

CHALLENGES FACING DEVELOPERS OF THE MARCELLUS SHALE PLAY

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Introduction

The Appalachian basin Marcellus Shale (Middle Devonian) gas play is one of the hottest, if not the hottest, shale plays in the United States. The potential of the play is so big – resource estimates have exceeded 500 TCF – the play is becoming the land of the giants. ExxonMobil entered the play with its purchase of XTO Energy and their portfolio of shale gas properties; Royal Dutch Shell followed with its own purchase of East Resources and their 650,000 acres of prime Marcellus acreage, mostly in Pennsylvania; and Chevron purchased Atlas Energy, one of the main players in southwestern Pennsylvania. International companies, such as Statoil, Mitsui E&P, Mumbai's Reliance Industries, and UK's BG Group also entered the play through joint ventures with US independents who already were involved.

All of this began when a deep test to the Lockport Dolomite (Upper Silurian) in Washington County, Pennsylvania was killed with 13 # mud and failed to come back, causing the operator to move up hole to take a look at shallower potential, including the Marcellus. Although the logs indicated few natural fractures in the Marcellus, they were similar to logs from a Floyd Shale well, which gave William Zagorski, who has been referred to as “The Father of the Marcellus Play,” the idea to apply the biggest frac job ever east of the Mississippi River. The result was the discovery well for the Marcellus play – the Renz #1 Unit – which was completed in late 2004.

Range, Equitable, CNX, Atlas and others quickly got involved in the southwest Pennsylvania play, and Chief, Cabot, Fortuna, Chesapeake and others moved into northeast Pennsylvania adjacent to the New York border.

Although shale gas production had been established in the Appalachian basin more than 80 years prior to the #1 Renz discovery, the Marcellus Shale never had attracted much interest as a reservoir. Most of the gas in the established Devonian shale play areas has been and continues to be from the Upper Devonian Huron Shale, which is present only on the western side of the basin, mainly in Kentucky, West Virginia and Ohio. During the late 1970's, when the Morgantown Energy Research Center funded the Eastern Gas Shales Project (EGSP), the US Geological Survey and the state geological surveys from New York to Kentucky mapped the structure, thickness and extent of all black Devonian shales from the Huron Shale to the Marcellus Shale, using data from thousands of Oriskany Sandstone (Lower Devonian) wells that had been drilled in the 1930's, 40's, 50's and 60's.

Many of these Oriskany Sandstone well records indicated the presence of gas in the Marcellus Shale, as well as in the underlying Huntersville Chert and Oriskany Sandstone, which continued to be the prime target of drillers. Unfortunately, most of these Oriskany wells were drilled in the western half of the basin, so maps of the Marcellus Shale produced by the EGSP contained question marks in a large blank area between the easternmost Oriskany wells and Marcellus outcrops further east.

But, it is this eastern area, especially in northeast Pennsylvania and southeastern New York, which is of interest to many of those who are developing the Marcellus play. Because this area had never been drilled, no drilling rigs or large trucks hauling water, sand or chemicals had been observed in the area; no oil and gas infrastructure had been established; no oil and gas inspectors had been assigned to work there; and no one had ever knocked on the door of a local resident asking if they would like to lease their mineral rights – for a typical fee per acre plus a one-eighth royalty on production.

What followed was a race among eager producers to acquire acreage in the play. As the available pool of acreage dwindled, the law of supply and demand resulted in ever increasing prices for both acreage and royalties. The end result was predictable – those who signed early for a lower price felt they deserved more, and those who had yet to sign organized to demand more than ever had been paid.

This eastward push in play development also extended into the drainage basins of the Susquehanna and Delaware Rivers, areas that provide essential water to eastern cities, such as New York, Philadelphia, Baltimore and Washington, DC. Consequently, the Delaware and Susquehanna River Basin Commissions became additional, first-time but highly-interested, stakeholders in the play, and numerous environmental groups began to express their serious concerns that the play could not be developed in a manner that would protect those public water supplies.

The state regulatory agencies in New York, Pennsylvania and West Virginia reacted to the concerns of environmental groups, local officials and the general public with draft copies of new rules and regulations, a moratorium on drilling in certain areas, public calls for a moratorium in other states, and a restriction on the volume of water that can be used to fracture a well that essentially eliminated horizontal drilling in New York.

