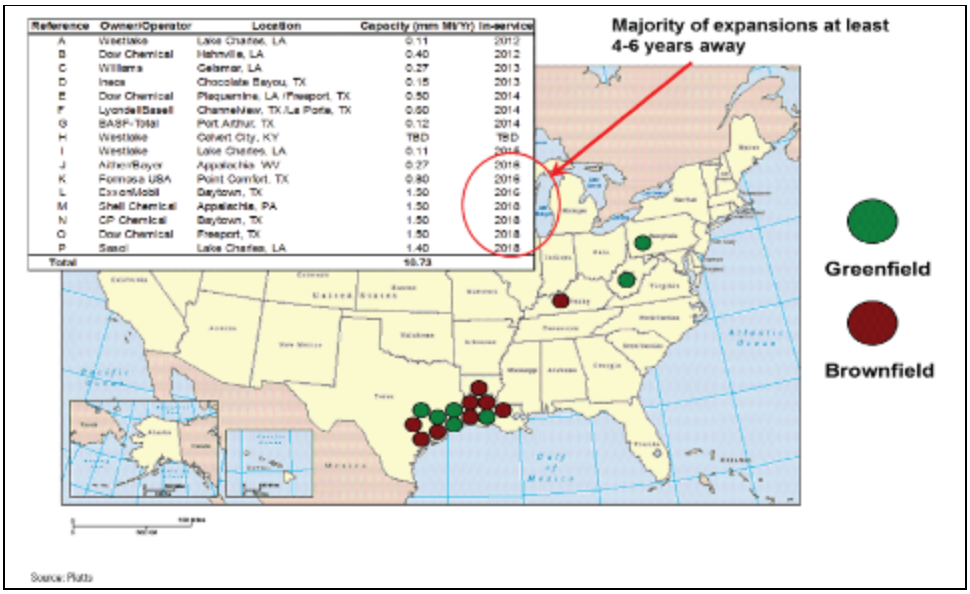
The second proposed solution to the ethane issue is to develop the necessary infrastructure for ethane cracking in the Marcellus/Utica Region. In March, 2012, Shell Chemical LP purchased a real estate option and announced its intention to construct a petrochemical complex, including an ethane cracker, on the Ohio River near Monaca, Pennsylvania. The action is pending additional environmental analysis of the site, further engineering design studies, assessment of the local ethane supply, and continued evaluation of economic viability. The project completion is currently estimated at 2018, and the cost has been reported at $2 billion. Key site selection criteria included good access to liquid-rich natural gas resources, water, road and rail

transportation infrastructure, power grids, and sufficient acreage to accommodate for a world-scale petrochemical complex and potential future expansions. Access to the Ohio River is a key decision element as outsized project cargo will need to be transported to the site. The only practical option for that movement is barge.

On July 31, 2012, Aither Chemicals announced that they are considering completion of a $500 million cracker facility in the Kanawha Valley near Charleston, WV.

The development of these plants is an element of a much larger ethane processing industry, as illustrated in Figure 42 below.

Figure 42: U.S. Ethane Cracking Capacity – Additions and Expansions



Chemicals and Plastics

For chemical companies, shale gas development has decreased the costs of both raw materials and energy. The U.S. chemical industry has recently invested an estimated $15 billion in ethylene production, increasing capacity by 33%. The United States could become a major low-cost provider of feedstock to the global chemical industry. [70]

Steel Production

At current prices the first stage of steel production can be performed at a 20% cost savings by using natural gas, instead of coal. As a result, like the electrical power industry, the steel industry is considering construction of a new generation of steel-making facilities that use gas as an energy source.[71]

One example of this development is Nucor Corporation's $750 million direct reduced iron production facility currently under construction in Convent, Louisiana (Figure 43). The facility is expected to be operational in mid-2013 and is currently permitted to produce 5.5 million tons per year of high-quality iron, primarily from scrap. The 4,000-acre site is located on the Mississippi

River. Full build-out would include a second facility, resulting in a $3 billion complex that would employ 1,000 full-time workers.[72] The firm has partnered with Encana Oil & Gas Inc. for a $3 billion, twenty-year onshore natural gas drilling program in the continental United States to ensure a stably priced supply of gas over the long term for this and for other Nucor iron and steel production facilities.

There are at least four other similar facilities in other U.S. locations, including Ohio and Minnesota, are in planning stages as of early 2013.

Figure 43: Nucor Covenant, LA Site

Fertilizer

Natural gas is the critical element in the production of nitrogen fertilizers. In 2007, 90% of the cost of fertilizer was natural gas, which is used both as a fuel and a feedstock. Virtually all the corn planted in the United States depends on nitrogen fertilizers,[73] and thus on natural gas.

During the period of high cost natural gas, many U.S. production facilities closed in favor of foreign production. Low cost natural gas could result is a considerable reduction in the cost of production of corn and ethanol. This has yet to be realized due to the current high demand for corn.[74]

Transportation Demand

LNG as a Vehicle Fuel

Transportation is the most significant and uncertain aspect of future natural gas demand. Vehicle fuel currently represents only 0.14% of natural gas demand and natural gas fuels only about 120,000 of the nation's 250 million highway vehicles. Major efforts are underway to

dramatically increase that share, but the work is in early stages with several competing technical options.

The amount of natural gas consumed by vehicles has more than doubled in the past decade as LNG vehicles have becoming more common in fleet vehicle applications (e.g. municipal fleets, garbage trucks, and taxis) where vehicles are operating near fueling facilities. About 40 percent of new garbage trucks and 25 percent of new buses in the U.S. can run on natural gas.[75]

The lack of a national natural gas fueling network is a major barrier holding back implementation. Clean Energy Fuels Corp. is the largest firm in this market and is seeking to develop 150 LNG fueling stations, with 70 anticipated to be open in 33 states by the end of 2012 and the balance in 2013 (Figure 44).[76]

Figure 44: Clean Energy Fuels, LNG Station network

Clean Energy Fuels is not alone in this effort; there are a host of smaller firms working to fill this need. In addition, Shell is planning to invest heavily in LNG production and retail.[77]

The next step in this evolution is expected to be in the area of long haul highway freight vehicles. Clean Energy Fuels believes the current natural gas engines available for the trucking market are not ideally suited to serve the U.S. heavy-duty trucking market, and that the lack of a natural gas engine that is optimized for the U.S. heavy-duty truck market has hampered the adoption of natural gas fuel. This is perceived as a short term problem and they are moving forward in the development of their national fueling network.

A lesser known natural gas conversion effort is being made by the rail industry, which is being attracted by the low cost of natural gas. The Canadian National, for example, is leading an industrial team that expects to field a prototype natural gas railway engine and standardized railway tender in 2014.[78]

Figure 45: CN Test of Natural Gas-Powered Locomotives

Figure 47 graphically illustrates the key stumbling block for wider use of LNG for long-haul vehicles: density. LNG has a density of about 82,664 Btu per gallon compared to 139,000 Btu per gallon for diesel[79]. For the same Btu content, LNG therefore requires about 70% more fuel tank capacity. For the same fuel tank capacity, an LNG vehicle could only go 60% as far as an equivalent diesel vehicle. This disparity implies a need for more fueling stops at points closer together or out-and-back operations from a central fueling point (the norm for municipal or taxi fleets).

The conversion to natural gas for transportation faces a host of uncertainties. A number of them are identified in Clean Energy Fuels' 2011 10-K report.

- Limited availability of natural gas vehicles and engine sizes restricts their wide scale introduction and narrows our potential customer base.
- Natural gas vehicles cost more than comparable gasoline or diesel powered vehicles because converting a vehicle to use natural gas adds to its base cost. As a result a price gap between liquid fuels and natural gas is a prerequisite for successful implementation.
- Advances in gasoline and diesel engine technology, especially hybrids, may offer a cleaner, more cost-effective option and make fleet customers less likely to convert their fleets to natural gas. Technological advances related to ethanol or biodiesel, which are increasingly used as an additive to, or substitute for, gasoline and diesel fuel, may slow the need to diversify fuels and affect the growth of the natural gas vehicle market.
- Use of electric heavy-duty trucks, or the perception that electric heavy-duty trucks may soon be widely available and provide satisfactory performance in heavy-duty applications, may reduce demand for heavy-duty LNG trucks.

- Hydrogen and other alternative fuels in experimental or developmental stages may eventually offer a cleaner, more cost-effective alternative to gasoline and diesel than natural gas.[80]

Gas to Liquids

Of particular interest is the competing development of facilities that convert natural gas directly to liquid diesel fuel. Sasol, a South African company, has built plants in South Africa and Qatar and is planning to build a "gas to liquids" (GTL) production facility in Louisiana to produce 96,000 barrels of fuel a day. The facility is proposed as an integrated GTL plant and ethane cracker to be located adjacent to Westlake, Louisiana, near Lake Charles.

The facility will be the second-largest plant of its kind in the world, after Royal Dutch Shell's Pearl plant in Qatar, and will cost $11 billion to $14 billion to build. Shell is considering building its own plant on the Gulf Coast[81] and two smaller GTL facilities have been announced in the Marcellus region.

Dual-Fuel and Bi-Fuel vehicles

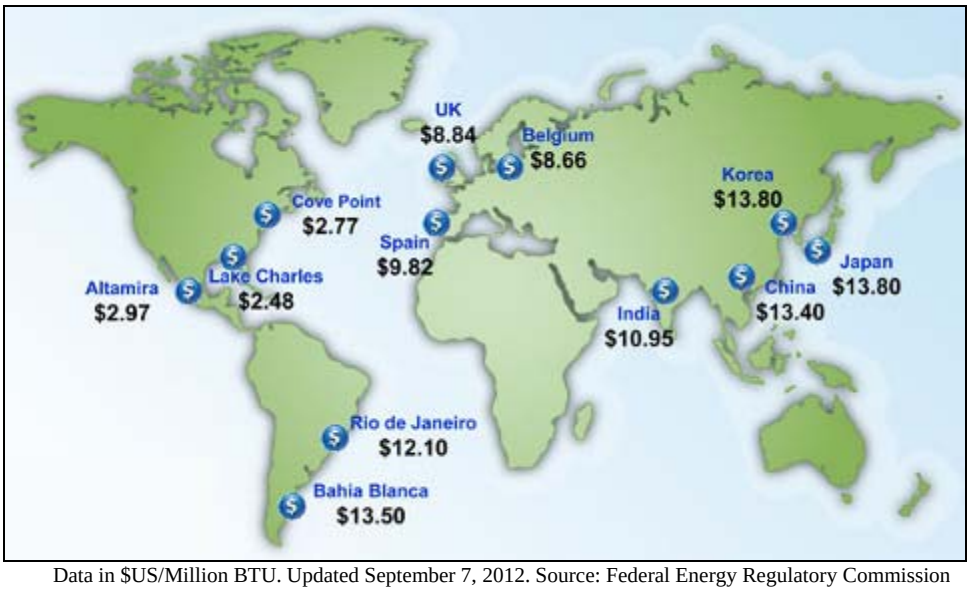
While dedicated natural gas vehicles are designed to run on natural gas only, dual-fuel or bi-fuel vehicles can also run on LNG or diesel. Since natural gas is stored in high-pressure fuel tanks, dual-fuel vehicles require two separate fueling systems, which take up passenger/cargo space. Some vehicles are being developed to run on a blend of diesel and natural gas; CNG injection increases the efficiency of an engine by allowing it to burn its fuel more completely than diesel alone.

Marine LNG Export Facilities

The United States currently imports and exports natural gas via pipeline to/from Mexico and Canada. There is serious interest in export of Liquid Natural Gas (LNG) to markets beyond North America, driven by the current price differentials in the global natural gas market[82] as illustrated in Figure 46.

LNG export policy has been somewhat controversial due to concerns over the impact on the domestic price of gas as well as the relative merits of exporting gas versus exporting the higher value products made from gas.

Figure 46: World Natural Gas Prices



Data in $US/Million BTU. Updated September 7, 2012. Source: Federal Energy Regulatory Commission

Sabine Pass, Texas, is the only facility in the continental United States which is permitted to export supplies to both free-trade and non-free-trade agreement countries. As of September 2012, 18 U.S. companies had applied for permits to construct liquefaction facilities at existing LNG import terminals or build new facilities, with a capacity of 27.4 Bcfd per year.[83] At least five additional marine export projects have been proposed for Canada.

The U.S. Department of Energy recently issued a report assessing the potential macroeconomic impact of LNG exports. The report was prepared by NERA Economic Consulting and found:[84]

- The U.S. was projected to gain net economic benefits from allowing LNG exports.
- U.S. natural gas prices increase when the U.S. exports LNG. The global market limits how high U.S. natural gas prices can increase under pressure of LNG exports because importers will not purchase U.S. exports if U.S. wellhead price rises above the cost of competing supplies.

