Introduction

Hydraulic fracturing is an integral component of a constantly evolving and controversial industry. Hydraulic fracturing has been used for decades to release natural gas from underground reservoirs through the use of water, sand, and a mixture of chemical substances which reduces friction. The mixture is pumped into the ground under pressure into micro-cracks in the shale. The mixture, combined with the great pressure, widens the cracks, allowing natural gas to flow in the well bore, where it is pumped to the surface. In the past five years, this technique has gained popularity in the Marcellus Shale region. The Marcellus Shale is a sedimentary shale rock that underlays much of Pennsylvania and West Virginia, as well as parts of Maryland, Ohio, and New York. Geologists estimate that anywhere between 80 to up to 489 trillion cubic feet of recoverable gas is contained in the Marcellus Shale (Arthur, Uretsky, and Wilson, 2011). Estimates with large ranges such as these are common in such a rapidly changing industry, where regulations are changed annually and new processes and more effective procedures may emerge. Different groups of people with differing agendas vie to manipulate the information to favor their sector. The gas and oil industry, along with politicians, promote hydraulic fracturing as a way to generate more revenue in a struggling economy, generate more jobs in America, and decrease the United State’s dependency on foreign energy. Environmental groups support hydraulic fracturing because natural gas is a cleaner alternative to other fossil fuels. However, they also concurrently
oppose hydraulic fracturing because the gas industry stresses a region’s water supply while
simultaneously putting it at risk from methane contamination. Landowners want hydraulic
fracturing by acquiring a profit from leasing their land to gas industries, but also dislike many of
the secondary effects of the gas industries “invasion” of their small towns. While all groups
have a valid claim in their beliefs, the misrepresentation of information and figures by advocacy
groups prohibits residents of these regions and scientists researching the effects of hydraulic
fracturing from formulating a sound, accurate opinion. Pennsylvania and New York both have
handled the Marcellus shale and hydraulic fracturing boom seen in the last five years quite
differently. The difference in information from these groups varies greatly due to the
environmental, social and cultural, physical, political and historical, and economic influences
and differences of New York and Pennsylvania.

Physical

Both New York and Pennsylvania are underlain by the Marcellus shale formation. The
Marcellus Shale formation dates to be from the Devonian Period in the Middle Devonian Epoch.
This makes the Marcellus formation as old as 384 million years. As stated previously, anywhere
from 80 to 490 trillion cubic feet of recoverable gas compose the Marcellus formation. Marcellus
Shale underlies both states, but the shale itself is not distributed equally. Pennsylvania subsurface
geology contains larger portions of shale, covering about 60% of the state. Pennsylvania has
more of the shale by area and by volume. This is significant because it directly influences
politicians’ and government’s legislation regarding the gas industry, which will be reviewed in a
later section. The Marcellus shale can be as deep as 9000 feet from the surface in Pennsylvania,
but is typically between 4000-7000 feet (Arthur, Bohm, Coughlin, and Layne, 2009). In New
York, this shale can be anywhere from protruding from the ground at the northern most reaches
of the formation to 5000 feet deep, with an average depth of 3000 feet (Arthur et al., 2009). These averages are obtained from interpolating data from graphs of the region. Because of the recent boom in the region and the natural gas industry, accurate baseline data in any subject is difficult to obtain, especially from those outside of the industry. The difference between the average depth in the shale in New York and Pennsylvania appears to be about 2500 feet. This is significant for several reasons. The shale is closer to the surface in New York, which means the risk of contamination from methane gas in New York is higher than it is in Pennsylvania.

Methane naturally occurs in the Marcellus shale region, and it can leak out of wells to the surface through improperly cased wellheads, which will be discussed in a later section. This poses a risk to residents who draw their water from local groundwater, as methane is a flammable and explosive gas. Physical differences also affect the way the oil and gas industry pursue the region and how policymakers implement their decisions. Drilling was not pursued as aggressively in New York as it was in Pennsylvania at the same time. The volume of recoverable gas as well as its depth played an important role in the decision making process. New York was more willing to halt projects and learn more about the impacts of hydraulic fracturing and any potential harm it could cause on water resources. In Pennsylvania, state government determined the economic benefits outweigh the possible environmental harm and allowed the industry to drill immediately. One of the most controversial issues regarding hydraulic fracturing is the use of water.