Meanwhile, industry was facing serious technical problems that had to be solved to extract gas economically from the shale. The existing gas infrastructure had to be upgraded and expanded, and by invoking horizontal drilling and large slickwater frac jobs, commercial production was established. But, high volumes of water, chemicals and sand were required, so industry needed to develop better water management practices to treat flow back water prior to disposal or reuse. And, even as industry developed best practices to resolve their technical problems, they had to deal with an ever-increasing, negative public outcry, which suggested the need for new public outreach and education programs, and with increased environmental awareness and challenges.

The following report will attempt to briefly summarize the various problems and issues facing operators involved in the Marcellus play, including technical, environmental and regulatory roadblocks to development. From reading this summary, one may correctly conclude that industry has been successful in overcoming technical barriers that challenged the economic development of the Marcellus play, i.e., by incorporating horizontal drilling and large hydraulic fracture stimulation into their plans. However, industry initially failed to alleviate the negative perception of the public regarding this play and the implementation of those technologies. This led to increasingly negative public outcry, which in turn led to increased social protests and

political activity, and ultimately to an increase in regulations and to a deceleration in play development, especially in New York.

Technical Challenges to Overcome

Although still in its infancy, the vast economic potential of a fully-developed Marcellus play has been established, along with a summary of technical problems facing those attempting to develop it. Engelder and Lash (2008), while pointing out the importance of natural fractures and modern stimulation techniques to economic production, estimated total gas in place in the play area to be at least 500 trillion cubic feet (Tcf), of which 50 Tcf was technically recoverable. An early report by Tristone Capital (2008) summarized the main problems facing producers, mainly upgrading or creating an adequate infrastructure and developing water management plans that meet regulatory approval, and outlined their methodology for the valuation of unbooked, upside resources and per share value for the main players. Moss and others (2008) produced a report on the potential of the natural gas resource in the Marcellus for the National Park Service, which has approximately 33 units of their system within, or in the vicinity of, the Marcellus play. In their report, the authors cited an estimate by unnamed experts of 31 Tcf of recoverable gas from the Marcellus.

As drilling continued and more production data became public, estimates of the gas resource in the Marcellus began to increase. The Ground Water Protection Council and All Consulting (2009), in a report prepared for the Department of Energy, increased the estimated gas-in-place to 1,500 Tcf, of which 262 Tcf was considered technically recoverable. The United States Geological Survey (USGS), which at one time (2002) had assumed that the Marcellus contained only 1.9 Tcf (based on production from a limited number of wells), not only increased their estimate to 84 Tcf of undiscovered gas reserves, but in another report (Soeder and Kappel, 2009) the USGS appeared to endorse an estimate of 363 Tcf of recoverable gas reported by Esch (2008). This estimated volume was based on production data provided by Chesapeake Energy Corporation, and is sufficient to supply the needs of the nation for 15 years, at 2009 rates of production. These early production numbers also caused Engelder (2009) to reconsider, resulting in a much higher recoverable gas estimate of 489 Tcf.

As estimates from various sources continued to be released to the public, confusion resulted, and charges of industry over estimating the resource to gain public support and move forward were made, especially after the USGS value of 84 Tcf and the EIA value of 410 Tcf were both released in 2011. In 2012 EIA attempted to reconcile their number with the USGS number and came up with 141 Tcf by using a higher EUR/well (1.56 vs 0.93 Bcf/well).

In March 2012, Terry Engelder assembled a panel of experts to discuss the divergent estimates for the gas resource in the Marcellus Shale play. His objective was to assure that the federal arbitrators (USGS and EIA) were using the best possible methodology to derive the correct estimates of resource size. At the March 2012 PSU meeting, Harry Vidas (ICF International) presented a methodology that resulted in an estimate of 461 Tcf on 80 acre spacing and 698 Tcf if the Marcellus is developed on 40 acre spacing.

Thus, when fully developed, the Marcellus Shale has the potential to be the second largest gas field in the world, with cumulative gas production equivalent to the energy content of 87 billion barrels of oil (Considine et al, 2009), enough to meet the energy needs of the entire world for nearly three years.

However, the economic development of this play would not have been possible without the advent of new technologies, mainly horizontal drilling from multi-well pads and large hydraulic fracturing jobs. Unfortunately, these technologies bring with them other technical and logistical problems to be solved, along with environmental challenges that led to a slowdown in the permitting process by regulatory agencies. Furthermore, because much of the play area is over pressured, the existing infrastructure had to be upgraded before it could handle the expected large volumes of high pressured gas from Marcellus wells.