The NERA report examines a large number of scenarios based on U.S. and world supply/demand assumptions, many of which produce no export movements. This no-export result would be consistent with a combination of higher domestic demand and prices, and relatively lower international demand and prices. This scenario might be consistent with rapid international transfer of fracking technology. Conversely, a scenario which assumes a combination of a large, low-cost U.S. domestic supply and high international demand produces a scenario in 2035 in which the wellhead price is $5.97/million Btu and 8.39 trillion cubic feet are exported annually. The key idea is that a low domestic price is a necessary condition for a high level of exports.

Marine transport of gas is very inefficient when a pipeline option is available, due to the high cost of the liquefaction/gasification processes in addition to the transportation costs. Table 6 is taken from the NERA report and shows the estimated cost associated with LNG transport. These costs illustrate the cost hurdle US exports will face in overseas markets. However, the availability of U.S. supply places a meaningful cap on prices in international gas markets.

Table 6: Estimated Total LNG Transport Cost, 2015 ($/million BTU)

	China/India	Europe	Korea/Japan
Wellhead to liquefaction facility	$1.00	$1.00	$1.00
Liquefaction cost	$2.14	$2.14	$2.14
Shipping	$2.87	$1.33	$2.60
Regas	$1.50	$1.50	$1.50
Regas to city gate	$1.50	$1.00	$0.50
Total LNG transport cost	$8.39	$6.30	$7.14

Note that the liquefaction cost estimate in Table 6: Estimated Total LNG Transport Cost, 2015 ($/million BTU)Table 6 assumes that the U.S. repurposes existing import facilities. Building new, greenfield facilities would result in a cost increase of 30%-40%. As such, the most likely export facilities are those shown below in Figure 47.[85]

Figure 47: Existing FERC Jurisdictional LNG Import/Export Terminals

To date, Sabine Pass has secured 1 Bcfd in "take or pay" contracts from BG Group and Spain's Gas Natural for its first liquefaction phase, and nearly 1.1 Bcfd of additional contracts from Korea Gas, BG Group, and India's GAIL.[86]

Future development of these facilities is largely dependent upon the evolution of U.S. energy policy. The U.S. domestic market has not reached equilibrium at this time and it is unclear how rapidly fracking technology will be adopted worldwide. As a result, it is very difficult to forecast the long term level of exports with any degree of certainty. While the export opportunity exists today, long-term demand uncertainty will likely cause private capital invested in export facilities

to (1) flow toward conversion of existing import facilities and (2) seek substantial short-term returns and long-term contracts.

NGL Exports

Recently, the Switzerland-based INEOS Europe announced that it will build and operate vessels to transport super-cooled ethane to crackers in Europe. These ships will support a 15-year agreement to ship Marcellus Shale ethane to Norway from a Sunoco Logistics terminal in Marcus Hook, Pennsylvania. Sunoco Logistics is currently modifying a pipeline to deliver propane (2014) and ethane (2015) from Western Pennsylvania to the former Sunoco refinery site in Marcus Hook in Pennsylvania on Delaware Bay.[87]

VI. Inland Waterway Opportunities

Inbound Cargo Flows

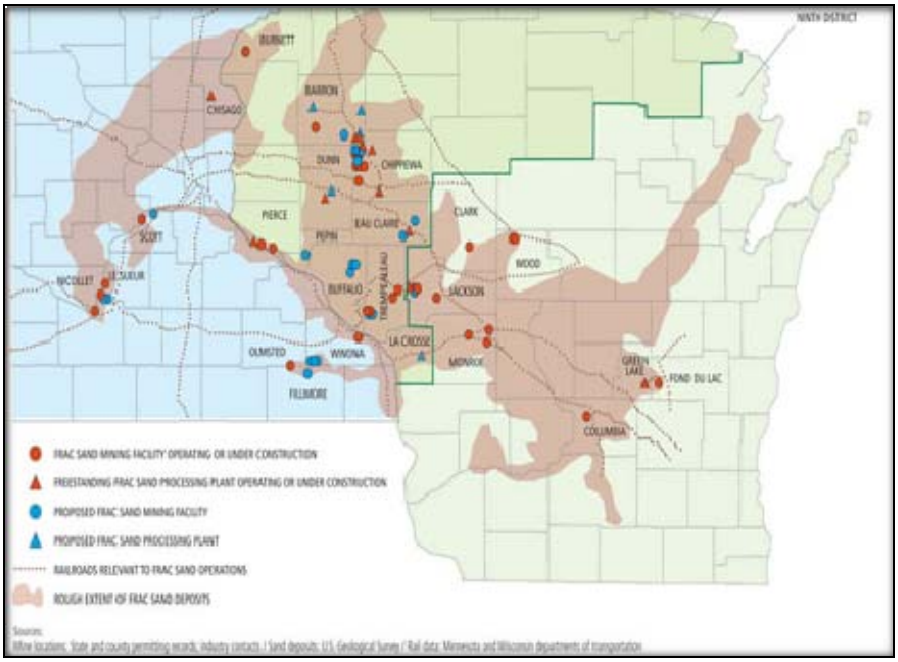
Frac Sand

The estimated long term demand for frac sand associated with Marcellus/Utica well drilling based on a forecast of 3,000 wells per year and an estimate of 3,500 tons of sand per well is in the range of 9-12 million tons per year.

Thus far, the rapidly developing Marcellus gas drilling activity has been served almost exclusively by rail and truck. In 2011 there were 36,944 tons of identifiable Ohio River barge frac sand movements from production areas. In 2012 the figure was 70,494 tons, something less than 1% of the market. Because logistics practices are changing in favor of low cost transportation, Tioga believes that the barge market share will continue to grow. A 10% share would produce about a million tons per year moving upriver on the Ohio. The actual number is likely to be quite volatile depending on many factors, most of all the future price level of natural gas.

Ingram Barge reports that a sand mine will need to be within 40 miles of the Mississippi or Illinois River for a competitive barge alternative.[88] This would include Illinois River facilities at U.S. Silica's major facility at Ottawa, Illinois, as well as Mississippi Sand's controversial planned major new mine slightly down stream near Starved Rock State Park. It also includes at least four facilities in Eastern Missouri along the Mississippi River. The largest number of mines is in Wisconsin and Minnesota as illustrated in Figure 48. Those several facilities (some without rail service) within or near the first tier of counties bounding the Mississippi River are strong candidates for barge service.

Figure 48: Existing and Proposed Sand Mine Operations[89]



The frac sand market is being strongly contested by rail carriers as evidenced by CN's investment in upgrading its rail lines in Jackson, Buffalo, and Trempealeau counties in Wisconsin. This upgrade will permit the railroad to better compete for sand business loaded on barges in Winona, Minnesota.

There is significant local environmental resistance at two critical upper Midwest terminal locations.

- In Winona, MN there is concern over truck traffic generation and the local stockpiling of frac sand. The city council in that community recently voted, against considerable public opposition, to double the number of barges that can be loaded each month, from 24 to 48.[90] To date frac sand loaded in Winona has moved to the Gulf Coast, not up the Ohio River.
- Mississippi Sand is seeking to develop a new quarry near U.S. Silica's home near Ottawa, IL. The development is controversial as it also near Illinois' Starved Rocks State Park. In July 2012, the La Salle County Board approved a special use permit that will allow American River Transportation Co. to construct a new storage and barge shipping facility for aggregate materials west of Ottawa. This will allow Mississippi Sand to access low cost waterway transport and to participate in the frac sand market near Ottawa along with U.S. Silica.

Cement

The estimated long term demand for cement associated with Marcellus/Utica well drilling is 375,000 tons per year based on a forecast of 3,000 wells per year and an estimate of 125 tons of cement per well. Some portion of this cargo will be moving on the Ohio River to distribution centers in the region. Barges moved 775,020 tons of cement up the Ohio to Ohio, West Virginia, and Pennsylvania for all uses in 2012

Outbound Cargo Flows

Wastewater

GreenHunter Water has plans to move fracking wastewater by barge to its facility at New Matamoros, Ohio, for further handling and disposal. These would likely be short distance movements on the Ohio River. The operation is currently being held up by the Coast Guard, which is currently seeking to determine if the wastewater should be considered hazardous and is promising a policy statement in early 2013.[91]

Natural Gas Liquids

While transportation of natural gas liquids is typically by pipleine, many of these facilities were constructed with truck and rail loading capabilities.

- **Wellsville, Ohio.** Marathon Petroleum Corporation and Harvest Pipeline Company are developing a truck-to-barge facility at Wellsville, OH for transportation of hydrocarbon liquids. The project will result in up to 24,000 barrels per day (Bbld) of truck unloading capacity and a terminal capable of loading up to 50,000 Bbld, and is expected to be complete by the end of 2013.[92]

- **Toronto, Ohio.** On December 21, 2012 Plains Marketing LP paid $2.5 million for a forty-acre site on the Ohio River near Toronto, Ohio. The local newspaper reports that Plains Marketing is planning to transport "wet gases" (most likely NGLs) from Utica shale wells to the site, where it will be stored and ultimately shipped by barge to refineries on the Gulf Coast. The brownfield site has been vacant since 1986.[93]
- **Half Moon Industrial Park.** In late 2012, at least one test barge shipment was made of natural gas liquids from Half Moon Industrial Park in Weirton, West Virginia, (Figure 49) to Houston, Texas.[94].

Figure 49: Half Moon Industrial Park, Weirton, WV

- **Bens Run, West Virginia.** This Dominion facility (Figure 50) is advertised as also having a loading facility for natural gasoline.

Figure 50: Dominion NGL Facility Bens Run, WV

VII. Level of Confidence

Overview

This USACE inquiry is well out in front of stability in shale gas production in the Marcellus/Utica region. As a result, there is a high degree of uncertainty regarding the future direction of gas development.

Regulatory Climate

The long-term regulatory climate is highly uncertain. Fundamentally, the nation lacks consensus regarding of encouragement of natural gas, which is a relatively cleaner burning fossil fuel, as a long term energy source.

At present each state is finding its own course regarding the promotion and regulation of oil and gas development and frac sand mining. Policies vary from New York, which currently bans hydraulic fracturing, to Pennsylvania, which actively promotes it. Other key states include Ohio, West Virginia, Minnesota, Wisconsin, Maryland, and Missouri. Each state has a different approach, somewhere between New York and Pennsylvania.

The Federal government has taken only small steps toward regulation of hydraulic fracturing. Most importantly, the EPA launched a large, long-term assessment of the risks and dimensions of shale gas drilling in 2011, and will not be issuing a draft report until 2014.

Long-term Demand

Long-term demand levels are uncertain. Current demand is about 70 billion cubic feet/day (Bcfd), which is primarily made up of residential, industrial, commercial, and electric power sectors. Current prices are stimulating conversion to gas in all sectors, now including transportation. In addition, current market conditions will support significant export activity: facilities are being proposed that would export gas at the rate of 40% of domestic demand. Finally, as natural gas provides only about a third of the nation's energy, there is a significant, but uncertain upside demand potential.

Long-term Supply

Long-term Marcellus/Utica supply levels are uncertain. At present, in Pennsylvania counties in the Marcellus region, the current extraction footprint is less than 3% of the region. While all the experts agree that the Marcellus/Utica region is a most significant gas play, there is considerable disagreement among experts as to just how much gas is actually available.

Fracking Technology

Fracking is a new and evolving technology. The number of wells being drilled from each well pad is increasing. The horizontal breadth of wells is increasing as well. This means that supply

chain planning factors based on consumption per well will likely change in the future. The number of drilling pads required will likely decline from present practice, and the amount of material required per well will likely increase. Well productivity, in terms of the amount of gas produced per well or per dollar invested can also be expected to increase.

For example, a possibly revolutionary innovation is currently being promoted by a Canadian firm, GASFRAC Energy Services, Inc. Their proprietary processes substitutes a propane-based gel, liquid petroleum gas (LPG), for water in the fracking process. The company advertises that its method as a more effective fracking method which enables higher initial and long term production of the well. The gel is recovered with the stimulated hydrocarbons, with the ability to recover 100% of the fracturing fluids eliminating the need for wastewater cleanup. In addition LPG does not dissolve and bring back to the surface the salts, heavy metals, or radioactive compounds that water-based fracking extracts from the rock underground. While this technology is not yet fully proven, the firm has fracked over 1,300 wells in Canada and the US, including at least one in the Marcellus/Utica region. This technology holds the promise of a further paradigm shift in fracking technology.

Supply Chain Practices

The price of natural gas is low and economic returns are thin at the present, which is stimulating a rapid evolution in supply chains. The initial boom was supported primarily by trucks, with rail cars serving as forward storage of frac sand, but this past logistics practice does not appear viable in the long term. A more likely future appears to be the establishment of logistics platforms served by truck, rail, and sometimes barge in the Marcellus/Utica areas, where frac sand and other drilling products can be forward deployed and warehoused. The point of sale for these commodities appears to be moving closer to the drilling location. The result of that business strategy is by no means assured, however. As a result, a stable transportation market with a stable barge, truck, and rail market share has yet to emerge.