In the northeastern United States, a surplus of water abounds. New York and Pennsylvania received an average of 35-50 inches of rainfall from 1961-1990 (US Department of Interior, USGS, 2005). Hydraulic fracturing at an average Marcellus shale well in New York or Pennsylvania requires an average of 3-5 million gallons per frack (Dr. Germanoski, personal
communication, 2012). A well may be fracked many times over its effective life, including several times per year. While the region as a whole experiences a surplus, observing local communities on a smaller scale shows that localized water resources have the potential to become stressed. If a drought were to occur in a community who withdrew its water from a small river, and hydraulic fracturing used the same water source to supply their well, a conflict would arise. A comparison often used involves the power industry and Susquehanna River basin, where some 150 million gallons per day are withdrawn for electricity generation. This comparison, as well as the golf course comparison (golf courses in Pennsylvania use up to one million gallons per week), is not suitable due to the circumstances surrounding it. The power industries in the Susquehanna basin operate primarily on the Susquehanna River, to create the most flow to generate the most energy. Many drill sites obtain water from the closest possible source to cut costs, which can be a smaller stream which will become subject to low flow during an elongated drought. The golf course comparison is not plausible because of the difference of the industries. Golf courses are for recreation, while gas wells that use hydraulic fracturing are used to generate revenue and natural gas for the energy industry. While examining the physical differences is useful when formulating a comparison, understanding how these differences effect the environment is paramount when considering hydraulic fracturing’s impact.

**Environmental**

The three primary environmental concerns when considering the consequences of hydraulic fracturing are methane contamination and water and air quality. As previously mentioned, methane is a naturally occurring compound in the Marcellus Shale subsurface geology. It occurs at all levels of shale strata in the region. A study at Duke University determined that methane concentrations in the Susquehanna valley region were higher in water
sources closer to wells than those further from them (Osborn, Vengosh, Warner, and Jackson, 2011). Methane concentrations from varying depths in subsurface geology indicate different external causes for contamination. Geologists attribute broken or improper sealed well casings as the cause of shallow sources of methane entering the groundwater. When wells are first drilled, before hydraulic fracturing commences, concrete is pumped into the well. The concrete seals the well, preventing natural gas and methane from entering the groundwater and seals the system from external contaminates. Pumping concrete underground can be monitored but not directly observed because the process does take place underground. Professional estimates indicate about 6% of wells do not seal properly and leak (Germanoski, personal communication, 2012). Pennsylvania’s legislative body issued nearly 9000 permits as of January 2011 (Germanoski, personal communication, 2012). According to this data, up to 540 wells will develop a methane leak that will be detected. For many small communities that depend on local water, methane in the water supply could cause problems in smaller communities. Even more dangerous are small, privately-owned wells that are subject to contamination. Local municipalities test water more often than private landowners who use their own wells.

The issue of methane contamination also shows an example of how different groups manipulate information. Environmental groups will mention the dangers of hydraulic fracturing and how methane can leak from where the natural gas is being mined. However, the methane gas can only reach the surface through an improperly sealed well casing. For methane to migrate vertically from over a mile deep, it would not only have to overcome tremendous pressure, but also gravity. Both environmental advocacy groups as well as the oil and gas industry use whichever version of this information that aligns with their values. Industries and organizations also have a difficult time forming a stance because of the constantly changing and sometimes
conflicting information that appears as more studies are done on hydraulic fracturing and its effects. One study released says methane can reach the surface at any time from any depth, while another report released three months later claims it can only be released from improperly sealed well casings (Osborn et al., 2011). Industries also hire scientists to make reports with results that place a positive light on the industry. Where so much information is present and so many secrets are contained, it is difficult to determine the truth about hydraulic fracturing. While methane’s effect on the environment is important, it is also critical to consider hydraulic fracturing’s impact on water resources, which are necessary for the survival of many small communities.