Other technologies also have been implemented, and continue to evolve, to drill and complete wells and to deal with flowback water with high concentrations of dissolved and suspended solids. Closed loop systems are being used to eliminate drill pits in which cuttings and flow back water formerly accumulated, and larger well pads were created from which multiple horizontal wells could be drilled and treated with large hydraulic fracture jobs. Because these pads reduce the need to excavate and create five or six other sites (per lateral) from which individual vertical wells would be drilled, the overall effect has been to reduce the environmental footprint in the area. Unfortunately, however, the public does not see these green areas that will not be disturbed. Instead, they only see an increase in activity at this one site, which can last for many months as the additional wells are drilled and completed.

Industry also had to create new gas infrastructure, including a network of gathering and collection lines, especially in northeastern Pennsylvania and adjacent southeastern New York, an area with little or no previous oil and gas activity, and to upgrade older gas infrastructure in the over pressured area of the play. In addition, other public infrastructure, such as local roads and bridges, has been impaired by the high volume of heavy truck traffic, and has to be upgraded, repaired and eventually replaced.

In areas of lower thermal maturity, mainly southwestern Pennsylvania and northern West Virginia, wet gas, condensate and natural gas liquids are produced. Although economically attractive, this liquid production has created the necessity of further infrastructure development, including gas processing plants and “crackers,” ethylene cracker plants designed to crack wet gases, such as ethane, propane, and butane, to make ethylene, propylene, and other hydrocarbons that are used to make plastics. Shell Chemical has announced plans to build such a plant on a site 30 miles west of Pittsburgh. EPA followed that announcement with a warning that this type of plant emits a wide range of pollutants, and Shell will need to use the best-available control technologies to meet air emissions laws.

Industry also is faced with developing technology, or implementing technology developed by others, to treat flowback water prior to reuse or disposal. This return water typically contains high concentrations of suspended solids that would reduce permeability if injected into another well, and high concentrations of total dissolved solids, that could reduce the effectiveness of chemical additives in frac water, and could cause precipitation of minerals in

induced and natural fractures in the reservoir. The concentration of TDS increases each day that water flows back following a frac job, typically reaching greater than 200,000 ppm after 30 days.

Water management technologies used by operators in the Marcellus play have been summarized by Veil (2010). Several commercial technologies have been applied in the field, and DOE currently is funding nearly a dozen research efforts designed to treat flow back water to the point where it can be mixed with makeup water and injected into the next well. The good news seems to be that of the approximately 5 million gallons used in a large frac job only 20% may return and need to be treated; the bad news is that of the 5 million gallons taken from streams and public water supplies only 20% returns. The remainder is lost forever from the water cycle, which is an additional concern for environmentalists and the general public.

As these technologies are being developed, the following areas of concern will be addressed:

- Life cycle planning and management of produced water (water withdrawal, transportation, storage, drilling, fracturing, treatment, reuse/recycle, disposal)
- Make up water sources: access to public supplies, streams and rivers, POTWs, mines; compliance and reporting
- Make up water blend; mix acid mine drainage (AMD) with flow back water (FBW)
- Flowback/well cleanup; chemical reactions that may occur in the reservoir
- Consumptive use: most (80%) of the water is lost in the reservoir, if flow back water is injected in a disposal well, total loss equals 100%
- Wide range of chemicals in flow back water; Ca, Ba, Fe, Mg, Mn, Sr, CaCO₃; TDS, NORMS
- Must deal with NORMs; Ur, Radon in solids and flow back water

Industry also is faced with the need to expand the local pool of well-trained, drug-free personnel to work in the gas field. Public opposition already has been directed at the number of trucks with out-of-area license plates being driven by gas field workers. To create a more general acceptance of the play, it may be advisable to develop a workforce training program for local workers.

