MARCELLUS SHALE GAS DEVELOPMENT:

RECONCILING SHALE GAS DEVELOPMENT WITH ENVIRONMENTAL PROTECTION, LANDOWNER RIGHTS, AND LOCAL COMMUNITY NEEDS

School of Public Policy
University of Maryland
July 2010

PREFACE

This report was prepared by the environmental policy workshop at the School of Public Policy of the University of Maryland. The environmental policy workshop is a course in the master's program of the School. Each student devotes a full semester of course work to the study of an important public policy issue. This year there were eleven students studying policy issues relating to the shale gas development of the Marcellus formation that covers much of Pennsylvania, New York State, West Virginia, and Maryland.

The combined efforts of the students amounted to more than 1,000 hours, including review of the literature, meetings with experts, and other methods of study. The environmental policy workshop is supervised by Professor Robert H. Nelson of the environmental policy program of the School of Public Policy.

The Executive Summary presents the principal findings, conclusions and recommendations. The report is available on the web under "professional papers" and "Robert Nelson" at http://www.publicpolicy.umd.edu/nelson/workshop .

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Overview

Greater reliance on natural gas as a source of energy offers potentially very large economic, environmental and national security benefits for the United States. Economically, it may be possible to obtain large supplies of energy from natural gas at a fraction of the energy equivalent price of petroleum. Since much of this natural gas would be produced within the boundaries of the United States, it would generate large levels of income and jobs for U. S. citizens. This is in contrast to the approximately $350 billion per year that is paid at present to foreign sources (often government owned) of petroleum in order to sustain oil imports of about 12 million barrels per day. These huge revenues, moreover, often work to the benefit of nations such as Venezuela, Iran, and Russia -- where the funds may well end up being used in ways contrary to U.S. national interests. In any case, the payments for foreign oil that are diverted outside the United States reduce correspondingly the resources available internally for U.S. consumption and investment.

Environmentally, per unit of energy obtained, natural gas emits about half the level of greenhouse gases as coal and about two thirds to three quarters the level of petroleum. If a significant price is set for carbon emissions – either by means of a carbon tax or a cap and trade program -- the greenhouse advantages of natural gas will translate into a direct economic advantage. Natural gas would gain a clear economic advantage over coal in the generation of electric power. Greenhouse gas considerations are already limiting the approval of new coal fired power plants in the United States, with natural gas as the leading alternative. Per unit of energy supplied, carbon pricing would further increase the existing cost advantage of natural gas relative to petroleum.

Since the enactment of the Clean Air Act in 1970, the United States has made significant progress in reducing air pollution. Even 40 years later, however, much of the United States is unable to comply with national air quality standards for important sources of pollution such as ozone and particulate matter, leaving more than 100 million Americans living in air quality "nonattainment" areas. The environmental advantages of natural gas over coal are even greater with respect to these conventional sources of air pollutants. In the generation of electricity, natural gas emits essentially negligible amounts of particulate matter and much less nitrogen oxide, for example. A large scale conversion of the electric power production in the United States from coal to natural gas would finally allow the nation to achieve air quality goals which were established 40 years ago and yet have been impossible to meet within the framework of the current national energy system.

While the environmental advantages of natural gas have long been recognized, the amounts of natural gas believed to be available for production within the United States were thought to be nowhere near large enough to sustain a newly dominant role for natural gas in supplying much of

U.S. energy. This has changed, however, with the development of new technology for the production of "unconventional" sources of natural gas. The physical existence of this gas has also long been known but it was believed to be uneconomic to produce. Estimates of economically recoverable reserves of unconventional gas in the United States, however, have increased drastically in the past decade.

The largest unconventional reserves are found in shale geological formations found widely across the United States. Within the past 15 years, estimates of the economic feasibility of producing these shale gas reserves have been radically altered by two technological developments. New technology has facilitated the drilling of horizontal extensions of natural gas wells far below the earth's surface. The technology of hydraulic fracturing of the shale has made possible the release and recovery of large amounts of natural gas from these horizontal wells. Although such shale gas production methods were pioneered in the Barnett shale formation in Texas over the past decade or so, they are now increasingly being extended to other large shale formations -- including the Marcellus shale formation extending across much of Pennsylvania, New York State, West Virginia and Maryland.

Reflecting these developments, *The Future of Natural Gas*, a June 2010 study by the MIT Energy Initiative, bringing together many of the leading energy experts at MIT, reports the following summary conclusions:

> • *Abundant global natural gas resources imply greatly expanded natural gas use, with especially large growth in electricity generation.*
>
> • *Natural gas will assume an increasing share of the U.S. energy mix over the next several decades, with the large unconventional resource playing a key role.*
>
> • *The share of natural gas in the energy mix is likely to be even larger in the near to intermediate term in response to CO_2 emissions constraints. In the longer term, however, very stringent emissions constraints would limit the role of all fossil fuels, including natural gas, unless capture and sequestration are competitive with other very low-carbon alternatives.*
>
> • *The character of the global gas market could change dramatically over the time horizon of this study.*

The MIT study also found that "the physical properties of natural gas, the high degree of concentration of the global resource and the history of U.S. energy policy have profoundly influenced the use of natural gas and the market structure governing its trade." Reflecting such factors, " the substantially lower carbon footprint of natural gas relative to other fossil fuels, combined with the development of North American unconventional natural gas supply and the high cost and slow pace of lower carbon alternatives, has focused attention on natural gas as a 'bridge' to a low-carbon future" over at least the next several decades.

While the potential energy importance of shale gas has been known to many natural gas industry insiders, and other energy experts, for a number of years, wider public awareness has spread only

in the past year. Fueled by expert reports such as the MIT study, in the first six months of 2010 articles about shale gas were featured across the leading national print media. In its June 25, 2010 issue, *Science* magazine reported that:

> *Engineering ingenuity is unlocking a vast storehouse of natural gas buried beneath American soil from Texas to New England. Drillers are turning their instruments from the vertical to horizontal and then blasting the rock that tightly holds the gas with high-pressure chemical brews. This "fracking" (pronounced and sometimes spelled "fracking") is finally making gas trapped in shale a profitable resource. That change, in turn, has driven up declining U.S. gas production, rescuing the American natural gas industry from seemingly inevitable depletion.*

While greater use of natural gas as an energy source can offer very large benefits to the United States as a whole, not every American individually will benefit. Increased production of natural gas on the scale now envisioned will require substantial new investments in pipeline and road infrastructure, as well as the drilling of thousands of gas wells in areas where sometimes there has been little intensive energy development in the past. All this shale gas production activity is bound to be locally disruptive for many people, and it may strain the financial capacities of state and local governments to manage it. Governments have well established processes for permitting individual wells in place but they have been much slower to set the wider ground rules for shale gas development, even as shale gas production has been growing rapidly in some states such as Pennsylvania. Little provision, for example, has been made thus far for compensating or mitigating the impacts on the many individual potential local losers in the shale gas development process.

Production of shale gas raises several important environmental issues. Hydrofracking of shale to release the gas requires large volumes of water that may strain the capacity of local water supply systems to deliver it. Wells must be drilled to reach shale deposits that are typically thousands of feet below the land surface. These wells must often be drilled through groundwater sources lying much closer to the surface, raising the possibility of the contamination of the groundwater that is used for municipal water supplies and private wells. The water used in the hydrofracking process includes a host of chemicals and also picks up additional natural contaminants underground. When the water pressure is released at the end of the hydrofracking process, significant amounts of this contaminated water returns to the surface – "flowback water" – and must be disposed in an environmentally responsible manner. Again, governments have been slow to implement the full environmental management and protection systems required to deal with the potential negative impacts of shale gas development.

National coordination of shale gas policy has been essentially absent at the highest levels of government such as the Congress and the White House, despite the potentially "game changing" nature for national energy policy of unconventional sources of natural gas. Within the executive branch, the national EPA has barely begun to address the environmental issues raised by shale gas development. While energy issues such as nuclear power, carbon sequestration, and renewable sources of energy have absorbed the attention of leading national energy policy makers, an arguably still more important new source of energy – unconventional natural gas --

has been comparatively neglected. Perhaps it is because natural gas is already so familiar that any radical new energy developments from this source are difficult for policy makers to comprehend.

State and local governments have been more involved but also failed to develop a focused response to the energy potential of unconventional sources of natural gas, and especially shale gas. Until recently, for example, some states still required that gas wells be spaced well apart and individually drilled, despite the large economic and environmental benefits of consolidating multiple horizontal wells on the same drilling pad. The levels of human and financial resources devoted by state government to regulation of shale gas development have lagged well behind the needs of a new industry that in some areas is facing explosive growth. States and local governments have moved too slowly to establish oversight systems to address local concerns relating to the proper provision of necessary roads and other infrastructure, protection of water sources and the environment generally, and compensation of those individuals who may be adversely affected in some significant way. Rather than addressing such cumulative impacts of shale gas development on whole regions and localities, the state response thus far has concentrated on the narrower processes for issuance of environmental permits relating to individual shale gas wells.

Some environmental groups, and some of the local groups who fear that they might be adversely affected, oppose the intensive development of shale gas as contemplated above. These groups rightly criticize governments at all levels for failing to take action rapidly enough to address the full social, economic and environmental issues raised by intensive shale gas development.

This report first reviews briefly the economic, environmental and national security benefits that development of shale gas may offer to the United States as a whole. It then examines the environmental and other local impacts that may constrain shale gas development, focusing on the Marcellus shale formation in Pennsylvania, New York State, West Virginia and Maryland. It makes various policy recommendations for avoiding negative environmental impacts and otherwise smoothing the transition to the use of shale gas as a leading source of national energy. While the national benefits of shale gas development are very large, it will also be necessary to address the local impacts in a satisfactory way, if the full wider benefits are to be realized.

Chapter Summaries and Recommendations

Chapter 1 – Shale Gas in the U.S. Energy Future

The outlook for the role of natural gas in the future of the United States energy supply is rapidly increasing due to progress of methods of extracting natural gas from shale formations found throughout much of the United States and its increased economic feasibility. There are large uncertainties regarding the actual amounts of shale gas that may be extracted, but resources are predicted to have great potential and the ability to transform the entire U.S. energy sector. As the U.S. needs to diversify its energy sources for economic, national security and sustainability reasons, natural gas could serve as a way to address costs, dependency on other countries, and harmful environmental impacts of energy sources currently relied upon. The U.S. consumed about 23% of the total world oil consumption in 2008, creating a large expense on energy use from oil alone. Natural gas also provides the opportunity for the U.S. to have a greater impact as an energy supplier itself.

The projected abundance of the natural gas supply as an alternative energy source could allow for industries to rely on generating power from natural gas. Shifting towards increased use for electricity, power plants and transportation would significantly reduce costs and begin to substitute away from the use of other fossil fuels reducing the output of harmful emissions. Also, there has been a gradual shift towards use of natural gas in the residential sector. Increased efforts for greater use of natural gas have already begun, specifically in the transportation sector, with the increase of retrofitted vehicles to run on natural gas. Natural gas transportation has the potential to reduce costs for companies and individual residents as natural gas prices are on average lower than gasoline prices. If more incentives are provided for natural gas use, the U.S. could become more self-reliant on its own energy sources and drastically change the landscape of the global energy sector.

Policy Recommendations

- **Develop new mechanisms for more inclusive shale gas policy coordination at the national, state and local levels**. The political response to the new energy promise of shale gas development has thus far been focused on issuance of drilling and other individual permits. Yet, shale gas development will have much wide consequences for the nation, states and many individual localities. These governing jurisdictions will need a greater awareness of the looming major economic and environmental impacts of shale gas development in the future and will need to create new administrative mechanisms to oversee such wider consequences in their jurisdictions.

- **Expand research opportunities for unconventional gas production technology.** More advanced technologies could improve efficiency, reduce costs and make shale gas more competitive. As a result, domestically-produced fuels would be better able to meet U.S. energy demands.

- **Renew expired Section 29 tax credits.** These instreluments would attract capital and build economies of scale, further reducing costs and lowering the retail price of natural gas.

- **Incentivize participation in the EPA Natural Gas STAR program.** This program helps reduce GHG emissions that are released in natural gas systems. Some companies have actually made a profit through the sale of captured methane gas. This program therefore has the potential to reduce the cost of meeting our GHG emission targets.

Chapter 2 – Shale Gas Development in the Marcellus Formation

The Marcellus formation spans four states: Pennsylvania, New York, West Virginia, and Maryland. While the impacts of development are similar, policymakers would benefit greatly from an understanding of the different experiences each state has had. Pennsylvania is thus far at the heart of the Marcellus Shale natural gas boom. Firms have been actively exploring and drilling wells in PA in recent years. Some firms are producing over 100 million cubic feet of natural gas per day and the number of drilling permits issued in Pennsylvania continues to increase every week. The drilling has provided substantial income to landowners from leases and royalties and tax revenue for the state. The industry has also created jobs, and the Marcellus play is widely viewed as a great opportunity for many in the state.

At the same time, the scale and speed of development has raised important issues regarding public safety and property rights. Pennsylvania has much to consider relating to its natural gas future. A severance tax was recently proposed on all gas extracted from the wellhead, and in March 2010, the state legislature passed a law requiring drilling companies to report their production rates. Neighboring states are looking to Pennsylvania to provide an example of how to balance the economic benefits of drilling with the environmental and social costs.

While Pennsylvania has embraced the natural gas boom, New York State has been much more cautious. Despite a $1 billion cash shortfall that threatened major state services, Governor David Patterson placed a moratorium on natural gas drilling. While awaiting the results of a Supplementary Generic Environmental Impact Statement (SGEIS) for high volume hydrofracking, Patterson announced, “We’re not going to worry about time because we’re talking about public safety.”

While the study was ongoing, political and economic pressure mounted to lift the restrictions. Few were surprised when the draft SGEIS found relatively few risks. Many New York local environmentalists, however, continue to oppose drilling. Ultimately, New York City officials decided to prohibit shale gas drilling in the large City watershed in the Catskills.

With the highest reserve projections by some estimates in the Marcellus region, the State of West Virginia can play a major role in the development, production, and transportation of shale gas. The hotspots for shale gas appear to be in the southwestern and north, northwestern counties. Job growth, severance taxes, and royalties have the potential to benefit the economy on state and local levels. Challenges that may tend to slow down permitting and drilling include

disagreements involving surface and mineral rights, the environmental consequences of hydrofracking, and enforcement of OSHA standards.

Industrial coalitions continue to form in West Virginia to ensure businesses and community members that a competitive economic market can thrive without aggressive governmental intervention and regulation. The State and local governments have also attempted to reassure communities that steps are being taken to decrease the risk of hazards like gas flares, fracking fluid spills, and infrastructure degradation. Key players in the planning, implementation, and public outreach of shale development include (but are not limited to) the West Virginia Department of Environmental Protection - Office of Oil and Gas, the West Virginia Geological and Economic Survey (WVGES), the Independent Oil and Gas Association of West Virginia, Inc. (IOGA), and WV Surface Owners' Rights Organization.

The Maryland portion of the Marcellus play is largely an unknown. Although there are expected to be significant reserves, Pennsylvania and West Virginia are currently more attractive for investment. With interest rising rapidly, however, it is likely that development will begin in the western-most counties in the near future. The Maryland government is aware of the opportunity but has not demonstrated much urgency in laying a legal and regulatory framework for shale gas development. The last two General Assembly sessions in Annapolis have seen the introduction of bills intended to encourage development and capture revenue, but the regulatory apparatus remains unprepared at present for large-scale development.

Chapter 3 – Hydrofracking Water Requirements

The hydraulic fracturing process in shale requires 2 to 8 million gallons of water – equivalent to four to twelve Olympic-size swimming pools -- for each well. Faced with such high water demand, regulators must reconcile hydraulic fracturing needs with other competing water uses, such as those for industrial, recreation, agricultural, and municipal activities. Current projections suggest that shale gas water demands will not be large enough to pose a major threat to state and local source waters. But a complex system of local water traditions, intergovernmental organizations, and state laws must be closely monitored to ensure that water supplies are property managed to fill all needs in the Marcellus play states.

The doctrine of riparian rights—rooted in British common law—establishes which landowners do, and do not, have water access rights. The Delaware River Basin Commission (DRBC) and Susquehanna River Basin Commission (SRBC) also manage water withdrawals from their respective watersheds. Finally, state laws and drilling permit applications set additional standards for areas that do not fall under DRBC and SRBC jurisdiction and help to insure against excess withdrawals that could degrade source waters.

Policy Recommendations

- **Promote wider reporting of low-volume withdrawals**. A program for all sectors (e.g., agriculture, industry, mining, recreation) would provide regulators with more data on withdrawals and facilitate policymaking. Greater reporting of water uses would augment

mandatory reporting, which, in Pennsylvania, is required only for withdrawals exceeding 10,000 gallons per day (GPD).

- **Restrict withdrawals during low-flow periods.** Targeted restrictions, if enforced, could help to protect source waters from degradation during periods of low water supply.

- **Periodically review withdrawal fees and adjust if necessary to reduce demand.**

- **Make flow-management tools easy to use and readily available.**

- **Develop preemptive water procurement policies in states such as Maryland, New York, and West Virginia that have seen little development to-date.**

Chapter 4 – Drilling Threats to Groundwater Drinking Supplies

Large scale production from the Marcellus shale gas formation raises concerns that the hydraulic fracturing process may contaminate underground sources of drinking water. Although most did not involve shale gas and many were long ago, there are over one-thousand reports confirming the contamination of drinking water in areas where natural gas drilling is occurring. Although some well contamination has occurred near current shale gas sites, industry representatives argue that there is no adequately documented evidence that shale gas drilling is to blame.

In the 2005 Energy Bill, Congress exempted hydraulic fracturing for the purpose of shale gas production from the provisions of the Safe Drinking Water Act. The recently proposed FRAC Act would repeal those exemptions. Given the novelty and lack of experience with shale gas development in the Marcellus region, the public is suspicious of the assurances of the natural gas industry. While objective information is scarce, threats to underground drinking water sources are being taken seriously by constituents and law makers alike.

Policy Recommendations

- **Repeal the 2005 exemption of hydrofracking from the provisions of the Clean Water Act**. As the recent enormous spill in the Gulf of Mexico has further revealed, even when most of the oil and gas industry is operating responsibly, the industry is not capable of controlling privately the behavior of its bad actors that are willing to take socially unacceptable risks for economic reasons. Public regulation is required to protect against potentially large environmental damages when accidents occur.

- **Require the full public disclosure by gas companies of the fracking fluid chemical composition.** States are allowed to regulate and oversee natural gas production. Keeping the chemicals secret prevents the state from effectively protecting the public from emerging risks.

- **Establish a comprehensive penalty system.** Lack of federal regulation has allowed drilling companies to take a lax approach with keeping their promises. There may not be

proof that hydraulic fracturing contaminates underground drinking water sources but there is proof that leading gas companies have lied to federal authorities on their use of diesel in their fracking fluids.

- **Emphasize the importance of spill response plans.** There is risk in all oil and gas extraction activities. Safety and environmental regulations are designed to minimize risk, but in the event that accidents occur, industry and government must be prepared to respond.

- **Privately support further research into contamination risks.** The oil and gas industry should work with university and other independent experts to assess the risks to groundwater from shale gas drilling and production. This research can supplement the current EPA study (which may not be officially released in time to contribute to pressing public decisions).

Chapter 5 – Disposal of Flowback Water

A significant portion of the water used in the hydrofracking process returns to the surface in a contaminated condition as "flowback" water. Twenty million gallons of such flowback water could be produced each day in Pennsylvania by 2011. Volumes at that magnitude will make wastewater management the most important environmental issue associated with hydraulic fracturing in the Marcellus shale states. Wastewater management requires compliance with the Emergency Planning and Community Right-to-Know Act (EPCRA), Clean Water Act (CWA), Safe Drinking Water Act (SDWA), and numerous state laws.

The EPCRA requires all facilities that must produce material safety data sheets (MSDS) to make chemicals publicly available. The CWA controls direct discharges of flowback water into rivers and streams, requires gas companies to pre-treat effluent before sending it to a municipal wastewater treatment plant, and requires municipal and industrial wastewater treatment plants to limit discharges to permitted levels. The SDWA dictates what can and cannot be injected into underground wells, though underground injection is likely to be limited in the Marcellus shale states, owing to the absence of suitable underground formations. Finally, state laws vary widely, with Maryland placing a moratorium on underground injection, New York regulating radioactive materials, and West Virginia placing minimum standards beyond those required by the CWA. New technologies, including those that use electrodialysis and acid mine drainage to remove total dissolved solids (TDS), hold promise for treating the large volumes of wastewater that are expected to be generated.

Policy Recommendations

- **Remove the proprietary chemicals exemption from EPCRA.**

- **Ensure that NPDES limits contain discharge limits for all flowback chemicals and not just common TDS.**

- **Ensure that effluent limitations guidelines adequately reduce all flowback chemicals to safe discharge levels.**

- **Re-evaluate whether or not municipal wastewater treatment plants that are designed to treat sewage should also be allowed to treat flowback water.**

- **Continue to build additional treatment capacity using funds, at least in part, from gas companies or severance taxes on natural gas extraction.**

- **Review the moratorium on underground well injection in Maryland.**

- **Review the New York wastewater removal and impoundment laws.**

- **Ensure that states beyond New York act to regulate radioactive materials.**

- **Promote alternative treatment technologies including the acid mine drainage technologies now being developed by Carnegie Mellon University and STW Resources.**
- **Promote reuse and recycling like the processes now being pioneered by Range Resources.**

Chapter 6 – Mitigating Transportation Impacts

The impacts of shale gas development on local infrastructure depend on the rate and intensity of drilling and extraction activities. Heavy truck traffic, road damages, pipeline construction, and the accompanying noise and visual pollution, negatively affect the local communities where the natural gas is being extracted.

Local governments are responsible for finding solutions to the damage done to local roads, or dealing with community complaints and traffic hazards if they delay repair. Road use agreements between drilling companies and municipalities can be used to delineate responsibility for repairs and limit truck use to specific times and locations to minimize damage and avoid community disruptions. However, there are no established best practices for road use agreements, and no way for municipalities to limit drilling-related activities while an agreement is negotiated. Current regulations and bonding requirements are not enough to ensure that communities are protected from drilling developments.

Policy Recommendations

- **Mandate the establishment of road use agreements between municipalities and producers.**

- **Require producers to include transportation plans when applying for permits.**

- **Reform laws to give municipalities authority to stipulate weight and access requirements for roads and increase the bond amount to cover the actual cost of repairs.**

Chapter 7 – Treating Land and Property Owners Fairly

It is in the communities where drilling occurs that the impacts of Marcellus Shale Gas development is most tangible. Large trucks filled with equipment and water drive past homes on small local roads. For weeks at a time, rigs rise above the tree tops and the sound of drilling can be heard. Families spend their royalty payments on local businesses, invest in their own property and pay for their children's education. Neighbors worry about the safety of their water and wonder if they are getting a fair share. Gas companies perform community service or invest in job training programs. And in attempting to balance these complex interests, local governments struggle against their legal constraints.

Because gas development is relatively new to the region, and because the potential impact is so large, many of the laws and policies are ambiguous, outdated or insufficient for the scale of the Marcellus gas play. The issue of split estates is particularly pervasive, as many of the mineral rights under properties in the region were separated from surface rights long ago. The result is surface owners that have little protection under the law, and who receive few of the economic benefits of gas development. Such benefits are significant; mineral rights owners have the opportunity to lease their property to gas producers for thousands of dollars per acre, and receive royalties of 12.5% or higher. However, it is important that property owners understand the full extent of the obligations in their leasing agreements. State governments have a responsibility to communicate these issues to the public.

It is also essential for states to clarify the balance of power between state regulators and local jurisdictions when it comes to shaping gas development. In all four states, the authority of local governments to regulate drilling is preempted by the respective state oil and gas laws. The Pennsylvania Supreme court recently decided two cases that define a distinction of how drilling can occur and where drilling can occur as the line between state and local authority. However, because local governments have limited resources, most are not willing to pass restrictive ordinances that would draw legal challenges. Despite the fact that planning and zoning is not a common tool in the rural areas where drilling is predominantly occurring, the law should be clarified for when exploration and production expands to more densely populated areas of the state.

Policy Recommendations

- **Expand state-level community outreach to property owners.** Property owners – whether surface, mineral, or both – do not have complete information when it comes to their rights. Communication materials should be more widely disseminated, giving recommendations such as: document the condition of the property before, during and after drilling; consider coordinating with neighbors to secure better leasing rates and royalty payments; negotiate terms for the use of the property throughout the entire

drilling lifecycle, including site restoration; and get all agreements with the gas producer in writing.

- **Pass the Pennsylvania Surface Owners Protection Act.** The Act, while strong, is necessary when split-estate situations are so prevalent.

- **Commission studies to determine the costs of surface owner protections and minimum royalty rate increases**. It is important to know what the full effect of such policies would be on industry and how such costs would affect the development of the resource throughout the state

- **Comprehensively study the value of gas reserves under state lands.** Officials need to have full information when determining policies for the extent to which such reserves should be developed and how revenues from signing bonuses and royalties should be spent.

- **Clarify the preemption clause of the Pennsylvania Oil and Gas Act.** Local governments need a clear picture of what the limits of their planning and zoning powers are so that they can plan accordingly for the development.

- **Increase the budget for extension services, and communicate best practices more extensively.** Such services are necessary to teach local governments about the tools they have to shape gas development in their jurisdictions. If the policy of the state is to encourage the use of "natural gas task forces," the state needs to teach local officials the best practices for engaging stakeholders and building consensus.

Chapter 8 – Socio-economic Consequences of Marcellus Shale Gas Development

Decisions to develop the Marcellus Shale gas play remain, at the most basic level, a matter of weighing perceived benefits versus costs. The development of this energy resource will lead to several key outcomes: increases in direct and indirect investment in communities, improvements to tax revenue streams for states and municipalities, and expanded job development opportunities in gas exploration and development.

Investment from natural gas companies will occur along three separate avenues: direct investment in natural gas exploration and drilling activities, indirect investment in services pertaining to gas drilling, and induced spending within communities spurred through shale gas development. The potential economic impacts of these combined activities are considerable, generating $2.3 billion in Pennsylvania alone in 2008, and an estimated $3.8 billion in 2009. Under current regulations, shale gas development in Pennsylvania will continue to increase throughout the next decade, climbing to a projected $13 billion in value by 2020. New York, while undergoing less development than Pennsylvania at the moment, could generate over $1.4 billion annually from the creation of only 300 gas wells. West Virginia is also expected to derive a substantial amount of investment from shale gas development, totaling almost $2.9 billion by

2020 projections. Understandably, this is a remarkable opportunity to bring significant investment into Pennsylvania, New York, West Virginia, and Maryland through development of shale gas.

States should expect to receive significant lease and tax revenue as development of the Marcellus Shale gas play continues. Pennsylvania received nearly $400 million in state and local taxes in 2009, and this figure will continue to grow as development expands, totaling an estimated $12 billion cumulatively through 2020. New York could receive $30 million in tax revenue through limited drilling expansion, and an additional $200 million from leasing of state lands for gas exploration. West Virginia received $68 million in state taxes in 2008, and by 2020, tax revenue from Marcellus Shale development is estimated at over $850 million.

Furthermore, there will be a significant amount of jobs created through the exploration, development, and production processes. Marcellus Shale gas drilling activities were directly responsible for the creation over 14,300 jobs in Pennsylvania in 2009, and lead indirectly to the creation of another 14,900. By 2020, the Marcellus gas industry is predicted to produce over 16,800 jobs in West Virginia and as many as 175,000 jobs in Pennsylvania. However, these jobs are heavily dependent on exploration and well creation – once production has started at a well, nearly all of the industry jobs are phased out, as maintenance of producing wells requires only a few workers to attend each well. In this sense, the Marcellus industry offers the prospect of large job creation, but jobs are heavily concentrated on development, and are not tied to a particular locality or region over the long run.

Development of the Marcellus Shale can lead to sustainable, long-term economic growth and enhanced revenue streams for state and local governments, predicated upon continual development of oil wells, enactment and retention of state severance taxes, dedicated funding for municipalities bearing the burdens of high infrastructure costs, and the promulgation of post-development municipal growth strategies.

Policy Recommendations

- **Hold community business association forums to discuss impacts of investment.** Retail, service and other local businesses within the Marcellus Shale gas play may not entirely understand the sweeping changes that can take place once industry enters the region. Businesses should be informed about the potential impacts that an expanding work force and increased investment will have on their businesses and the surrounding townships, cities, and counties.

- **Plan long term.** The gas supplies are plentiful, but they are not unlimited. Local businesses that are created during the boom years could easily fail when gas production wanes. State extension services and economic development agencies can communicate sustainable business strategies to local business owners.

- **Create an assessment and training program for local workers**. In order for local workers to benefit most from shale gas employment opportunities, local and county

governments should form a collective partnership with gas companies to provide a training program for community residents during the exploration phase. This will provide local workers with competitive skill sets and assist them in obtaining jobs during the development process.

- **Develop State and Regional post-Marcellus Task Forces**. Marcellus operations will continue long into the future, but employment and growth in localities will be dynamic and subject to rapid change. State and county officials should determine the likely effects of sudden changes to community growth, investment, and income at the municipal level. State and local governments must be ready to respond as changes to revenue streams and government services fluctuate during and following the development phase.

- **Encourage property purchases by out-of-state workers**. A reliance on transient workers puts heavy pressure on communities and the state to provide ample services, both to local citizens and the whole of the work force. Bringing workers into the state will prove economically beneficial, so long as the state can retain them as a stable source of income.

- **Enact an energy production severance tax in Pennsylvania.** While the proposed severance tax has been decried by several industry associations, the large potential revenues to the state makes it too attractive and important to pass up, especially during a time when the state government is experiencing a massive budget shortfall. However, limiting the severance tax to natural gas production alone may unfairly target an industry that produces more desirable low-carbon energy. Pennsylvania should explore severance taxation for all non-renewable energy sources within the state.

- **Ensure equity of revenue collection with local governments.** West Virginia transfers approximately six percent of severance tax collections to county government; Pennsylvania can ensure local impacts are adequately compensated by enacting a similar transfer mechanism.

- **Change state law to allow for local government assessments to include oil and gas assets in property values.** The largest portion of local revenues comes from property taxes, but gas producers are exempt from special property tax assessment. Counties and municipalities need to be able to derive some benefit from these operations, given the damages occur primarily on the local level.

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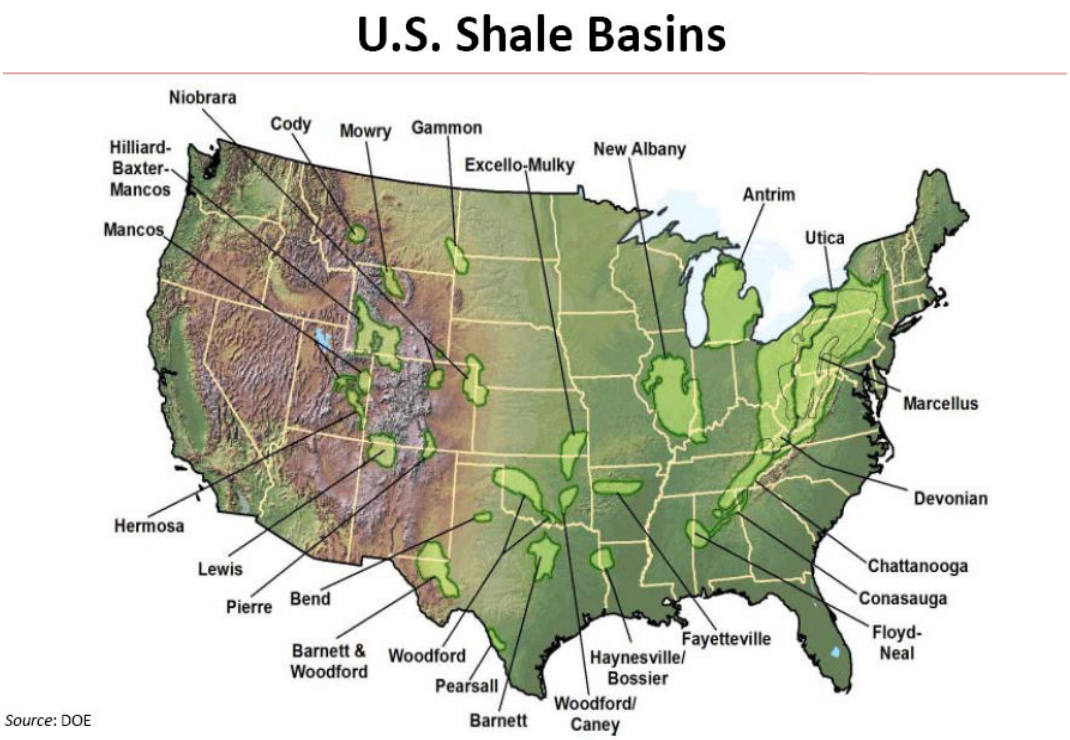
Part I – Shale Gas Development, History and Prospects

Chapter 1: Shale Gas in the U.S. Energy Future

Projections of the likely future role of natural gas in the United States energy system have been increasing rapidly in recent years. This is due in significant party to the discovery of economically feasible methods of extracting natural gas that is found in shale formations that are common over much of the United States (see Figure 1.1). There are large uncertainties regarding the actual amounts of shale gas that may be extracted but, with several basins already in production, and many more expected to come into production, there is the possibility of supplying natural gas for an increasing share of U.S. energy consumption for at least several decades.

According to some recent estimates, , the U.S. now holds around 1,800 trillion cubic feet of natural gas, one third of it in shale gas, the equivalent of some 320 billion barrels of oil. That's more than Saudi Arabia's 264 billion barrels.[1] With such projections of an abundant U.S. natural gas supply , the entire U.S. energy sector has the potential to undergo a major transformation. In the near term, natural gas may significantly displace coal as a source of electric power production and over a longer time frame could also increasingly displace petroleum as a fuel for the transportation sector.

Figure 1.1: Current U.S. Shale Basins

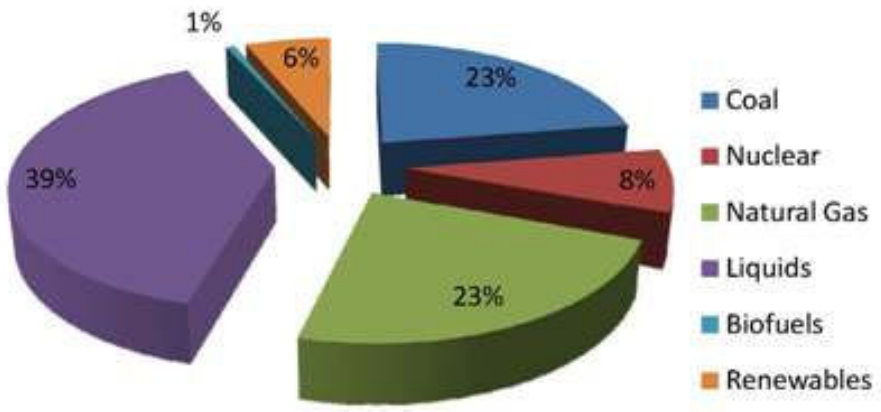


Source: Lucian Pugliaresi, Energy Policy Research Foundation, Inc. "The Shale Gas Revolution" 2010

Overview of Natural Gas

In 2008, about 23% of total energy used in the U.S. came from natural gas. Figure 1.2 shows the distribution of types of U.S. energy sources for 2007:

Figure 1.2: Total Energy Consumed in the U.S. 2007

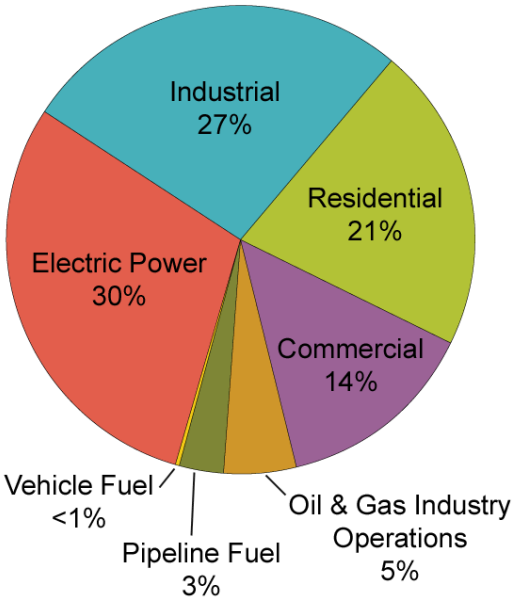


Source: EIA - Annual Energy Outlook 2009

Regulation of natural gas by the U.S. government has taken various forms throughout its history and natural gas continues to be regulated in some ways at the federal level. From 1938 to 1978, the Federal government directly regulated prices in the interstate natural gas market. Artificially low price ceilings were often below the market value of gas causing a surge in demand. The low prices gave little incentive for natural gas producers to invest and produce new natural gas reserves, while stimulating demand. Furthermore, wellhead prices for natural gas were regulated for the interstate market, so sales within the intrastate market were free of regulation. Producers could sell their natural gas at higher prices to intrastate consumers. Natural gas thus was often available for consumers in producing states, while consuming states were experiencing supply shortages.

Natural gas is used in the residential sector mainly for household heating and cooking, with natural gas accounting for 62% of home heating in new homes in 2007.[2] In the industrial sector, natural gas is used widely as an energy source for power plants. Figure 1.3 shows the break-down of the uses of natural gas for 2009 in the U.S.:

Figure 1.3: Natural Gas Use 2009

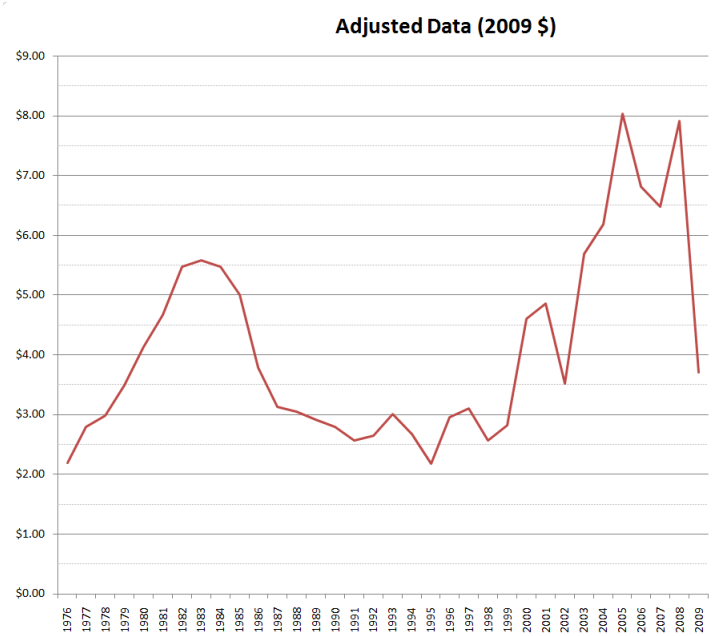


Source: EIA- Natural Gas Monthly, Feburary 2010

In 1978, the Natural Gas Policy Act (NGPA) granted the Federal Energy Regulatory Commission (FERC) authority over both intrastate and interstate natural gas production. It also gradually ended price controls, deregulating the U.S. market for natural gas. The goal was to create a single national natural gas market, bring supply into equilibrium with demand, and to allow for market forces to establish the wellhead price of natural gas.

Contract prices for all categories of natural gas increased in the first years after the NGPA was passed. As natural gas demand and petroleum prices declined, the contract prices reversed this trend and a general decline occurred after 1982. In January of 1985, price ceilings on almost all new gas were removed and the ongoing abundant supplies of natural gas resulted in the continuation of a downward price trend -- see Figure 1.4. [3]

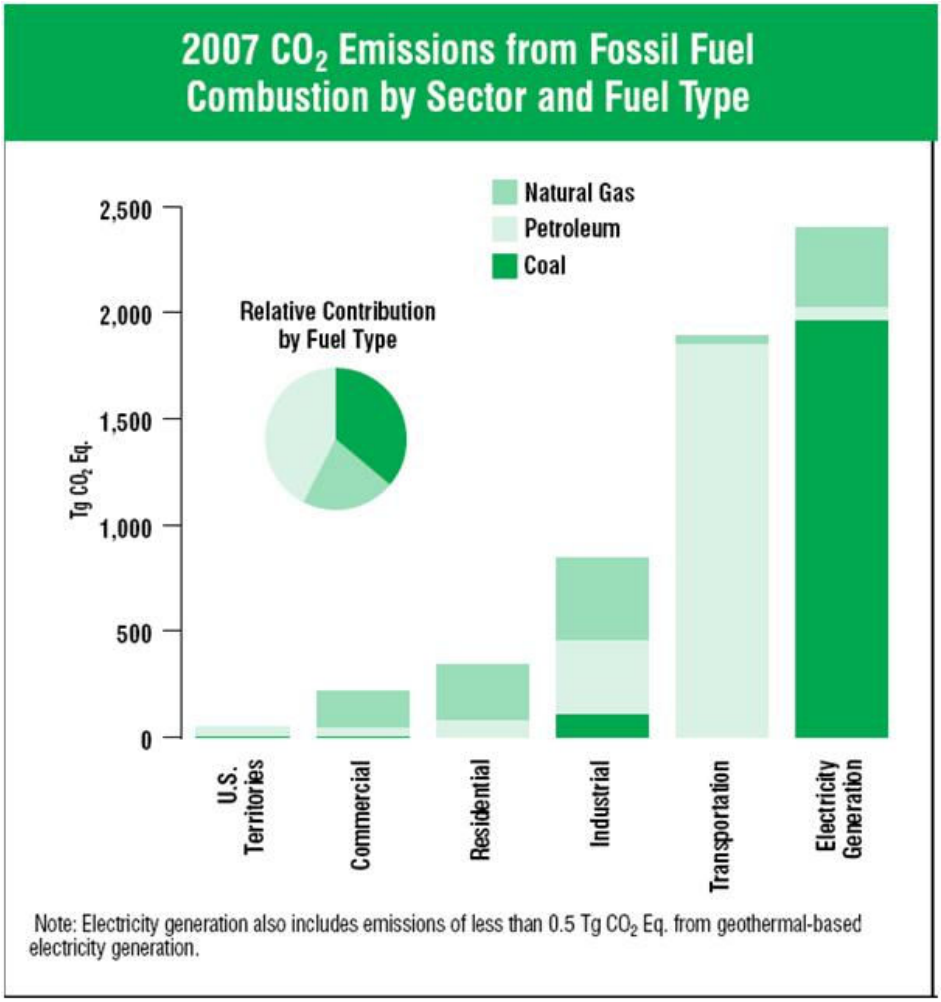
Figure 1.4: Natural Gas Prices, 1976 to 2009



Environmental Advantages of Natural Gas

Coal is the most greenhouse intensive fossil fuel, producing 205 to 227 pounds of CO_2 per million Btu, depending on the type of coal burned. Combustion of petroleum, mainly used in the transportation sector, produces 139 to 173 pounds of CO_2 per million Btu. Burning natural gas, however, produces only 115 to 139 pounds of CO_2 per million Btu (Figure 1.5).

Figure 1.5: CO2 Emissions from Fossil Fuel – Combustion by Sector and Fuel Type 2007

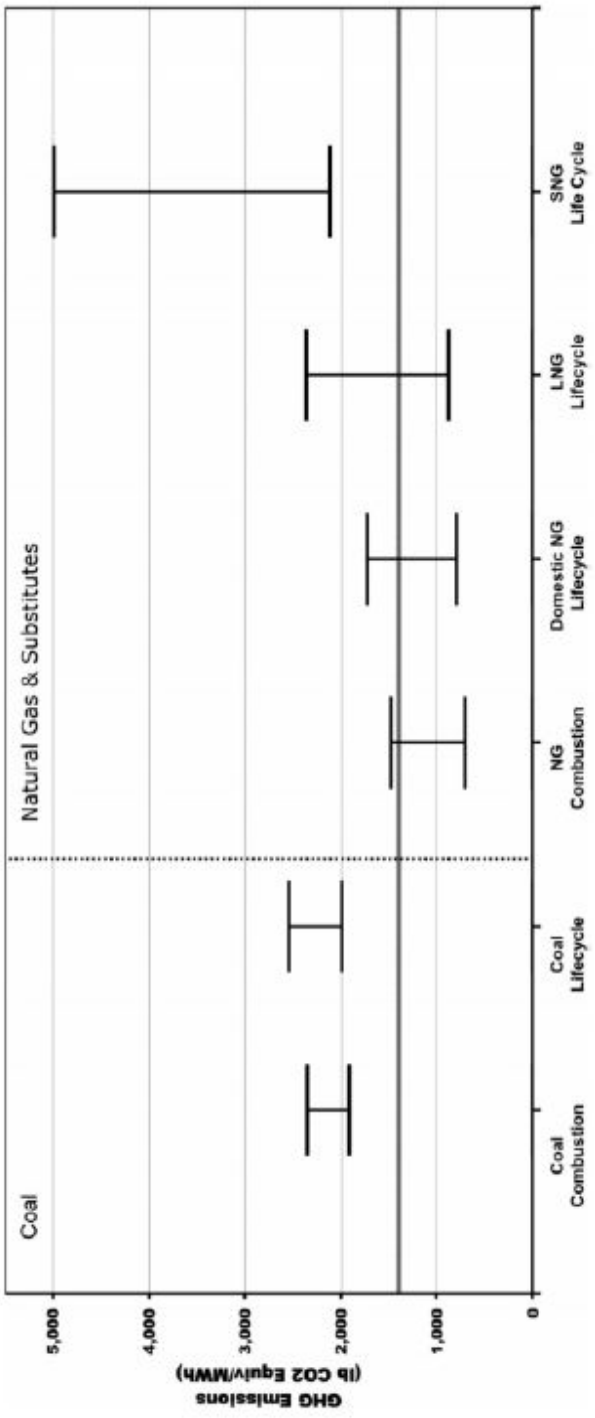


Source: U.S. EPA, 2009. U.S. Greenhouse Gas Inventory. Available http://www.epa.gov/climatechange/emissions/downloads09/GHG2007-ES-508.pdf. Last accessed 4/4/10.

Besides combustion, fossil fuels generate additional greenhouse gases in the production and distribution stages. Natural gas production systems produce twice as much methane per unit of energy as the mining of coal, although methane emissions have declined by about 25 percent between 1990 and 2007 as technology and management practices have changed. An overall life cycle analysis nevertheless shows that with currently available technologies, natural gas production and its use as a fuel for electricity generation produces substantially lower total GHG emissions (Figure 1.6) per unit of energy. Liquefied natural gas, however, has emissions closer to coal when its full life cycle is considered, implying that relying on LNG imports for natural

gas consumption is not much better than coal in terms of reducing GHG emissions. Synthetic natural gas (SNG) has the highest emissions of the three.

Figure 1.6: Life Cycle Analysis of Coal and Natural Gas



Source: Jaramillo, P., Griffin, W. M., and Matthews, H. S. 2007. Comparative life-cycle air emissions of coal, domestic natural gas, LNG, and SNG for electricity generation: Environmental science & technology 41:6290-6296.

Non-Greenhouse Pollution

Besides GHGs, many other pollutants are released into the atmosphere in the burning of fossil fuels. Increasing the use of natural gas in the U.S. could prove beneficial in significantly reducing non-GHG pollutants as well. As shown in Figure 1.7, burning of natural gas produces much smaller emissions of carbon monoxide and nitrogen oxide, compared with coal. Natural gas emissions of sulfur dioxide and particulates are negligible relative to coal.

Figure 1.7: Fossil Fuel Emission Levels

Fossil Fuel Emission Levels
- Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Source: EIA - Natural Gas Issues and Trends 1998

Source: U.S. EIA - Natural Gas Issues and Trends 1998

Nitrogen oxides are regulated by the U.S. EPA under the National Ambient Air Quality Standards (NAAQS). Nitrogen oxides can cause respiratory problems as they react with ammonia, moisture, and other compounds to form small particles. These particles can penetrate deep into parts of the lungs possibly causing or worsening respiratory diseases, such as emphysema and bronchitis, and also possibly aggravating existing heart diseases which can lead to increased hospital admissions and the possibility of premature death.[4]

Ozone (often referred to as "smog") is formed by a chemical reaction in the atmosphere of nitrogen oxides and volatile organic compounds. Ozone can also pose serious health risks to those who work or exercise outdoors including reduction in lung functions and increased respiratory symptoms and respiratory-related hospital visits. Reducing nitrogen oxide levels through further reductions in coal and oil use would have the important co-benefit of reducing the formation of ozone and fine particles which both pose significant public health threats.[5]

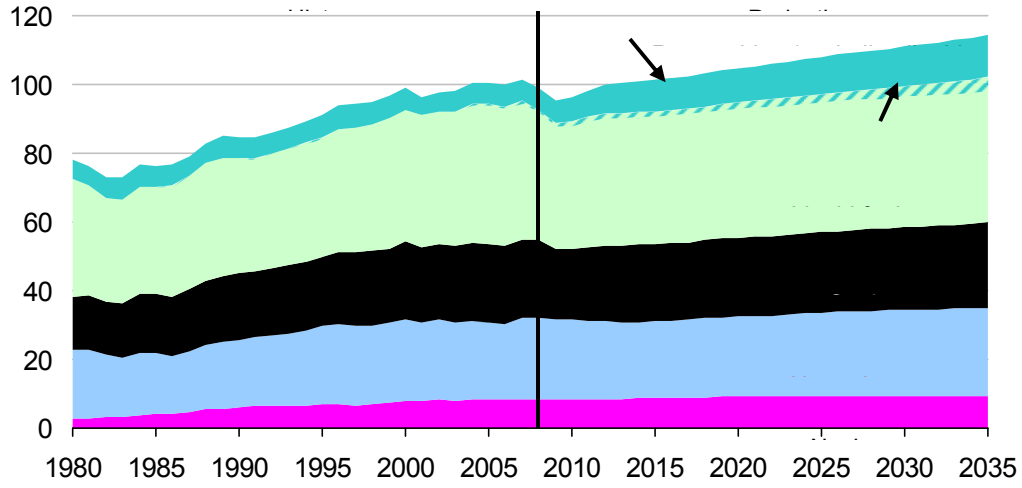
Sulfur dioxide is a cause of acid rain which is harmful to fish populations and the ecology generally of lakes and other water bodies. Emissions of SO_2 from the Midwest, mostly from coal power production, significantly damaged lakes throughout the Mid Atlantic states and Northeast states. For the U.S. as a whole, the largest sources of SO_2 are from fossil fuel combustion at power plants, 66%, and from various industrial facilities, 29%.[6]

Particulates formed from SO_2 emissions are also related to numerous hazardous health effects on the respiratory system. They are especially harmful as they can combine with other compounds in the atmosphere to form small particles which can penetrate deeply into the lungs and cause or worsen respiratory diseases such as emphysema and bronchitis, as well as aggravate existing heart diseases, possibly leading to increased levels of hospitalization and premature death. A major U.S. shift towards natural gas, and lesser reliance on coal and oil for U.S. energy supplies, thus would not only be beneficial in terms of GHGs, but also other forms of pollution.[7] With a major shift to natural gas for power production, many areas of the United States that are now in nonattainment with respect to criteria air pollutants might well come into attainment.

Natural Gas as a Bridge Energy Source and Means of Providing Greater Energy Security

Although GHG intensive, fossil fuels provide about 78 percent of total energy use in the U.S. because they are abundant and generally have a low cost. Concerns about GHGs have driven the recent rapid development of renewable energy. However, fossil fuels are still predicted by the Department of Energy to continue meeting about 78 percent of total U.S. energy needs until at least 2035 (Figure 1.8).

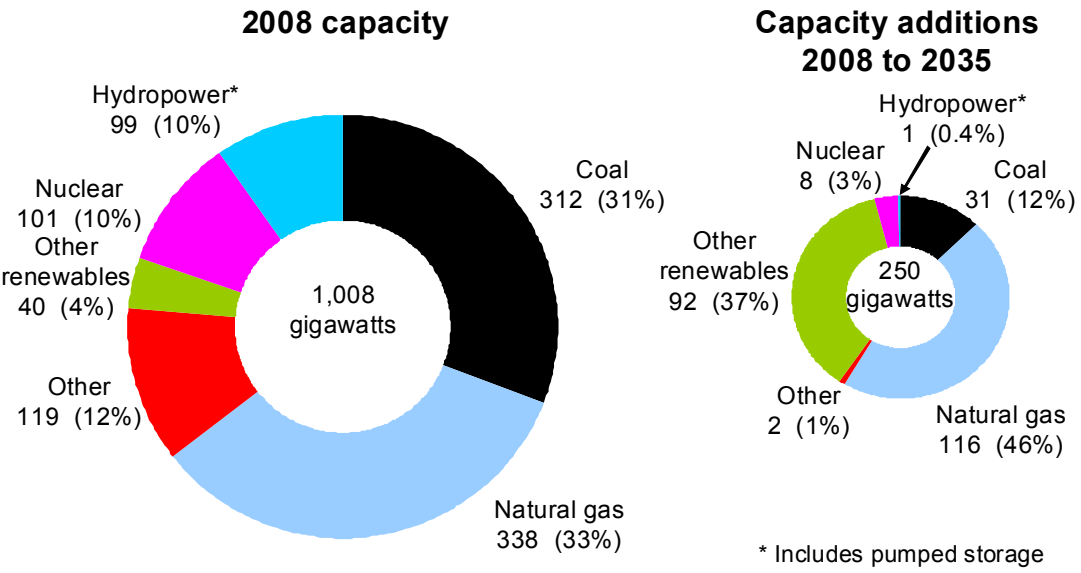
Figure 1.8: Fossil fuels are expected to be the primary source of energy to 2035 and beyond[8]



Source: U.S. EIA, 2009

At present thirty-six percent of the energy from fossil fuels produces electricity. Capacity additions (Figure 1.9) to meet growing consumer demand in electricity generation are expected to be primarily in renewables and natural gas. Use of natural gas alone is expected to increase in use by 22.5 percent by 2030 – and given the rapid current increases in estimated total shale gas reserves in the United States, this estimate may well be conservative. Renewables are expected to gain market share, up to 14 percent of electricity generation by 2035, particularly at the expense of coal, which is the most GHG intensive fossil fuel. [9]

Figure 1.9: Capacity additions in electricity generation will primarily use natural gas and renewables[10]

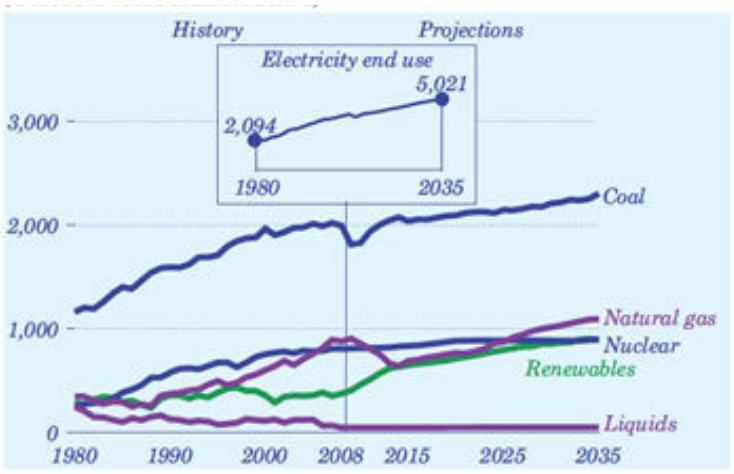


Source: U.S. EIA, 2009

Coal is currently the cheapest fossil fuel for producing electric power at about $2 MMBtu, a main reason it is now the source of nearly 50 percent of U.S. electricity. Putting a price on carbon emissions through a carbon tax or a cap and trade system, however, would make natural gas more competitive. Indeed, depending on the magnitude of the carbon charge, electricity from existing gas-fired power plants could be less expensive than existing coal-fired power plants. Combined cycle plants using natural gas priced at $5 MMBtu (the recent price level) become competitive with coal when the CO_2 value reaches about $35 per ton. With gas prices at $7, the value of CO_2 must be at least $60 per ton in order for gas to compete with coal. These prices are well within the range of recent historic gas prices.

For new power plants, natural gas is much more competitive with coal over a wider range of prices because gas-fired power plants have relatively low capital costs and short lead times when compared to new coal-fired power plants[11]. Additionally the concern over an as yet undecided carbon policy may make the lower GHG intensive natural gas a more attractive option to investors. As noted above, there are also significant non-GHG environmental benefits to production of power with natural gas. The political environment for new coal fired power plants has made their approval more difficult in recent years. By some estimates, given the large increases in the availability of natural gas supplies, there may be few new coal power plants built in the United States within even the next decade.

