

SHALE GAS ROCKS THE WORLD

BY BARBARA BILLITZER

When two geoscience professors projected that 500 trillion cubic feet of natural gas was buried under Pennsylvania and surrounding states, the energy industry took notice.

Located in the Appalachian Basin, the Marcellus Shale stretches from New York through Pennsylvania, Ohio, Maryland and West Virginia. It also extends under the Great Lakes, across into Canada in the province of Ontario. With roughly 10% of the natural gas estimated to be recoverable, the volume would be enough to supply the entire United States for about two years and have a wellhead value of one trillion dollars.

At a depth of 5,000 to 8,000 feet, extracting this natural gas had long been considered prohibitively expensive. That was then. This is now.

EARLY ESTIMATES

The Marcellus Shale, also referred to as the Marcellus Formation, is a widespread layer of gas-bearing shale that was deposited millions of years ago in vast protected seas that once covered North America. For years, every geologist involved in Appalachian Basin oil and gas has known about the Devonian black shale called the Marcellus. Its black color is easy to spot in the field and its slightly radioactive signature makes it a very easy pick on a geophysical well log.

While geologists had long known that the Marcellus contained natural gas, its depth and low permeability made it an unconventional target. In fact, before 2000, the volume extracted was considered insignificant. It wasn't

until 2002, when the United States Geological Survey released its Assessment of Undiscovered Oil and Gas Resources of the Appalachian Basin Province, in which it calculated that the Marcellus Shale contained an estimated undiscovered resource of about 1.9 trillion cubic feet of gas. Understandably, interest in the energy producing potential of the shale increased considerably.

One of the largest drillers, Range Resources - Appalachia, LLC is credited with starting the Marcellus Shale gas play. In 2003, they drilled a Marcellus well in Washington County, Pennsylvania and found a promising flow of natural gas. Their first Marcellus gas production from the well began in 2005. By the end of 2007, more than 375 exploratory gas wells had been permitted in Pennsylvania.

Then, in early 2008, Terry Engelder, a geoscience professor at Pennsylvania State University, and Gary Nash, a geology professor at the State University of New York at Fredonia, surprised the industry with estimates that the Marcellus might actually contain more than 500 trillion cubic feet of natural gas, 10% of which might be recoverable. At a Petroleum Technology Transfer Council workshop in January 2008, they projected that, according to volumetric calculations, the Marcellus would become one of the world's top super giant gas fields. Once the press got wind of the numbers, a land rush in the Appalachian Basin followed.

LEVERAGING TECHNOLOGY

Originally deemed too expensive to drill, two recent technological efforts have made the 54,000-square-mile Marcellus reservoir a more attractive resource.

Several years earlier, two new drilling methods were perfected for the shale reservoirs in the Barnett Shale of Texas. To capture the gas, one of the new technologies involves horizontal drilling. Using a vertical well reoriented to the horizontal, it penetrates a maximum number of vertical rock fractures and extends a maximum distance within the gas-bearing rock. With horizontal drilling, oil and gas companies can drill sideways and expose more surface area for gas to seep out.

