Sage Policy Group, Inc.

The Potential Economic & Fiscal Impacts of Natural Gas Production in Western Maryland

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The Potential Economic & Fiscal Impacts of Natural Gas Production in Western Maryland

Executive Summary

Introduction

This Sage Policy Group, Inc. (Sage) report focuses upon the potential economic activity that could be generated by applying modern technologies (horizontal drilling and hydraulic fracturing) to the Marcellus Shale formation in Western Maryland to produce natural gas. Had the report been authored several years ago, the analysis would have been largely speculative. But with several years of industry activity and technology diffusion having already taken place, the study team was able to leverage the experience of Pennsylvania, West Virginia and other natural gas producing states to provide meaningful estimates.

Economic and Fiscal Impacts

The utilization of Marcellus Shale formation in Western Maryland in order to produce natural gas would have transformative economic and fiscal impacts. Below are Sage's key findings that reflect these impacts. The report provides statistical detail regarding project specifics, direct economic and fiscal impacts, secondary impacts, and total impacts. We have chosen to elaborate on the mid-case scenario which is by far the most likely possibility provided that the State of Maryland allows this activity to occur with reasonable safeguards and competitive cost factors. The mid-case scenario is based on U.S. Geological Survey's 50 percent estimate of natural gas located in Maryland as well as the reference forecast of natural gas prices projected by the Energy Information Administration.

- Under the mid-case scenario, **710.1 billion cubic foot (bcf)** of natural gas could be produced in Allegany and Garrett counties of Western Maryland between 2016 and 2045;
- Under the study's mid-case scenario, Western Maryland would be producing $300 million in natural gas output in constant $2011 by the year 2025. The mid-case scenario incorporates the reference price case from the Energy Information Administration's AEO 2011;
- Applied to the estimated amount of total extractible natural gas available within the play, the study team projects that in its mid-case scenario, approximately **365** wells would be operating over the period 2016-2045.

- According to the Marcellus Shale Education & Training Center (MSETC), it requires approximately 420 individuals across 150 occupations to bring a single Marcellus well on line (only refers to direct jobs)[1];
- In 2025 (the peak year of drilling activity), **1,814** Marylanders will enjoy employment opportunities (full and part-time, annual) under the mid-case scenario related to well drilling and maintenance, the payment of royalties to landowners/mineral rights owners and expanded State and local government spending activity.
- The industry is particularly good at putting blue collar workers back to work and teaching them industry specific skills. A significant portion of workers emerge from the local economy.
- Over the course of developing the Marcellus Shale play (2015-2045), the State of Maryland would collect **$213.8 million** in 2011 constant dollar revenues under the mid-case scenario;
- Garrett County would collect **$162.4 million** and Allegany County **$64.9 million** in 2011 constant dollars; and
- Roughly **$441 million** in 2011 constant dollars of total positive fiscal impact would be experienced over the course of the Western Maryland Marcellus Shale development.

Exhibit E1 provides relevant summary detail regarding projected natural gas production, the value of that production, royalty and severance tax payments. Exhibit E2 provides a summary of analytical findings regarding key economic impacts. These figures do not encompass the possible emergence of related manufacturing and other sectors that presently do not exist in Maryland. Many services would initially be purchased from operating entities in neighboring jurisdictions such as Pennsylvania and West Virginia — increasing the size of the regional economy. The possibility of greater local equipment purchases over time has not been embodied within this analysis. To the extent that Maryland is able to birth new companies and industries, this analysis understates potential impact.

[1] Marcellus Shale Education & Training Center (MSETC). (June 2011). "Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment."

Exhibit E1: Summary of Results: one year, five year, fifteen year, lifetime

		2016	*Five Years (2016-2020)*	*Fifteen Years (2016-2030)*	*Lifetime of Wells (2016-2045)*
Natural Gas Extracted (billion cubic feet)	Low-Case	1.8	41.7	261.1	387.8
	Mid-Case	3.3	77.0	479.3	710.1
	High-Case	5.8	140.2	877.4	1,299.7
Value of Natural Gas[2] Extracted (2011$millions)	Low-Case	$9.4	$231.9	$1,711.7	$2,708.6
	Mid-Case	$14.3	$354.8	$2,538.1	$4,040.1
	High-Case	$22.4	$558.4	$3,796.0	$5,856.6
Royalties Paid to Landowners (2011$millions)	Low-Case	$1.2	$29.0	$214.0	$338.6
	Mid-Case	$1.8	$44.3	$317.3	$505.0
	High-Case	$2.8	$69.8	$474.5	$732.1
Severance Tax Paid to Garrett County (5.5%; 2011$millions)	Low-Case	$0.4	$9.1	$67.3	$106.5
	Mid-Case	$0.6	$14.0	$99.8	$158.9
	High-Case	$0.9	$22.0	$149.3	$230.3
Severance Tax Paid to Allegany County (5.5%; 2011$millions)	Low-Case	$0.1	$3.6	$26.8	$42.4
	Mid-Case	$0.2	$5.6	$39.8	$63.3
	High-Case	$0.4	$8.8	$59.5	$91.8
Severance Tax Paid to Maryland (2%; 2011$millions)	Low-Case	$0.2	$4.6	$34.2	$54.2
	Mid-Case	$0.4	$9.8	$69.4	$155.2
	High-Case	$0.6	$15.3	$103.8	$214.4

Source: Sage

Exhibit E2: Summary of Findings

Economic Impact of Drilling Activity in 2025, Annual Impact			
	Low-Case	*Mid-Case*	*High-Case*
Jobs	1,129	1,814	3,094
Labor Income ($millions)	$52.1	$85.6	$149.5
Business Sales ($millions)	$191.7	$316.4	$557.2
Total Impacts 2015 through 2045			
	Low-Case	*Mid-Case*	*High-Case*
Natural Gas Extracted (billion cubic feet)	387.8	710.1	1299.7
Value of Natural Gas Extracted ($millions)	$2,708.6	$4,040.1	$5,856.6
Royalties Paid to Landowners ($millions)	$338.6	$505.0	$732.1
Fiscal Revenues for Allegany County ($millions)	$43.4	$64.9	$94.1
Fiscal Revenues for Garrett County ($millions)	$108.9	$162.4	$235.4
Fiscal Revenues for State of Maryland ($millions)	$89.8	$213.8	$312.5

Note: All Dollar Figures are in Constant $2011

Based on drilling activity in the Pennsylvania Marcellus Shale between 2008 and 2010, a study published by the Manhattan Institute estimated that the environmental impacts from

[2] Prices based on Energy Information Administration's AEO 2011

a typical Marcellus Shale well generated $14,000 in economic damages. This is substantially lower than the $4 million in economic impacts the study concludes can be attributed to the typical Marcellus well.[3]

Conclusion

Maryland has an opportunity to participate in the nation's energy boom. Such an opportunity should not be dismissed lightly. Other states have already begun to move ahead, generating jobs and associated income in the process. Fortunately, natural gas production is not a zero sum game and though Maryland is not a first mover in this instance, it retains its opportunity to participate in the Marcellus Shale play. Maryland is also fortunate to be able to learn from the experience of earlier state adopters like Pennsylvania, including from the perspective of mitigating environmental impacts.

Policymakers should note that though Maryland has an opportunity to participate in the Marcellus Shale play, its allure to the natural gas industry is somewhat limited. Maryland is home to only about 1 percent of the Marcellus Shale play and could therefore be easily overlooked. There are at least 22 states that have shale plays and Maryland is competing with all of them for investment. Given current low natural gas prices ($2.60/MMBtu as of this writing), Maryland is even more likely to miss the opportunity if it creates an exceedingly regulated and expensive environment. There is also some belief that the Maryland Marcellus resource is more associated with dry gas. With oil prices now well over $100/barrel, investors and the Industry are more drawn to wet gas. Generally, investors are also more drawn to crude oil than natural gas.

Perhaps most importantly, the Marcellus Shale play in Maryland would benefit Western Maryland, a part of the state that suffered deeply during the economic downturn. Allegany County continues to be associated with among the state's lowest incomes and highest unemployment rates. Marcellus Shale development represents a way for both Allegany and Garrett counties to secure a key driver of business investment and future job creation.

[3]Timothy J. Considine, Robert W. Watson & Nicholas B. Considine. (May 2011). "The Economic Opportunities of Shale Energy Development," Center for Energy Policy and the Environment at the Manhattan Institute.

The Potential Economic & Fiscal Impacts of Natural Gas Production in Western Maryland

A. Introduction

Study Objective

This Sage Policy Group, Inc. (Sage) report focuses upon the potential economic activity that could be generated by applying modern technologies to the Marcellus Shale formation in Western Maryland to produce natural gas. Had the report been authored several years ago, the analysis would have been largely speculative. But with several years of industry activity and technology diffusion having already taken place, the study team was able to leverage the experience of Pennsylvania and other natural gas producing states to provide meaningful estimates.

The goal of the study is to help stakeholders understand the full potential of Marcellus Shale-related activity. That said, in the narrative, the study team has worked to help readers understand all of the limits associated with reaching full production potential. Moreover, this study only reflects the anticipated economic activities generated by the drilling and maintenance of wells. It does not focus upon ancillary economic activities related to the marketing and distribution of natural gas.

What is Shale?