Figure 1.10: Electricity generation (billion kilowatt hours) by fuel



Source: U.S. EIA, 2009 [12]

In the power sector, new coal plants and receiving capacity for foreign liquefied natural gas (LNG) were planned and built when the general perception was that the U.S. natural gas supplies were declining. The result is that there is increased competition on the supply side due to an increase in LNG deliveries and storage capacity. By some estimates, both U.S. and world markets for natural gas may face a glut of supply over the next decade or two.

Eventually, however, rapidly growing renewables may curb demand for natural gas. Today's low natural gas prices are a function of increased supply and natural gas production occurring in a low cost environment for steel, labor, diesel, etc. As the economy improves, some of these numbers will reverse. Overall, U.S. natural gas production is expected to decline as the recession continues then move into a period of growth around 2012-2013 to meet the growth in power demand, with a long term price expectation of $6-$7 MMBtu (Figure 1.10).[13] All of these estimates, however, are very uncertain.

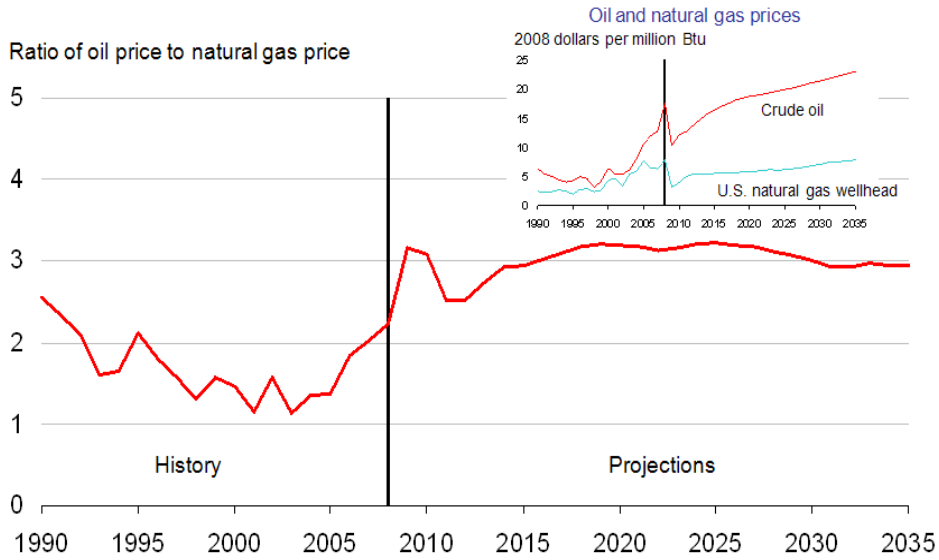
Given the current obstacles to large scale reliance on renewables to meet our around the clock energy needs, a backup energy source will be necessary for some time. Because burning natural gas is about 50 percent less greenhouse intensive per energy unit than coal, natural gas is considered by many to be a leading possibility for a bridge fossil fuel to a new green energy future. Gas power plants can be turned on and off more easily than coal-fired or nuclear power plants, making gas a natural complement to irregular sources of wind and solar electric power production.[14]

International Economic Considerations

The U.S. also needs to diversify its energy sources for natural security and international economic reasons. In 2008, the U.S. consumed a total of 7.14 billion barrels of oil (refined petroleum products and biofuels), about 23% of total world oil consumption. The price ratios of

natural gas to oil show the potential economic advantages that shifting towards natural gas could provide for the U.S. (see Figure 1.11). Not only would natural gas be less expensive but the production would occur internally within the United States, contributing to gross domestic product, increases in tax revenues, and to other measures of domestic well being.

Figure 1.11: Oil to Natural Gas Price Ratios



Source: EIA, Annual Energy Outlook 2010

In 2008, about 57% of the petroleum consumed by the U.S. was imported from foreign countries, which includes crude oil and refined petroleum products like gasoline. 88% of the imports were crude oil and approximately 66% of the crude oil processed in the U.S. refineries was imported.[15] The U.S. spends more than $25 billion a year for Persian Gulf oil imports alone.[16] Total U.S. imports of crude oil and petroleum products and the top five countries that the U.S. imports from are shown in Figures 1.12 and 1.13:

Figure 1.12: 2008 U.S. Imports of Crude Oil and Petroleum Products

U.S. Imports of Crude Oil and Petroleum Products 2008		
U.S. Imports of Crude Oil and Petroleum Products (Thousand Barrels)	U.S. Imports from Persian Gulf Countries of Crude Oil and Petroleum Products (Thousand Barrels)	U.S. Imports from OPEC Countries of Crude Oil and Petroleum Products (Thousand Barrels)
4,726,994	867,559	2,179,305

Source: U.S. EIA, 2009

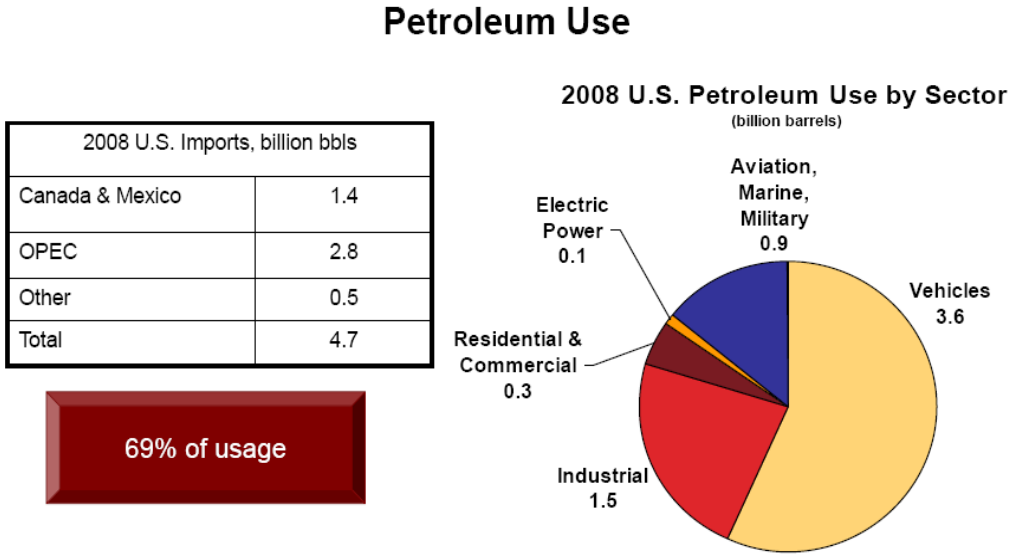
Figure 1.13: Top Countries for U.S. Imports and Petroleum Products

Top 5 Countries for U.S. Imports of Crude Oil and Petroleum Products in 2008 (Thousand Barrels)	
Canada	912,263
Saudi Arabia	559,750
Mexico	476,366
Venezuela	435,029
Nigeria	361,659

Source: U.S. EIA, 2009

Particularly, the breakdown alone of petroleum used that is imported contributes to the high cost of energy that the U.S. incurs through importing its energy supply, see Figure 1.14:

Figure 1.14: U.S. Petroleum Use



Source: Murry Gerber, "Washington Energy Policy Conference - Appalachian Shales: Opportunities & Challenges" 2010

Diversifying the supply of energy sources throughout the U.S. will reduce economic costs and allow the U.S. more growth opportunity as an energy supplier itself. Natural gas as compared to oil is more affordable. Natural gas is now priced at $5 per Mcf, which is the equivalent to $30

per Bbl of oil, while the current oil price remains around $80 per Bbl.[17] For example, the high use of oil for transportation fuels determines the increased costs of gasoline used in vehicles throughout the country. With an increased supply of natural gas usable for transportation fuel from natural gas vehicle adoption, the U.S. could reduce oil imports by as much as 68% and save $265 billion per year.[18]

National Security Considerations

The current global situation makes the U.S.'s dependency on oil not only a major financial concern, but a major political one as well. The U.S. must maintain favorable relations with other countries, particularly potentially hostile countries, in order to ensure its energy supplies will stay intact and that it is not cut off from its fuel sources (Figure 1.15).

Figure 1.15: "Top Sources of Imported Petroleum to the United States in 2008"

Top Sources of Imported Petroleum to the United States in 2008			
In Million Barrels per Day (and Percent Share of Total Imports)			
Import Sources	**Gross Imports**	**Exports to Import Source**	**Net Imports**
Total, All Countries	12.915	1.802	11.114
OPEC Countries	5.954 (46%)	0.055	5.899 (53%)
Persian Gulf Countries	2.370 (18%)	0.002	2.368 (21%)
Top Five Countries			
Canada	2.493 (19%)	0.264	2.229 (20%)
Saudi Arabia	1.529 (12%)	0.001	1.529 (14%)
Mexico	1.302 (11%)	0.333	0.969 (9%)
Venezuela	1.189 (9%)	0.027	1.162 (10%)
Nigeria	0.988 (8%)	0.006	0.982 (9%)

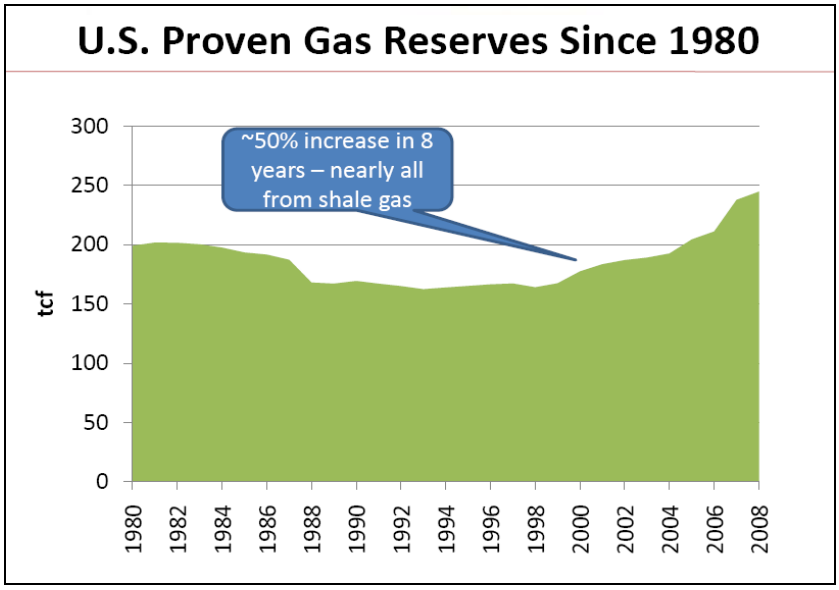
Source: U.S. EIA, 2009

The degree of reliance on these countries for the majority of U.S. fuel is a large determining factor in a number of international political actions. According to one report, "It is a remarkable turnaround. Just three years ago, most U.S. energy executives were working out how the U.S. could import enough gas from places as far away as Nigeria, Russia and Qatar, while competing with the demands from China and other energy-hungry developing countries."[19]

Recent Natural Gas Developments

In order to reduce the U.S.'s dependence on foreign oil, the supply of natural gas must be adequate to help meet energy demands throughout the nation. The increase seen in natural gas reserves in the past 20 years is largely due to the increased expectations for the development of shale gas (see Figure 1.16) and other unconventional sources:

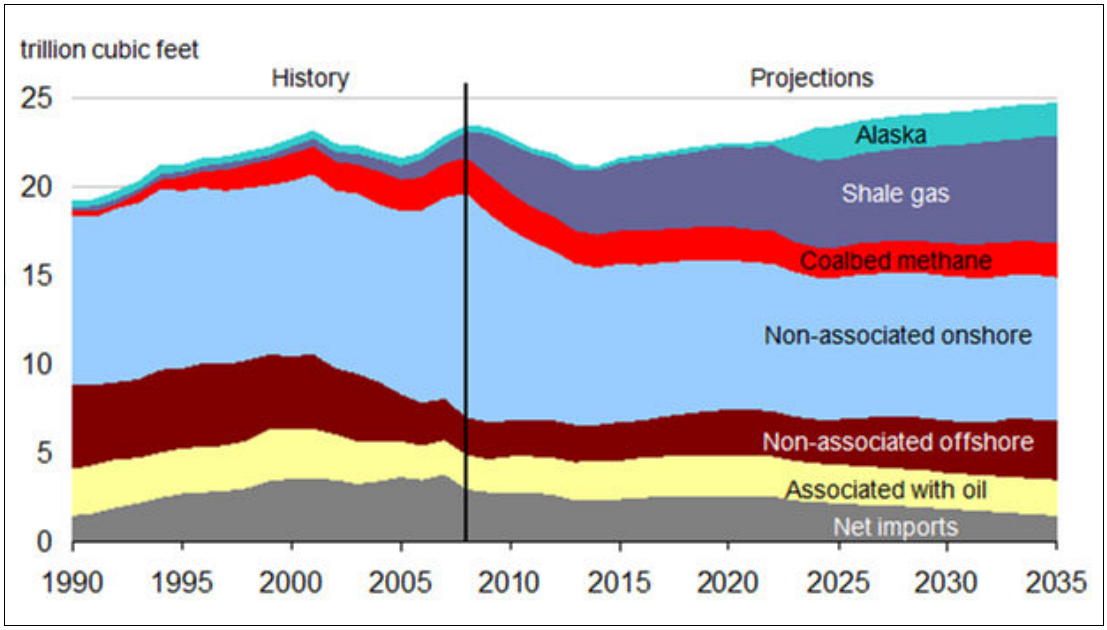
Figure 1.16: U.S. Proven Gas Reserves Since 1980



Source: Lucian Pugliaresi, Energy Policy Research Foundation, Inc.
"The Shale Gas Revolution," 2010

The development of shale formations across the country has led to the discovery of the abundant supply that shale gas could have provide. There are numerous shale basins in the U.S. already increasing the supply of natural gas available and are still showing potential for more. There has been major speculation and interest in the U.S.'s growth as a supplier of natural gas as it will have offsetting effects in its energy position throughout the world. One student of U.S. natural gas potential finds that "the newly accessible U.S. shale deposits are so big that executives now believe the country has enough gas to last it for a century. This extra supply and the U.S.' new found self-sufficiency has created a worldwide gas glut that has driven down prices.[20]" The price effects of the U.S.'s increased reliance on its own natural gas can already be seen throughout world markets and will have a large impact on the energy economic situation for years to come. The U.S. Energy Information Administration has analyzed the possibilities for natural gas a major energy provider in the future, see Figure 1.17:

Figure 1.17: EIA 2010 Natural Gas Production Forecast

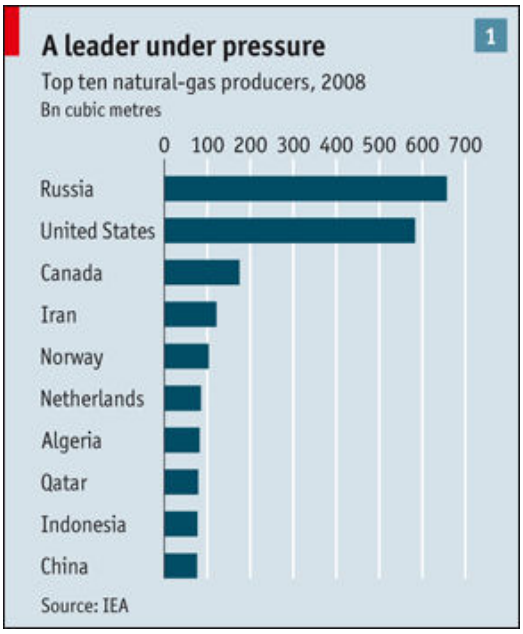


Source: Lucian Pugliaresi: "The Shale Gas Revolution" 2010

The rapid development of shale gas in the U.S. has made it one of the world's natural gas leaders, as well given it the potential to become the leading producer in the near future. Due to this increase in its own supply, the U.S. imports of liquefied natural gas (LNG) have already begun to decrease. Lucian Pugliaresi in the presentation "The Shale Gas Revolution" stated that "successful North American development of unconventional gas resources has already and is anticipated to reduce U.S. and Canadian LNG imports."[21]

Increasing the U.S.'s shale gas supply will also directly affect other countries currently involved in natural gas production. Until the recent increase in production of shale gas in the U.S., Russia was the world's leader in natural gas (see Figure 1.18):

Figure 1.18: "Natural Gas: An Unconventional Glut"



Source: The Economist, 2010

As Russia has become accustomed to the lead position in the industry, decreased imports from the U.S. poses a threat to their own natural gas market. An *Economist* article, "Natural Gas: An Unconventional Glut" states that "in 2008 Russia was the world's biggest gas producer; last year, with output of more than 600 billion cubic metres, America probably overhauled it. North American gas prices have slumped from more than $13 per million British thermal units at their peak in mid-2008 to less than $5 at present. The 'unconventional'—tricky and expensive, in the language of the oil industry—has become conventional."[22]

Many U.S. energy companies are also looking to apply their advanced technology techniques to the development of shale formations in various parts of Europe and elsewhere around the world. The potential for shale gas production in Europe could prove to be a large supply as well, but the actual projections are still very uncertain. It is also foreseen that there may be greater difficulty in production throughout Europe, as a region where shale reserves lie in more densely populated areas. "Now the world's biggest, richest and most sophisticated energy companies believe that they may be able to repeat the American shale gas revolution in Europe, potentially undermining the power of Russia, the region's biggest gas supplier."[23] Through its own production along with leading the production throughout Europe, the potential impact of the U.S.'s share in natural gas remains so vast that could well change the scope of the entire global energy situation.

Major energy companies, previously focused more on other fossil fuels, have also realized the large effect that natural gas will have on the energy industry and have started to take action in acquiring parts of the natural gas sector. Consol Energy Inc., the fourth-largest U.S. coal

producer, has recently acquired Dominion Resources Inc.'s natural-gas business for $3.4, billion adding to its existing gas operations and becoming one of the largest participants in the Marcellus Shale formation. This acquisition is only the last in a string of natural-gas deals recently: Exxon Mobil Corp. paid about $30 billion for XTO Energy Inc., a big natural gas producer, in December. Total SA, from France, and BP PLC, from Britain, both bought shares in Texas gas fields this year. And very recently, Petrohawk Energy Corp. sold its interest in a Louisiana gas field for $320 million to an undisclosed buyer.[24]

New Technologies for Unconventional Gas, Impact on Recoverable Reserve Estimates

Estimates of future supplies of natural gas in the U.S. have risen sharply over the past few years. Much of this increase in estimated developable gas reserves is due to improved technology and the potential development of unconventional sources of natural gas. Owing to improved extraction methods, very large amounts of shale gas are now economically viable for near term production.[25] As a result, between 1998 and 2007, unconventional natural gas production increased 65 percent.[26]

Unconventional natural gas deposits include coal bed methane, tight sands, and shale gas. These differ from conventional gas in that the gas is spread over large areas rather than in discrete traps that can be more easily tapped. Coal bed methane is gas that is adsorbed in coal and requires depressuring and usually dewatering for extraction. Tight sands gas is found in unusually impermeable and non porous sandstone. Shale gas is adsorbed in the organic matter of tidal flats and deep-water basins that compressed and hardened into shale over geologic time. Because of the low permeability of shale, the gas does not flow freely. Extraction requires a pervasive fracture network, either natural or created through hydraulic fracturing.

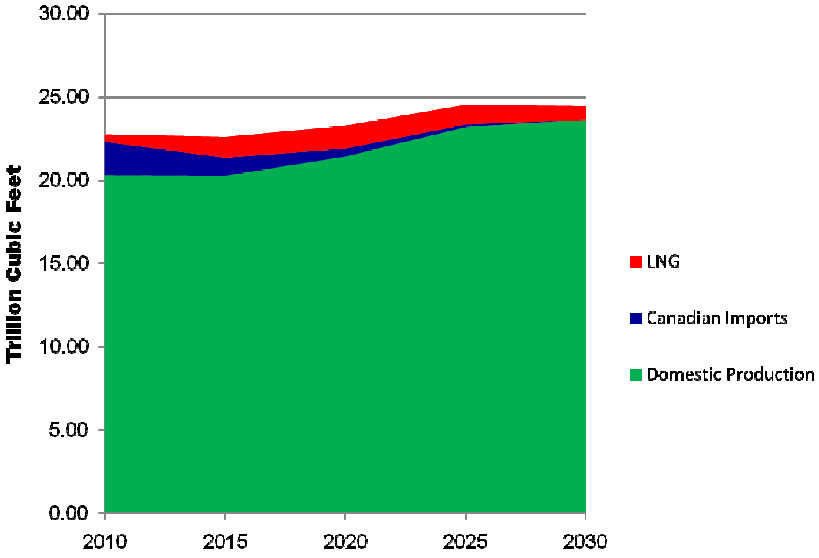
The technology to extract shale gas is not new; the first known shale gas well in Fredonia, New York, began production in 1821. For many decades, shallow-basin shale gas was produced in the Appalachian and Michigan basins where natural fractures made extraction relatively easy. Although hydraulic fracturing techniques have been in use since the 1940s, recent breakthroughs in horizontal drilling technology and intensive fracturing techniques enabled the production of deeper shale gas formations such as the Marcellus. As technology continues to develop through longer well lengths, multiple wells per drilling pad and multi-lateral boreholes, more shale gas formations have become economically viable. Unconventional gas is currently supplied at a lower cost than conventional gas. A natural gas price of $5/Mcf is equivalent to an oil price of $30/barrel.[27]

Analysts believe that OPEC wants to keep a barrel of oil in the price range of $75 to $85 because higher prices would harm the economic recovery and lower prices would lead to underinvestment.[28] If natural gas prices continue to fall well below oil prices, gas consumption is expected to expand beyond the levels predicted by the EIA.[29] The current price of oil at $85/barrel compared to natural gas at $4/Mcf fit this scenario.

Future Gas Scenarios

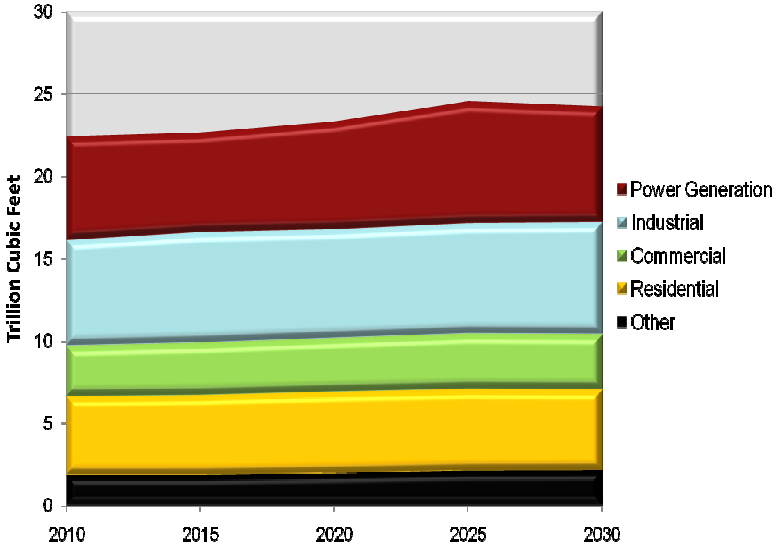
The EIA estimates that the supply of natural gas will reach nearly 25 Tcf by 2030 and that most of this will be the result of domestic production within the U.S. (Figure 1.19). Demand in nearly all sectors is predicted to remain relatively stable (Figure 1.20), except in the power generation sector, which is expected to absorb the major increase in the supply of natural gas[30].

Figure 1.19: Future natural gas supply estimates[31]



Source: U.S. EIA, 2009

Figure 1.20: Future natural gas demand estimates[32]

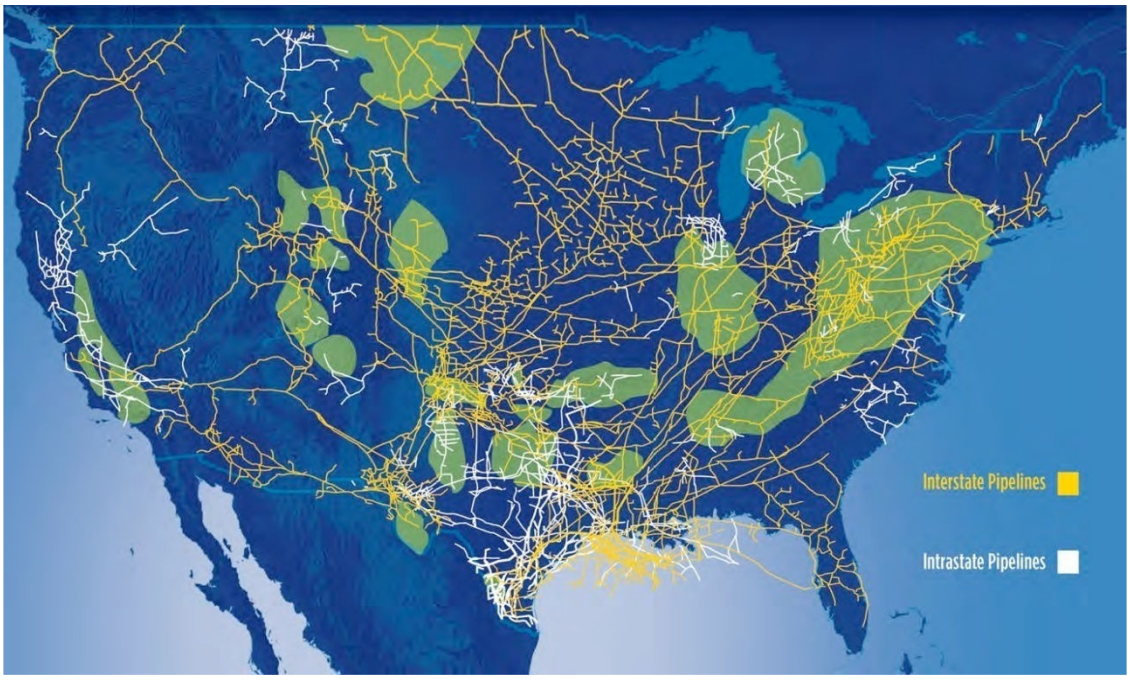


Source: U.S. EIA, 2009

U.S. Distribution of Shale Gas Reserves

Natural gas production from shale gas in 2010 is expected to reach 10 Bcf/day (or 18 percent of U.S. natural gas production), across the seven main producing basins in the U.S. and Canada (Figure 1.21). These basins include the Barnett, Marcellus, Fayetteville, Woodford, and Haynesville in the eastern U.S. Other unconventional gas supplies include 5 Bcf/day from coalbed methane and 18 Bcf/day from tight gas sands. By 2020, all unconventional gas production is expected to reach 46 Bcf/day, about 65 percent of the total U.S. natural gas production (assuming sufficient demand and a gas price of $7/MMBtu).[33]

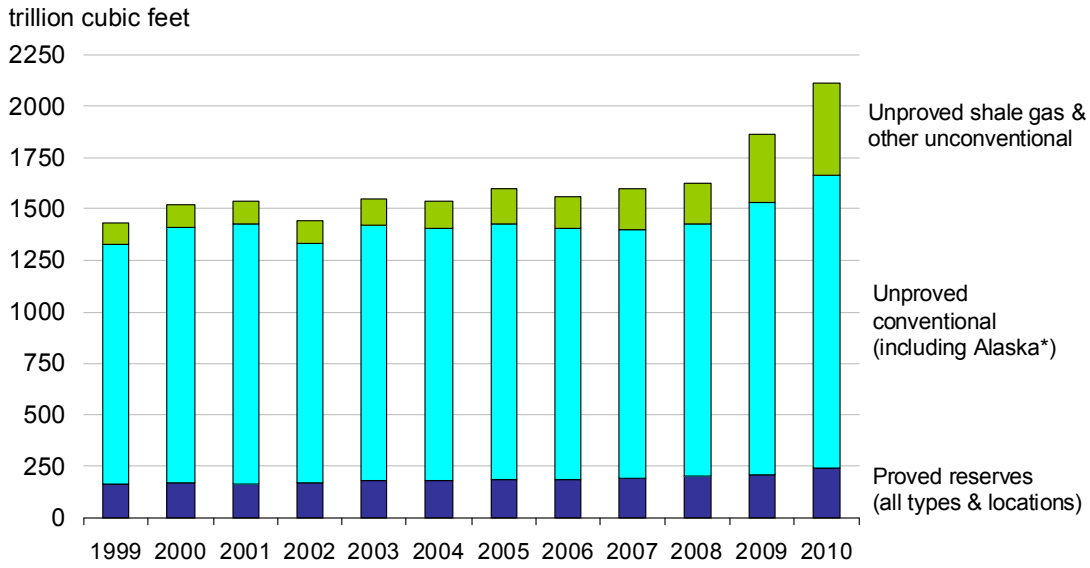
Figure 1.21: Location of shale basins and existing gas pipelines



Source: American Clear Skies Foundation

Estimates of shale gas have increased considerably over the past decade (Figure 1.22). EIA estimates that recoverable shale gas resources are 347 Tcf and the American Gas Association estimates that the Marcellus shale has 34 Tcf. For comparison, the U.S. used about 23 Tcf in 2008. As these shales have a lower cost production than off-shore sources, shale gas production is expected to displace off-shore production. Even in Canada, where conventional natural gas production continues to decline, unconventional production is expected to increase over time as shale gas extraction technologies are exported from the U.S.[34]

Figure 1.22: Shale gas has lead to an increase in the estimates of recoverable natural gas resources in the U.S.[35]



Source: U.S. EIA, 2009

Prospects for Natural Gas in Transportation (Cars, Trucks, etc.)

Next to electricity generation, the transportation sector is the largest source of CO_2 emissions, coming primarily from petroleum products[36]. Some of these emissions could be reduced by using natural gas directly in cars and trucks. Although compressed natural gas has not become a popular option in the transportation sector, it would also be possible to use natural gas to produce electricity that is then used to power cars – a process 35% more efficient than directly using compressed natural gas in the cars themselves.[37] A switch to electric cars that are ultimately powered by gas-fired power plants would also increase demand for natural gas. For cars, it may be the most efficient way to use natural gas for transportation purposes (large trucks will probably have to be operated with their own natural gas engines).

Used directly, natural gas has the potential to be more widely accessible and affordable for the U.S. as it is a cheaper fuel source. Compressed natural gas, CNG, which is largely used as a transportation fuel, is becoming more available across the country for vehicles that can run on natural gas. For 2008, a national average of $3.25 for retail gasoline and $2.04 for CNG (U.S. Dept. of Energy) resulted in an average savings of $2.01 per gasoline gallon equivalent."[38,39] As the U.S. relies heavily on importing oil for transportation fuels, the abundant supply of a cheaper natural gas would provide great savings to individual consumers and the country as a whole. Historically, the comparison of retail natural gas prices to gasoline and diesel equivalents are lower and more stable, see Figure 1.23:

Figure 1.23: National Average Retail Gasoline, Diesel, and Natural Gas Prices

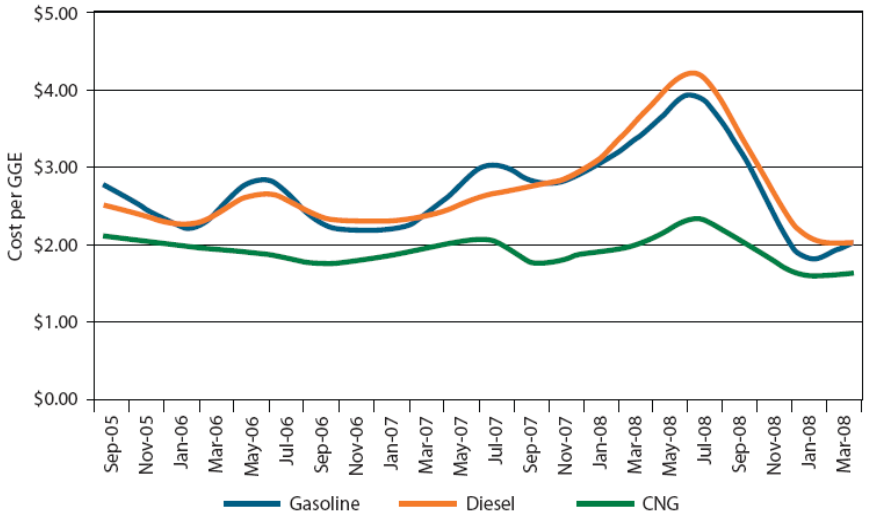


Figure 1. Nationwide Average Retail Gasoline, Diesel, and Natural Gas Prices

Source: US DOE, AFDC

The use of natural gas as a transportation fuel is becoming more accepted and encouraged throughout the country. Today there are over 120,000 natural gas vehicles on U.S. roads and over 8.7 million worldwide.[40] Vehicles that use and are retrofitted for natural gas fuel are becoming available through companies such as American Honda Motor Company and various qualified system retrofitters for those with vehicles suitable for conversion. Currently, some financial incentives provided by the U.S. EPA exist for consumers in the form of income tax credits for certain emission standards, and incentives for fuel retailers through tax credits by sale of natural gas for use as motor vehicle fuel. Vehicles that use natural gas emit less carbon per unit of energy than any other fossil fuel per vehicle mile traveled providing environmental as well as financial incentives for vehicle conversion.[41] In order to increase the use of natural gas throughout the country, action must be taken in providing greater incentives, specifically for automakers and individual citizens, throughout the country to retrofit their vehicles. Unfortunately, there is currently a lack of available fueling stations across the country making it difficult for natural gas consumers to refuel.

Policy Recommendations

In order to be a viable option in a low-carbon economy, natural gas needs to be abundant and cheap. This requires the continued development of the unconventional gas supplies such as the Marcellus shale. Furthermore, environmental concerns need to be addressed such that the public supports rather than fears unconventional gas production. Additionally, reducing GHG emissions in natural gas systems will make gas-fired power even more attractive. Several policies could support these goals.

- **Research and development to build the knowledge base and improve technology for unconventional gas production can make recovery from shale gas more efficient thus reducing costs and lowering the retail price of natural gas supplies.** This would also have the effect of making shale gas more competitive. As a result, we could continue to meet U.S. energy demands with domestically produced fuels staving off foreign imports of LNG, which might otherwise increase our dependence on foreign supplies of fuel.

- **Renewing now expired Section 29 tax credits would attract capital and build economies of scale further reducing costs and lowering the retail price of natural gas supplies.**

- **Incentives or requirements that increase participation in the EPA Natural Gas STAR program could help reduce GHG emissions that are released in natural gas systems.** For some companies this has been such a cost effective program that it has actually resulted in a profit through the sale of captured methane gas. This program therefore has the potential to reduce the cost of meeting our GHG emission targets.

- **Incentives to increase green development practices associated with unconventional gas production can help to assuage public fears about environmental contamination and disruption.** This includes efforts to increase the recycling of flowback water, repurpose drilling mud in other construction activities, and reduce the surface impact of drilling activities**.**

- **Public education campaigns can reduce fears about water consumption and the chemical makeup of hydraulic fracturing fluids.**

- **The U.S. has an extensive system of natural gas pipelines yet there are some areas that have a relatively sparse network.** The American Gas Association (AGA) estimates that a $100 billion dollar investment in distribution infrastructure will be required to meet the projected natural gas demand by 2030. The AGA also recommends changing tax law to accelerate the depreciation rate for natural gas infrastructure.

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Chapter 2 – Shale Gas Development in the Marcellus Formation

As Chapter 1 documents, natural gas is expected to play a significantly increasing role in providing U.S. energy supplies over at least the next several decades. Much of this increased natural gas production will come from "unconventional" sources, most importantly, the production of natural gas from shale formations that are found widely in the United States. The presence of vast amounts of natural gas in shale formations has long been known but until recently its production was uneconomic. The development since the 1990s of new methods of shale gas extraction involving the horizontal hydrofracking of the shale has dramatically altered the economic picture. Indeed, production of shale gas is possible at costs far below the international price of oil (per unit of energy output) and may even turn out to be significantly below the current production costs of conventional natural gas.

Using the new extraction methods, shale gas production began in Texas in the Barnett formation in the late 1990s. It is now occurring on a major scale in several other shale formations around the United States. The Marcellus shale formation covers a large area including parts of Pennsylvania, New York, West Virginia, Maryland and Ohio. Shale gas production from the Marcellus formation began in the early twenty-first century in Pennsylvania where it is still concentrated. In the past two or three years, shale gas production has been growing rapidly in Pennsylvania and is projected to grow even more rapidly in the next few years. Production has grown much more slowly in New York, West Virginia and Maryland but there is now growing recognition in these states of the potential economic benefits and a new interest in encouraging the expansion of the shale gas industry.

Range Resources, a leading natural gas producer in the United States, has pioneered in the development of Marcellus shale gas in Pennsylvania. In April 2010 the company issued a public statement that its Marcellus production in Pennsylvania "has the best economics of any large scale, repeatable gas play in the U.S." where it was operating. This was attributable in part to the proximity of leading sources of natural gas demand in nearby mid-Atlantic and Northeast states, thus lowering transportation costs. Range Resources also had the benefit of operating in areas of Southwest Pennsylvania that had the highest quality and thus most economical shale gas resources within the Marcellus formation.

This chapter will examine the history and current status of shale gas development within the Marcellus formation. Since differences are so great from one state to another, the chapter is organized into separate sections for Pennsylvania, New York, West Virginia and Maryland.

Pennsylvania

The Marcellus Shale formation in Pennsylvania has been known as a gas reservoir for more than 75 years. Recently, there has been a boom in enthusiasm for the development prospects as the press, landowners, and state and municipal authorities view the Marcellus as a major economic asset for Pennsylvania.[1] With all the excitement, environmental concerns have also increased as some landowners have experienced contamination of their water supplies.

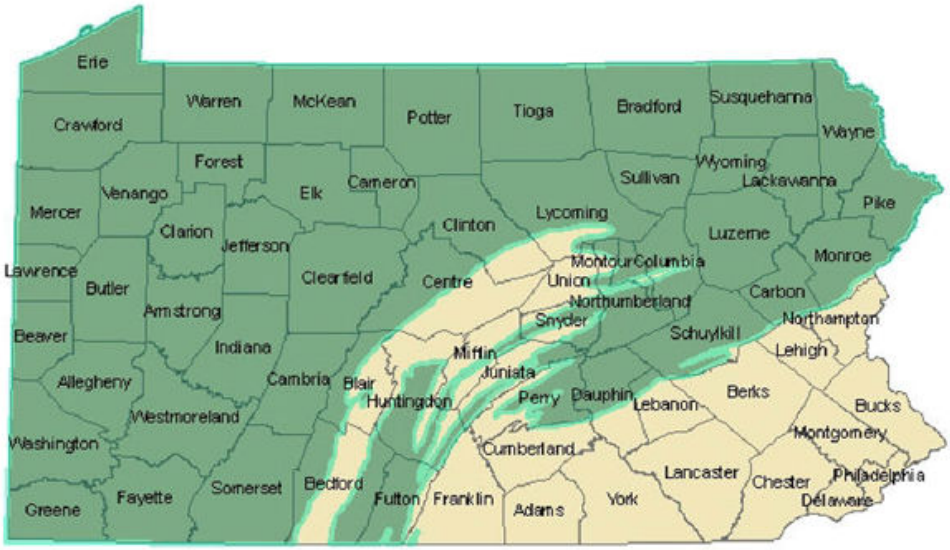
In Susquehanna County in PA's northeast, after Cabot Oil & Gas started drilling near some residents homes, they discovered cloudy, discolored water coming from their faucets that had a foul odor and taste. One family even witnessed their own well explode on New Year's Day 2009. This prompted a state investigation that found Cabot Oil & Gas had allowed gas to escape into the regions groundwater supply.[2] Cabot is currently paying fines to the DEP and is involved in a federal lawsuit with over 12 families who are asking for compensation of over $75,000 each.[3] There are also other environmental issues in Pennsylvania such as increased truck traffic near drilling sites, which have added to noise in once quiet areas. Overall, there is growing attention to the extent of environmental impacts from natural gas drilling and the policies that may be required to address these impacts.

Geologists are routinely changing their shale gas estimates as new information is obtained. In 2002, the U.S. Geological Survey projected only 1.9 trillion cubic feet of economically recoverable natural gas for the entire Marcellus formation but that number by 2008 had increased to somewhere in the (admittedly very wide) range of 168 to 516 trillion cubic feet. To put this in context, total annual U.S. consumption of natural gas at present is about 25 trillion cubic feet. Much of the highest quality Marcellus shale resource is found in Pennsylvania.

Geology and Geography

The Marcellus formation underlies most of Pennsylvania and is typically defined as a Middle Devonian-age black, low density, organically rich shale.[4] In Pennsylvania it runs through the western, central and northeastern quadrants of the state (see Figure 2.1). Within PA the depth ranges from 5,000 – 8,000 feet,[5] with the southwestern and northeastern areas closer to the surface. Given these depths drilling costs are relatively high, so significant amounts of gas are required to financially break-even.[6]

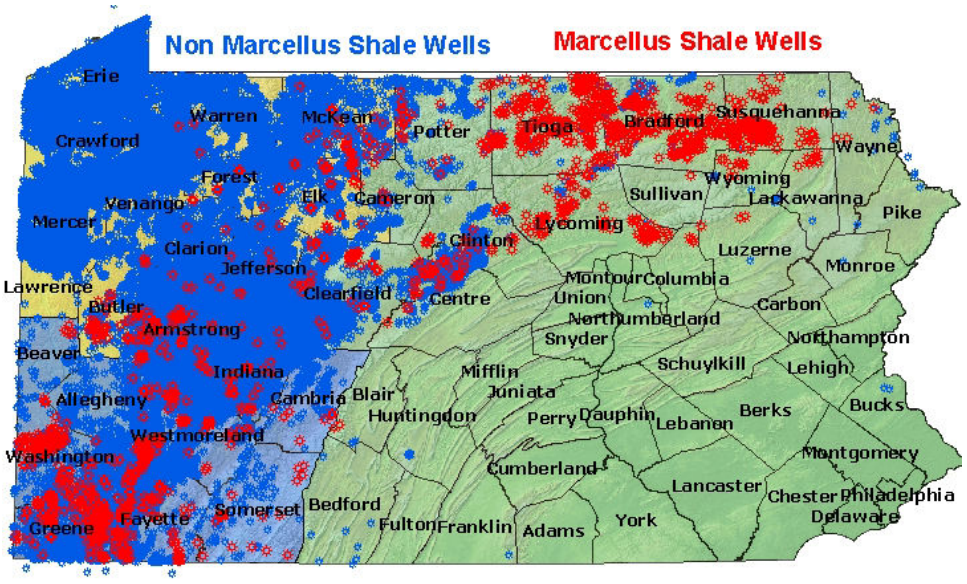
Figure 2.1: Marcellus Shale Formation in the State of Pennsylvania



Source: State of Pennsylvania - Department of Environmental Protection – Bureau of Oil and Gas Management

Shale gas also occurs in the region in other shale formations which can lie above or below the Marcellus. The northwestern quadrant of the state has been a target area historically for non-Marcellus wells. But with the development of horizontal hydrofracking technology, natural gas activity has been shifting to areas that are well suited to Marcellus gas production (see Figure 2.2).

Figure 2.2: Marcellus Shale Wells vs. Non-Marcellus Wells in Pennsylvania



Source: State of Pennsylvania, Department of Environmental Protection

Marcellus Shale Industry

Pennsylvania's Marcellus shale gas play began in 2003, when Range Resources drilled its first well to the Lower Silurian Rochester Shale in Washington County. Using hydraulic fracturing techniques, Range Resources began producing Marcellus gas in 2005. As of 2009, 45 private firms had drilled at least one well in the Marcellus, while the top ten firms have completed more than 78 percent of all wells.[7] These companies include Chesapeake Energy, Range Resources, Exco Resources, Anadarko E&P, Atlas Resources, East Resources, EOG Resources, Cabot Oil & Gas and Talisman Energy amongst others.

Information on acres leased, numbers of permits, Marcellus wells, estimated production by company and future production potential by company is shown in Figure 2.3. These companies have not been required to release their annual natural gas production rates. As of March 22, 2010, a bill was signed into law in PA requiring natural gas companies to disclose their production rates. The bill states:

> *"every well operator shall file with the department, on a form provided by the department, an annual report specifying the amount of production on the most well-specific basis available. Annual reports shall also specify the status of each well; however, in subsequent years, only changes in the status need be reported."*[8]

Figure 2.3: Marcellus Shale Gas Production in PA by Individual Company

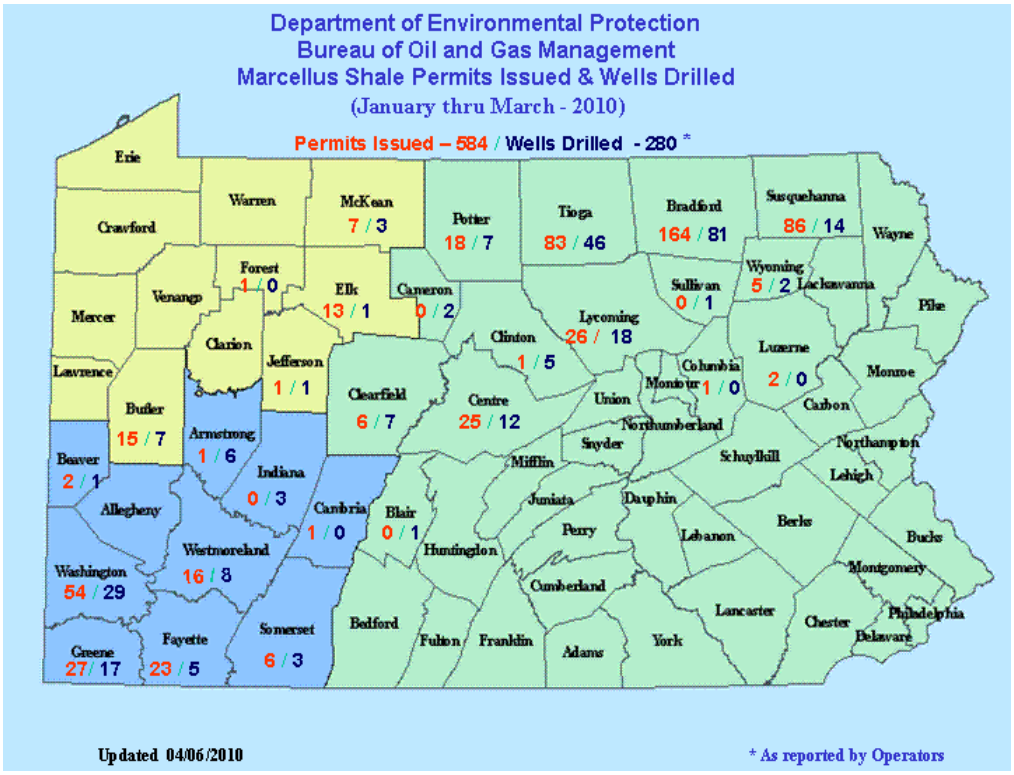
Company	Acres Leased	Permits	Wells	Production	Production Potential
Chesapeake Energy	590,00	519	56	65 Mmcfe per day	270 Mmcfe per day
Range Resources	900,000	405	50 horizontal wells in 2009, drill 150 horizontal in 2010	115 Mmcfe per day	27 trillion cubic feet
Exco Resources	x	102	34	56 Mmcfe per day	x
Atlas Energy	266,000	305	18	x	x
Anadarko E & P	350,000	108	23	x	x
East Resources	x	283	103	x	x
EOG Resources	220,000	133	68	x	x
Cabot Oil & Gas	150,000	160	92	x	x
Talisman Energy	218,000	287	45.5. in 2009, expected 170 in 2010	65 mmcf/d in 2009, expected 250-300 mmcf/d in 2010	x

Sources: Individual Company Websites

In Pennsylvania's experience, the natural gas development process has many stages. It typically takes 4-6 months for the land to be leased, 4 months for exploration and seismic activities, 4-8 weeks for site preparation and drilling, and 2 weeks for drill site reclamation (leaving only the much smaller permanent production area and facilities). The subsequent extraction and transportation processes can take anywhere from 5-40 years. Finally, after all the economic gas is extracted, the well is plugged and the entire site reclaimed.[9]

As illustrated in Figure 2.4, shale permits issued and wells drilled from January to March 2010 are heavily concentrated in the NE, Central, and SW corridors of the State. For example, the southwestern quadrant, which includes Washington, Greene, and Westmoreland counties, had 130 permits issued and 74 wells drilled. Between January and March 2010,the NE quadrant saw surge 417 permits issued and 196 wells drilled. Target NE counties include Tiega, Breadford, Susquehanna, Lycoming, Potter, and Centre. On the other hand, the NW quadrant has seen modest development with 37 permits issued and 12 wells drilled.

Figure 2.4 Marcellus Shale Permits Issued and Wells Drilled From January to March 2010



Source: PA Department of Environmental Protection –
Bureau of Oil and Gas Management, 2010

It is expected that more than 1,000 Marcellus wells will be drilled during the remainder of 2010. Then, the rate is projected to increase steadily over the next ten years, perhaps reaching as many as 2,800 wells in 2020. A competitive market, striving for cost efficiency, has fueled advancements in drilling technology and methodology. Since 2003, the drilling method has transitioned from vertical to horizontal. During early production, some horizontal wells using hydraulic fracturing techniques have produced over 8 million cubic feet per day.[10]

Political Environment

The political environment in Pennsylvania regarding Marcellus shale gas production reflects multiple influences. The industry has been praised by Governor Edward Rendell for creating jobs and boosting local economies; he has often declared himself the "best ally" of the natural gas industry.[11] At the same time, he has also criticized the industry for opposition to a proposed severance tax. Rendell has proposed a 5% tax on the value of gas collected at the well head and another 4.7 cents per thousand cubic feet of gas produced.[12] He has proposed allocating 10% of the revenue to communities affected by the drilling and using the rest to supplement the state's budget.

In January 2010, Rendell invited leading gas-drilling executives to his mansion in Harrisburg to discuss the possible tax, but only one drilling executive accepted the invitation.[13] He complained

that, "As governor, I've never had that experience before - I've never invited major CEOs, even to talk about things as difficult as taxes, to come to the residence and had them turn me down." [14] Rendell also believes the shale gas industry has not been prepared for the backlash against its possible negative environmental and local community impacts, as development continues to grow and many communities are significantly affected. He believes that industry has not adequately reached out to the public to discuss its plans and ways of mitigating any negative impacts, stating that "So the industry is making mistake after mistake right now, and the tide of public opinion is turning, and even though it is truly the golden goose, we could blow it."[15] Although he agrees that some reports of negligence have been blown out of proportion by the media, polls have shown that public support for shale gas development is decreasing as activity moves into more populated areas of the state.

In response to the governor's remarks, the Marcellus Industry Coalition, a group comprised of mostly shale gas industry members, stated that "with respect to public opinion, the industry has found an overwhelming number of Pennsylvanians who support the development of this local resource."[16] The coalition has also claimed that most Pennsylvanians oppose the Governor's proposed severance tax.[17]

Another issue in the severance tax debate is the fact that over 70% of the Marcellus shale wells in Pennsylvania are subject to PA's 3.07% income tax rate, not the standard 9.99% corporate tax rate in the state.[18] Critics of the severance tax have often stated that these PA drillers, "face the highest corporate tax rate in the nation,"[19] but this is not the case for most of the companies drilling in the Marcellus, which are operating as individual, LLC or LP in order to avoid the corporate tax. Among these companies paying the lower 3.07% rate are Anadarko E&P, Atlas Resources, Chesapeake Energy, EOG Resources and Range Resources. Of the top producers in the state of PA, only Exco Resources, East Resources and Cabot Oil & Gas pay the higher 9.99% tax rate. *

All of these issues come on the heels of the state heavily investing in Alternative Fuel Transportation Projects, where natural gas has been praised as a clean energy source for homes and businesses. $8 million will be invested for over 20 projects to advance alternative fuels. Equitable Gas Co. received $700,000 to construct one of the first public-access natural gas refueling stations in the Pittsburgh area. The project also will demonstrate how compressed natural gas can be used effectively and efficiently in business operations.[20] Since Rendell's term comes to an end this year, the political climate regarding natural gas in PA is bound to see some changes in the near future. Thus, overall, even while recognizing the large economic benefits, there is also a degree of frustration in Pennsylvania state government with the natural gas industry.

There is a large amount of interest from NGO's regarding the impacts of natural gas drilling in Pennsylvania. Many of them are concerned about its impacts on the environment; including its

* Corporations with a limited number of shareholders operating in Pennsylvania can legally pay the lesser PIT rate by organizing as a limited partnership (LP), limited liability corporation (LLC), or subchapter S corporation. Even if the parent corporation has many shareholders, it can create a subsidiary that qualifies as an LP, LLC, or S corporation. All of the business in a state is then conducted through the subsidiary, which pays the lower PIT rate.

drinking water supplies and land resources, while others are committed to the responsible development of natural gas.

The main NGO's currently working on issues relating to Marcellus shale in Pennsylvania are PennEnvironment (water and land), Clean Water Action (water), Trout Unlimited (water and land), PA Environmental Council (land), the Sierra Club (water and land), the Delaware Riverkeeper Network (water), Earthjustice (based in NYC) (environment, water, and land), Earthworks (environment, land, water, and natural gas), PITT Environmental Law Clinic (environment, water, land, natural gas), PITT Center for Healthy Environments and Communities (CHEC) (environment and water), ALAARM (out of Dickinson College) (water), Chesapeake Bay Foundation (environment, water, land), Natural Resources Defense Council (environment, water, land, natural gas), Citizens for PA's Future (PennFuture) (environment and land), PA Environmental Council (environment, water, and land) and over 25 Northern Pennsylvania Watershed Associations:

Earthjustice -- Earthjustice is concerned about increased drilling in the Marcellus Shale formation, and other unconventional shale plays throughout the country. They are working to repeal the exemption in the Safe Drinking Water Act that exempts hydraulic fracturing. When asked what Earthjustice was most concerned about, a staff member stated, "The SDWA exemption is just one of multiple exemptions from environmental laws that the oil and gas industry enjoys. People across the country already report being sick from contaminated air and water from drilling, and as drilling continues to occur on more people's property, closer to their homes, more examples of contamination will likely surface. Increased drilling without increased environmental safeguards in place is irresponsible."[21]

Earthworks -- Earthworks works with Earthjustice and other NGO's to address issues in the natural gas industry in PA and other areas of the country. They are working to reform state oil and gas regulations as well as federal regulations and are seeking to get the federal FRAC Act passed. They believe it is important for oil and gas companies to disclose the chemicals they use in the fracking process and that the industry should be regulated under the SDWA. Earthworks has organizers on the ground throughout the Marcellus Shale play in PA, OH, NY, WVA and MD to work with citizens and address their concerns about how the natural gas industry is affecting their communities and the environment.[22]

PennEnvironment -- PennEnvironment (PennEnv) and has become increasingly concerned with the rush to drill in the state. They have been working with PA's state and local governments as well as its citizens to develop policy recommendations to curb the adverse impacts of natural gas drilling. When asked about their views on the increase in drilling activity, a PennEnv staff member stated, "While some gas drilling companies might claim that they are working in the best interest of the environment or of the public, and some companies might indeed be doing that, there are still far too many families and communities that have been forced to deal with the negative effects of drilling." The staff member added that, "Some families have lost access to clean drinking water, and others have seen leaks and spills from drilling operations that they were not told up front would be taking place on their land. That's why PennEnv is working to pass strong statewide rules and laws that will ensure that the companies that are not acting in the

environment's or public's best interest have certain minimum standards to meet – for protecting drinking water, rivers and streams, forests and open space, and air quality."[23]

PennEnvironment recommends strengthening the clean water laws in PA by setting water withdrawal limits, expanding protective buffer zones around streams and requiring that PA's Department of Environmental Protection be held accountable for the cumulative impacts of multiple drilling sites when permitting new drilling.[24] They have been working to place pristine places off limits to drilling and restrict drilling in public lands until the gas industry can demonstrate that their activities will not cause damage to the environment. In order to improve the public's right to know, they are working towards requiring companies to disclose the chemicals used in the fracking process and to report water withdrawals from PA's waterways. By requiring companies to report natural gas withdrawals and using an electronic reporting system for public access, this will provide better information to the public.[25]

In working to increase public participation, PennEnv recommends allowing the public to voice their opinions regarding gas exploration on both public and private lands. A comprehensive public comment process would be put into place for decisions involving large tracts of state land or activities that impact PA's waterways. They are seeking to improve PA's property rights and land use laws by amending the municipalities planning code to allow local officials and residents to determine best practices for land uses in their communities.[26]

In working to improve tools for regulators, PennEnv is seeking to increase DEP's funding for permitting in order to tackle the growing number of drilling proposals. As of this writing, the DEP has received funding to hire more employees. When asked about an increase in Marcellus related jobs, a DEP staff member stated: "Last Fiscal Year (FY) DEP increased by 37 positions for Marcellus related activities. This FY we got approval for 68 additional positions."[27] PennEnv is also seeking to increase the time period for reviewing permits; currently it takes 45 days to issue a permit which is relatively fast compared to other states. Efforts to increase funding to monitor and control drilling water and discharges are currently underway.[28] PennEnv wants polluting industries to pay for their environmental damages. They recommend levying extraction fees, paying for air and water pollution, loss of habitat and other environmental and health threats they are responsible for. PennEnv believes that companies, not taxpayers should be footing the bill for cleanup as well as the cost of plugging a well.[29] Lastly, PennEnv is working with the Federal Government to reinstate the portion of the SDWA that exempts hydraulic fracturing, to set more stringent effluent limitation guidelines, to require full disclosure of chemicals and to create best management practices for companies to abide by.[30]

Trout Unlimited -- Trout Unlimited is concerned with water withdrawals in PA and the effect it may have on fish and wildlife. There has been an increased interest among the hunting and fishing community as natural gas drilling expands. The main concerns are chemical spills, disposal of water, a blowout in the casing of a well and stormwater runoff. Trout Unlimited is working with the World Wildlife Fund and the Theodore Roosevelt Partnership to address these issues.[31] When asked about Trout Unlimited's concerns in PA, a staff member stated: "Pennsylvania has some issues that need to be addressed before the natural gas picture gets any better from a fisheries standpoint. One has to do with the pace of development and the state's

capacity to regulate effectively. I'm told that in order to process the volume of permit applications they're receiving, staff has been consolidated in the headquarters office and fewer people are out on the ground conducting site inspections. Furthermore, the volume of produced water has outstripped the state's ability to effectively treat wastewater before discharge. It's important for the pace to match the state's ability to effectively apply regulations and treat wastewater."