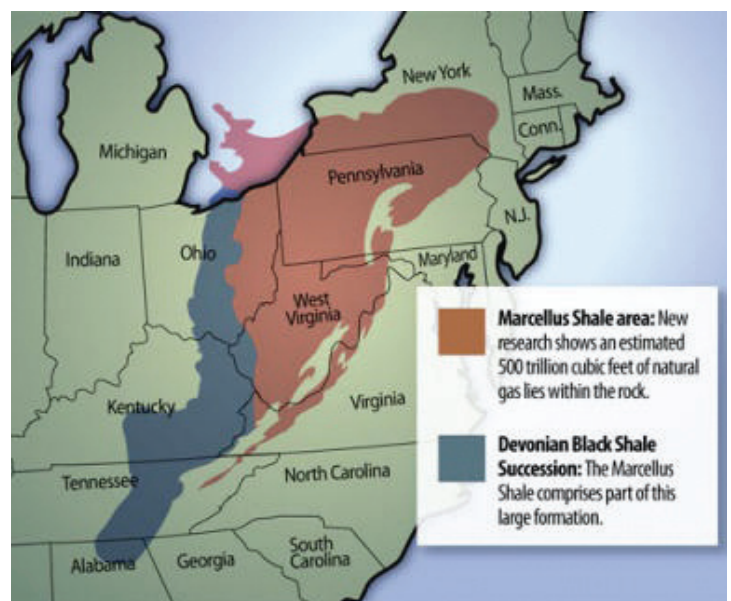
The second method is hydraulic fracturing, which has already demonstrated a production rate of more than one million cubic feet of natural gas per day. With this technique, water is pumped into the vertical portion of the well and then continues into the perforated horizontal portion to produce a pressure that is high enough to fracture the surrounding rock. This water contains sand which prevents the fractured shale from collapsing back to its original tight formation. The result is a highly fractured stratum penetrated by a long length of perforated well bore held open by the sand. Upon release of the water pressure, a back-flush of contaminated wastewater comes to the surface followed by the natural gas.

LANDOWNERS AND LEASING

In 2005, there was very little interest in leasing properties for Marcellus Shale gas production. It was not considered to be an important gas resource, and an economically feasible technology for tapping it had not been demonstrated. At that time, the level of uncertainty in the minds of the buyers was very high and the signing bonuses were just a few dollars per acre.

When the potential of the Marcellus was first suspected in 2006, a small number of speculators began leasing land - paying risky signing bonuses that were sometimes as high as \$100 per acre. By late 2007, signing bonuses of a few hundred dollars per acre were common. Then, as the technology was demonstrated and publicized, signing bonuses began to rise rapidly. By early 2008, several wells with strong production rates were drilled, numerous investors began leasing and the signing bonuses rose from a few hundred dollars per acre up to over \$2,000 per acre for the most desirable properties.

According to Aaron Hubbard, a Project Manager for Mason Dixon Energy, "Five years ago, landowners leased out of speculation, and realistically, most didn't expect anything to come from leasing their land. Today, everyone takes it seriously, and they know that development is more likely. The overall knowledge base is higher, and attorneys are frequently consulted. The owners ask a lot of questions and negotiations are slower."



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There are several types of leases being used to access the Marcellus natural gas. One is a mineral lease, which is a private contractual agreement between the owner of a mineral tract who grants the right to develop deposits of the mineral to a producer. Oil and gas leases are also used, where the mineral rights can be sold or leased separately to different parties. Oftentimes, a lessee will insist on the right to sell or reassign a mineral lease to another party.

To expedite the leasing process, signing bonuses are offered in many cases, and the amount can vary significantly. It is typically based on the level of uncertainty in the mind of the buyer and the number of other buyers competing to make the purchase. Although signing bonuses generate a guaranteed income, royalties can indeed be a more significant source of revenue for the owner. A royalty is a share of a well's income, and a customary royalty rate is 12.5 percent of the value of gas produced by a well. Higher royalty rates are sometimes paid by aggressive buyers for highly desirable properties. The royalties paid to eligible property owners from a well yielding over one million cubic feet of natural gas per day can be hundreds of thousands of dollars per year.

According to those who have negotiated with property owners, establishing realistic expectations can make a huge difference in the level of landowner cooperation. "We're just now seeing widespread drilling, and not very many people are receiving royalties yet," notes Aaron. "The landowners who are getting wells are virtually pioneers in the process, and they don't know what to expect. There's some skepticism about whether the nuisance will be worth it in the long run. Attitudes will improve as the overall level of understanding and experience increases. For example, we had a man that was difficult to deal with last fall while we were getting ready to drill the first well on his property. Now that we're preparing to drill a second well, he's been much easier to work with. He understands the process better, and he's been receiving royalty checks for the last few months. He knows what to expect."

