The League of Women Voters of Pennsylvania

Marcellus Shale Natural Gas Extraction Study
2009-2010

Study Guide I

Marcellus Shale Natural Gas: From the Ground to the Customer

League of Women Voters of Indiana County
2008-2009 Marcellus Shale Study Committee

Mary Beth Sweeney, Chair
Susan McClure
Stephanie Chandler
Clarice Reber
Peggy Clark
JoAnne Ferraro
Pepita Jimenez-Jacobs
Dreama Van Cise-Watta
Cindy Rogers
Vera Bonnet
Aida Shotts
Lori Rittle
Sherene Hess, President LWVIC
palwv.org/Indiana

This guide was researched and drafted by Susan McClure of the LWV of Indiana County with editing and review by Roberta Winters, LWV-PA Director, and Lora Lavin, LWV-PA Vice President/Issues and Action

Marcellus Shale natural gas, one of more than twenty natural gas shale deposits in the United States, is the largest on-shore natural gas reserve in the world. It lies a mile or more down under two-thirds of Pennsylvania, waiting to be extracted to supply our country's natural gas needs for up to an estimated eighty years. The extraction depends upon horizontal drilling and hydraulic fracturing, technology refined for extracting natural gas from Texas's Barnett Shale. Once extracted the natural gas must be prepared for and delivered to the customer.

About 380 million years ago during the Middle Devonian period the African continent shoved against the North American continent and created an anticline or fold that is today known as the Appalachian Mountains. Under intense pressure rotting vegetation became trapped in the sediment that became Marcellus Shale, a rock so dense that the gas was trapped within it.

The Marcellus Shale basin extends from western New York to West Virginia and eastern Ohio to eastern Pennsylvania. It lies under forty of Pennsylvania's 67 counties (See Appendix I). It ranges in depth from 4,000 to 8,000 feet under the surface, and varies from 50 to 200 feet in thickness. The formation is estimated to contain 250 trillion to 500 trillion cubic feet of natural gas. Geologists have long known that natural gas is trapped inside Marcellus Shale, but until recently the technology for releasing the natural gas in commercial quantities was unavailable.

Maps of the Marcellus Shale formation can be viewed at:

http://geology.com/articles/marcellus-leases-royalties.shtml
or
http://www.marcellusshales.com/marcellusshalemap.html

Drilling For Marcellus Shale Natural Gas

Before drilling a Marcellus Shale natural gas well, the drilling company needs to know who owns the gas rights. In Pennsylvania, rights to the subsurface minerals can be separated from the surface rights through deeding. Because subsurface rights to minerals may be held by the current owner or have been sold by others in the past, it is imperative that drilling companies find out who owns these rights. To find the rightful owner, drilling companies use agencies that specialize in title searches to determine with whom to negotiate a lease. Usually a representative of the drilling company contacts the owner to lease the rights. Under Pennsylvania law, the owners of gas rights are paid at least a 12.5% royalty, although they may negotiate a higher royalty and a bonus. Owners who hold both surface and gas rights may also negotiate a lease for the land that the drilling company uses. At this point people who own the surface and the natural gas rights can negotiate how the surface will be treated. This includes siting access roads, specifying whether on-site water will be used or the water will be trucked in, and what kind of reclamation will be done. In Pennsylvania surface owners cannot stop lease holders from obtaining their oil, coal, or natural gas.

Once seismic testing is done to ascertain the depth of the Marcellus Shale and the drilling rights are secured, the drilling company applies for a permit from the state. The Pennsylvania Department of Environmental Protection (DEP) requires drillers to name both the source of the water needed to drill the well and the site where the wastewater or flowback will be treated. Because of the depth of a Marcellus Shale well, two to ten million gallons of fresh water are needed. During drilling, the water is used both to cool the drill bit, creating a clay slurry, and to

remove the rock cuttings. The used water or sludge is stored at the well site in lined pits until it can be hauled away.

Drillers drill both vertical and horizontal wells to access the natural gas. The vertical bores are like conventional natural gas wells that go straight down. Horizontal wells are part of the new technology that is used to retrieve the natural gas in the Marcellus Shale. Both types of wells are drilled using multiple layers of steel and concrete casings to avoid contaminating the ground water aquifers. The casings also serve to keep the natural gas flowing upward toward the wellhead.

At a depth determined by geoscientists, the drillers start the horizontal drilling. A 600 foot arc is drilled to change the pipe from vertical to horizontal. Horizontal drilling can extend out more than 5000 feet (Ground Water Protection Council & ALL Consulting, April ,2009; [there are 5280 feet in a mile]). Once the horizontal pipe is in place, the well is hydraulically fractured.

Hydraulic Fracturing

Once the drilling is finished, the drilling rig is broken down and moved. The support equipment such as pipe racks and tool sheds are also removed. Then the well is ready to be "fraced." The "fracing" company brings in its equipment- including generators, trailers with the computer equipment to monitor the fracing,and possibly hundreds of truckloads of water. To frac a Marcellus Shale gas well, millions of gallons of fresh water are hauled in or withdrawn from a local source, above or below the surface, and chemicals and sand are added to the water. The chemicals are used to make the natural gas flow more efficiently up to the well head. They include a lubricant to reduce pipe friction, biocides to eliminate pipe fouling, a scale inhibitor to break down mineral deposits inside the pipe, oxygen scavengers to reduce rust-causing oxygen in the wellbore, and acids to clean the perforations in the horizontal pipe through which the gas enters. Sand is added to the fracture fluid as a proppant to keep the fractures in the shale open so the gas can escape from the rock. DEP requires fracing companies to list the chemicals they use on the permit, although not the proportions which are considered proprietary knowledge.