Shale is a fine-grained sedimentary rock that is often rich in petroleum and natural gas. Shale gas is natural gas trapped in shale formations. When shale formations that embody significant accumulations of natural gas also possess certain geologic characteristics, they are considered by potential producers and consumers as a "shale play."[4]In an American context, shale plays exist in 22 states in the Northeast, Gulf Coast, Mid-Continent, Southwest, Rocky Mountains, and West Coast regions. Exhibit 1 provides statistical detail regarding estimates of the amount of technically recoverable shale gas and oil reserves in various regions of the U.S. Maryland is in the Northeast region and Marcellus is the relevant shale formation.

[4] U.S. Energy Information Administration. (August 4, 2011). "What is shale gas and why is it important?"

Exhibit 1: Estimated undeveloped technically recoverable shale gas and shale oil resources remaining in discovered shale plays as of January 1, 2009

Region	Shale gas resources (trillion cubic feet)	Percent of Total
Northeast	472	63%
Marcellus	*410 (1)*	*55%*
Gulf Coast	100	13%
Mid-Continent	60	8%
Southwest	76	10%
Rocky Mountain	43	6%
West Coast	-	
Total onshore Lower-48 States	**750**	

Source: INTEK, U.S. Energy Information Administration, "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays," July 2011

(1) The U.S. Energy Information Administration recently reduced its estimate of shale gas resources in the Marcellus from 410 tcf to 141 tcf in its "2012 Annual Energy Outlook Early Release Review"

U.S. Natural Gas Production and Shale Gas Drilling

During the 1980s and 1990s, the Mitchell Energy and Development Corporation began experimenting with deep shale gas production in the Barnett Shale of North Central Texas using hydraulic fracturing techniques and horizontal drilling. Mitchell's success demonstrated the commercial potential of shale gas production. Other companies quickly began entering the market.[5]

Although large-scale shale gas production did not emerge until Mitchell's venture, use of and experimentation with fracturing techniques have a much longer history. Experimentation with fracturing dates back to the 19th century. In the 1950s, deployment of fracturing techniques to stimulate oil and gas production expanded rapidly. Technologies that have ultimately become crucial to the production of shale gas began to be developed in the 1970s. Fostered by collaboration between the U.S. Department of Energy, the Gas Research Institute, and private operators, technologies such as horizontal wells, multi-stage fracturing, and slick-water fracturing emerged.[6]

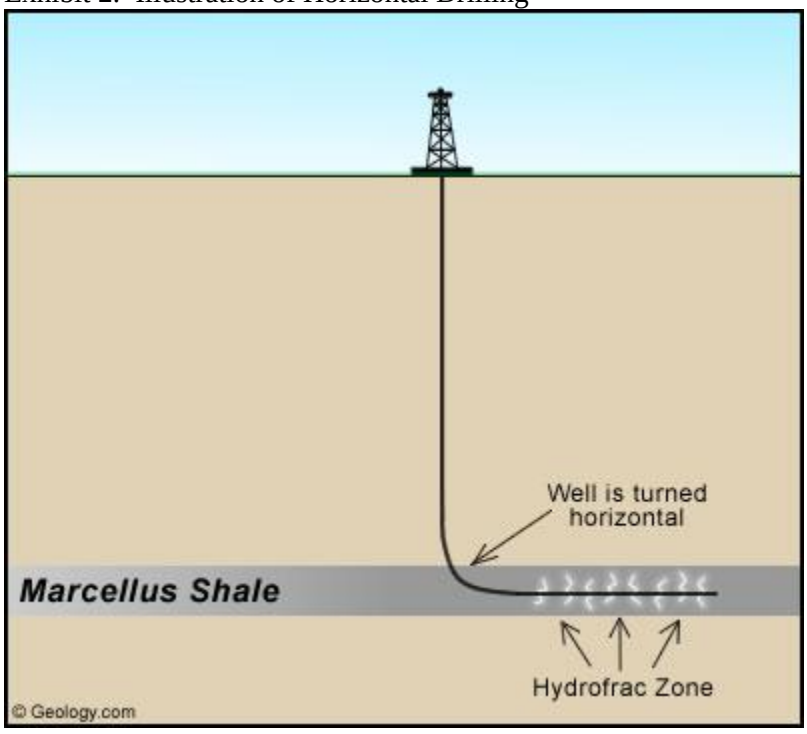
Hydraulic fracturing involves sealing off a section of a well and then injecting fluids at high pressure into that section of the well. The high pressure breaks (or fractures) rock, and sand is inserted to keep these fissures open allowing natural gas to move freely. This enables higher rates of extraction. Horizontal drilling was adopted in the early 1980s and

[5]U.S. Energy Information Administration. (July 2011). "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays."

[6] Ibid.

involves drilling vertically to just above the shale and then making a gradual 90 degree turn to drill laterally for lengths up to 3,000 feet.[7,8]Used in conjunction, horizontal drilling and hydraulic fracturing have greatly facilitated efficient, profitable recovery of natural gas from shale plays.[9]Exhibit 2 represents a useful illustration.

Exhibit 2: Illustration of Horizontal Drilling



Source: Geology.com

Between 1989 and 2009, the number of producing gas wells in the U.S. increased by 88 percent and domestic production increased by 19 percent.[10] By 2009, 87 percent of total natural gas consumed in the U.S. was domestically produced.[11] In 2009 and 2010 the Henry Hub price of natural gas fell to an average of $4.17/MMBtu in response to higher volumes of shale production.[12]

[7] Independent Oil and Gas Association of New York. "The Facts About Natural Gas Exploration of the Marcellus Shale," p. 4-5.
[8] U.S. Energy Information Administration. (July 2011). "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays."
[9] Ibid.
[10] 19% increase refers to total marketed production defined as: "Gross withdrawals less gas used for repressuring, quantities vented and flared, and nonhydrocarbon gases removed in treating or processing operations. This includes all quantities of gas used in field and processing plant operations."
[11] U.S. Energy Information Administration, "Natural Gas Production, Number of Producing Gas Wells," Form EIA-895 A, "Annual Quantity and Value of Natural gas Production Report," EIA estimates based on U.S. Minerals Management Service data, and *World Oil Magazine.*
[12] HIS Global Insight. (December 2011). "The Economic and Employment Contributions of Shale Gas in the United States," p. 4.

About Marcellus Shale

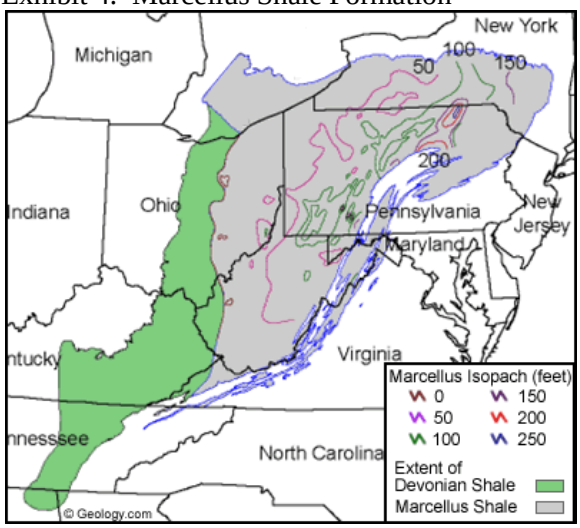
Situated in a shallow inland sea in the eastern United States where the present-day Appalachian Mountains now stand, the Marcellus Shale is a sedimentary rock formation that was deposited more than 350 million years ago.[13]Marcellus Shale covers an estimated total area of 95,000 square miles. Drilling in the Marcellus Shale play has predominately occurred in Pennsylvania and West Virginia to date. These states comprise most of the active area (acreage reportedly under lease by companies) of the Marcellus, estimated at 10,622 square miles in 2008.The remaining 84,271 square miles of the Marcellus Shale represents the area not yet been leased by companies.[14] The states across which the Marcellus Shale play stretches are detailed in the three exhibits below (3, 4 and 5).

Exhibit 3: State Distribution of the Marcellus Shale Play

State	Area % of Marcellus
Maryland	**1.09**
New York	20.06
Ohio	18.19
Pennsylvania	35.35
Virginia	3.85
West Virginia	21.33
Sources: U.S. Energy Information Administration, "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays," July 2011.	

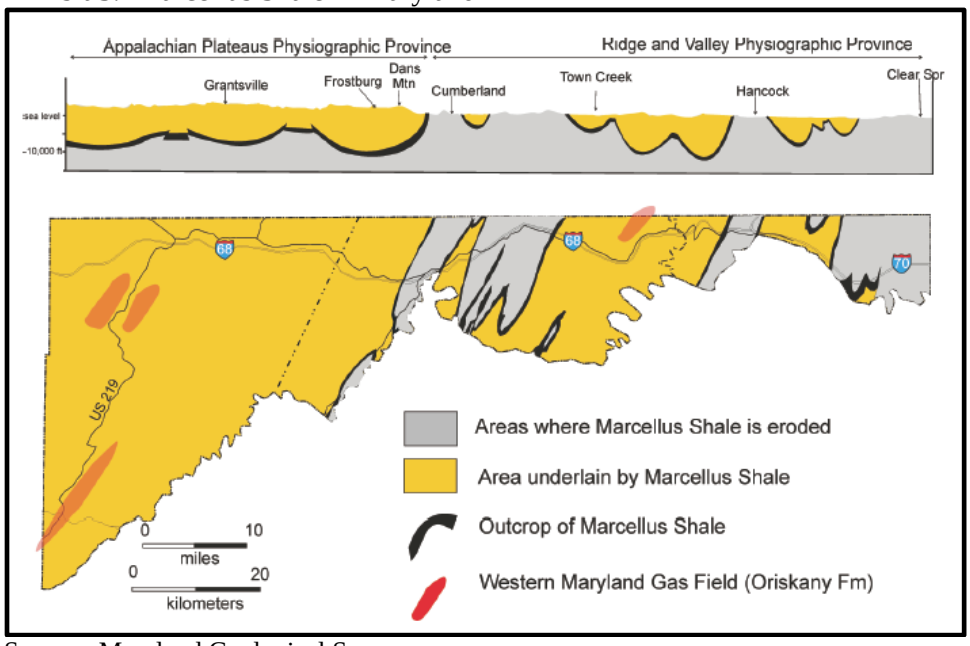
[13] Soeder, D. and Kappel, W. (May 2009). Water Resources and Natural Gas Production from the Marcellus Shale. U.S. Geological Survey. Available at http://geology.com/usgs/marcellus-shale/.
[14] U.S. Energy Information Administration. (July 2011). "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays."