The majority of surface owners also own the oil and gas, however in some cases, there are different owners. "Severances are not uncommon," according to Aaron. "Because of the oil and gas activity in Pennsylvania in the late 1800s and early 1900s, we frequently find reservations of oil and gas. We recently had a situation where two sisters inherited a property from their father in 1913. One sister conveyed her interest in the property to the other sister in 1920, but she reserved one-half of the oil and gas. The other one-half interest came forward to the current surface owner, but we had to track the heirs of the severed one-half interest to Missouri."

Many property owners are being asked to sign right of way agreements that will allow natural gas pipelines and gathering systems to be built across their land. If the property owner is not associated with the gas production, there could be compensation for granting the right of way.

PIPELINES AND RIGHT OF WAYS

The Pennsylvania Department of Environmental Protection (DEP) says drilling permits are up strongly since 2005 and that much of the activity increase can be attributed to wells targeting the Marcellus shale. Some of the new wells appear capable of yielding millions of cubic feet per day. This level of volume has motivated companies to work faster to acquire leases on desirable properties and complete new wells.

DEP's Bureau of Oil and Gas Management has reported on the tremendous growth in Marcellus wells across the state. In 2008, 196 wells were drilled and 519 wells were permitted. In 2009, 763 wells were drilled and 1,985 were permitted. As of mid-2010, 280 wells have been drilled and 584 have been permitted.

However, most of the leased properties are not adjacent to a natural gas pipeline, and the gas pipeline capacity currently available is a tiny fraction of what will be needed. With hundreds of thousands of acres leased for drilling natural gas, several new pipelines must be built to transport millions of cubic feet of natural gas per day to major markets. In addition, thousands of miles of natural gas gathering systems must be built to connect individual wells to the major pipelines.

IMPACT OF DRILLING

The natural gas well construction needed for the Marcellus Formation will involve extensive earth disturbances that impact roads, drilling pads and pipelines, all of which can speed erosion. Various regulations, implemented through the DEP, are in place to protect surface water and groundwater from erosion and sedimentation due to earth disturbances. Erosion and sediment control plan requirements under state law apply to any earth disturbance activities, and plans require gas companies to use preventative measures to restore the site and vegetation within nine months of well completion by planting grass, trees or crop plots.

The DEP's field operations staff inspects well sites to ensure that the operator sites and drills the well according to the permit and applicable laws. DEP staff also investigate complaints where an oil or gas well or drilling activity may be causing environmental or public safety concerns, especially when contamination of a drinking water supply is suspected.



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There is an enormous amount of water typically required for hydraulic fracturing. This might range anywhere from one million gallons for a vertical well to roughly five million gallons for a vertical well with a horizontal lateral. Given such a large volume of water required during the drilling process, the amount of wastewater is massive. Consequently, there are significant concerns about water use, treatment and potential contamination.

As part of the permit application process, drilling companies must identify where they plan to obtain and store the water used in their drilling operations, specify the sources and location of fresh water and the anticipated impacts of water withdrawals on water resources, and obtain approval from the appropriate river basin commission.

The DEP, in cooperation with the Susquehanna and Delaware River basin commissions, has created additional permit guidelines for drilling in the Marcellus Shale formation with consistent rules for water withdrawal, usage, treatment and disposal. Wastewater must be reused and recycled, or collected and treated at an authorized waste water treatment facility. DEP approval is required before the receiving treatment facility can accept the wastewater for processing and/or disposal.

Pennsylvania law requires drillers to case and cement Marcellus Shale natural gas wells through all fresh water aquifers before drilling through deeper zones known to contain oil or gas. This casing and cement protects groundwater from the fluids and natural gas that will be contained inside the well, and keeps water from the surface and other geologic strata from mixing with and contaminating groundwater.