Further comments were as follows: "Another has to do with the adequacy of the regulations themselves. As long as development continues in the absence of Clean Water Act stormwater protections and the Safe Drinking Water Act underground injection control program, the risk of pollution will be heightened." Trout Unlimited emphasizes that "Finally, it must be recognized that certain places simply should not be developed. For brook trout (the native trout species in PA), much of the remaining habitat is found on state forest lands, which the state has been leasing for development. While there are places that are appropriate for development, certain high quality habitats should not be leased," leaving them free of shale gas development. [32]

Chesapeake Bay Foundation -- In April of 2009, Pennsylvania's DEP eliminated local conservation districts from the review process of Erosion and Sediment Control plans and permits and Stream and Wetlands Encroachment permits in relation to the shale gas industry. In place of the review process DEP implemented an expedited permit process that reduced the levels of technical reviews of erosion and sediment control, as well as stormwater management plans. These reviews are required under PA Law.[33] In August of 2009, in response to these events, the Chesapeake Bay Foundation filed two appeals with the Pennsylvania Environmental Hearing Board. The appeals involve permits that were issued without any review of erosion and sediment control plans and without local conservation district involvement. In addition, one of the permits allows for a pipeline to be constructed through wetlands that qualify as "exceptional value" wetlands under Pennsylvania law. This matter is currently being handled by the Pennsylvania state attorney.[34]

Marcellus Shale Coalition – This is a group of Industry members committed to the responsible development of natural gas. The Coalition is mostly made up of energy companies and a few trade organizations. The members of the Coalition work with partners across the state to address issues with regulators, government officials and residents of Pennsylvania about all aspects of drilling and the extraction of natural gas from the Marcellus Shale formation.[35]

The coalition recently condemned the actions of two individuals who illegally poured 200,000 gallons of brine fluid from a shallow well drilling operation down an abandoned well in Mckean County. Stating that companies engaged in oil and natural gas development activity must meet the regulatory requirements of the state, the coalition applauded government agencies with the investigation of this crime.[36] The Coalition argues that shale gas can be responsibly developed with minimal negative impact to the local environment, while generating significant local economic benefits. In a broader context, much great use of natural gas can offer major environmental benefits to the nation, such as reduced greenhouse gases and criteria air pollutants (whose emissions have kept many localities around the United States in a non-attainment pollution status).

Next Steps for Pennsylvania

As drilling activity increases in Pennsylvania, the cumulative environmental impacts are bound to become larger. The State of Pennsylvania along with NGO's and local governments will need to become more involved in monitoring these activities. The possibility of regulating hydraulic fracturing is currently being considered by EPA and others at the national level.

If Pennsylvania adopts a severance tax on extraction of natural gas, this could slow production in the industry and could impact local economies and jobs. The revenue, however, could be used to mitigate negative impacts of shale gas development and could also be used for property tax relief or for other purposes. Pennsylvania will have to consider the tradeoffs between increased revenues to the state and the impact on the natural gas industry and the state's economy.

The natural gas industry in Pennsylvania has had much success over the past five years since development began in the Marcellus Shale play. State and local economies have benefitted from job creation, tax revenues, and increased business activity. Many landowners have and continue to be compensated in the form of large up-front lease payments and royalties. This is in a state that has suffered major manufacturing job losses in the past and recent high unemployment rates.

Despite this, environmental factors are still a concern. State officials, municipalities, residents, NGO's and natural gas companies should work together to ensure that the best practices are in place to protect the environment and prevent significant negative impacts from occurring. Pennsylvania can still benefit greatly from its natural gas industry but there needs to be a suitable balance between the economic benefits and environmental costs.

New York State

"We're not going to worry about time because we're talking about public safety."[37] These words from New York Governor David Paterson succinctly sum up the New York approach to the Marcellus Shale. Go slow, see how others are doing it, and give it more study. Despite budget woes that threaten major services in the state, and a $1 billion cash shortfall,[38] Paterson and the New York State Department of Environmental Conservation (NYSDEC) have decided that their environment is too valuable to unduly risk for perceived short term gains. Though New York has rich reserves ready to tap, this "blue state" showed deference to environmental concerns when Paterson called for a new Supplementary Generic Environmental Impact Statement (SGEIS) for high volume hydrofracking, suspending further shale gas permitting until it was completed.

While the study was ongoing, the governor and legislature made moves to prepare for drilling, so it was little surprise when the draft SGEIS came back with comparatively few restrictions. This incited a large response from local environmentalists, focusing primarily on watershed concerns for New York City. Some of these local NGOs were perplexed, however, when national boards in some cases even of the same NGOs came out in favor of a switch from coal to natural gas. Industry groups, meanwhile continue to tout the economic benefits, and to remind citizens of the opportunities for both public and private profit. These arguments seem to have made an impact, as even longtime Democrats are showing a willingness to accommodate shale gas development in some form heading into the November elections. With the recent decision to effectively close off the New York City watershed from drilling, thus resolving this issue, it is beginning to look like drilling in much of the state is inevitable.

Reserves and Production

New York's reticence in tapping their reservoirs is made all the more impressive in light of the significant deposits the state contains. Specific industry measures show a large promise,[*] and while estimates vary widely, the NYSDEC expects that the Marcellus play holds 7.5 to 9.5 trillion cubic feet of gas.[39] To put this in perspective, total production from *all* plays in New York in 2008 totaled a mere 50.3 billion cubic feet (bcf),[40] or roughly 0.2%[†] of total national gas production.[41] A range of 2 trillion, however, is large – and estimates are rapidly changing as wells in Pennsylvania exceed even industry expectations.[42] Extrapolating from NYSDEC calculations, the high end estimates would provide enough energy to meet the gas needs of nearly 1.4 million homes for the next 100 years.[‡] In a rather fitting juxtaposition for legislators, these shale deposits statewide mirror the distribution in Albany County where the state capitol lies. The play reaches from the far southwest of the state to just shy of the eastern border, though it never reaches further north than about the city of Utica (see Figure 2.5). At the northeastern

[*] Avg total carbon is 2.5-5% with highs of 12%. Vitrinite reflectance is 1.18 – 1.65%, well within the "gas window"

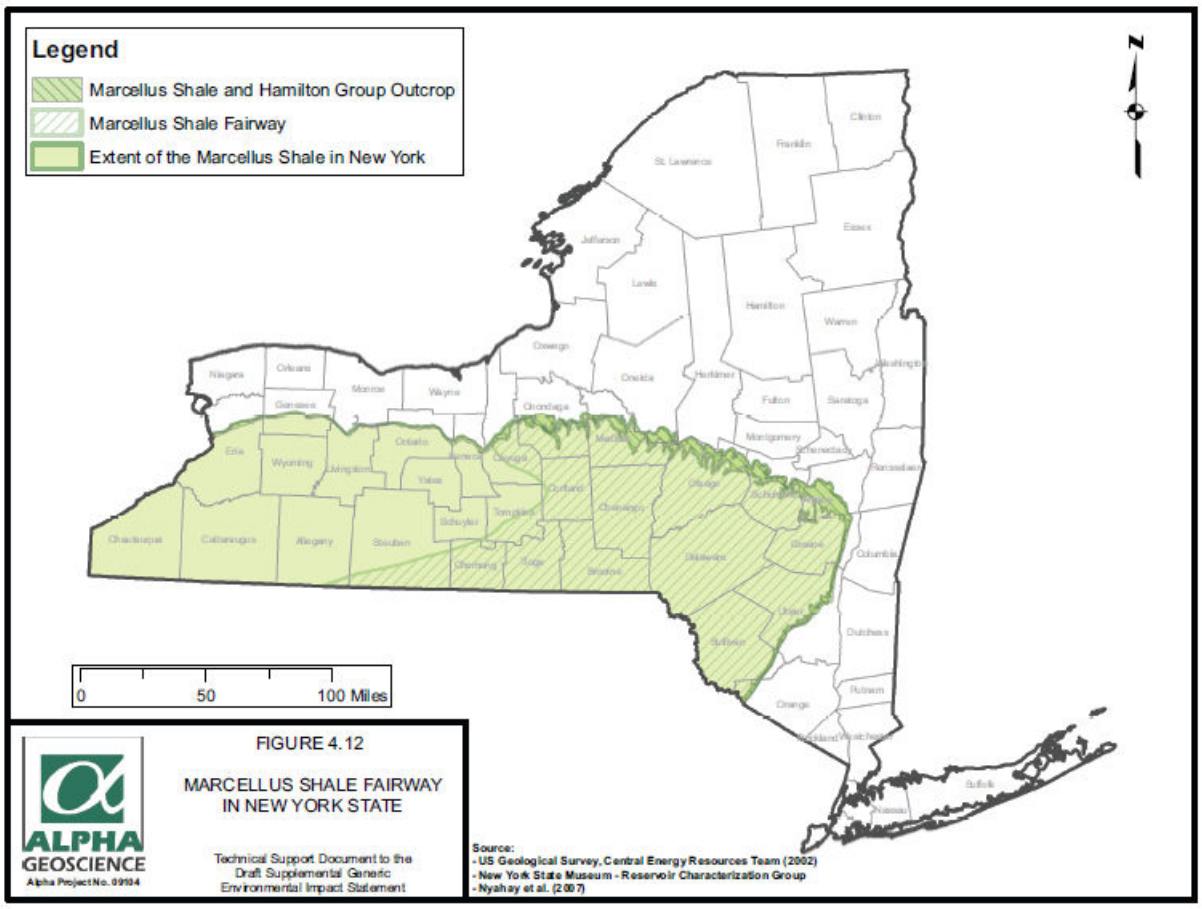
[†] Gross national production for 2008: 25,754,348

[‡] NYSDEC estimates the 2008 production to meet the needs of 728,000 homes for 1 year. This equates to a need of approx. 69,121 cubic feet per house per year. Dividing the 9.5 tcf by this yields enough energy for 137.4 million homes for a year, or 1.374 million homes for a century.

borders the shale sometimes reaches high enough to break the surface of the ground. In the south where the greatest development is likely, however, it descends to more than 5,000 feet.

For all the reservations New York State seems to have regarding drilling, action in the Marcellus play in New York is hardly new. The oldest Marcellus well dates back to 1880, and produced nearly 32.18 million cubic feet (mmcf) over its lifetime. In the 1980's, despite the absence of horizontal drilling techniques, the Marcellus saw further development. Five of the seven

Figure 2.5 -- Extent of Marcellus Shale in New York



Draft SGEIS 9/30 /2009, Page 4-23
Source: SGEIS, 2009

exploratory wells drilled between 1981 and 1982, in fact, are still producing. As of 2001, these wells had produced a cumulative 76 mmcf.[43] Today however, Marcellus formation wells accounted for only 0.13%[*] of total New York natural gas production.[44] This is in contrast to Pennsylvania, where Marcellus production from only four companies reaches over 300 mmcf *per*

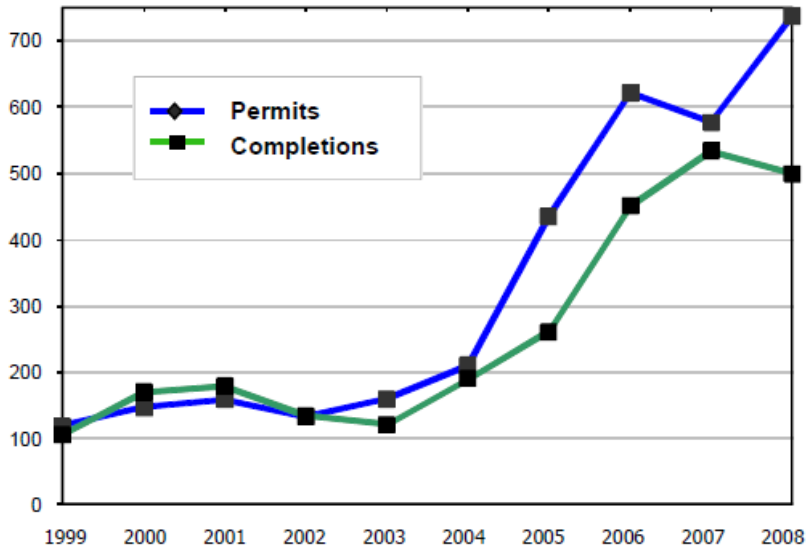
[*] 2008 production: 64.51 mmcf from Marcellus, 50.320 bcf total

day.* NY production to date clearly pales in comparison to the projections that could result from wide application of horizontal drilling and high pressure hydrofracking.

In fact, this trend is already beginning to appear despite a moratorium on horizontal drilling. The introduction of hydrofracking, even in strictly vertical wells, has boosted production thirty-fold from 3,000 thousand cubic feet (mcf) in 2004 to 64,000 mcf in 2008.[45] Ten of the nineteen active Marcellus wells were drilled after 2005, although recent political turmoil has effectively shut down the permit application process. The oldest of these wells were towards western New York, but newer Marcellus wells are rapidly migrating closer to the East – a point important to consider as drilling begins to encroach on New York City's interests.[46]

Regardless of the current "official" state of the Marcellus play, natural gas developers are rapidly moving into the area to lease land before their competitors. In the town of Maine, New York, for example, 115 landowners controlling 3,000 acres signed a leasing agreement with Inflection Energy of Denver for $18 million. Inflection's enthusiasm is based in no small part on the samples they've collected from the Marcellus shale while drilling vertical wells into other gas bearing shales. Additionally, although deals were never struck, organizations have formed of landowners in the towns of Binghamton, Conklin, and Kirkwood seeking to arrange drilling leases.[47] Chesapeake Energy, another major player in the Marcellus, also owns leases in the state[48] and has significant interest in development. Talisman Energy, which owns the most Marcellus wells in New York, has stated that "we need to build systems, we need to build capability, we need to build all that."[49] It is thought that, at peak, New York development could hit 2,000 well per year (± 500 wells) though it is uncertain as to how long it would take development to ramp up.[50]

Figure 2.6 – Well Permits and Completions, New York State



Drilling Permits, 2008

Gas	429
Oil	250
Other	58
Total	737

Well Completions, 2008

Gas	270
Oil	172
Other	58
Total	500

* See Table 2.3 on production data from specific companies

The Supplementary Generic Environmental Impact Statement (SGEIS)

In light of these prospects, the caution shown by New York is notable. Although the state had commissioned a Generic Environmental Impact Statement for natural gas drilling activities in 1992, the conclusion "that issuance of a standard, individual oil or gas well drilling permit anywhere in the state, when no other permits are involved, does not have a significant environmental impact" was out of date after 16 years of significant changes. Initially the major source of contention was the fact that modern hydrofracking utilized water far in excess of the 80,000 gallons according to 1992 standards. Additionally, as the new Marcellus play extended viable reservoirs much closer to important watersheds, concerns were raised about how drilling and hydrofracking materials would affect water supplies.[51]

Particularly in light of the budget shortfall, the draft of the SGEIS issued in September 2009 found that prohibiting development would be "contrary to New York State and national interests."[52] Indeed, they referred to the duty of the NYSDEC to provide for the development of natural resource assets.[53] The draft SGEIS suggests relatively few absolute restrictions, focusing instead on a series of specific recommendations and limitations in the permitting process* intended to allay and address public safety concerns. The idea behind such extensive permitting requirements was to ensure that the NYSDEC, and by extension the public, would be aware of the drilling risks and able to take proactive measures to ensure that all extractive actions proceeded as safely as possible. The level of specificity for these permits suggests that many of them were created in response to specific stakeholder concerns. In recognition of the industry efforts to "green" their production methods, the draft also suggests that the limitations could be relaxed if more environmentally friendly methods are developed.

* These include requirements for the:
• Issuance of a permit to drill in State Parklands.
• Issuance of a permit to drill within 2000 feet of a municipal water supply well.
• Issuance of a permit to drill that will result in disturbance of more than 2.5 acres in an Agricultural District"
• Issuance of a permit to drill when high-volume hydraulic fracturing is proposed shallower than 2,000 feet anywhere along the entire proposed length of the wellbore.
• Issuance of a permit to drill when high-volume hydraulic fracturing is proposed where the top of the target fracture zone at any point along the entire proposed length of the wellbore is less than 1,000 feet below the base of a known fresh water supply.
• Issuance of a permit to drill when high-volume hydraulic fracturing is proposed and the fluid disposal plan required by 6 NYCRR 554.1(c)(1) includes use of a centralized flowback water surface impoundment that has not been previously approved by the Department.
• Issuance of a permit to drill the first well when high-volume hydraulic fracturing is proposed on a well pad within 300 feet of a reservoir, reservoir stem or controlled lake.
• Issuance of a permit to drill the first well when high-volume hydraulic fracturing is proposed on well pad within 150 feet of a private water well, domestic-use spring, watercourse, perennial or intermittent stream, storm drain, lake or pond.
• Issuance of a permit to drill when high-volume hydraulic fracturing is proposed and the source water involves a surface water withdrawal not previously approved by the Department
• Issuance of a permit to drill any well subject to Article 23 whose location is determined by NYCDEP to be within 1,000 feet of subsurface water supply infrastructure.

Political Environment

That the state SGEIS would favor drilling is hardly a surprise. In 2008, while the study was still underway, Governor Paterson signed bill A10526[*] into law. This bill restructured well spacing rules so as to allow for the multi-well pads now common in horizontal hydrofracking operations. Although putting multiple wells on a single pad has the additional benefit of reducing infrastructure needs and impacts from shale gas drilling, such aspects were largely ignored by environmental groups who saw it as an attempt to push an extraction agenda forward.[54] Indeed, Paterson is already planning on capitalizing on Marcellus extraction by placing a 3 percent tax on natural gas extraction from the Marcellus Shale formation in the Southern Tier and in central New York using horizontal wells. The ope is to raise $1 million starting in 2011-2012 in order to help close the budget gap.[55] Despite the executive motions and an encouraging SGEIS, however, several agencies and regional groups have come out with explicit opposition to tapping the Marcellus.

Inside the state, the City of New York has come out as strongly opposed to tapping into the Marcellus in the City main watershed area in the Catskills. In their comments, the New York City Department of Environmental Protection (NYCDEP) strongly criticizes the State document, stating that, "the dSGEIS is fundamentally incompatible with principle of watershed protection and pollution prevention."[56] The city is particularly concerned with the potential for drilling in the Catskill region. As the Marcellus play has drawn rigs eastward, the NYCDEP fears an inevitable migration into the watershed that provides key supplies for the city.[57]

Of particular importance is the fact that NYC's water supply is of such high quality that it operates without filtration.[†, 58] If drilling were to occur, the Catskill watershed might no longer be eligible for its exemption, as significant waste water treatment would be necessary to deal with runoff, fracking fluids, and/or potential spills. The state estimates the cost of producing such a filtration facility to be approximately $10 billion, and would render the $1.5 billion already spent moot.[59] Paul Rush, a deputy commissioner for the NYCDEP confirmed this at a recent energy conference, calling for a "near-zero risk" scenario before allowing drilling.[60] The US Environmental Protection Agency (EPA) concurred with this, and responded in their comments on the draft SGEIS that the analysis of human health and environmental effects was deficient. Furthermore, the EPA criticized the lack of consultation with local groups and Indian Nations.[61] This federal pressure seems to have had an effect. In combination with NYC's political clout, the NYSDEC has been forced to exclude the Catskill watershed from authorizing regulations. Although this isn't an outright prohibition, it does add costly hurdles for any company that might try to drill.[62] Surprisingly, this does not seem to be a large concern for the gas industry. Paul Hagenmeier, during a question and answer session opposite Paul Rush, announced that Chesapeake Energy would not be drilling in their Catskill leases – calling it unpractical.[63] One

[*] "An act to amend the environmental conservation law, in relation to statewide spacing for oil and gas wells"

[†] The city's Filtration Avoidance Deterination was reauthorized in 2007 by the EPA thanks to "the substantial funds NYC has spent to develop the "long-term watershed protection program for its Catskill/Delaware water supply that meets the requirements of the Surface Water Treatment Rule and the Interim Enhanced Surface Water Treatment Rule for unfiltered water supply systems."

can only assume that, in an effort to gain access the rich reserves beneath the rest of the state, his company is willing to make concessions.

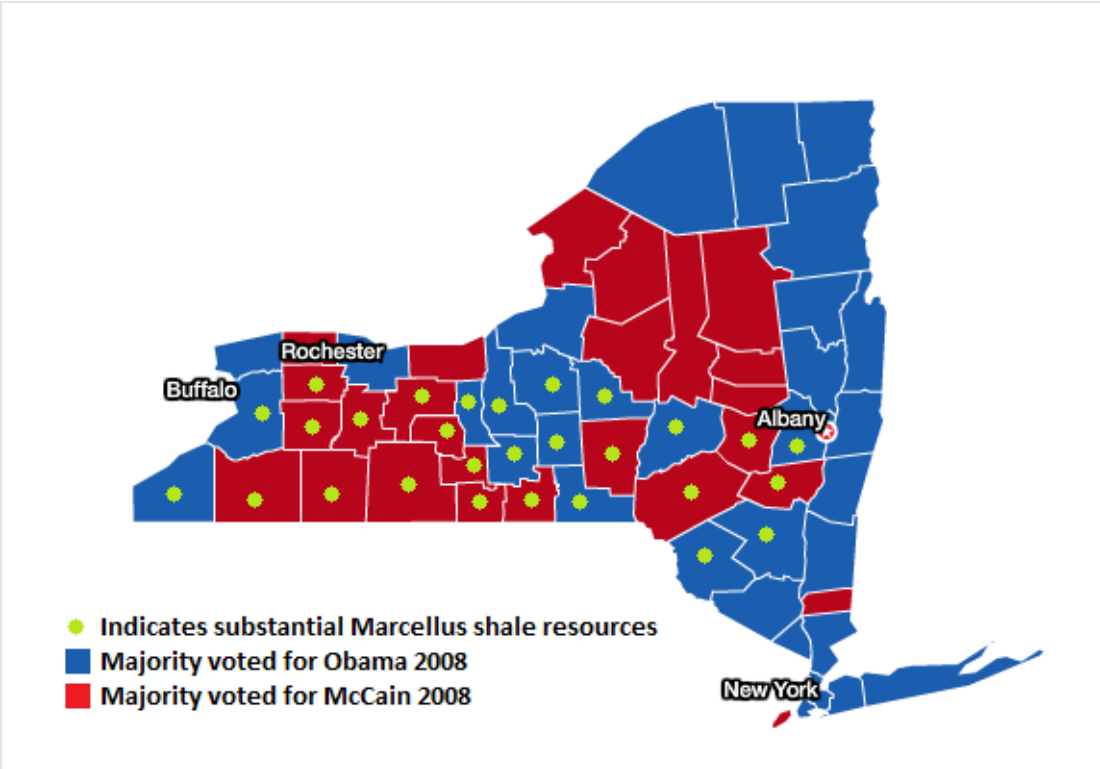
Such prohibitions (formal or otherwise) are not uniformly popular, however. In light of the recent Catskill events, landowner coalitions are trying to organize. Groups such as the Joint Landowner's Coalition of NY are actively seeking contributions so that they can "make sure our voices are not drowned out by better-funded extremists."[64] In January of this year seven hundred advocates representing 23 landowner groups rallied in Albany.[65]

But as with anything else, a silver lining is splitting local groups. "[S]ome believe watershed landowners are being unfairly penalized, [while] others think this may speed up the process of drilling for everyone else by removing a key objection. . ."[66] The lack of (and difficulty in creating) state-wide cohesive interests in this regard has left many pessimistic regarding seeing drilling progress any time soon – especially with both federal senators, the governor, the entire state legislature, and House of Representative members all up for election in 2010.[67] Consider the 2008 presidential election results to understand why local politicians might be worried. The Marcellus shale reaches into many "blue" districts where environmentally-minded politicians will likely be wary of electoral retaliation (see Figure 2.6). Yet, with elections looming, and Democrats already expected to take substantial losses,[68] candidates will be more sensitive to landowners sitting on potential gold mines. Candidates who might otherwise object to drilling may be surprisingly willing to accommodate shale gas development.

From 2006 to 2009 drilling and pipeline organizations donated nearly $55,000 to campaigns, committees, and lobbying groups. A central New York poll of its legislators further exposed the reticence to commit one way or the other. Of the 17 lawmakers polled, 9 would not even take a position[*], while the remaining 8 were split 5-3 in favor. The concerns expressed seem to be fairly consistent with party affiliation (See Figure 2.8), with Republicans such as Gary Finch favoring swift action, "The positive economic impact of natural gas drilling in Upstate New York has been proven over and over," whilst Democrats such as Joan Christensen worry about negative environmental impacts, "Jobs are wonderful, but if people's water has been contaminated . . . you create a bigger problem."[69]

[*] Of these nine, four reported as undecided while five refused to even respond.

Figure 2.7: Substantial Shale Resource Availability versus Election 2008 Votes



Source: CNN.com

Figure 2.8: Poll of central New York legislators

Cayuga County	Do you support high-volume hydrofracking?	Should fracking be allowed in watersheds?	Should fracking be permitted in 2010?	Do the DEC draft regulations adequately protect the environment and public health?
SENATE				
Michael Nozzolio, R-Fayette	No response	No response	No response	No response
David Valesky, D-Oneida	No answer	No answer	No answer	No answer
James Seward, R-Milford	No answer	No answer	No answer	No answer
ASSEMBLY				
Gary Finch, R-Springport	Yes	Yes	Undecided	Undecided
Barbara Lifton, D-Ithaca	No	No	No	No
Robert Oaks, R-Macedon	Yes	Undecided	Yes	Yes
Brian Kolb, R-Canandaigua	Yes	Undecided	Yes	Undecided
Madison County				
SENATE				
Joseph Griffo, R-Rome	Undecided	Undecided	Yes	Undecided
David Valesky, D-Oneida	No answer	No answer	No answer	No answer
James Seward, R-Milford	No answer	No answer	No answer	No answer
ASSEMBLY				
Gary Finch, R-Springport	Yes	Yes	Undecided	Undecided
Barbara Lifton, D-Ithaca	No	No	No	No
Bill Magee, D-Nelson	Undecided	Undecided	Undecided	Undecided
David Townsend, R-Kirkland	No	No	No	No

S

Onondaga County				
SENATE				
John DeFrancisco, R-Syracuse	No answer	No answer	No answer	No answer
David Valesky, D-Oneida	No answer	No answer	No answer	No answer
ASSEMBLY				
Will Barclay, R-Pulaski	Yes	Undecided	Undecided	Undecided
Joan Christensen, D-Syracuse	No	No	No	No
Brian Kolb, R-Canandaigua	Yes	Undecided	Yes	Undecided
Bill Magnarelli, D-Syracuse	Undecided	No	No	Undecided
Al Stirpe, D-North Syracuse	Undecided	No	No	Undecided
Oswego County				
SENATE				
Darrel Aubertine, D-Cape Vincent	No answer	No answer	No answer	No answer
Joseph Griffo, R-Rome	Undecided	Undecided	Yes	Undecided
Michael Nozzolio, R-Fayette	No response	No response	No response	No response
ASSEMBLY				
Will Barclay, R-Pulaski	Yes	Undecided	Undecided	Undecided
Robert Oaks, R-Macedon	Yes	Undecided	Yes	Yes
Dede Scozzafava, R-Gouverneur	Yes	Undecided	Yes	Undecided
David Townsend, R-Kirkland	No	No	No	No

* No answer means the lawmaker would not answer without an explanation.
* No response means the lawmaker did not respond.

Source: Goldberg, Delen, "Many Central New York lawmakers undecided on hydrofracking." *The Post-Standard*, 2010

Non-Governmental Organizations (NGO)

At the local level, environmental NGOs have come out almost uniformly against horizontal Marcellus drilling. Though initially they were caught off guard by the sudden onset of drilling interest in 2008 and 2009, they quickly caught up. Local groups found they lacked the resources to pursue judicial action, so instead they focused on public awareness. The absence of stronger regulatory suggestions of the draft SGEIS provided a rallying point for their efforts. On January 4th, 2010, the Atlantic Chapter of the Sierra Club gathered three U.S. representatives, six New York City representatives, a county legislator, and six other environmental groups to call for the withdrawal of the existing SGEIS and to start the entire process over.[70] Groups like the Catskill Mountainkeeper, Delaware Riverkeeper, and Audubon New York* all continue to speak out against drilling, pointing out that the NYSDEC is critically understaffed. Other news outlets have been more specific, noting a total of 16 oil and gas enforcement staff[71] to cover the entire state. Recalling the peak estimate of 2,000 wells per year, without any staffing increases this equates to 125 permits to review per staffer annually. Environmental groups worry that such an over commitment of work will lead the NYSDEC to over-rely on industry provided data and evaluations. Despite this outpouring of local opposition, national groups are more conflicted.

The tensions within the environmental community are illustrated by some recent internal disputes within the Sierra Club. In 2008, as interest in the Marcellus shale gas was picking up, Sierra Club chairman Carl Pope came out as an advocate for more U.S. natural gas use – the "uniquely clean" fossil fuel.[72] While the general opinion since the 1970s had been that gas was a "green" fuel, those impacted by the local effects of drilling often feel differently. But for Mr. Pope, these NIMBY† concerns miss the larger picture. "What's happening with the new discoveries of natural gas is that parts of the country that historically didn't pay any environmental bill for energy production because they didn't produce energy are going to start paying a bigger share of the bill and people don't like that."[73] Bruce Nilles, in charge of the Beyond Coal campaign for the club, is inclined to agree. He sees increased natural gas use as a critical part of transitioning from coal burning plants over the next two decades. His view, essentially, is a pragmatic one comparing the realities of today against one another, rather than against the potential of future technologies.[74]

Kate Bartholomew and the Sierra Club Atlantic chapter, however, are in strong disagreement. In her own words, "Bruce and I had a little bit of a tense moment."[75] Indeed, the Finger Lakes chapter‡ of the Sierra Club outlines ground rules that basically would disallow any hydrofracking activities. Their position is that: (1) If it pollutes, don't do it, and (2) If it isn't potable or edible, don't put it in the ground.[76] Like many of the local environmental groups, Ms. Bartholomew doesn't want to see the "huge [drilling] pimples all over the place," or contamination of her drinking water.[77] A call to the national Sierra Club legislative office reveals that the issue

* See their websites for plentiful examples

† Not In My Backyard, generally used to refer to local objectors whose primary objection to projects is due to their proximity to their home or neighborhoods

‡ Which includes all or part of 11 counties in New York State: Allegany, Cayuga, Chemung, Cortland, Livingston, Schuyler, Seneca, Steuben, Tioga, Tompkins, and Yates

remains unsettled – representatives there support natural gas in principle, but also insist that more study is needed.[78]

Individual companies and industry NGOs in New York have tried to largely remain off the public radar. Instead, they've focused their efforts on informing the public of benefits through the use of informative sites such as ShaleData.com, Marcellusfacts.com, and the Marcellus Shale twitter feed. "We think education is a critical component of moving forward and understanding how we operate the protections we put in place."[*,79] With so much room remaining for PA development, there seems to be little pressure to push NY harder than the state is willing to go on its own. Indeed, the natural gas industry position appears to be "Look at the benefits PA is reaping, wouldn't you like some?" Groups such as the Independent Oil & Gas Association of New York are pushing hard on that point, suggesting that the revenues from drilling could save parks and historic sites from closure. The group's executive director, Brad Gill, puts it this way, "We are an industry not in the search of a handout, but one that is willing to be part of the solution – both to the state's economic crisis and to the future of the environment, including state parks and historic sites."[80]

His group also insists that the Catskill prohibition on gas development is "excessive and unnecessary."[81] The group offers a form letter to send via email or the postal service and even locates the appropriate state representatives through a zip code search[†]. They've also engaged lawmakers directly, sending a roughly 75-man delegation to Albany in order to push against both delays and severance taxes.[82] They also pushed again on the economic front, stating that Marcellus development bolsters existing job creation proposals in the state.[83]

Despite the slow pace to date, Marcellus drilling in New York is gathering an air of inevitability. Although the state has already made concessions for water safety, it is likely to encourage more regulation as the draft SGEIS is reviewed. That said, an outright prohibition is unlikely in the face of huge budget shortfalls and potential voter retribution. Though opinions may differ, the natural course of politics implies that the issue will not be resolved prior to the upcoming 2010 mid-term elections. New York today is being patient, following the old political adage "when in doubt, wait it out."

[*] Matthew Sheppard, senior director of corporate development for Chesapeake Energy Corp

[†] The form letter is available here: http://www.capwiz.com/iogany/issues/alert/?alertid=14756416&PROCESS=Take+Action

West Virginia

The State of West Virginia possesses substantial reserves of Marcellus shale gas. Regionally, shale gas sits in a competitive market with coal and natural gas. But good accessibility to markets, high potential profit margins, and an abundant labor supply are just a few of the leading factors that suggest a future competitive advantage for shale gas. Also, the West Virginia permit process stands as one of the most detailed, organized, and developer-friendly processes in the nation.

By some estimates, West Virginia leads the Marcellus market in potential for total shale gas development. As shown in Figure 2.8, there are at least some estimates that suggest that West Virginia has the highest projected shale reserves (as well as the largest range of uncertainty). With these figures, West Virginia conceivably could have three to four times the potential of PA and over ten times that of the State of New York. Admittedly, reserve estimates are highly uncertain, and the uncertainties for comparative purposes are compounded when the numbers are developed by different parties (potentially using different methodologies).

Figure 2.9: Estimates of Shale Gas Potential

State	Projection		Year of Projection	Source
	Minimum	Maximum		
New York	7.5 tcf	9.5 tcf	2009	New York State Department of Environmental Conservation
Pennsylvania	8.4 tcf	31.4 tcf	2002	United States Geological Survey
West Virginia	98 tcf	150 tcf	2008	ALL Consulting

Source: NY – DEC, USGS, ALL Consulting

The key elements of West Virginia's venture into the shale gas business include research and development, infrastructure revitalization, water resources management, competitive market strategies, and inter/intrastate legislation and policies.

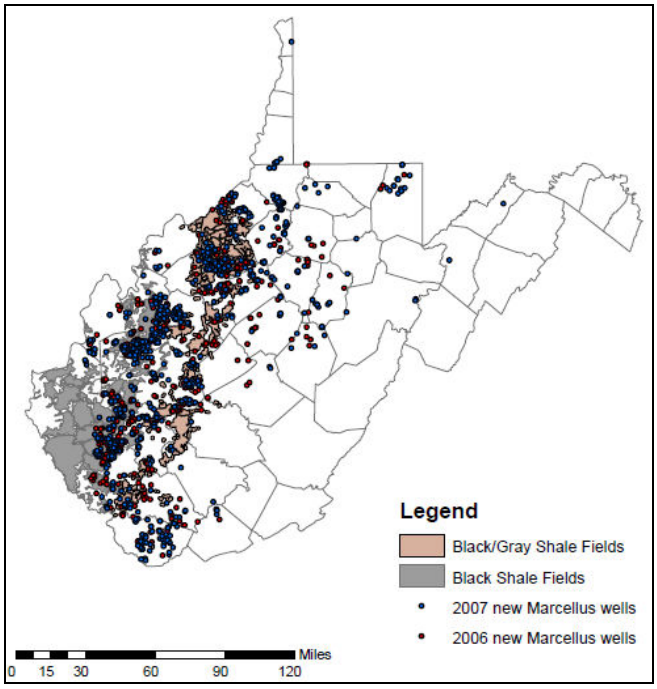
Geology and Geography

According to the West Virginia Geological and Economic Survey, Marcellus shale is present at various depths throughout a large swath of West Virginia. Research has shown a low presence of shale the in extreme eastern or western sections of the state. External shale has been identified in sections of the Valley and Ridge province in eastern WV. It is also important to note that the shale varies in thickness throughout the state, but the thickest areas have been identified in the north east- central portion of the state. [84] In order to calculate target drilling depths, geologists and developers have used existing studies which have found, "The Onondaga Limestone immediately underlies the Marcellus. Knowing the elevation of the top of the Onondaga and the

surface elevation at a particular location provides a way to estimate the depth of a well drilled all the way through the Marcellus Shale." [85]

Figure 2.10 illustrates West Virginia's vibrant drilling market. "According to the WVG&ES, most Marcellus wells range in depth from 5,000 to 7,000 feet; with shallower production in Randolph County. East of the Allegheny thrust the Marcellus is present (e.g., in portions of Berkeley, Grant, Hampshire, Hardy, Morgan, Mineral, and Pendleton Counties) at shallow depths with limited porosity, but it may be over-maturing in this area and so non- or only marginally productive… Production in this area is often for private use rather than commercial use (e.g., a paper company in Mineral County operates several wells to serve their own natural gas needs, but not for commercial sale of the gas)"[86] .

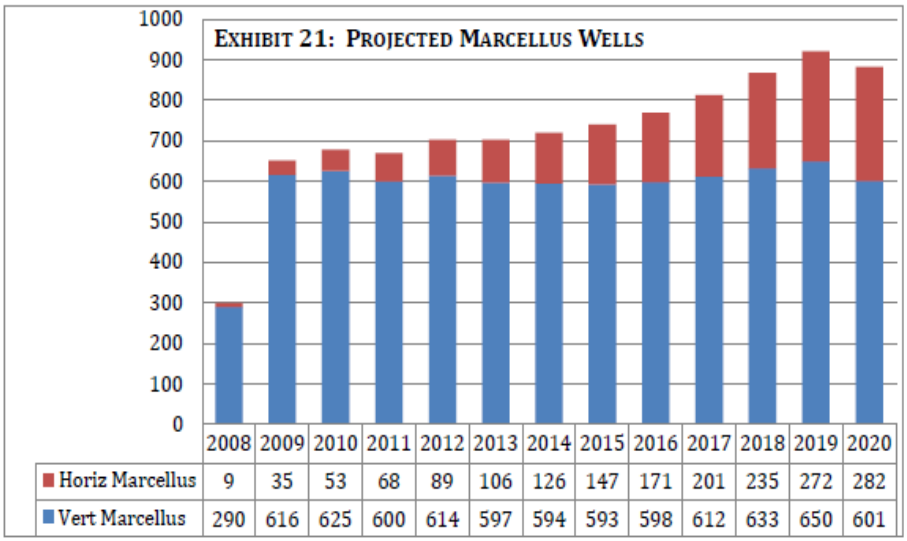
Figure 2.10 Historic Devonian Shale Gas Fields and new Marcellus wells permitted in 2006 and 2007



Source: West Virginia Geological Survey

In order to estimate a range of potential yield of shale gas in West Virginia, ALL analysts combined a series of equations using national averages, estimates from T. Engelders, "Report card on the breakout year for gas production in the Appalachian Basin," and Chesapeake Energy's 2008 pro forma curve. The final estimates fall between 98 TcF and 150 Tcf [87], enough to supply all current U.S. natural gas consumption for 4 to 6 years. As Figure 2.11 shows, most existing Marcellus wells are vertically drilled but drilling of horizontal wells is expected is expected to grow rapidly in West Virginia over the next decade.

Figure 2.11: Cumulative Marcellus Wells, by Year.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Horiz Marcellus	9	35	53	68	89	106	126	147	171	201	235	272	282
Vert Marcellus	290	616	625	600	614	597	594	593	598	612	633	650	601

Source: ALL Consulting, 2009

WV Marcellus Shale Industry

Oil and natural gas drilling began in West Virginia in the late 1850s. Devonian black shale development commenced in 1981 and the first Marcellus Shale gas reservoirs were established in 2002. As illustrated in Figure 2, "Through the end of 2008, 924 wells have been completed in the Marcellus in West Virginia, including 883 vertical wells and 41 horizontal wells."[88] Due to recent technological advancements to maximize cost efficiency and environmental stewardship, future shale exploration and development will mainly utilize horizontal drilling instead of vertical drilling. Horizontal well drilling has the potential to significantly reduce drilling site surface spacing . "According to WVG&ES, as many as 10 horizontal wells may be developed from a single well pad," with each well having the lateral capacity to extend 4,000 to 5,000 feet from the well pad.[89] The sharp spike in vertical wells was a result of intense competition to find the shale hot spots, using a "trial and error" system.

The Competitive Market

The shale gas market in West Virginia is quite competitive. The main shale developers include, but are not limited to, Atlas, Carrizo, Chesapeake Energy, Consol, CNX, Dominion, Marathon, Range Resources, and Stone Energy. Though the companies have a common goal of profit maximization, each has its own strategy and timeline. Some companies are at the exploration stage while others are well into hydro fracking and plugging. For example, Carrizzo has established 4 pilot vertical wells in WV (as well as 4 in PA).[90] They are conducting exploratory drilling to identify prime sites for vertical and/or horizontal drilling.

Stone Energy, on the other hand, is accelerating out of the R&D phase and is unfolding its plan to transition to horizontal drilling into northeastern Pennsylvania and West Virginia. In 2009, Stone Energy opened a local office in Morgantown, VA and commenced vertical drilling. In 2010, the aim is to strategically reserve an estimated 40,000 acres for drilling and to establish 14 gross wells, preferably horizontal. The target counties in West Virginia include Heather, Buddy, and Mary, totaling approximately 24,000 acres.[91]

As of February 2010, EQT had produced 10 satisfactory wells in WV. Though the initial production rates were not astounding, they were attracted by the slower rate of decline than in PA. With EURs projected in the range of 3.5 bcfe, CEO Gerber stated that the "…West Virginia program is looking really, really good to us at this point in time."[92] Overall, "EQT drilled 46 horizontal Marcellus wells in 2009 and plans to drill 40 to 50 in 2010, with locations depending on where pipeline capacity is available. The company's Marcellus sales were 37 million cubic feet equivalent per day at the end of 2009, and it expects to double that by the end of 2010." The biggest outstanding questions are how to spatially distribute productive wells and pipelines and how to explain geological variations in rates of decline.[93] Though the surge in initial production rates from their West Virginian wells has begun to taper off to averages of approximately 2.1 mcf, West Virginia declines in production are slower than at the Pennsylvania wells, [94]

Dominion Resources, drilling in north-central West Virginia, states that a conventional vertical well into the Marcellus "would cost" about $1 million, while the cost of a horizontal well would rise to about $3 million.[95]. Dominion Resources, Inc., a leading pioneer of the Marcellus in the north-central part of the state, recently sold CNX over 500,000 acres of Marcellus shale in Pennsylvania and West Virginia. With the addition of the Dominion leasehold, CNX's combined production amounted to an annualized production rate of 141 Bcf.

CNX has an aggressive strategy to expand in the West Virginia Marcellus Shale. During 2008, the company had invested $34 million in the drilling of an estimated 22 wells, and had forecasted a total of 34 wells to be drilled by year-end 2008. In 2009, the company shifted technological strategies towards horizontal drilling and fracking.[96] The company had also invested around $10 million in gas processing plants.[97] How does CNX maintain a competitive advantage? The company's successful pursuit of outright ownership has allowed CNX to operate with limited capital costs as well as "no obligation to drill in order to retain land." [98]

The primary entity in charge of the shale gas permit process is the WV Department of Environmental Protection – Office of Oil and Gas. The OOG requires developers to complete an extensive permit application along with other various attachments. The OOG also manages site inspections and the enforcement of environmental protection standards. Other agencies involved in the permitting process include the Environmental Quality Board, the Surface Mining Board, the US Army Corps of Engineers, and the DEP – Division of Water and Waste Management.

Even though the law is explicit with respect to oil and gas permits, it still remains broadly written with respect to shale gas development locations. In 2009, Logan County Circuit Judge Roger Perry made a ruling that challenged the WV DEP's authority to prohibit the granting of permits for five gas wells in Chief Logan State Park... "Perry ruled that the DEP lacked the authority to

deny permits for the gas wells to Cabot Oil & Gas Corp., because the 1965 statute cited by the agency in its denial refers to the state Division of Natural Resources, not the DEP"[99] (Houston Chronicle 2009).

Political Environment

The biggest concerns for State Legislators have been proprietary rights, water quality management, infrastructure revitalization, mitigation measures to address hydraulic fracturing, and occupational safety. When examining steps taken by legislation to promote gas development, legislation dating to 1983 stands out as one of the pillars in addressing infrastructure and transportation of natural gas.[100] The 1983 law "required intrastate pipelines and local distribution companies to provide open access for the transportation of natural gas," and "granted the [State of West Virginia] Public Service Commission the authority to require a local distribution company to transport natural gas on behalf of the natural gas provider." [101]

In more recent actions[102], in 2009 the House and Senate proposed legislation that addressed water pollution, geological research and development, and privacy rights. House Bill 2960 would have charged the State Department of Environmental Protection with the task of developing specific standards to control levels of total dissolved solids that are present in the State's rivers streams. House Bill 3028 focused on improving geological research and development by increasing quality assurance/quality control measures as well as site monitoring of fracturing and core sampling. The bill also endorsed a systematic strategy of shale drilling reports and proprietary and biogeochemical privacy. All of these tasks would be implemented thoroughly a partnership between the Department of Environmental Protection and the State Geological and Economic Survey. A State Senate Resolution was simply an expression of communal support of the oil and natural gas industry with respect to technological and economical advancements.

2010 has served as a busy natural gas year for the State Senate.[103] Proposed legislation spoke to property valuation, biodiversity and wildlife, gas rights, water pollution, green initiatives, and waterway management. Senate Bill 426 would give the DEP and Tax Assessor the responsibility of clarifying property valuation terminologies like "small property owner" and valuation exemptions. According to Senate Bill 336, the DEP would be required to enforce mitigation measures to recover the possession or value of wildlife. Senate Bill 39 concentrates on gas rights via the Public Land Corporation. The Corporation would address gas rights from natural gas lessors on public lands and would be expected to provide annual reports to the Legislature. The Water Pollution Control Act, addressed in Senate Bill 101, would force the DEP and federal agencies to establish a cooperative effort to manage issuance of new permits or modification of existing permits for underground injection of coal slurry. Water resource and estuary management strategies are also mentioned in proposed Senate Bill 211 as well as the Water Withdrawal Guidance Tool distributed by the DEP. The bill would also require studies to be submitted to the Legislature. Senate Bill 493 focuses on the 21st Century Business Technologies Property Valuation Act by encouraging developers and businesses to utilize alternative energy sources.

Non-Government Organizations

Economic, legal, and environmental challenges loom in the hands of the State of West Virginia as well as local governments, contractors, and community members. The key legal battles involve zoning codes, proprietary infringements, and transportation regulations.[104],[105] NGOs like the Independent Oil and Gas Association (IOGA), the West Virginia Surface Rights Organization (WVSORO), and the West Virginia Land and Mineral Owner Council have lead efforts to increase community awareness regarding the potential economic impact of shale gas development as well as the often murky legal process in establishing property owners' rights agreements.[106]

The West Virginia Surface Rights Organization (WVSORO), led by Mr. Dave McMahon[107], strives to increase community awareness and governmental action in leveling the playing field between surface owners, companies, and the state/local government officials. The WVSORO stresses the need for surface owners to have a stronger voice and opportunity to reap a just share of the economic benefits of the mineral rights of the property. In order to accomplish this, the government should introduce legislation that requires oil and gas companies to talk to surface owners prior to surveying the property. This will create a greater balance of power and cooperative effort between the community and developers.

Drilling and hydraulic fracturing continue to raise concerns regarding public health and ecosystem sustainability.[108] Unfortunate incidents like the recent Clearfield County, PA "blowout" from a surge in gas, a methane flare in northern West Virginia as well as the stream contamination in Drunkard Creek, PA have prompted drillers and government officials to reexamine drilling in natural gas hot spots, underground injection strategies, waste water discharge, biodiversity management, and nutrient recovery. [109],[110],[111] NGO coalitions and community members are pushing for stronger hydrofracking regulations, adherence to OSHA standards, and more public outreach. The West Virginia Geological and Economic Survey has created the Marcellus Interactive Mapping Application to enhance data management and to increase the general public's access to information on shale gas production in their community.

The Independent Oil and Gas Association[112] of West Virginia is seeking to promote a cohesive, but competitive oil and natural gas market in West Virginia. The association currently has approximately 500 corporate members. They help companies and the general public learn more about the importance, challenges and opportunities confronting the oil and gas industry. They have noted key issues like economic potential of shale gas development, the public's perception of water use issues relating to hydrofracking, and the surface versus mineral rights ownership questions. As previously stated, shale gas development can serve as a large benefit to West Virginia's economy. Academics such as Tom Whitt of West Virginia University will be leading a study with students on the economic impact and future projections.

With respect to water quality, community members tend to have a negative perception of the use and management of water in shale gas development. Companies have acknowledged the concerns and continue to take steps towards "recycling" the water used for hydrofracking and

staying in communication with governmental officials regarding monitoring water quality. Surface versus mineral right ownership is one of the most confrontational issues in shale gas development. Community members often do not understand the concept of mineral rights, and feel alienated after purchasing property without the mineral rights. As noted, mineral rights can have an influence on the purchase price of property. Locals tend to feel uninformed in the on-goings of real estate on a communal scale, which can complicate the property acquisition process or the overall relationship between the company and community. However, new technologies like horizontal drilling have increased the pressure(s) on property owners, because horizontal drilling allows companies to access leased/contracted shale gas reserves by drilling around or "under" the property owners' property. IOGA continues to highlight the efforts of the government and the industries to work cooperatively in creating statutes that better regulate Marcellus well acquisition and drilling.

Economic Impacts

The estimated economic impacts on West Virginia by 2020 include an almost $3 billion in gross economic activity; $1.6 billion in value added, $1.3 billion in direct payments to households through royalties and industry payroll, almost 17,000 additional jobs, and over $800 million in state and local taxes .[113] When gauging West Virginia's developing shale gas market, consumers and investors should consider levels of lease bonuses, royalties, and severance taxes. Thriving counties are seeing some of the higher lease bonus and royalties within the West Virginia Marcellus.[114]According to a 2009 Congressional Research Service Memorandum, "Some landowners in West Virginia have seen their bonus bids climb from $5 per acre in 2007 and early 2008, to more recent bonus payments of $1,000 to $3,000 per acre. Royalty rates have increased from 12½% through 16% to 18%. Rents are often included in the signing bonus or sometimes paid out in the form of a "delay rental." [115]

The WV DEP, US EPA, and other State governments continuously refine legislation relating to water use , withdrawal and storage, purification, and recycling. West Virginia State has published water resource management strategies, pollution control regulations, and a toolkit of guidance manuals[116]. The Water Resources Protection Act of 2003 requires the users of water resources (whose withdrawals exceed 750,000 gallons in any given month for one facility) to register with the DEP's Division of Water and Waste Management[117]. The DWWM will take a proactive effort to assist developers with waste pond construction techniques by establishing Dam Safety Sections and Local Natural Resource Conservation Service Field Offices. The department has incorporated an erosion and sediment control manual to complement the DEP's construction storm water guide.

When examining infrastructure, developers and government officials must address capital costs and interconnectivity of pipeline transportation. Currently, pipelines have been made to focus in intrastate transportation of natural gas. West Virginia's geographic location is well suited to serve as an interchange between the Northeast, Mid-Atlantic, Southeast, and Midwestern states. State and national government officials have the task of working with private developers and county officials to renovate existing pipeline and mobile infrastructure that can meet the

demands of capacity, flow, and fluctuation of shale gas reserves. The infrastructure must also account for employee safety and threats to bioterrorism through homeland security policies.

How will the State maintain an efficient gas transportation system that satisfies inbound gas flows from other regions, the new supply of intrastate shale gas, and the fluctuating markets for energy? The State must carefully coordinate the composition and implementation of policies that encourage a competitive market. For example, the PSC imposes a tariff that establishes services and pricing rates[118]. From an environmental perspective, land-use and land-cover change and water quality in the Appalachian Region will continue to be hot topics for non-profits like Earthworks as well as community members.

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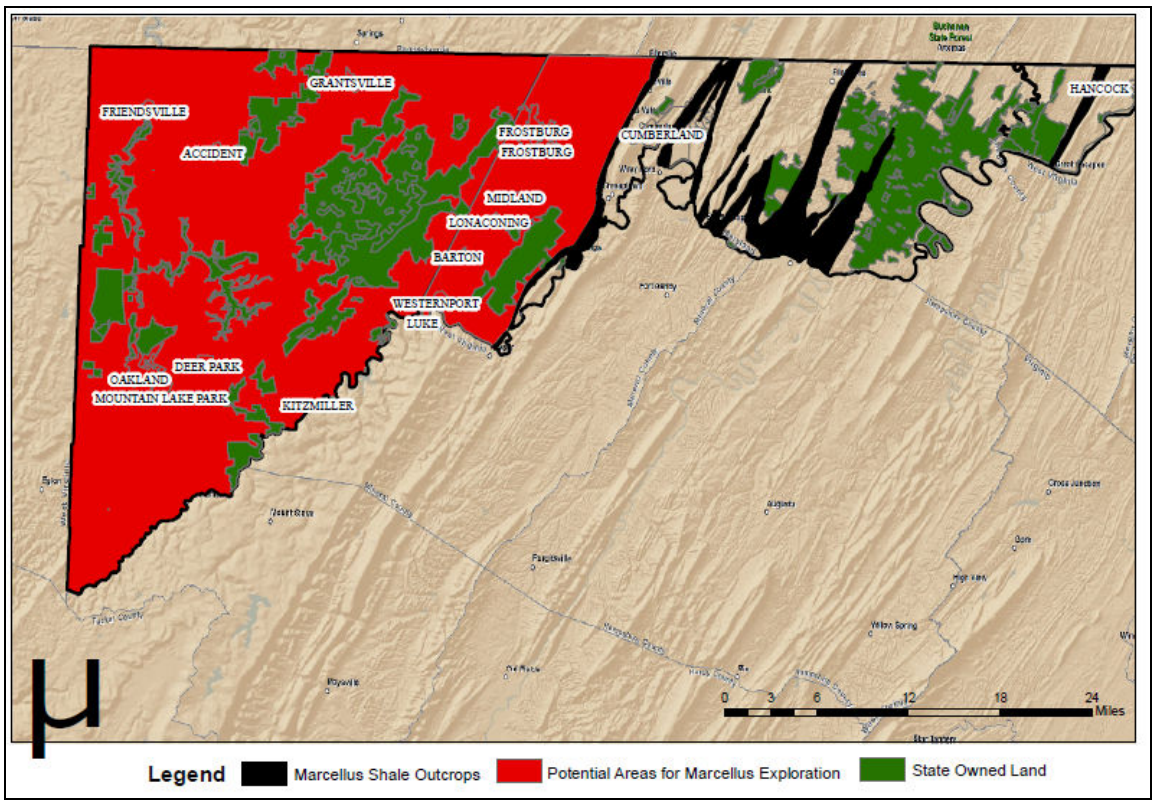
Maryland

In the Marcellus shale gas world, Maryland is currently only a very "small fish", but may have influential powers in key issues like pipeline development, resource distribution, and watershed management. As shown in Figure 2.12, the Maryland shale gas is potentially located under two counties in the westernmost portion of the state, Garrett and Allegany. Until now, the natural gas drilling industry has not made a noticeable footprint in the Marcellus shale in Maryland, but with increased revenues from natural gas in other states such as Pennsylvania and West Virginia, it is starting to gain attention.