Exhibit 4: Marcellus Shale Formation



Source: Geology.com

Exhibit 5: Marcellus Shale in Maryland



Source: Maryland Geological Survey

Recent estimates show that recoverable reserves of natural gas within the formation could amount to 500 TCF. To put this into perspective, the United States uses about 23 TCF of natural gas per year according to the U.S. Energy Information Administration. This means that the Marcellus gas resource may be large enough to supply the needs of the entire nation for nearly 15 years.[15]

[15] National Park Service, U.S. Department of the Interior. (November 2009). Development of the Natural Gas Resources in the Marcellus Shale. Available at http://marcellus.psu.edu/resources/PDFs/marcellusshalereport09.pdf.pdf.

Marcellus Shale Activity in Maryland

Shortly after it became clear that natural gas can be extracted from the Marcellus Shale formation, companies from as far away as Texas, Oklahoma and Colorado have been reviewing existing geologic and geophysical data as a first step in developing plans for leasing the mineral rights and drilling test wells in Western Maryland.[16]Thereafter, Garrett County began seeing the arrival of "land men," an industry term for those who come to an area in advance of the actual drilling of test wells for natural gas. These land men typically contact land owners (and mineral rights owners) to arrange to lease the land on which drilling may ultimately occur.[17]

Governor O'Malley issued an Executive Order in June, 2011 establishing the Marcellus Shale Advisory Commission to study the issue for three years and recommend whether to develop this natural resource in Western Maryland. Currently, the Commission and the appropriate state agencies are taking the steps to answer questions regarding associated environmental impact and land use. Specifically, the protection of aquifers and surface water represents a major consideration and falls under the regulatory and permitting authority of the Maryland Department of the Environment.

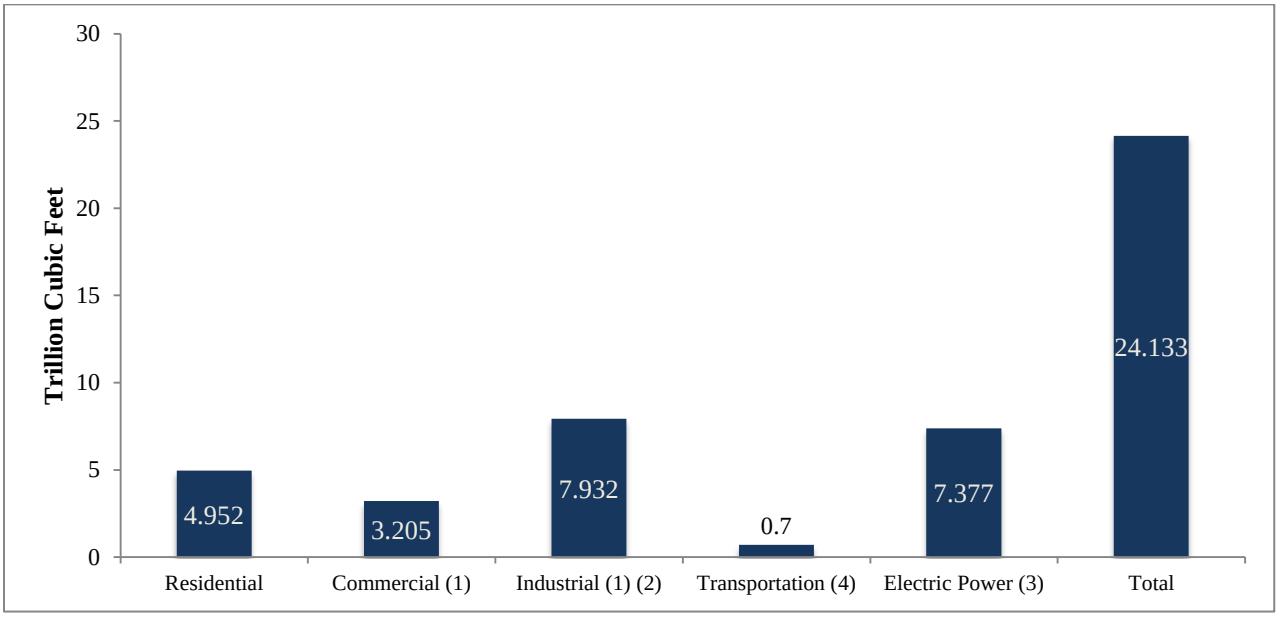
Within Garrett County and the western portion of Allegany County, the Marcellus is between 5,000 and 9,000 feet deep and between 150 to 200 feet thick. Eastward from Dans Mountain to Town Creek, the Marcellus has been eroded along the crests of anticlinal folds, but is shallowly buried within synclinal troughs. The shale ranges from 200 to 230 feet thick in this part of the state.[18] From Town Creek to Tonoloway Ridge the Marcellus is deeply buried beneath the Town Hill and Sideling Hill synclines. In this area, the Marcellus Shale may be buried by as much as 10,000 feet of overlying rocks. The Marcellus in this part of the Tate is between 230 and 250 feet in thickness. East of Tonoloway Ridge, folding of the rock layers has preserved small areas underlain by the Marcellus Shale between Hancock and Clear Spring. In this area, the Marcellus exceeds 250 feet in thickness.[19]

[16]*Information Concerning the Marcellus Shale and the Search for natural Gas in Western Maryland*. Maryland Geological Survey, Department of Natural Resources, 2300 Saint Paul St., Baltimore, MD 21218.
[17] Ibid.
[18]Brezinski, D. *Geology of the Marcellus Shale in Maryland*. Maryland Geological Survey. Maryland Department of Natural Resources.
[19] Ibid.

Natural Gas and Energy Markets

Current demand for natural gas in the U.S. is approximately 22.7 tcf (trillion cubic feet) per year.[20] The electricity sector is a large consumer of natural gas (second only to industrial consumption). In 2010, the electric power sector, defined as electricity-only and combined-heat-and-power plants whose primary business is to sell electricity or electricity and heat to the public, consumed 7.4 tcf of natural gas, representing 31 percent of total U.S. consumption. Between 1950 and 2010, U.S. consumption of natural gas has increased by almost 320 percent.[21]

Exhibit 6: U.S. Natural Gas Consumption by Sector (2010)



(1) Includes combined-heat-and-power plants and a small number of electricity-only plants
(2) Lease and plant fuel, and other industrial.
(3) Electricity-only and combined-heat-and power plants whose primary business is to sell electricity, or electricity and heat, to the public.
(4) Natural Gas consumed in the operation of pipelines (primarily in compressors), and as fuel in the delivery of natural gas to consumers; plus a small quantity used as vehicle fuel.
Source: U.S. Energy Information Administration, Annual Energy Review 2010, Table 6.5

Higher demand for electricity coupled with the replacement of aging coal-fired power plants and new EPA requirements will likely expand natural gas consumption in the future. This could significantly reduce greenhouse gas emissions associated with electricity generation because of the lower levels of emissions from burning natural gas vis-à-vis coal.[22]

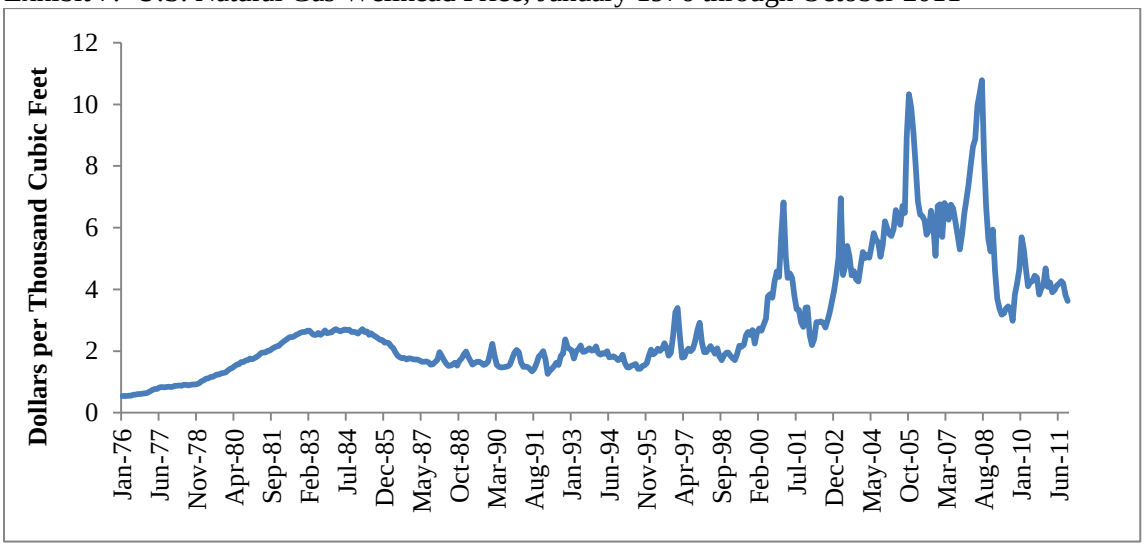
[20] Average of yearly consumption 2000-2010
[21] U.S. Energy Information Administration. (2010). "Annual Energy Review 2010."
[22] Timothy J. Considine, Robert W. Watson & Nicholas B. Considine. (May 2011). "The Economic Opportunities of Shale Energy Development," Center for Energy Policy and the Environment at the Manhattan Institute.