Chesapeake Energy representatives met with more than 600 landowners in Wyoming County to discuss the process involved with leasing mineral rights.

Bryan Swistock, a Penn State Water Resources Specialist, has been studying the connections between the water used for the drilling process (brine), and the drinking water supply. He recommends that property owners get it stated in their lease that the drill site has to be at least 500 feet from a water supply. While Pennsylvania law states it only has to be 200 feet, Bryan considers this distance inadequate. He also believes that only 30 percent of what the company uses to drill will resurface within a couple of months and that not enough studies have been completed to find out when and where the remaining water will resurface in the future.

REGULATIONS AND PERMITTING

The DEP's Bureau of Oil and Gas Management regulates the safe exploration, development and recovery of Marcellus Shale natural gas reservoirs in a manner that will protect the region's natural resources and the environment. The technical staff in the DEP regional offices is responsible for reviewing each well permit application to determine whether the proposed well would cause environmental impacts, conflict with coal mine operations or exceed well spacing requirements.

To secure a permit, an applicant must show the location of the well, proximity to coal seams, and distances from surface waters and water supplies, including reports on well completion, waste management, annual production and well plugging. Each operator is required to post a bond, which serves as a financial incentive to ensure that the operator will adequately perform the drilling operations, address any water supply problems the drilling activity may cause, reclaim the well site and properly plug the well upon abandonment. The bond amount for a single well is \$2,500, and a blanket bond to cover any number of wells is \$25,000.

Recognizing that compliance assistance helps to prevent incidents of environmental damage, the DEP holds

workshops for the industry and will meet with applicants as needed to address environmental matters in advance of well site construction. They also instruct and advise well drillers and operators on best management practices and procedures for environmental control and waste management. The DEP is also responsible for inspecting drilling operations and responding to complaints about water quality problems, and their inspectors will conduct routine and even unannounced inspections of drilling sites and wells.

Many landowners and municipalities are interested in receiving notices of well permit applications in their area. In response, DEP introduced a no-cost subscription service called eNotice that notifies land owners and municipalities by email when a well permit application is received. Considered one of the most innovative ways government has developed to keep its citizens informed, the DEP received the Council of State Governments Innovations Award for their eNotice system.

PIPELINE CHALLENGES

Much of the pipeline activity is expected to take place in Pennsylvania, and the prospect of such large levels of construction has state officials rethinking the relevant regulatory authorities. Since development of the Marcellus shale formation could potentially last 50 years, regulators are seeking authority to make sure that the underground pipelines carrying the natural gas product are well maintained and safe.

The Public Utility Commission (PUC) regulates the safety of intrastate natural gas pipelines. The agency is pushing for state legislation to extend this authority over non-utility pipelines that will eventually be built throughout the Marcellus shale. State law requires that individuals or contractors notify a "one-call" center three days before excavation work to determine if natural gas pipelines are nearby. The center then notifies utilities of the pending work so they can mark the pipeline route.

PUC Chairman James Cawley outlined the agency's goals earlier this year before the House Consumer Affairs Committee. The agency is seeking authority to inspect pipelines owned by commercial natural gas producers that are outside its traditional jurisdiction over public utilities. Historically, a significant amount of state utility pipelines have been made of cast iron or steel. Many of these systems are getting to be quite old, and increasingly vulnerable to the freeze-and-thaw cycle of Pennsylvania winters. "We are seeing a lot of corrosion, breaking and cracking," says PUC spokeswoman Jennifer Kocher.