Other interesting technical issues to be resolved may lead to funding for future research:

- Over pressured versus normal pressured areas
 - Mapping over pressured areas
 - Determining/predicting causes/locations of over pressured areas
 - Determining ranges and distributions of critical physical properties of shale
- Mapping & geologic modeling programs
 - Mapping TOC, thermal maturity thickness
 - Determining key criteria for well placement

- Determining key criteria for lateral location/direction/length
- Geologic modeling to predict low flow back areas
- Reservoir & water chemistry, interaction; stray gas
 - Chemistry of rock-water interaction that controls composition of FBW
 - Produced water carrying trace element contaminants (Hg, As, Ba)
 - Produced water carrying radiogenic materials
 - Potential formation damage with reused FBW
 - Sulfate-reducing bacteria; precipitation of minerals in the reservoir
 - Precipitation of CaCO_3 , FeCO_3 , in reservoir
 - Need to deal with high variability of FBW over time
 - Technology to treat FBW lags behind frac technology
 - Isotope fingerprinting to identify the source of stray gas
- Improved treatment technology
 - Alternative (greener) frac fluids
 - Smart proppants (reduce use of sand resources)
 - Low percent of FBW; rest may “plug” portions of the reservoir
 - Making frac chemistry work in high salinity FBW in the next well
 - Improved efficiency to reduce trucks, water use, land disturbance
- Inadequate infrastructure, especially in the northeast & east
 - Roads – upgrade and repair public roads; build location roads
 - Drill sites – wooded, hilly; cross many streams; pits versus tanks, cover
 - Rigs – begin to use smaller, lighter?
 - gathering network – gathering & collection lines

Finally, it should be noted that the fracturing process itself and the combination of additives used in the process are continuing to evolve and improve to more effectively stimulate the reservoir, enhance production, and improve environmental and safety concerns.

Expanding Environmental and Social Issues

The Marcellus Shale, and the two main technologies that have enabled industry to begin to extract natural gas from it, i.e., horizontal drilling and hydraulic fracturing, have become the targets of a variety of groups, including environmental organizations, the media, local and state politicians – even “film” makers (including semi-professional and student amateurs).

Shortly after the play began to be developed, in 2010, American Rivers included West Virginia’s Monongahela River in their list of America’s most endangered rivers due to what they referred to as toxic pollution created by natural gas extraction in the river basin. “We must put the brakes on the rampant gas drilling that is already threatening the drinking water for hundreds

of thousands of people,” stated Rebecca Wodder, President of American Rivers. “We simply can’t let energy companies rake in the profits while putting our precious clean water at risk.”

Leaders of other regional environmental groups were quick to respond with warnings of their own. “The scale of this gas drilling has caught regulators by surprise, and the environmental problems associated with it are affecting millions of people” added Shandra Minney, who is with the West Virginia Rivers Coalition. “State and federal governments must move quickly to put regulatory safeguards in place that protect our resources for the benefit of all.”

“Just as mountaintop removal coal mining is rightfully known as ‘strip mining on steroids’, horizontal drilling and hydrofracing deep in the Marcellus Shale is surely ‘gas drilling on steroids’” according to Cindy Rank with the West Virginia Highlands Conservancy. “Enforceable standards are needed to control fresh water withdrawal, the use and disposal of chemically-laced frac and flowback water, and the treatment and disposal of the brine and naturally occurring radioactive material in the produced water.”

Politicians were less than reluctant to express their opinions on “the Marcellus problem.” Protection of New York City’s pristine water supply was an issue in a mayoral election in the city; city councilmen and state legislators were quite outspoken with demands for increased regulation; former New York Governor David Patterson instructed the NY DEC to update their environmental impact statement in regard to the Marcellus; even Secretary of State Hillary Clinton, in a letter to the New York State Environmental Conservation Commissioner, said she was concerned about the environmental impact of drilling in the Marcellus Shale and further stated that current federal protections are fairly weak.

Articles and editorials in newspapers from New York to West Virginia warned of the dangers associated with drilling and fracing in general, and in exploiting the Marcellus Shale in particular. Headlines such as “Natural gas rush stirs environmental concerns” (Morgantown Dominion Post, 11/16/08), “Drilling in shale is a shell game” (Morgantown Dominion Post, 12/7/08), “Gas drilling in Appalachia yields a foul byproduct,” (Associated Press, 2/2010), “Time to repeal ‘Halliburton exemptions,’” (Binghamton Press & Sun Bulletin, 4/4/10), and “Drilling companies won’t take no for an answer” (Syracuse Post Standard, 7/11/10) helped to create a negative environment for those involved in the early development of this play, and for the state regulatory agencies charged with regulating the industry and protecting the environment.