Moreover, because the supply of natural gas is less dependent on foreign producers than is the supply of crude oil, delivery had been less subject to interruption in recent years. As Exhibit 7 reflects, the price of natural gas has fallen substantially in recent years, making the commodity even more attractive to end users.

In addition to providing natural gas stability, landowners can benefit from the extraction of gas from the Marcellus Shale. According to "Marcellus Shale: Appalachian Basin Natural Gas Play," the size of signing bonuses depends upon the level of uncertainty in the estimation of the buyer and the number of other buyers competing for purchases. As recently as 2005, there was very little interest in leasing properties for Marcellus Shale gas production and signing bonuses were typically just a few dollars per acre.[23] But when the potential of the Marcellus throughout the region was more fully understood by 2006, a small number of speculators began leasing land -- paying signing bonuses that were sometimes as high as $100 per acre. Since then, bonuses have increased to over $2,000 per acre for the most desirable properties.[24]

Additionally, hundreds of thousands of acres above the Marcellus Shale have been leased with the intent of drilling wells for natural gas, most of which are not adjacent to a natural gas pipeline.[25] While miles of pipeline have already been constructed, more pipeline is necessary to realize the potential of the Marcellus Shale formation. This represents another source of potential industry economic impact.

Exhibit 7: U.S. Natural Gas Wellhead Price, January 1976 through October 2011



Source: Energy Information Administration

[23] Ibid.
[24] Ibid.
[25] Ibid.

Marcellus Industry Activity to Date

A number of companies are actively involved in leasing or drilling Marcellus Shale properties. Range Resources, North Coast Energy, Chesapeake Energy, Chief Oil & Gas, East Resources (Shell), Fortuna Energy, Equitable Production Company, Cabot Oil & Gas Corporation, Southwestern Energy Production Company, Atlas Energy Resources (Chevron), XTO (Exxon), Anadarko Petroleum Corporation, Talisman Energy, Hess, Chevron, and Shell are some of the companies already operating in the Marcellus zone. According to the Pennsylvania Department of Environmental Protection, the number of drilled wells in the Marcellus Shale has been growing rapidly in recent years. Only 27 Marcellus Shale wells were drilled in 2007 statewide. By 2010, the number of wells drilled had risen to 1,386. Many of these wells may yield millions of cubic feet of natural gas each day in their first year.[26]

The determinants of Marcellus shale development are depth, thickness and access. Depth largely determines the cost of drilling. Deeper wells cost more to drill and the relationship is nonlinear rather than linear.[27] That is, the cost of drilling increases in greater proportion as the depth of the well increases.

Exhibit 8: Average Characteristics of the Marcellus Shale Play

Depth (ft)	6,750
Thickness (ft)	125
Porosity (%)	8
Total Organic Content (% wt)	12
Source: U.S. Energy Information Administration, "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays," July 2011.Table 3	

Moreover, the Independent Oil and Gas Association of New York estimates the cost ratio of horizontal versus vertical wells at 2 to 1.[28] The volume of horizontal shale drilling is largely influenced by the price of natural gas. Because horizontal drilling is more expensive than vertical drilling, a minimum natural gas price is required for drilling to be profitable. In 2009, analysts at the Center for Business and Economic Research examining the Fayetteville Shale play reported that for exploration and drilling to be profitable, the price of gas needed to be $6.00+/MMBtu.[29] That price is likely lower today as a result of advances in drilling technology and practice.

[26] "Natural Gas Drilling Activity," Available at http://geology.com/articles/marcellus-shale.shtml.
[27]Timothy J. Considine, Ph.D. (July 14, 2010). "The Economic Impacts of the Marcellus Shale: Implications for New York, Pennsylvania, and West Virginia."
[28] Independent Oil and Gas Association of New York. "The Facts About Natural Gas Exploration of the Marcellus Shale," pg. 4.
[29] The League of Women Voters of Pennsylvania, Marcellus Shale Natural Gas Extraction Study 2009-2010, Study Guide III-Marcellus Shale Natural Gas: Its Economic Impact.

Economic analysis by Talisman Energy Inc., a Canadian company that has been active in the Marcellus and Eagle Ford shales in the United States, and the Utica and Montney shales in Canada, shows a steady decline in the breakeven price for shale gas development in recent years. In 2008 the company's breakeven price was $8.50/Mcf; in 2009 it fell to $6.50; and fell even further in 2010 to $4.50. That number was projected to rest between $3 and $4 in 2011.[30] This price may also vary among different shale plays because characteristics such as depth and thickness are not the same across different geographic areas. Also, production rates differ in and among shale plays.

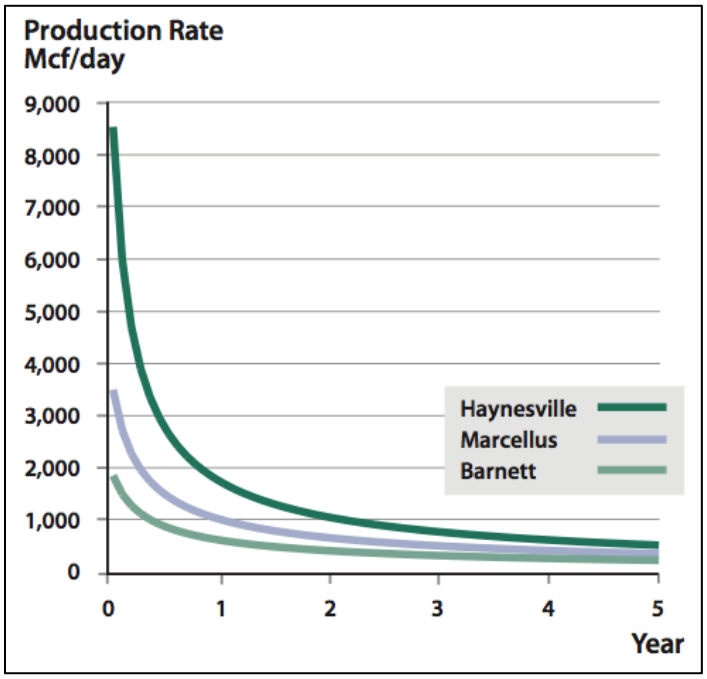
Considine's Penn State study team estimated a simple regression model linking drilling activity in the Barnett Shale with Henry Hub Price.[31] Regression results indicate that price significantly affects drilling in the Barnett; the price elasticity of drilling is estimated at 2.7. This means that for each one percent increase in the price of natural gas, drilling increases by approximately 2.7 percent.

Production Rates

Most shale gas wells have steep production decline curves, meaning that over time wells become less productive. Accordingly, companies must drill additional wells each year to maintain or increase production. Horizontal and vertical wells both follow this type of production curve, but vertical wells are associated with substantially lower levels of output. The production ratio of horizontal wells to vertical wells is 3.2 to 1.[32] Presently there exists a mix of horizontal and vertical drilling in the Marcellus Shale play. However, because vertical well output is substantially lower than horizontal well output, it is widely predicted that the proportion of resources devoted to horizontal drilling will grow in years to come. The exhibit below compares production in the Marcellus, Haynesville, and Barnett shale plays.

[30] Brown, David. American Association of Petroleum Geologists (AAPG) Explorer, "What is the Cost of Shale Gas Play?" April 2011.
[31] Henry Hub price refers to the price of natural gas at the Henry Hub in Louisiana, a major trading point for natural gas
[32] Independent Oil and Gas Association of New York. "The Facts About Natural Gas Exploration of the Marcellus Shale."

Exhibit 9: Variation in Production Rates between Shale Plays



Source: MIT, "The Future of Natural Gas," 2010 (study cites HPDI production database, various industry sources)

Jobs Associated with Shale Drilling

As stated earlier, this report benefits tremendously from the experiences of Pennsylvania, which provide a sense of how industry activity would look in Maryland. The Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment conducted by the Marcellus Shale Education & Training Center (MSETC) recently analyzed the types of jobs and job skills required for drilling in the Pennsylvania Marcellus Shale and concluded that it requires approximately 420 individuals across 150 occupations to bring a single Marcellus well on line (only refers to direct jobs).[33] Exhibit 10 provides a sense of the occupational mix involved in the emerging natural gas industry.

[33] Marcellus Shale Education & Training Center (MSETC). (June 2011). "Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment."

Exhibit 10: Natural Gas Workforce Occupations by Category

General Office	20%
CDL	10%
General Labor	20%
Heavy Equipment	17%
Geologists	3%
Lawyers	4%
Paralegal	1%
Cartog/GIS	1%
Timber Logging	1%
X-Ray	1%
Engineers	3%
Inspectors	1%
Landmen/Realty	5%
Semi-Skilled Tech.	6%
Source: "Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment," Marcellus Shale Education & Training Center (MSETC), June 2011	

Pre-drilling and drilling phase jobs represent 98 percent of natural gas development jobs needed to bring a well into production. These types of jobs are labor intensive and largely involve constructing the infrastructure needed to drill.