EXPANDING THE TRANSPORTATION INFRASTRUCTURE

All of this drilling has producers and pipeline operators looking for ways to expand the region's natural gas transportation infrastructure. One example is Atlas Pipeline Partners, L.P., who announced the formation of Laurel Mountain Midstream, LLC, a joint venture whose goal is to be the leading gathering system in the southwestern Pennsylvania portion of the Marcellus shale. As part of the deal, Atlas Energy Resources, LLC, announced that it would sell the joint venture two natural gas processing plants and associated pipelines located in Southwestern Pennsylvania for \$12 million. Laurel Mountain Mainstream will manage the ongoing operation and anticipated expansion of the Appalachian system, which will in turn be utilized by Atlas Energy and other third-party producers in the Marcellus shale. Gene Dubay, President and Chief Executive Officer of Atlas Pipeline, observed that the new venture will provide "the financial leverage needed to fund expansion capital for anticipated growth in production from the Marcellus Shale."

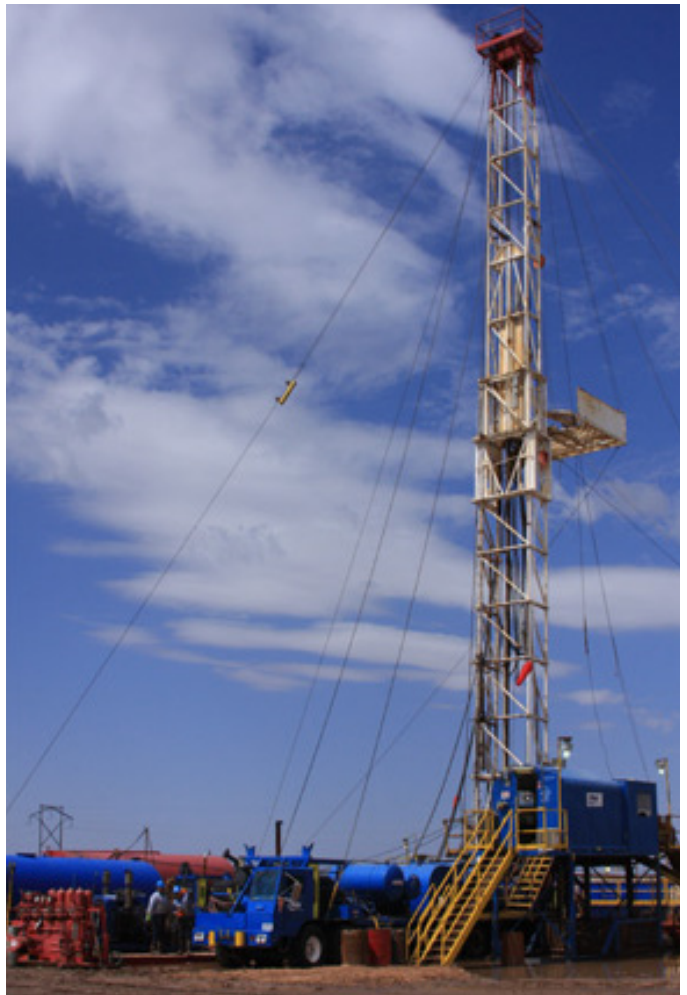
Another key player is Richmond, Virginia-based Dominion Resources Inc., which recently agreed to the price of \$552 million for the natural gas drilling rights on more than 205,000 acres, mostly in western Pennsylvania and West Virginia, to Antero Resources. Dominion will reportedly gain after-tax proceeds of about \$325 million, plus receive a 7.5% royalty interest on future natural gas production from the assigned acreage. The proceeds will enable Dominion to build a pipeline that will deliver gas from southwestern Pennsylvania to the East Coast.

Dominion's planned pipeline, called Dominion Keystone, would take natural gas from southwestern Pennsylvania to Chester County, Pennsylvania, where it would connect to pipelines operated by Dominion, Spectra, Williams and NiSource. Antero and a Dominion subsidiary would provide about 500 million cubic feet of gas per day to the pipeline, and about one billion cubic feet per day by the end of 2012. According to a company news release, "The pipeline project is a response to the many Appalachian producers who are seeking reliable natural gas pipeline transmission for increased production from conventional drilling, coalbed methane and Lower Huron shale, as well as Marcellus shale."