Hydraulic fracturing places tremendous stress on water infrastructure, particularly at the local level. Looking at a regional scale, the northeast suffers no shortage of water. Observing the local scale, however, shows many different hydraulic fracturing operations in the same region can severely impact local water resources. Many small communities in northern and southwestern Pennsylvania and southern New York draw their water from local rivers. Hydraulic fracturing wells draw their water from the same resources. In most instances, drill sites pipe water from the closest possible source that can sustain their operation. Many of the water systems, excluding large rivers such as the Delaware and Susquehanna Rivers, cannot handle multiple withdrawals of such large amounts of water, relative to the stream system. Another downside to hydraulic fracturing water use is the time period it is used in. Hydraulic fracturing uses three to five million gallons in one day of operation. If water was withdrawn in these increments, a large river may be able to adjust. Yet, when all the water is withdrawn at once from a stream, its associated ecosystems are critically threatened. Many fish native to Pennsylvania, particularly the rainbow and brook trout, need excellent quality stream to survive and thrive. Large water withdrawals in addition to withdrawals already made for drinking water
threatened fish species in small streams in Pennsylvania. In addition to the withdrawals, workplace accidents such as spills or fires can also adversely affect the environment. These accidents are attempted to be controlled through workplace best practices and safety.

Water quality is also potentially affected by water disposal. When hydraulic fracturing operations use large quantities of water, the next step is disposing of the water. Three options exist, each with varying degrees of environmental impact. The first option, which many corporations in the gas industry are implementing, is reusing water from the previous frack. While not all water is reusable, it does decrease both the cost to the corporation, the amount of water that must be withdrawn, and the amount of water that is disposed. Another, much more common option is a deep injection well. Here, water is drilled thousands of feet into the ground, where it is absorbed by limestone. This option is effective, but the full effects are not currently known. Injection wells require more research, particularly in the Marcellus formation in New York and Pennsylvania. Earthquakes have been linked to injection wells, the most famous case being Rocky Mountain Arsenal in Colorado. A third option is to create a waste water treatment facility for hydraulic fracturing fluid waste. This option is also just being explored, with only a handful of facilities currently operating. They are expensive and require a large capital investment, which makes other cheaper options currently more appealing.

Another, more recent concern that highlights the dynamism of the industry is air quality. Until recently, an afterthought when considering the harmful effects of hydraulic fracturing, research is being conducted to determine how hydraulic fracturing is altering the air quality around drill sites. It also highlights the different stances of different groups. One gas industry source indicated that pollution was only temporary, and that most of it came from diesel engines. The source also mentions that the federal laws regulate how air emissions are managed. Less
than two weeks before this paper was completed, the EPA issued an updated rule that required air quality tests for well sites, as well as stricter regulations for well leaks, leak detection, and repairs (EPA, 2012). This highlights not only the use of information from certain sectors, but its rapidly changing nature. Environmental impacts are significant because they alter the immediate area in a negative way, creating risks of contamination and pollution. Only through stricter rules and more research into the process of hydraulic fracturing and its impacts can the environment and those who live in it be more completely ensured of its protection.