After the necessary infrastructure is in place, these positions are no longer required with respect to a particular well. Production phase jobs are longer-term in nature and some may be considered permanent. Roughly 70-80 percent of the jobs in the Marcellus Shale natural gas development workforce are relatively low-skilled or semi-skilled occupations. Most of these jobs do not require formal post-secondary education, although a few occupations (CDL, welding, x-ray, etc.) require trade certification or specialized license.

Nearly all occupations involve knowledge and skills that are specific to the natural gas industry and usually learned through on-the-job experience. In other words, the industry is particularly good at putting blue collar workers back to work and teaching them industry specific skills. The remaining 25 percent of the Marcellus Shale workforce are associated with white collar occupations that require post-secondary education, including engineers, geologists, realtors, supervisors and attorneys.[34]

The MSETC model determines the number of full-time equivalent workers (FTE) that are needed to produce a Marcellus shale well using a 2,080-hour work-year. Summary detail is provided in Exhibit 11 below.

[34] Ibid.

Exhibit 11: FTE (full-time equivalent worker) by Phase and Type of Well

Phase	Single Well	Additional Wells on Pad
Pre-drilling (1) (2)	2.41	0.65
Drilling (1) (2) (3)	10.49	8.81
Production (1) (2)	0.19	0.19
Natural Gas Processing (2)	0.2	0.2
Dry Gas Total	13.09	9.65
High-BTU gas Total	13.29	9.85
Total	39.67	29.35

Source: "Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment," Marcellus Shale Education & Training Center (MSETC), June 2011
(1) Dry Gas Calculation
(2) High-BTU Gas Calculation
(3) Includes Pipeline Construction
Notes:
Full-time equivalent (FTE) is defined at 260 eight-hour workdays or 2,080 hours per year
The model assumes that:

- The average drilling rig drills approximately 12 wells per year
- Each single well or first well will require, on average, one mile of pipeline construction (additional wells on a multi-well pad will not require pipeline construction beyond connection.
- One compressor station will be constructed, on average, for every 20 wells.
- Companies' current drilling rig projections are relatively accurate (for the 'median' development scenarios).

IHS Global Insight recently published a study pertaining to shale drilling in the entire United States. The study, entitled "The Economic and Employment Contributions of Shale Gas in the United States" reported that the shale gas industry supported more than 600,000 jobs in 2010 directly and indirectly, a figure estimated to grow by 45 percent to 870,000 by 2015. This represents a 7.7 percent annual rate of job growth over the 2010-2015 period. IHS forecasts that by 2035, the shale drilling employment base will have nearly tripled surpassing 1.66 million jobs.[35] The exhibit below provides summary detail of 2010 shale gas industry employment across the U.S.

[35]IHS Global Insight. (December 2011). "The Economic and Employment Contributions of Shale Gas in the United States."

Exhibit 12: Employment Contribution by Industry in 2010: Shale Gas (Number of workers)

Sector	Direct	Indirect	Induced	Total
Agriculture	0	1,576	5,962	7,538
Mining	51,534	5,165	682	57,381
Construction	47,917	12,814	2,540	63,270
Manufacturing	38,946	32,246	13,992	85,183
Transportation and Utilities	6,558	18,639	14,441	39,637
Retail and Wholesale Trade	0	17,669	51,940	69,608
Services	3,189	102,941	166,446	272,576
Government	0	2,661	3,493	6,153
Total	**148,143**	**193,710**	**259,494**	**601,348**

Source: IHS Global Insight

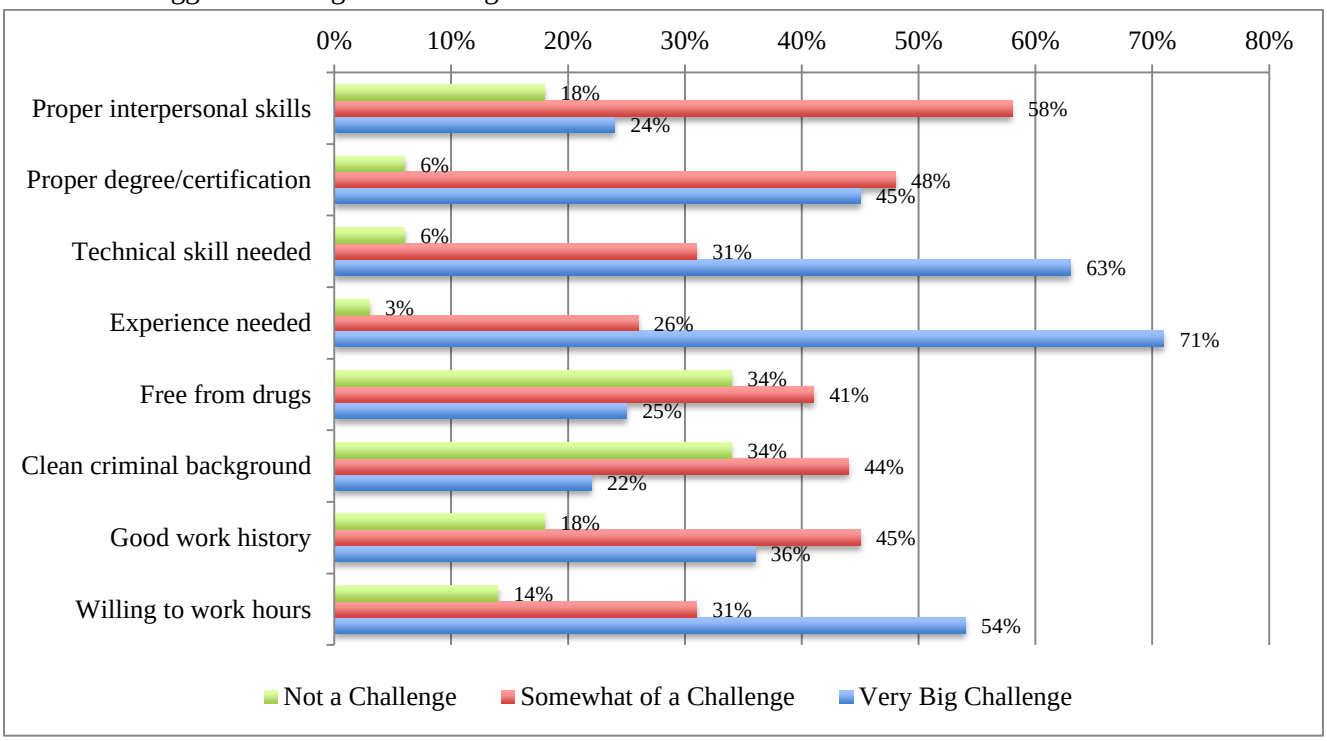
This type of growth is consistent with the notion that more states will see fit to allow the industry to expand. In other words, the IHS Global Insight researchers do not anticipate that environmental or other considerations will prevent the industry from continuing to expand natural gas production.

From the perspective of maximizing economic impact, it is important that a significant proportion of workers hired by the industry emerge from the local economy. Based on online workforce assessment results, MSETC reports that the largest barrier to identifying local workers is a lack of general experience within the industry.

However, broader trends are encouraging. According to MSETC, when drilling activity first began to accelerate, approximately 70-80 percent of employees came from outside Pennsylvania. Today, approximately 65-70 percent of new Marcellus workers are Pennsylvania residents. Based on 2010 employment records, a separate analysis performed by the Pennsylvania Department of Labor and Industry found that 71 percent of new hires in natural gas core and ancillary industries in the Pennsylvania Marcellus Shale region were residents of the state.[36]

[36] Marcellus Shale Education & Training Center (MSETC). (June 2011). "Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment."

Exhibit 13: Biggest Challenges to Finding New Workers in Marcellus Natural Gas Industries



Source: Marcellus Shale Education & Training Center (MSETC), "Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment," June 2011, Table 11.

B. Methods for Modeling Potential Marcellus Shale Impacts in Maryland

A Discussion of Analytical Assumptions

Certain variables affect the location of drilling such as infrastructure access, topographic and geologic data, and political considerations (for example proximity to hospitals or schools). Such locations are unlikely to be distributed evenly across a study area.[37] Therefore, assuming that drilling will occur uniformly across a study area would typically produce an overestimate of likely expenditures.

Additionally, the results of an economic impact study are subject to assumptions made regarding the cost of drilling, wells per pad/acreage of pad, and other production-specific variables. There are also key assumption regarding the pace at which royalty and bonus payments will be spent by landowners. Considine treats royalty and bonus payments by landowners as current income rather than as an increment to wealth; meaning these payments will be spent in the year received and in essentially the same proportions as income from the workplace. This type of assumption would tend to boost estimates of economic impact. By contrast, a 2009 study of Haynesville Shale (Scott 2009) treated landowner receipts as additions to wealth such that in the conservative base case analysis only 5 percent of the value of this new wealth was assumed to be spent on consumption by landowner households.[38]

Projecting Natural Gas Production in Maryland

Local jurisdictions are already preparing for potential drilling. According to the Board of Garrett County Commissioners' Marcellus Shale Natural Gas in Garrett County Fact Sheet, natural gas has been extracted in Garrett County for at least 70 years. Moreover, within the Cumberland, MD, Uniontown, PA, and Morgantown, WV areas, housing capacity within an hour's drive to Garrett County is sufficient to supply the industry. Opportunities for ancillary businesses to benefit from Marcellus shale abound – hotels/motels, restaurants/food service, excavation companies, trucking, security firms, etc.