Range Resources and Markwest Energy Partners signed an agreement under which MarkWest will construct and operate gas gathering pipelines and processing facilities associated with Range's Marcellus shale acreage in the Appalachian basin. After having slated \$50 million for regional development last year, MarkWest was reportedly scheduled to invest up to an additional \$125 million based on projects currently being

developed. John Pinkerton, Chairman and CEO of Range Resources, commented that the arrangement with MarkWest Energy Partners will enable his company to fully develop its acreage in the Marcellus play. "Having the pipeline and processing infrastructure in place will be important for us to develop the reserve potential of the play," said John.

Superior Pipeline of Tulsa, a Unit Corp. subsidiary, has launched a multimillion-dollar effort to build infrastructure around the Marcellus shale. Superior Appalachian Pipeline, a subsidiary of Superior Pipeline, has signed a long-term agreement with Appalachian Producer Services of McMurray, Pennsylvania, for developing midstream pipeline projects in the Appalachian basin. Those efforts, which mark Superior's physical growth beyond its primary asset base in Oklahoma, Texas and Louisiana, seek to tap potential natural gas supplies in the Marcellus shale and other Appalachian formations.



Range Resources designed a customized rig specifically for Marcellus drilling with state-of-the-art technology and low environmental impact.

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In a report published by the Oklahoma City Journal Record, Unit Corp. President and Chief Executive Officer Larry Pinkston noted, “We’re interested in constructing new gathering systems to both relieve existing bottlenecks and gather natural gas from these potential sources.”

Epsilon Energy Ltd., another producer in the Marcellus shale, recently announced that it had initiated natural gas production on its Highway 706 project in northeastern Pennsylvania, which is within the boundary of the developing shale play. The company says that this is its first domestic project in which it is the operator and holds a 100% working interest. In two and a half years, the company has acquired roughly 12,000 acres of prospective Marcellus shale leasehold, assembled 25 miles of pipeline right of way, drilled a combination of three vertical and five horizontal wells, and hydraulically fractured and completed five of those wells to date.

Last year, Tennessee Gas announced plans to increase their capacity of its 300 line to transport new diversified natural gas supplies, including newly accessed Appalachian and Marcellus shale gas, to serve the growing demand for interstate natural gas transmission service in the northeastern United States. The project would provide access to diversified natural gas supplies from Gulf Coast, Appalachian, Rockies and Marcellus shale supply areas. It would also facilitate gas deliveries to points along the 300 line path and into various interconnections with other pipelines in northern New Jersey, as well as an existing delivery point in White Plains, New York.

ECONOMIC SIGNIFICANCE

According to a Penn State study and reports from Consol Energy, the natural gas boom is expected to create 200,000 jobs in the region during the next 10 years. “We’re sitting on gold here,” said U.S. Representative Tim Murphy (R-Upper St. Clair). “Marcellus Shale is now being considered the best economic engine seen in decades.”

Jason Norris, of Dura-Bond Industries Inc., knows firsthand the economic impact of drilling for natural gas in the Marcellus Shale formation. As the Vice President of Commercial Tubular Products for the pipe manufacturer coatings company, Jason said

the company has expanded its employee roster and has spent \$1 million on new equipment. The 50-year-old company is looking to build an \$8 million plant which will coat pipe to resist corrosion, will employ 55 to 65 people and should be operational within one year. Dura-Bond recently received a \$30 million contract from Dominion Transmission for 45 miles of 30-inch pipe, and 65 miles of 24-inch pipe.