Magazines also became involved, warning of “The hidden danger of gas drilling” (Business Week, 11/24/08) and implying that hydraulic fracturing is an expletive to be deleted (“A colossal fracking mess”; Vanity Fair, 6/21/10).

But neither the newspapers nor the magazines could keep pace with the explosion of websites dedicated to revealing the dangers of horizontal drilling and applying massive hydrofracs in the Marcellus play. Propublica’s website (www.propublica.org) featured seemingly daily articles on the dangers of developing the Marcellus with horizontal wells and large frac jobs, and pushed for increased government control, and the Shaleshock Action

Alliance (www.shaleshock.org) defined their role as “a movement that works toward protecting our communities and environment from exploitative gas drilling in the Marcellus Shale region.”

Some of these websites contained short film clips produced by concerned environmentalists, would-be film makers, and university amateurs. The most notable of these probably is the film “Gasland,” which was shown at the Sundance Film Festival and found its way to HBO, resulting in an Oscar nomination. Lesser known, and actually quite humorous, is “Frac attack: dawn of the watershed,” available in both PG-13 and R-rated versions, which was released on the internet (www.fracattackthemovie.com) and shown on public television in the central New York area and at local film festivals.

Conversely, more positive articles on the Marcellus play, especially on the huge economic potential, have appeared in the New York Times, the Oil & Gas Journal, Technology Review, and other media. In addition, websites have been created by groups such as Energy in Depth that are attempts to conduct public outreach and education while addressing some of the more serious environmental concerns.

Universities in upstate New York also began to conduct due diligence. Cornell University established an ad-hoc advisory committee on “leasing of land for exploration and drilling of natural gas in the Marcellus Shale” and charged it with producing a set of guidelines for their President when he was attempting to decide whether or not to lease university-owned land for natural gas drilling. And, several professors in the Department of Earth Sciences at Syracuse University attempted to present unbiased, scientific information to prove that drilling for natural gas in New York would benefit the state far more than it might hurt, and that the risk to water supplies posed by chemical additives in the fracking process has been highly exaggerated. They also acknowledged that hydrofracing needs to be regulated and suggested that the New York DEC needs more staff to do this effectively.

Industry support groups, like the Marcellus Shale Committee, a joint initiative between IOGA-PA and POGAM, and the Marcellus Shale Coalition, were formed to address public concerns and enhance outreach and education efforts. The Marcellus Shale Coalition, now the largest of these groups, produces weekly, if not daily news releases, and has become well organized, funded and respected, with a large membership of Marcellus stakeholders.

The Pennsylvania Council of Professional Geologists (PCPG), a group that advocates “the use of sound science to formulate public policy, protect human health and the environment, establish and evaluate regulatory programs and disseminate accurate information,” also released a position statement on the Marcellus.

According to the PCPG, Marcellus Shale gas exploration and production are worthwhile and necessary, and will have a positive effect on Pennsylvania’s economy. PCPG also stated that information on the Marcellus, as reported in print, broadcast media and the Internet, often conveys erroneous information that can lead to “unnecessary confusion and exaggerated concerns.” However, natural gas drilling and production “can and must be done in an environmentally responsible and scientifically sound manner” to minimize adverse impact on the environment. PCPG believes that horizontal drilling and hydraulic fracturing technologies have

had a “low incidence of proven adverse impacts to potable water quality,” but gas drilling and production “can and must be conducted in accordance with best industry practices and well-established state oil and gas, and environmental regulations.”

WPSU-TV, the PBS affiliate for central Pennsylvania produced two programs on the Marcellus, “Gas exploration in Pennsylvania,” and “PA gold rush.” Both were posted on YouTube. And, Branded News, located in Oklahoma City, produced two DVDs on the Marcellus play, one that focused on Pennsylvania, the other on West Virginia.

With all of the attention, both pro and con, that the Marcellus Shale has and is still receiving in the media, on websites, and through numerous public meetings, it is easy to lose sight of exactly what are the legitimate environmental concerns that should and must be addressed. As the debate became increasingly more emotional, it became increasingly more difficult to focus on what were substantive environmental issues and not concerns based on fear rather than fact.

Initially, concerns expressed during public settings focused on the perceived dangers inherent in hydraulic fracturing, specifically, fear of unknown chemicals in the frac fluid, potential danger to water supplies, and health hazards to people, pets and farm animals that came in contact with contaminated water. Additional concerns were focused on the high volumes of water that was used, and the impact of reduced stream flow on other users and the aquatic environment in streams and rivers, and dangers associated with dealing with large volumes of flow back water, including potential contamination of public supplies of drinking water.