According to the U.S. Geological Survey, a single well can produce 4,000,000 cubic feet per day for a total lifetime production of 2,500,000,000 cubic feet at an estimated production cost of $1.00 per thousand cubic feet. Therefore, a single well in theory could generate a gross of $8,350,000 (2.5 billion cubic feet times $3.34 per thousand cubic feet)

[37] Ibid.
[38] Kay. (2011). "A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale-The Economic Impact of Marcellus Shale Gas Drilling-What have we Learned? What are the Limitations?

at a cost of $2,500,000 (2.5 billion cubic feet times $1 per 1,000 cubic feet) for a net of $5,850,000.[39] Lease payments, royalties, severance taxes, permit fees, and the economic activity associated with drilling-related jobs could bring significant economic benefits to Garrett and Allegany counties. According to the University of Maryland Extension, as many as 1,600 wells could be drilled in 128,000 acres in Garrett County and another 637 wells in 51,000 drillable acres in Allegany County.

Sage's Model Inputs

While it is not fully clear how much natural gas exists within Maryland Marcellus Shale until drilling begins, the study team based its economic considerations upon the most recent estimates produced by the USGS. According to the USGS, there is a 95 percent chance that at least 703 BCF of natural gas is located in Western Maryland's Marcellus Shale formation. There is a 50 percent chance that there is at least 1,286 BCF of natural gas, and there is a 5 percent chance that there is 2,351 BCF of natural gas in Western Maryland. The study team used the 50 percent scenario as the basis for its mid-case scenario for natural gas recovery in Maryland.

The study team also presumed that each well would generate approximately 2.5 BCF of natural gas over its lifetime (as projected by the USGS). Applied to the estimated amount of total extractible natural gas available within the play, the study team projects that in the mid-case scenario that approximately 365 wells would be developed over time.

Based on the experience of Marcellus Shale well drilling in Pennsylvania, it is apparent that well drilling begins slowly over the initial one or two years and then begins to ramp higher. The study team used the experience of Pennsylvania and the projections by Considine et al. to project well development for the Marcellus play in Maryland. The study team assumed that it would take one year for wells to go on line.[40]

[39] Analysis of the FY 2012 Maryland Executive Budget, 2011; K00A- Department of Natural Resources.
[40] Based on interviews with members of the industry, it would be more accurate to assume wells go on line within three to six months of when they are created. However for simplicity's sake, the study team assumed that it requires one year for a well to go on line.

Exhibit 14: Projected Well Creation by Year in Western Maryland

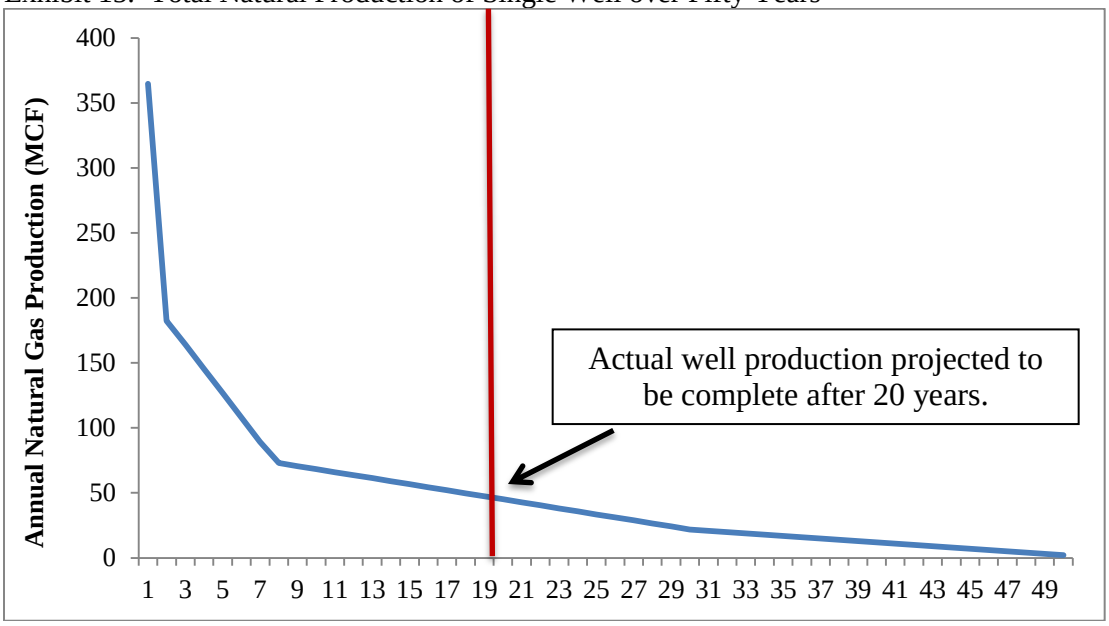
Year	*Low-Case Scenario*		*Mid-Case Scenario*		*High-Case Scenario*	
	Wells Created	Wells Online	Wells Created	Wells Online	Wells Created	Wells Online
2015	5		9		16	
2016	12	5	22	9	40	16
2017	15	17	28	31	51	56
2018	17	32	31	59	58	107
2019	18	49	34	90	61	165
2020	19	67	35	124	65	226
2021	20	86	37	159	68	291
2022	21	106	39	196	72	359
2023	22	127	41	235	75	431
2024	23	149	43	276	79	506
2025	27.08	172	45.56	319	82.24	585
Total		**199**		**365**		**667**

Source: Sage

As Marcellus is developed, royalties will dominate payments to land owners, eventually exceeding lease and bonus payments.[41] Considine asserts that "the production profile of typical shale wells entails a rather sharp initial decline in the production rate and after a few years a much slower rate of decline." Several Marcellus Shale operators have published typical decline curves for horizontal wells based on their early drilling experience in Pennsylvania.[42] Exhibit 15 embodies this experience. The notion is that not all natural gas available is extracted because the cost of extracting each additional unit of gas tends to rise after a certain threshold is achieved.

[41]Considine, Timothy, et al. (May 24, 2010). Low cost natural gas could attract gas intensive manufacturing industries to expand capacity in Pennsylvania Gas Play: An Update.
[42] Ibid.

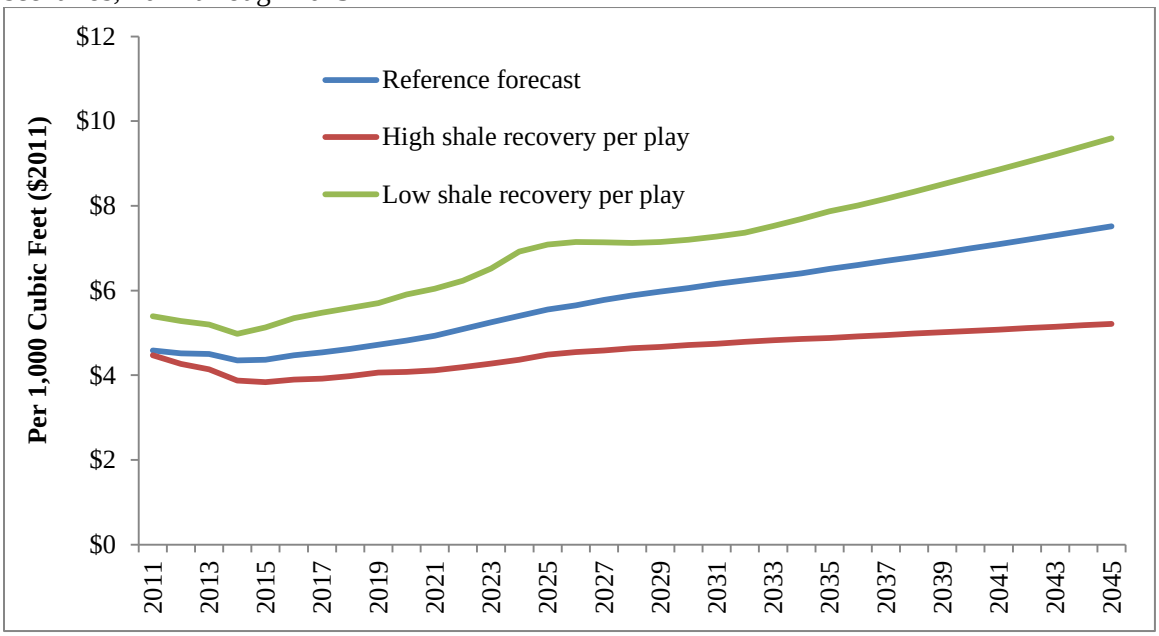
Exhibit 15: Total Natural Production of Single Well over Fifty Years



Source: Sage

Based on the Energy Information Administration's Annual Energy Outlook 2011, Sage projected future natural gas prices based on three scenarios: a baseline forecast if current trends hold up; a high shale recovery per play scenario, where the result is a lower price for natural gas; and low shale recovery per play scenario, resulting in higher natural gas prices for the region. Exhibit 16 reflects these three scenarios.

Exhibit 16: Projected Prices of Natural Gas Wellhead Prices in Northeast Region across three scenarios, 2011 through 2045



Source: Energy Information Administration 2011 Annual Energy Outlook; Sage (projected values beyond 2035 based on EIA Forecast)

The Sage study team further estimates that 71.5 percent of gas production would take place in Garrett County and 28.5 percent of production would take place in Allegany County. This assumption is based on drillable acreage estimates by the University of Maryland Extension, which projects drillable acreage in Garrett County to be 128,000 acres and drillable acreage in Allegany County to be 51,000 acres.

However, while all of that acreage is drillable, it is not likely that all will be drilled. For instance, the study team assumed that no drilling will take place on State-owned property, except where other parties own mineral rights on state lands. In all, 30 percent of drillable area was excluded from the analysis, including for topographical and other reasons.