**Political History**

The state of Pennsylvania has long been rich in the natural resources needed for energy, industrial growth, and economic expansion in the United States. The exploitation of Pennsylvania’s oil and gas reservoirs began in the middle of the nineteenth century. According to the Pennsylvania Department of Environmental Protection (DEP), as many as 350,000 oil and gas wells have been drilled since the first oil well near Titusville in 1859 (National Sea Grant Law Center). Drilling permits for new oil and gas wells were not required until 1956, and the requirement to register existing wells was not instituted until 1985. The status of many wells drilled and abandoned before the institution of permitting and registration requirements is unknown. DEP estimates that more than one-half of the wells drilled are unknown as to location and status. Many of these legacy wells that are no longer producing oil or gas were never plugged. Some leak gas, oil, and/or brine into freshwater aquifers and the surface environment (Mitchell, A. L. and E. A. Casman, 2011). To remedy this situation, Pennsylvania’s Oil and Gas Act of 1984 required all wells from which economic benefits were accrued after 1979 to be plugged according to the latest standards and the well sites reclaimed by their owners.
The oil and gas regulation structure of Pennsylvania was created for vertical well development and is not adequate to manage the escalating development of horizontal shale formation well development. The previously existing structure insufficiently covered activities such as the withdrawal, transportation, underground injection, and subsequent management of the high volumes of water required to hydraulically fracture a deep Marcellus Shale formation well. The Pennsylvania General Assembly recently enacted Act 13, which substantially revised the Oil and Gas Act of 1984. Governor Corbett signed Act 13 into law on February 14, 2012, and most of its provisions take effect on April 16, 2012. Act 13 provides for new well fees to be assessed and collected on unconventional wells, a formula for distribution of these fees, substantial revisions to environmental protections for both surface and subsurface activities, and restrictions on the authority of local governments to impose burdens on oil and gas activities beyond those required by the state or those imposed upon other commercial and industrial activities. According to the website of the Pennsylvania Environmental Council, Act 13 requires drilling companies to report to the DEP the chemicals they use in the hydraulic fracturing process, including concentrations on a well-by-well basis, as well as publically disclosing chemicals on FracFocus.org.

In the state of New York, the effective ban on hydraulic fracturing was put in place since 2010 by an executive order from the former Governor David Patterson (New York State Department of Environmental Conservation, 2012). The entire West-of-Hudson portion of the New York City Watershed supplies 90% of drinking water to over half the state’s population and sits on top of part of the Marcellus Shale. Although the New York State Department of Environmental Conservation (NYS DEC) recommended protecting some areas from hydraulic fracturing, including the watersheds of New York City and Syracuse, they allowed it in others.
Recently, the New York State Assembly passed legislation A.7013, which closed a loophole in Department of Environmental Conservation regulations that exempted hydraulic fracturing waste from treatment as hazardous waste. The act relates to the uniform treatment of waste from the exploration, development, extraction, or production of crude oil or natural gas. While the process of preparing the Supplemental Generic Environmental Impact Statement (SGEIS) is ongoing, any entity that applies for a drilling permit for horizontal drilling in the Marcellus Shale and opts to proceed with its permit application will be required to undertake an individual, site-specific environmental review.

Low-volume hydraulic fracturing, or conventional fracking, has been used successfully and safely in New York State for many years to extract natural gas consistent with the GEIS for Oil, Gas and Solution Mining Regulatory Program promulgated by the NYS DEC in 1992. But further research is needed in high-volume hydraulic fracturing combined with horizontal drilling prior to deployment in New York State. In 2008, the Commissioner of Environmental Conservation initiated a formal public process to update the 1992 GEIS to ensure that any new technologies deployed in New York State were first thoroughly analyzed and regulated to ensure that all environmental and public health impacts were mitigated or avoided. While regulations are going through the state process, more than 70 cities, towns and counties in New York have enacted various rules and restrictions, and in some cases bans.

Economic

A typical horizontal drilled well, using multistage fracturing techniques, costs roughly $3-5 million to complete. As much as 50% of the total drilling cost is consumed by drilling the last 10% of the hole. The large amount of water used, and management of the wastewater are also very costly factors. Nevertheless, Marcellus Shale extraction is expected to create jobs. A
large demand for laborers at the gas fields and support businesses, such as drilling contractors, hydraulic fracturing companies, and trucking companies is also expected to increase. In Pennsylvania alone, 2008 estimates show the creation of more than 29,000 jobs and revenues of $2.3 billion (Kargbo, D. M., R.G. Wilhelm, and D.J. Campbell, 2010). Tax revenues for state and local governments, generated from indirect business taxes, including excise taxes, property taxes, and sales taxes increased by more than $238 million from the previous year. Many land owners are expected to benefit financially. Thousands of leases have been signed with prices ranging from hundreds of dollars to $5,000/acre, paying 12-20% royalties, and offering hopes of economic prosperity.