Specific comments expressed in public meetings included:

- High consumptive use, high water withdrawal volumes
- Adverse impact of high water use on water resources
- Adverse impact on fish and wildlife
- Ensuring water supplies to meet public needs
- Fear for New York City’s unfiltered water supply
- Negative impact on streams and stream flow
- Competing use for water
- Storm water runoff near wellsites and roads; damage to streams
- Carcinogens and radioactivity in flow back water
- Surface spills contaminating water supplies
- Water management, size of locations, treatment & disposal of FBW
- Safety procedures
- Health effects of operations
- Composition of frac fluids
- Protecting fresh water zones from frac fluid & flowback water
- Water treatment and discharge plan
- Radioactive water and solids in FBW (NY Times article 3/11)
- Water left in reservoir – future migration upward to fresh water zones
- Waste treatment & disposal; storage and hauling

- Municipal plants and POTW inadequate to treat FBW
- Intentional (illegal) dumping of FBW
- Subsurface pathways for methane migration into shallow water zones
- Inadequate set back from water supplies, dwellings and farm buildings
- Recent studies that dispute the claim that fracking has never polluted a water well

Later, once drilling began and truck traffic increased – along with noise, dust and degradation of local roadways and bridges – residents began complaining that their quiet rural environment had been turned into what they termed “an industrial zone.” Concerns voiced by local residents included:

- Increase in truck traffic; road & bridge destruction
- Dust control
- Noise
- Night time “light pollution” due to rig lighting in formerly dark, rural areas
- Air quality and emissions near wells, pipelines and compressors
- Increased duration of local activity due to multi-well pad drilling & fracking
- Over drilling in an area
- Potential problems with pits and liners; spill potential
- Well location, roads, pipelines, pit construction - all involve land disturbance
- Land disturbance results in habitat fragmentation, riparian degradation, increased sediment in streams
- Inadequate casing and cementing programs; shallow gas migration into aquifers
- Material Safety Data Sheets (MSDS) inadequate for chemical disclosure
- Re-fracking of wells within a few months re-introduces these problems
- Fracking multiple wells from a single site requires hauling high volumes of water & chemicals on the same roads and bridges
- Injection into disposal wells may have triggered small earthquakes in Ohio
- Cumulative, long-term impacts are not being addressed

Eventually, as protests became more organized, protection of property rights, especially for non- mineral owners, and the threat of declining property values, along with increased costs for local communities, became more important, and residents expressed these concerns:

- Protection of property rights & the environment; receive fair royalties
- Increasing opposition among an increasing number of groups
- Need for groups to become more organized, more vocal, better funded
- Websites with or without videos became numerous; movies (documentaries) produced
- Decreasing property values
- Increase in crime, drug use, prostitution; leads to a higher cost for police force
- Compensation for property owners who do not own mineral rights
- Encroachment into buffer zones around cities and towns
- No public notice and comment period prior to issuing well permits
- Will the Marcellus play be a short-term boom followed by an economic bust?

- Decreasing property values
- Overnight millionaires versus property owners without mineral rights
- Displace low-income people
- Short term increase in rentals, vacancy rates, housing prices, etc
- Boom-bust cycles as industry moves on
- Public services break down significantly when population growth reaches 15%
- New hires come from other industries
- Jobs are filled by experienced out of state workers
- By the time locals are trained for hire, industry has moved on
- Local inflation increases more than wages
- Farming decreases as local farmers “cash out” and move away
- Evidence of a decrease in new subdivisions
- Decrease in tourism

It is important to note that industry responded by testing well water to develop baseline data prior to drilling, and by developing new best practices, including better casing and cementing programs, closed-loop drilling systems, replacing lined pits with steel tanks, using impervious well pads, and bringing “disappearing roads” into the basin from the southwest. In addition, microseismic detectors are being installed and left in place to serve more than one well, providing a better regional picture of induced fractures. Most of these changes were made even before new laws, rules and regulations were passed.

The Changing Regulatory Landscape

The increase in public opposition to drilling and fracturing Marcellus Shale horizontal wells did not go unnoticed by local and state governments. Consequently, operators involved in developing the play have had to deal with a constantly changing regulatory landscape that varied state-by-state.