The application of severance taxes was also a key assumption used by the study team. As defined by the Maryland Department of the Environment, a severance tax is a tax imposed on the value of natural resources such as coal, oil or gas extracted from the earth. Severance taxes are determined after completion of drilling when the gas is extracted and can be measured. Generally, a severance tax is based on the value of the gas extracted at the wellhead, the volume or weight when it is extracted, or a combination of the two. Revenue from a state severance tax is usually placed in the general funds of the state.[43] Exhibit 17 reflects severance tax for several key energy-producing states.

Exhibit 17: Severance Tax Rates from Select States

Alaska	25% of net value at production
Kansas	8% of gross value
Texas	7.5% of market value at well
Oklahoma	7% of average monthly price
Wyoming	6% of gross value, including royalties
West Virginia[44]	5% of gross value
Ohio	$0.025 per thousand cubic feet to be paid by the person who actually removes the gas

Source: Department of Legislative Services; Maryland Department of Environment

The study team used the assumption that Garrett and Allegany counties would have a 5.5 percent severance tax rate and that the State of Maryland would maintain a 2 percent rate. Garrett County levies a tax of 5.5 percent on the wholesale market value of gas produced from wells in Garrett County. Ten-elevenths of the money received is distributed to the County and one-eleventh to the municipalities in the County on a per capita basis (Public

[43] Maryland Department of the Environment, Maryland Department of Natural Resources. (December 2011). Marcellus Shale Safe Drilling Initiative Study.

[44] Department of Legislative Services, Maryland Marcellus Shale: A Preliminary Look at its Revenue Potential. (January 2012). "Imposes a severance tax of 5.0% of the market value of the gas in the immediate vicinity of where it is produced plus $0.047 per thousand cubic feet of gas, to be paid by the person in the business of severing the gas for sale, profit, or commercial use."

Local Laws of Garrett County, Section 51.01 through 51.07). Allegany County levies a 7 percent tax on the wholesale market value of natural gas produced in Allegany County (Chapter 394, Allegany County Code). However, it is likely that legislation to change Allegany's severance tax rate to match Garrett's will be proposed in 2012. While Maryland currently does not have a tax in place, the University of Maryland Extension used a 2 percent rate in its estimates. The study team thought it was wise to follow this example.

According to a recent report by the Maryland Department of the Environment, Maryland and Pennsylvania are the only gas-producing states in the Mid-Atlantic area that do not have some form of state-level severance tax. Pennsylvania just enacted legislation imposing significant per well fees instead of a severance tax. Most states apply a statewide tax while some authorize counties to impose the tax.

A Wyoming study used a model to simulate the impact of raising severance taxes.[45] The study found that raising the severance tax does little to affect production and therefore overall tax collections increase. However, the authors noted that their simulations showed that a tax increase slows down drilling in the early years of the program and shifts it to the future compared with a no tax increase scenario.[46]

Looking specifically at Pennsylvania, another study[47] concluded that a severance tax "would have potentially small negative effects on some economic metrics,[48] but that these would probably be more than offset by the positive effects of state and local government spending made possible by the severance tax. By contrast, a survey of Fayetteville Shale operators was performed that included a survey question regarding a hypothetical 5 percent severance tax. At the time of the survey, the relevant rate was 0.3 percent of production. The survey indicated that the response to an increase in the severance tax to 5 percent would on average be a 13 percent decline in investment in activities in the Fayetteville Shale. [49]

As acknowledged by the Maryland Department of the Environment, it is difficult to predict whether the imposition of increase of a severance tax in Maryland would affect

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[45] Kunce, M. *et al.* (2003). *State Taxation, Exploration, and Production in the U.S. Oil Industry,* 43 Journal of Regional Science 749-770.

[46]Ibid.at 759. Several Commissioners have suggested that Maryland should ramp up drilling activity slowly in the early years.

[47]Baker, R. M. and Passmore, D.L. *Benchmarks for Assessing the Potential Impact of a Natural Gas Severance Tax on the Pennsylvania economy* at 15 (September 13, 2010). Available at SRN: http://ssrn.com/abstract=1667022.

[48] Total employment, private nonfarm employment, gross state product, real disposable personal income and population. Ibid.at 15.

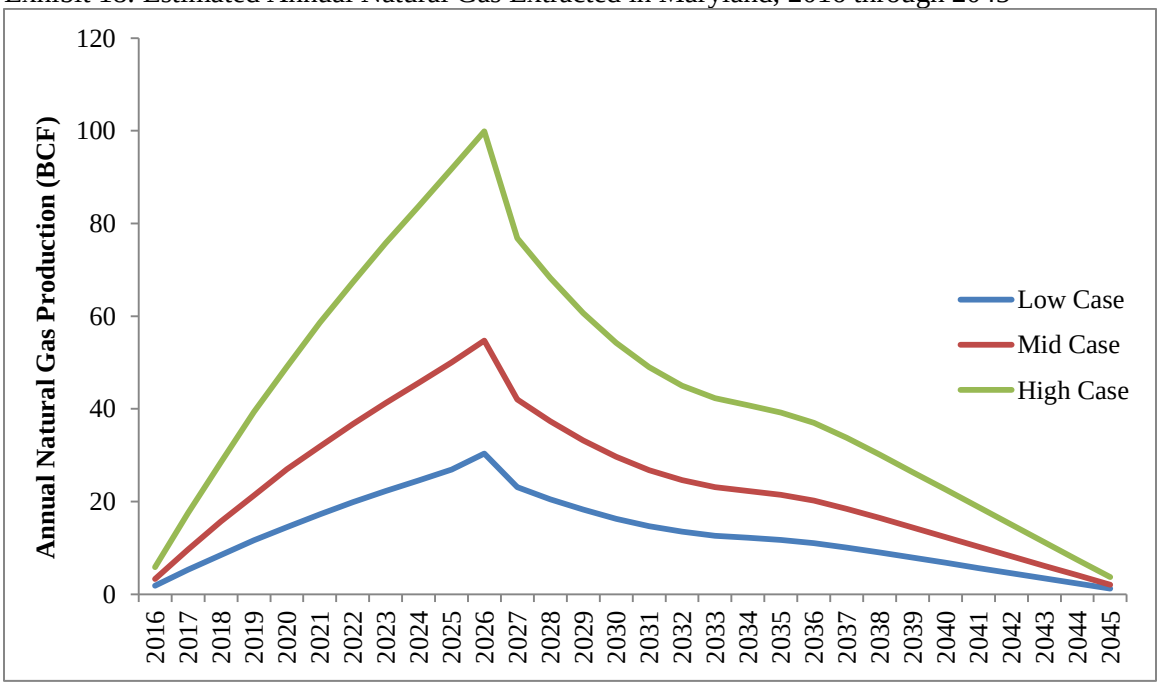
[49] The Center for Business and Economic Research. (March 2008). "Projecting the Economic Impact of the Fayetteville Shale Play for 2008-2012."

the pace of gas exploration and production activity and to what extent. A severance tax is a factor amongst many that companies consider before investing in drilling efforts. Companies likely consider the total tax burden as well as non-tax related factors including natural gas prices, labor costs, access to pipelines, and regulatory requirements.

The study team estimated that royalties of 12.5 percent of the wholesale market value of gas produced on one's land would be paid out to landowners who have leases with the companies extracting the natural gas. This represents a standard industry percentage.

Finally, with respect to the year during which impacts begin to be generated, the Sage study team chose 2015. This was due to a variety of reasons, including ongoing uncertainty regarding how various political processes will treat the economic and environmental implications of drilling. Accordingly, the estimated impacts provided below begin in 2016, the year that wells would begin to go on line. It has been projected that total well-life could amount to twenty years based on conversations with industry experts. Exhibit 18 provides estimates of the amount of natural gas extracted in Maryland under three scenarios.

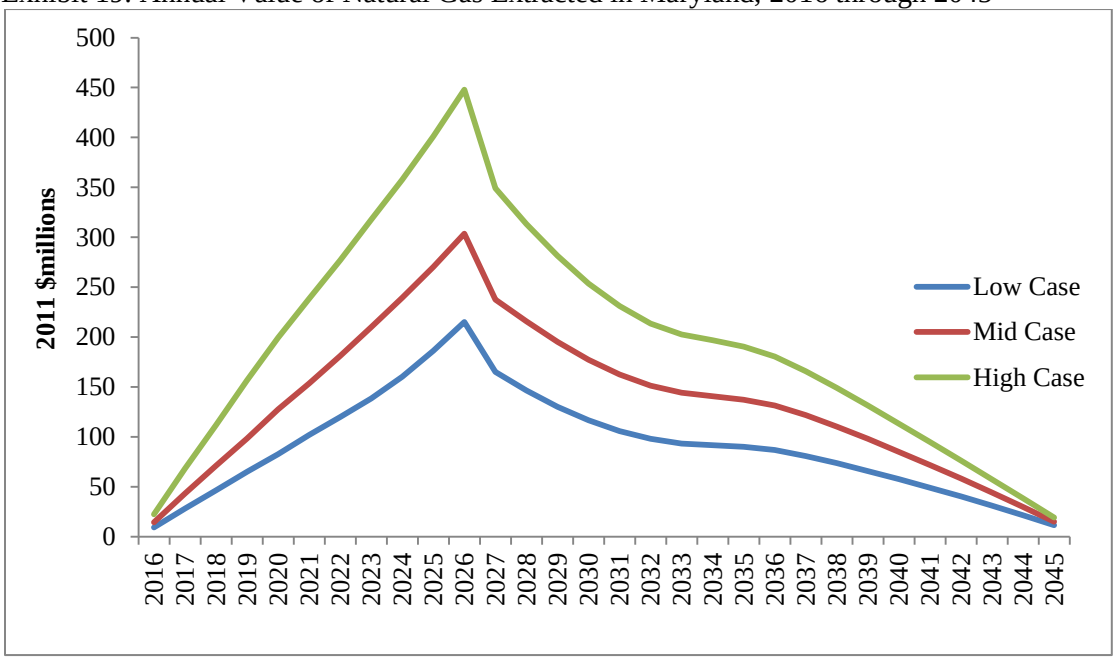
Exhibit 18: Estimated Annual Natural Gas Extracted in Maryland, 2016 through 2045



Source: Sage

Exhibit 19 attaches dollar values to this output.[50] The peak year for production is 2026 for all scenarios. Under the mid-case scenario, the annual value of extracted natural gas that year would be in the range of $300 million.