Figure 2.12 Marcellus Extent in Maryland



Source: Maryland Department of the Environment. (2010, January 12). *Potential Areas for Marcellus Shale Exploration*

Although there are expected to be significant Marcellus shale gas reserves, a lack of past development has prevented careful estimation of reserves. With interest rising rapidly, however, it is likely that the next few years will see the state come to terms with drilling in its western-most counties. The environmental and legislative communities, previously content to more or less let local issues be dealt with on local's terms, are just beginning to awaken on this issue. The last two General Assembly sessions in Annapolis have seen the start of bills intended to

encourage development and capture funding. Environmental response has as so far been slow, though one would expect NGOs to ramp up quickly as development commences.

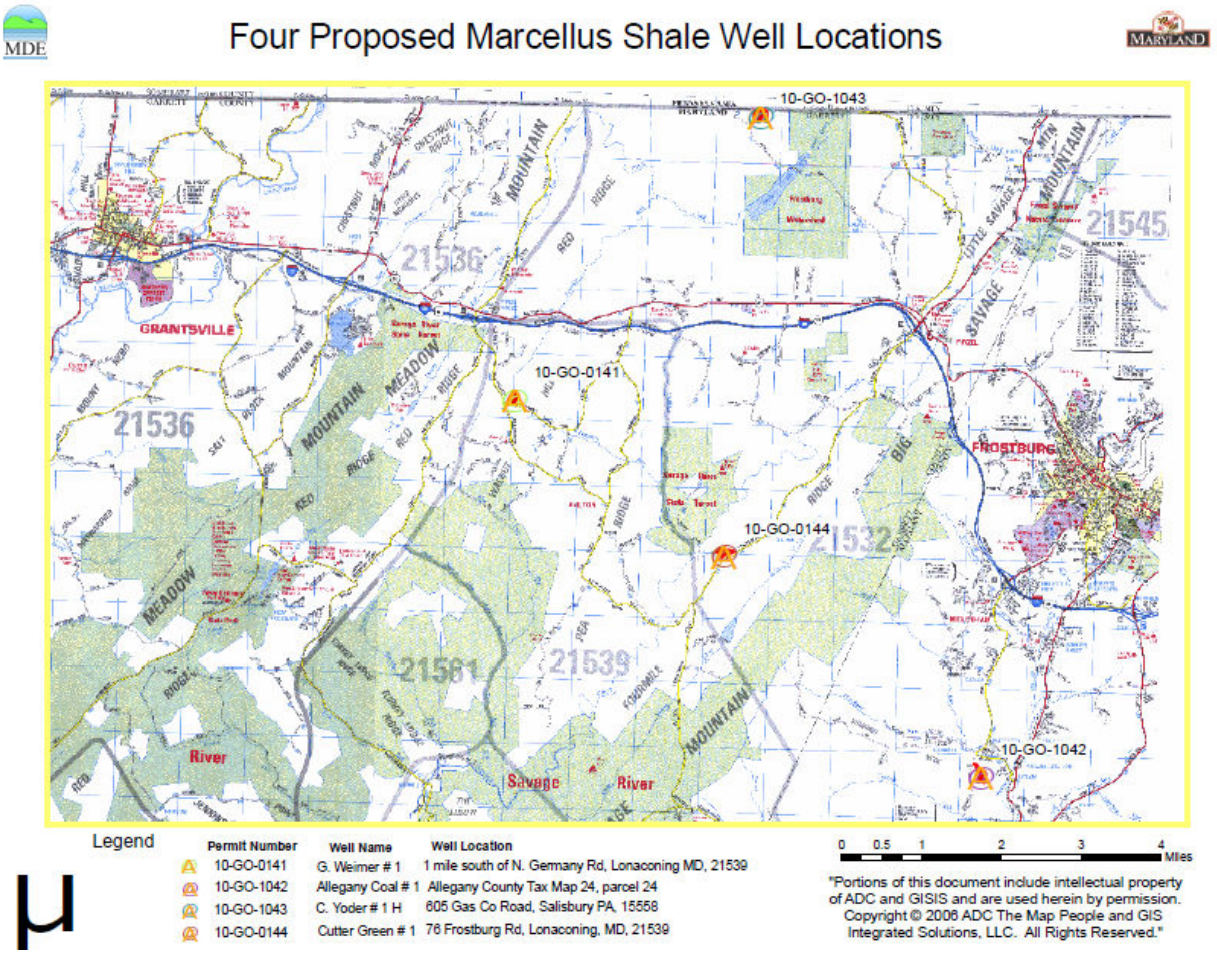
As of this writing, Maryland has no active Marcellus wells, and the test wells are still in the permitting phase. As such, the potential reserves in the state are largely unknown. Interest tracks to 2006, however, when energy companies started to inquire about the Marcellus shale formation in Maryland. In the later months of 2009, the Maryland Department of the Environment began to receive applications for drilling and operating permits. If natural gas drilling is found to be plentiful in Maryland it is likely that development will occur, following the trend in other states. Natural gas extraction is not new to Maryland; the first exploration well was drilled in 1888 in the Cumberland Narrows. After encountering biogeochemical complications relating to salt content in 1944, gas drilling in Maryland declined. The recent wave of interest in the Marcellus Shale, and cutting edge horizontal drilling strategies, has opened the door for energy companies to actively consider entering Maryland in search of shale gas.

As of 2008, including all sources, Maryland was producing only a very small amount (28 million cubic feet) per year of natural gas, Since 1995, only three new exploratory wells have been drilled, located in Garret and Allegany counties[*]. However, total annual production of shale gas may become significant within the next 5 to 10 years. Innovations in technology, the availability of compatible transportation, and the acceptable regulation of water and brine are three important factors that will influence the speed and direction of Maryland shale gas development.

Although construction has not yet begun, as of this writing there are 4 applications for exploratory wells in the Marcellus shale: G. Weimer #1, Allegany Coal #1, C. Yoder #1 H, and Cutter Green #1. Their respective locations are visible on the map in Figure 2.13.

[*] Broadwater #1 in Garret County, and Curry #1, Barton #1 in Allegany County

Figure 2.13: Four Proposed Marcellus Shale Well Locations



Source: Maryland Department of the Environment. (2010, January 12). *Four Proposed Marcellus Shale Well Locations*

With more major development occurring in Pennsylvania and larger stocks in New York, there has been a new interest in Maryland's portion of the Marcellus shale market. Since 2006, over thirty companies have made inquiries to the MDE regarding research and development efforts as well as potential drilling efforts in the northwestern corridor of the state.[119] According to the Maryland Department of the Environment – Office of the Secretary, "In October of 2009, the Maryland Department of the Environment received applications for four Drilling and Operating permits from Samson Resources Company to conduct exploratory drilling."[120] Judging by the large returns in Pennsylvania along with accelerated horizontal drilling in West Virginia, it is probably only a matter of time before Maryland sees active development.

Though Samson Resources Company is taking the lead in Maryland, one information source, Mineral Web – Oil and Gas Mineral Services, regards the following energy companies as

contenders in the region: "Range Resources, Chesapeake Energy, North Coast Energy, Chief Oil & Gas, East Resources , Fortuna Energy, Cabot Oil & Gas Corporation, Southwestern Energy Production Company, StatoilHydro, Nomac Drilling, EQT Corp, Energy Corporation of America, Anadarko Petroleum, and Atlas Energy Resources"[121].

Political Environment

Shale gas development thus far has received less attention in Maryland than in New York or Pennsylvania. A web search of the *Baltimore Sun* is more likely to find a brief comment on the status of New York drilling than any note of Maryland activities. Turning to a local paper for Allegany or Garrett County, however, and there are regular updates from across the Marcellus play. Some articles even provide tips for landowners on how to negotiate leases.[122] Enthusiasm for drilling even led the Penn State College of Agriculture Sciences Cooperative Extension to arrange a meeting for interested landowners. Of particular note during the meeting was the concern that state officials were ignoring the issue. One member of the Allegany County Chamber of Commerce commented, "This has got to be a government-wide effort. Please pressure the right people in the government to get the proper procedures in place."[123]

Garrett county has similarly encouraged citizens to "keep an eye" on the Marcellus issue, as they prepare for four permits under review.[124] The sessions hosted by the county, however, have been largely industry-centric. At the January program, "Your Business & Marcellus Shale: Voices of Experience," the presenters were local businessmen, industry representatives, and Penn State experts.[*125] Undoubtedly, the industry is trying to be proactive here. The Allegany Chamber also recently welcomed Samson Resources, a Marcellus drilling company, into its membership.[126] Further driving this interest is the fact that Garrett county is well poised to take advantage of shale gas. The severance tax on gas in the county provides revenue for the county. Although historically this has been fairly insubstantial,[†] it is expected to climb rapidly. Indeed, Allegany County has sought legislation that would give it a revenue stream of its own.[127] With 36,000 acres already leased as of 2008, the western counties are looking forward to the possibility of substantial new local revenues.[128]

In 2009, however, Governor O'Malley signed into law a decrease in Garrett's tax so as to encourage drilling while simultaneously redirecting revenues to the general fund and away from specific purposes.[‡] The current session saw the introduction of several further measures, including a seemingly popular measure to allow the termination of dormant mineral rights. This would allow surface estate owners to reclaim such rights when the mineral interest owner is missing or unknown – potentially opening further regions for development[§]. Another measure, introduced by the state senator for Allegany and Garrett counties, proposed to relax the proximity requirements for producing wells.[**] Unfavorable reports from the respective House

[*] Penn State being the authoring institution of the favorable drilling report "An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play"
[†] $3,649 in 2006, $500 in 2007 and 2008 – Garrett County Revenue reporting
[‡] 2009 Session, SB 651 & HB 803
[§] 2010 Session SB288 & HB 320
[**] 2010 Session SB 448 & HB 398

and Senate Environmental committees[129] seem to have killed the bill for the time being. Although a minor "defeat" in terms of drilling, it is a significant response indicating that the General Assembly is still sensitive to environmental interests. Prior to this, the only mention of environmental concern was an emphasis on the importance of public hearings in protecting other public interests[130].

Of arguably more importance, though, is the significant overlap between the Marcellus play and state lands. The State of Maryland directly owns lands that cover significant portions of the shale gas exploratory areas. Issues of whether the state should lease these lands and mineral rights as a means to help budget concerns in a time of severe fiscal pressures have not yet been addressed. Should the test wells in the area turn out to be high producers, however, there might be a new state interest. As such options might run counter to current Maryland objectives such as Program Open Space, and serious conflict could easily arise.

Non-Governmental Organization (NGO) Responses

With no active wells at present, and only four undergoing the permit process, it is not unfair to say that the Maryland portion of the Marcellus play has flown under the radar of most groups so far. Although many groups purport interest, they generally seem more focused on activities in New York or Pennsylvania, with limited (if any) explicit coverage of Maryland[*]. Even the local chapter of the Sierra club, which has several articles opposing local LNG natural gas plants, has no mention of the Marcellus shale gas potential anywhere at their website.[131]

Some local groups do seem to be taking notice, however. The Chesapeake Bay Commission, for example, recognizes the potential harm from drilling and plans to continue examining the issue.[132] The Maryland Forests Association has also come out against drilling, pointing out the multitude of potential environmental hazards.[133] The Nature Conservancy in Maryland is also paying attention to the debate, with eight of the "Places We Protect" immediately in the shale gas play area.[134] Despite currently low levels of active interest, it is likely that as drilling interest increases there will be more response from local groups. In New York, after all, environmental groups never really mobilized until the governor pushed legislation favoring drilling and the draft SGEIS was published.[†]

Maryland, with such small Marcellus deposits relative to other states in the play, is unlikely to drive regional policies on the issue. That said, the relative isolation of the shale in the state may be allowing industry to more or less "get their way" on the issue, with Garrett and Allegany counties happy to pocket their proceeds. The environmental community has yet to make their presence felt, but parties in favor of drilling will likely need to step carefully.

Before Maryland shale gas development can take off, greater attention at the state level will be required. More resources will have to be directed to the creation of an appropriate regulatory framework, drawing on the experiences of neighboring states that have set the stage. Increased staffing levels to administer this framework will also be necessary. Growing shale gas

[*] Marcellus-shale.us, Earthworks, Natural Resources Defense Council, etc.
[†] See New York discussion

production could generate substantial tax revenues and other economic benefits to the State of Maryland. If suitably controlled to avoid significant environmental harms, shale gas development could be a positive development for Maryland in the years to come.

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- Payroll was calculated at 2.5% of revenue received by the gas producer.
- Payments to suppliers were calculated as the sum of drilling and operational costs.
- Drilling costs were assumed to be $3,500,000 for horizontal wells103 and $800,000 for vertical wells.104 Average operational costs over the life of a well were conservatively assumed to be $2,000 per month for horizontal wells and $1,000 per month for vertical wells.

- Severance taxes were calculated using the West Virginia rate of 4.7¢ per Mcf of natural gas produced plus 5% of produced gas value.
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Part II – Marcellus Shale Gas Development, Key Environmental Issues

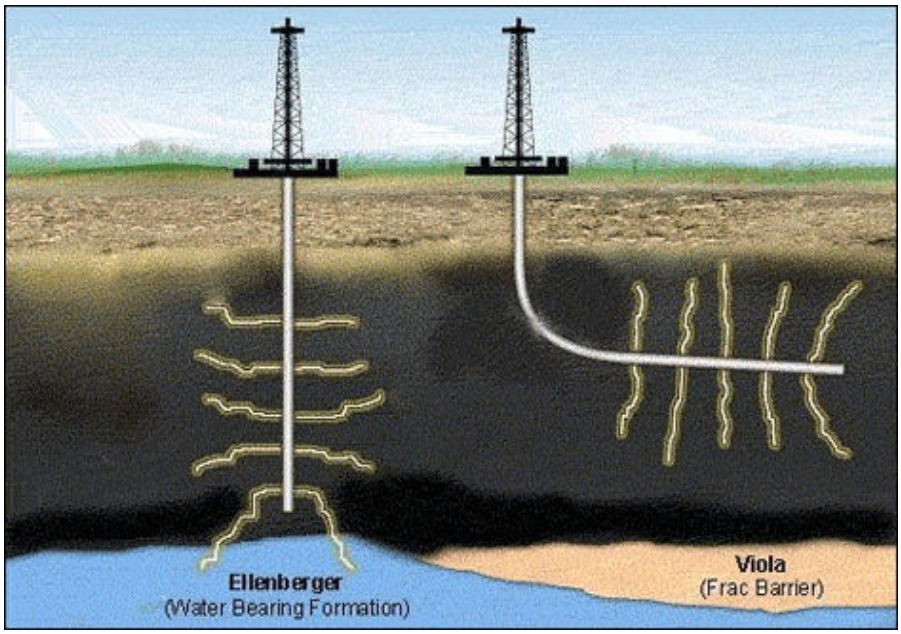
Chapter 3 – Hydrofracking Water Requirements

The hydraulic fracturing process used for producing natural gas from Marcellus shale takes 2.4 to 7.8 million gallons (four to twelve Olympic-size swimming pools) of water for each well. As a result, water availability is a potential limiting factor in developing unconventional natural gas shale. Water availability is especially important for development of the Marcellus play, where traditional power producers, farmers, industrial users, municipal drinking water plants, recreation operations, and many others demand water for their own use. A complex mix of water-use traditions, intergovernmental coordinating bodies, and state laws attempt to balance the many competing uses of limited water supplies in the area of the Marcellus play. So far, the system is effectively allocating water, but changes may be necessary to balance future demands.

The Technology of Hydraulic Fracturing and Use of Water in the Process

Horizontal drilling and hydraulic fracturing are two drilling technologies that make unconventional natural gas plays (e.g., Barnett shale, Marcellus shale, Fayetteville shale) economically viable for gas recovery. A horizontal wellbore that begins vertically but slowly changes direction and then extends out several thousand feet has much greater surface area exposed to the gas-bearing geologic formation than a simple vertical wellbore by itself (Figure 3.1).

Figure 3.1: Vertical drilling (left) exposes less of the surface area of the gas-bearing geologic formation to the wellbore than horizontal drilling (right).



Source: Petrocasa Energy. Available online at: http://www.petrocasa.com/images/gaswells1.jpg.

Once the well has been drilled, hydraulic fracturing further increases the wellbore surface area within the gas-bearing geologic formation and physically frees gas trapped in the formation. The fracturing process begins when the wellbore is cased with an outer cement "string" that extends from the ground surface to below the water table, and an inner string that extends from the ground surface to the end of the wellbore.[1] After the well is cased, a wellhead that pressurizes the wellbore, and accompanying equipment that manages reclaimed water and delivered natural gas, is placed at the point where the wellbore meets the ground surface.[2]

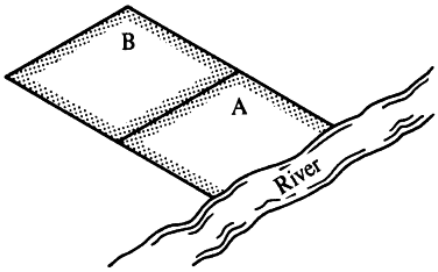
Physical fracturing occurs after the well is cased and the equipment is in place. A fracturing engineer perforates the casing in the farthest 300 to 500 feet of the wellbore first, causing holes to form in the cement and fractures to form in the shale.[3] He then injects 300,000 to 500,000 gallons of slick water—water mixed with chemical proppants and sand or silicate—at high pressure into the wellbore from the surface to extend the fractures caused by perforating. After the water has fractured the shale formation, sand is injected to keep the fracture lines from closing and the natural gas flowing. The fracturing engineer repeats the same process for each subsequent 300 to 500 foot section of the horizontal section of the wellbore. A 4,000 foot well could require 2.4 to 7.8 million gallons of water.[4] By comparison, an Olympic-sized swimming pool holds 660,000 gallons of water—in other words, each hydraulic fracturing operation requires the equivalent of four to twelve large swimming pools of water per well.

Sources of water supply for gas development—current status and legal use

Gas companies have obtained water for the hydraulic fracturing process from various sources. Companies have reused or recycled recovered flowback water, tapped available surface water, purchased bulk water from municipal water suppliers, and/or developed groundwater. Chapter five focuses on managing wastewater, including reusing and recycling flowback water. This chapter focuses on the various legal requirements and costs for obtaining surface water, water from a municipal supply, and groundwater.

Surface water in the Marcellus shale states is allocated through the doctrine of riparian rights. Landowners whose property borders a river, stream, pond, or lake have equal withdrawal rights to the water body (Figure 3.2). Rights may only be transferred through deeds to land that hold the right, but courts give preference to prescription—a party that uses the water for more than 20 years has superior title over the original owner.

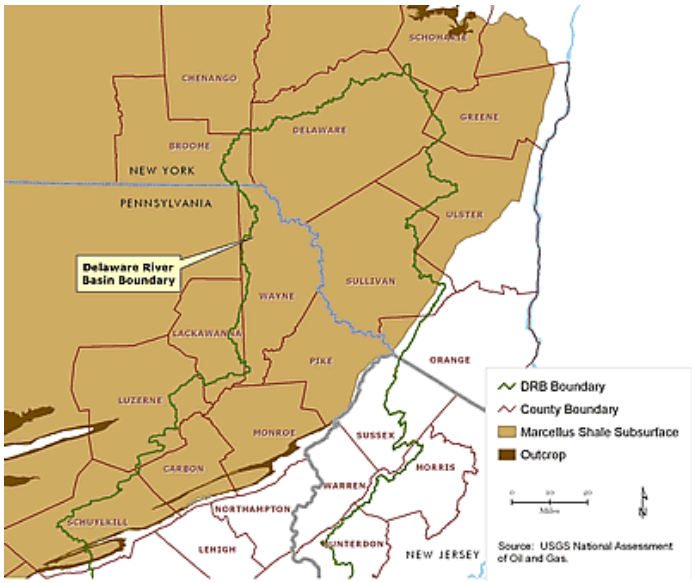
Figure 3.2: The riparian rights doctrine provides landowner A with access and withdrawal rights to the river. Landowner B has no riparian rights.



Source: Answers.com riparian owner definition. Available online at http://www.answers.com/topic/riparian-owner.

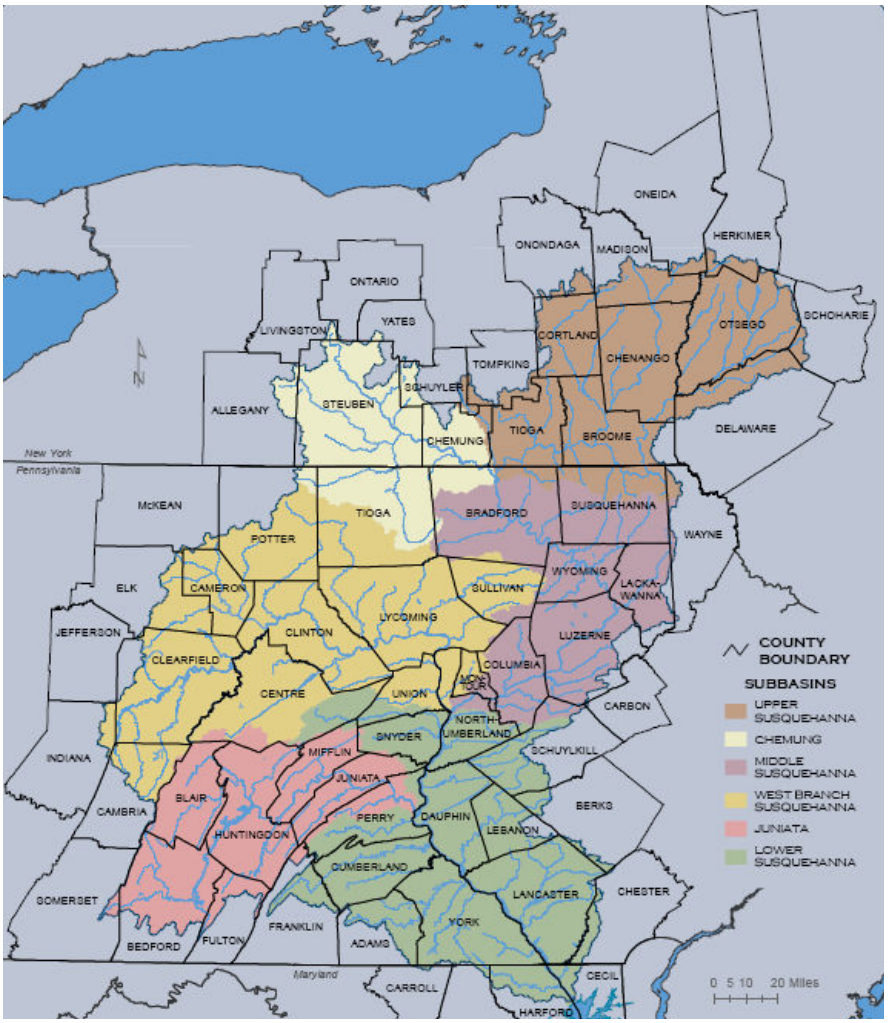
The doctrine of riparian rights limits landowners to withdraw for "reasonable use." However, the reasonable use definition varies based on state law. In at least two Marcellus play states (New York and Pennsylvania), withdrawals from major water bodies are coordinated by river basin commissions. The Delaware River Basin Commission (DRBC) coordinates withdrawals from the Delaware River in eastern New York and Pennsylvania (Figure 3.3). Likewise, the Susquehanna River Basin Commission (SRBC) coordinates withdrawals from the Susquehanna River in east-central New York and Pennsylvania (Figure 3.4). The SRBC could also coordinate withdrawals for gas companies operating in western Maryland, though withdrawn water would need to be transported from eastern Maryland or southeastern Pennsylvania.

Figure 3.3: The Delaware River Basin Commission coordinates withdrawals from the Delaware River in eastern New York and Pennsylvania.



Source: Delaware River Basin Commission. Available online at http://www.state.nj.us/drbc/naturalgas.htm

Figure 3.4: The Susquehanna River Basin Commission coordinates withdrawals from the Susquehanna River in east-central New York and Pennsylvania.



Source: Susquehanna River Basin Commission, Available online at http://www.srbc.net/atlas/downloads/BasinwideAtlas/PDF/1151_SRBC_Counties.PDF

The SRBC and DRBC must review and approve any project proposing to withdraw 100,000 gallons per day (GPD) or more (based on a 30-day average) from surface waters or groundwater.[5,6] In addition, the SRBC must authorize consumptive use (that is—water that does not return to the Susquehanna River) of 20,000 GPD or more (also based on a 30-day average).[7] Withdrawal applications are evaluated for their potential adverse impacts to water bodies, including excessive lowering of water levels; rendering competing supplies unreliable; causing permanent loss of aquifer storage capacity; degrading water quality to levels that could be injurious to any existing or potential water use; adversely affecting fish, wildlife, or other living resources or their habitat; and substantially impacting the low-flow of perennial streams.[8]

The SRBC staff reviews withdrawal applications on a quarterly basis. Because the natural gas industry requires a more rapid turn-around for permit approvals, the SRBC reformed the permit-

approval process for natural gas companies between 2008 and 2009.[9] The reforms provided gas companies with greater flexibility to purchase water from municipal supplies, including lower-quality municipal treatment plant effluent.[10] The DRBC also reformed its permit approval process in 2009 to require natural gas extraction projects to obtain explicit commission approval.[11] DRBC staff may not approve withdrawals for hydraulic fracturing. Rather, the decision is made by a majority vote of commissioners at a public hearing.[12]

The riparian rights system and permitting processes require gas companies to pay several fees to withdraw water legally. Landowners with riparian rights may charge for access to their property, and fees can vary based on ease-of-access, distance from wells, and other site-specific variables. In addition, river basin commissions charge to review permits (Table 3.1). Fee schedules are tiered and based on the planned withdrawal, beginning at 20,000 GPD for consumptive use applications.[13] Further, a company that modifies its application by requesting additional withdrawals may be required to pay additional review fees.[14] Finally, the river basin commission may charge annual compliance and monitoring fees and fees for consumptive use withdrawals.[15] The SRBC, for example, charges $0.28 per $1,000 gallons withdrawn for consumptive use.

Table 3.1: SRBC charges natural gas companies a flat-fee of $10,000 per application and additional fees may apply.

Project Category	Requested Quantities[1] or Capacities	Standard Fee	Municipal Fee
Consumptive Water Use	20,000 gallons per day (gpd) – 99,999 gpd	$ 2,520	$ 2,020
	100,000 gpd – 499,999 gpd	5,060	4,050
	500,000 gpd – 999,999 gpd	10,070	8,050
	1 million gpd (mgd) – 5 mgd	30,200	24,160
	Over 5 mgd	50,350	40,280
Approval by Rule Consumptive Use	Approval by Rule: 18 CFR §806.22(e):		
	20,000 gpd – 99,999 gpd	$ 1,260	
	100,000 gpd – 499,999 gpd	2,530	
	500,000 gpd – 999,999 gpd	5,040	
	1 mgd – 5 mgd	15,100	Not Applicable
	Over 5 mgd	25,180	
	Natural Gas Approval by Rule: 18 CFR §806.22(f):	$ 10,000	
Withdrawals[1,2,5]	Less than 100,000 gpd	$ 4,400	$ 3,520
	100,000 gpd – 249,999 gpd	6,600	5,280
	250,000 gpd – 499,999 gpd	8,800	7,040
	500,000 gpd – 999,999 gpd	11,000	8,800
	1 mgd – 5 mgd	13,200	10,560
	5,000,001 gpd – 10 mgd	28,650	22,920
	Over 10 mgd	28,650 + $4,875 for each additional 1 mgd increment[4,5]	22,920 + $3,900 for each additional 1 mgd increment[4,5]
Diversions	Up to 250,000 gpd	$ 8,400	$ 6,720
	Greater than 250,000 gpd	25,200 (plus consumptive use fee unless inapplicable)	20,160 (plus consumptive use fee unless inapplicable)
Hydroelectric Projects (New or Re-licensing)	Greater than 10 megawatts (anything less subject to "all other projects" category below)	$ 200,000	Not Applicable
All other projects requiring review and approval and not otherwise specified.	Not Applicable	$ 4,200	$ 3,360
Aquatic Resource Survey[2,5,6]		$ 5,720	$ 5,720
Constant-Rate Aquifer Testing Plan Evaluation[2]		$ 3,380	$ 2,700
Emergency Certificate		$ 4,200	$ 4,200

Source: Susquehanna River Basin Commission. 2009. *Regulatory Program Fee Schedule*. Available online at http://www.srbc.net/programs/docs/FINAL2010RegulatoryProgramFeeSchedule120909.pdf.

Bulk water from municipal water suppliers is another potential source for hydraulic fracturing water . The amount of water demanded from municipal suppliers will vary depending on the amount supplied from surface waters through the SRBC and DRBC. In addition, three issues could further affect demand from municipal suppliers. First, municipal utilities must fill residential and commercial demand first, and then fill industrial requests as a second priority. Water for fracturing operations may only be supplied if the municipal supplier has enough withdrawal allocation remaining after planning for average and peak demand in accordance with system capacity. Second, high quality finished water commonly sold by municipal suppliers may involve an unnecessarily high cost for the oil and gas industry. Raw or grey water could be sufficient for the hydraulic fracturing process, but municipal suppliers may not have adequate supplies of raw water available. Third, municipal water supplies are usually not located near rural drilling sites, so operators must transport bulk water. Transport costs for bulk water can be large.

Cost may also affect demand for municipal water. The cost for municipal water varies greatly across the United States, with residential costs for drinking-water quality water ranging from $0.34 to $0.65 per gallon.[16] However, Range Resources, an active company in the Marcellus play, has paid between $4.00 and $30.00 per 1000 gallons.[17] Some municipal water utilities may encourage industrial use by charging lower rates for larger withdrawals, while utilities in water-scarce regions may charge more.

Groundwater provides still another option. Like surface water, groundwater withdrawals of 100,000 GPD or more, and consumptive withdrawals of 20,000 GPD or more based on a 30-day average, must be approved through the applicable river basin commission. The same decision criteria that are used to evaluate withdrawal applications for surface water apply to groundwater, but the SRBC institutes additional requirements. An applicant that applies to withdraw groundwater from the Susquehanna River Basin must conduct a 72-hour, constant rate aquifer test to determine the availability of water during a 1-in-10 year recurrence interval.[18]

Groundwater is only a practical source if significant supplies are located near the drilling site. Because of this limitation, groundwater is expected to provide only four percent of the water used for hydraulic fracturing in the Marcellus play.[19]

The challenges in using any of the four procurement options will require gas companies to apply innovative water management practices at the drilling site. Water is delivered from the source to an impoundment area or directly to the well pad by truck or pipeline.[20] If delivered to an impoundment area, water is stored in earthen holding ponds of up to five acres in surface area.[21] The holding ponds allow the gas company to withdraw from the specific source at those times when water is most available and to retain it for use during low-flow periods. When delivered to the site from the source or the impoundment area, water is stored in steel tanks until it is injected into the wellbore.

Additional state laws and drilling permit processes affecting water withdrawals

The doctrine of riparian rights and river basin commissions provide some uniformity across the major states in the Marcellus play (i.e., New York, Pennsylvania, Maryland, and West Virginia). However, each state may also have additional rules that affect water procurement. In addition, states that are not subject to DRBC and SRBC requirements may coordinate withdrawals from state waters on their own. The state-imposed drilling permits that are required for natural gas operations ensure compliance with state water laws.

In New York, gas companies are required to comply with DRBC and SRBC regulations. However, regions outside the purview of the river basin commissions must comply with regulations established by the New York State Department of Environmental Conservation (NYSDEC).[22] NYSDEC requires explicit notification for withdrawals in excess of 100,000 million gallons per day (MGD).[23] In addition, NYSDEC may also require withdrawals outside of the DRBC and SRBC to adhere to a "natural flow regime"—passby flow for reservoirs for each month of the year must be greater than 30 percent of either average daily- or average monthly flows for the river.[24, 25]

The permitting process for drilling operations in New York ensures compliance with additional laws. Applicants for drilling permits are required to submit an environmental assessment that provides information on the project and site, range of possible impacts, and whether or not the project requires additional reporting.[26] The assessment requires a description of the applicant's near-term and long-range water conservation program, including implementation and enforcement procedures, effectiveness-to-date, and any planned modifications for the future.

Similar to New York, Pennsylvania requires compliance with DRBC and SRBC rules. In addition, the *Water Resources Planning Act* requires the Pennsylvania Department of Environmental Protection (PADEP) to issue permits for any withdrawals exceeding 10,000 GPD.[27] Any commercial, industrial, agricultural or individual activity that withdraws 10,000 GPD or more, averaged over a 30-day period, must register and periodically report their water use to PADEP within 30 days of initiating water withdrawal.[28] Those activities that use less than 10,000 GPD may choose to register voluntarily to help PADEP develop a more complete picture of water use.[29]

Pennsylvania's permit application for natural gas development requires a water management plan approved by PADEP that is similar to the environmental assessment required in New York.[30] The water management plan requires well operators to provide a list of water sources with information on location, amount of water withdrawn, and type of water source. Information on location includes the municipality or county, eight-digit hydrological unit code, and identification of major river basin (i.e., Delaware, Great Lakes, Ohio, Potomac or Susquehanna).[31] In addition, the average daily quantity in GPD of water withdrawn and the maximum withdrawal rate in gallons per month, must be specified. Finally, the type of source must be specified (i.e., surface, groundwater, wastewater/mine water/cooling water discharge, public water supply).[32] A withdrawal impact analysis also requires applicants to explain how they plan to minimize impacts to fish and other aquatic life, avoid impacts to wetlands through

mitigation or other actions, and manage low-flow that could cause local impairments from wastewater treatment plant discharges, among other factors.[33]

In Maryland, state law requires any agricultural, commercial, institutional, industrial, or municipal entity withdrawing significant amounts of water to obtain a withdrawal permit.[34, 35] Entities in the Potomac River basin that apply to withdraw more than 1 MGD must withdraw less than 1 MGD during periods specified by Maryland Department of the Environment (MDE) or accept low-flow augmentation for consumptive use.[36] The MDE permitting process further insures wise-water management. Activities that require 10,000 GPD or more of surface or groundwater must obtain local land use zoning approvals, check for consistency with county water and sewer plans, submit applications for technical review, and allow MDE to perform a site inspection.[37]

Finally, West Virginia's *Water Resources Act of 2003* requires entities to notify the state if they withdraw more than 750,000 gallons in any one month. Interestingly, the law allows entities to notify the state after the withdrawal has occurred, but the drilling permit application ensures that the state knows of significant withdrawals for hydraulic fracturing before they occur. The drilling permit requires applicants to submit an addendum to the drilling permit application when planned water withdrawals exceed 5000 barrels (i.e., 210,000 gallons).[38]

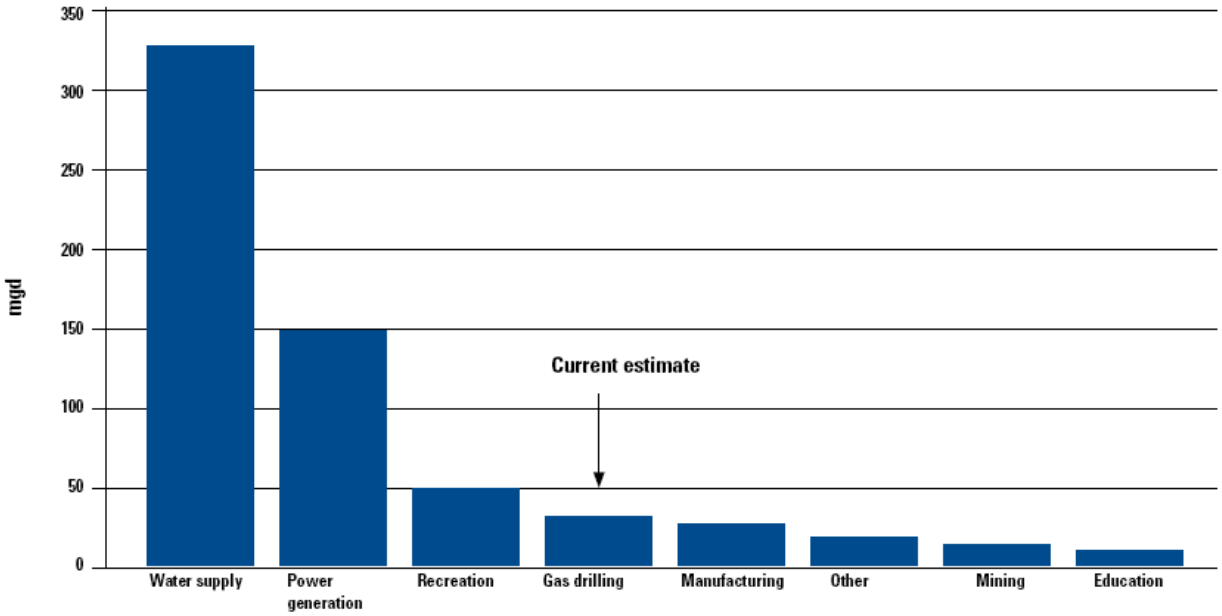
Also in West Virginia, the Department of Environmental Protection provides gas companies with a real-time "water withdrawal guidance tool." The tool allows users to select the watershed where they are permitted to withdrawal. It informs the user of whether withdrawal throughout the watershed is allowed, withdrawal in one section is allowed, or if withdrawal is not allowed due to seasonal low-flow.[39]

Assessment of degree of magnitude of water problem for shale gas development, degree of risk

The water requirements for hydraulic fracturing will increase demand from surface water, municipal supplies, and groundwater. Withdrawals for hydraulic fracturing are considered 100 percent consumptive use, meaning that withdrawn water is not returned to the same source water where it was obtained. Approximately 70 percent of injected slick water remains in the wellbore and the flowback water must be treated before it can be discharged into receiving water.

The challenge with accommodating additional consumptive water demand is to provide enough water for existing use while safeguarding the environmental integrity of the source water. In order to determine whether source water can fill projected demand, one may consider demand at regional and state levels. At a regional level, the SRBC had approved combined withdrawals of 18.1 MGD, averaged over a representative 30-day period, at 37 locations as of 2009. The SRBC further estimates natural gas withdrawals to peak at 30 MGD over a 30-day period. By comparison, water supply (325 MGD), power generation (150 MGD), and recreation (50 MGD) exceed projected additional demand for gas drilling (Figure 3.6). Similar rates are projected for the Delaware River Basin. At a state level, limited information is available. PADEP estimates hydraulic fracturing water withdrawal to total 10 billion gallons per year at peak production. In comparison, residential water use in Pennsylvania is estimated at 10 billion gallons per *day*.[40]

Figure 3.6: Estimated demand for water withdrawals from the Susquehanna River is not excessive compared to other consumptive uses.



Source: Susquehanna River Basin Commission as reported in Penn State Cooperative Extension. 2009. "Marcellus Education Fact Sheet: Water Withdrawals for Development of Marcellus Shale Gas in Pennsylvania." Available online at: http://resources.cas.psu.edu/WaterResources/pdfs/marcelluswater.pdf.

The regional and state assessments show that withdrawals for hydraulic fracturing are not expected to strain existing water supply capacities. The applications received, and volumes requested, by SRBC are consistent with historic withdrawals for natural gas development. The projected withdrawal volume, verified by actual withdrawal rates from hydraulic fracturing operations in the Barnett shale of Texas, will equal only the amount currently withdrawn from the Susquehanna River Basin in a 3-day period for power production.[41] It is important to note a few issues with these projections, however. The withdrawal estimate is based on historic use and actual withdrawals could vary greatly depending on the number of new applications received. In addition, withdrawal rates appear to be sustainable on average. Withdrawals could have significant environmental impacts if they remain at a constant rate during high- and low-flow periods or in particular areas of water shortage.

Recommendations for policy makers

The issues associated with procuring water for hydraulic fracturing suggest several recommendations for policy makers. By following these recommendations, users may receive necessary withdrawal allocations and environmental integrity may be ensured:

- **All withdrawals from all sectors (e.g., agriculture, industry, mining, recreation) should report all withdrawals**. For example, users who withdrawal below 10,000 GPD in Pennsylvania should report voluntarily to PADEP;

- **Withdrawal restrictions during low-flow periods should be strictly enforced**;

- **River basin commissions should periodically review withdrawal fees**. If withdrawals exceed basin capacity, the applicable river basin commission should consider raising rates as a means for reducing withdrawal demand;

- **Flow-management tools should be easy to use and readily available.** For example, passby-flow equations in New York should be easy to calculate. The web-based flow-monitoring system in West Virginia should be accessible at public institutions (such as libraries and municipal centers) for use by remote offices without internet access;

- **Policies for procuring water in states that have seen little demand to-date (e.g., Maryland, New York, West Virginia) should be developed in advance.** This is especially true in Maryland where the Potomac River, a major potential source of water, provides 75 percent of the Washington, D.C. municipal water supply.[42]

Endnotes to Chapter 3

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Chapter 4 – Drilling Threats to Groundwater Drinking Supplies

Shale gas development has caused wide concerns regarding the potential contamination of underground sources of drinking water during the process of well drilling and hydrofracking. Hydraulic fracturing is the process used to open the Marcellus shale formation to release its gas. The wells used to produce the gas often pass through underground sources of drinking water before reaching the shale formations, which are typically deep below the surface (usually 3,000 feet or more). The well drilling process and the recovery of gas from the well, increases the possibility for the release of contaminated water and chemicals used in the hydraulic fracturing process. There is also a concern that natural gas could somehow be released from sources deep below the surface and then rise through rock factures to reach groundwater supplies. Groundwater is often used both as a source of municipal water and the drinking water obtained by individual property owners from private wells.

In 2005, seemingly convinced that there was not a significant threat to groundwater, Congress exempted hydraulic fracturing from regulation under the Safe Drinking Water Act. Congress may also have been influenced by a voluntary 2003 agreement not to use diesel fuels as a chemical additive in the hydrofracking process. The agreement was signed by Halliburton, BJ Services, and Schlumberger, at the time the leading industry players involved with hydraulic fracturing.[1] Halliburton and BJ Services, however, recently admitted to using diesel in their subsequent hydraulic fracturing methods . Specifically, Halliburton reported using fracking combinations involving diesel from 2005-2007 in oil and gas well in 15 states. During that time period, over 807,000 gallons of seven different diesel fuels were used.[2]

The hydrofracking technique was first used in 1903, greatly improved by Halliburton Co., and employed commercially in 1948.[3] Hydrofracking was initially used in the process of drilling vertical wells designed to tap gas sources large enough to sustain production on an economic basis. In the past ten years, the use of hydrofracking has been extended to horizontal wells, opening up the possibility of economically developing natural gas trapped far below the surface in shale formations.

History of Contamination

More than 1,000 past cases of drinking water contamination are believed to be related to the historic use of hydraulic fracturing, most of which are tied to older vertical wells. Vertical wells are more land intensive than horizontal wells. On average, vertical wells on 1,000 foot spacing take up to 23 acres per well with 19% surface disturbances[4]. Horizontal drilling is considered fairly new technology and will likely be the primary drilling method in the Marcellus wells. Some states like New York have yet to see wide use of the new drilling methods, only 10% of its 2007 permits were for horizontal or directional drilling[5]. As new wells are built for the use of horizontal hydraulic fracturing procedures, some of the past concerns about groundwater contamination could subside. Besides the use of improved technology, horizontal drilling is

more effective, decreasing the overall number of wells needed per unit of gas output because they can serve a larger underground area.

Contamination incidents have been documented by courts and state and local governments. Tests from these incidents have sometimes shown high levels of benzene turning up in groundwater and stream samples. Benzene is of significance because eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, and even death. Benzene is classified as a human carcinogen and its maximum permissible limit is regulated by the EPA. Water and soil contamination are important pathways of concern for transmission of benzene contact. In the United States, 100,000 different sites have some form of benzene soil and groundwater contamination.

New York has stated in its SGEIS that only about 0.8% of the hydrofracking fluid contains benzene, but with 2-8 million gallons of water used per well, the levels of benzene present can potentially be harmful[6]. The precise compositions of these fluids are largely unknown to the public because Congress has all but completely exempted oil and gas exploration companies from the Federal Emergency Planning and Community Right to Know acts. The fracking fluid mixture is heavily protected by intellectual property laws. Thus, although tests show benzene and other carcinogens in contaminated wells, putting blame on hydraulic fracturing fluids is complicated by the fact that its exact chemical composition is still a mystery.

During the process of natural gas well drilling, groundwater protection is provided by creating cement casing barriers between the well bore and the groundwater outside of it. Some critics, however, question the ability of such methods to adequately protect drinking water sources from the effects of hydraulic fracturing [7] Even with the large number of past contaminated wells being reported to authorities, it should be noted that few direct negative human impacts can be linked to the fluid or solids injected during the hydraulic fracturing process. Significant public fears nevertheless persist, partly attributable to a series of events in which unplanned releases have occurred and other parts of the drilling process have not worked as the natural gas industry had promised. The recent huge oil spill in the Gulf of Mexico, following an April 20 gas explosion at an offshore well, has further reduced public confidence in the safety procedures and the public promises of the oil and gas industry.

Gas industry activities not now regulated by the Safe Drinking Water Act include: oil and gas production activities, surface discharge, hydraulic fracturing related to energy production, and natural gas storage. Although EPA does not regulate these activities, the states themselves still are free to do so if they wish. Some oil and gas producing states do regulate some aspects of the hydraulic fracturing process. Typically, however, they do not require companies to provide detailed information on types and quantities of the chemicals injected. Such information is considered a trade secret which is tightly protected by the companies involved.
In October 2008, legislation was introduced to end the 2005 Congressional exemption of hydrofracking from the Safe Drinking Water Act. In June 2009, the Fracking Responsibility and Awareness of Chemicals -- also known as the FRAC ACT -- was introduced. The prospect of future tighter regulation is increasingly recognized among oil and gas producers. Exxon Mobile negotiated the right to back out of a deal to buy XTO Energy if Congress passes a law to

make hydraulic fracturing illegal or commercially impractical.[8] Some parts of the industry may be seeing regulation in a more favorable light because one bad actor (e.g., BP in the Gulf of Mexico) can impose very large costs on the rest of the oil and gas industry.

Recent Contamination Incidents

Some are attributing growing calls for federal oversight to recent drilling-related accidents connected to Cabot Oil & Gas in Pennsylvania. Some critics of hydraulic fracturing even see the actions of Cabot single-handedly jeopardizing the development of Marcellus shale. In September 2009, Pennsylvania's Department of Environmental Protection (PA DEP) banned Cabot Oil & Gas from using hydraulic fracturing following three chemical spills at a single well-site in Dimock.

Later that year in November, the agency signed a consent decree with Cabot agreeing to pay a $120,000 fine, take steps to improve its drilling operations, and replace or restore the affected water supplies in Dimock Township. More than a dozen families have filed a federal lawsuit against Cabot asking for environmental clean-up, medical monitoring and additional damages in excess of $75,000 for each family.[9]

In April 2010, Cabot Oil & Gas was also ordered by the PA DEP to plug a well and pay large fines for contaminating local drinking water in Dimock Township. The settlement requires Cabot to permanently shut down some of its wells, pay $240, 000 in fines, pay $30,000 a month until all obligations are met, and permanently provide drinking water to affected families. ibid

PA DEP announced that it is suspending its review of Cabot's pending applications for new drilling permits across the state and will not allow the company to drill any new wells at all in the Dimock area, even those already permitted for 12 months. Despite their problems, Dimock has proven valuable to Cabot. The Dimock fields accounts for 15% of the company's gas assets and are its second largest development area. ibid Cabot had planned to drill 100 new wells in Dimock in 2010 alone. Surprisingly enough, Cabot's CEO doesn't expect the PA DEP's order to affect its overall gas production. Cabot's defense rests on the possibility that the high levels of methane detected in the wells near its drilling sites were caused naturally. Cabot's spokesperson contends that it could take years before experts can say what is causing methane levels to spike.

A recent controversy in Fort Worth surrounding Barnett Shale gas development has also heightened the concerns of environmental critics relating to public health impacts of hydraulic fracturing. New findings show that levels of hazardous chemicals, including benzene and other carcinogens, can reach alarmingly high levels in the area around some Ft. Worth well sites. However, the Texas Commission on Environmental Quality released test results conducted on 126 well sites that showed no hazardous chemicals exceeding commission standards. Opponents argue that the tests represent a one-day snap shot of a test performed in cold temperatures that are known to give misleading results. Temperatures have to be warm enough for chemicals to evaporate and give an accurate reading of their presence in the air surrounding the well.

On March 18, 2010, the U.S. Environmental Protection Agency announced that it would conduct a nationwide scientific study to determine what problems may be caused by the practice of injecting chemicals and water underground to fracture gas-bearing shale rock. The study is in response to concerns about drinking water and other forms of environmental contamination believed to be related to the large amounts of water and chemicals injected deep underground in the hydraulic fracturing process.

In 2004, research was conducted on the impacts of hydraulic fracturing of coalbed methane on underground sources of drinking water. EPA concluded that it could find no confirmed cases that could link hydraulic fracturing to drinking water well contamination. This study was used by the Bush Administration and Congress to justify legislation exempting hydraulic fracturing from oversight of the Safe Drinking Water Act[10]. The new EPA study should add insight into the hydraulic fracturing debate. Unlike the 2004 study, the 2010 version will address natural gas drilling in shale formations. Unfortunately, the EPA effort is just beginning, and definitive results will probably not be available for one or two years.

Environmental NGO Concerns Raised

A number of environmental nongovernmental organizations have stated their concerns about the impacts of hydraulic fracturing on water supplies. Many have recently come forward, reasserting their disapproval for current exemptions from federal laws and regulations given the oil and gas industry. They are calling for a comprehensive look by EPA's Science Advisory Board on hydraulic fracturing effects on public health and drinking water in EPA's recently announced study. Some of these NGO's have included Earthworks and Clean Water Network.

Earthworks included recommendations asking that the future EPA study focus on actual fracking operations, water quality, post-fracking activity, preventing those with financial interest in the study's outcome from carrying out or reviewing the study, and analyzing risks posed to public health and drinking water from short-comings in current legislation. They are calling for the use of verified science to be used in the study and forthcoming recommendations.

Earthworks representatives also questions the desirability of drilling in the New York City watershed in the Catskills. Chesapeake Energy, leaseholder for land in the watershed, understands the public preference to not risk public drinking water for more natural gas. The future of the watershed has received so much attention because it provides over 9 million people with clean, untreated water. Although Chesapeake Energy has opted out of drilling in the watershed, Earthworks responded with a statement that "welcome and unenforceable declarations aside, the greater issues of permanent protection for the watershed and an unregulated polluting technology with a checkered history remain."[11] Earthworks has also encouraged Chesapeake to "walk their talk and relinquish their leases in the watershed so that the area can be permanently protected" and "support the FRAC Act, so that in areas where drilling is appropriate, the public can have greater assurance that oil and gas drilling is done right." ibid

The Clean Water Network (CWN) is asking that EPA's new study adequately take into account baseline data. A lot of information can be gained from knowing the hydrologic and

environmental conditions prior to drilling. CWN wants EPA to consider how aquifers and shale formations will change over time. Also, as hydraulic fracturing procedures differ in the mining of different types of shale, they would like the EPA to investigate how the stages of hydraulic fracturing vary in different regions of the country.

Pennsylvania's State Regulatory Regime

Pennsylvania is clear that it will not follow in the footsteps of New York, by imposing a moratorium on Marcellus shale development. For the most part, the state has relied on self-regulation of drilling practices. In response to public inquiry on the impacts to drinking water, the state promised to be more vigilant in the drilling process. The state will make increased efforts to strictly enforce its rules because it finds that "self-regulation doesn't work."[12] Secretary Hager of the PA DEP says he is erring on the side of caution, taking precautionary steps to prevent water supplies from contamination. He believes that this extra effort to better protect against negative groundwater and other environmental impacts associated with Marcellus shale gas development will not overwhelm the large benefits now being realized by the State.

In efforts to keep up with the growing industry the Pennsylvania Department of Environmental Protection in 2010 announced that it would double its enforcement staff, open a new office closer to the drilling action, and release new drilling regulations. In 2008, there were only 35 staff personnel overseeing 74,774 wells. In 2009, that number was increased to 76. [13] The Bureau of Oil and Gas Management now plans to add 68 people to its staff paid for with the revenue received from drilling permit fees. Forty-five of the new hires will be added to the oil and gas staff, increasing its workforce to 121.

Assessment of Degree of Contamination Risk to Groundwater

There are varying views with regards to the degree of risk facing underground sources of drinking water. Consumers and government officials alike are not willing to move forward with producing Marcellus shale gas without knowing if hydraulic fracturing puts air quality and drinking water sources at risk of contamination. Assessing the risks is complicated by the recent development and use of horizontal drilling and hydrofracking methods. In the Marcellus formation most such wells have been drilled in the past five years, and the largest number in just the past two years. This provides a small base of experience relative to the much larger number of horizontal Marcellus wells expected to be drilled in the next decade.

Many of the past contamination incidents occurred in the past involving different shale beds, drilling methods and regulatory regimes. Hydrofracking is also used in the production of coal bed methane which has also experienced widely publicized contamination events. Methane production, however, differs in important ways from shale gas production (coal beds are typically much closer to the surface, for example, than shale beds) and the relevance of existing methane development experience is uncertain.

Most stakeholders agree that production of shale gas in the Marcellus formation should and will happen. Recent Marcellus contamination incidents have aroused public fears of the unknown –

even as the damages to human health and structures so far have not been large. Many would feel more comfortable and give greater support to such production if the full impacts to drinking water were better understood and explained . The natural gas industry has an important role to play in this regard, a fact better recognized at present by certain gas producers than others.

Policy Recommendations

- **Federally require the disclosure of the fracking fluids chemical composition.** States are allowed to regulate and oversee natural gas production. Keeping the chemicals secret prevents the state from effectively protecting the public from emerging risks.

- **Establish a comprehensive penalty system.** Lack of federal regulation, has allowed many of the companies involved to take a lax approach with keeping its promises. There may not be proof that hydraulic fracturing contaminates underground drinking water sources but there is proof that several of these companies have lied to federal authorities on their use of diesel in their fracking fluids and in other ways have behaved in a deceptive manner.

- **Emphasize the importance of spill response plans.** There is risk in all oil and gas extraction activities. Safety and environmental regulations are designed to minimize risk, but in the event that accidents occur, industry and government must be prepared to respond.

- **Privately support further research into contamination risks.** The oil and gas industry should work with university and other independent experts to assess the risks to groundwater from shale gas drilling and production. This research can supplement the current EPA study (which may not be officially released in time to contribute to some pressing public decisions).

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Chapter 5 – Disposal of Flowback Water

By 2011 twenty million gallons of contaminated wastewater—enough to fill 29 Olympic-size swimming pools—could be produced each day in Pennsylvania as a result of hydraulic fracturing.[1] For this reason, it is likely that wastewater management will be the most contentious environmental issue associated with hydraulic fracturing in the Marcellus shale states. Stakeholders, including gas companies, regulators, investors, and environmentalists, all want to know how the wastewater is produced, what it contains, what it can do to humans and the environment, what can be done to minimize it, and what can be done to treat it.

Sources of flowback water

In the hydraulic fracturing process to produce natural gas from shale formations, a fracturing engineer injects "slick" water—water combined with chemical proppants and sand—at high pressure into a horizontal wellbore. Each well requires 2.4 to 7.8 million gallons of slick water, which is enough to fill four to 12 Olympic-size swimming pools.[2] Despite the fact that slick water is approximately 99.5 percent pure water and sand (Table 5.1), between 12,000 and 39,000 gallons of chemicals are injected into each well.

Table 5.1: Slick water is 99.5 percent water and sand and 0.05 percent proppant compounds.