Implications

To date, the Marcellus/Utica gas development has had little impact on Ohio River cargo flows, there may be significant impact in the future--depending upon the ultimate resolution of open logistics, environmental, and regulatory questions. Given the political status quo, Tioga expects:

- The trend toward increasing use of existing Ohio River barge terminals to serve the oil and gas industry will continue.
- Ohio River traffic related to the oil and gas industry will increase, led by increasing frac sand and cement movements. The absolute volume is difficult to forecast at this time, but could exceed a million tons per year.
- The Coast Guard will ultimately permit waste water to be transported by barge short distances on the Ohio. Commodities of much greater hazard are regularly transported by barge currently.

Appendix A: Legislative/Regulatory Analysis

Overview

This appendix provides an analysis of current proposed fracking legislation at Federal and State level.

Federal Government

Environmental Protection Agency (EPA)

EPA launched its long-term assessment of the risks and dimensions of shale gas drilling in 2011 and will not be issuing a draft report until 2014. On December 21, 2012, EPA issued a preliminary progress report. To quote from the executive summary:

In 2011, the EPA began research under its Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources. The purpose of the study is to assess the potential impacts of hydraulic fracturing on drinking water resources, if any, and to identify the driving factors that may affect the severity and frequency of such impacts. Scientists are focusing primarily on hydraulic fracturing of shale formations to extract natural gas, with some study of other oil-and gas-producing formations, including tight sands, and coal beds. The EPA has designed the scope of the research around five stages of the hydraulic fracturing water cycle. Each stage of the cycle is associated with a primary research question:

- *Water acquisition: What are the possible impacts of large volume water withdrawals from ground and surface waters on drinking water resources?*
- *Chemical mixing: What are the possible impacts of hydraulic fracturing fluid surface spills on or near well pads on drinking water resources?*
- *Well injection: What are the possible impacts of the injection and fracturing process on drinking water resources?*
- *Flowback and produced water: What are the possible impacts of flowback and produced water (collectively referred to as "hydraulic fracturing wastewater") surface spills on or near well pads on drinking water resources?*
- *Wastewater treatment and waste disposal: What are the possible impacts of inadequate treatment of hydraulic fracturing wastewater on drinking water resources?*

This report describes 18 research projects underway to answer these research questions….

[The summary concludes] *The EPA has designated the report of results as a "Highly Influential Scientific Assessment," which will undergo peer review by the EPA's Science Advisory Board, an independent and external federal advisory committee that conduct s peer reviews of significant E PA research products and activities. The EPA will seek input from individual members of an ad hoc expert panel convened under the auspices of the EPA Science Advisory*

Board. The EPA will consider feedback from the individual experts in the development of the report of results.

Ultimately, the results of this study are expected to inform the public and provide decision-makers at all levels with high-quality scientific knowledge that can be used in decision-making processes.[95]

In sum, policy decisions apparently will not be driven by the EPA study for at least two years. Marcellus states could adjust their laws and regulations based on EPA's results, but with a 2014 draft date. Major changes appear unlikely before 2015.

Department of the Interior

On May 4, 2012, the Department of the Interior published draft rules covering fracking, requiring that "companies…publicly disclose the chemicals used in hydraulic fracturing operations on public and Indian lands, with appropriate protections for proprietary information." The press release notes:

The draft rule…contains two additional, commonsense measures to ensure development continues safely and responsibly:

- *Improving assurances on well-bore integrity to verify that fluids used in wells during fracturing operations are not escaping; and*
- *Confirming that oil and gas operators have a water management plan in place for handling fracturing fluids that flow back to the surface.*[96]

The proposal drew immediate criticism from industry groups, which called it unnecessary, and from environmental groups, which called it insufficient. The consulting firm ClearView Energy Partners estimated that 13 percent of U.S. natural gas production and six percent or less of onshore oil production would be affected.[97]

The Department of the Interior had held out the prospect of issuing a final rule by year-end, but instead the Department announced on January 18, 2013 that it would be delaying issuance of a revised proposal, without announcing a specific timeline.[98] The date of a final rule cannot be predicted, and the impact on drilling practice is also unclear, but may be small.

Occupational Safety and Health Administration (OSHA)

In its latest semiannual regulatory agenda, OSHA indicated its intention to publish a notice of proposed rulemaking on silicosis in May. It would promulgate an entirely new exposure limit based on micrograms per cubic meter, as opposed to particle counting under a formula dating from 1968.[99] Silicosis results from prolonged exposure to sand particles, as from sand blasting, but the exposure limit presumably would apply to frac sand mining operations as well. The interaction of a future OSHA rule with any applicable state regulations, and with the jurisdiction of the specialized Mining Safety and Health Administration, remains to be determined.

Congress

No relevant legislation has been introduced yet in the current, 113th Congress. However, corresponding bills were introduced in both Houses in the previous Congress: The FRAC Act: S. 587, by Sen. Casey (D-PA) and seven cosponsors, all Democrats and six also from the Northeast or Mid-Atlantic; and H.R. 1084, by Rep. DeGette (D-Co) and 73 cosponsors, all Democrats. The Congressional Research Service summarized the legislation as follows:[100]

Fracturing Responsibility and Awareness of Chemicals Act or the FRAC Act - Amends the Safe Drinking Water Act to repeal the exemption from restrictions on underground injection of fluids or propping agents granted to hydraulic fracturing operations relating to oil and gas production activities under such Act.

Requires: (1) state underground injection programs to direct a person conducting hydraulic fracturing operations to disclose to the state (or the Administrator if the Administrator has primary enforcement responsibility in such state) the chemicals intended for use in underground injections before the commencement of such operations and the chemicals actually used after the end of such operations; and (2) a state or the Administrator to make such disclosure available to the public.

Requires the applicable person using hydraulic fracturing, when a medical emergency exists and the proprietary chemical formula of a chemical used in such hydraulic fracturing is necessary for medical treatment, to disclose such formula or the specific chemical identity of a trade secret chemical to the state, the Administrator, or the treating physician or nurse upon request, regardless of the existence of a written statement of need or a confidentiality agreement. Authorizes such person to require the execution of such statement and agreement as soon as practicable.

This approach to federal regulation has been criticized in a new report from the Hudson Institute, *Institutional Choices for Regulating Oil and Gas Wells*.[101] Water quality issues do not meet the traditional criteria for interstate regulation or preemption, including trans-boundary effects, network or scale economies, superior information, or averting poor choices by state or local jurisdictions. Conversely, those same traditional criteria would indicate a federal role in dealing with fugitive methane emissions, which can and do cross state lines; in research and development on improved drilling, removal, and mitigation efforts; and in capacity-building for state and local units working hard to keep up with rapid industry developments.

Marcellus/Utica Shale States

Maryland

Maryland's two westernmost counties fall into the potential producing area, but no shale gas wells have yet been drilled in the state, where the idea has not been that popular. On June 6, 2011, Governor O'Malley signed an Executive Order establishing the Marcellus Shale Safe Drilling Initiative.[102] It requires the Maryland Department of the Environment (MDE) and the Department of Natural Resources (DNR), in consultation with an advisory commission made up of a broad array of stakeholders, to undertake a study in three parts:

- A presentation of findings and related recommendations regarding the desirability of legislation to establish revenue sources, such as a state-level severance tax, and the desirability of legislation to establish standards of liability for damages caused by gas exploration and production. That report called for leasing fees, a severance tax, and legislation to create a zone of presumptive liability around a well for water contamination.[103] The latter has already been enacted, with Governor O'Malley signing House Bill 1123 on May 22, 2012.[104]
- Recommendations for best practices for all aspects of natural gas exploration and production in the Marcellus Shale in Maryland were to be due by August 1, 2012, but a year-long extension was granted. Environment Secretary Summers testified before the Maryland House Environmental Matters Committee last January 13, noting that the four applications to drill which had been received in 2009 had all been withdrawn.[105]
- A final report to address possible contamination of groundwater, handling and disposal of wastewater, environmental impacts, impacts to forests and important habitats, greenhouse gas emissions and economic impact is due August 1, 2014. No drilling will take place before then, and it does not appear to be a foregone conclusion that drilling will take place afterwards either. Deep Creek Lake is a highly valued resort area, and flared off gas from wells in southern Pennsylvania lacking takeaway capacity has spilled over the border, creating noticeable pollution.[106]

New York

Of the producing or potentially producing states, New York has taken by far the most cautious approach. Applications for fracking have been on hold for over four years at the same time that development has proceeded quickly in Pennsylvania and West Virginia. The state Department of Environmental Conservation imposed the moratorium at the same time that it began its Supplemental Generic Environmental Impact Statement process in 2008, and it is still not complete. Draft regulations were reissued on December 12, 2012,[107] in accordance with state administrative law requirements, but the accompanying statement from the Department made clear that it was taking no position at this time as to whether fracking should be allowed to go forward. Public comments would be accepted for 30 days, and the Department has 90 days either to make a decision, or else to reopen the process for public hearings. That effort is supplemented by an additional review undertaken by the state Department of Health, which apparently has no public information about the study on its website.[108] The Department of Environmental Conservation is waiting for the results from the Department of Health before making its final public decision.[109]

In the legislature, members, led by Democrats in the Assembly, have taken a more skeptical stance than in other states.[110] Democrats have retained control of the lower house in the 2012 election, but evenly divided results and two recounts have produced a fluid and unsettled situation in the Senate in which, most recently, five Democrats have announced that they will vote to organize with Republicans, more inclined to favor drilling.[111] The most forward-leaning position has been taken by St. Sen. Mark Grisanti, senior Republican on the Environmental Conservation Committee, who has put forth a five-point plan that goes farther than what the

Department of Environmental Conservation is proposing.[112] The amount of support they will be able to attract remains to be seen.

At the local level, electoral returns were positive for candidates in the southwest part of the state who favored drilling. In particular, Broome County Executive Debbie Preston, who won re-election, has moved to create a new department to help drillers.[113] In the most recent development in Broome County, on January 2, 2013 the Chenango Town Council rejected a proposed drilling moratorium by 3-2. The County Department of Planning and Economic Development had recommended against it, and members voting against it recognized that passage would have entailed expensive defense against a legal challenge.[114] Other towns, Dryden and Middlefield, had already adopted drilling bans, which have been challenged in state courts, initially upheld, as in Pennsylvania (see below), and now subject to appellate review.[115] Public opinion remains divided, and skeptics cite numerous lapses in Pennsylvania.[116]

Ohio

Industry has shown high confidence in the prospects for shale gas development in Ohio in the form of two new investments in the billion-dollar range. On October 5, Ohio officials approved plans for the Nexus Gas Transmission line, a 30- to 36-inch pipeline using existing rights-of-way to go around the western end of Lake Erie into Ontario. Projected to cost $1.3 to $1.5 billion, it is a joint project of Houston-based Spectra Energy Corp., Enbridge Inc. of Canada and Detroit-based DTE Energy and awaits approval by FERC. [117]

The first of several large natural gas processing plants in eastern Ohio is scheduled to open in May 2013, a $1 billion plant being built in eastern Columbiana County. M3 Midstream LLC, a Houston-based company, is building the plant under a partnership with Chesapeake Energy Corp. of Oklahoma and EV Energy Partners, another Texas company. The facility will be connected through a 24-inch high-pressure pipeline to a sister plant about 40 miles south in Leesville in Harrison County. The two plants will be able to process 800 million cubic feet of natural gas a day.

Chesapeake (Comment – Chesapeake who?) has leases to drill into the Utica Shale rock under about 1 million acres in Ohio, and is planning a pipeline system to move the gas from the wells to the plant. The Kensington plant will clean the gas as it arrives from the wells as well as remove any naturally occurring crude oil. The other plant will separate the more valuable gases from the methane. [118]

On June 11, 2012, Ohio Gov. John Kasich signed into law SB 315[119], which requires owners and operators of oil and gas wells to provide detailed disclosures regarding their horizontal drilling operations in the Utica shale formation, as follows:

- Applicant must identify the proposed source of the water used in the wells
- Applicants for permits to drill new horizontal wells must include the results of sampling of water wells within 1,500 feet of a proposed well prior to the commencement of drilling
- Applicant must disclose to the Division of Oil and Gas Resources Management the chemicals used in the fracking process, with an exception for deep underground operations.

Under the legislation signed into law by Gov. Kasich, well owners must provide to the Division a well completion record, including, if applicable, the trade name and total volume of all products, fluids, and substances used either to facilitate the drilling of any portion of a well or to stimulate a well. However, instead of both designating a substance as a trade secret -- and disclosing to the Division the identity, amount, concentration or purpose of such substance used in the fracking process (as provided in the original bill passed by the Ohio Senate) -- well owners may designate that a substance used in the fracking process is entitled to trade secret protection *without disclosing* the identity, amount, concentration or purpose of such substance. A property owner, an adjacent property owner, or any person or state agency that has an interest that is or may be adversely affected by a substance used in the fracking process may pursue a civil action challenging the validity of such trade secret protection.[120] Opponents had complained that the new law is too weak, but the acceptability to industry seems to be signaled by the two new investment announcements.

Gov. Kasich has also expressed his intent to seek in 2013 an increase in the existing severance tax, which he puts as the nation's lowest, to be offset by a decrease in the state's income tax. Some Republican legislative leaders have indicated their support.[121]

Pennsylvania

The primary reason that Pennsylvania has been at the center of shale gas drilling in the east is the strong support for Marcellus gas exploitation provided by Governors Rendell and Corbett in consecutive Democrat and Republican administrations.