Much of this was predictable and was due, at least in the early years of development, to industry moving into eastern areas of the basin with no prior history of drilling and completing gas wells, areas in which no oil and gas inspectors had ever been assigned, and areas in which no gas company had ever attempted to lease mineral rights. These areas also were in the river basins that supplied drinking water to major eastern cities, especially New York City with its unfiltered water supply. Thus, the various river basin authorities became reluctant but necessary stakeholders in the regulatory process, which added additional layers to the permitting and approval process.

Opponents of play development made the case that current state laws, rules and regulations were written for shallow, vertical wells, not for deep, horizontal wells which required large pads, and consequently large surface disturbance, high volumes of frac water, sand and chemicals, and more equipment to be moved on local roads and bridges. Thus, groups from New York to West Virginia began to call for new, Marcellus-specific regulations, which would require a complete overhaul in the regulatory framework for drilling and completing these wells. Consequently, New York imposed a drilling moratorium while the regulatory agency wrote a draft supplemental generic environmental impact statement (dSGEIS) and permitting slowed in

Pennsylvania and West Virginia while the legislatures of both states considered new, Marcellus-specific rules and regulations.

The movement toward increased regulations and control was not restricted to the states alone. Numerous towns and cities in New York, Pennsylvania and West Virginia – 115 in Pennsylvania alone – insisted on more local control and imposed their own restrictions on land use, road use, noise limits, gas well setback requirements, and even moratoria on the drilling of Marcellus Shale wells within their boundaries and within a buffer zone around their municipalities. Others suggested using the river basin model to include local involvement in the regulatory process. This lack of a consistent set of statewide operating rules has made it very difficult for gas companies to remain in compliance and still operate efficiently.

Other groups insisted that this was not enough, and believing that no state had a totally comprehensive oil and gas regulatory framework, and thus could not adequately protect the environment, called for more federal control, including a federal bill to remove the water injection exemption from the Safe Drinking Water Act.

EPA responded with a 2-year study of the possible impact of hydraulic fracturing on drinking water, the US House of Representatives issued a report on the chemicals used in hydraulic fracturing, and DOE Secretary Steven Chu appointed a panel of experts – the Energy Advisory Board Shale Gas Production Subcommittee – to produce a report on the immediate steps that could be taken to improve the safety and environmental performance of shale gas developers. After three months of deliberations and public hearings, the subcommittee issued a series of recommendations in four key areas: making information about shale gas operations more accessible to the public; immediate and longer-term actions to reduce environmental and safety risks of shale gas operations, especially to protect air and water quality; creation of a shale gas industry operation organization committed to continuous improvement of best practices; and research and development to improve safety and environmental performance.

Eventually, new laws, rules and regulations were drafted in all three states in which the play is being developed. While developing these new laws, rules and regulations, the states were conscious of the fact that the play is providing a huge economic boost to the area, and is impacting a large, diverse group of individuals with conflicting points of view, and thus is presenting a big challenge to legislators to balance economic benefits with safety and environmental preservation.

In New York, a State DEC report (June 2011) concluded that controversial hydrofracing could be done safely, and the draft supplemental generic environmental impact statement (dSGEIS) was released for public comment.

The draft SGEIS contains 9 chapters, one of which is a geologic summary of the Marcellus and Utica shales. A second chapter deals with natural gas development and high-volume hydraulic fracturing. Twenty six appendices were attached, of which Appendix 10 focused on high volume hydraulic fracturing permit conditions for among other things, site preparation, site maintenance, drilling, stimulation and flowback, and reclamation.

- Closed loop system for floodplains; no reserve pits
- Biocides to be registered with NYS
- All frac chemicals must be identified & submitted to NYS
- Flowback fluids must be contained in steel tanks, no lined pits
- NORM testing of flowback and production fluids prior to removal

In Pennsylvania, a revised set of stray gas regulations was issued in June 2011; the Marcellus Shale Advisory Commission assembled by Governor Tom Corbett issued a sweeping set of 96 recommendations to address environmental, health and safety policies on how best to responsibly develop the play; and the legislature passed new laws that dealt with better casing and cementing programs, that included the following:

- Increases the minimum setback from 200 to 500 feet from a Marcellus gas well to a private water well and 1000 feet from a public water supply
- Gives the PA DEP authority to require water management plans designed to protect the ecological health of water resources
- Provides local communities with additional resources to address local, short-term impacts
- Provides regulatory certainty across municipalities, thus providing a framework to enable the most environmentally and economically responsible means for gas production
- Provides for sharing of best management practices between state regulators and industry to ensure natural gas development in an environmentally responsible manner

In West Virginia, the initial changes were issued in December 2008 (WV Pit Inspection Directive), and March 2009 (WV DEP Guidance Policy on water issues, site construction and fluid disposal that was finalized in January 2010), and continued with the WV Governor's Executive Order (July 2011), that required disclosure of fracturing additives, certification of plans for sites greater than 3 acres, a water management plan for water use greater than 210,000 gal/month, a well site safety plan, adequate public notice for permits within municipalities, and review by DEP of overall regulatory authority over horizontal drilling and hydraulic fracturing. Eventually, a special session called by the Governor reached agreement on a new law regulating the drilling and fracturing of horizontal wells other than coal bed methane (CBM) wells.

The new West Virginia Horizontal Well law applies to any proposed natural gas well (other than CBM) that would employ a horizontal drilling method that:

- will disturb three or more acres of surface land or use more than 210,000 gallons of water in a 30-day period; and
- was not permitted or the subject of an order relating to a permit application filed

The Act requires further study and authorizes potential rulemaking by the West Virginia Department of Environmental Protection (DEP), including:

- a report to the Legislature due by December 31, 2012 on the noise, light, dust, and volatile organic compounds generated by horizontal drilling operations;
- a report due by January 1, 2013 on the safety of pits and impoundments, and need for new regulatory requirements for such structures;
- a study due by July 1, 2013 on the need for rulemaking establishing additional requirements for the control of air pollution from horizontal well sites;
- rules regarding drilling in karst terrain; and
- regulations establishing casing and cementing standards

Some of the major provisions of the new legislation are as follows:

- \$10,000 permit application fee for the first horizontal well at a particular location, and \$5,000 application fee for each additional well drilled from the same pad;
- a proposed erosion and sediment control plan; well site safety plan; site construction plan; and a detailed water management plan (to include a listing of anticipated and actual additives used in fracturing or stimulating the well);
- detailed surface owner compensation requirements, including a proposed surface use and compensation agreement containing an offer of compensation to be included as a part of the pre-filing notice given to surface owners;
- performance standards applicable to: disposal of drilling cuttings and associated drilling mud; protection of quantity and quality of surface and groundwater systems; advance designation of water withdrawal locations to the DEP; and recordkeeping and reporting for all flowback and produced water;
- prohibiting any well from being drilled within 100' of a perennial stream or other water body (including wetland), or within 300' of a "naturally reproducing trout stream," and prohibiting any well pad within 1000' of a surface or groundwater intake for a public drinking water supply;
- restricting location of wells (prohibited within 250' from any existing drinking water well or developed spring) and well pads (prohibited within 625' of an occupied dwelling or farm building of a size of 2500 square feet or greater), subject to waiver and/or DEP approval of specific plans allowing for closer locations that are sufficiently protective; and
- rebuttable presumption of causation for contamination or loss of a drinking water source located within 1500' of a well pad, subject to certain delineated defenses (including pre-drilling water quality analyses performed by an independent certified laboratory showing that the problem existed prior to drilling), and upon DEP order, mandatory temporary and permanent replacement of water supplies to persons whose use of water for domestic, agricultural, industrial or "other legitimate use" was adversely affected by the gas well operation (unless waived in writing by the owner).

Final statement

Industry has done an adequate job of solving the technical problems that had prevented the Marcellus from becoming an economic play, i.e., by employing horizontal drilling and large

hydraulic fracture programs. However, industry has been much less successful in dealing with the fallout from the use of these technologies. A failure to reach out and educate local communities and concerned environmental groups that horizontal drilling and fracturing are not inherently dangerous has led to local protest meetings and cries for more regulatory control. This in turn has led to revised rules and regulations from oil and gas regulatory agencies and bills being passed in New York and Pennsylvania to establish a drilling moratorium and lower the amount of acceptable TDS in treated flow back water.

Thus, the biggest challenge facing those who wish to develop the Marcellus play cannot be solved with geology or engineering – it is a sociological issue. Better public outreach and education programs targeting concerned citizens and lawmakers, coupled with strict adherence to all rules and implementation of best practices at well sites, are necessary to meet this challenge.

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