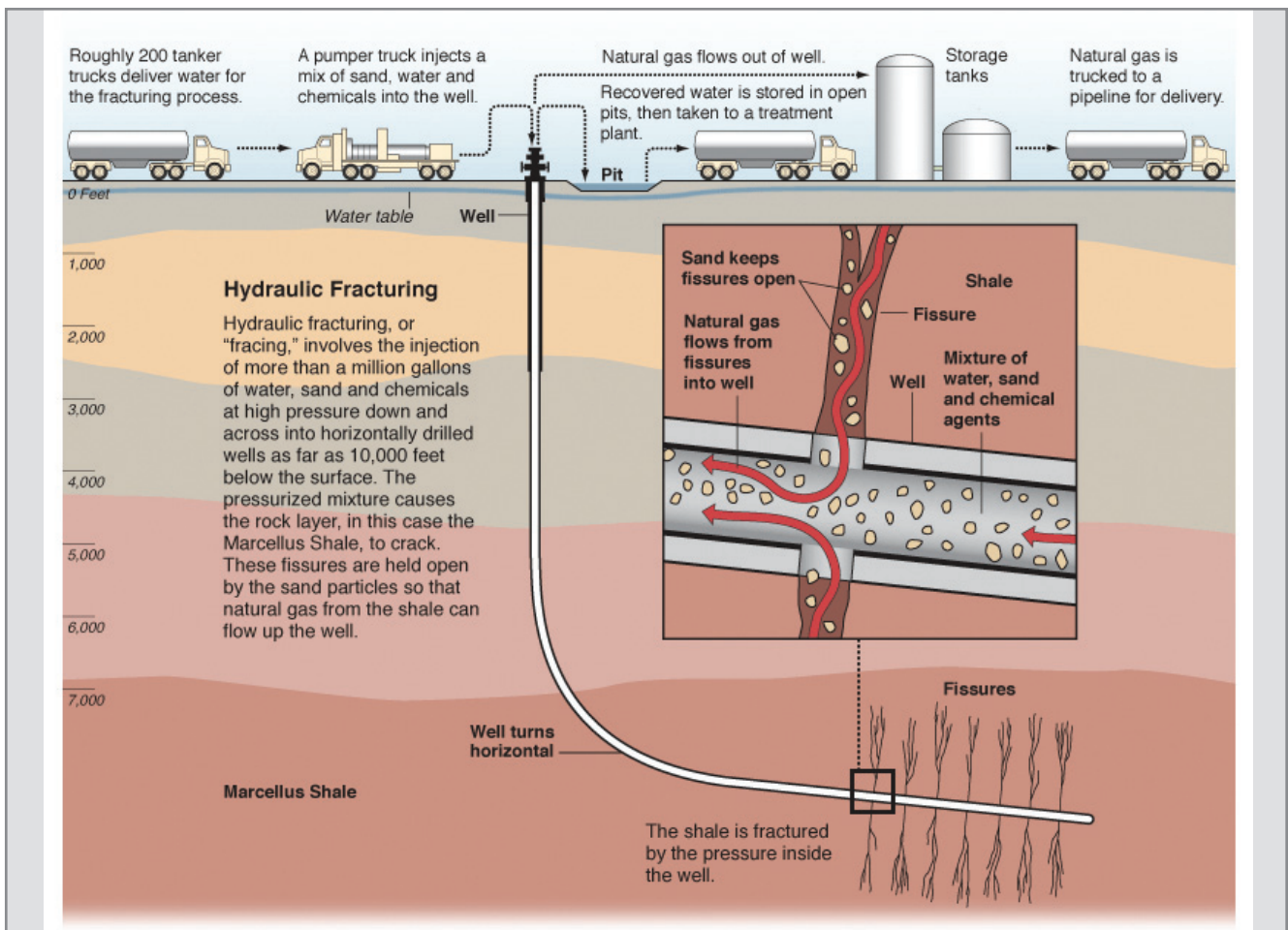
U.S. Steel, North America’s largest pipe maker, can also capitalize on its location close to the shale. The company claims that drilling for shale gas and shale oil around the country is having a significant impact on their operations. They recently received an order from longtime customer Chief Oil & Gas for 50 miles of pipe. Dallas-based Chief Oil & Gas is one of the largest Marcellus shale players in Pennsylvania. The cost of pipe, securing the right of way, surveying and site preparation is estimated at roughly \$1.2 million per mile, and the 50-mile project is expected to cost Chief about \$60 million. The company has about 75 people in the state working its Marcellus operations and is looking for more people every day.