After long debate, a bill setting a fee on shale gas wells was signed Feb. 13, 2012 by Pennsylvania Gov. Tom Corbett. The bill, H.B. 1950,[122] limits the ability of local jurisdictions to regulate oil and gas activity and also updates the state's Oil and Gas Act for the first time since Marcellus drilling began.

A tax on gas production had first been proposed by Democratic Gov. Ed Rendell in February 2009. Proponents noted that Pennsylvania was the only major gas-producing state without a severance tax. Under the new law, counties will impose the impact fee, as it is called, at their discretion, linked to the price of natural gas and ranging from $40,000 per well for gas below $2.25 per thousand cubic feet (Mcf), to $60,000 per well for gas above $6 per Mcf, declining annually to zero over 15 years. A current price under $3 would yield a fee of $50,000 per well. Fees would amount to $190,000 to $355,000 per well over the 15-year period. The state would collect the fees and would distribute them by a formula with about 40 percent being retained by the state, 20 percent to counties that adopt the fee, and 40 percent to municipalities within those counties.

At the same time, counties and municipalities cannot impose regulations on shale gas operations stricter than those imposed on other industries. Numerous local ordinances had appeared in the previous year.

Some observers criticized the fee, which they said amounts to less than 2 percent of value of gas extracted, as much lower than severance tax rates in other states and too low to offset industry impacts on localities. West Virginia's severance tax is 5 percent of the value of gas plus 4.7 cents/Mcf. The state estimated in a memo sent to lawmakers that the Pennsylvania levy would

generate $220 million in 2012 plus $191 million in retroactive fees for production in 2011. Environmental groups decried both the inadequacy of the fee and the removal of local control, characterizing the local ordinance measure as a "takeover" of municipalities. However, the bill was supported by the County Commissioners Association and the Association of Township Supervisors.

Updates to the broader Oil and Gas Act include some recommendations made by Corbett's Marcellus Shale Advisory Commission, which issued its report unanimously in July 2011.[123] Accordingly, the law increases bonding amounts and widens setbacks from homes and waterways. It requires more thorough notification to landowners, more comprehensive measures against spills, and disclosure of fracturing fluid additives.[124] The Department of Environmental Protection has summarized its current regulations in several pages.[125] A separate bill would have implemented the Commission's recommendation to promote use of acid mine water for Marcellus shale natural gas well development. Senate Bill 1346 would have liability protections for the development of treatment systems for such water. While passage was unanimous on October 17, it came at the end of the session, such that it was impossible for the House to act.[126]

Led by several entities in Washington County, municipal opponents of the new law, Act 13, have challenged part of its legality under the state constitution, claiming that it usurps the proper powers of local governments by allowing drilling to go forward in all types of land use areas, including those zoned for residential use. Opponents won a 4-3 victory in the court of first instance, Commonwealth Court, last July. The state Supreme Court held oral argument on appeal by the state on October 17. Given a continuing vacancy and only six sitting justices, a tie is possible, which would have the effect of upholding the lower court ruling.[127] The matter is unresolved at this writing.

West Virginia

According to a newsletter from the State Legislature, A 2011 study produced by West Virginia University and the Oil and Natural Gas Association, concluded that between 2002 and 2008, West Virginia led the nation in the number of gas drilling permits issued. More than 2,800 permits were issued for new drilling in 45 of the state's 55 counties. The industry-funded study focused on the economic impacts of growing efforts to extract natural gas from the Marcellus. The study showed that in 2009 West Virginia's natural gas industry generated more than $12 billion in business, created more than 24,000 jobs in the state, and paid more than $550 million in wages. The report stated that Marcellus development created between 7,600 and 8,500 additional jobs in West Virginia in 2010. According to the report, by the year 2015, West Virginia could see 19,000 more jobs because of Marcellus development and related activities.[128]

In December 2011, the legislature convened in special session to produce the Horizontal Well Act, HB 401[129], which passed the House by 92-5 and the Senate unanimously. It provides as follows:

- Increased permit fees to fund the regulatory efforts of the West Virginia Department of Environmental Protection. The Act sets $10,000 permit fees for initial wells and $5,000 fees for each well added to a site
- Increased well location restrictions to protect water resources and surface uses

- A requirement that a road use agreement be in place prior to permit issuance
- Increased notice provisions and a new compensation statute for surface owners
- Increased enforcement authority for the state DEP, including increased potential civil penalties for violations of the law
- The codification of water use and wastewater handling regulations contained largely in the Governor's emergency rule
- Provides for the state DEP to promulgate further legislative rules in the near term regarding air quality and cementing and casing issues.

Gov. Earl Ray Tomblin, who signed the bill, had participated in a major conference on shale gas drilling earlier in the year in which he indicated his fundamental support for drilling, supported by U.S. Sen. and former Gov. Joe Manchin. Under the new legislation, the state Department of Environmental Protection has issued a three-page checklist for parties submitting an application for a drill site.[130] The Department has been issuing between 50-60 permits per month.[131]

The political, regulatory, and industry situation in West Virginia has stabilized, following an unusually productive 2011 in which the acting governor directed the state department to issue emergency rules, which were then codified by the state legislative meeting in an extraordinary special session which yielded near-unanimous legislation.

Sand-Producing States

Minnesota

There are currently six active sand mines in Minnesota, and some processing facilities are handling sand from Wisconsin. Localities may oppose sand mining for any of the following problems, in addition to any financial or liability questions that might arise:

- Unsafe and destructive truck traffic on town, county, and other roads
- Air and water pollution from mining, trucking, rail transportation, and processing activities
- Dust from mining and trucking operations
- Waste and mine reclamation issues
- Groundwater pollution and withdrawal issues
- Noise and vibrations from blasting, mining, processing, and trucking
- Devaluation of affected properties near mining operations and adjacent to haul routes.

Four counties – Fillmore, Houston, Goodhue, and Wabasha – have imposed moratoria effective until dates ranging from February to September 2013.

In addition, The Mississippi River port City of Winona's has an issue over port related truck traffic. Their concern relates to traffic volume and to sloppy and careless practices such as

trucks tracking dirt onto the roads and proceeding through the town without tarpaulins.[132] Sand shipments have almost quintupled from 2010 to 2012, from under 5,000 tons to almost 25,000 tons. The city council in that community recently voted, against considerable public opposition, to double the number of barges that can be loaded each month, from 24 to 48.[133]

The lead Minnesota state agency is the Environmental Quality Board. On its website for silica, the Board summarizes the respective regulatory responsibilities for sand mining:

- Department of Natural Resources (DNR): Water Appropriation Permit; Public Waters Work Permit; Burning Permit; and Endangered or Threatened Species Taking Permit.
- US Army Corps of Engineers: Section 404 Permit (discharge of dredged or fill material or excavation within waters and wetlands may require approval of the US Army Corps of Engineers).
- Environmental Quality Board (EQB): Requires environmental reviews in the form of an Environmental Assessment Worksheet (EAW) for operations excavating 40 or more acres of land at a mean depth of 10 feet, and Environmental Impact Statement (EIS) for operations exceeding 160 acres.
- Board of Water and Soil Resources (BWSR): Wetland Conservation Act.
- Pollution Control Agency (MPCA): Section 401 Certification; Water Quality, and Air Quality Regulations.[134]

The agency has been asked to initiate a broad-based Generic Environmental Impact Statement process, going beyond case-by-case review, but has not yet done so. One state senator from the southeastern sand-mining Mississippi River counties, in making his request, said that he would seek an extra appropriation for the agency to do the work, which otherwise constitute a major new work program without any extra resources with which to conduct it.

Wisconsin

In January 2012, the state Department of Natural Resources issued a long descriptive document, *Silica Sand Mining in Wisconsin*, laying out the state of the industry, the challenges to be met in mining responsibly, and the general standards to be met, alongside the specific regulatory requirements for sand mining operations, principally in air and water permits.[135]

The state notes that operators must deal with local authorities with respect to zoning, operational requirements, and reclamation, the latter under statewide guidelines.

In Wisconsin, towns have the legal power to regulate nonmetallic frac sand mining tightly, even to the point of excluding it altogether. In February 2012, the Wisconsin Supreme Court ruled in a challenge to the exclusion of such mining by the town of Cooks Valley in Chippewa County that the town had acceptably exercised its non-zoning police power.[136] Other towns have placed moratoria on mining, but the state legislature this past year tightened the criteria for moratoria based on the local zoning power in Minnesota Statues 66.1002.

In August 2012, four sand mining companies organized themselves into a Wisconsin Industrial Sand Association (WISA), which notes that sand mining dates back over a century in the state

and that the image of a miner is to be found in the state symbol and the state flag. According to the home page at the WISA website:

As leaders of the state's sand mining industry, WISA is focused on working cooperatively with state and local governments and others to help develop effective and scientifically based safety, health, environmental and land-use standards. Our members follow a mandatory Code of Conduct with strong principles and tough standards that guide the Association's efforts to be a leader in fostering a healthy, safe and environmentally responsible sand mining industry in Wisconsin. WISA and its members will work to show that there are many positives when taking the right approach to sand mining. With a proper balance between sound operations, adherence to responsible regulations and good relationships, we can operate safely and protect the environment while generating significant economic impact.[137]

Evidently the industry believes that it has a positive future in the state. The latest count of mines stands at 37 in operation, 41 more permitted, and 29 more proposed. However, the pace of permit applications at the state Department of Transportation has slowed over what it had been, and one mine reportedly is stockpiling sand until a price rise would make it more profitable to process it.[138]

Appendix B: Annotated Bibliography

Introduction

Tioga conducted a limited literature review using standard literature and on-line search technologies to create source documents necessary to describe the Marcellus/Utica gas industry. An important factor in this review is that the Marcellus/Utica development is a recent phenomenon, with most of the activity occurring in the last five years. As a result much of what has been published recently is already obsolete and, because of the interest in this area, new literature is being produced regularly.

For this literature search, public sources have been categorized by local, state, and federal agency. Other categories include universities, trade organizations, and environmental groups. There is also a "current events" component to this study, and media sources have been included. Sources cover the major topics of project inquiry: industry overview; major facilities from wells to cracking plants and steel mills; and cargo flows for a variety of commodities (sand, steel, water, etc.).

U.S. Government

Energy Information Agency (EIA)

The U.S. EIA is the standard source for current and forecast information regarding energy statistics including production, markets, inventories, transportation, pricing and reserves. It produces regular reports on shale gas on an annual, monthly, and weekly basis.

U.S. Energy Information Administration. Annual Energy Outlook 2012 with Projections to 2035. Web. 25 Sept. 2012.
< http://www.eia.gov/forecasts/aeo/pdf/0383%282012%29.pdf>

U.S. Energy Information Administration. Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays. Washington, DC: INTEK, 2011. Web. 25 Sept. 2012. < http://www.eia.gov/analysis/studies/usshalegas/pdf/usshaleplays.pdf>

U.S. Energy Information Administration. Short-Term Energy Outlook August 2012. Web. 25 Sept. 2012. < http://www.eia.gov/forecasts/steo/special/pdf/2012_sp_03aug.pdf>

U.S. Energy Information Administration. Short-Term Energy Outlook October 2012. Web. 18 October 2012.< http://www.eia.gov/forecasts/steo/pdf/steo_full.pdf>

"EIA - Natural Gas Pipeline Network - Transporting Natural Gas in the United States." ***EIA - Natural Gas Pipeline Network - Transporting Natural Gas in the United States*****. Web. 15 Oct. 2012.**
<http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/index.html>

Environmental Protection Agency

"Natural Gas Extraction - Hydraulic Fracturing." EPA. Environmental Protection Agency. Web. 25 Sept. 2012. <http://www.epa.gov/hydraulicfracture/>

This is the key web reference providing basic information and summarizing EPA's ongoing activities and studies regarding shale gas extraction.

"EPA Dimock, PA Water Test Results Show No Contamination | Marcellus Drilling News." EPA Dimock, PA Water Test Results Show No Contamination. Web. 25 Sept. 2012. <http://marcellusdrilling.com/2012/03/epas-dimock-pa-water-test-results-show-no-contamination/>

This source includes industry background on the landmark "Dimock, PA Case." The EPA provided, in the form of an email, a second opinion for the residents of Dimock that their water was not being contaminated by shale gas extraction.

“Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report.” EPA. Environmental Protection Agency. Web. 28 Jan. 2013. <http://epa.gov/hfstudy/pdfs/hf-progress-report-exec-summary20121214.pdf>.

The purpose of the study is to assess the potential impacts of hydraulic fracturing on drinking water resources.

U.S Army Corps of Engineers

United States. U.S. Army Corp of Engineers Navigation Data Center. Web 17 October 2012. <http://www.ndc.iwr.usace.army.mil/wcsc/wcsc.htm>.

The site provides the public information on cargo movement statistics which are used to set priorities for new investment, and for the operation, rehabilitation and maintenance of existing infrastructure. Data is at a summary level so as to not disclose movements of individual companies.