Recent assessments have shown significant employment opportunities during natural gas development but it remains to be seen how many of the jobs created will be long-term, local employment opportunities. If the gas is taxed and the money stays in the local economy, county infrastructure such as schools, hospitals and roads could be improved. Jobs will be created to support the industry directly and indirectly. Property and rental value will increase. Farmers will be paid for leases on their land and royalties if gas is extracted. The most notable and upfront positive effect of drilling for the Marcellus Shale will be the job increase in the current economy. In the city of Clearfield, Pennsylvania the unemployment rate dropped from 10.1% in December 2010 to 9% in February 2011 after shale drilling was started in the area. Over time, as local people receive training, more locals may be employed. In the short-term, local truck drivers are needed to drive the millions of gallons of water to each drilling site and the millions of gallons of water and chemicals from the site to a water treatment plant for recycling. Furthermore, people will be needed to work at hotels and restaurants that the workers visit while they are drilling in the area. Local businesses would gain more customers from the many people employed by the
industry that are working and traveling through that area which may lead them to expand and hire more employees. Another financial benefit is that owners of rental properties will be able to ask higher rates due to housing being in high demand for the drilling crews.

Social/cultural

As previously stated, New York passed legislation to halt high volume hydraulic fracturing because the state sits atop a large gas reserve known as the Marcellus Shale. It has become a large debate, largely because of plans of hydraulic fracturing in the New York City watershed. The New York State Assembly voted 93 to 43 to impose a statewide moratorium on hydraulic fracturing while a comprehensive review of the practice is undertaken. With the moratorium in place, the Independent Oil and Gas Association of New York believes that it could result in the potential loss of 5,000 industry jobs, threaten the future of more than 300 businesses and temporarily eliminate $1 million in annual revenue that the state collects from traditional drilling permit fees.

Hydraulic fracturing can also be socially disruptive damaging roads, creating long traffic jams in rural communities, driving up local rental costs and, in some locations, increasing crime rates. A common concern is the increase in truck traffic. This is a danger to small cars, children, and families, as the big trucks are much larger and often have poor visibility of smaller objects. This also causes significant wear on roads not designed for such traffic. While oil and gas companies do pay to replace roads that lead directly to their sites, they do not repair roads that are further away. According to media reports, county and local governments have had to cope with the cost of dealing with more people, more social service referrals and more crime, the latter due to the presence of hundreds of young, unattached men with high wages (Germanoski, personal communication, 2012). Police calls for service in Bradford County, PA, which has more
Marcellus wells than any other in the state, are up 25 percent this year. While property values do increase, some local citizens complained that this led to an unwelcomed increase in their property taxes. Rates for rentals have increased on long-term renters, forcing some to move to other areas (Lehigh University forum, 2012). Leasing of mineral rights puts neighbor against neighbor because of pollution, and different lease terms.

Conclusion

Hydraulic fracturing and the oil and gas industry have many ways to display the information relevant to their technologies. Different advocacy groups choose different pieces of information to display, each group motivated by different morals and agendas. The oil and gas industry as well as politicians are motivated by profit and public image, which allows them to generate more product. Environmental advocacy groups worry about the harmful effects hydraulic fracturing can produce, and focus on information that can be displayed negatively. Homeowners with mineral rights want profit and safety, while those without mineral rights deal with the congestion from the industry and receive no benefits. While these are universal trends in the Marcellus Shale region, important physical, political, and historical differences exist in Pennsylvania and New York. Historical trends in Pennsylvania’s political system favored drilling, while New York favored a more environmentally cautious approach. Pennsylvania is also underlain with much more natural gas than New York. These trends are important to consider when analyzing the differences in Pennsylvania and New York and their stance toward the natural gas industry and hydraulic fracturing, and information is often distorted or omitted to generate the most appealing image to the general public. Understanding these images and the background to hydraulic fracturing is necessary to create an accurate, scaled
model. Understanding the political, historical, social, environmental, and physical differences allows for an accurate comparison, contrast, and critique between New York and Pennsylvania in the Marcellus Shale region.