Product category	Main ingredient	Purpose	Other common uses
Water	99.5 percent water and sand	Expand fracture and deliver sand	Landscaping and manufacturing
Sand		Allows the fractures to remain open so the gas can escape	Drinking water filtration, play sand, concrete and brick mortar
Other	**Approximately 0.5 percent**		
Acid	Hydrochloric acid or muriatic acid	Helps dissolve minerals and initiate cracks in the rock	Swimming pool chemical and cleaner
Antibacterial agent	Glutaraldehyde	Eliminates bacteria in the water that produces corrosive by-products	Disinfectant; Sterilizer for medical and dental equipment
Breaker	Ammonium persulfate	Allows a delayed break down of the gel	Used in hair coloring, as a disinfectant, and in the manufacture of common household plastics
Corrosion inhibitor	n,n-dimethyl formamide	Prevents the corrosion of the pipe	Used in pharmaceuticals, acrylic fibers and plastics
Crosslinker	Borate salts	Maintains fluid viscosity	Used in laundry

		as temperature increases	detergents, hand soaps and cosmetics
Other	**Approximately 0.5 percent**		
Friction reducer	Petroleum distillate	"Slicks" the water to minimize friction	Used in cosmetics including hair, make-up, nail and skin products
Gel	Guar gum or hydroxyethyl cellulose	Thickens the water in order to suspend the sand	Thickener used in cosmetics, baked goods, ice cream, toothpaste, sauces and salad dressings
Iron control	Citric acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice ~7% citric acid
Clay stabilizer	Potassium chloride	Creates a brine carrier fluid	Used in low-sodium table salt substitute, medicines and IV fluids
pH adjusting agent	Sodium or potassium carbonate	Maintains the effectiveness of other components, such as crosslinkers	Used in laundry detergents, soap, water softener and dishwasher detergents
Scale inhibitor	Ethylene glycol	Prevents scale deposits in the pipe	Used in household cleansers, de-icer, paints and caulk
Surfactant	Isopropanol	Used to increase the viscosity of the fracture fluid	Used in glass cleaner, multi-surface cleansers, antiperspirant, deodorants and hair color

Source: Hydraulic fracturing facts. Available online at http://www.hydraulicfracturing.com/Fracturing-Ingredients/Pages/information.aspx

Slick water is used to expand fractures in the shale created during the fracturing phase of the operation* and is kept in the wellbore at high pressure for five to ten days. When finished, the fracturing engineer releases the pressure on the wellbore, causing flowback water to flow rapidly up toward the wellhead. As much as 60 to 130 gallons per minute exit the wellbore with 60 percent of the total flowback water returning in the first four days after pressure is released.[3] Of the slick water that is injected into the wellbore, 9 to 35 percent will return to the surface as flowback.[4] For a wellbore that contained 2.4 million gallons of slick water, a nine percent return would generate 216,000 gallons of wastewater. If 7.8 million gallons were injected and 35 percent returned, the total amount of wastewater would be 2.7 million gallons. Some of the remaining water and chemical mix returns to the surface slowly over several months, but most remains permanently in the horizontal chamber.

* Explosives perforated the cement well casing and shale formation during the fracturing phase.

Flowback water contains chemical compounds from both injected slick water and the natural shale formation. These can significantly impact human health, aquatic health, and ecosystems. Many chemicals, such as benzene, ethylbenzene, toluene, xylene, and naphthalene, are carcinogenic at certain levels of concentration and exposure in humans.[5] Compounds such as total dissolved solids, or TDS (i.e., salts), acquired from the shale formation are toxic to many aquatic species and ecosystems. Striped bass spawning, for example, is reduced at TDS concentrations of 350 parts per million (ppm), while flowback water contains TDS concentrations of 105,000 ppm.[6, 7] Beyond these chemicals and compounds, flowback water can contain naturally-occurring radioactive materials acquired from the shale formation. In New York the Department of Environmental Conservation (NYSDEC) found levels of radium-226 thousands of times higher than the limit for safe drinking water in representative flowback water samples.[8]

The chemicals and properties in flowback water have the potential to dramatically impact receiving waters. In Pennsylvania, for example, the Pennsylvania Department of Environmental Protection (PADEP) fined Range Resources $23,500 for spilling 4,200 gallons of wastewater into a tributary of Cross Creek Lake near Pittsburgh in May 2009.[9] The PADEP report states that "The entire creek was walked down to the mouth to Cross Creek Lake. The creek was impacted by sediments all the way down to the lake and there was also evidence of a fish kill as invertebrates and fish were observed lying dead in the creek."[10] In another incident, a gelling agent called LGC-35* was spilled by Cabot Oil and Gas near Dimock, Pennsylvania in September 2009.[11] Approximately 5,000 gallons of gel mixture† containing human carcinogens were spilled in total.[12]

Laws governing flowback water management and sector compliance

Because of the potential impacts of flowback water, proper management is critical and required by law. At the federal level, the Emergency Planning and Community Right-to-Know Act (EPCRA), Clean Water Act (CWA), and Safe Drinking Water Act (SDWA) all impact flowback water management. In addition, major Marcellus shale states, including Maryland, New York, Pennsylvania, and West Virginia have their own laws to ensure human health and protect ecosystems.

Emergency Planning and Community Right-to-Know Act

The Occupational Safety and Health Administration requires a material safety data sheet (MSDS) with chemical information for each substance used during the hydraulic fracturing process. The EPCRA requires facilities that must develop MSDS to release them to State Emergency Response Commissions (SERC), Local Emergency Response Commissions (LERC), and local fire departments.[13] The information is required to evaluate chemical components in chemical spills, identify specific chemicals causing damage to humans and animals, identify chemicals in spills into surface water and groundwater resources, and identify chemicals in drinking water resources**.**[14] In addition, EPCRA reporting provides transparency necessary to

* The gel mixture was developed by Halliburton and is contained in flowback water,
† The mixture was concentrated at 5 gallons gel to 1,000 gallons water,

enforce the CWA, SDWA, and state laws. Since flowback water contains many of the chemicals that were initially injected into the well, MSDS and EPCRA requirements are important for its effective management.

Companies may apply for exemptions from the MSDS and EPCRA requirements if their substances are trade secrets. Specific chemical components of hydraulic fracturing materials must be reported to the SERC and LERC, but the public must only have access to the object class.* Such ambiguity jeopardized a Colorado woman's health in August, 2008.[15] Cathy Behr, an emergency room nurse in Durango, faced multiple organ failure after treating a wildcatter who had been splashed with hydraulic fracturing fluid at a BP natural gas rig.[16] Doctors could not derive the specific chemical components of the fluid from the available MSDS, and had to wait weeks to receive them from the manufacturer. Even then, the doctors were not allowed to discuss the chemicals with the patient.

Clean Water Act

The CWA's National Pollutant Discharge Elimination System (NPDES) regulates pollutant discharges from discrete conveyances (e.g., pipes, ditches) into surface waters. The NPDES program attempts to achieve water quality goals through cooperative engagement between the federal Environmental Protection Agency (EPA) and state environmental regulatory agencies. The EPA sets the parameters of the permit application process and establishes national effluent limitation guidelines (ELGs) for selected pollutants from industrial wastewater treatment plants.[17] State governments establish water quality standards that contain a designated use and quantitative water quality criteria. The criteria evaluate whether or not the water body achieves its designated use.

All shale gas facilities, including drilling sites or facilities that receive wastewater from drilling sites, must obtain NPDES permits to discharge into receiving waters. Permit applicants may apply to their state environmental regulatory agencies when the state is granted authority to manage the permitting process.[18†] A permit writer that reviews the application establishes permit conditions, the most important being whether technology-based effluent limits (TBELs) are sufficient to achieve water quality criteria. If they are not sufficient, the permit writer must require more stringent water-quality based effluent limits (WQBELs).The TBELs and WQBELs differ for municipal and industrial wastewater treatment plants. Municipal treatment plants must have secondary treatment that degrades the biological components of human sewage. If the receiving water is impaired for pollutants other than those found in biological waste, such as heavy metals or TDS, the municipal treatment plant may be subject to additional standards through WQBELs.

Conversely, TBELs for industrial wastewater treatment plants are established through ELGs. The ELGs are industry-specific and based on the amount of pollutant that could be removed from the most-advanced treatment technology available in the industry. However, the ELGs do not mandate a specific technology; rather they allow the regulated facility to choose the compliance

* e.g., friction reducer, clay stabilizer

† Forty-six states have authority to manage the NPDES permit process. All Marcellus play states have authority.

option that works best for it while still achieving the required discharge. Such flexibility is intended to lower costs for regulated sources and spur competition among firms that produce treatment technologies.

U.S. water bodies are much cleaner than they were in 1972 when the CWA was passed. However, the law has yet to achieve its goal of making all U.S. waters "fishable and swimmable" in part due to challenges of enforcing such an ambitious act.[19] The challenges of enforcing the CWA for hydraulic fracturing activities demonstrate the difficulty of achieving the CWA goal. For example, municipal plants that are equipped primarily to treat sewage, and industrial plants that may receive flowback water containing chemicals that are not reported in MSDS, may not have the proper technologies in place to process the flowback water.[*] In addition, those treatment plants that are equipped to treat flowback water may already be operating at capacity and therefore unable to accept more wastewater.[20]

The CWA contains a provision that is intended to overcome the treatment technology challenge. The National Pretreatment Program (NPP) requires industrial dischargers that send effluent to municipal treatment plants to process it to levels that can be safely treated by the receiving plant. The requirements are intended primarily to reduce TDS concentration. In addition, local communities and private gas companies appear to be adding capacity to treat anticipated volume increases. PADEP recently permitted three new plants with combined treatment capacity of 2.9 million gallons per day.[21] The permit for TerrAqua Resource Management LLC of Williamsport requires TDS treatment to 500 ppm and chloride and sulfate treatment to 250 ppm. The permit also requires TerrAqua to monitor for radioactivity, barium, strontium, iron, manganese, aluminum, toluene, benzene, phenols, ethylene glycol, and surfactants.

Despite additional CWA programs and increased capacity, challenges stemming from high wastewater volumes and unclear chemical mixes remain. Such challenges recently contributed to a CWA violation in Jersey Shore Borough, Pennsylvania. Between 2008 and 2009, a sewage treatment plant in Jersey Shore Borough attempted to treat more than the 50,000 gallons per day of flowback water than it was permitted to accept on more than ten occasions. PADEP ordered the plant to stop accepting flowback water immediately and to pay a $75,000 fine.[22] In another violation demonstrating pretreatment and volume challenges, the owner and site supervisor for Swamp Angel Energy dumped 200,000 gallons of flowback water down an abandoned well in Alleghany County because they apparently had nowhere else to put it. The two men are awaiting trial but could receive three years each in prison and a fine of $250,000.[23]

[*] The New York City Department of Environmental Protection (NYCDEP) made these [illegible] NYSDEC's *Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program (dSGEIS)*. NYCDEP challenged the dSGEIS conclusion that wastewater treatment facilities would be able to accommodate the treatment and release of any pollutants contained in flowback water. NYCDEP forecasts that new facilities or upgrades will be required to handle additional waste.

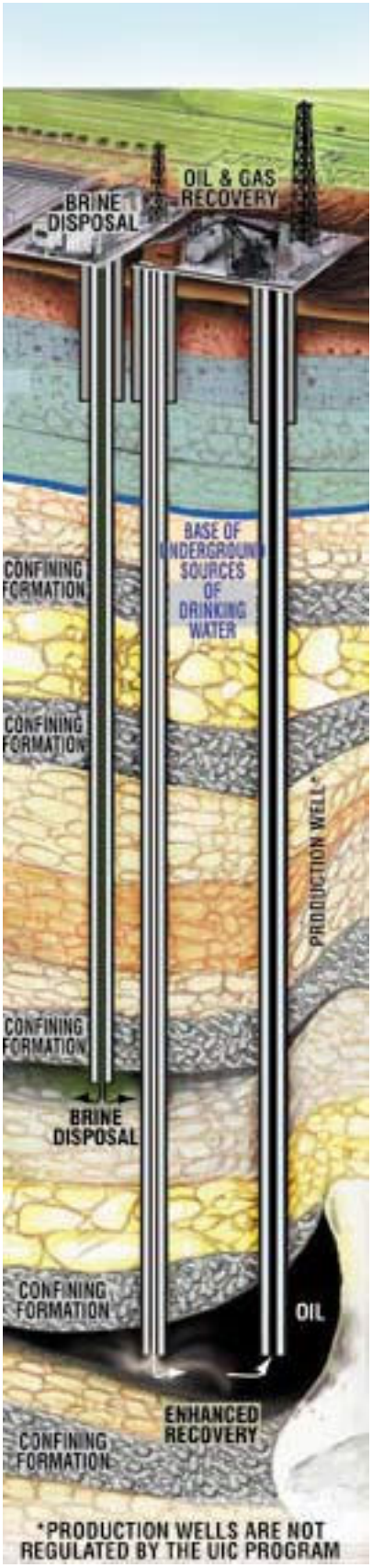

Figure 5.1 Injection Wells used for Production

Safe Drinking Water Act

The SDWA is the final federal law governing flowback water management. It establishes the Underground Injection Control (UIC) program, which regulates waste injections into six categories of wells. The UIC regulations are designed to ensure that injected gases and wastewater do not migrate upward and pollute groundwater. Class II wells are the most relevant to underground storage of flowback water (Figure 5.1). Other sections of the law, such as those that regulate water injected into the wellbore during the fracturing process, are discussed in Chapter 4.

Underground injection is a standard process for dealing with flowback water in other regions where shale gas occurs (such as the Barnett shale of Texas). However, injection well capacity in the Marcellus shale region is extremely limited. In Pennsylvania, for example, eight permitted disposal wells may each accept an average of 42,000 gallons per day.[24] Due to limited capacity, underground injection is not expected to be a viable option for managing flowback water in the Marcellus play. There is little additional opportunity to dispose of flowback water other than to transport it to states outside of the Marcellus play.

State laws

In addition to the ECPRA, CWA, and SDWA, individual states may have their own water quality laws. Gas companies must comply with state and local laws and regulations when drilling.

- Maryland prohibits any wastes that would be toxic to residents or impair navigation to be discharged into receiving waters.* In addition, Maryland expressly forbids any underground injection of wastes.[25] The state's expectations are that gas companies will transport their flowback water out of the state for disposal rather than find in-state solutions.[26]

- New York prohibits discharge of radioactive waste into receiving waters through its Environmental Conservation Law † Flowback water with high radium-226 levels could be regulated under the law.

- Pennsylvania requires additional treatment for residual wastes under its Solid Waste Management Act. Drill cuttings from oil and gas mining are omitted, as long as they are disposed of properly at the rig.[27]

- West Virginia does not have additional wastewater treatment or management laws beyond the CWA. However, West Virginia Department of Environmental Protection's "Oil and Gas Industry Guidance" suggests that gas companies consider recycling flowback water as a means of dealing with waste.[28]

Flowback water treatment options

Due to CWA rules affecting pretreatment and direct discharge into receiving waters, SDWA requirements and limited underground injection capacity in Marcellus shale states, and the varied state laws, wastewater treatment plants and gas companies must invest in treatment technologies.

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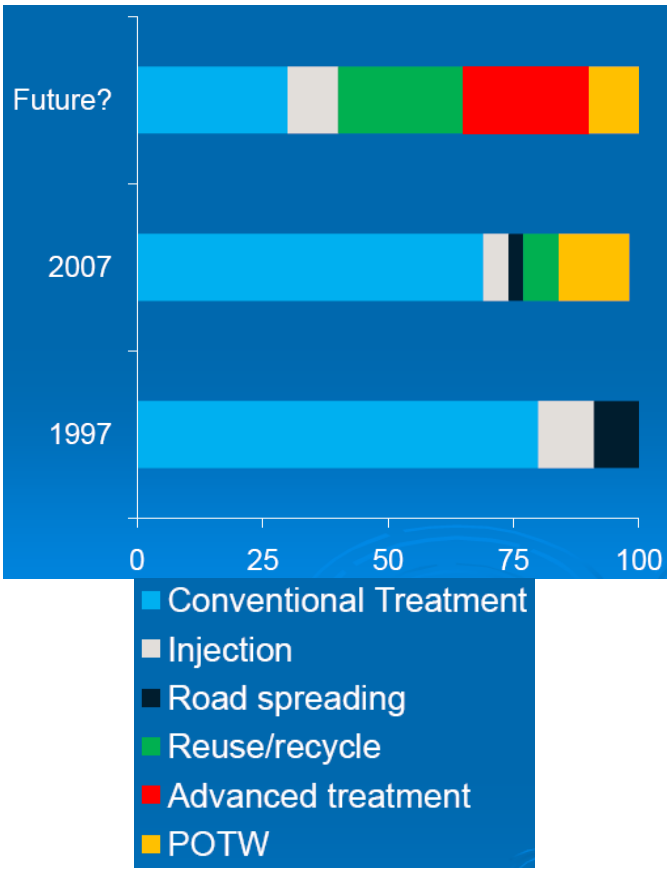
* Expressly prohibited by COMAR 26.08.03.01 are:
1. Substances which accumulate to toxic amounts during the expected life of organisms in the surface water, or
2. Substances which produce deleterious behavioral effects on the organisms;
3. The discharge of any radiological, chemical, or biological warfare agent;
4. The discharge of any high level radioactive waste;
5. Any discharge which would substantially impair anchorage and navigation;
6. Any discharge to which the Administrator of the Environmental Protection Agency has objected in writing under the Federal Act;
7. Any discharge which is in conflict with a plan approved by this State;
8. The discharge of sewage from vessels while moored, berthed, or docked in waters of this State except through a federally and State-approved marine sanitation device;
9. The discharge of sewage or other wastes from vessels to the waters of Deep Creek Lake in Garrett County, Maryland; and
10. The discharge of sewage from vessels to the waters of this State, designated as restricted zones.

† "…the discharge of any radiological, chemical or biological warfare agent or high-level radioactive waste, as such terms are defined by the Act or pursuant thereto." §17-0807 of the Environmental Conservation Law

Many treatment facilities are exploring these technologies, as demonstrated by expanded recycling and reuse and less reliance on conventional treatment (Figure 5.2).

Figure 5.2: Flowback Water Treatment options are expanding.



Source: Swistock, Bryan. 2010. "Water Issues Related to Marcellus Gas Drilling Activity. Available online at http://www.empoweredmunicipality.com/library/files/PSATSApril2010-Marcellus.2.pdf

A main option for gas companies is to recycle or reuse flowback water. Any remaining water should be pretreated or treated by wastewater treatment plants for TDS and additional chemical discharge restrictions (if such restrictions exist considering lack of available chemical components from MSDS). Various technologies exist to fill the needs of gas companies and wastewater treatment plants.

Recycling

Gas companies that recycle flowback water may need to treat it to a minimum level of quality. Figure 5.3 shows the difference between conventional limits for water treatment and characteristics of flowback water.

Figure 5.3: Recycled flowback water may need treatment.

Parameter	Conventional limits	Blended Marcellus water
pH	6.0 to 8.0	1,500 mg/L
Chlorides	<25 mg/L	1 million/100 mL
Iron	<50 mg/L	Ca – 4,200 mg/L, Mg – 488 mg/L,
Ca, Mg, Ba, SO_4	<100/100 mL	Ba – 39 mg/L, SO4 – 124 mg/L
Bacteria count	*f*(P,T,pH) (+/- 350 mg/L)	14.5 mg/L
Suspended solids	<20 mg/L	26,000 mg/L
Oil and soluble organics	<20,000 mg/L	4.6 mg/L

Source: Guadlip, Tony, et al. 2008. *Marcellus Shale Water Management Challenges in Pennsylvania*. Paper for presentation at the 2008 Society of Petroleum Engineers Shale Gas Production Conference, Fort Worth, Texas, U.S.A., 16-18 November 2008.

Most recycling efforts focus on removing total dissolved solids (TDS), including chlorides and calcium. Selected technologies to remove TDS include:[29]

- *Reverse osmosis*: The reverse osmosis process forces wastewater through a selective membrane, yielding high concentration and low concentration solutions. The low concentration solution may require finishing through pH stabilization or mineralization. The high concentration solution is a waste product and must be disposed.
- *Nanofiltration*: Nanofiltration is similar to reverse osmosis, but requires less energy. Approximately 75 to 90 percent of the feed water is recovered, so minor amounts of high concentration brine is produced.
- *Electrodialysis*: The electrodialysis process treats water as it flows between a stack of anion- and cation-exchange membranes. The membranes work together to systematically concentrate pollutants. System costs are high but recovery rates are significant, with nearly 90 percent of feed water consistently reclaimed.

Freeze thaw

The freeze thaw process begins when freezing water below 32°F is sprayed into an ice pile. Runoff contains high TDS concentrations when the ambient temperature is freezing or below. Conversely, runoff contains low TDS concentrations when the ambient temperature is above freezing. The limiting factors to using freeze thaw technology are the climate of the region where it is used and the large area it requires. A 1,000 barrel per day facility would require tens of acres for treatment. *An additiona*l recycling option still in development would use acid mine drainage (AMD) as a source of water for hydrofracking. AMD is abundant in former coal-producing regions such as the northeast United States because it forms when coal mining exposes rainwater and groundwater to pyrite and other chemicals. The resulting fluid is high in sulfuric acid, iron

hydroxide, sulfates, and suspended solids. If left untreated, runoff into water bodies causes metal oxides to form an impervious surface on the bed of receiving water. The impervious surface destroys the aquatic ecosystem.

Researchers at Carnegie Mellon University recently received a $1 million grant from the U.S. Department of Energy to explore using acid mine drainage to remove electrochemical cells to achieve minimum water quality requirements necessary to use for hydraulic fracturing.[30] In addition, at least one water reclamation company, STW Resources, has adapted the large-scale acid mine drainage treatment process for use at drilling operations. Large treatment plants normally oxidize the acid mine drainage in lagoons and alter the pH level by adding lime and other base chemicals. The STW process completes the same process in a mobile unit. The unit can handle 360,000 gallons per day and costs are mitigated substantially by government grants and subsidies.[31]

Reuse

Water that meets minimum criteria may be simply reused. Range Resources announced in October 2009 that it would reuse 100 percent of the flowback water from its operations in Washington County, Pennsylvania.[32] Reusing does not produce any concentrated brine that must be disposed. However, it is important to note that, while 100 percent of reclaimed water will be recycled, only nine to 35 percent of water injected into a wellbore comes back to the surface.[33]

Evaporation In western states drillers often leave flowback water in a lined pit and allow it to evaporate naturally (Figure 5.5). The resulting solid residue is composed mostly of TDS and can be sold to local governments for cold weather road treatment or disposed of as a solid under applicable laws.

Figure 5.5: Evaporation pits are used to manage flowback water in Western states.

Source: Gaudlip, Tony. “Preliminary Assessment of Marcellus Water Reuse.” 2010

Several factors make natural evaporation an unlikely option for flowback water management in the Marcellus play. First, western states are able to utilize evaporation thanks to the hot and dry climate of the region. The cooler and more humid climate of northeastern states will not evaporate wastewater as quickly. In addition, laws in New York and Pennsylvania restrict the ability to build pits and retain wastewater. New York, for example, requires flowback water to be removed from the well pad site within 45 days after operations have ceased.[34] Pennsylvania limits each impoundment to a 250,000-gallon capacity and limits total site impoundments to 500,000 gallons.[35] Depending on the amount of injected water recovered, flowback water could consume available storage space. Additional temporary storage, including stainless steel containers, may be necessary to hold remaining wastewater.

Recommendations

A review of the components of flowback water, impacts on humans and ecosystems, laws governing flowback water management, and treatment options reveal several issues that merit policy development or need further evaluation. If appropriate policies and regulations are followed, hydraulic fracturing operations can contribute to state economies and minimize impacts to human health and ecosystems:

- **Remove the proprietary chemicals exemption from EPCRA**. Policy makers should ensure that the information necessary to protect people during emergencies and enforce laws such as the CWA and SDWA are available to the public. Progress appears to be occurring on this issue. The Chairperson of the House of Representatives Energy and Commerce Committee and the Chairperson of the Subcommittee on Energy and Environment began to investigate hydraulic fracturing processes through a memorandum issued on February 18, 2010. [36] The memorandum noted "Federal regulators currently do not have access to a full accounting of the types and quantities of chemicals used in hydraulic fracturing fluids… under the [EPCRA] approximately 22,000 industrial and federal facilities must report to EPA the quantity of toxic chemicals they release, store, or transfer… Oil and gas exploration and production facilities are exempt from this reporting requirement."

- **Ensure that NPDES limits contain discharge limits for all flowback chemicals and not just common TDS**;

- **Ensure that ELGs adequately reduce all flowback chemicals to safe discharge levels**;

- **Re-evaluate whether or not municipal wastewater treatment plants that are designed to treat sewage should also be allowed to treat flowback water**;

- **Continue to build additional treatment capacity**. Treatment plants that are owned by local governments should not finance all expansion; rather companies should help finance themselves or severance taxes on natural gas extraction should help pay;

- **Review the moratorium on underground well injection in Maryland**;

- **Ensure that states beyond New York to regulate radioactive materials**;

- **Promote alternative treatment technologies including the acid mine drainage technologies developed by Carnegie Mellon University and STW Resources**;

- **Promote reuse like the process pioneered by Range Resources**; and

- **Review the New York and wastewater removal and impoundment laws**. Such laws could restrict wide-deployment of cost-effective wastewater treatment options.

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Part III – Impacts on Property Owners and Local Communities

Chapter 6 – Mitigating Transportation Impacts

Future shale gas development in the Marcellus shale gas play on the scale now expected will have many significant effects on local communities. Some of these will be positive such as increased retail revenues, tax revenues, and other boosts to the local economy as well as increases in income to recipients of shale gas lease bonuses and royalties. Others will be negative such as the increases in truck traffic, disruptions due to pipeline construction, adverse visual impacts of well drilling activities, and other forms of local disruption of normal activity. There may be significant distributional impacts as some local individuals are positively affected while others are negatively affected. Policies to address local impacts of shale gas development – both maximizing the positive and minimizing the negative elements – can play an important role in maximizing the overall social gains from shale gas development.

Local transportation impacts, including increases in traffic volumes, air and noise pollution, and the wearing down of roads, among others, will be among the most important. . The largest nuisance impacts – traffic, air and noise – are typically limited to the first 20 to 30 days of the drilling process and its completion period. This increased traffic may cause road disturbances, the results of which would last until the roads are repaved. In fact, damages to local roads are one of the greatest negative consequences that shale gas drilling will have on municipalities.

In the Town of Cochecton, New York, local roads have suffered from large cracks and other damages as a result of the increased hauling of heavy equipment – upwards of 160,000 pounds – for drilling. As highway superintendent Brian DuBois puts it, "Town roads just can't take that weight."[1] Even though trucks that outweigh state weight limits need special permits to travel on town roads, this has not prevented any damage. However, even in the presence of weight limits, enforcement and monitoring can be difficult. A natural gas industry service truck in Pennsylvania was fined more than $25,000 for being more than 41.6 tons over the limit of 10 tons, after initially being charged with parking illegally.[2] Another company was fined $31,304 in Towanda, PA, for being oversized and 49.7 tons overweight.

Joseph Latona, of Latona Trucking, sees a need for enhanced enforcement as a result of rapid growth in the amount of truck traffic due to shale drilling activities. With so many trucks hauling equipment back and forth, "[a] lot of people are abusing it. A lot of people ain't getting permits."[3] Trucking companies, however, state that the police are now increasingly cracking down on enforcement.

The economic impact of road damages can be substantial. Recently in Pennsylvania, damages have been reported on Routes 44 and 144, both of which are used regularly by the public and are essential for trucking materials to and from drilling sites. In this case, some gas companies have shown their willingness to fix the roads that its trucks have damaged.[4] The permanence of the pending repairs is uncertain because damages may not be limited to the surface – instead, sometimes "the very foundations of the road are damaged and total reconstruction is frequently required."[5]

During the initial stages of well development, heavy truck traffic uses the local roads. These tractor-trailers are necessary to haul the excavation equipment, the hundreds of tons of material for the construction of the drilling pad, the drilling rig, tons of sand during hydrofracking, and other equipment such as holding tanks. The same material must be trucked away from the well site afterwards. It can take between 400 to 1,300 trips during the construction and completion of just one well, and can weigh as much as 100,000 lbs, fully loaded.[6] Drilling one well requires two to eight million gallons of water, which may need to be transported on trucks over local roads that weren't built to carry that kind of load. Table 6.1 lists the number of truck trips that could be needed for drilling a single well or multiple wells on a single pad. Some individual pads, as shown, may involve up to 8 wells and pose correspondingly larger transportation requirements.

Table 6.1 Estimates of possible numbers of truck trips[7]

Activity	Number of Truck Trips	
	Per single-well pad	Per multi-well pad
Drill Pad and Road Construction Equipment	10-45	10-45
Drilling Rig	30	60
Drilling Fluid and Materials	25-50	200-400
Drilling Equipment	25-50	200-400
Completion Rig	15	30
Completion Fluid and Materials	10-20	80-160
Completion Equipment	5	10
Hydraulic Fracture Equipment	150-200	300-400
Hydraulic Fracture Water	400-600 Tanker Trucks	3,200-4,800 Tanker Trucks
Hydraulic Fracture Sand Trucks	20-25	160-200
Flow Back Water Removal	200-300	1,600-2,400 Tanker Trucks

As a result of road damages – potholes, cracks, etc. – due to the trucking of sand, water, and equipment, municipalities often opt to bond their roads before drilling starts, thus incentivizing

the gas companies to repave and repair the roads once they have finished drilling. Much of the responsibility falls on local municipalities, with local governments expected to complete road studies and other such investigations. However, since municipalities have to contend with the upfront costs and careful planning and scientific investigations associated with conducting such studies and determinations, some have not enacted weight limits on their roads.

In Pennsylvania, local authorities are subject to the state's Bureau of Maintenance and Operations' state vehicle code, which states that municipalities must complete an engineering and traffic study and determine not only how many miles of roads are located in the area, but also what they are made of. Town of Tusten Supervisor Ben Johnson explains that in order for Tusten, NY, to get gas companies to pay for damages to their roads, town officials must prepare a scientific analysis of the roads in order to develop any fee assessment or bonding plan.

Roads in towns are often made of different material – earthen, cold-mix asphalt, hot-mix asphalt, or gravel – and they each can be differently impacted by increased heavy tractor-trailer usage. Thus, in order to determine possible damages, engineers must be called in to calculate potential impacts using an "equivalent single axle load" (ESAL) measure developed by the American Association of State Highway Transportation Officials.[8] In addition, towns must pass an ordinance that identifies the segment of the road with the weight restriction, advertise the weight limit "two times in a general circulation newspaper at least five days prior to actual posting," contact the heavy haulers about maintenance agreements, and place the proper signs displaying the new limit.[9] The maintenance agreements are between the local governments and each hauler operating overweight vehicles on the particular road, and place the responsibility of repairing damages onto the hauler.

Another concern has to do with speeding. The trucks, carrying tons of heavy equipment, are "going fast up there at 2, 3, 4, 5 o'clock in the morning," a resident of Foster Township, Pennsylvania, says, "And I'll tell ya – they're raising hell." He continues to raise concerns about drivers using Jake Brakes when coming down hills, saying that the trucks are "leaving mud on the road, which could be dangerous…If you hit that mud that they've left there…"[10]

If the municipality requires a road use agreement, states reserve the right to request a copy of the agreement. Taking into account that drilling of the Marcellus Shale is relatively in its beginning stages, well pad siting can be limited to rural areas which present a number of opportunities for drilling companies to avoid large populations, community disturbances, major traffic impacts, and noticeable noise pollution. In order to reduce the adverse impacts of drilling activities and its associated noise level and roadway disturbances, local governments should work to create ordinances to regulate the impacts of drilling activities within its community.

The New York town of Lebanon was one of the many towns that was forced to face road repair issues. Town supervisor Jim Goldstein explained that four to five years passed before Nornew Energy's representatives agreed to meet with local officials to discuss road repair, but the company finally agreed to pay for the damage their heavy rigs had done to local roads. In 2007 an agreement was reached that requires the gas exploration company to repair roads at their own cost, notify the town two weeks before road use, and work with the highway superintendent to

determine the best truck route.[11] Due to the relative powerlessness of local governments with respect to gas drilling, municipalities are turning to road use agreements to ensure that drilling companies take responsibility for the damage trucks are doing to local roads.

Although Lebanon was able to work out a road use agreement with Nornew, the years of damage done before the agreement was made has set the town behind approximately 15 years with respect to funding. In the town of Candor, progress on a road use agreement has been slow. In November of 2009 citizens and local officials worked together to draft a road use agreement. The draft was given to the town board in January, however no progress has been made in passing a final ordinance. One concerned citizen went beyond participating in the drafting process and requested that the town board hold a workshop to construct a final road use agreement "and not leave Town Hall until their work is done"[12]. A response to this citizen's request has not yet been given.

Without statewide requirements for the transportation issues that arise with horizontal drilling, it is the responsibility of local governments to protect their communities and govern their local roadways. Citizen involvement is beneficial to the creation of road use agreements and can assist local officials in providing towns with a road plan that works best with local traffic patterns and specific community needs.

There are also other social costs associated with heavy truck traffic. The trucks can be noisy; their sheer size can strike fear into ordinary drivers of much smaller vehicles; the presence of large number of large trucks can be visually offensive for many local residents. In Jay Township, Pennsylvania, supervisors voted to refuse access to water to EOG Resources for drilling in early 2009, because the town did not want the oversized trucks around recreation areas where children play.[13]

Mitigating Truck Impacts

In order to minimize traffic disturbances to local roads, the following precautions might be taken:

- plan and select a route that reduces traffic disturbances,
- schedule deliveries and truck use during off-peak traffic hours, avoiding school bus schedules and late night truck use,
- coordinate travel routes and truck schedules with local and state agencies and departments,
- perform frequent road repairs and upgrades to frequently traveled access roads,
- provide the community with public notification of roadway use and any major road closures,
- designate sufficient area at the well-pad for parking and truck movement[14]

The responsibility of mitigation of road use impacts and damages, as discussed earlier, now falls mostly on local municipalities to address with operators. State vehicle traffic laws must be adhered to, and local governments should not only be aware of the regulations, but should be

proactive in addressing any potential impacts. Road use agreements should include proper siting and route selection, avoidance of peak traffic hours, repairs and improvements to roads frequently traveled by trucks, etc.

In New York, the DEC "strongly encourages operators and municipalities to attain road use agreements,"[15] but does not have the authority to require them to enter into any such contract. Instead, under the proposed Supplementary Permit Conditions for High-Volume Hydraulic Fracturing, the Department requires road use agreements or trucking plans be filed with the DEC for "informational purposes prior to site disturbance."[16] Municipalities can establish "heavy haul" routes and enact regulations prohibiting overweight and oversized trucks from entering specified roads. Local governments are given this authority by sections 1640, 1650, and 1660 of the state's Vehicle and Traffic Law.[17] Specifically, municipalities can create haul routes for trucks weighing more than 10,000 pounds; temporarily prevent trucks weighing more than 8,000 pounds from entering a roadway; and exclude trucks and other overweight vehicles from roadways under certain provisions.

A number of municipalities have exercised their power to enact such regulations. The Steuben County Public Works Department (NY) has highway engineers draw up a countywide road use agreement plan to address potential damage from heavy equipment due to activities associated with drilling.[18] Additionally, in March 2010, the Broome County Administration (NY) submitted a Proposed County Local Law for the local legislature to review and consider.[19] If passed, the proposal will prohibit vehicles weighing more than is allowed in Section 385 of the Vehicle and Traffic Law from operating on county roads, unless they have been issued a permit issued by the Commissioner of Public Works of the County of Broome.

The proposal specifies that "with the exception of normal wear and tear, the permit holder is responsible for *all* damages done to the roadways, ditches, curbs, sidewalks or other improvements and to public utilities in the roadway."[20] If the county determines that hauling operations have indeed resulted in excessive wear, then county officials can ask the permit holder to repair all damages after proper notice has been given. Or, the county can make the necessary arrangements and charge the permit holder for the costs of repair. The proposal also stipulates a maintenance bond of $250,000 and a bank letter of credit of $10,000 "in favor of the County guaranteeing compliance with the provisions of the permit." Should the permit holder violate any provision of the permit, the permit may be suspended for a period of time.

Pennsylvania has, since 1978, given local governments the authority to require owners of overweight vehicles to apply for permits and post bonds of up to $12,500 per mile of road. If the road becomes damaged due to the heavy loads, the funds are then used to cover such costs. Otherwise, the bond is returned to the company.[21] However, the costs of actually repairing one mile of roadway can be about $100,000. In April 2010, PennDOT revoked Chesapeake Energy's road use permit to use State Route 1007 in Bradford County, because Chesapeake had failed to fix the severely damaged road. The permit stipulated that Chesapeake would repair damages to the stretch of road, and after the company failed to act in response to two notices of "unsafe conditions" on Route 1007, PennDOT revoked the permit. Earlier, in March, Chesapeake had its permit for State Route 1001 in Bradford County revoked for the same reasons, but the permit has

since been restored. However, the road was closed for a week while Chesapeake made the necessary repairs, thus burdening commuters and local users of the road.[22]

A current bill in the West Virginia legislature seeks to mitigate road use damages as a result of Marcellus drilling. Senate Bill No. 643, introduced by Senators Kessler and Edgell, seeks to require the Division of Highways to "establish vehicle weight and size limits for public highways, including natural gas resource transportation roads…[and requires the] certification of natural gas permitting areas by the Department of Environmental Protection to Division of Highways."23 SB 643 also holds well owners accountable and responsible for the costs associated with road repairs, and allows for the suspension and revocation of permits, should the well owners fail to meet the provisions. If passed, this statewide legislation would make it easier on the local municipalities, as there would be a uniform regulatory framework which local governments can follow.

Some drilling companies have enacted measures that lessen truck traffic, though without widespread adoption of similar practices by all companies, issues of truck traffic and the subsequent road damages and noise pollution will unlikely be fully resolved. For example, Range Resources' recycling of waste water produced during drilling operations will decrease the volume of truck traffic to and from the site. According to Range Resources, recycling has eliminated 7,500 trucks from the road.[24] It won't solve the problem, but it will alleviate the effects, to a degree.

Truck Traffic: Recommendations

Engineering and traffic studies: Instead of leaving it to municipalities to complete the costly engineering and traffic studies in order to mitigate and prevent road damages, states could require gas companies to conduct the studies. However, the process should be a collaborative effort, with local governments and municipalities overseeing the studies being done by companies – or contractors. The result of these efforts would be a transportation plan that would be publicly available for review as part of the approval process for each well permit application. It would detail the numbers of trucks expected to be used in the various components of well construction and the plans for their local road use.

Mandatory road use agreements: State agencies such as the New York DEC "strongly encourage" municipalities and operators to enter into road use agreements, but as stated above, cannot require such contracts to be signed. This leaves it up to the municipalities and gas companies to work together to reach an agreement regarding road use. Instead of leaving this as a voluntary measure, states should not only have the authority to require such contacts, but should strictly require them between localities and operators as a condition for issuing a well drilling permit. These road use agreements should not only establish pre-determined routes for trucks to take, but should also stipulate specific times of the day when trucks are and are not allowed to travel through the towns. This would ensure that during peak times, community life is not negatively affected by the heavy truck traffic, and that during the night, the trucks do not keep everyone awake. The road use agreements should also emphasize coordination with emergency management agencies, and should provide for adequate advanced public notice of

any road closures or detours, so as to prevent unnecessary inconveniences. The agreements should include provision for gas companies to pay promptly for repairs to roads damaged by truck traffic and for effective enforcement mechanisms.

Tighten bonding requirements. Municipalities have few methods available to counteract the localized costs borne by shale gas drilling. The state is responsible for exploration, development, and production permitting authority. Additionally, leasing and royalty payments generally avoid the county and municipal level; the state profits from sales and income taxes, while individuals receive income from leasing bonuses and royalties. One way for municipalities to control some of the costs associated with natural gas operations is through road bonding authority. By stipulating weight and access road requirements, municipalities can create a means for generating revenues in order to handle infrastructure deterioration. Instead of setting bonding requirements at what seems to be arbitrarily low amounts, such as Pennsylvania's blanket bond of $25,000, such bonds should be set at the true cost of repairing the roads – or, at least, a tailored estimate of such a cost.

Gas Pipelines

The current pipeline infrastructure may be inadequate to transport gas from the Marcellus Shale, as drilling sites are often not connected or even close to existing natural gas pipeline infrastructure. In order to remedy this, and to actually have a means of transporting the gas once it is extracted, new pipelines may have to be constructed. However, the installation of new, permanent pipelines to transport the gas can result in significant road damage and other local disruptions. The Millennium Pipeline, a 182-mile, 30-inch diameter steel pipeline that runs through parts of New York, has resulted in road damages of well over $1 million, and only follows a single path. More damage would occur if there were multiple well sites.[25]

The Town of Cochecton had only a $250,000 bond from the Millennium Pipeline Company. Due to these types of discrepancies, town supervisors have suggested that the New York DEC support the creation of road assessment agreements between municipalities and pipeline companies "that would allow towns to require drilling companies to post bonds that would fully cover the cost of any damage created to local roads" – from either well or pipeline construction. As Ben Johnson states, towns "cannot afford to have this bond in place that does not fully address the risk of damage and then leave us unable to complete the full repair of our infrastructure."[26]

Figure 6.2: Gas Pipeline Explosion

Source: http://graphics1.snopes.com/photos/accident/graphics/gasline2.jpg

Gas pipelines can explode unexpectedly, causing significant damage to the nearby environment and land. Gas is highly flammable, can escape through leaks or corrosion, and can ignite. Pipelines, especially in the Marcellus formation, are subject to harsh winters, and can corrode, break, and crack. In September 2008, a pipeline exploded along Highway 26 near Appomattox, Virginia. It "demolished two brick homes, strewed rubble on Oakville Road, and singed the grass in a nearby field."[27] There were no fatalities, unlike some other pipeline explosion incidents, but residents were evacuated. Figure 6.2 shows the damage caused by the explosion. The gas pipeline failed due to external corrosion that weakened the line. According to Williams Gas officials, there was an error in pipeline testing devices, and as a result, there were no warnings.

Another issue regarding pipelines is noise pollution. New gas compressor stations must be constructed and operated in order to increase gas pressure so it can be pushed through the pipelines. A landowner who lives about 500 feet away from one of these compressor stations says, "It runs 24 hours a day seven days a week…It sounds like a lawnmower running outside my window all the time. This is ruining my life."[28] Compressors are extremely noisy, producing about 95 decibels of consistent noise, which can cause hearing loss if people are exposed to it for long periods of time. A jackhammer produces about 100 decibels, for comparison.[29] Towns with zoning ordinances are able to require site plan approvals for the construction of new compressor

stations, but those without zoning "won't be able to control where compressor stations are located."[30]

Before constructing pipelines, the drilling companies must obtain Pipeline Right-of-Way Agreements, or easements, from property owners. These agreements are negotiated between the parties, after which the pipeline installation company can then begin construction. Pipeline right-of-ways are strips of land surrounding the gas pipelines where property owners' rights have been granted to operators. Generally, rights-of-way extend twenty-five feet from both sides.[31] Such agreements are long-term and legally binding, and conditions vary between different landowners and are negotiable. Many landowners opt to hire attorneys to review contracts – in fact, such an action is encouraged in order to ensure the proper usage of land.

In Pennsylvania, drilling companies do not have eminent domain for natural gas collection pipelines. Companies have to negotiate with landowners.[32] However, Laser Marcellus Gathering LLC of Houston, Texas, has recently applied to the Public Utility Commission "to be declared a utility in Pennsylvania." If Laser becomes a utility, the company would have the power to exercise eminent domain rights to obtain right-of-way agreements. Gathering pipelines, such as the 30-mile pipeline that Laser is planning to build, are considered midstream, and midstream companies can become utilities.

Nevertheless, most companies prefer not to rely on condemnations for easements, as it causes bad publicity and is expensive. They typically compensate landowners by a payment per linear foot or rod (16.5'), versus a payment per square feet or acre (such as those for oil and gas leases). The payment is determined by the easement's length, not the width. Such payments vary depending on prevailing rates in the particular area, zoning and development potential, and other valuation determinations. Because pipeline companies prefer to negotiate, landowners should be made aware of their rights and what they can stipulate in their agreements.[33]

Pipelines: Recommendations

- **Inform landowners of their rights:** Landowners may be unaware of their rights, and as such, may enter into easement agreements that permit pipeline companies to build any and all surface facilities they want. Instead, state and local governments should ensure that landowners are trying to restrict surface facilities to the best of their abilities.

- **Pipeline depth:** Pipeline companies should be required to bury pipelines at least 48" below the surface, so as to maximize landowners' future development options. Currently, pipeline companies bury pipelines at around 36" below the surface.

- **Secure adequate land restoration*:*** Pipeline companies should be required to re-seed easement areas in order to ensure proper reclamation. This also includes road repair, should pipeline companies cause any damage to landowner's roads.

- **Enact pipeline Right-of-Way standards*:*** Make it a requirement that such contracts contain the same basic stipulations. For example, the state should require all pipeline companies to bury their pipelines below 48", to restore the easement area, to limit their surface facilities, to inspect the pipelines on a regular schedule, to place warning signs, and to pay fees to the landowner should damages occur, among others.

Another recommendation is for the permits to stipulate certain sums of money to be paid to local communities for the noise pollution. The amount may vary according to distance from the site itself, but will provide a means of compensation for the nuisance.

Reclamation and Well Plugging

Restoration concerns arise once drilling and hydrofracking activities have been completed. Once an area of land has been used as a drilling site, immediate reversal to its pre-drilling state is impossible. Restoration takes time. While responsible operators are able to restore the land to a state that's close to the original, individual leases between land owners and drilling companies must address not only the immediate damages and problems, but also the long-term reclamation issues. This involves undertaking soil tests, redistributing topsoil, removing unnecessary equipment, among others, as well as educating land owners about their rights. Though companies claim that they will restore the drilling site to its original condition after their activities have been completed, evidence shows that that is often not the case. Returning a site to its original condition involves treating and cleaning the area, as well as seeding and re-vegetating the site.

The long-term concern of restoring the site after gas production has ended is another issue. Many sites have either been semi-restored, or not at all, as can be seen in Figure 6.3. Large stones litter the once-pasture, and it is unknown when and whether – and by whom – the land will be restored to its original state. Pennsylvania, New York, West Virginia, and Maryland all have regulations in place that attempt to ensure that well sites are properly reclaimed and plugged, though the effectiveness of such bonds and policies is questionable.

Figure 6.3 "Restored" Well Pad

Source: http://www.marcellus-shale.us/restored_gas-wells.htm

Pennsylvania. To drill a new natural gas well in the state, the operator must also post a bond, a financial incentive to ensure that the operator will perform the drilling operations as stated, address water supply issues, reclaim the site, and plug the well upon abandonment. A bond for a single well is $2,500, and a blanket bond to cover any number of wells is $25,000.

Currently under review in the Pennsylvania state government is HB 808, which amends the Oil and Gas Act. It would double current well bonding requirements, from $2,500 to $5,000 for single wells, and from $25,000 to $50,000 for blanket bonds. It would also create an Orphan Well Plugging Fund from permit fee increases for new wells.

County Conservation Districts, along with the Pennsylvania DEP, were in charge of protecting groundwater from erosion and sedimentation. However, in Spring 2009, the DEP implemented a new "expedited permitting review process" for Marcellus drillers, which effectively allowed for the faster processing of permits – around 14 business days. In doing so, the DEP stripped the County Conservation Districts of their authority, and stated that permit applications simply had to be signed by an engineer, surveyor, geologist, or landscape architect. Technical reviews were no longer necessary.[34]

In Pennsylvania, within nine months of the completion of drilling, companies must restore the site, remove or fill the pits, and remove all equipment not needed for production. Within nine months of plugging a well that is no longer producing, all equipment and production and storage facilities must be removed.[35] Activities must be in compliance with Pennsylvania's Clean Streams Law.

Conclusion

While the technological advances of horizontal drilling and hydraulic fracturing have increased the of rate natural gas extraction from shale formations, these activities can have negative consequences, and can potentially leave a large physical footprint on local communities. Some adverse impacts of Marcellus shale gas development are inevitable, but with proper and adequate regulations, enforcement, and agreements, such disturbances can be compensated and mitigated.

Much of the mitigation responsibilities fall on local municipalities who often do not have the capabilities to ensure that their communities are properly protected from undue nuisances and harms as a result of drilling activities. Prescriptive road bonding and road use agreements should be in place to address this issue.

The impacts of shale gas development on local infrastructure depend on the rate and intensity of drilling and extraction activities. While both the rate and intensity are unpredictable, it is certain that towns will continue to be negatively affected by many stages of development. As the examples illustrated earlier in this paper demonstrates, heavy truck traffic, road damages, pipeline construction, and the accompanying noise and visual pollution, can negatively affect the residents of the local communities where the natural gas is being extracted. As such, proper regulations and policies must be put in place so as to ensure that these impacts will be minimized

to the greatest extent possible. Most importantly, this involves authorizing states to regulate drilling activities in accordance to acceptable road use and noise impacts guidelines. Local governments should be given a larger role in permitting, as they are most familiar with their surroundings and the needs of their citizens.

Recommendations for future policy changes include the establishment of mandatory road use agreements between municipalities and operators, which would stipulate certain requirements regarding road use, such as time limits, and route limits, among others. Additionally, permits for drilling should include transportation plans that provide for the suspension of permits in the case of violations. In addition, municipalities should have the authority to stipulate weight and access road requirements and to set bonds at a higher amount – at an amount that takes into account the actual cost of road repair.

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Chapter 7 – Treating Land and Property Owners Fairly

Many land and property owners in the area of the Marcellus formation are likely to see significant increases in income and wealth from the lease revenues provided by shale gas development. With the economic benefits that gas development promises, it will be important to structure a system of gas development rights so that the profits are divided as fairly and equitably as possible between the rights owners involved. Determining equitable compensation and protecting the rights of property owners raises a number of difficult issues. What rights should surface property owners have in relation to mineral property owners? What sort of information should gas producers be required to provide? What are common leasing agreements, and are they fair? This chapter will explore the salient legal and procedural issues involved in the leasing of shale gas property rights.

The leasing process begins at the county courthouse, where 'landmen' can research information on property owners. Gas companies need to know whether the land they wish to explore and develop is owned in 'fee simple' – meaning the property owner holds the rights to both the surface and the minerals underground – or if it is a 'split estate.' The experience of a property owner in each case can be much different. The mineral rights owner has an opportunity to lease the rights to a gas company on negotiated terms and receive royalty payments for the gas extracted from the property. Though the natural gas trapped underground has no value unless extracted with the proper equipment, mineral rights owners do not have to allow drilling if they do not like the terms they are offered.

On the other hand, the surface owner, if he or she does not own the mineral rights on his or her property, is at a disadvantage. By law, they must allow whoever owns the mineral rights (or the lease thereto) access to the natural gas under the property. Access includes the right to explore for resources on the property, construct roads, pipelines and other drilling facilities, and conduct drilling operations. The protections afforded to surface owners in split estate situations are limited.

Split Estates

If a producer decides to drill in a particular location, it must apply for a permit with the respective state regulatory body. Ideally, the company will contact the surface owner prior to or in the course of exploring or surveying a drill site, and will have had a chance to express concerns and perhaps negotiate some sort of agreement. However, this informal, "good neighborly" contact is not required by law.[1*] Many times, a surface owner will have had no interaction with the producer – and therefore little idea that his property is about to be drilled – until he is notified of the permit application by the producer. The specific requirements for that notification differ between states. For example, Section 201.b of Pennsylvania's OGA reads as follows:

[*] The exception being that if a property owner posts a "No Trespassing" signs in accordance with the law, people are required to get permission before entering the property.

The applicant shall forward, by certified mail, a copy of [the proposed] plat to the surface landowner, all surface landowners or water purveyors whose water supplies are within 1,000 feet of the proposed well location… and shall submit proof of such notification with the well permit application…With respect to surface landowners or water purveyors whose water supplies are within 1,000 feet of the proposed well location, notification shall be made on forms and in a manner prescribed by the department sufficient to identify, for such persons, the rights afforded them under section 208 and the advisability of taking their own predrilling or prealteration survey.[*2]

Surface owners have only 15 days from receipt of this notification to file an objection to the permit, at which point it goes before the Department of Environmental Protection (DEP) for approval. Producers are not even required to inform surface owners of their rights to object, the grounds for which are very limited anyway:[3] State gas well permitting laws were generally written when the expectation was that a single well would be vertically drilled and one well would be drilled per site. They are often ill suited to the current circumstance when a single pad may hold 5 to 10 wells, and the associated surrounding disruptions are correspondingly larger. At present, grounds for surface owners objecting for a well permit are quite restricted:

When a well is located on a tract whose surface is owned by a person other than the well operator, the surface landowner has the right to file objections with the Department pursuant to Section 202 on the following bases:

a) *The information on the application is untrue in any material respect;*
b) *The well location is within 200 feet measured horizontally from any existing building or existing water well and the owner thereof has not given his written consent and the operator has not been granted a variance;*
c) *The well site is within 100 feet measured horizontally from a stream, spring or body of water as identified on the most current 7½ minute topographic quadrangle map and the operator does not have a waiver, or the well site is within 100 feet of any wetland greater than one acre in size and the operator does not have a waiver; or*
d) *The well location violates Section 205 of The Oil and Gas Act.*

These regulations mean that, for example, a gas company could insist upon drilling just over 200 feet away from one's home and the surface owner would have no recourse to object to the site location. Moreover, Section 205 allows well operators to request a variance to the distance restriction if "the distance restriction would deprive the owner of the oil and gas rights of the right to produce or share in the oil or gas underlying said surface tract." If DEP grants the variance, the surface owner would not have the opportunity to object. DEP can and would require "additional terms and conditions…to insure the safety and protection of affected persons and property;" however, the law takes almost all oversight out of the hands of the surface owner.[4]

[*] Section 208 of the OGA refers to the protection of water supplies.

After the permits have been approved (a process that generally takes around 45 days), producers only have to give 24 hours notice before drilling activities can commence. For the reluctant surface owner, it can certainly be a distressing experience. Surface owners should be afforded more time to take pictures, calculate the value of their property, and plan accordingly for the drilling period. Producers should be required to engage surface owners throughout the process and clearly communicate their rights in addition to the risks involved with drilling activities. The balance of property rights is currently weighted heavily in favor of mineral rights owners, and such a situation could lead to significant unfairness as natural gas production expands across the state. As will be described below, legislation is currently under consideration in Pennsylvania that would strengthen surface owner protections.

The law in West Virginia does provide slightly stronger protections for surface owners. Surface owners have 15 days from the time the application is filed to formally comment on the application. Comment regarding any of the following issues will be seriously considered and could serve as grounds for denying the permit:[5]

1. The proposed well work will constitute a hazard to the safety of persons;
2. The plan for soil erosion and sediment control is not adequate or effective;
3. Damage would occur to publicly owned lands or resources;
4. The proposed well work fails to protect fresh water sources or supplies;
5. The applicant has committed a substantial violation of a previous permit or a substantial violation of one or more of the rules promulgated under (West Virginia Oil and Gas Law) Chapter 22, and has failed to abate or seek review of the violation;

Unlike in Pennsylvania, producers in West Virginia are required to notify surface owners of their right to comment. Upon submitting comments, the state will send an inspector to the property, examine the issues raised, and encourage a voluntary settlement between the surface owner and the producer. Furthermore, surface owners can appeal the issuance of a permit to the Circuit Court if they believe the state granted a permit without taking into consideration their comments (a right that was up upheld by the West Virginia Supreme Court in the 2002 Lovejoy decision).[6]

By allowing the surface owner to effectively create development obstacles for producers, the law creates significant incentives for gas companies to engage them. As McMahon characterizes, time is very important to gas producers:

> *"Your comments could cause the permit not to be issued or for it to be changed. It will no doubt cause some time and delay in the issuance of the drilling permit even if the State does nothing based on your comments. Some of these folks are under tremendous pressure to get the well drilled in a hurry. They may be in line for a drilling rig and don't want to lose their place in line. They may have people financing their well that don't want to have limitations. They may have borrowed money and have to pay interest, so the longer it takes to drill the more interest they have to pay."*[7]

In exchange for agreeing not to comment, West Virginia surface owners can negotiate with producers to move the location of the well site, access roads or pipelines to an acceptable location. Surface owners can also request compensation, either monetary or in the form of services like bulldozing or road repair. Producers will also sometimes offer free gas to surface owners, and while this is valuable it is also important to understand that the gas coming directly from the well is unrefined and could pose greater risks than normal gas. Regardless of the content, it is essential that surface owners get these agreements in writing. By establishing a contract, surface owners can enforce their rights through Common Law statutes and sue for damages.