Kelly, Lloyd, Karl Lang, and Gregory Washington, eds. Forecast of Utility Steam Coal Consumption, Sourcing and Transportation for the Great Lakes and Ohio River Basin Regions Shale Gas Scenario, Draft Report. Rep. no. W91237-08-C-0010-P00009. Leonardo Technologies, 2012.

The report updates previously generated forecasts by adjusting applicable assumptions by incorporating current thinking with regard to expected future shale gas development and utilization, with a leaning towards a scenario that favors the use of natural gas in electric generation.

Department of Energy

Projecting the Economic Impact of Marcellus Shale Gas Development in West Virginia: A Preliminary Analysis Using Publicly Available Data. Rep. no. 402/033110. ALL Consulting, LLC, March 2010. Web. 18 October 2012.

<http://www.netl.doe.gov/energy-analyses/pubs/WVMarcellusEconomics3.pdf>.

This report informs the public about the magnitude, economic effects, and the future outlook of the Marcellus Shale gas industry in the State of West Virginia.

Bureau of Labor Management

"Interior Releases Draft Rule Requiring Public Disclosure of Chemicals Used in Hydraulic Fracturing on Public and Indian Lands." ***Interior Releases Draft Rule Requiring Public Disclosure of Chemicals Used in Hydraulic Fracturing on Public and Indian Lands*****. N.p., n.d. Web. 28 Jan. 2013.**

<http://www.blm.gov/wo/st/en/info/newsroom/2012/may/NR_05_04_2012.html>.

The Bureau of Land Management (BLM) is proposing a rule to regulate hydraulic fracturing on public land and Indian land.

National Economic Research Associates (NERA)

"Macroeconomic Impacts of LNG Exports from the United States." NERA Economic Consulting, 3 Dec. 2012. Web. 29 Jan. 2013.

<http://www.fossil.energy.gov/programs/gasregulation/reports/nera_lng_report.pdf>

Federal Energy Regulatory Commission (FERC)

"FERC: LNG - Existing FERC Jurisdictional LNG Import/Export Terminals." ***FERC*****. 19 Apr. 2012. Web. 29 Jan. 2013.** <http://ferc.gov/industries/gas/indus-act/lng/exist-term.asp>.

Map of Existing FERC Jurisdictional LNG Import/Export Terminals

States

Pennsylvania

Pennsylvania Department of Environmental Protection (DEP), "Marcellus Shale." Web. 18 October 2012. <http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-85899/0100-FS-DEP4217.pdf>.

Fact Sheet for land owners and other citizens provided by the PA DEP summarizing commonwealths environmental regulations.

Governor's Marcellus Shale Advisory Commission**. Rep. Harrisburg, PA, 2011. Web 18 October 2012.**
<http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf>.

Governor Tom Corbett's commission to identify, prioritize and craft recommendations regarding the safe, efficient and environmentally responsible extraction and use of unconventional natural gas reserves in Pennsylvania

"Pipeline Safety." ***PA Public Utility Commission*****. Web. 15 Oct. 201**2. <http://www.puc.state.pa.us/utility_industry/natural_gas/pipeline_safety.aspx>.

The report outlines pipeline safety regulations established by the Pennsylvania Public Utility Commission (PUC).

Pennsylvania Department of Labor and Energy, "Marcellus Shale Fast Facts" Web. 18 October 2012.
<http://www.portal.state.pa.us/portal/server.pt?open=514&objID=1222103&mode=2>

The purpose of this Fast Facts publication is to provide the most current available data on Marcellus Shale related economic activity.

Kasey, Pam. "PA Establishes Gas Impact Fee, Limits Local Regulation - Business, Government Legal News from throughout WV." ***PA Establishes Gas Impact Fee, Limits Local Regulation - Business, Government Legal News from throughout WV*****. 11 Mar. 2012. Web. 28 Jan. 2013.** <http://www.statejournal.com/story/16906145/shale-gas-legislation-only-awaits-pa-govs-signature>**.**

A bill that establishes an impact fee on gas extracted from unconventional, horizontally drilled or hydraulically fractured wells was signed Feb. 13 by Pennsylvania Gov. Tom Corbett, which limits the ability of local jurisdictions to regulate oil and gas activity.

A**mico, Chris, Danny DeBelius, Scott Detrow, and Matt Stiles. "Natural Gas Drilling in Pennsylvania."** ***StateImpact Pennsylvania*****. Web. 28 Jan. 2013**. <http://stateimpact.npr.org/pennsylvania/drilling/>.

"Bill Encourages Use of Mine Water in Gas Well Drilling." ***Heraldstandard.com*****. 18 Oct. 2012. Web. 28 Jan. 2013**. <http://www.heraldstandard.com/marcellus_shale/bill-encourages-use-of-mine-water-in-gas-well-drilling/article_c3d4d911-d617-5c5a-8d55-90131c69168b.html>.

PA State Senate has unanimously approved legislation that would encourage the use of mine water for Marcellus shale natural gas well development.

Puko, Timothy. "Large, Lively Crowd Turns out for Supreme Court Arguments on Gas Drilling Laws." ***TribLIVE.com*****. 18 Oct. 2012. Web. 28 Jan. 2013.**
<http://triblive.com/news/2788534-74/state-court-justices-drilling-gas-activists-act-law-mccaffery-questions>.

At a Pennsylvania Supreme Court legal argument on the state's new oil and gas laws, two Democratic justices challenged a lawyer arguing to save the state's limits on local control of gas drilling.

H**enderson, Patrick, Energy Executive, Office of Governor Tom Corbett.** ***Report To The General Assembly On Pipeline Placement Of Natural Gas Gathering Lines,*** **December 11, 2012.**

Maykuth, Andrew, ***Fifteen-year deal to ship ethane via Marcus Hook.*** **Philadelphia Inquirer, January 24, 2013.** <http://articles.philly.com/2013-01-25/business/36529244_1_ship-ethane-mariner-east-sunoco-logistics>.

A European petrochemical producer has entered into a 15-year agreement to ship Marcellus Shale ethane to Norway from a Sunoco Logistics terminal in Marcus Hook.

"SH BELL CO - East Liverpool Terminal." ***SH BELL CO - East Liverpool Terminal*****. Web. 20 Mar. 2013**. <http://www.shbellco.com/East_Liverpool.htm>.

This site discusses the East Liverpool Terminal located in Midland, PA.

"Eureka Resources." ***Eureka Resources*****. Aug. 2012. Web. 20 Mar. 2013.** <http://www.eureka-resources.com/news.html>.

Eureka Resources, LLC, announced that it has obtained the necessary permits and approvals to begin construction of a world-class centralized wastewater treatment facility in Standing Stone Township, Bradford County, Pa., to treat wastewater generated during development of oil and gas wells in the Marcellus and Utica Shale.

"Marcellus Shale Advisory Commission." ***Pennsylvania DEP*****. N.p., n.d. Web. 20 Mar. 2013**. <http://www.portal.state.pa.us/portal/server.pt/community/marcellus_shale_advisory_commission/20074>.

Marcellus Shale Advisory Commission.

Ohio

Ohio Department of Natural Resources. "The Facts About Hydraulic Fracturing." Web. 18 October 2012. <http://ohiodnr.com/Portals/11/pdf/fracking-fact-sheet.pdf>.

The report discusses the history, purpose, process, and statistics of hydraulic fracturing in the state of Ohio.

Ohio Department of Natural Resources. "Wastewater (Flowback) from Hydraulic Fracturing." Web. 18 October 2012. <http://ohiodnr.com/Portals/11/pdf/wastewater-fact-sheet.pdf>.

The report describes the harmful wastewater that results from hydraulic fracturing.

Ohio Environmental Protection Agency. "Drilling for Natural Gas in the Marcellus and Utica Shales: Environmental Regulatory Basics." Web. 18 October 2012. <http://www.epa.state.oh.us/Portals/0/general%20pdfs/generalshale711.pdf>.

The report is a summary of Ohio gas drilling regulations.

Funk, John. "New $1.5 Billion Natural Gas Pipeline Proposed for Northern Ohio." *Cleveland.com*. 4 Sept. 2012. Web. 28 Jan. 2013. <http://www.cleveland.com/business/index.ssf/2012/09/new_15_billion_natural_gas_pip.html>.

Two major pipeline corporations and a large diversified energy company are proposing a major new gas transmission line to run 250 miles across northern Ohio. It would link existing transmission lines and storage facilities in Michigan and Canada.

Funk, John. "$1 billion Ohio natural gas processing plant to open in May, encouraging more drilling." *Cleveland.com*. 7 Dec. 2012. Web. 28 Jan. 2013. <http://www.cleveland.com/business/index.ssf/2012/12/1_bilion_ohio_natural_gas_proc.html>.

The first of several large natural gas processing plants in eastern Ohio is scheduled to open in May.

"Akin Gump Strauss Hauer & Feld LLP." - *Ohio Passes Shale Gas Drilling Law*. 13 Jun. 2012. Web. 28 Jan. 2013. <http://www.akingump.com/en/news-publications/ohio-passes-shale-gas-drilling-law.html>.

Ohio Gov. John Kasich signed into law Senate Bill 315 (“SB 315”), which requires owners and operators of oil and gas wells to provide detailed disclosures regarding their horizontal drilling operations in the Utica shale formation.

"Horizontal Utica-Point Pleasant Well Activity in Ohio." *Ohio Department of Natural Resources*. N.p., 5 Dec. 2012. Web. 29 Jan. 2013. <http://www.dnr.state.oh.us/portals/10/Energy/Utica/UticaWellsActivity_12052012.pdf>.

Map displaying Utica shale well activity in eastern Ohio.

Miller, Mark J. "Johnson Discusses Gas Traffic, Local Roads." - *News, Sports, Jobs*. 12 Jan. 2013. Web. 29 Jan. 2013. <http://news-register.net/page/content.detail/id/579781/Johnson-Discusses-Gas-Traffic--L---.html>.

Representative Bill Johnson, R-Ohio, visited Jefferson County to discuss road projects, as well as road-use agreements between municipalities and companies involved in Utica shale exploration.

LaRue, Dennis. "Marathon Oil Invests $2.4M at Wellsville Intermodal Site." *Business Journal Daily*. 17 July 2012. Web. 20 Mar. 2013. <http://businessjournaldaily.com/company-news/marathon-oil-invests-24m-wellsville-intermodal-site-2012-7-17>.

Several hundred trucks a day will deliver the liquids of “wet” natural gas from the Utica shale to the four holding tanks Marathon Petroleum Company owns in the Wellsville Intermodal Facility, but first Marathon must build a pipe linking the tanks.

Downing, Bob, *Marathon, partner plan truck-barge shipments at Wellsville.* Akron Beacon Journal on Line. October 14, 2012. Web. <http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/marathon-partner-plan-truck-barge-shipments-at-wellsville-1.341703>.

Marathon Petroleum Corporation and Harvest Pipeline Company signed a letter of intent agreeing to jointly develop infrastructure that will facilitate transportation of hydrocarbon liquids production from the Utica Shale in eastern Ohio and western Pennsylvania.

Bell, Jeff. "Ohio Approves 4 More Fracking Injection Wells after Strengthening Rules." ***Shale Drillers Getting More Fracking Injection Wells in Ohio*****. N.p., 14 Nov. 2012. Web. 20 Mar**. 2013. <http://www.bizjournals.com/columbus/blog/2012/11/ohio-approves-4-more-fracking.html>.

The Ohio Department of Natural Resources has resumed issuing operating permits for new disposal wells for fracking fluids produced during drilling for oil and natural gas in shale plays.

Schoenberger, Robert. "Northeast Ohio." ***The Plain Dealer*****. N.p., 16 Nov. 2011. Web. 20 Mar. 2013.**
<http://www.cleveland.com/business/index.ssf/2011/11/republic_steel_to_add_450_jobs.html>.

Republic Steel plans to invest $85.2 million and create 450 jobs in Lorain, Ohio three years after shutting its blast furnace and cutting 700 jobs.

"NEXUS Gas Transmission." Web. 20 Mar. 2013.
<http://www.dtepipeline.com/pdfs/nexusFactSheet.pdf>.

Additional pipeline transportation infrastructure is needed in the upper U.S. Midwest and eastern Canadian regions to support growing demand for clean-burning natural gas.

"Akin Gump Strauss Hauer & Feld LLP." - ***Ohio Passes Shale Gas Drilling Law*****. N.p., 13 June 2013. Web. 20 Mar. 2013.** <http://www.akingump.com/en/news-publications/ohio-passes-shale-gas-drilling-law.html>.

On June 11, 2012, Ohio Gov. John Kasich signed into law Senate Bill 315 (“SB 315”), which requires owners and operators of oil and gas wells to provide detailed disclosures regarding their horizontal drilling operations in the Utica shale formation.

New York

"Marcellus Shale." - NYS Dept. of Environmental Conservation. Web. 25 Sept. 2012.
<http://www.dec.ny.gov/energy/46288.html>.