Katy Klaber, executive director of the Marcellus Shale Coalition, a trade group representing drillers and other companies, says, “We hear the macroeconomic view about the thousands of jobs created by Marcellus shale drilling, but these examples show that someone locally has a job due to the Marcellus impact.”

Experts said it’s no surprise that Marcellus shale activity is having an impact on local companies. “We found there was a great deal of indirect, business-to-business spending related to the Marcellus,” said Timothy Considine, a professor of energy at the University of Wyoming in Laramie. “Companies, for example, must buy a lot of pipe, and they will use a lot of construction services at a drill site,” he said. Timothy is the co-author of a major study published in August that measured the economic impact of Marcellus shale development. The study found that the natural gas industry generated \$2.3 billion in economic impact in 2008 and roughly \$3.8 billion for 2009.

A study conducted by the Pennsylvania Economy League stated that more than 26,000 jobs in Pennsylvania can be traced either directly or indirectly to the natural gas industry already. The industry’s direct economic impact, which includes drilling, extraction and support activities, brings \$4.5 billion each year to local communities. This will be some of the closest natural gas to the highly populated areas of New Jersey, New York and New England. The proximity benefit will give Marcellus gas a distinct advantage in the marketplace.

Washington County is right at the heart of drilling activity right now, and as exploration and production operations have increased, so have the economic opportunities for Washington County’s citizens. “Natural gas drilling is very exciting for our area,” said Representative Timothy Solobay (D – Washington). “We are



At a depth of 5,000 to 8,000 feet, hydraulic fracturing has made the Marcellus reservoir an attractive resource.

hearing that for each job created in the drilling field, as many as 10 to 15 jobs are created in support of the industry.”

In addition, the increased demand for energy has brought this industry to the forefront of economic development. Many of the companies benefitting from natural gas drilling aren't doing any drilling at all. Local restaurants, retail stores, caterers, hotels, banks, and landscaping companies all benefit from natural gas drilling.

As new wells are brought online, there will be a need for production employees to keep the wells up and running and maintain equipment. However, the biggest economic impact will come during the drilling phase where the most up-front money is spent. As production comes online, the tax coffers of local municipalities and the state will be boosted, meaning billions of dollars over the coming years for education, roads and social programs.

Putting size into perspective, imagine the size of a Boeing aircraft plant. In the Barnett Shale of North Texas, it was estimated that the developmental impact was equal to the building and operation of five Boeing aircraft plants. The Marcellus Formation is estimated to be up to ten times larger than the Barnett Shale, and therefore destined to have a far greater economic impact and implications on our energy future.

ADAPTING TO CHANGE

Mason Dixon Energy's Aaron Hubbard, who relocated to Pennsylvania in 2008, says the greatest challenge is adapting to a dynamic environment with constant change. "Everybody is still in the learning curve. The geologists are still learning about the formation. The engineers continue to experiment with techniques and new ideas. Regulators are still learning about the risks and how to deal with them. There are minimal statutes and case law to deal with some of the issues being raised. The landowners are still learning what to expect."

Success in the Marcellus and other shale formations is the result of combining old information, technology, and techniques in new ways. When asked whether the BP situation has affected public perception or slowed the process, Aaron believes that it has increased awareness for safety. However, it has also increased the hope for more emphasis on alternative sources of energy, particularly natural gas.

Shale gas reserves like the Marcellus shale formation may hold the key to energy independence in the United States. According to some estimates, the United States has enough natural gas to last for over one hundred years, thanks to major shale deposits such as the Marcellus shale. With up to 500 trillion cubic feet of natural gas reserves, the Marcellus Formation is hoped to go a long way toward helping the U.S. become less reliant on foreign oil.