In all states, surface owners are also entitled to receive payment for damage to their crops, cropland and/or timber. Surface owners can negotiate the value of the property ahead of time, taking into account the opportunity costs of removing land from production for the duration of well operation. West Virginia's Oil and Gas Production Damages Compensation Act states that:

> *"The oil and gas developer shall be obligated to pay the surface owner compensation for: ...the diminution in value, if any, of the surface land or other property after completion of the surface disturbance done pursuant to the activity for which the permit was issued determined according to the actual use made thereof by the surface owner immediately prior to the commencement of the permitted activity."*

The law does not consider land to be diminished in value indirectly; for example, the area of land surrounding the well site but not directly altered by drilling activities is not covered, even if the location of the well site increases the cost of cultivating the surrounding area.[8] Also, the well operator is only required to compensate for the value of the land at the time of drilling, not the value of some potential future land use. These limitations are understandable because of the difficulty in calculating potential future value or indirect affects with any certainty. Property owners can attempt to incorporate such calculations in their private negotiations with producers, but the law should not mandate compensation for indirect or future loss of value. As it is, the expressed right of compensation in West Virginia provides surface owners more protection than their counterparts in Pennsylvania.

At the time of this writing, Pennsylvania does not require well operators to negotiate compensation arrangements. Voluntary agreements are common, and surface owners have some recourse under Common Law if their property is damaged, but there is significant leeway for abuse. The Pennsylvania Department of Environmental Protections (PaDEP) recommends that surface owners take photographs of all proposed sites prior to alterations to best enforce their rights, but the ideal policy would encourage collaboration between producers and property owners from the beginning.[9] Pennsylvania does require well operators to restore any alterations after production is finished, but such restoration does not have to be conducted to the specifications of the surface owner.[10]

The Pennsylvania legislature is currently considering a new law entitled the "Surface Owners' Protection Act" (House Bill 1155 in the 2009 Session). This is an ambitious piece of legislation which, according to George Bibikos of K&L Gates, "quite simply rewrites over a century of

Pennsylvania law."[11] According to the sponsor, Rep. Camille 'Bud' George (D-Clearfield County), the bill would do the following:

a) *Require surface owners to be notified at least 15 days before a driller enters a tract and at least 45 days before drilling begins;*
b) *Provide surface owners with basic information, such as the scope of planned operations, the drilling operator and plans for protection of water sources;*
c) *Compel agreements governing drilling operations, drainage changes, nuisance controls, liability and reclamation responsibilities and compensation for damages;*
d) *Implement standards governing operations of oil and gas wells [specifically with respect to water supplies].*[12]

These protections, in essence, reverse the balance of power when it comes to the relationship between surface and mineral rights. The longer timeframe gives surface owners more time to seek counsel, take photographs, and determine the value of their property, while the information provision requirements ensure that surface owners will not be duped into signing away their rights. Most significant is the requirement that well operators negotiate the terms of the surface impacts, "compensate fully" for the affects of surface impacts, and "'reclaim' the entire surface of the land affected by oil and gas operations 'to the same, or substantially similar, condition that existed prior to oil or gas operations.'"[*13] Tenants are even afforded compensation if the operations diminish the value of their leaseholdings, though any additional terms must be negotiated between the tenant and the property owner.[14]

If the surface owner does not like the terms of the agreement, the well operator is allowed to commence operations after 45 days if it pays the surface owner 120% of its "best offer," up to a maximum of $250,000 for each well.[15] The bill would create some of the strongest protections for surface owners in the country, and it has come under attack from industry. Bibikos argues that it "swings the pendulum entirely to the side of the surface owner, and it does so seemingly without regard to the impact these requirements might have on existing contractual relationships, existing regulatory compliance, and orderly development of important energy resources in the Commonwealth."[16]

The bill is currently awaiting consideration by the House Appropriations Committee, and seems to have lost some momentum. Until then, surface property owners have the following voluntary options at their disposal to protect themselves:

- Purchase part of the mineral rights beneath the landowner's property in order to have a stake in negotiations with drilling companies.
- Purchase the right of ingress and egress from the mineral rights owner. This option will not remove any rights of the mineral rights owner to lease the mineral rights and collect royalties. It will, however, require drilling companies to arrange their entrance and development of the property with the landowner.

[*] Including, but not limited to "control and management of noise, weeds, dust, traffic, trespass, litter and other interferences with the use and enjoyment of the surface owner or tenants." [HB 1155, Section 3.b.5.viii]

- Negotiate a land-use agreement with the mineral rights owner which could allow landowners to restrict operations to a specific area of the property.
- Negotiate a surface-use and surface-damage clause with the mineral owner for future leases between the mineral rights owner and gas companies.
- Negotiate a surface use agreement with the gas company to protect the property and ensure environmental restoration.[17]

A study researching the additional costs that mandatory protections would create for industry, and how such costs would affect the development of the resource throughout the state, is needed to better inform lawmakers. State community outreach programs should communicate voluntary options more extensively, but even if such options were widely known, surface owners still need explicit protection under the law.

Private Leasing and Royalties

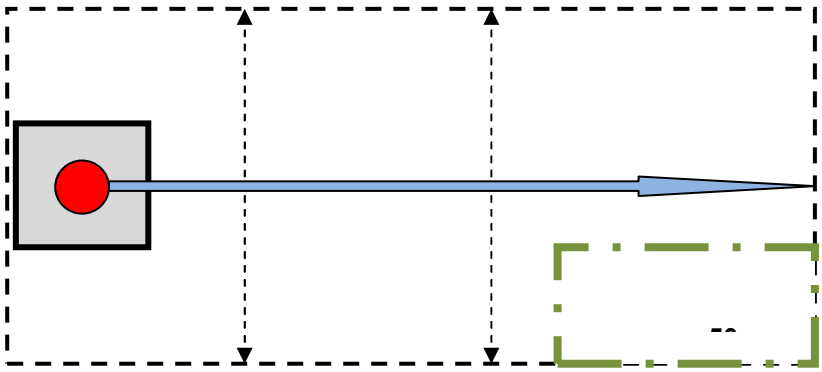
For landowners that hold the rights to the mineral estate under their property, such additional protections are unnecessary. In order to access the resources, gas companies make private lease agreements that give them the right to extract and sell the gas. The terms of the agreements are mostly based on market factors, such as the price of gas, the value of land, the availability and terms of financing, etc., and geological factors, such as the thickness and depth of the shale formation. According to the Marcellus Shale Coalition, "The lease typically includes a per-acre signing bonus for a specified number of years and an agreed-to royalty payment to the property owner if a drilled well produces natural gas."[18]

The methods used to extract natural gas in the Marcellus Shale formation complicate the leasing process. Drilling horizontally, producers can extract gas from mineral estates over a mile away from the well pad. Because gas can move through pores and fractures in the rock, a single well could drain the gas reserves from a large area. The science behind the size of that area, however, is not exact.

Because many owners of mineral rights may be involved, most oil and gas producing states have adopted statutes that define the process for the "unitization" of such resources.[19] Unitization is calculated based on a standardized understanding of how gas travels underground, with a unit representing the total area that a well can pull from. According the State of Pennsylvania, a lease agreement must exist for all mineral estates within 330 feet of the well, which is interpreted to extend underground for the entire length of the borehole.[20] The total area that must be leased, then, is equal to 330 feet on either side of well for the length of the well, with each property owner receiving compensation based on the percentage of the total unit their property takes up.[21]

For example, assume a single well is drilled for 5,000 feet horizontally. The total area that must be leased in this case equals 1,650,000 square feet. Now assume that the unitized resource encompasses 50,000 square feet of a property owner's land, or 3.03% of the total. Figure 7.1, below, illustrates how a unit is calculated for horizontal drilling activities.

Figure 7.1 – Example of Unitization Calculation



The producer will send a landman to that property owner to negotiate a lease of that person's mineral rights. What the gas company offers – and what the property owner can demand – as stated above, depends on the market in that region. In Wayne County, PA the going rate had long been $25 per acre. However, in 2007 Chesapeake Energy began offering $750 per acre, and then doubled the rate in early 2008 to as high as $1,500.[*22] Table 7.1 below illuminates how signing bonuses have increased dramatically in just a short amount of time.[23] Because the geology of the shale is different between states and even within states, there is a wide variety in the value of the land. No matter where drilling is occurring, however, the gas boom in the Marcellus region has increased the demand for gas leases significantly and property owners have greater bargaining power today.

Figure 2.2. Increases in signing bonuses for gas production land leases in the Marcellus Region.

State	Previous private signing bonuses (year)	Current private signing bonuses (2008-2010)
Pennsylvania	$25/acre (2002)	$2500-2900/acre
New York	$5/acre (1999)	$3000/acre
West Virginia	$5/acre (2007/2008)	$1000-3000/acre

Source: Congressional Research Service "Marcellus Shale Gas Development: Royalty Rates, Surface Owner Protection, and Water Issues." 2008

In addition to signing bonuses, property owners are entitled to royalties on the gas that is produced from the property. A minimum royalty payment of one-eighth or 12.5% of the value

[*] It was widely recognized that Chesapeake was attempting to price its competition out of the market by offering – and advertising – such high rates. The result has been an increase in the market rate for land leases across the Marcellus region.

produced from the leased premise is required by law in all Appalachian states.[24] Using the formula for unitization, the hypothetical property owner above would be entitled to approximately 0.38% of the total production revenue, paid out annually. Property owners can secure better deals for themselves if they join together, and the internet can also serve as a good resource for sharing information about leasing rates. Royalties negotiated by land owners of 15% and above have now become common. State agencies should promote collaborative efforts in the information materials they provide.

In some instances, states may hold the leasing rights to a particular property that gas companies are interested in exploring. Similar to the contracts between individuals and companies, the state may negotiate leasing agreements with gas companies on state lands. The decision of whether to allow gas development on state land, especially if such land is ecologically or culturally valuable, raises a number of normative questions. State agencies in the Marcellus region should comprehensively study the value of gas reserves under state lands and determine policies setting out the extent to which such reserves should be developed and how revenues from signing bonuses and royalties should be spent.

While the financial benefits of allowing gas development are significant, landowners should also be mindful of other issues when negotiating lease agreements. The Penn State Cooperative Extension program recommends landowners pay attention to "the length of the lease, whether it "holds" the entire property, whether the company is granted access to the surface of their property, whether the landowner has a say on where a well is sited or where access roads are built on their property, and other issues which may affect their quality of life and other uses of their land."[25] A longer lease secures royalty payments for a longer time, but with a shorter lease a landowner might have the opportunity to renegotiate if demand and prices increase – though it is hard to know whether the well will still be producing. Fee-simple landowners should take full advantage of their ability to control how producers use the surface of their property.

Failure to carefully negotiate the terms of a leasing agreement can lead to buyer's remorse. The boom in gas production has also brought an increase in litigation. The majority of suits that have been filed in the past couple of years involve landowners seeking to invalidate their lease agreements, whether because they heard about a neighbor getting a much better rate or they felt the producer was not living up to their side of the bargain. The rulings on the majority of these cases do not highlight any glaring weaknesses in the law that would require legislative correction.

However, the much-awaited decision in Kilmer v. Elexco Land Services, made by the PA Supreme Court in March 2010, does. In Kilmer, the court ruled that gas companies are allowed to subtract drilling costs from total production revenue when calculating royalties, saying that the Minimum Royalty Act (MRA) does not define how compensation should be calculated.[26] This is a very important decision that allows for royalty payments below 12.5% of the value of resources produced, which would weaken Pennsylvania's law in relation to its neighbors.[*]

[*] Other states, such as West Virginia, explicitly state that royalty payments are calculated from the gross production value, not including drilling costs. [Independent Oil and Gas Association of West Virginia, "Explanation of Oil and

The state legislature should consider redefining the terms of the MRA so that it is explicit. Again, an economic impact study should be conducted to determine the extent to which requiring 12.5% gross value royalties – or any change in minimum royalty rates – would affect development.

Local Government Land Use Authority

Because the Marcellus Shale play is so new, the laws governing the placement of natural gas wells are not entirely clear. The relationships between the rights of property owners, gas companies, local governments and state regulators is currently being redefined through legislation and litigation. To what extent are local jurisdictions allowed to use their zoning authority to decide where drilling can occur? What options do local governments have to protect their citizens and their own financial interests within the legal context? This section will explore whether and the extent to which these questions have been answered in the Marcellus Shale formation.

Pennsylvania is currently the largest producer of Marcellus Shale gas with the number of wells now increasing exponentially every year. It is likely that Pennsylvania's experience will set examples for local governments and state regulators in neighboring states. As described previously, the Pennsylvania Oil and Gas Act (OGA) establishes a statewide regulatory framework for almost all activities related to oil and gas extraction. Explicit in all the law is a preemption of local government authority over the regulation of oil and gas activities. Section 601.602 of the OGA reads as follows:

> *"Except with respect to ordinances adopted pursuant to the act of July 31, 1968 (P.L. 805, No. 247), known as the Pennsylvania Municipalities Planning Code, and the act of October 4, 1978 (P.L. 851, No. 166), known as the Flood Plain Management Act, all local ordinances and enactments purporting to regulate oil and gas well operations regulated by this act are hereby superseded. No ordinances or enactments adopted pursuant to the aforementioned acts shall contain provisions which impose conditions, requirements or limitations on the same features of oil and gas well operations regulated by this act or that accomplish the same purposes as set forth in this act. The Commonwealth, by this enactment, hereby preempts and supersedes the regulation of oil and gas wells as herein defined."*[27]

The OGA gives state regulators the authority to establish fees and procedures for permitting and creates safety and environmental protection requirements for oil and gas wells. Such requirements include setbacks from important features such as property lines, buildings, water wells, wetlands and bodies of water. A statewide regulatory framework delineates clear authority and ensures minimum standards with the goal of permitting "the optimal development of the oil and gas resources of Pennsylvania consistent with the protection of the health, safety,

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Gas Leases in West Virginia" accessed April 2010 at <http://www.iogawv.com/pdfs/Tax_Seminar-Explanation_of_Oil_&_Gas_Leases.pdf>]

environment and property of the citizens of the Commonwealth".[28] For local governments, however, the preemption of their authority can cause a headache, especially with regard to well location.

In Pennsylvania, the power of local jurisdictions to regulate land use decisions is defined in the Municipalities Planning Code (MPC). The MPC gives counties and municipalities the authority to establish zoning ordinances and comprehensive plans to, among other purposes, "provide for the general welfare by guiding and protecting amenity, convenience, future governmental, economic, practical, and social and cultural facilities, development and growth, as well as the improvement of governmental processes and functions."[29] The MPC only gives cursory mention to oil and gas drilling – which it defines in the context of "minerals" - stating that a comprehensive plan must "Identify land uses as they relate to important natural resources and appropriate utilization of existing minerals" and that "Zoning ordinances shall provide for the reasonable development of minerals in each municipality."[30, 31]

Recent Court Decisions

The language of state laws is ambiguous when it comes to where, exactly, the authority of local government ends and that of the state begins. In early 2009, the Pennsylvania Supreme Court made two concurrent decisions that clarified the role of counties and municipalities. First, in *Huntley & Huntley vs. the Borough Council of the Borough of Oakmont*, the court ruled that "the Act's preemptive scope is not total in the sense that it does not prohibit municipalities from enacting traditional zoning regulations that identify which uses are permitted in different areas of the locality, even if such regulations preclude oil and gas drilling in certain zones."[32] However, municipalities would not be able to exercise their zoning power to permit drilling on a conditional basis related to "features of well operations regulated by the Act."

This final point was reinforced in the decision that came down the same day in *Range Resources-Appalachia, LLC. vs. Salem Township*. While the Borough of Oakmont simply included a prohibition of gas drilling operations in R-1 (low-density, single-family residential) districts in their zoning ordinance, Salem Township's ordinance included the following drilling-specific regulations:

> *"Permitting procedures specifically for oil and gas wells; bonding requirements before drilling can begin; regulation of well heads, including the capping of the same once they are no longer in use; site restoration after drilling operations cease; a requirement of restoring nearby streets to their pre-drilling conditions regardless of whether the wear and tear on such roadways was caused by vehicles associated with drilling activities; pre-operation water testing of all water sources within 1,000 feet of a well site; pipeline depth and marking; slope and construction of access roads and tire cleaning areas; and the location of water cleaning facilities."*[33]

The court ruled that Salem's ordinance was "a regulatory apparatus parallel to the one established by the [Oil and Gas] Act and implemented by the Department [of Environmental

Protection]," and therefore subject to the preemption clause of the OGA. Indeed, Salem's regulations went above and beyond those established by the PaDEP and even stated that – upon meeting the conditions of the ordinance – a permit was still subject to approval at a public meeting.[34]

The regulations represented an attempt by local government to secure greater accountability from gas companies, but the approach taken by Salem Township was deemed to be too heavy-handed. Some interpretations of the Salem decision argue that a more general approach that did not focus solely on drilling-related activities – for example one that placed greater restrictions or preconditions on all commercial or industrial activities – could be allowed to stand. On the other hand, the specific language in the Huntley decision raised some questions about whether the law would be so supportive of municipal zoning rights if gas production was prohibited in districts other than R-1 residential, or prohibited altogether.[35]

Such a test will likely come soon. Recently, Greenfield Township in Lackawanna County, PA discovered that the only drilling operation in the county was taking place in a zone where oil and gas activities were not permitted. According to Greenfield's zoning ordinance, gas drilling is only allowed on a conditional basis in rural agriculture and industrial districts. The drilling was taking place in a commercial recreation zone – next to a golf course – and when a resident complained, the township ordered the company to stop drilling.[36]

Exco Resources, the holder of the lease, questioned the municipality's authority to regulate the location of drilling activities. Less than a month later, the township granted the property owner's petition to change their zone to rural agriculture in order to avoid a legal confrontation.[37] Despite the resolution, the Greenfield case raises a number of interesting issues. The fact the original permit was granted to Exco Resources by the PaDEP demonstrates a potentially serious lack of oversight on the part of both the state and the municipality. Additionally, the statements made by township officials – calling the petition a "gift from God" – reflect a wariness to test the boundaries of their newly-clarified authority.

The Supreme Court decisions were important for local governments, according to Holly Fisher of the Pennsylvania State Association of Township Supervisors (PSATS), because "oil and gas well drilling is now treated like every other use and subject to reasonable land use regulations."[38] However, there remains a large degree of ambiguity in the law, and the gas industry is prepared to challenge zoning restrictions that it does not like. This can prove to be quite a headache for local jurisdictions seeking to protect the interests of their residents and plan soundly for gas development.

A recent Commonwealth Court decision – *Arbor Resources v. Nockamixon Township* – maintained that property owners must first challenge ordinances with the municipality's zoning board before filing in trial court, as required by the MPC. This requirement is burdensome for parties wishing to drill, but it also provides another layer of accountability and could discourage producers from challenging every ordinance that stands in their way. Ironically, the ordinance in question established by Nockamixon Township – which included restrictions on the number of well pads on a single property and setbacks from certain features, among others – was deemed to

be invalid by the township's own Zoning Hearing Board due to preemption by the OGA.[39, 40] Whether a higher court would have allowed the ordinance is unknown, but the experience speaks to the difficulty of local governments to navigate preemption.

In addition, even if a local zoning ordinance is designed in such a way that it avoids crossing the line, those wishing to drill can still challenge through other legal avenues. First and foremost, the ordinance can be deemed a regulatory taking. The justification is as follows: "[If] a producer only has one use of its property interest—to develop and produce oil and gas pursuant to a lease—[and the] producer is substantially restricted or barred from pursuing that development, there is a strong argument that there is no other beneficial use available to the producer. As a result, the producer is completely deprived of its property interest and an improper taking has occurred." A producer could still sue the municipality for delaying drilling under the ordinance even if the development is ultimately allowed – a "temporary taking." Finally, if the ordinance restricts oil and gas activities but does so in "broad, undefined terms that allow the municipality vast discretion in its application, the ordinance may be challenged as unconstitutionally vague."[41]

Ultimately, the risks associated with instituting stringent controls through zoning ordinances may be too high. Natural gas companies can leverage far greater resources than the boroughs and townships they would be challenging, especially with many local governments struggling financially. Instead, local governments may find it in their best interest to remove "surface constraints" in order to attract as much investment as possible. With the tremendous economic potential of the Marcellus Shale, such an approach is not entirely imprudent; however, a race-to-the-bottom could have high environmental and social costs. The ambiguous legal context that exists in Pennsylvania – and to a lesser extent in its neighbors – makes such a weakening of the local regulatory role more likely.

Proper Local Authority

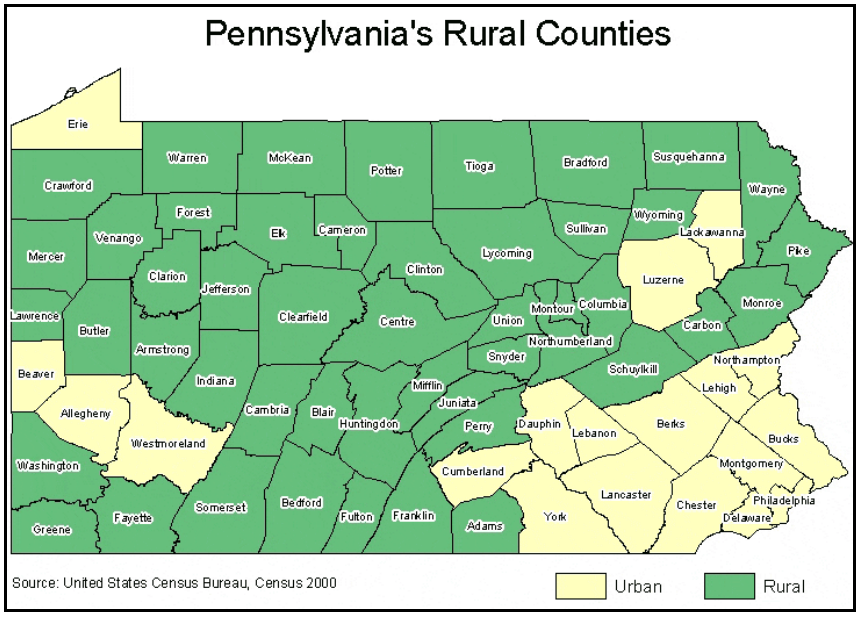
It would be preferable if the state laws were reformed to clearly define what local governments can and cannot do with regard to the regulation of oil and gas operations. Granting greater authority to local jurisdictions to govern gas well location could be beneficial because local governments are more attuned and accountable to the unique needs of their citizens. The placement of drilling operations in relation to property lines, parkland, water sources, etc. is partly a safety issue, but it also involves important questions of justice and aesthetics that a statewide regulatory apparatus is ill-equipped to answer. In addition, the location of oil and gas wells can have a significant impact on the viability of comprehensive plans, which municipalities are encouraged to use to guide sound public investment in infrastructure.

On the other hand, granting too much power to local jurisdictions could severely obstruct drilling operations. Though many jurisdictions would allow for reasonable development of gas resources in the interest of their citizens, some might get caught up in the "Not in My Backyard!" spirit of local politics. If they had the right to approve or deny individual shale wells, local jurisdictions might favor more politically influential members of the community, while unfairly restricting development opportunities for others. Restrictive local zoning ordinances can hurt property

owners who, by leasing their land for drilling, would have an opportunity to increase their income significantly.

As of 2002, over 70 percent of Pennsylvania's land was either forest or farmland.[42] And while recent trends show faster growth in rural and suburban areas, 48 of the state's 67 counties have a population density of fewer than 275 people per square mile, see Figure 7.3.[43] It is quite possible that, in the majority of cases, neighbors will not have legitimate grievances against drilling, in which case statewide standards and preemption should protect property owners.

Figure 7.3: Pennsylvania Counties with fewer than 275 people per square mile



Source: The Center for Rural Pennsylvania 2010.

Currently, there is no legislation under consideration to clarify local government powers in this matter. Therefore, the State of Pennsylvania should provide clearer guidance to local governments regarding their rights and best-practices with respect to zoning and the development of comprehensive plans. The PA Department of Community and Economic Development (DCED) is the agency responsible for providing technical assistance to local governments, and it does so through publishing 'fact sheets', compiling resources on their website, funding studies, and organizing training courses. DCED worked closely with the Penn State Cooperative Extension program to put together a series of webinars in 2009, but funding for such efforts was eliminated in the 2010 budget.[44] It is important to note that no new materials have been published following the Huntley decision; instead, DCED recommends that municipal officials contact their solicitors for advice on interpreting the law.

This cautious approach is understandable; DCED might be held responsible if a municipality instituted a zoning ordinance based on their advice that was later struck down in court. Nevertheless, the information provided by DCED, Penn State Extension, and others can be very

useful to local officials. A January 2009 report by PSU – Extension entitled "Marcellus Shale; What Local Government Officials Need to Know" characterized the importance of local planning as follows:

> *"[Z]oning and subdivision and land development ordinances remain a vitally important tool for influencing the potential secondary effects of natural gas activity, such as from possible new residents, housing, supporting businesses, patterns of development, and the other spinoff impacts. Much of the economic opportunity (and challenge) from Marcellus will be these secondary effects, which can be influenced and regulated through zoning and other land use tools."*

Some of the issues that local officials can address directly through their comprehensive plans and zoning ordinances without fear of industry challenges include: providing opportunities for adequate housing so that industry employees can live in the communities in which they work; improving the opportunity for communities to grow economically as incomes increase by expanding and improving commercial and/or industrial districts; planning for recreational spaces with an understanding of the aesthetic and physical disruptions that drilling can create; ensuring the protection of community character, historical landmarks, and open spaces; and planning for the expansion of local public infrastructure to serve all the above.[45]

It is important to note that almost half of Pennsylvania's 2,500 municipalities have neither comprehensive plans nor zoning ordinances. According to Denny Puko, the North West Regional Representative for the DCED, "the perception of zoning [in rural areas] is of a tool to take away individual property rights".[46] This sentiment is echoed in rural areas in neighboring states as well. These jurisdictions are not rushing to formally amend their municipal code in response to drilling pressures; however, they are taking action. Some have formed natural gas task forces consisting of local officials, business owners, service providers and residents in the hopes of improving their clout with industry.

These voluntary, collaborative approaches are much more applicable on a broad scale than creative – and potentially illegal – zoning provisions, and could be the best way for local governments to protect both individual property rights and community interests. Unfortunately, local government officials do not always have the technical expertise necessary to bring stakeholders together, find collaborative solutions, and engage industry. The DCED, as well as extension services in other states, should implement programs to communicate such best practices to local jurisdictions.

Recommendations

- ***Expand state-level community outreach to property owners.*** Property owners – whether surface, mineral, or both – do not have adequate information when it comes to their rights. Communication materials should be more widely disseminated, giving recommendations such as: document the condition of the property before, during and

after drilling; consider coordinating with neighbors to secure better leasing rates and royalty payments; negotiate terms for the use of the property throughout the entire drilling lifecycle, including site restoration; and get all agreements with the gas producer in writing.

- ***Pass the Pennsylvania Surface Owners Protection Act.*** The Act, while strong, is necessary when split-estate situations are so prevalent.
- ***Commission studies to determine the costs of surface owner protections and minimum royalty rate increases***. It is important to know what the full effect of such policies would be on industry and how such costs would affect the development of the resource throughout the state
- ***Comprehensively study the value of gas reserves under state owned lands.*** Officials need to have full information when determine policies for the extent to which such reserves should be developed and how state revenues from signing bonuses and royalties should be spent.
- ***Clarify the preemption clause of the Pennsylvania Oil and Gas Act.*** Local governments need a clear picture of what the limits of their planning and zoning powers are so that they can plan accordingly for the development.
- ***Increase the budget for extension services, and communicate best practices more extensively.*** Such services are necessary to teach local governments about the tools they have to shape gas development in their jurisdictions. If the policy of the state is to encourage the use of "natural gas task forces," the state needs to teach local officials the best practices for engaging stakeholders and building consensus.

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Chapter 8 – Socio-economic Consequences of Marcellus Shale Gas Development

Large new development of unconventional sources of oil and gas will have major economic and social consequences in many areas of the United States. This is no less true of the development of Marcellus shale gas in Pennsylvania, New York State, West Virginia and Maryland. Policy makers should have an awareness of these impacts and incorporate them into the planning for future shale gas development.

Oil and Gas: National Employment and Impact

The oil and gas industry has a large impact on the national economy. In 2007, direct and indirect employment resulting from oil and gas industry investment amounted to 7.8 million operating function jobs and 1.4 million capital investment jobs throughout the United States. This accounts for 5.2 percent of total employment throughout the United States. In total, U.S. oil and gas industry operations were responsible for $1.03 trillion in value-added economic activity and impacts. Several states in the southern and Midwest United States boast significant job markets based on oil and gas exploration: more than one-eighth of the workforces of Wyoming (18.8 percent), Oklahoma (16.3), Louisiana (13.4), and Texas (13.1) are employed either directly or indirectly in the oil and gas industry. Income associated with direct and indirect jobs attributed to oil and gas operations was estimated at $558 billion in 2007.

Recommendations

Seek to avoid large fluctuations in natural gas production and prices. While natural gas production will provide the nation with a low-carbon alternative to other fossil fuels, natural gas prices have not proven stable in recent years. Without a national or international mechanism for stabilizing natural gas prices, involved parties should expect production to rise and fall based on even small short run changes in market conditions. The natural gas market might benefit from greater use of long term contracts between demanders and suppliers.

Severance Taxes

Severance taxes are taxes placed upon a natural resource that is extracted from the land. As of 2008, 39 states had imposed severance taxes upon a variety of different resources, including minerals, oil, gas, precious metals, and even shellfish [112]. Figure 8.1 illustrates select energy resource taxes and fees enacted by states as of 2008.

Figure 8.1 Severance Taxes by State

State	Energy Resource Taxes and Fees
Alabama	Coal, forest products, oil and gas
Alaska	Oil and gas
Arizona	Severance tax (timber)
Arkansas	Natural resources, oil and gas
California	Oil and gas, timber
Colorado	Severance tax; oil and gas
Florida	Oil and gas
Idaho	Oil and gas
Illinois	Timber
Indiana	Petroleum
Kansas	Severance tax; oil and gas
Kentucky	Natural resources, oil, coal
Louisiana	Natural resources, oil
Maryland	Local taxes
Michigan	Oil and gas
Minnesota	Local taxes
Mississippi	Oil and gas, timber, local taxes
Missouri	Coal
Montana	Oil and gas, coal
Nebraska	Oil and gas, uranium
North Carolina	Oil and gas, forest products
North Dakota	Oil and gas, coal
Ohio	Natural resources, oil and gas
Oklahoma	Oil and gas
Oregon	Oil and gas, forest products, timber
South Dakota	Energy minerals
Tennessee	Oil and gas, coal, local taxes
Texas	Oil and gas
Utah	Severance tax; oil and gas
Washington	Uranium and thorium
West Virginia	Severance tax
Wisconsin	Oil and gas
Wyoming	Oil and gas

Source: National Conference of State Legislatures

Currently, states within the Marcellus Shale gas play have a variety of differing severance tax rates for natural gas.

- **West Virginia** employs an severance tax of 5 percent of revenue, plus 4.7 cents levied on every thousand cubic feet (MCF) extracted.

- **Maryland**: Garrett County, MD has imposed a severance tax rate of 5.5 percent of production revenues. State delegates enacted this county severance tax rate change following the 2009 legislative session, lowering the rate from 7 percent[113]. Currently, Garrett County in Maryland is authorized to collect a county severance tax on natural gas, the only county in the Marcellus Shale region allowed to do so. This tax is based on total production revenues, with ten-elevenths of the tax receipts going to the County, and the remaining one-eleventh provided to municipalities within the County.

- **New York** does not have a severance tax in place. Governor David Patterson introduced a proposal for a 3 percent severance tax on natural gas producers in the FY2010-11 executive budget, aiming to raise $1 million in revenue in FY2011-12. A bill currently in the New York State Assembly, S01234, would also impose an energy business tax on natural gas companies.

- **Pennsylvania** does not have an enacted severance tax. Governor Ed Rendell has also incorporated a severance tax into the FY2010-11 executive budget. In 2009, the Pennsylvania General Assembly saw introduction of HB 1489, which would impose a severance tax rate equal to that of West Virginia (5 percent of revenues plus 4.7 cents per MCF extracted). This bill has been recommitted to committee action but has not yet been passed. The FY 2010-2011 budget forecasts that severance taxes will generate $160.7 million for Pennsylvania this upcoming fiscal year[114], and will continue to increase over the next several years.

Penn State submitted a study in 2009 concerning the potential impact of a severance tax in Pennsylvania. One of the assertions was that approving the 4.7 cent per MCF tax on shale gas production in 2005 might have lead companies to reduce shale gas exploration activities in West Virginia. Additionally, researchers contended that a Pennsylvania severance tax might decrease well drilling by 30 percent[118]. Despite the severance tax, West Virginia natural gas withdrawals increased from 221,108 MCF in 2005 to 245,578 MCF in 2008, a production increase of 11 percent in just three years[119]. Over the same time frame, Pennsylvania saw a production increase of 17.6 percent, and this followed a large decrease in production from 2004[120]. While a severance tax may have some effect on drilling and production, it should be noted again that natural gas prices in the marketplace are the primary factor affecting gas production.

Income and Corporate Taxes

Individuals that received royalties from natural gas extraction report the royalties as earned income. This income is subject to a 3.07 percent personal income tax in Pennsylvania. Corporate taxes, which are also collected by the state, are scheduled at 9.99 percent of corporate earnings. However, a vast majority of drilling companies are organized as either limited liability partnerships, limited liability corporations, or master limited liability partnerships[115]. Companies with these designations can avoid the corporate income tax rate of 9.99 percent, and are only subject to the lower personal income tax.

Local Taxes

Natural gas exploration within the Marcellus Shale will produce considerable increases in state taxes, and severance taxes provide an additional means for the state to generate revenue. Local jurisdictions cannot impose additional taxes on natural gas extraction[116]. Additionally, local jurisdictions in Pennsylvania receive no direct tax benefit from either royalty payments or increased sales taxes, as these revenue streams both belong exclusively to state government. Property taxes, while assessed based on land value, do not account for resource value of the land. Therefore, a drilling company can purchase exploration rights for oil and gas resources, but pay no tax for resource ownership. At the moment, counties have no method of assessing property taxes to companies for leased land[117].

Issues

While shale gas drilling may lead to a large increase in industrial and commercial activity around a well site, the producer deals primarily with private lease holders in distributing revenue generated through shale gas production. These transactions are private in nature, yet there are many costs borne by the community, or by local or state government, which may not be properly compensated- thus creating an externality. Costs are more easily identified when they result in visible physical damages, such as wear and tear to roads or improper dumping of waste materials. However, costs may also include less direct problems that create real, tangible issues, such as increased demand for public goods and services (road congestion or greater burdens on local health care providers), a rise in assessed property taxes for long-time residents, or declines in air quality.

Areas of some states may be more ready to accommodate the burgeoning workforce and industry processes – for instance, much of Western Pennsylvania is already home to a large historic coal industry presence, and infrastructure needs (and therefore taxes) may not be as high. However, many areas are ill prepared to handle the infrastructure costs associated with shale gas drilling. The introduction of a severance tax also raises questions about efficiency and opportunity, as to how much the severance tax may affect industry growth potential. However, some industry sources have indicated that they do not expect a proposed severance tax to deter drilling activities[121]. At least a few industry members support a severance tax as an appropriate form of compensation to states for burdens they bear in the process of shale gas development.

Policy Recommendations

- **Enact an energy production severance tax in Pennsylvania**. While the proposed severance tax has been decried by several industry associations, the enormous value to the state makes it too attractive and important to pass up, especially during a time when the state government is experiencing a massive budget shortfall. However, limiting the severance tax to natural gas production alone may unfairly target an industry that produces more desirable low-carbon energy. Pennsylvania should explore severance taxation for all non-renewable energy sources within the state.
- **Ensure equity of revenue collection with local governments**. Surrounding Marcellus Shale states and localities have enacted severance taxes, so Pennsylvania would not be putting itself at a competitive disadvantage compared to other states. West Virginia transfers approximately six percent of severance tax collections to county government – Pennsylvania can ensure local impacts are adequately compensated by enacting a similar transfer mechanism. Distributing an even larger percentage of the severance tax revenues to counties and municipalities would allow local governments to increase regular maintenance of roads and other infrastructure most affected through natural gas drilling operations.
- **Change state laws to allow for local inclusion of oil and gas value as an element in taxable property values**. The largest portion of a local government's revenues come from property taxes. Individuals receive large signing bonuses and royalty payments for exploration and production rights, while drilling companies are exempted from property value taxation while conducting exploration and production. Local governments need to be able to derive greater tax benefit from these operations, given that the impacts occur primarily on the local level. States should enable local governments to reconsider how land and property values are assessed in the region, with a focus on the tax treatment of oil and gas development.

<u>Community Reinvestment</u>

The major players in natural gas well drilling are companies such as Chesapeake Energy, Chief Oil & Gas, Talisman Energy, Range Resources, Equitable Production Company and Southwestern Energy Production Company. Although all of these companies vary in size, structure and scale of natural gas production, they have all designated a portion of their website to highlighting the community initiatives the company has taken. Initiatives vary from employee volunteer programs, donations to benefit the community, and public education programs. For instance, Chesapeake Energy lists its 2009 contributions to community investment as $21 million. Among its programs is the creation of the H.E.L.P Initiative, or Helping Energize Local Progress Initiative, which encourages its employees to volunteer within the community. For Chesapeake's 20th anniversary, the company used its newly established H.E.L.P. Initiative to reach its goal of 20,000 hours of community service in five weeks. In order to meet this goal, each employee was granted four hours of company time to volunteer towards the cause. Examples of volunteer opportunities are the renovation of a local playground in West Virginia

and volunteering at a Texas animal shelter. The company's program stimulated volunteer work in over 70 communities nationwide[122].

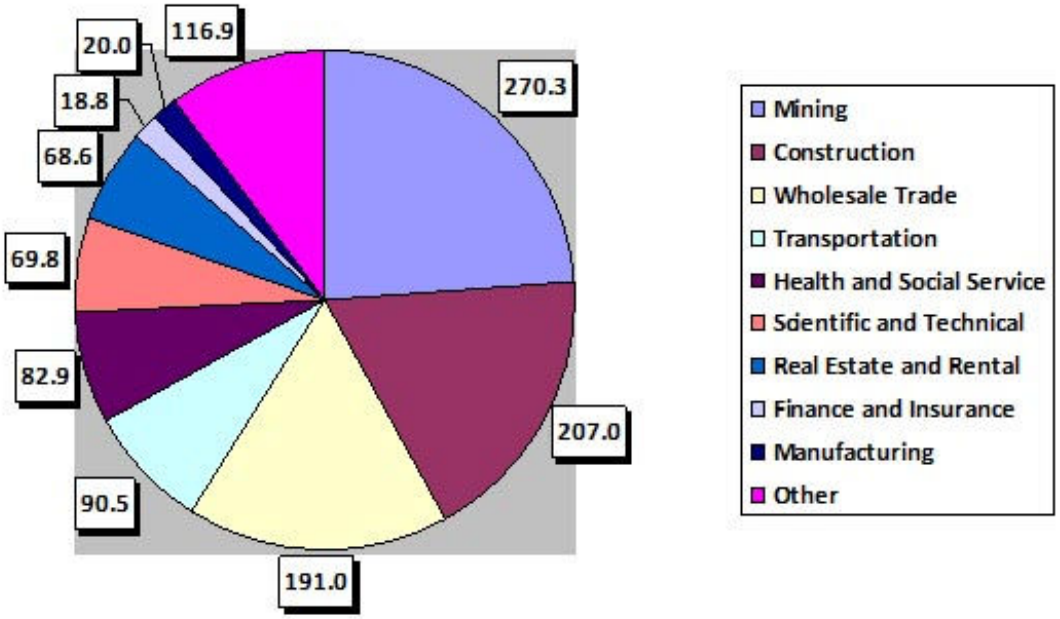
Chief Oil & Gas, LLC has pledged a donation of $402,000 to Pittsburgh, PA public schools for a gang prevention and mentoring program called the LAMP program. LAMP provides at-risk public school children in grades 4 through 8 with positive role models. In addition to the LAMP donation, Chief donated $50,000 in January of 2009 to help community members who were struggling to pay their home heating bill[123]. To facilitate community relations and address local concerns, Talisman Energy has established a Good Neighbor Hotline which allows the company to answer any questions community members may have, take and address complaints, as well as provide information when requested[124].

The Marcellus Shale: Economic Impacts on Pennsylvania

In Pennsylvania, Marcellus shale gas development is responsible for significant industry investment – amounting to $3.09 billion in 2008[127]. In Pennsylvania alone, the Marcellus Shale generated $2.3 billion in total value added in 2008, including $240 million in state and local taxes. Additionally, the shale gas development spurred the creation of 29,000 jobs in the same year. In 2009, an estimated $400 million in state and local taxes and 48,000 jobs were generated. By the year 2020, forecasts show the economic impact of Marcellus Shale gas drilling at $13.5 billion for the state of Pennsylvania, leading to the establishment of over 175,000 jobs[128].

Of the $2.3 billion in total value added within Pennsylvania, direct spending accounts for almost half of this figure (over $1.13 billion), with the largest direct expenditures occurring in mining activities, construction, wholesale trade, transportation, and health and social services[129]. Direct expenditures by industry cover all of the activities directly associated with Marcellus Shale exploration and drilling. A breakdown of direct investment is provided in Figure 8.2.

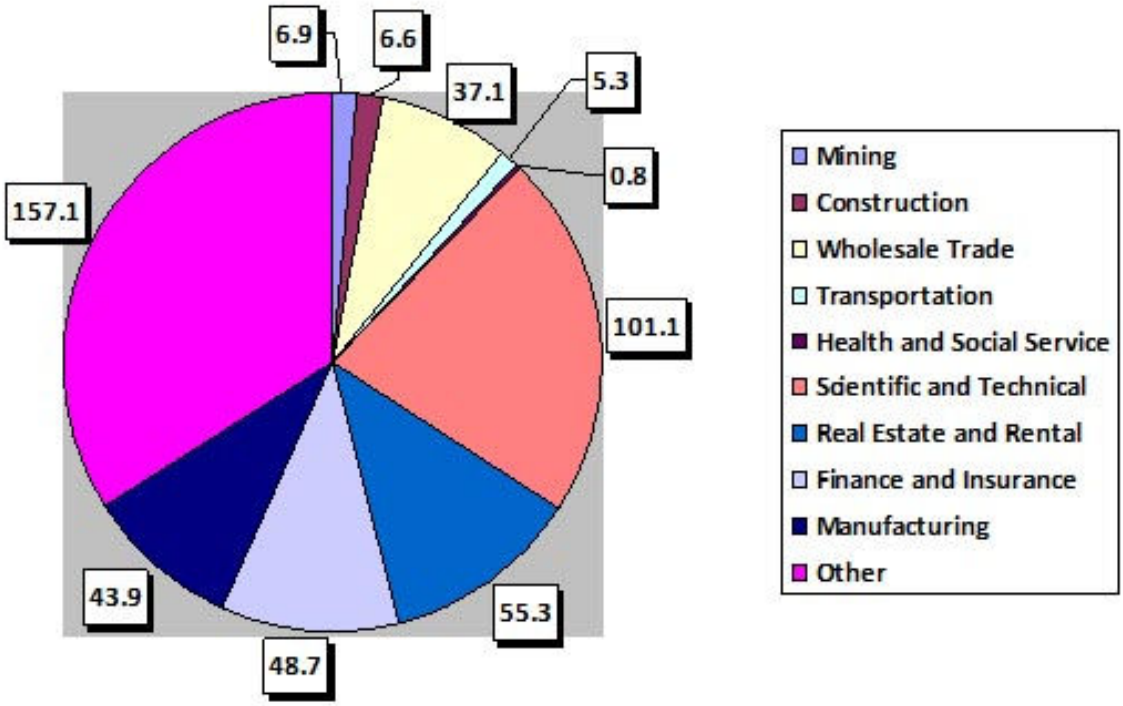
Figure 8.2: Direct Spending in Pennsylvania, in Millions of 2008 Dollars



Indirect Investment

Indirect expenditures provides another $462 million in value-added investment, with the largest impacts occurring in the scientific and technical services, real estate and rental, finance and insurance, and manufacturing industries[130]. Indirect investment is identified as investment in resources or services utilized by Marcellus industries in shale gas exploration, drilling, and production. This may include material purchases, legal assistance, real estate transactions, technical advising, or any industry that contributes to operations without involvement within the actual industrial process. Figure 8.3 illustrates the division of indirect expenditures.

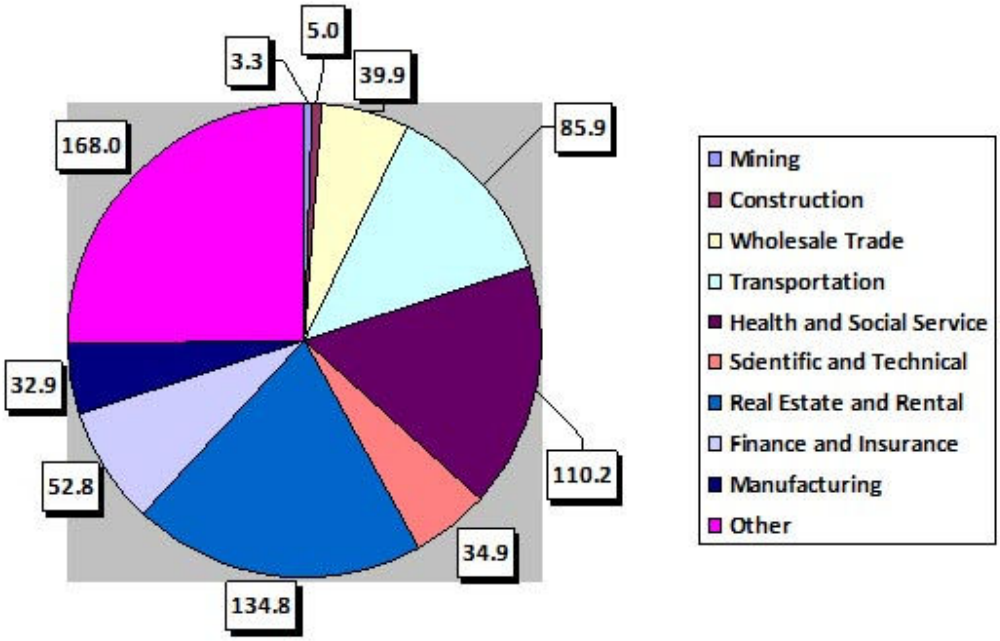
Figure 8.3: Indirect Spending in Pennsylvania, in Millions of 2008 Dollars



Induced Spending

Induced spending accounts for another $664 million in total spending. This spending occurs primarily in retail sales, real estate and rental, health and social services, transportation and warehousing, and finance and insurance[131]. Induced spending can be considered the "local economic effect" produced through Marcellus Shale gas drilling. When a company undertakes operations within an area, the company provides payments to the labor force and households, and in turn these workers function as consumers, purchasing goods and services provided in the area. A breakdown of each sector is provided in Figure 8.4.

Figure 8.4: Induced Spending in Pennsylvania, in Millions of 2008 Dollars



Issues

Exploration of the Marcellus Shale gas play does not affect every industry in the same manner, nor evenly over time. While the construction, wholesale trade, and other heavy labor industries may benefit from increased investment, real estate operators and health and social services providers might find some difficulty in adjusting to consumer demand throughout the labor-intensive development phase. Encouraging firms to remain in the community following the development phase may prove crucial in preventing a "boom and bust" cycle from occurring in Marcellus communities. Additionally, large firms with greater resources may be able to take advantage of new market opportunities more quickly than smaller firms, reducing growth and investment prospects for smaller firms.

Policy Recommendations

- **Hold community business association forums to discuss impacts of investment**. Local businesses within the Marcellus Shale gas play may not entirely understand the sweeping changes that can take place once industry enters the region. Businesses should be informed about the potential impacts that an expanding work force and increased

investment can have on their businesses and the surrounding townships, cities, and counties.

- **Develop local forecasts of the economic impacts of shale gas development**. In order to plan effectively for the local impacts of shale gas development, state and local officials, as well as the wider public, need better information on these impacts, including economic forecasts.

Job Creation and Employment Distribution

Thus far, drilling activities in Pennsylvania have been most heavily concentrated in two specific areas of the state: the northeastern counties of Tioga, Bradford, Lycoming, and Susquehanna, and the southwestern counties of Washington, Greene, and Westmoreland. A comparison of median income for each of these areas is provided in Figure 8.5.

Figure 8.5: Median Household Income in Pennsylvania and Select Counties, 2008

Jurisdiction	Median Household Income
Pennsylvania	*$50,702*
Washington	50,791
Westmoreland	46,994
Susquehanna	43,467
Lycoming	42,005
Greene	40,589
Bradford	40,033
Tioga	38,699

Source: U.S. Census Bureau

From an equity standpoint, this may be an effective means of raising household income levels in poorer jurisdictions. Every county above, save for Washington, has a median household income significantly lower than the state median. Expanded gas drilling and development in these areas should lead to a rise in median household incomes as residents obtain salaried jobs, lease payments, and royalties from drilling companies.

It should also be noted that the industry witnessed tremendous growth over the last two years despite national economic trends. Goods and services purchases alone have lead to the direct creation of 14,307 jobs by the Marcellus Shale industry. Indirect and induced spending has contributed to the generation of an additional 14,977 jobs[134]. The impact on the job market, however, should be evaluated at two primary phases: development (due to the intensity) and production (due to the length).

Drilling requires a large amount of labor to service the well site throughout the exploration process. The Marcellus Shale Education and Training Center estimates that drilling a single well

requires direct worker input from "over 410 individuals", producing enough labor to account for a total of 12 full-time jobs on an annual basis[135]. As drilling rises within Marcellus communities, a tide of short-term industry opportunities including (but not limited to) material and resource shipment, heavy labor, logging, permitting, fracturing, office automation, and construction may become available to area residents.

However, there is little long run effect on these jobs – once drilling concludes at a site, these jobs largely disappear unless any further drilling takes place. Years of anticipated drilling within the Marcellus Shale gas play will ensure that these jobs will remain, but availability is entirely dependent upon where drilling takes place at any given time. This phase involves skilled, semi-skilled, and unskilled labor, with the majority of drilling work performed by the latter two groups. Many of the higher skilled workers are likely to be mobile, working in pre-designated crews assigned to particular drilling sites[136].

Following exploration and fracturing processes, the well sites shift towards the production phase. Long-term jobs associated with this phase would be few in number – only 0.17 full-time jobs per well are created each year through production[137]. Most of these industry jobs would be focused towards maintenance and on-site assessment. While few in number, these jobs will remain available for as long as the well sites continue to produce natural gas (estimated in many cases to be around 40 years). Owners of mineral leases will continue to receive significant royalty payments over the long term, also generating indirect local economic benefits.

This phase relies upon primarily skilled and semi-skilled labor to perform most maintenance and monitoring duties. However, jobs in this phase are not necessarily kept within local jurisdictions and may be held by mobile workers as well. Additionally, this phase may involve re-drilling or re-fracturing, allowing for a new influx of semi-skilled and unskilled jobs[138]. Much of the workforce may be from out-of-state, as companies conducting exploration or drilling operations are found in areas with previous shale gas drilling sites, such as Texas, Arkansas, and Wyoming. As drilling ventures expand, companies may find that relocating offices or branches within state, or closer to operations, proves more cost-effective in the long-run. Additionally, as the local workforce develops into a more skilled group, the drilling industry will likely rely less on the transient labor in favor of the local workforce.

While a great number of jobs are created during the drilling phase, an even bigger impact lies in the indirect and induced job creation. The Pennsylvania Economy of League of Southwestern Pennsylvania estimates that every job in the oil and gas industry indirectly leads to the creation of an additional 1.52 jobs within the state[139]. This would result in 17.53 full-time jobs generated due to each drilling operation, with most jobs stemming from retail and services provided. Employment in these sectors rely heavily on industry operations and worker investment for growth opportunities, but may not be entirely dependent on the shale gas industry presence.

<u>New York</u>

Currently, New York State is operating under a moratorium on horizontal drilling, so the amount of shale gas development taking place is minimal compared to Pennsylvania. Yet, several studies have pointed to the large potential impact that shale gas drilling could have on the New York economy.

The Independent Oil and Gas Industry (IOGA) of New York estimates that development of Marcellus shale gas in New York could generate $1.4 billion annually, based on an assumption of only 300 wells. This would include $32 million in tax revenues for the state, and potential lease payments for land owners valued at over $100 million[141]. The state has significant revenue possibilities available through leasing of state lands. In 2008, New York could receive $217 million in revenue by leasing 30 percent of leasable state-owned lands[140].

Locally in New York, Broome County has issued a report projecting the economic impact of shale gas development. Assuming 2,000 wells, economic impact is estimated at $400 million in wages and 8,100 person-years of employment (measured as the amount of jobs created over a year; this may also be calculated as 810 jobs lasting 10 years)[142].

West Virginia

In 2006, natural gas wells in West Virginia numbered at least 41,488, with an additional 7,069 wells capable of producing both oil and gas. Employment in natural gas operations rose by nearly 15 percent between 2003 and 2006 – this reflects the trend of higher natural gas prices (and therefore increased drilling and production) during this time period. Direct employment totaled 7,520 in 2006, with an additional 7,480 jobs created through indirect and induced employment. The total income estimated for direct and indirect impact was $627 million[143]. Furthermore, the state and county governments collected a total of $209.6 million in taxes in 2006. The largest tax items include local property taxes ($74.9 million), state severance taxes ($61.9 million), personal income taxes ($25.3 million), and sales taxes ($19.7 million)[144].

In 2008, Marcellus shale gas activities in West Virginia produced $371 million in gross economic output, $68 million in state taxes, and 2,200 jobs. Future impacts are likely to be much higher; by 2020, economic projections are $2.89 billion in gross economic output. This level of industry operation within the state will lead to the creation of 16,863 jobs, and $1.63 billion in value added economic activity. Total state and local tax revenue generated in West Virginia by 2020 is expected to reach $872 million[145].

Issues

Many of the Marcellus Shale job opportunities are generated during the development phase of shale gas extraction. While development of the Marcellus Shale will likely continue for another 30 to 40 years, the positions are not permanent in nature. Employment moves along with development, and workers must be able to frequently relocate in order to take advantage of these opportunities. Once the development phase ceases within a particular area, the amount of permanent positions available due to direct and indirect shale gas industry involvement is small.

Furthermore, the shale gas industry may employ a large out-of-state labor force. While this transient workforce may bring with them experience from previous gas drilling operations, they do not provide the same positive effects on the local economy as local workers.

Policy Recommendations

- **Create an assessment and training program for local workers**. Currently, much of the natural gas drilling labor force is comprised of out-of-state workers. In order for local workers to benefit most from shale gas employment opportunities, local and county governments should form a collective partnership with gas companies to provide a training program for community residents during the exploration phase. This will provide local workers with competitive skill sets and assist them in obtaining jobs during the development process. Additionally, this may benefit out-of-state companies, as it could decrease travel and housing costs.

- **Develop State and Regional post-Marcellus Task Forces**. Marcellus operations will continue long into the future, but employment and growth in localities will be dynamic and subject to rapid change. State and county officials should determine the likely effects of sudden changes to community growth, investment, and income at the municipal level. State and local governments must be ready to respond as changes to revenue streams and government services fluctuate during and following the development phase.

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< http://www.alleghenyconference.org/PEL/PDFs/EconomicImpactOilGasInPA1108.pdf>ways in proportion to their importance. This report could be helpful in making a number of recommendations in this area. It seems to be relatively understudied compared with other issues. Overall, the chapter is stronger on the discussion of the problem than of how to solve it.

Part IV – A Financial Model of Shale Gas Development

Chapter 9 -- Marcellus Shale Gas Model: How Best to Tap an Emerging Resource

This model, titled "Marcellus Shale: How Best to Tap an Emerging Resource," is available on a CD. A save-disabled version of Stella is available for free at the URL below if the reader should want to manipulate the model his or herself. This chapter was written by Kiki Schneider and A. Michael Sheer.

http://www.iseesystems.com/community/downloads/STELLA/STELLADemo.aspx

Background

In the face of tremendous resources and significant budget shortfalls, it is unsurprising that states would want to capture a portion of revenues for themselves. For some states in the play, the absence of significant recent mineral or oil extraction has caught them "flat-footed" in the face of such a booming industry. Many have no severance tax at all, or only a very limited version of one – intended to stimulate what little development was possible. In the face of huge interest and production, however, some are questioning whether such incentives are still necessary. Even PA, the leading state in Marcellus development, is preparing to enact severance legislation.[1] To date, the only major modeling effort of the effects of such a tax comes from a largely industry favorable Penn State report. This report implied that any severance tax would dramatically reduce drilling, and thus state revenues.[2] In the interests of examining alternative scenarios for industry response to taxes, we attempted to design a model that would help evaluate a few different policy tools and their effect on state revenues. In addition to severance taxes, we examined the effect of minimum royalty laws and rebate programs on state revenue.