New York’s Department of Environmental Conservation provides background on gas well drilling in the Marcellus Shale, exploring the sudden interest, benefits, and environmental concerns.

"High Volume Hydraulic Fracturing Proposed Regulations." - ***NYS Dept. of Environmental Conservation*****. Web. 28 Jan. 2013**. <http://www.dec.ny.gov/regulations/77353.html>.

The New York State Department of Environmental Conservation (DEC) filed a Notice of Continuation with the Department of State to extend the rulemaking process by 90 days. If DEC

decides that hydraulic fracturing cannot be safely done in New York, the process will not go forward.

Wilber, Tom. "New York's Fracking Clock Reset for End of February." *Blogspot*. N.p., 29 Nov. 2012. Web. 28 Jan. 2013. <http://tomwilber.blogspot.com/2012/11/new-yorks-fracking-clock-reset-for-end.html>.

New York State Department of Environmental Conservation has been given more time to finish the shale gas development task it began in 2008.

Wilber, Tom. "No Quick Resolution on Shale Gas Moratorium in New York." *Planet Forward*. 6 Apr. 2012. Web. 28 Jan. 2013. <http://planetforward.org/2012/04/06/no-quick-resolution-on-shale-gas-moratorium-in-new-york/>.

Andrew Cuomo has promised the public that the Department of Environmental Conservation would release a final version of the permitting guidelines within months. Legislative leaders spoke with this week have a much different outlook.

Robinson, David. "Southern Tier Panelists, Pro and Con, Discuss Hydrofracking." *Stargazette*. 3 Jan. 2013. Web. 28 Jan. 2013.
<http://www.stargazette.com/article/20130103/NEWS11/301030036/Panel-Important-deadlines-loom-New-York-fracking-debate?odyssey=tab|topnews|text|FRONTPAGE&gcheck=1>.

Community leaders on both sides of the debate are coming close to a decision on whether or not to allow hydraulic fracturing in New York.

West Virginia

"Legislative Deliberations Regarding Marcellus Shale Move Forward." *Wrap-Up*. Vol. XXII, Iss.4. 9 Feb. 2011. Web. 29 Jan. 2013.

<http://www.legis.state.wv.us/Wrapup/pdfs/Vol.XXII_issue4.pdf>.

West Virginia lawmakers are contemplating multiple issues that could result from hydraulic fracturing in the numerous Marcellus Shale reserves in that state.

Stover, Jamie. "WV DEP Explains Permitting Process for Well Sites - WBOY.com: Clarksburg, Morgantown: News, Sports, Weather." *WBoy*. N.p., 23 Aug. 2012. Web. 29 Jan. 2013. <http://www.wboy.com/story/19239370/wv-dep-explains-permitting-process-for-well-sites>.

The West Virginia Department of Environmental Protection (DEP) is issuing permits to construct natural gas wells, but permit distribution is not moving as quickly as some had hoped.

West Virginia Legislature.
<http://www.legis.state.wv.us/Bill_Status/bills_text.cfm?billdoc=hb401%20enr.htm&yr=2011&sesstype=4X&i=401>.

Wisconsin

Wisconsin Geological and Natural History Survey. *Frac Sand in Wisconsin*. Rep. Madison, WI: Extension, 2012. Web. 18 October 2012.
<http://wisconsingeologicalsurvey.org/pdfs/frac-sand-factsheet.pdf>.

This article is about Wisconsin's frac sand, which is in high demand due to recent advances in hydraulic fracturing.

Wisconsin Dept. of Natural Resources, *Silica Sand Mining in Wisconsin*. Rep. Madison, WI: 2012. Web 18 October 2012.
<http://dnr.wi.gov/topic/Mines/documents/SilicaSandMiningFinal.pdf>.

This article discusses silicon sand mining in Wisconsin. It is an informational report that summarizes the best current information on the mining process, possible environmental impacts, and applicable regulations.

Prengaman, Kate. "Updated Map: Frac Sand Rush Slowing | WisconsinWatch.org." *Updated Map: Frac Sand Rush Slowing | WisconsinWatch.org*. 25 Oct. 2012. Web. 29 Jan. 2013. <http://www.wisconsinwatch.org/2012/10/25/updated-map-frac-sand-rush-slowing/>.

The growth boom in Wisconsin's frac sand industry has been declining.

"Wisconsin Department of Natural Resources." *Silica Sand Mining*. Web. 29 Jan. 2013.
<http://dnr.wi.gov/topic/mines/silica.html>.

Silica sand mining in Wisconsin.

Stoddard, Glenn M. "Town Regulation of Frac Sand and Nonmetallic Mining Operations in Wisconsin." June 2012. Web. 29 Jan. 2013.

<http://midwestadvocates.org/assets/resources/Town_Regulation_of_Frac_Sand_Nonmetallic_Mining_%283%29.pdf>.

Impacts of frac sand and nonmetallic mining in Wisconsin.

"Wisconsin Industrial Sand Association." *Wisconsin Industrial Sand Association*. Web. 29 Jan. 2013. <http://wisconsinsand.org/>.

The Wisconsin Industrial Sand Association (WISA) is an organization formed to promote safe and environmentally responsible sand mining standards in Wisconsin.

Minnesota

Arends, Heather. "Industrial Silica Sand Mining In Minnesota." Web. 29 Jan. 2013.

<http://www.eqb.state.mn.us/documents/2012_07_18-EQB-Combined%20Frac%20Sand.pdf>.

"Industrial Silica Sand." FAQs: Minnesota DNR. N.p., n.d. Web. 29 Jan. 2013. <http://www.dnr.state.mn.us/lands_minerals/silicasand.html>.

Frequently Asked Questions about Industrial Silica Sand from the Department of Natural Resources in Minnesota.

Texas

Vasquez, Leticia. "Slowdown in Pipeline Builds to Cut Marcellus Gas Output Growth: Report." - *Natural Gas*. Ed. Jeff Barber. N.p., 29 Nov. 2012. Web. 29 Jan. 2013. <http://www.platts.com/RSSFeedDetailedNews/RSSFeed/NaturalGas/6851017>.

A decline in the construction of pipelines will lead to lower natural gas production growth in some parts of the Marcellus Shale and could lead to higher gas prices next year as supply from higher-priced regions makes up some of the shortfall.

Shauk, Zain. "Drillers Looking at Cutting Need for Lots of Water." *San Antonio Express-News*. 29 Sept. 2012. Web. 29 Jan. 2013.
<http://www.mysanantonio.com/business/article/Drillers-looking-at-cutting-need-for-lots-of-water-3878703.php>.

Oil and gas companies are in need of huge volumes of water for working in shale formations, despite improvements in drilling speeds that have lowered other costs.

Regional Agencies

Northern Tier Regional Planning & Development Commission

Gannett Fleming GFX and Navarro & Wright Consulting Engineers, Inc. Marcellus Shale Freight Transportation Study. Rep. Towanda, PA: Northern Tier Regional Planning & Development Commission, 2011. Web. 18 October 2012.
<http://www.scribd.com/doc/83141921/Marcellus-Shale-Freight-Transportation-Study-prepared-by-Gannett-Fleming-for-the-Northern-Tier-Planning-Development-Commission-November-2011>.

The report provides details on freight and transportation activity associated with the Marcellus shale industry in five counties in northeast Pennsylvania. A primary issue is damage caused by increased heavy truck traffic to rural roads.

Universities

Carnegie Mellon

"Marcellus Shale Drilling." - Carnegie Mellon University. Web. 25 Sept. 2012.
<http://www.cmu.edu/homepage/environment/2010/summer/marcellus-shale-drilling.shtml>.

This article outlines the environmental concerns associated with shale gas drilling in Southwestern PA, particularly to the water resources.

Penn State University

Considine, Timothy J., Robert Watson, and Seth Blumsack. The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update. Rep. Pennsylvania State University College of Earth and Mineral Sciences Department of Energy and Mineral Engineering, 2010. "How Much Natural Gas Can The Marcellus Shale Produce?" Marcellus Center for Outreach & Research. 2012. Web. 18 October 2012. <http://marcelluscoalition.org/wp-content/uploads/2010/05/PA-Marcellus-Updated-Economic-Impacts-5.24.10.3.pdf>.

This study, conducted by professors at Penn State University, aims to inform the public about the magnitude, economic effects, and the future outlook of the Marcellus Shale gas industry in the Commonwealth of Pennsylvania.

Penn State University, Marcellus Center for Outreach and Research. *"Maps and Graphics"* Web. 18 October 2012. <http://www.marcellus.psu.edu/resources/maps.php>

This website is Penn State University's resource for excellent maps, graphics, and publications related to Marcellus and Utica shale. The Marcellus Center's objective is to explore the geology, technology, economics, business and sociology of the Marcellus Shale with a goal of understanding both the resource as well as the environmental, economic and social challenges posed by its exploration and development.

Institute for Energy and Environmental Research for Northeastern Pennsylvania (IEER)/Wilkes University

Klemow, Kenneth M., Ph.D., Dale A. Bruns, Ph.D., and Brian Oram, P.G. Institute for Energy and Environmental Research for Northeastern Pennsylvania (IEER) /Wilkes University commentary on Osborn et al. (2011) article: Methane contamination of drinking water accompanying gas well drilling and hydraulic fracturing, published in Proceedings of the National Academy of Sciences (vol. 108, pages 8172-8176). Web 18 October 2012 <http://energy.wilkes.edu/PDFFiles/IEER%20Commentary/IEER.Osborn.Commentary.pdf>.

This article summarizes a study conducted which analyzed water quality samples from drinking water wells located near shale drilling sites in northeastern PA and south-central New York State. The samples were found to have rather high concentrations of methane. However, the study concluded that there is no evidence to prove that flowback water from hydrofracking contaminates drinking water.

West Virginia University

"WVU Study: Marcellus Shale Has Potential For significant Economic Development in West Virginia." WVU Study on Marcellus Shale. Web. 25 Sept. 2012. <http://www.be.wvu.edu/news_events/marcellus_shale/index.htm>.

The report quantifies the economic importance of the natural gas industry and the Marcellus Shale play in West Virginia in calendar year 2009. In addition, the report outlines key policy questions, including some of the tax, legal, and environmental issues that must be addressed as the industry matures in the state.

Rice University

Medlock, Kenneth B., Ph.D., Amy M. Jaffe, and Peter R. Hartley, Ph.D. Shale Gas and U.S. National Security. Rep. Houston, TX: James A. Baker III Institute for Public Policy of Rice University, 2011. Web. 18 October 2012.
<http://www.bakerinstitute.org/publications/EF-pub-DOEShaleGas-07192011.pdf>.

This report discusses the impact of U.S. domestic shale gas development on energy security and national security, emphasizing the effects of increasing domestic shale gas and the potential issues that may arise regarding foreign policy.

Medlock, Kenneth B., Ph.D., Jill Nesbitt, and Peter R. Hartley, Ph.D. Rice University World Gas Trade Model. Rep. Houston, TX: James A. Baker III Institute for Public Policy of Rice University. Web 18 October 2012.
<http://www.ruf.rice.edu/~ecforum/presentations/Forum04/Peter%20Hartley%20-%20Presentation%20-%20An%20Economic%20Model%20of%20the%20Gas%20Industry.pdf>.

This model examines the political and economic influences on the gas market, by addressing the issue of declining reserves in North America and the growing energy demand in Asia.

Environmental Organizations

Sierra Club

"Welcome to the Marcellus Drilling Resource Page." Sierra Club Pennsylvania Chapter. Web. 25 Sept. 2012.
<http://pennsylvania.sierraclub.org/PA_Chapter_2008/Conservation/Energy/MarcellusDrillingResourcePage.htm>.

The article outlines the Sierra Club's position on hydraulic fracturing and related demands of the Pennsylvania Legislature regarding needed regulations. The club advocates that all natural gas production, including deep shale gas, should be governed by a robust and effective regulatory structure; all gas should be produced using rigorous best management practices to limit environmental damage.

Marcellus-Shale.us

"Natural Gas Pipeline Construction." ***Marcellus-Shale.us*****. Web. 15 Oct. 2012.**
<http://www.marcellus-shale.us/gas-pipelines.htm>.

Provides numerous photographs on the construction of natural gas pipelines.

"Our look at ROAD DAMAGE from heavy truck traffic." Marcellus-Shale.us**. Web. 18 Oct.** 2012. < http://www.marcellus-shale.us/road_damage.htm>.

Provides numerous photographs showing damaged to local, rural roads associated with shale gas development.

Environmental and Energy Study Institute

Glass, Kate. Shale Gas and Oil Terminology Explained: Technology, Inputs & Operations. Rep. Ed. Carol Werner. Washington, DC. Web. 18 October 2012.
<http://files.eesi.org/fracking_technology_120111.pdf>.

The Environmental and Energy Study Institute (EESI) is a nonprofit organization founded in 1984, which aims to discover new environmental and energy solutions. This article discusses the technology and operations behind hydraulic fracturing.

EarthWorksAction

"Hydraulic Fracturing 101" *EARTHWORKS*. Web. 26 Sept. 2012.
<http://www.earthworksaction.org/issues/detail/hydraulic_fracturing_101>.