During fracing, millions of gallons of the frac fluid are pumped into the well under great pressure to break up the shale at predetermined intervals along the horizontal pipe. Between 30% and 70% of the frac fluid returns to the surface as "flowback". Flowback contains any matter that is dissolved in the frac water, including salt from the ancient sea bed. What is dissolved depends on the locale. The briny flowback may contain radioactive material (Shultz, 1999, p. 792) and other compounds such as arsenic, depending upon what is naturally in the rock. The flowback is held in plastic lined pits at the well site until it is trucked to a DEP-approved treatment plant.

Moving The Natural Gas To The Customer

Existing pipelines are inadequate to handle distribution of a gas resource as large as the Marcellus Shale. Distribution will require new facilities, new processing and transporting equipment, and new pipelines--partly because much of the gas will be sent outside of Pennsylvania. All of these matters will affect Pennsylvanians.

Once natural gas comes to the surface, it is "wet," which means that it is not only methane but also other gases and water. Propane, for example, can be removed at the well head

and trucked away. Or the propane, along with the other hydrocarbon products, can be sent through underground gathering lines to a cryogenic processing plant. Cryogenic processing "sorts" the water and gas using a super-cooling process that liquefies the gases at different temperatures, separating the raw gas into ethane, butane, propane, and methane.

Marcellus Shale natural gas is about 85% methane, the type that is used residentially. Surface right owners can use gas extracted directly from conventional wells to heat their homes. But this is not possible with Marcellus Shale natural gas because it burns at too high a temperature and pressure to be safely used residentially.

Leaving the processing plant, the natural gas may be sent into main pipelines. In Pennsylvania there are currently not enough pipelines to move the anticipated millions of cubic feet per day of Marcellus Shale gas to existing northeastern and Atlantic seaboard markets. With permits from DEP, pipeline companies may build along an existing public right-of-way but need the surface owners' permission to build pipelines on private property. The mainline pipelines are of wide diameter, 42 to 48 inches, and as many as five or six may lie side by side. Many pipelines are "looped"--that is, fitted with connectors between the pipes lying side by side underground. Looping allows technicians monitoring the pipes via computer to isolate pipe sections. The technicians can stop the flow by section, which allows the natural gas to be stored or "line-packed" so the gas will be available during times of peak usage (Arthur, J.D. Langhus,B., & Alleman, D., 2008).

Between the processing plant and the market area, or "city gate," compressor units move the gas along under pressure. A large compressor station in a rural area may have as many as ten to sixteen units, either of a centrifugal (turbine) or reciprocating (piston) type. These have overall horsepower ratings of 50,000 to 80,000 horsepower and are usually driven by natural gas. In urban areas, to reduce noise pollution, the compressors may be powered by electricity. Distance between compressor stations varies from 40 to 100 miles. At the "city gate" where the natural gas approaches its market, the pressure is reduced from 200 to 500 pounds per square inch (psi) to about 2 psi. Along main pipelines, safety cutoff meters are installed to stop the flow of natural gas when a drop in pressure or leak is noted.

Because the demand for natural gas is not steady, storage is also needed. Salt mines, depleted gas and oil wells, and geologic formations can be used. Pennsylvania's geology does not favor storing natural gas in rock formations. If pipelines are not at capacity, the gas may be stored in a pipeline. Natural gas can also be stored above ground in tanks as compressed, liquefied natural gas or LNG. This is the most expensive way to store natural gas but also the quickest way to retrieve it during peak usage.

If there is too much natural gas in storage, the well may be "capped," keeping the natural gas in the well. To cap a well is to block the pipe between fifty to a hundred feet below the well head. Then a second block is placed closer to the surface. At the surface the valves are closed. Otherwise the natural gas proceeds through gathering lines

After a well is fraced, the hydraulic fracturing company and its many trucks leave. The trailers used for on-site offices and the portable toilets are moved on to the next job. The last of the frac fluid is pumped from the plastic lined pit to be taken to an approved wastewater disposal treatment plant. A bulldozer then pushes the plastic sides toward the middle of the pit and covers the plastic with dirt. After the topsoil is spread back over the ground, seed and straw are spread. All that shows of the four- to six-acre drilling site is the gas field "Christmas tree," consisting of pipes and valves about four feet high. There may also be condensate tanks to capture water in the gas and solar-powered measuring equipment that sends data to monitor production from a

remote site. Once the area is reclaimed, the four-to-six acre well site is reduced to the size of a two-car garage.

When the well is exhausted, the site is abandoned. The "Christmas trees, monitoring devices, and any tanks are removed. Fresh cement is poured down the well and flows between the casing and the earth. It also flows into any tubular piping elements and solidifies. The bore is then capped at the wellhead and the surface is cemented over.

Site reclamation after the completion of drilling and extraction is addressed in Study Guide II, Environmental Impact.

Resources and References for Study Guide I

Adventures in Energy. http://www.adventuresinenergy.org An educational website developed by the American

Petroleum Institute to describe technlogies and practices used in the exploration, production and

transportation of oil and natural gas.

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