For our analysis, this particular model is based on the state of Pennsylvania's drilling activity in the Marcellus Shale play. With a variety of scenario tools within the model itself (see Figure 9.1), it can be adjusted to fit other states that are newer to Marcellus Drilling.

General Points on Model Construction and Assumptions

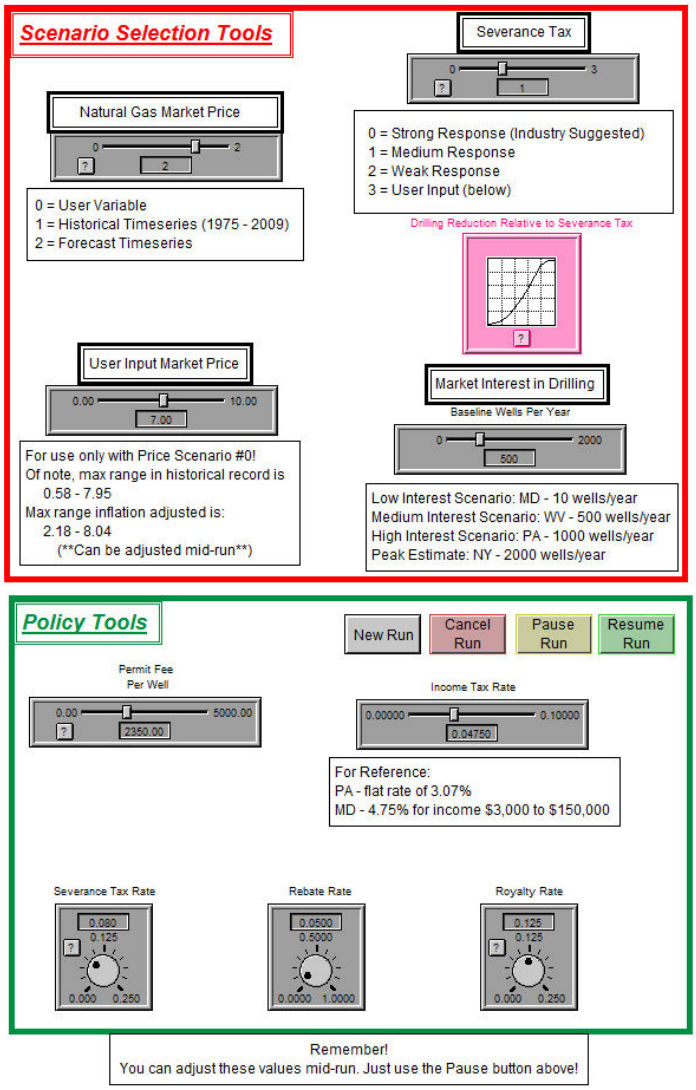
Industry sources are, naturally, loathe to disclose their operating costs, profit streams, and their decision making process. As such, we were forced to make a number of assumptions throughout the model. Although all of our assumptions are described in greater detail later, three particulars are worth mentioning early and explicitly:

1. For our model, industry makes an excessively simple decision on whether to drill or not. If industry takes a loss, then they cease drilling activities for the following year. Conversely, if they draw a profit drilling resumes in the next year. Data for operations costs and yields are made from estimates based on literature where available.

2. This model assumes a fixed maximum drilling interest level. That is, with no taxes at all, industry will drill X* number of wells. Taxes then reduce that number by a variable percent based on tax rate.

3. The actual severance tax response curve is unknown. As such, we generated 3 scenarios: Strong, Medium, and Weak. These S-curves attempt to examine the responses across a variety of possible scenarios. The model allows for a user input response curve, however, if one should want to reexamine our results.

Figure 9.1 - Adjustable options in the model to manage different state or policy scenarios. This is the main control panel in the Stella model.



* This number is variable, our model allows for a user-set range of 0 to 2000 wells per year. See figure 9.1 for interface.

Model Results Overview

Although graphs and more detailed discussion can be found below, here is a brief summary of our results.

Severance and Income Taxes

By virtue of the model's construction, increasing severance tax will reduce wells drilled per year. This, in turn, reduces income tax revenues as less jobs are created. Even in the strongest response scenario, however, a small severance tax will increase revenues over the no-tax scenario. This is dependent on income tax rates, however, and should be examined on a state by state basis. At Maryland income tax rates (4.75%), the Strong tax response maximized revenue at 2.5%, the Medium tax response at 4%, and the Weak tax response 9.5%. If industry responds to drilling in the manner we propose, [*] the severance tax could serve as a means to limit new well production rates. Since some groups have questioned the ability of state environmental departments to deal with high numbers of applications, this could serve as a means to cap drilling at manageable levels.

Rebates versus Royalties

In the interests of ensuring state residents prosper from the extraction of state resources, legislatures may be tempted to rely on either rebate or royalty measures. For our purposes we treated rebates as being government issued based on severance tax returns and royalties as being a minimum royalty rate law. Since rebates do not impact the bottom line of producers, they had no effect on drilling rates and thus kept production high. Thus the rebate scenarios showed little effect on total state revenues. Royalties, in contrast, increase production costs for the industry and thus dramatically reduce gas extraction. [†] This, by extension, dramatically reduces severance tax returns and total state revenues. It is our recommendation, based on these results that states hoping to ensure direct citizen benefit rely on rebates over royalties. Of course, it is worth noting that rebates offer much smaller but widely dispersed benefits while royalty laws offer higher but more concentrated benefits.

A Note to Policymakers

As seen in Chapter 2 of this report, each state has its own peculiarities when it comes to obstacles in and enthusiasm for Marcellus drilling. As such, we recommend that those interested in our results attempt to replicate them with the current conditions of their own state. If Maryland is of interest, enter Maryland income tax rates and drilling interest levels. If New York is the preferred jurisdiction, do the same. With each region viewing this resource through a different lens, it is entirely appropriate to look at each case individually and in detail. To this end, we've attempted to make the model easily accessible. As models like these can always be improved, however, we would like to welcome questions and suggestions at amsheer@gmail.com.

[*] That is, it reduces wells drilled directly in response to severance taxes
[†] And by extension, severance tax returns

Detailed Model Analysis

Questions Addressed in the Model

This model seeks to answer the following questions:

1. How should a state best use severance and income taxes to maximize revenue?

2. If a state uses rebates to return drilling revenue to citizens, how does it affect State revenue?

3. If a state uses a minimum royalty law, how does it affect revenues?

Model Summary

The schematic for this model is seen in Figure 9.2. As it is designed to compare differences in revenue, the centerpiece revolves around the "Total Revenue" stock. This stock represents the total revenues paid to the State.

- To the left are sources of income from Citizens:
    - This section contains a small jobs model and an estimate of income taxes

- To the right are sources of income from Industry:
    - This section contains revenue from severance taxes and permit fees

- Beneath are the costs to the state
    - This contains Administrative costs to cover new employees needed for permitting, Rebate costs, and Environmental & Infrastructure costs
    - Environmental & Infrastructure costs are currently disabled, as no consistent estimates exist. They can be easily activated later, however, should data become available

The model also contains a "Drilling Sub-model" which estimates natural gas production from the Marcellus Shale and the effects of various policies on Industry. It contains:

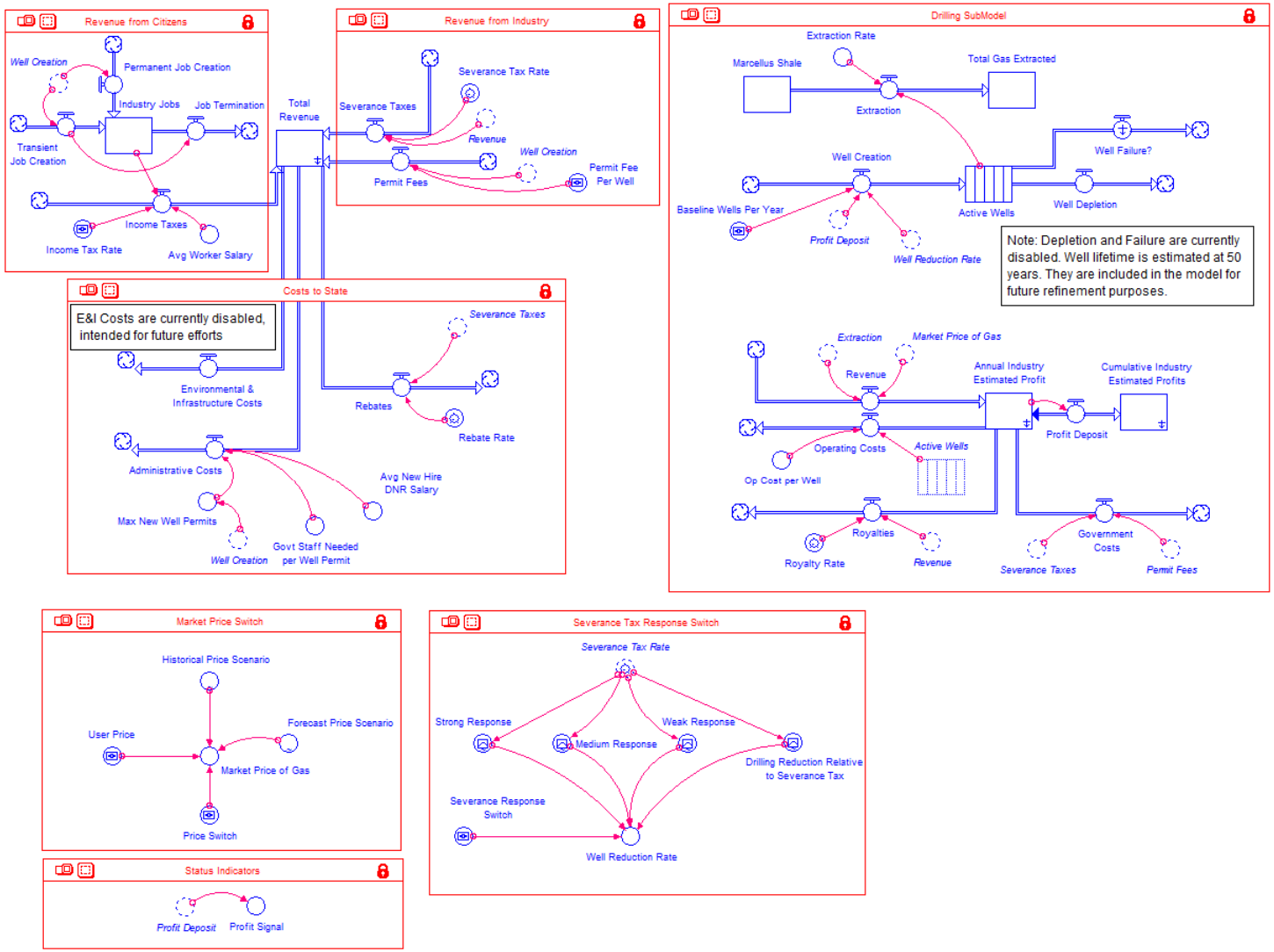
- Estimates of gas production based on the number of active wells
- Estimates of drilling activity based on policy tools and scenario assumptions
- Industry profits and actions, based on policy tools and scenario assumptions

At the very bottom the model has a few scenario switches and indicators tied to the interface.

[1] Pennsylvania Budget and Policy Center (2010, May 11). Pa. House Revenue Package Will Close Tax Loopholes, While Preserving Critical Services. *PennBPC.org*, available at: http://www.pennbpc.org/pa-house-revenue-package-will-close-tax-loopholes-while-preserving-critical-services

[2] Considine, T., et al. (2009, July 24). An Emerging Giant: Prospects and Economic Impacts of Developing the Marvcellus Shale Natural Gas Play. *The Pennsylvania State University Department of Energy and Mineral Engineering.*

Figure 9.2 - Schematic for the Marcellus Shale model



Key Assumptions and Data Sources:

Revenue from Citizens Assumptions:

- Assumption 1: State Revenue streams are limited to Severance Taxes, Permit Fees, and Income taxes on industry jobs. Property taxes and additional income taxes on royalties were excluded as "devaluation of property" often offsets these.
    - Source: http://www.irs.gov/publications/p525/ar02.html
- Assumption 2: 0.17 full-time jobs are created per well after drilling
    - Source: Marcellus Shale Workforce Needs Assessment. Marcellus Shale Education & Training Center. June 2009. Page19
- Assumption 3: 11.53 annual temporary jobs per well. These jobs do not carry over year-to-year
    - Source: Marcellus Shale Workforce Needs Assessment. Marcellus Shale Education & Training Center. June 2009. Page 19

Revenue from Industry Assumptions:

- Assumption 1: Corporate taxes do not form substantial revenues. Many (70% in PA) drillers escape taxation by operating as individual, LLC or LP
    - Source: PA Budget and Policy Center, Over 70% of Marcellus Shale Wells Will be Subject to 3.07% Personal Income Tax - Not the Corporate Net Income Tax, June 29, 2009
- Assumption 2: Industry annual profit is determined as revenue from extracted gas minus operating costs per well. Operating costs are estimated at $2,000 per month for the life of the well, $2000 x 12 months = $24,000/year.
    - Source: ALL Consulting, LLC (2009), Projecting the Economic Impact of Marcellus Shale Gas Development in West Virginia: A Preliminary Analysis Using Publicly Available Data prepared for the United States Department of Energy - National Energy Technology Laboratory

Costs to State Assumptions:

- Assumption 1: State Environment/Resource departments needs 0.048177 staffers per well drilled. As long as staff is >= the needed for the peak number of permits required, no additional hires are needed.
    - Source: This estimation is based on PA data from the Department of Environmental Protection Bureau of Oil and Gas Management 2009 Year End report).

- Assumption 2: "In 2009, to cope with the addition of 768 wells the DEP hired an additional 37 positions." 37 / 768 = 0.048177 new government positions per well.
    - Source: Pennsylvania Department of Environmental Protection Bureau of Oil and Gas Management 2009 Year End Report
- Assumption 3: Average DEP salary is $35,000, (Grade ST05, P.S. level 1 - $34,864)
    - Source: David, English, PA, Department of Environmental Protection and Commonwealth of Pennsylvania 40 hour standard Pay schedule 2009

Drilling Sub-Model Assumptions:

- Assumption 1: Marcellus resources are infinite (this is not an extraction/resource maximization model).
- Assumption 2: The extraction rate of gas is 4909.25 MMcf per well per year. Per Range Resources, "Extraction rates for early wells reached 13.3 and 13.6 Mmcfe per day." For this model the average of 13.45 is used, (13.45 Mmcfe per day * 365 days per year = 4909.25 Mmcfe per year)
    - Source: Range Resources Investor Statement: http://www.b2i.us/profiles/investor/ResLibraryView.asp?BzID=790&ResLibraryID=36412&Category=1640)
- Assumption 3: The maximum drilling # of wells per year that would exist in the absence of severance taxes is estimated in the model. Severance taxes reduce this maximum by a percentage based on the graphical functions embedded in the Strong Response, Medium Response, and Weak Response severance tax converters (see interface : y-axis is drilling reduction up to 100%, x-axis is severance tax rate up to 25%) The data for this is based on the following point: According to an industry favorable Penn State Study a roughly 5% tax equates to a 30% reduction in drilling. We then created S-curves that imply a light response to early low taxes followed by a rapid response. We also did not set a 0 development rate, assuming that there would always be at least some development regardless of tax.
    - Source: PennState, College of Earth & Mineral Sciences, Department of Energy and Mineral Engineering, An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play, July 2009
- Assumption 4: Firms decide to drill or not drill by looking at the previous year's profit. If profit is negative, drilling stops and vice-versa.
- Assumption 5: Wells are assumed to last more than the 24-year run-time of our model and do not fail. We were unable to get consistent data to make a better assumption, though the (disabled) outflows remain in our model for future refinement.

Analysis

Base Scenario Info - all scenarios used the following price and interest baseline:

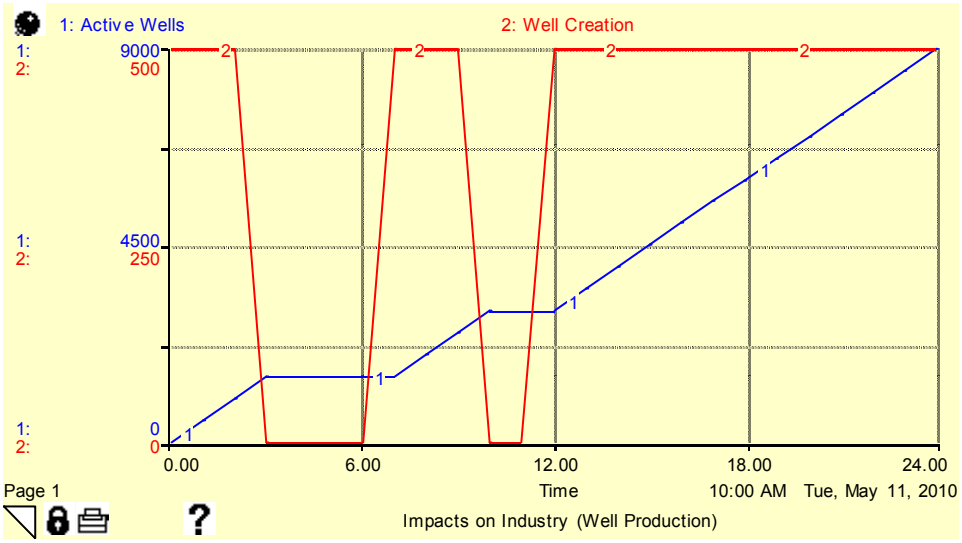
1. Forecasted Price Scenario - Historical prices only allow for very limited production due to cost constraints. The forecasted scenario allows for a more robust analysis due to higher production levels and

2. Medium Interest Scenario - Choosing 10, 500, or even 2000 wells base interest will generally only change the magnitude of observed effects. Choosing the middle scenario allows us to capture the effects at a visible level without necessarily over- or under- stating impact.

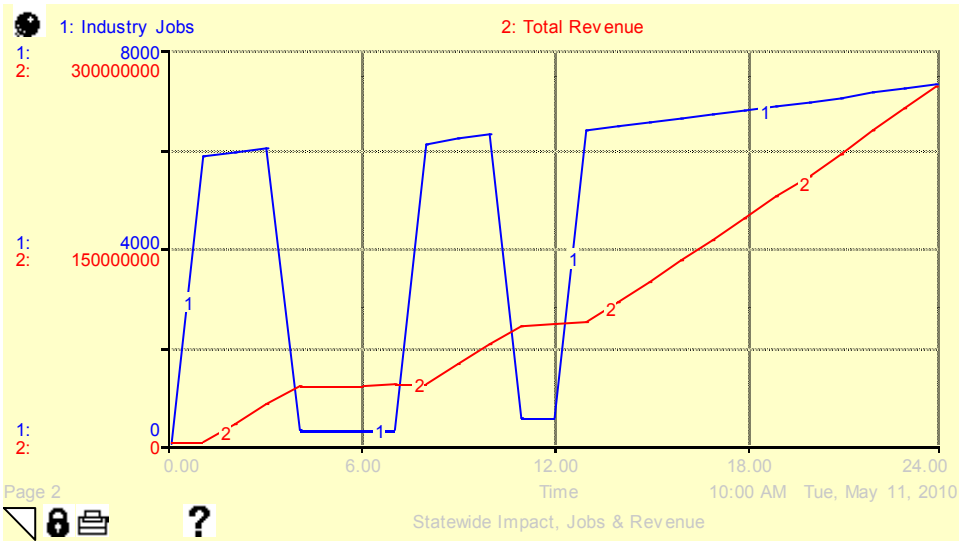
Severance Tax/Income Tax

The first set of scenarios analyzed were the effect of different severance tax responses on income for the state. This was split into four different components with the following values:

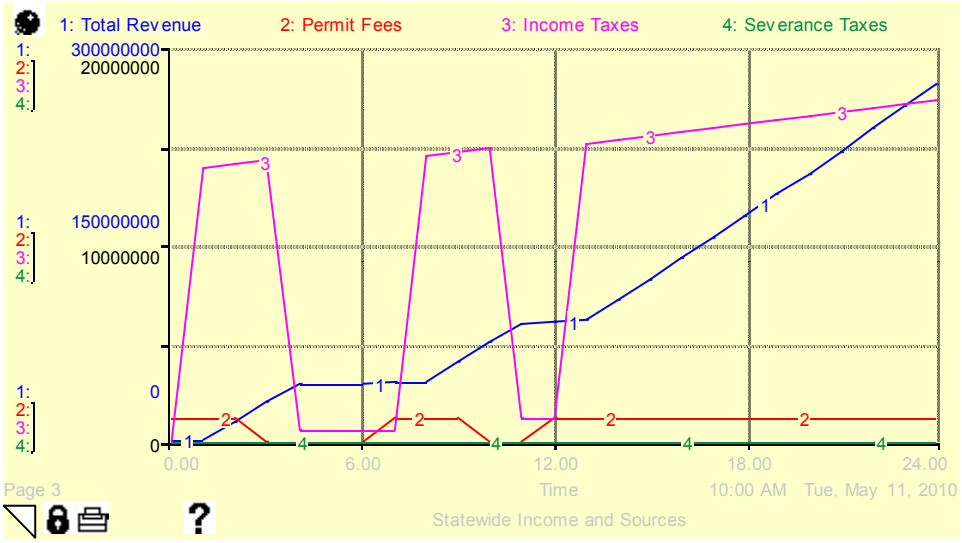
Scenario 1: 0% Severance Tax, Baseline: $0 Permit Fee, 4.75% Income Tax, 0% Rebate, 12.5% Royalty



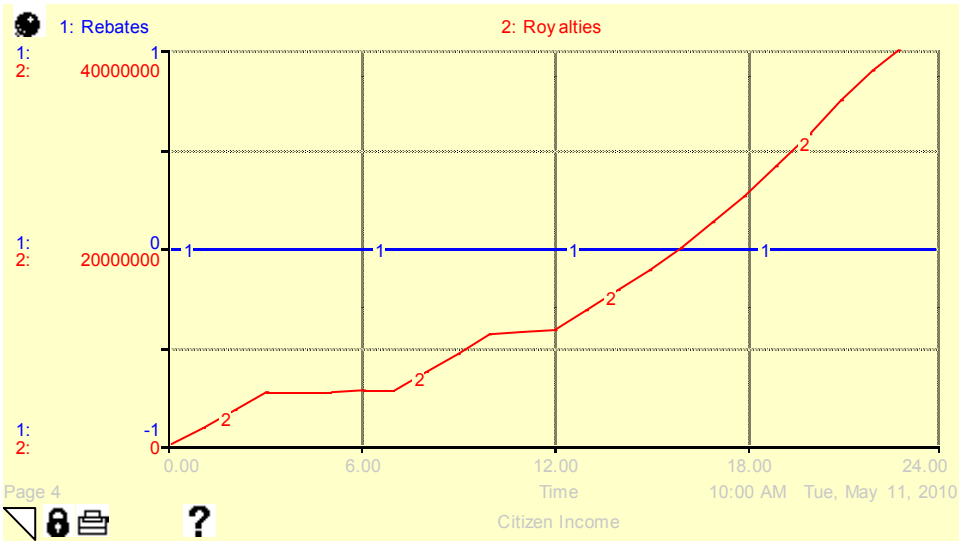
The well creation in this scenario is always at the maximum, therefore strong/med/weak response is not pertinent.



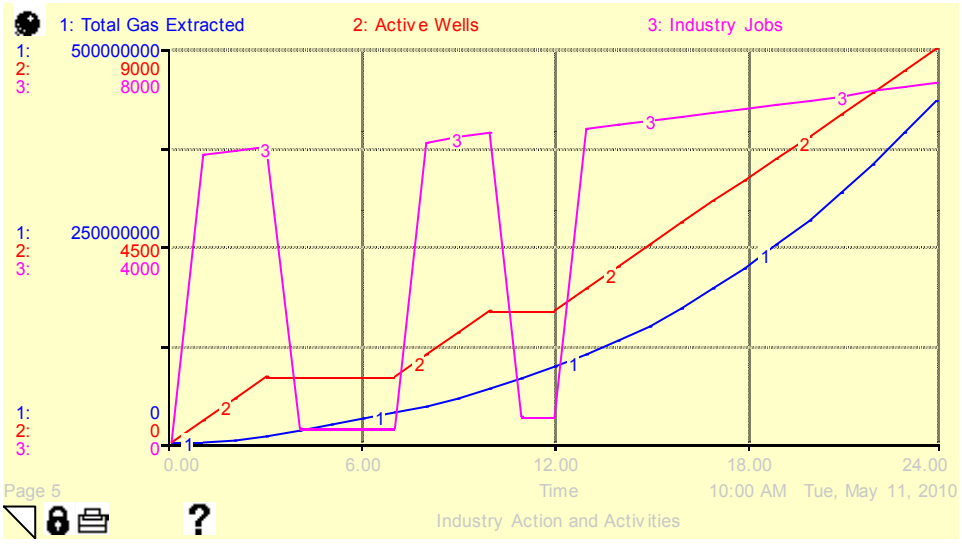
Jobs created rises as wells are created initially, then go down during the production phase when less jobs are needed. Jobs rise again when more wells are created. Total revenue increases with well creation and job creation, levels out when job creation drops and rises again as more jobs are created and production continues.



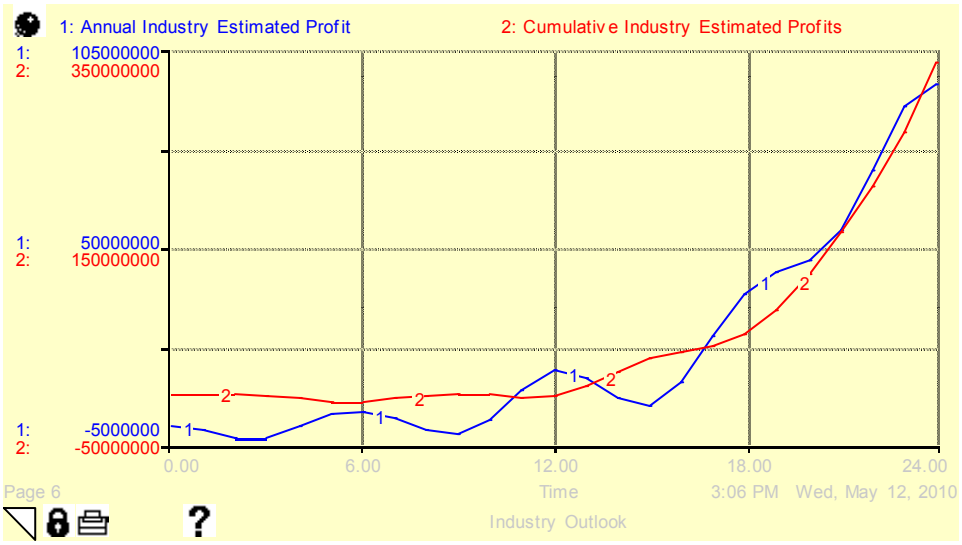
Income tax revenue rises with initial well creation, fall during extraction and rise again well more well creation occurs.



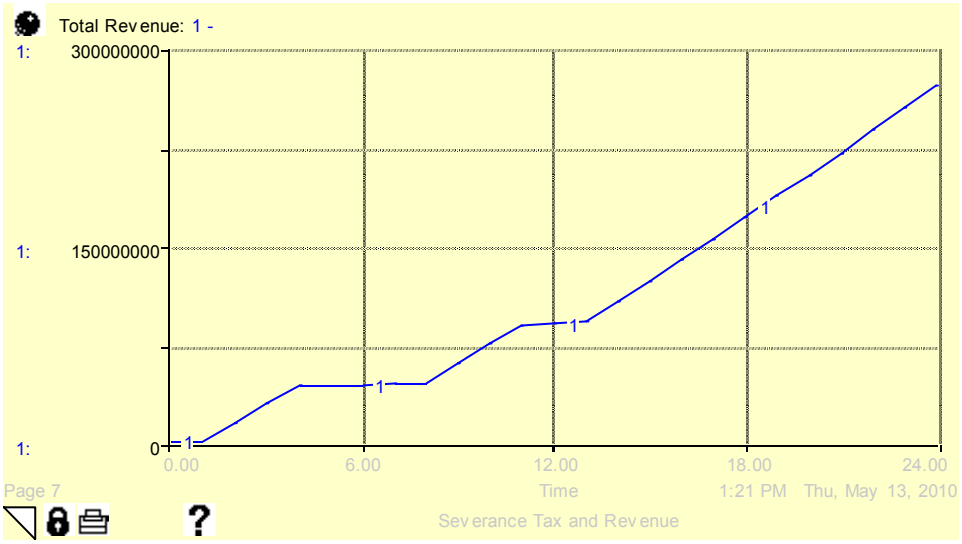
Royalties increase over time as more gas is extracted.



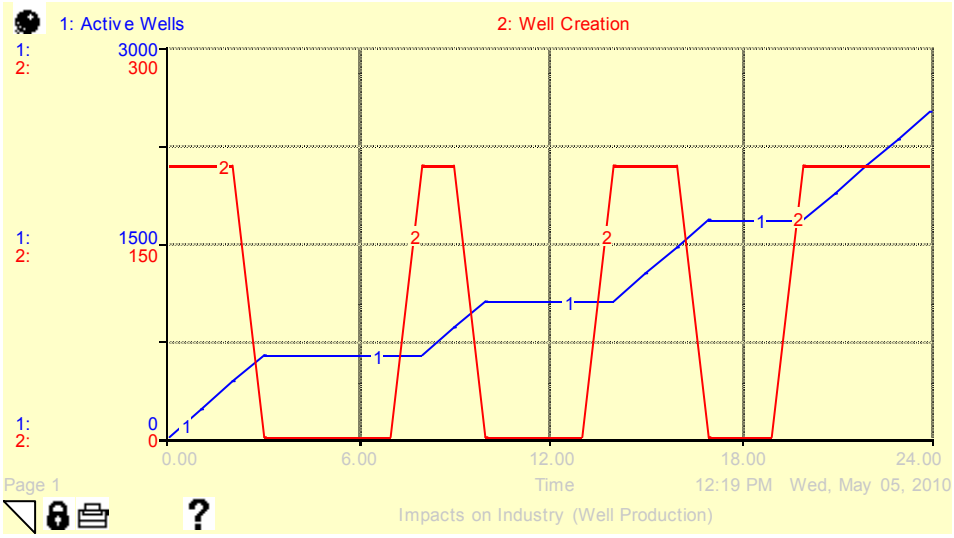
Total gas extracted increases with active wells.



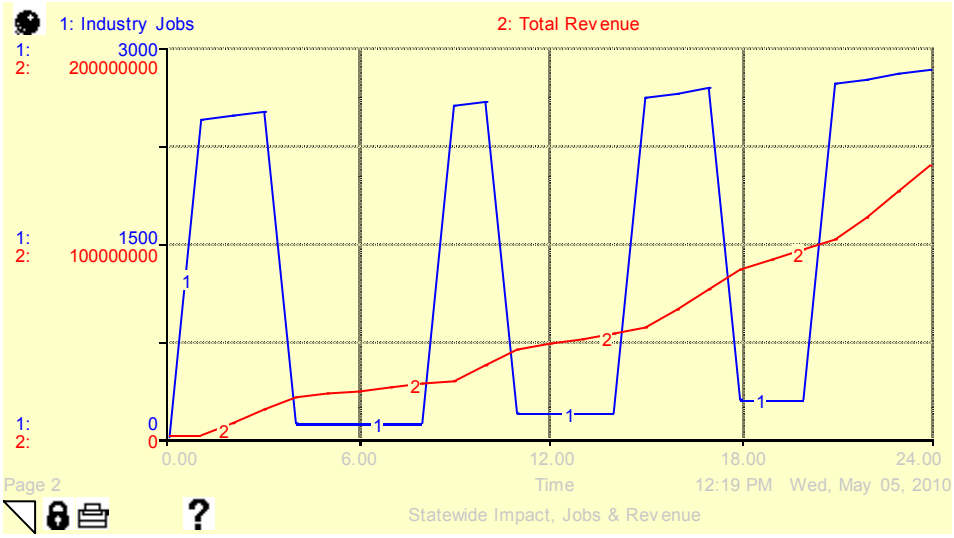
When profit is less than zero, companies will still run wells because some income is better than none and they cannot just stop running wells. Profits become positive after 6 years.



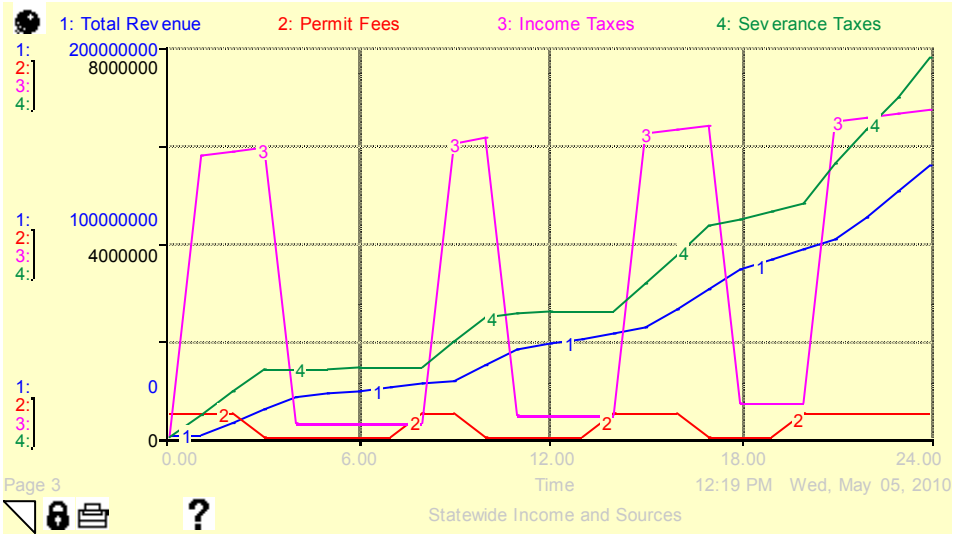
Scenario 2: Strong Severance Tax Response, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 5% Rebate, 12.5% Royalty



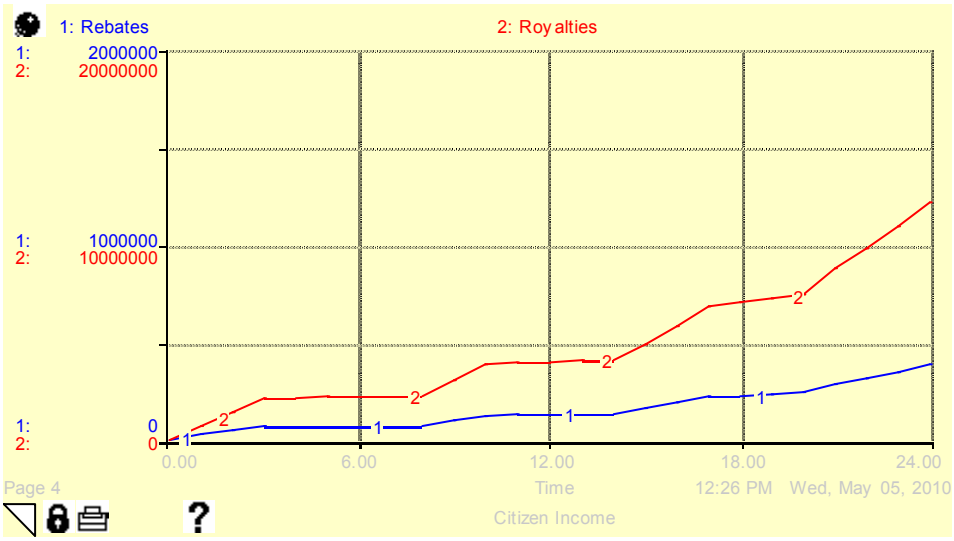
Fewer wells are created with a strong severance tax response. Drilling decreases in response to a severance tax.



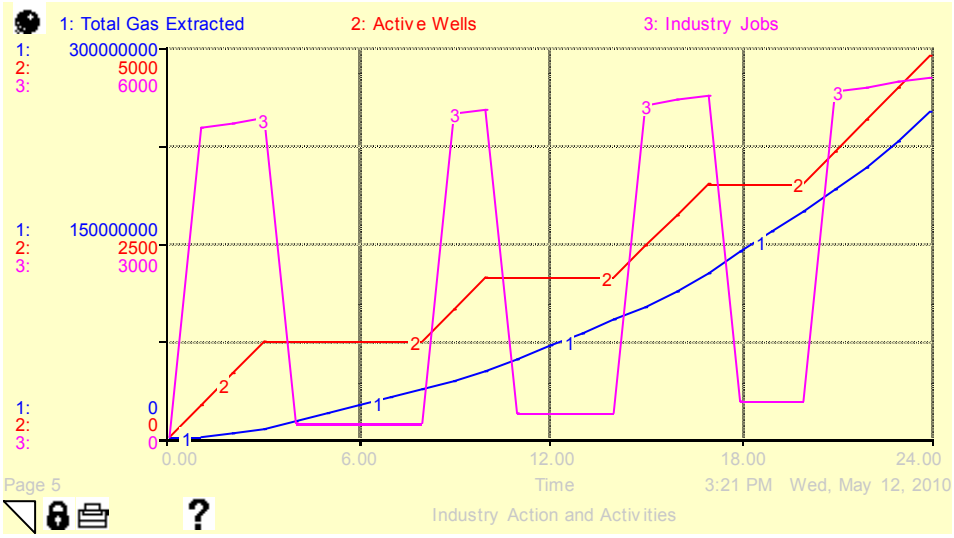
Creating more wells creates more jobs which increases income tax revenue to the state.



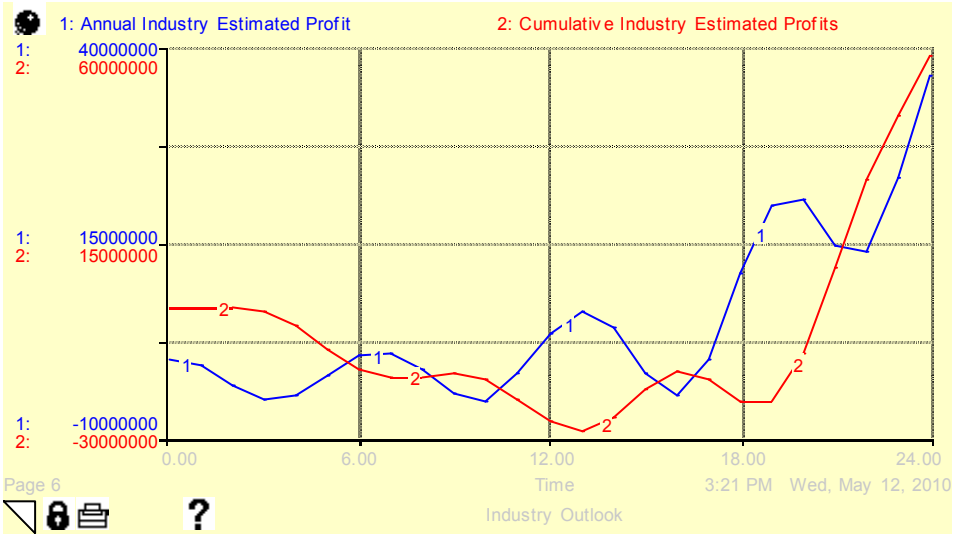
Severance tax revenue keeps rising over time while income tax revenue peaks during well creation and falls again during the production phase. Income tax is responsible for state income as long as wells are created because this creates the most jobs initially.



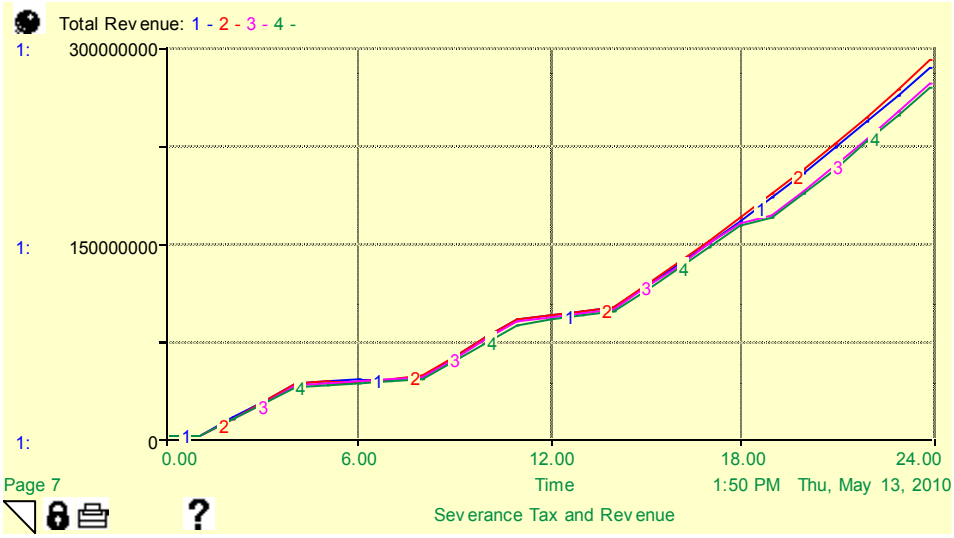
Rebates and royalties increase with drilling activity.



Total gas extracted rises with number of active wells.

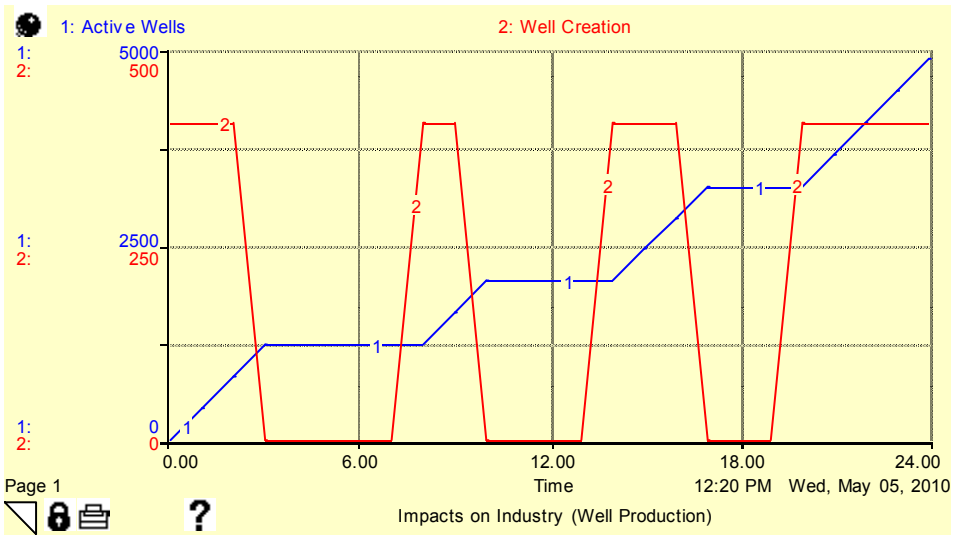


Profits rise and fall over time with well creation and gas extraction and eventually continue to rise over time as the well numbers increase.

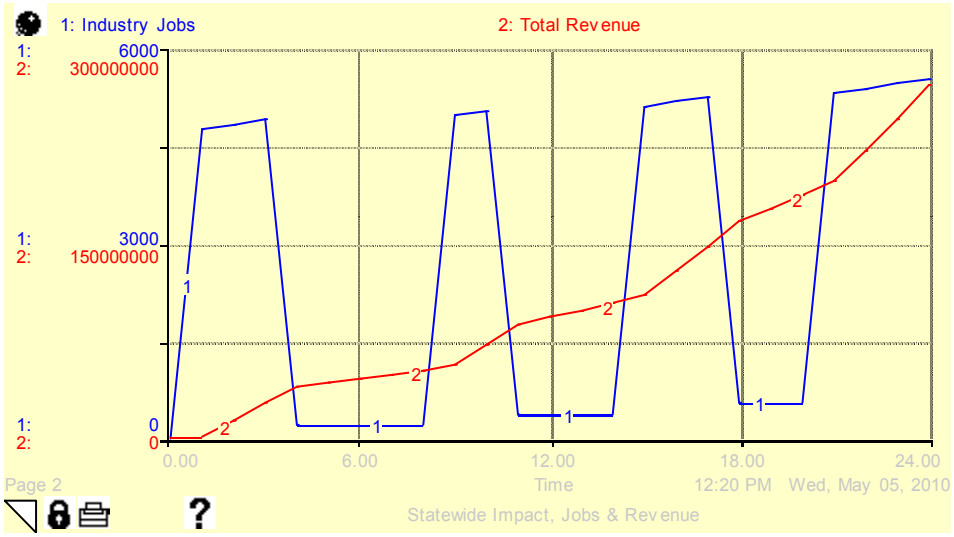


A 2.5% (Line 2) severance tax seems to maximize revenue. Line 1 starts at 2% and increases by 0.5% with each run.

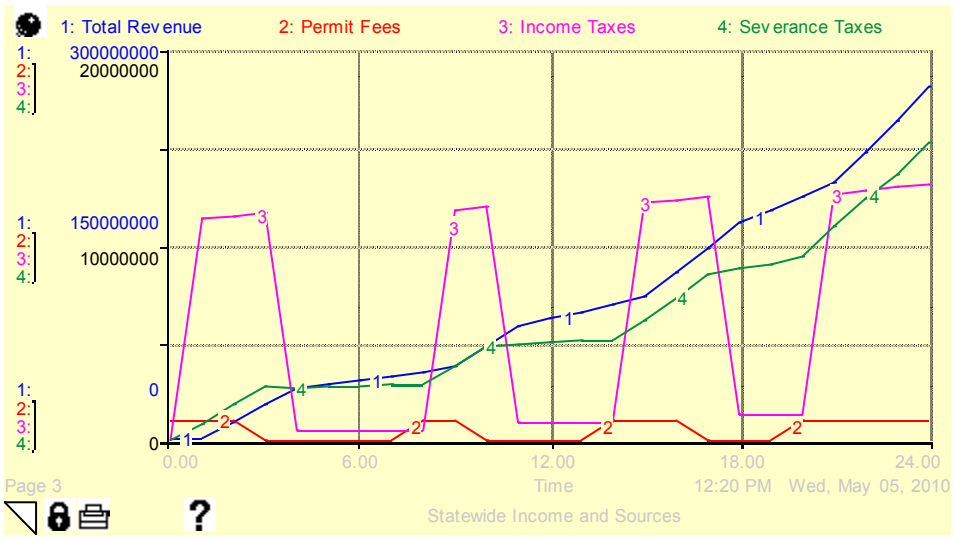
Scenario 3: Medium Severance Tax Response, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 5% Rebate, 12.5% Royalty



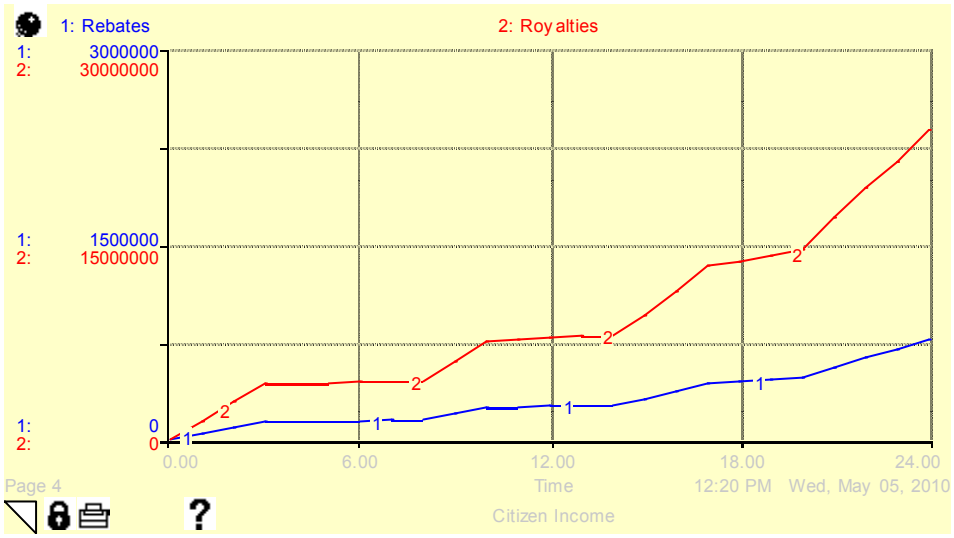
About twice as many wells are created here compared to the strong response.



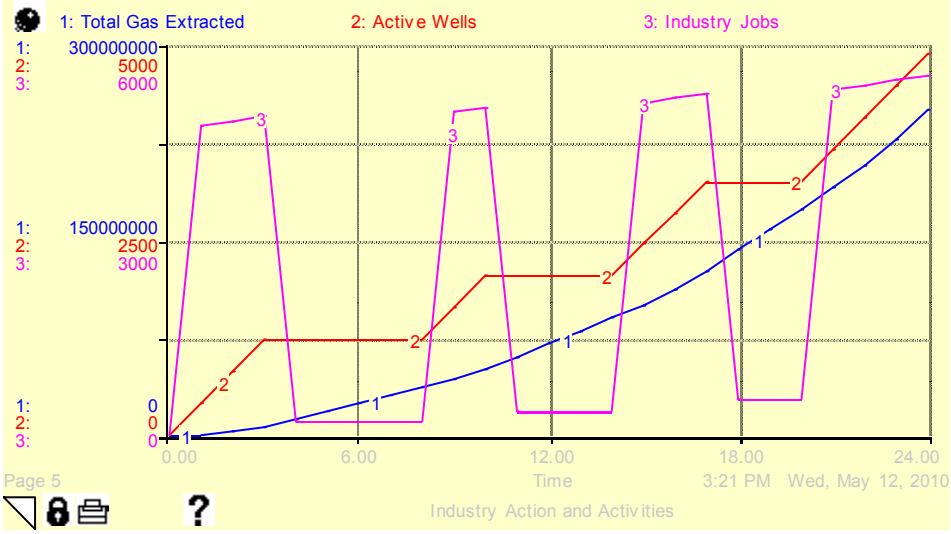
A medium response also creates about twice as many jobs as the strong response and income tax and severance tax revenue is about twice as high.



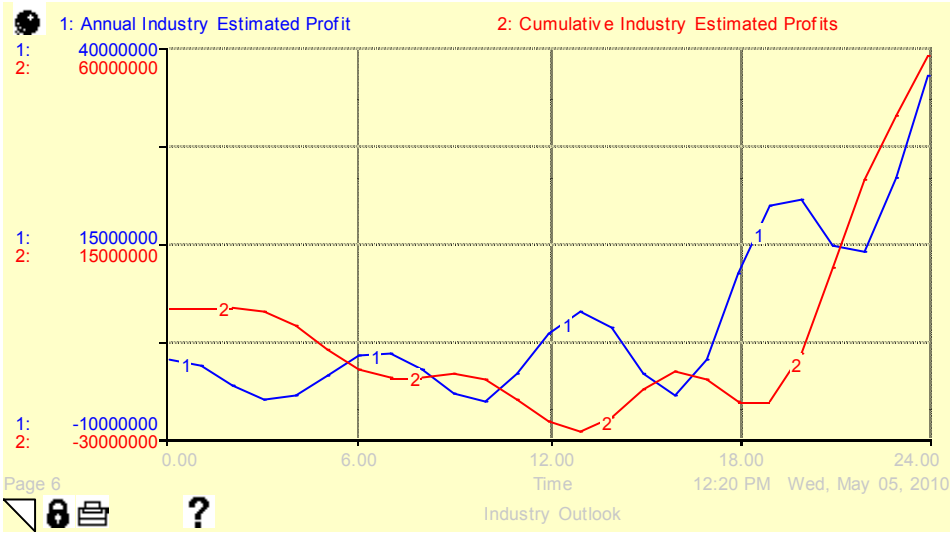
Severance tax revenue keeps rising over time while income tax revenue peaks during well creation and falls again during the production phase.



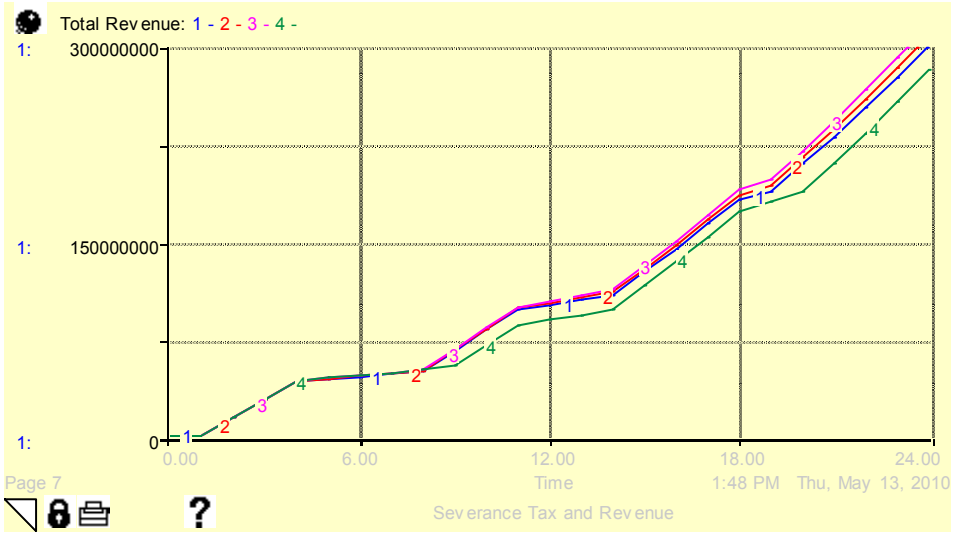
Royalties and rebates increase faster over time than the strong response model because of increase drilling activity.



Total gas extracted is greater overall than the strong response but is extracted at about the same rate as the strong response.

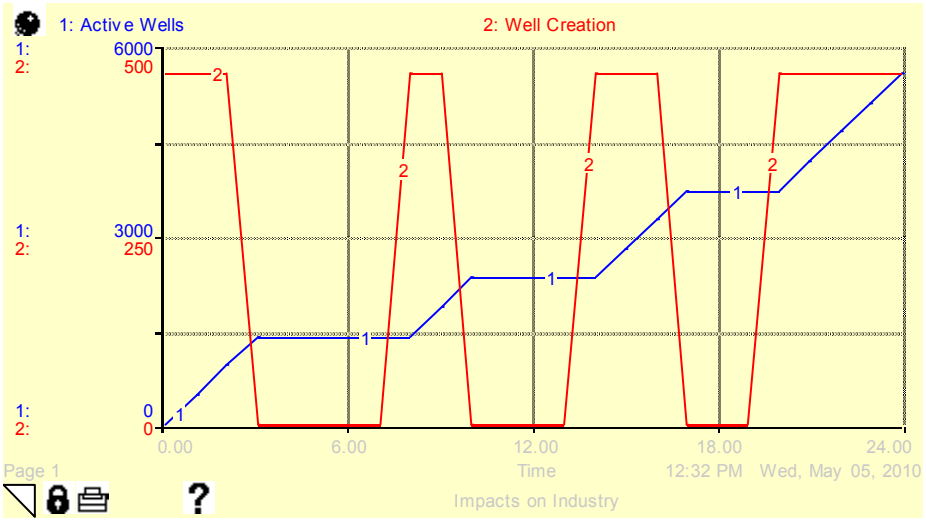


Profits rise and fall over time with well creation and gas extraction and eventually continue to rise over time as the well numbers increase.

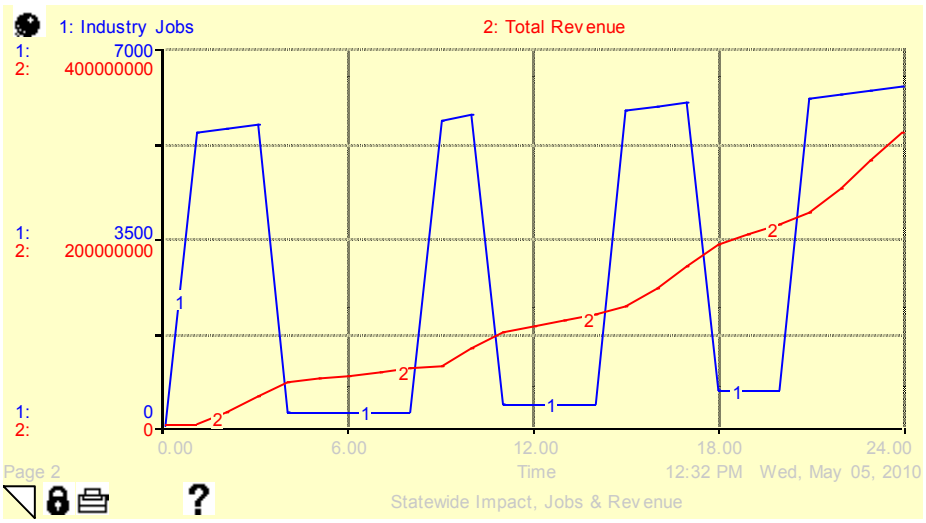


A 4% (Line 3) severance tax maximizes total revenue in this Scenario. Line 1 starts at 3% and increases by 0.5% with each run.