Comprehensive summary of fracking issues and impacts, including: water use, sand and proppants, toxic chemicals, health concerns, surface water and soil contamination, groundwater contamination, air quality, waste disposal, and chemical disclosure.

Industry Organizations

Marcellus Coalition

"Drilling." Drilling. Web. 25 Sept. 2012.
<http://marcelluscoalition.org/marcellus-shale/production-processes/drilling/>.

"Hydraulic Fracturing." Hydraulic Fracturing. Web. 25 Sept. 2012.
<http://marcelluscoalition.org/marcellus-shale/production-processes/fracture-stimulation/>.

The Marcellus Shale Coalition (MSC) is a trade organization that provides information to policymakers, regulators, media, and other public stakeholders on the positive impacts responsible natural gas production.

FracFocus.org

"Groundwater Quality & Testing." Home. Web. 25 Sept. 2012.
<http://fracfocus.org/groundwater-protection/groundwater-quality-testing>.

This article is about groundwater contamination, which may result from fracking. It also discusses the process of testing the quality of drinking water and points out that there may not necessarily be an obvious indicator of contamination because many hazardous contaminants are undetectable to the human senses.

"Hydraulic Fracturing: The Process." Home. Web. 25 Sept. 2012.
<http://fracfocus.org/hydraulic-fracturing-how-it-works/hydraulic-fracturing-process>.

FracFocus is a national hydraulic fracturing chemical registry. The site provides the public access to reported chemicals used for hydraulic fracturing. FracFocus is managed by the Ground Water.

MarcellusGas.org

" Information Related to Marcellus Gas Well Activity." Home. Web. 18 October 2012.
< http://www.marcellusgas.org/help.php >.

This website provides detailed, individual well information for gas wells in Pennsylvania including:

- Well-Pad name (which is often the landowner's name)
- Well-Pad summary report (including royalty estimates, waste value, violations)
- The county and township that the well-pad is located in
- Individual well status (indicating if well development has started)
- Production values for producing wells
- Royalty estimates for producing wells
- Detailed waste reports for well-sites and the individual wells
- Detailed inspection & violation reporting for individual wells
- Gas Company name and contact information
- Availability of Fracturing Fluid Composition Reports
- Well type (vertical or horizontal)
- Availability of Drilling Maps and/or complete Well Packets
- Permit application and approval dates
- Geographical coordinates (latitude and longitude)

Association of American Railroads

Association of American Railroads Policy & Economics Department, "*Rail Time Indicators A Review of Key Economic Trends Shaping Demand for Rail Transportation,"* Washington, D.C., October 5, 2012. Web. 17 October 2012.
<http://www.aar.org/~/media/aar/railtimeindicators/2012-10-rti-updated.ashx>

The Association of American Railroads publishes a monthly analysis of the rail business. The October edition reports that "Car loads of crushed stone, sand, and gravel were up 9,044 carloads, or 12.3%, in September 2012 Much, if not most, of the increase in this category is probably attributable to higher frac sand movements."

GreenHunter Energy, Inc.

"GreenHunter Water Closes on Acquisition of Salt Water Disposal Wells in Marcellus and Utica Shale Plays" GreenHunter Energy, Inc. Press Release. Web. 25 October 2012.
http://phx.corporate-ir.net/phoenix.zhtml?c=219127&p=irol-newsArticle&ID=1749920&highlight=

GreenHunter Water, LLC, has acquired two operating Class II salt water disposal (SWD) wells located in Washington County, Ohio and Ritchie County, West Virginia. These SWD wells are strategically positioned in the heart of the Marcellus and Utica Shale Unconventional Resource Plays and will bring an additional 3,000 to 4,000 Barrels per day (Bbld.) of combined commercial SWD capacity into the Company’s existing water services portfolio.

Carlyle Group L.P.

"A Case Study." ***The Carlyle Group and Sunoco Agree to Form Philadelphia Refinery Joint Venture*****. N.p., n.d. Web. 27 Sept. 2012.** <http://www.carlyle.com/news-room/news-release-archive/carlyle-group-and-sunoco-agree-form-philadelphia-refinery-joint-ventu>.

The Carlyle Group L.P. and Sunoco, Inc. formed a joint venture called Philadelphia Energy Solutions, which will allow the historic Philadelphia refinery, the oldest one on the East coast, to resume operations. This will save hundreds of jobs and create hundreds of new ones, and secure the region's fuel supply.

Ohio Business Development Coalition

"Marcellus and Utica Shale Gas Supply Chain." Rep. Ohio Business Development Coalition, 2011. Web. 18 October 2012.
<http://enterpriseappalachia.com/assets/shalegas_whitepaper_fnl.pdf>.

The report touts Ohio as optimally situated in the five-state Marcellus and Utica Shale region for supply chain companies serving the gas industry.

NaturalGas.org

"NaturalGas.org." ***Overview of Natural Gas*****. Web. 15 Oct. 2012.**
<http://naturalgas.org/overview/overview.asp>.

Insight on the background and history of the natural gas industry.

Marcellus Drilling News

"New Interstate Pipelines Mean Thousands of Jobs in PA | Marcellus Drilling News." ***New Interstate Pipelines Mean Thousands of Jobs in PA | Marcellus Drilling News*****. Web. 15 Oct. 2012**.
<http://marcellusdrilling.com/2011/08/new-interstate-pipelines-mean-thousands-of-jobs-in-pa/>.

Talks about the new interstate pipelines that will be built in Pennsylvania and the thousands of new jobs it they will create.

The Brookings Institution

Ebinger, Charles, Kevin Massy, and Govinda Avasarala. ***Liquid Markets: Assessing the Case for U.S. Exports of Liquefied Natural Gas*****. Rep. Washington, DC: Brookings Institution, 2012. Web. 18 October 2012.**
<http://www.brookings.edu/~/media/research/files/reports/2012/5/02%20lng%20exports%20ebinger/0502_lng_exports_ebinger>

This is report provides general overview of the gas industry and assesses the outlook for U.S. Liquefied Natural Gas (LNG) exports.

Media

Business Week

Malik, Naureen S. "Natural Gas Pipelines to Expand U.S. Supply Glut: Energy Markets." ***Bloomberg Businessweek*****. 26 Sept. 2012. Web. 15 Oct. 2012.** <http://www.businessweek.com/news/2012-09-26/natural-gas-pipelines-to-expand-u-dot-s-dot-supply-glut-energy-markets#p2>.

Discusses the expansion of natural gas pipelines throughout the U.S.

National Public Radio

"A Cracker Means Jobs, But Environmentalists Worry About Air Pollution." StateImpact Pennsylvania. Web. 25 Sept. 2012. <http://stateimpact.npr.org/pennsylvania/2012/08/06/a-cracker-means-jobs-but-environmentalists-worry-about-air-pollution/>.

The Marcellus shale boom in Pennsylvania has created thousands of jobs, but environmentalists are concerned with air pollution.

"Philadelphia's Sunoco Refinery Will Process Shale Oil With the Help of Natural Gas." StateImpact Pennsylvania. Web. 25 Sept. 2012. <http://stateimpact.npr.org/pennsylvania/2012/07/02/philadelphias-sunoco-refinery-will-process-shale-oil-with-the-help-of-natural-gas/>.

The Sunoco refinery in southwest Philadelphia, which was scheduled to shut down, will now stay open to process shale oil using natural gas.

"Southeast Pa. Refineries Look to Marcellus Shale as a Savior." ***StateImpact Pennsylvania*****. Web. 25 Sept. 2012.** <http://stateimpact.npr.org/pennsylvania/2012/07/06/southeast-pa-refineries-look-to-marcellus-shale-as-a-savior/>.

"Marcus Hook Refinery to Process Marcellus Shale Gas." ***StateImpact Pennsylvania*****. Web. 27 Sept. 2012.** <http://stateimpact.npr.org/pennsylvania/2012/09/26/marcus-hook-refinery-to-process-marcellus-shale-products/>.

Sunoco's Crude Oil Refinery in Marcus Hook, which shut down last year, will now reopen and process Marcellus shale gas. Natural gas, in liquid form, is essential in the manufacturing of plastic.

"Your Guide to Pipelines in Pennsylvania." ***StateImpact Pennsylvania*****. Web. 15 Oct. 2012.** <http://stateimpact.npr.org/pennsylvania/tag/pipelines/>.

The report discusses the new pipelines that are planned to be constructed in Pennsylvania.

Reuters

McGurty, Janet. "Delta's Trainer Refinery Begins Making Jet Fuel-source." ***Reuters*****. Thomson Reuters, 24 Jan. 2012. Web. 27 Sept. 2012.** <http://www.reuters.com/article/2012/09/24/uk-refinery-operations-delta-trainer-idUSLNE88N01R20120924>.

Delta Airlines' oil refinery in Trainer, PA is now producing jet fuel.

McAllister, Edward and Houlihan, Eileen. "Analysis: Waking giant-Marcellus Shale bullies U.S. gas market." *Reuters*. 15 October 2012. Web. 31 October 2012.

< http://www.reuters.com/article/2012/10/15/us-energy-natgas-marcellus-idUSBRE89E12B20121015>.

Only now is the Marcellus beginning to realize its full potential. It's a bearish signal for both day- and month-ahead gas prices and could threaten the profitability of producing gas for companies. About ten projects coming online in the next three months alone will add an extra 3 billion cubic feet per day (Bcfd) of pipeline capacity, according to government data. Another 5 Bcfd of projects are in the works for 2013, at least. More than 1,000 drilled wells are waiting to be hooked up to pipelines in the Marcellus - about 700 above the norm - thanks to a busy drilling program in the region since 2009 that ran ahead of the infrastructure needed to move the gas to market, including pipelines, processing facilities and compressor stations. It is not clear how fast this production will be brought on line due to low gas prices.

Business Insider

"The Environmental Defense Fund Comes Out In Support Of Fracking." *Business Insider*. Web. 11 Oct. 2012. <http://www.businessinsider.com/environmental-defense-fund-supports-fracking-2012-9>.

The EDF's chief counsel has expressed support for hydraulic fracturing of natural gas primarily because it will replace coal.

Bloomberg

"Youngstown Opens Mills Again as States Jockey for Fracking Jobs." *Bloomberg*. Web. 27 Sept. 2012. <http://www.bloomberg.com/news/2012-01-10/youngstown-opens-mills-again-as-states-jockey-for-fracking-jobs.html>.

A new mill is being built in Youngstown, Ohio due to the natural-gas drilling boom, which will create many new jobs. Employment by businesses in the Marcellus shale industry is increasing significantly.

"Taxpayers Pay as Fracking Trucks Overwhelm Rural Cow Paths." *Bloomberg*. Web. 18 October 2012. <http://www.businessweek.com/news/2012-05-15/taxpayers-pay-as-fracking-trucks-overwhelm-rural-cow-paths>

The article outlines the different approaches taken by states in response to the increase in heavy truck traffic on rural roads associated with shale gas development.

Roston, Eric. "Shale Fracking Makes U.S. Natural Gas Superpower. Now What?" *Bloomberg*. 25 Sept. 2012. Web. 29 Jan. 2013. <http://www.bloomberg.com/news/2012-09-26/shale-fracking-makes-u-s-natural-gas-superpower-now-what-.html>.

Asian demand for natural gas has increased dramatically and Alaska wants to build a $50 billion pipeline and export terminal to move its stranded supply offshore.

Elmquis, Sonja. "Shale-Gas Revolution Spurs Wave of New U.S. Steel Plants: Energy." *Bloomberg*. 31 Dec. 2012. Web. 20 Mar. 2013. <http://www.bloomberg.com/news/2012-12-31/shale-gas-revolution-spurs-wave-of-new-u-s-steel-plants-energy.html>.

The U.S. shale-gas revolution, which has revitalized chemicals companies and prompted talk of domestic energy self-sufficiency, is attracting a wave of investment that may revive profits in the steel industry.

The Patriot-News

"Pipeline Projects: Focus in Marcellus Shale Gas Region Turns to Interstate Transportation | PennLive.com." The Patriot-News. Web. 25 Sept. 2012. <http://www.pennlive.com/editorials/index.ssf/2011/08/pipeline_projects_focus_in_mar.html>.

Drilling companies already know how to drill for the shale gas. Now they want to install interstate pipelines to be able to transport it.

Geology.com

"Marcellus Shale - Appalachian Basin Natural Gas Play." Marcellus Shale Gas: New Research Results Surprise Geologists! Web. 25 Sept. 2012. <http://geology.com/articles/marcellus-shale.shtml>.

Provides background and statistics on Marcellus shale gas production in the Appalachian region.

Forbes

"George Mitchell." *Forbes*. Forbes Magazine, n.d. Web. 26 Sept. 2012. <http://www.forbes.com/profile/george-mitchell/>.

The article is about George Mitchell who is known as the father of natural shale gas drilling. He was the first to use hydraulic fracking to break open the Barnett shale field in Texas.