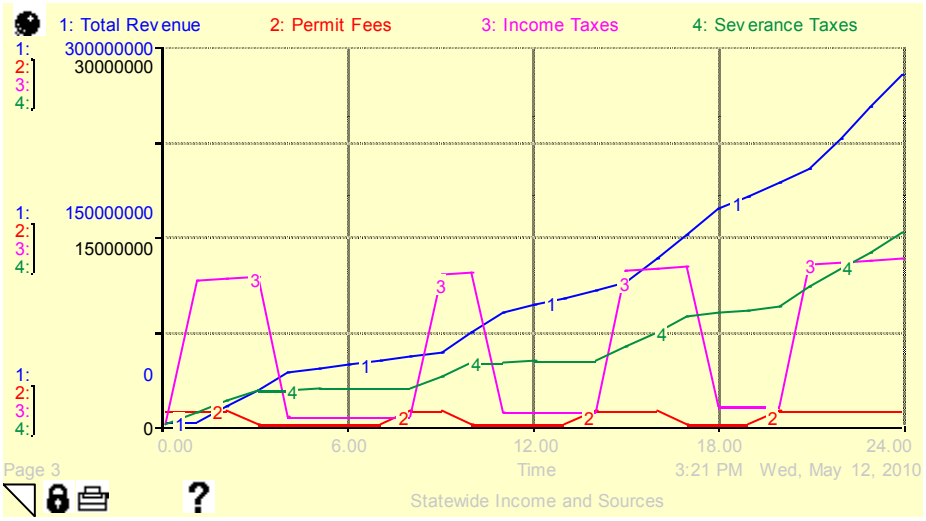
Scenario 4: Weak Severance Tax Response, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 5% Rebate, 12.5% Royalty



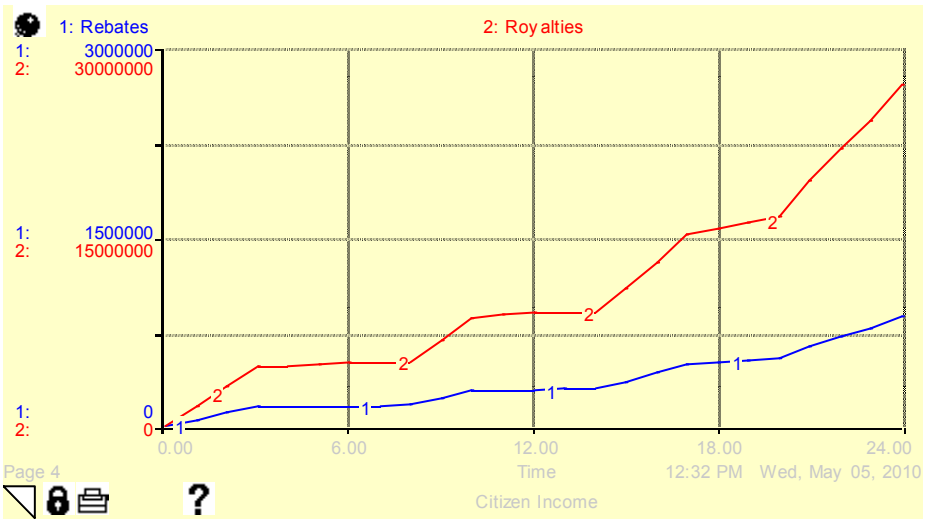
Proportionally, there is a small increase in wells created here compared to the medium response.



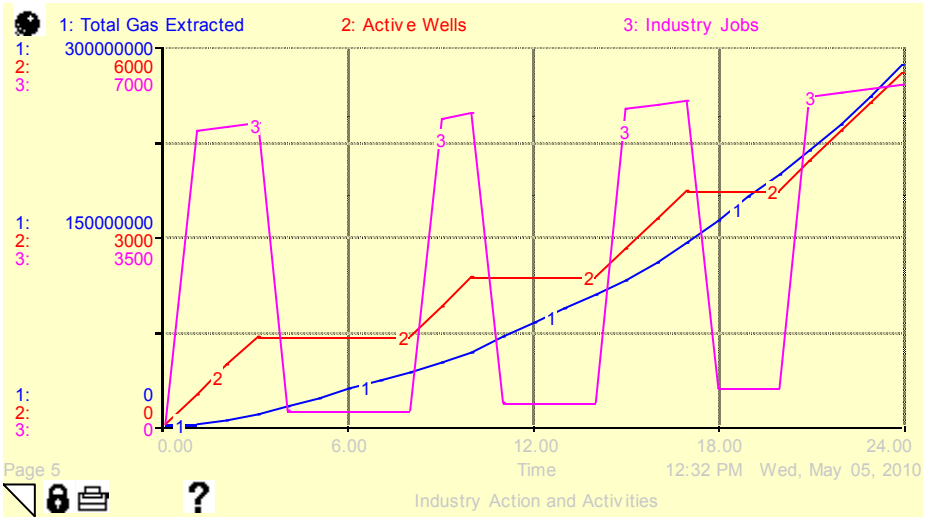
A weak response also creates a small increase in jobs and income tax and severance tax revenue than the medium response.



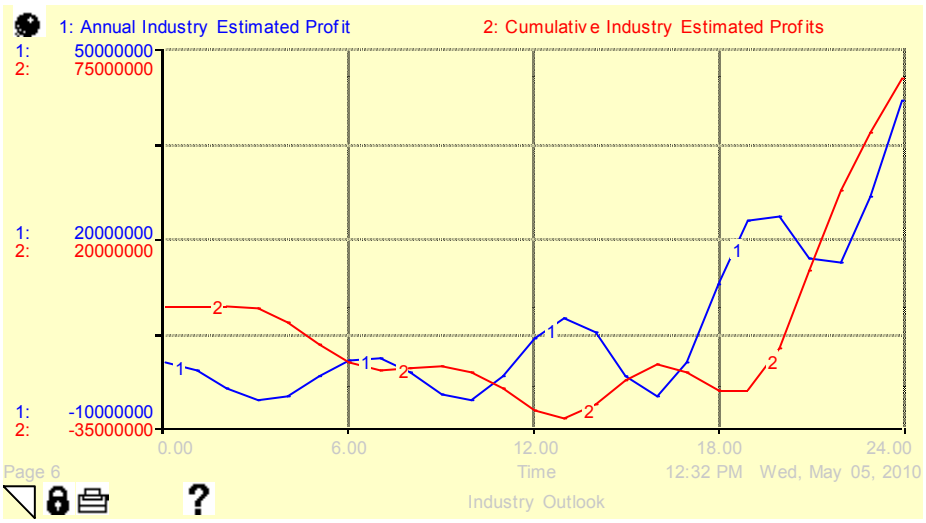
Severance tax revenue keeps rising over time while income tax revenue peaks during well creation and falls again during the production phase.



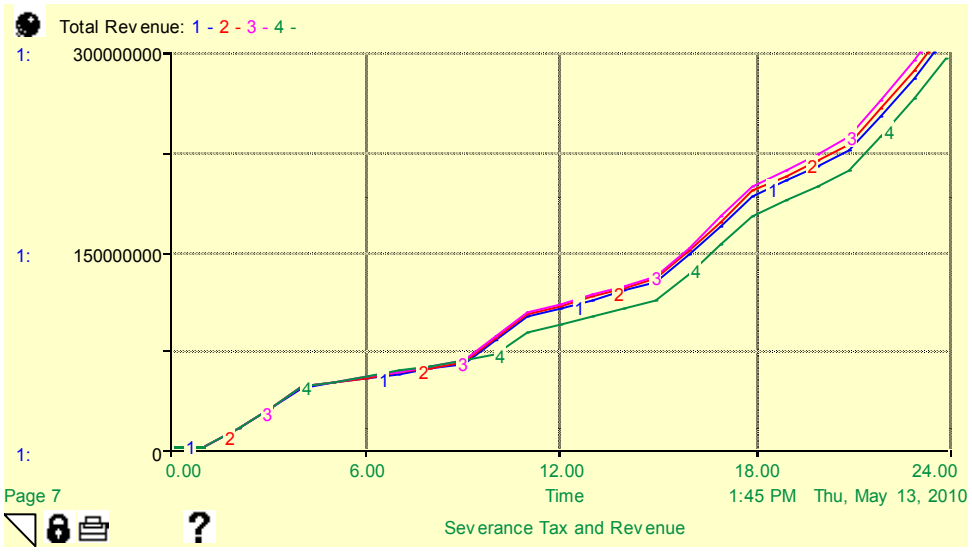
Royalties and rebates increase a little faster over time than the medium response model because of increase drilling activity.



Total gas extracted is a little greater overall than the medium response but is extracted at about the same rate as the medium response.



Profits rise and fall over time with well creation and gas extraction and eventually continue to rise over time as the well numbers increase.



A 9.5% (Line 3) severance tax maximizes total revenue in this scenario. Line 1 starts at 8% and increases by 0.5% with each run.

Results/Conclusions

Income tax revenue is the highest during well creation. Severance tax revenue is the highest during well production. The more gas that is extracted, the more severance tax revenue goes to the state. When drilling ceases, there is not severance revenue and that will produce little income for the state. If a severance tax is too high this will discourage drilling and will create less jobs.

More job creation translates into more indirect effects in the form of increased sales revenue in localities, more homes purchased, property tax revenue and more local businesses which all add to state revenue in some form.

The state can gain considerable revenue from a severance tax but it should not be too high that it discourages drilling. If it is too high, companies will only drill when the price of gas is high as well.

Income tax revenue can generate comparable revenue as well. Job creation and the indirect effects of it should be considered when levying a severance tax on gas extraction.

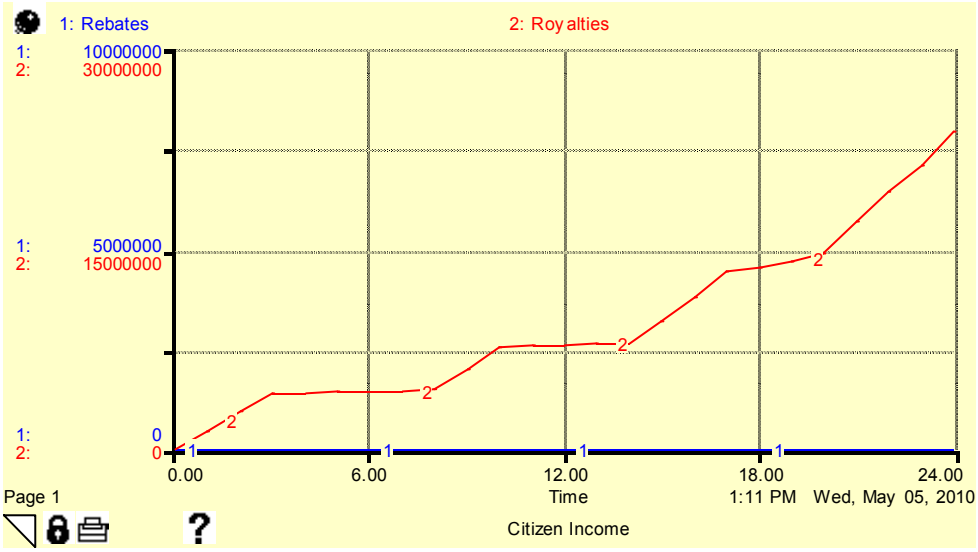
Our model results imply that under any scenario other than the Industry suggested "strong" response, a severance tax will not discourage drilling so much as to have a dramatic effect on total revenues. States would be wise to levy some sort of severance tax in order to both capture proceeds and hold the gas industry directly responsible for any environmental or infrastructure effects. Additionally, as severance taxes do, in fact, decrease the number of wells drilled it may be wise to manage intra-state drilling rates using such a tool. This could be used to keep permitting and infrastructure damage at manageable levels.

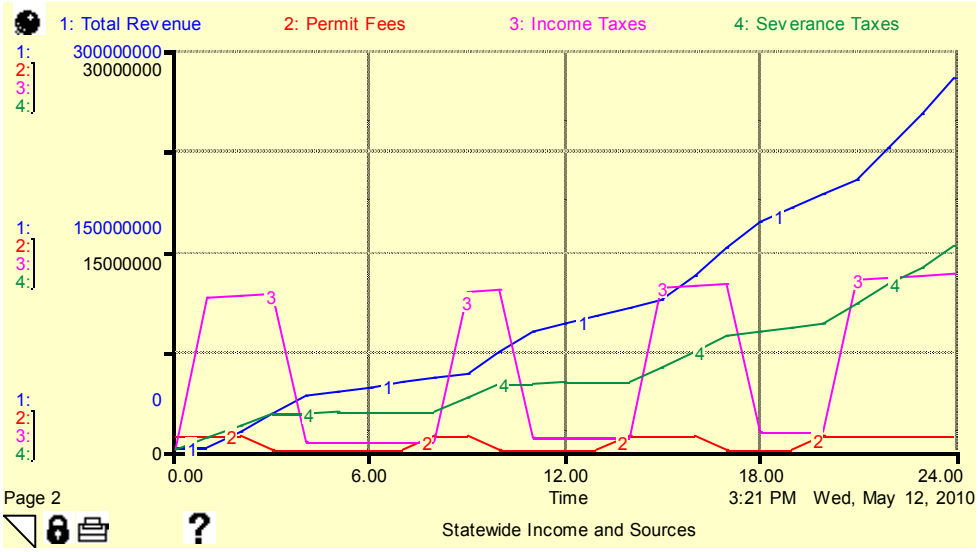
Maximizing total revenue by severance tax changes based on the response scenarion. Per the graphs to the details to the right, the Strong Response maximized at 2.5%, the Medium Response maximized at 4%, and the Weak Response maximized at 9.5%.

Rebate Response

The second set of scenarios analyzed were the effects that different rebate rates could have on drilling and state income. All of these scenarios used the “medium” severance tax response.

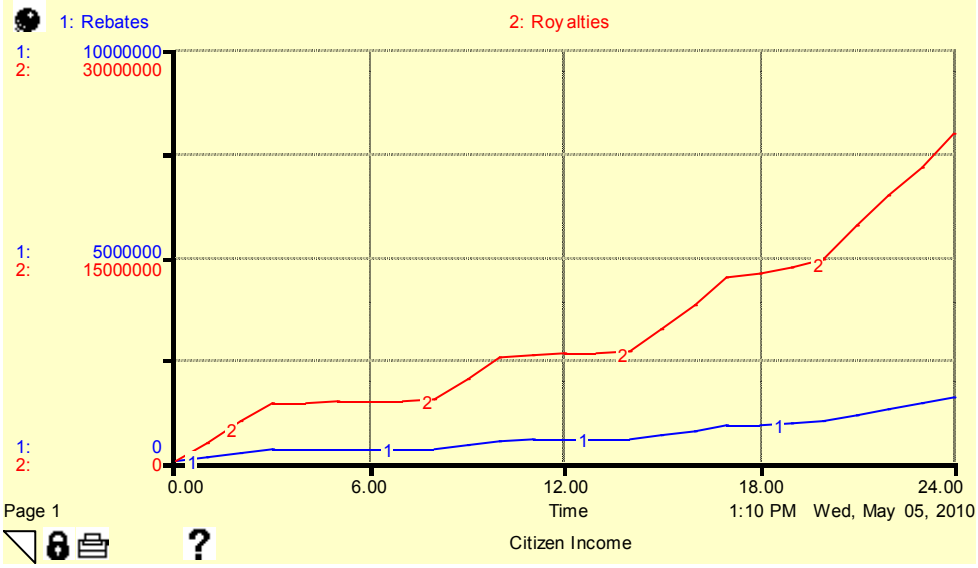
Scenario 1: No Rebate, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 0% Rebate, 12.5% Royalty

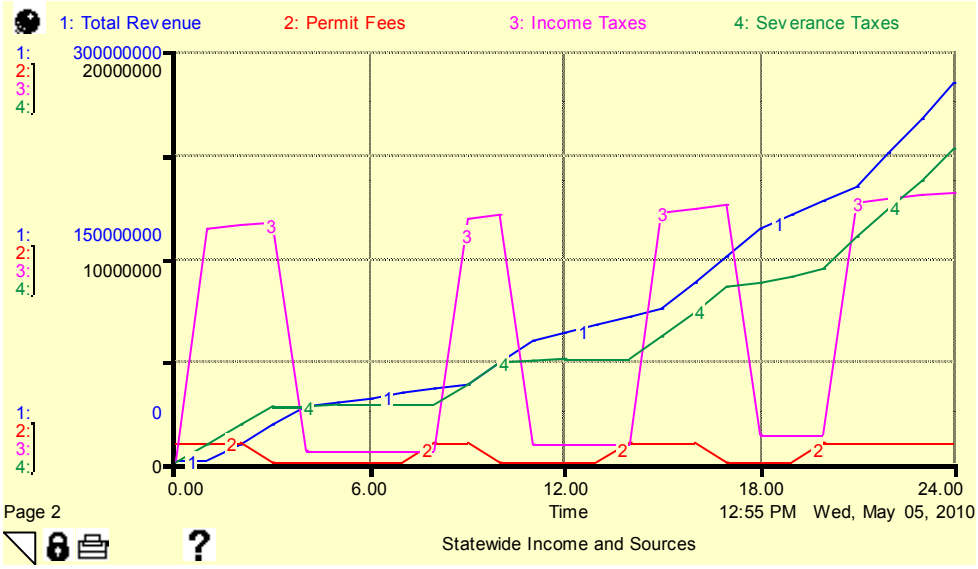




If there is no rebate there will be more severance tax revenue for the state since the rebates come out of this revenue source. Rebates do not have an effect on royalties or state income tax revenue. Rebates do have an effect on total revenue for the state.

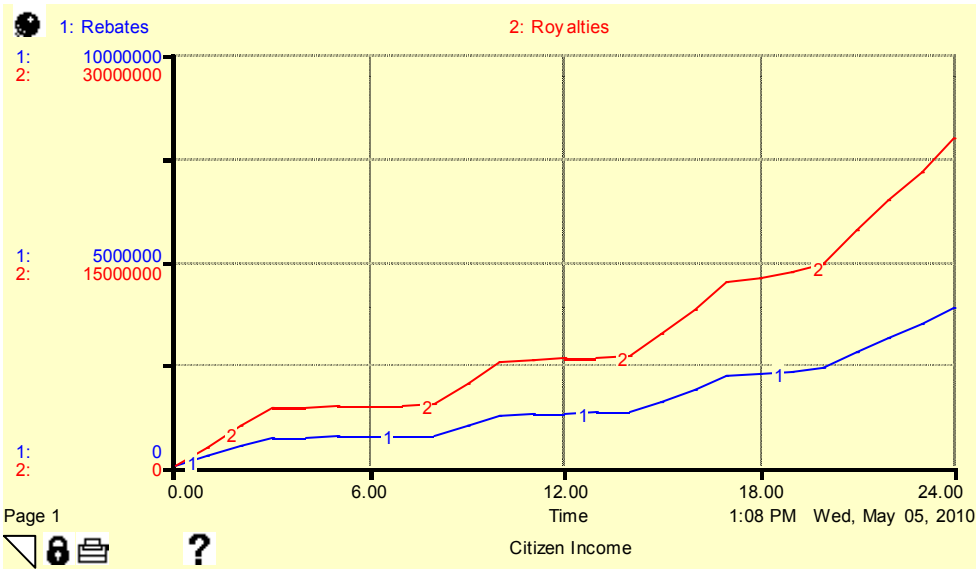
Scenario 2: Medium Rebate, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 10% Rebate, 12.5% Royalty

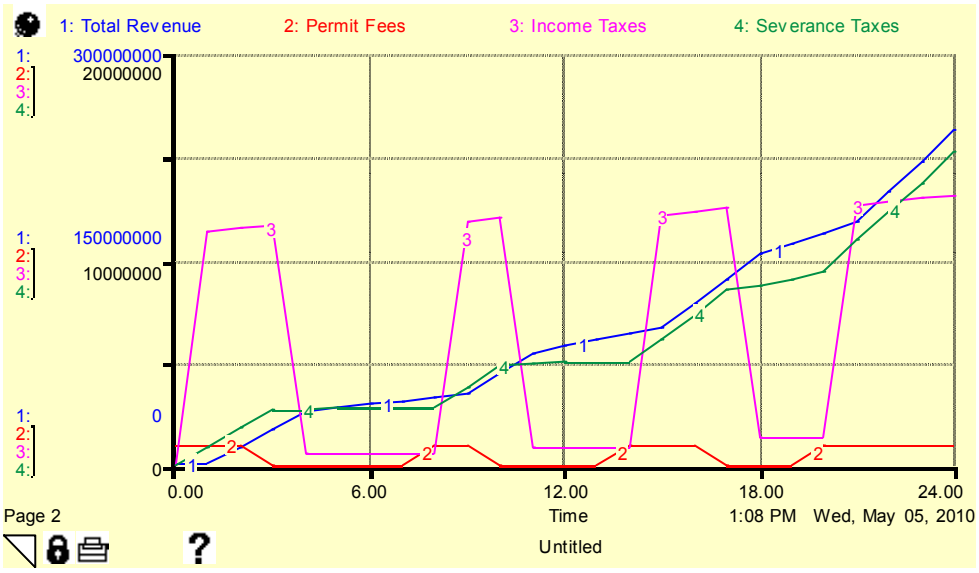




Total revenue for the state decreases here with an increased rebate rate. Because of this severance tax revenue will decrease as well.

Scenario 3: High Rebate, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 25% Rebate, 12.5% Royalty





Total revenue for the state decreases further here with an increased rebate rate. Because of this severance tax revenue will decrease as well.

Results/Conclusions

A rebate will have an effect to total revenue for the state. As the rebate rate increases total revenue decreases, but not by a large proportion

This could be used as a political tool to encourage support for a severance tax on the industry because it sits well with homeowners. It depends what percentage of property tax residents pay and if the revenue from severance tax would actually make a noticeable difference

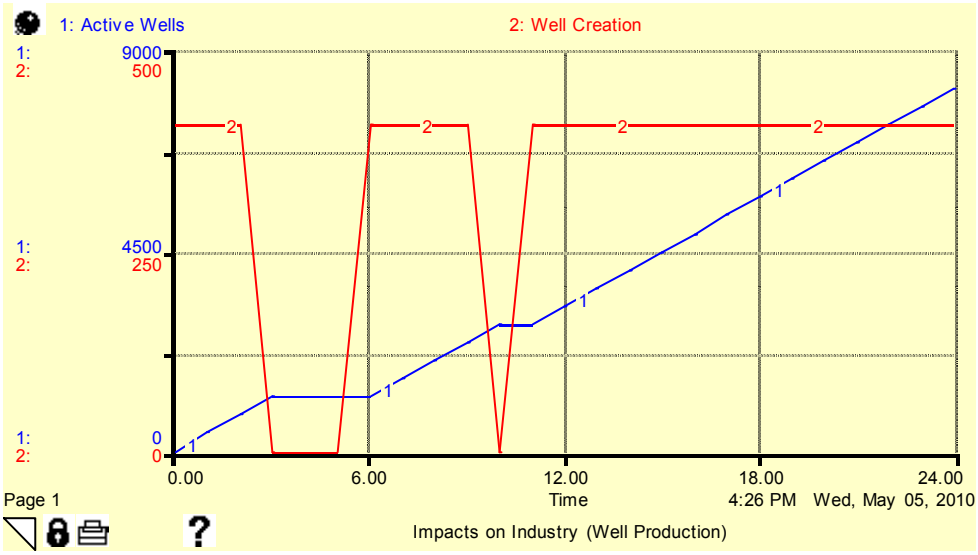
in their property tax rates. If citizens are paying less in property taxes they will have more income to spend which could circle back to the state through indirect effects.

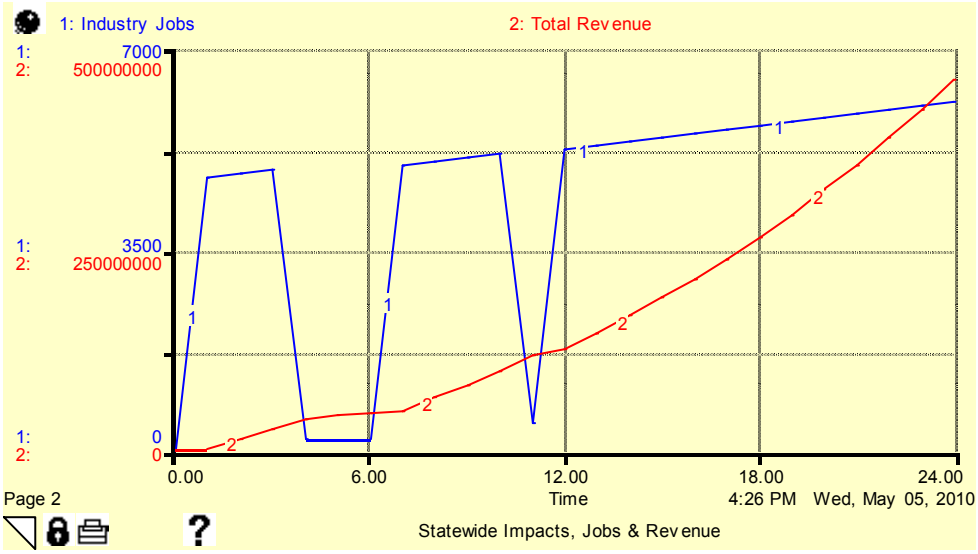
Since rebate rates don't have a big impact on total state revenue it would be in the states best interest to provide them.

Royalty Rate

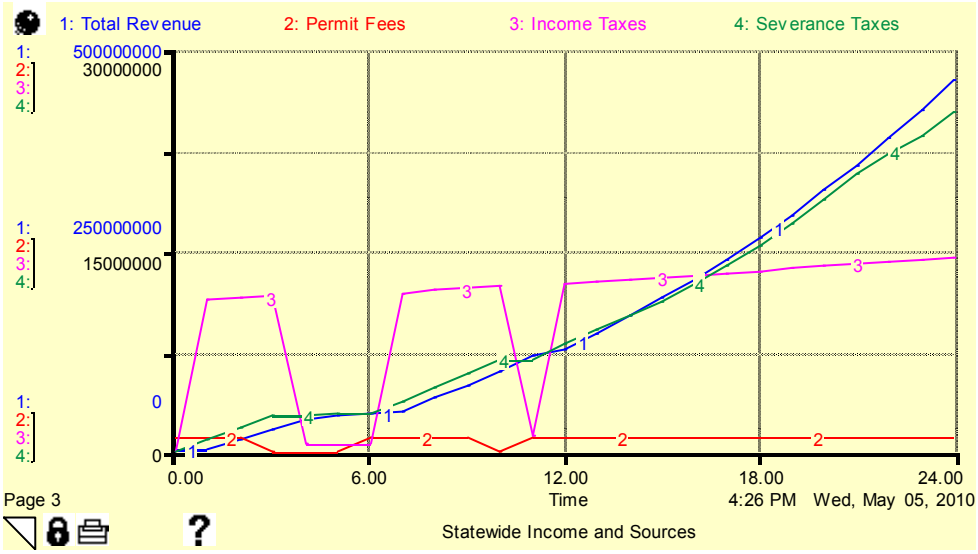
The third set of scenarios analyzed the effect that a minimum royalty law might create. All of these scenarios used the "medium" severance tax response.

Scenario 1: No Royalty, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 5% Rebate, 0% Royalty

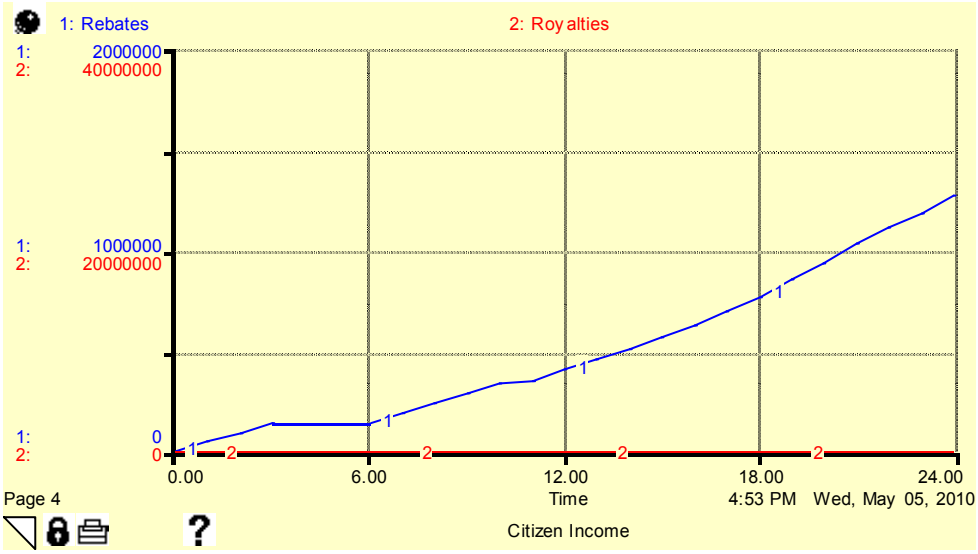


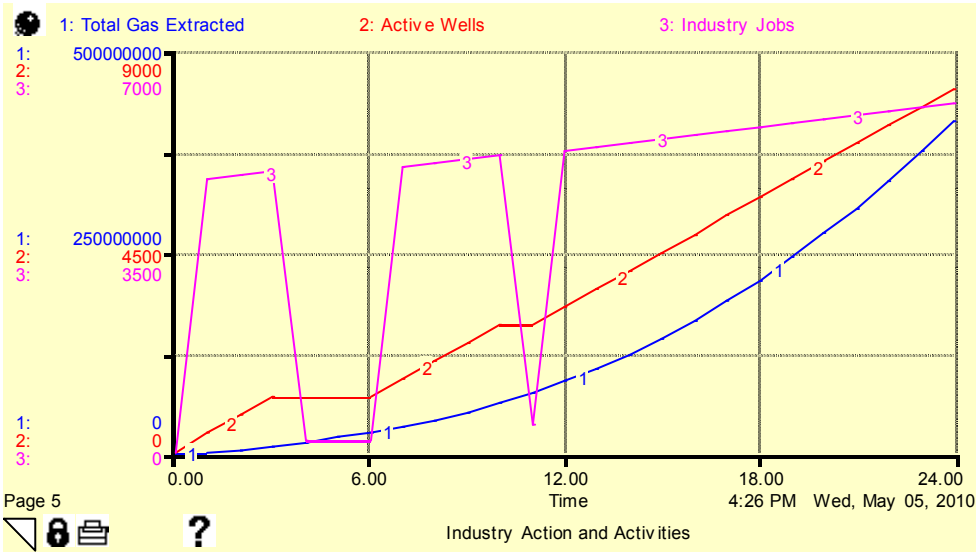


Industry jobs will be a little higher but no substantial difference.

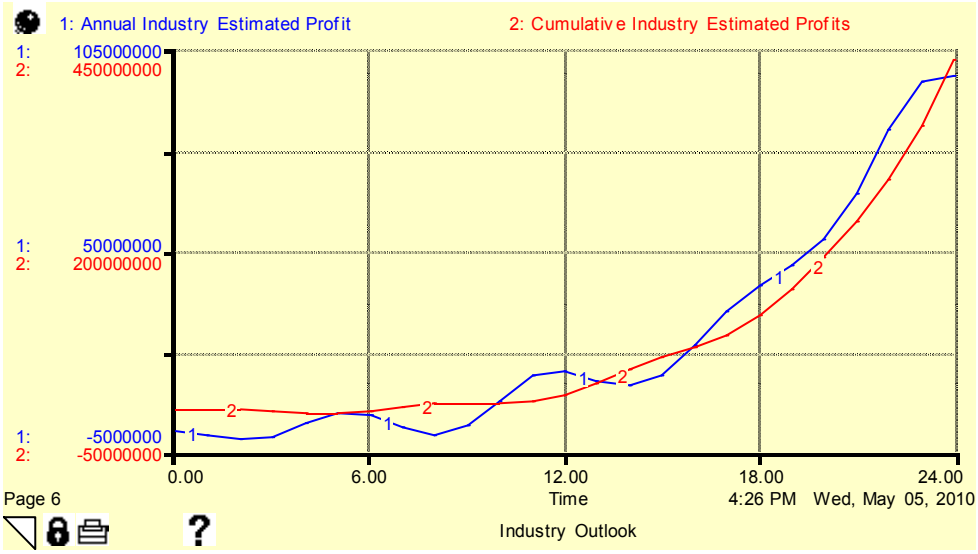


Severance tax revenue and income tax revenue will increase much faster over time than the other royalty scenarios.



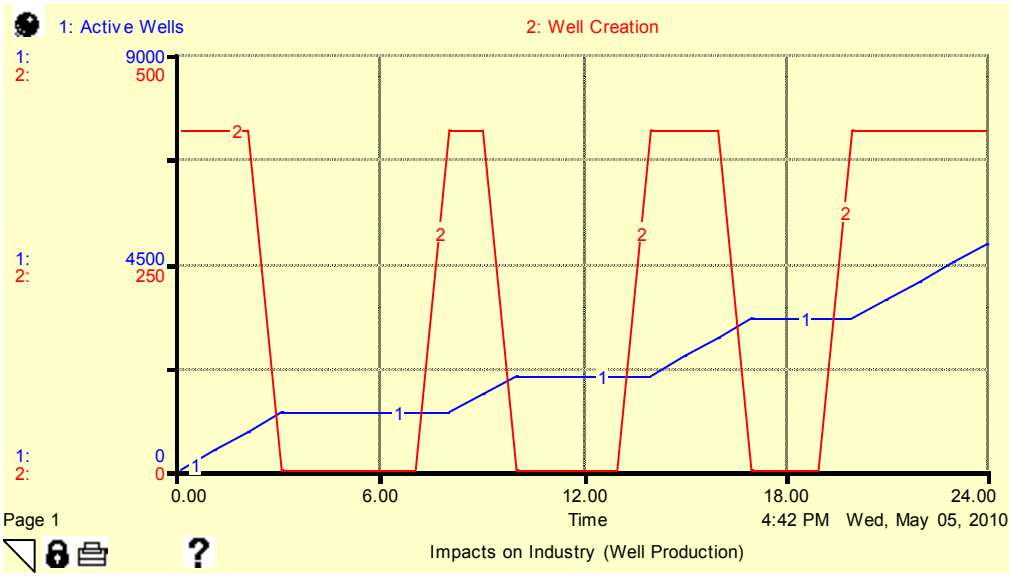


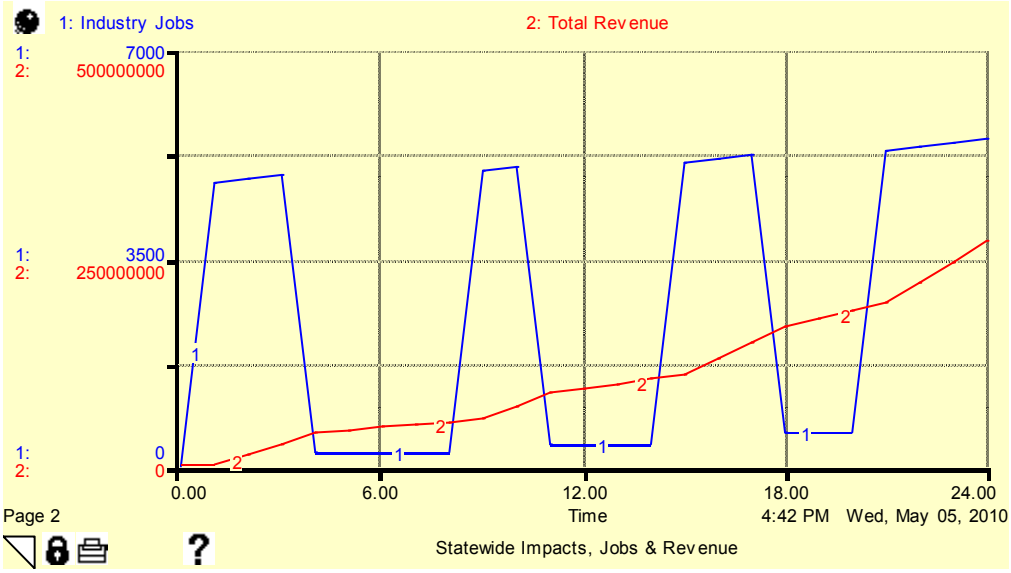
Total gas extraction is greater over time but the rate of extraction is not substantially higher.



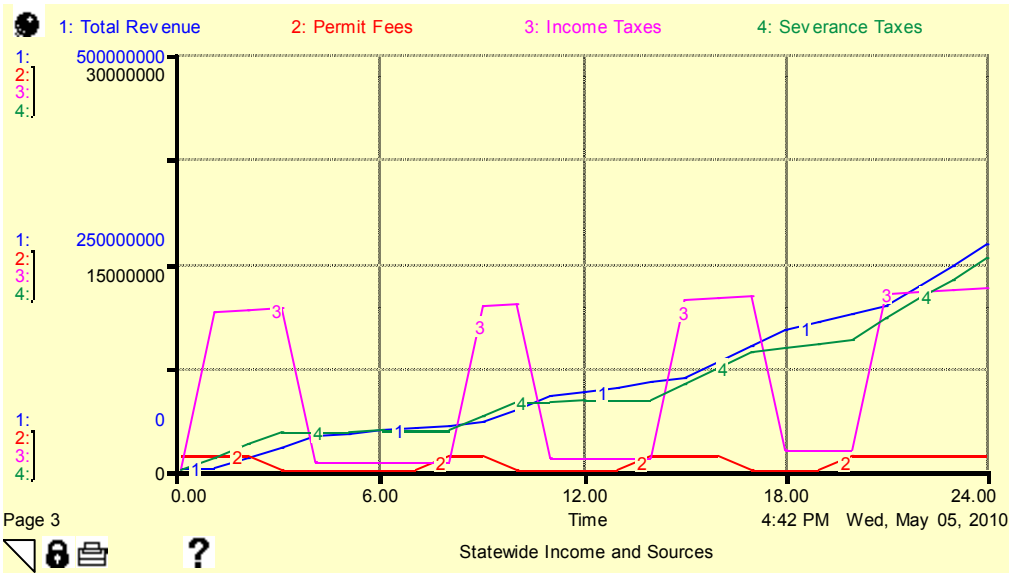
Industry profits will be substantially higher and rise much faster over time.

Scenario 2: Medium Royalty, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 5% Rebate, 12.5% Royalty

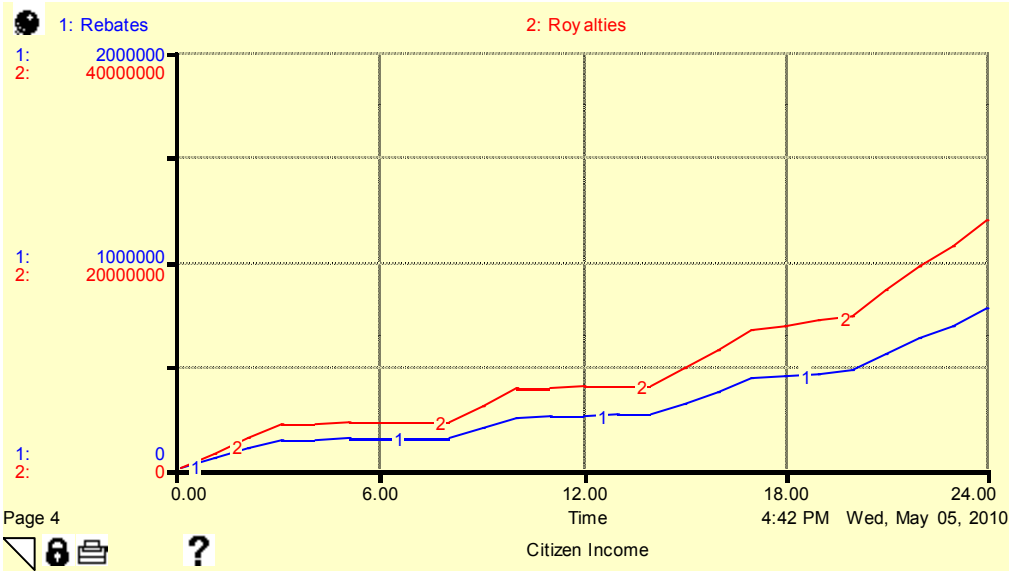


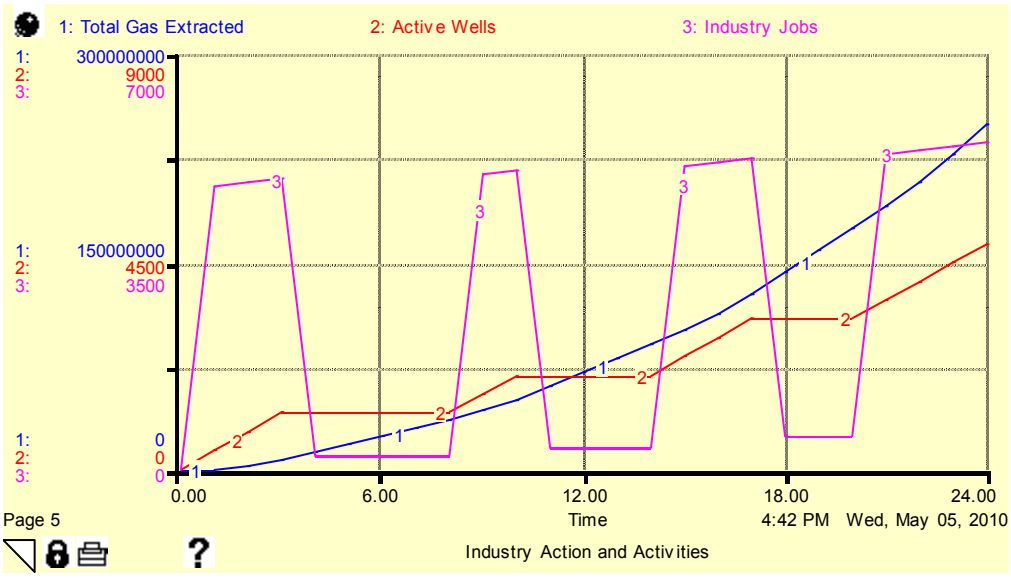


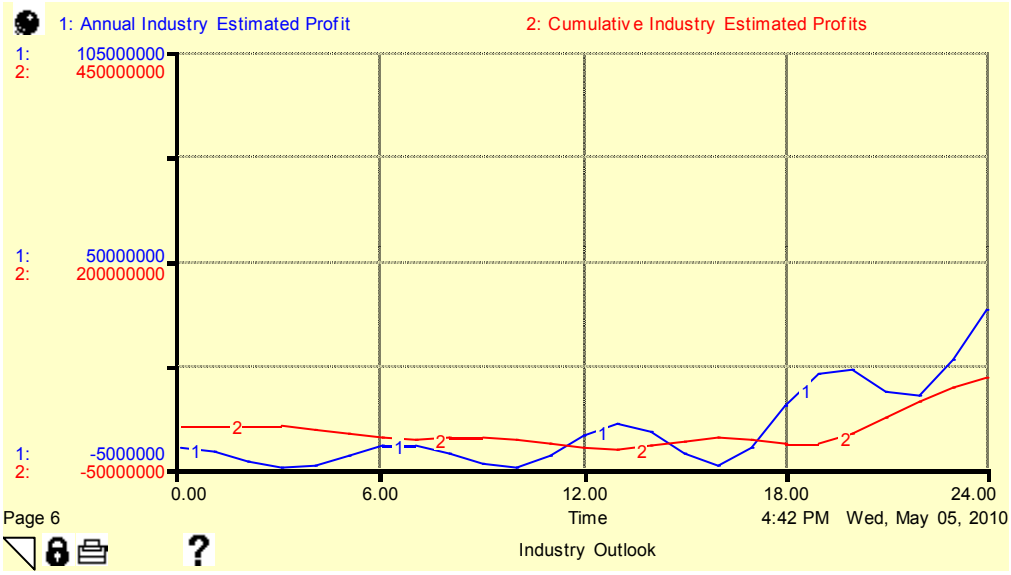
Industry jobs are not very far behind the no royalty scenario, therefore income tax revenue is not substantially less.



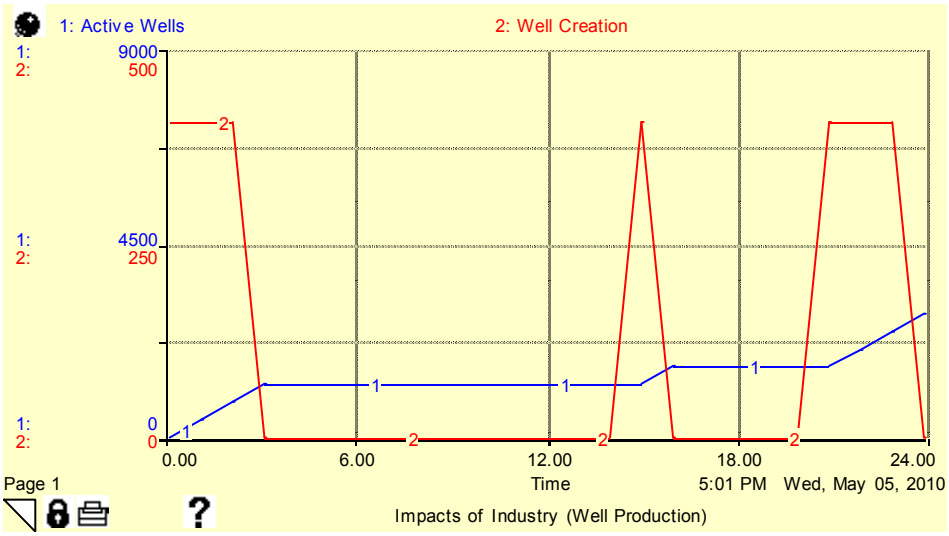
Industry profits are much less here than the no royalty scenario. Severance tax income is less due to less gas extracted. Total revenue decreases a little as well due to deceased jobs and gas extracted.

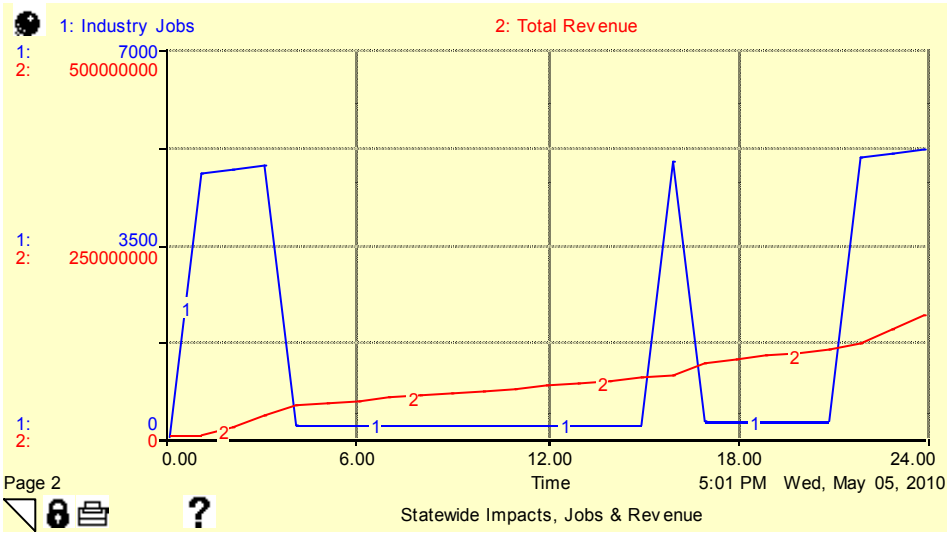


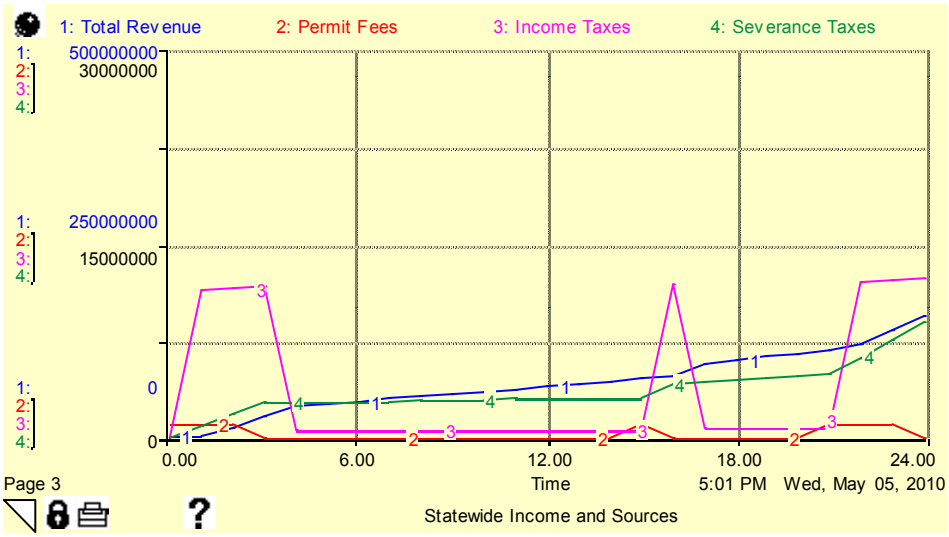

1: Total Gas Extracted
2: Active Wells
3: Industry Jobs
1: 300000000
2: 9000
3: 7000
1: 150000000
2: 4500
3: 3500
1: 0
2: 0
3: 0
0.00
6.00
12.00
18.00
24.00
Time
Page 5
4:42 PM Wed, May 05, 2010
Industry Action and Activities


1: Annual Industry Estimated Profit
2: Cumulative Industry Estimated Profits
1: 105000000
2: 450000000
1: 50000000
2: 200000000
1: -5000000
2: -50000000
0.00
6.00
12.00
18.00
24.00
Time
Page 6
4:42 PM Wed, May 05, 2010
Industry Outlook

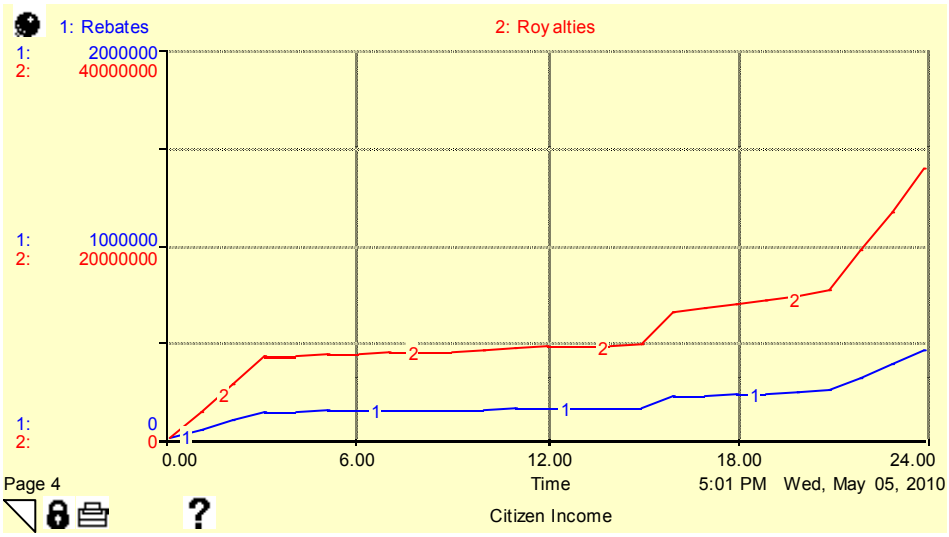
Scenario 3: High Royalty, Default: 8% Severance Tax, $2350 Permit Fee, 4.75% Income Tax, 5% Rebate 25% Royalty

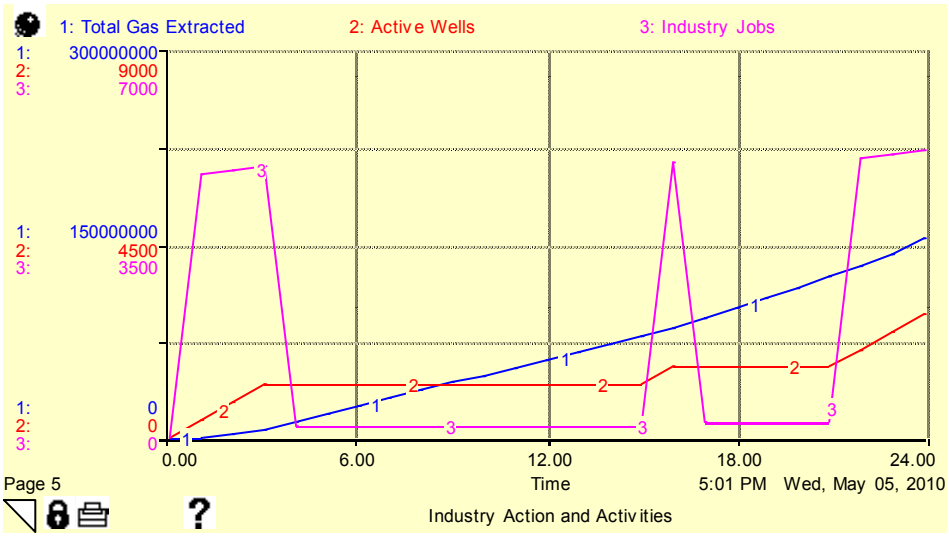


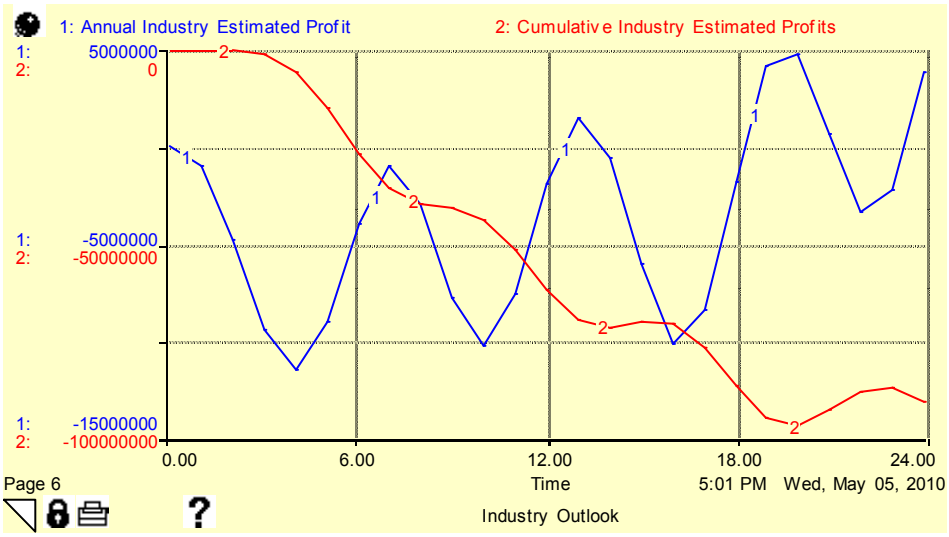




Income and severance tax revenue is less here as well compared to the medium royalty level. Total revenue to the state is considerably less due to less drilling activity and less income from severance tax.







Due to the high royalty rate here, industry profits have trouble staying positive. The industry will drill based on making a 1 year profit last year so they end up drilling a few more wells. But the problem is the royalties cost so much that those wells then cost more than the profits. When the prices rise enough to start drawing a profit, the cycle repeats.

Results/Conclusions

Increased royalty rates do not have big effect on income tax, but income tax receipts decrease as royalty rates increase because of less drilling activity. Income from severance tax goes down due to less drilling activity as well. If royalty rates are increased too much, companies will only drill when gas prices are high because it will not be profitable for them to drill otherwise.

States may want to steer clear of minimum royalty laws because the income lost from them is fairly high. As royalty percentages increase, the state total revenue goes down substantially.

With that said, minimum royalty laws are beneficial for landowners and provide large amounts of income for them which may be put back into the state's economy with the purchase of property, sales, etc. States will have to decide on their own regarding the political necessity of such a tool.