Silverstein, Ken. "All Roads Lead to Natural Gas-Fueled Cars and Trucks." *Forbes*. Forbes Magazine, 15 Dec. 2012. Web. 20 Mar. 2013. <http://www.forbes.com/sites/kensilverstein/2012/12/15/all-roads-lead-to-natural-gas-fueled-cars-and-trucks/>.

Royal Dutch Shell is now making plans to invest heavily in liquefied natural gas, or LNG. Shell, and others, see the export of the super-cooled natural gas as a lucrative venture.

Scranton Time-Tribune

"Are Leaking Wells Letting Methane Get into Dimock's Water?" - *Gas Drilling*. Web. 11 Oct. 2012. <http://thetimes-tribune.com/news/gas-drilling/are-leaking-wells-letting-methane-get-into-dimock-s-water-1.1381012>.

The local newspaper article identifies the various, sometimes conflicting, state and federal reports which are producing confusion and frustration for local residents.

New York Times

Navarro, Mireya. "Bloomberg Backs 'Responsible' Extraction of Gas and Pays to Help Set Up Rules." Web. 26 Sept. 2012. <http://www.nytimes.com/2012/08/25/nyregion/bloomberg-backs-gas-drilling-with-rules-to-protect-the-environment.html?_r=0>.

Mr. Bloomberg came out strongly in favor of natural gas extraction through the controversial drilling process, known as fracking, as a way to lower utility bills, spur economic growth and reduce the nation's dependence on coal. But the mayor said the drilling should take place under "common sense" regulations, to minimize environmental harm.

Schneider, Keith. "SQUARE FEET; As Demand Rises, Ohio's Steel Mills Shake Off the Rust and Expand." ***The New York Times*****. The New York Times, 25 Apr. 2012. Web. 27 Sept. 2012**. <http://www.nytimes.com/2012/04/25/business/energy-environment/ohio-steel-mills-expand-to-meet-demand-in-energy-and-auto-industries.html?_r=0>.

Due to increasing demand for motor vehicles and a drilling boom in the gas and oil industry, the Ohio steel industry (second-largest in the U.S.) will expand once again.

Rbnenergy.com

Fielden, Sandy. "Tales of the Tight Sand Laterals – Understanding Horizontal Drilling and Fracking." Web. 26 Sept. 2012.
<http://www.rbnenergy.com/tales-of-the-tight-sand-laterals%E2%80%93understanding-horizontal-drilling-and-fracking>.

This article explains horizontal drilling, how it works, and its importance.

Standard & Poor's

Standard & Poor's Financial Services. "How The Marcellus Shale Is Changing The Dynamics Of The U.S. Energy Industry" Web 18 October 2012.
<http://www.standardandpoors.com/ratings/articles/en/us/?assetID=1245342008525>

The article is a summary of S&P's expectations regarding the future of Marcellus shale gas development. It forecasts that in the longer term, once sufficient takeaway capacity is in place, low-cost production in the Marcellus will displace higher-cost gas production in other U.S. regions.

Pipeline News

"Study Shows Need For Multi-Billion Dollar Spending On Natural Gas Infrastructure." ***Pipeline News*****. Web. 15 Oct. 2012.**
<http://pipeline-news.com/feature/study-shows-need-multi-billion-dollar-spending-natural-gas-infrastructure>.

The report estimates costs associated with natural gas infrastructure the U.S. and Canada.

The American Oil and Gas Reporter

Brickle, Jennifer. "December 2012 Cover StoryBack to Archives." ***Surging NGL Production Drives Infrastructure Projects In Marcellus, Utica Plays*****. 2012. Web. 20 Mar. 2013.** <http://www.aogr.com/index.php/magazine/cover-story/surging-ngl-production-drives-infrastructure-projects-in-marcellus-utica-pl>.

The Marcellus and Utica shale plays in the U.S. Northeast are experiencing one of the most dramatic growth curves in North America. However, gas production has been limited by changes in historical flow and pricing patterns, as well as the region's ability to handle the associated natural gas liquids.

The Intelligencer / Wheeling News-Register

"Dominion Plans December Start" ***The Intelligencer / Wheeling News-Register,*** **Web 25 October 2012.** <http://news-register.net/page/content.detail/id/576352/Dominion-Plans-December-Start.html?nav=515>.

More than 900 construction workers are now building the $500 million Dominion Resources facility in Marshall County, WV with plans to have it ready to process 200 million cubic feet of natural gas per day by December. Wet Marcellus and Utica shale gas will travel to the Dominion plant via the company's pipeline network. The plant will separate the ethane, butane, propane and other natural gas liquids from the "dry" methane gas so that all the products can be individually marketed. Dominion will hire 40-45 full-time, permanent workers for jobs at the plant itself upon completion. These jobs will pay from $20-$30 per hour.

The Hill

German, Ben. "Interior Floats New Draft Rules to Regulate Oil-and-gas 'fracking'." ***The Hill*****. 4 May 2012. Web. 28 Jan. 2013.** <http://thehill.com/blogs/e2-wire/e2-wire/225473-interior-unveils-fracking-rules-amid-industry-boos>.

The Interior Department floated plans Friday to regulate the controversial oil-and-gas extraction method dubbed "fracking" on federal lands, drawing quick attacks from industry groups that said the requirements aren't needed.

German, Ben. "Obama officials delay 'fracking' rules." ***The Hill*****. 18 Jan. 2013. Web. 28 Jan. 2013**. <http://thehill.com/blogs/e2-wire/e2-wire/278107-interior-pumps-brakes-on-gas-fracking-rule-plans-revision>.

The Interior Department is delaying planned rules that would impose new requirements on the controversial oil-and-gas production method called hydraulic fracturing.

PressConnects

Campbell, Jon. "Martens: Fracking Health Experts Coming 'soon'" ***PressConnects*****. 19 Oct. 2012. Web. 28 Jan. 2013**.
<http://www.pressconnects.com/article/20121019/NEWS11/310190024/Martens-Fracking-he?nclick_check=1>.

Outside health experts are not yet under contract to help assess the state's review of shale-gas drilling, but an agreement is soon expected.

Reilly, Steve. "Chenango Council Votes down Drilling Moratorium." ***PressConnects*****. 3 Jan. 2013. Web. 28 Jan. 2013**. <http://www.pressconnects.com/article/20130103/NEWS01/301030077/Chenango-Council-votes-down-drilling-moratorium?nclick_check=1>.

Municipal leaders have opted against a measure that would have made Chenango the first town in the Southern Tier to ban oil and gas drilling.

National Journal

Shepard, Steven. "Poll: Cuomo, State Senate Coalition Popular in N.Y." ***National Journal*****. 12 Dec. 2012. Web. 28 Jan. 2013.** <http://www.nationaljournal.com/blogs/hotlineoncall/2012/12/poll-cuomo-state-senate-coalition-popular-in-n-y-12>.

New York Governor Andrew Cuomo has received from some national Democrats for supporting the coalition between Republicans and breakaway Democrats that has formed to control the state Senate in Albany and Cuomo's approval ratings have hit a record high halfway through his first term.

Winona Daily News

Christenson, Jerome. "Welcome!" ***Winona Daily News*****. N.p., 24 Jan. 2013. Web. 20 Mar. 2013.** <http://www.winonadailynews.com/news/local/article_ec15c8aa-65d7-11e2-88d1-0019bb2963f4.html>.

The Winona City Council turned down a citizens group's objection late Tuesday night to increasing frac sand barge loading at the Port Authority dock.

Pittsburgh Post-Gazette

DeMarco, Emily. "Shale Drillers Want to Move Wastewater on Barges." ***Pittsburgh Post-Gazette*****. 16 Dec. 2012. Web. 20 Mar. 2013**. <http://www.post-gazette.com/stories/local/marcellusshale/shale-drillers-want-to-move-wastewater-on-barges-666573/>.

The shale gas drilling industry wants to move its wastewater by barge on rivers and lakes across the country. But the U.S. Coast Guard, which regulates the nation's waterways, must first decide whether it's safe.

Weirton Daily Times

Harris, Linda. "Natural Gas Liquids Shipped from Half Moon Industrial Park." ***News, Sports, Jobs*****. 7 Dec. 2012. Web. 20 Mar. 20**13.

<http://weirtondailytimes.com/page/content.detail/id/592113/Natural-gas-liquids-shipped-from---.html>.

A tanker barge carrying a million gallons of natural gas from a tank farm in the Half Moon Industrial Park is on its way to Houston. This is a "significant milestone" in the Weirton port's development.

Miscellaneous

"Platts Appalachian Gas Conference." MarkWest Energy Partners, L.P., 16 Oct. 2012. Web. 29 Jan. 2013. <http://investor.markwest.com/phoenix.zhtml?c=135034&p=irol-presentations>.

MarkWest Energy Partners presentation at Platts Appalachian Gas Conference

Platts Price Group, Power, Oil, and Petrochemical Divisions, *The North American Gas Value Chain: Developments and Opportunities.* September, 2012, p5.

US natural gas liquids production is expected to rise dramatically this decade thanks to recent favorable economics for drilling.

American Chemistry Council, *Shale Gas, Competitiveness and New U.S. Investment: A Case Study of Eight Manufacturing Industries,* May 2012.
http://www.americanchemistry.com/Policy/Energy/Shale-Gas/Shale-Gas-Competitiveness-and-New-US-Investment.pdf

This report examines the potential economic and employment benefits of natural gas development from Marcellus Shale reserves.

PWC, *Shale gas, A renaissance in US manufacturing,* October 2012. <http://www.nam.org/~/media/01A2FACA40ED41F3A20FA08FBD6522C0/Shale_Gas_A_renaissance_in_Manufacturing.pdf>.

This document offers views on how shale gas resources can help the sector address these challenges and create more jobs in the United States.

PWC, *Shale gas, Reshaping the US chemicals industry,* October 2012.
<http://www.pwc.com/us/en/index.jhtml>.

"Baker Hughes Investor Relations." *Baker Hughes*. Web. 20 Mar. 2013.
<http://gis.bakerhughesdirect.com/Reports/StandardReport.aspx>.

This report contains a graph, which compares the number of rigs in the current year to the number of rigs in the previous year, showing a decline in the current year.

***Water Use in Marcellus Deep Shale Gas Exploration*, Chesapeake Energy Fact Sheet. May 2012. Web.** <http://www.chk.com/media/educational-library/fact-sheets/marcellus/marcellus_water_use_fact_sheet.pdf>.

Water is an essential component of Chesapeake Energy Corporation's deep shale gas development. Drilling a typical Chesapeake Marcellus deep shale gas well requires approximately 100,000 gallons of water.

***US Silica: The First IPO in the "Fracking Sand" Industry,* 17 Feb. 2012. Web.** <http://oilandgas-investments.com/2012/stock-market/us-silica-ipo-fracking-sand/>.

US Silica (NYSE: SLCA) went public on the NYSE on February 1st at $17/share, raising $42 million. Prior to this IPO, the only frac sand companies were either private or held by oil companies.

***Oil & Natural Gas: The Evolving Freight Transportation Impacts.* 5 Mar. 2013.** <http://prologisticsgroup.com/wp-content/uploads/2013/03/PLG-REFC-Presentation-030513-FINAL.pdf>.

This report describes the impact of freight transportation on hydraulic fracturing.

The Marcellus Multiplier, Marcellus Shale Coalition. Web. <http://marcelluscoalition.org/wp-content/uploads/2011/08/Marcellus-Multiplier.pdf>.

This site describes the multiple components of the Marcellus Shale Coalition.

Davies, Phil, *Sand surge: In Minnesota and Wisconsin, frac sand mining has lifted local economies--and stirred opposition*, Fed gazette 16 July 2012. Web <http://www.minneapolisfed.org/publications_papers/pub_display.cfm?id=4921>.

Mining development can impose costs, such as lost revenues in other industries, environmental harm and diminished public health and safety. In many communities, new or proposed sand mines have provoked public outcry, leading counties and townships to pass moratoriums on new frac sand operations.

Pirog, Robert and Ratner, Michael, *Natural Gas in the U.S. Economy: Opportunities for Growth,* Congressional Research Service, 6 Nov. 2012. Web. <http://www.fas.org/sgp/crs/misc/R42814.pdf>.

Due to the growth in natural gas production, primarily from shale gas, the United States is benefitting from some of the lowest prices for natural gas in the world and faces the question of how to best use this resource.

Finch, James, *Ethanol, Fertilizer & Higher Natural Gas Prices*. Market Oracle, 29 Apr. 2007. Web. <http://www.marketoracle.co.uk/Article891.html>.

This article explains how the ethanol boom could lead to higher natural gas prices.

"Consol Invests in Epiphany Solar Water Systems." - *Pittsburgh Business Times*. N.p., 25 June 2012. Web. 20 Mar. 2013.

<http://www.bizjournals.com/pittsburgh/blog/energy/2012/06/consol-invests-in-epiphany-solar-water.html?page=all>.

As part of Consol Energy Inc.'s (NYSE: CNX) newly unveiled Water Division, the Southpointe-based coal and natural gas company is investing in New Castle-based Epiphany Solar Water Systems.

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