Exhibit 19: Annual Value of Natural Gas Extracted in Maryland, 2016 through 2045

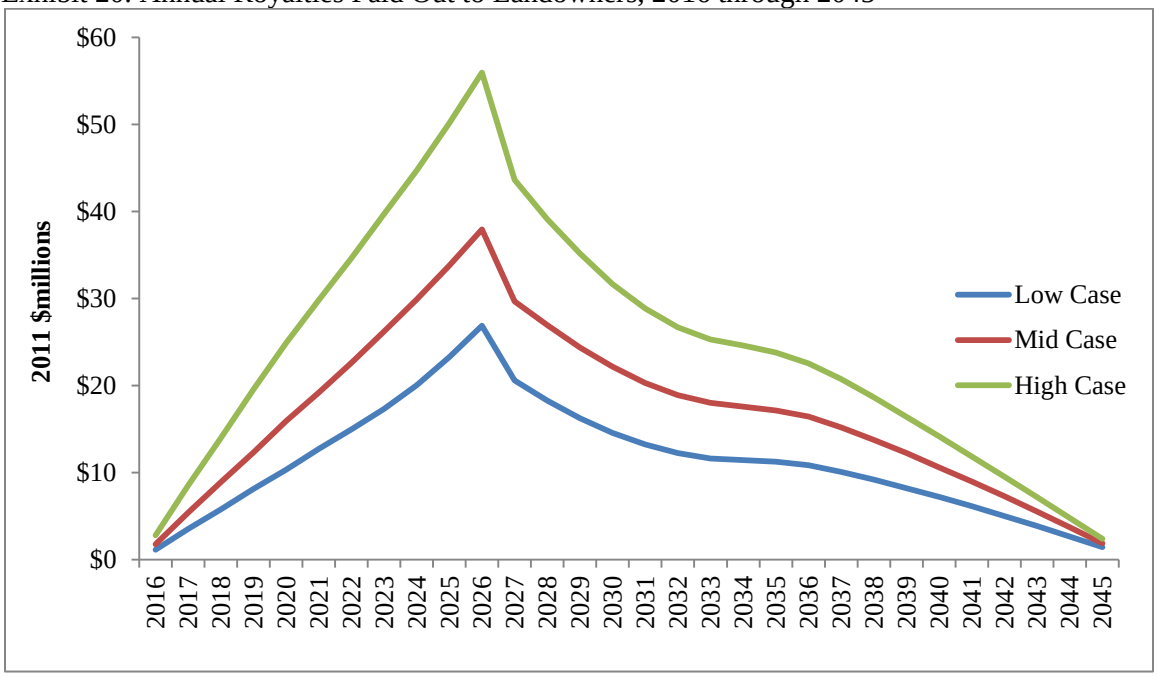


Source: Sage

Exhibit 20 reflects estimates of annual royalties paid to landowners in Maryland. Exhibits 21, 22, and 23 provide statistical detail regarding estimated severance tax payments to Garrett and Allegany counties, respectively. Total severance tax collections would be in the millions of dollars under any scenario.

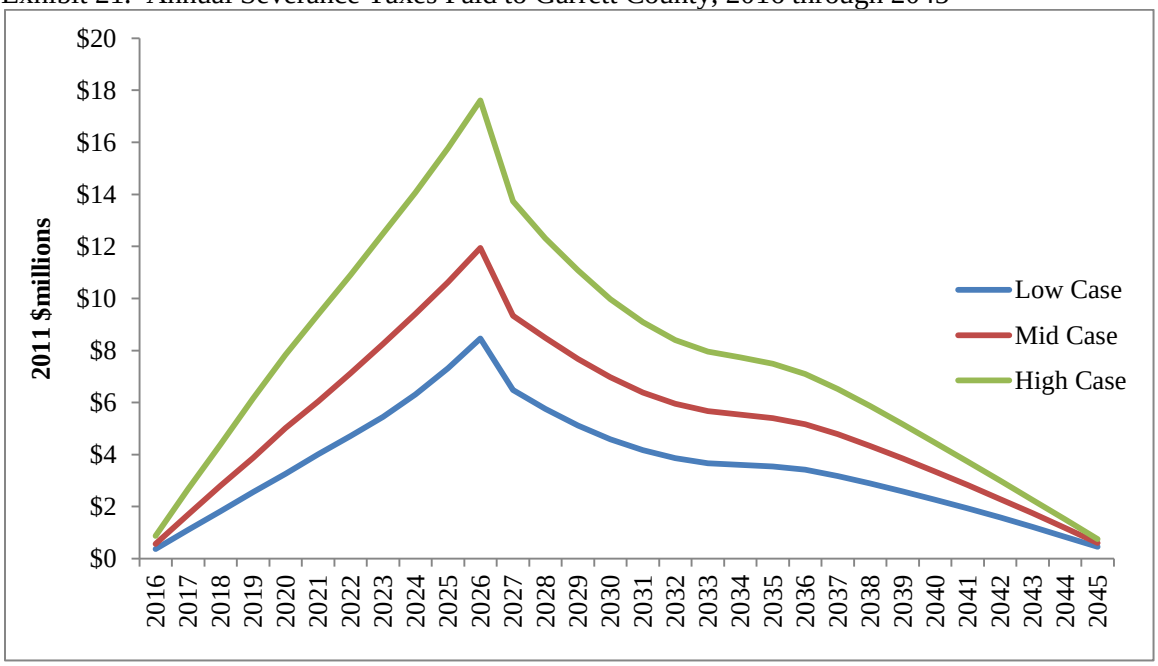
[50] Based on the Energy Information Administration's Annual Energy Outlook 2011, Sage projected future natural gas prices based on three scenarios: a baseline forecast if current trends hold up, a low shale recovery per play scenario, resulting in higher natural gas prices for the region, and a high shale recovery per play scenario, resulting in lower natural gas prices for the region.

Exhibit 20: Annual Royalties Paid Out to Landowners, 2016 through 2045



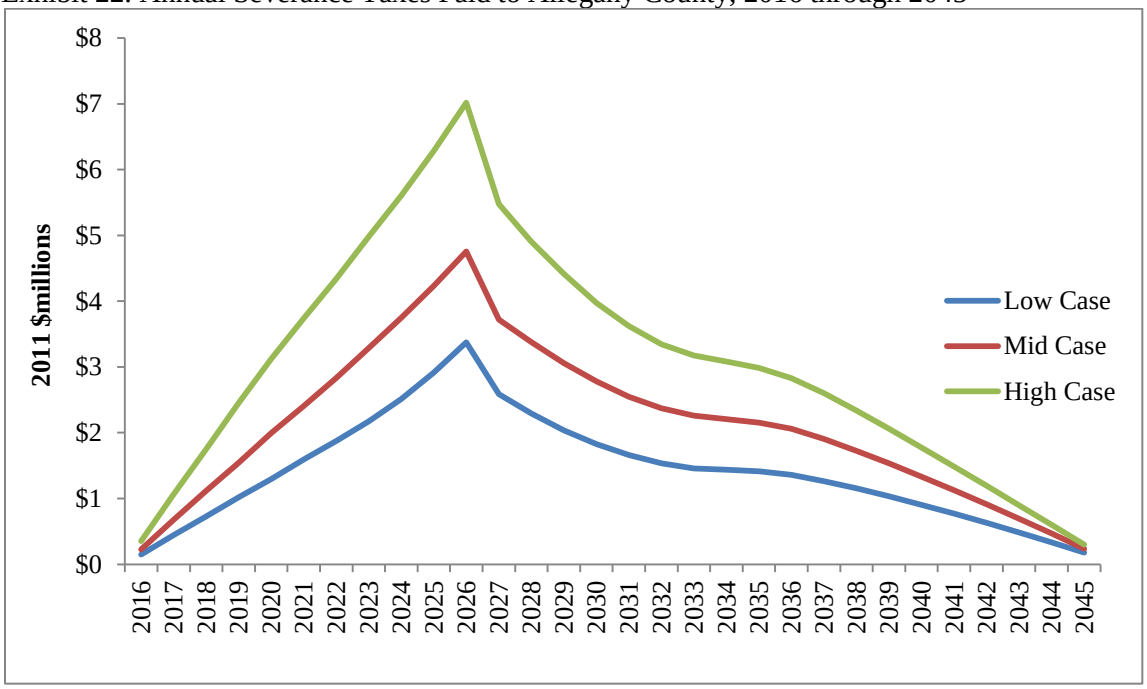
Source: Sage

Exhibit 21. Annual Severance Taxes Paid to Garrett County, 2016 through 2045



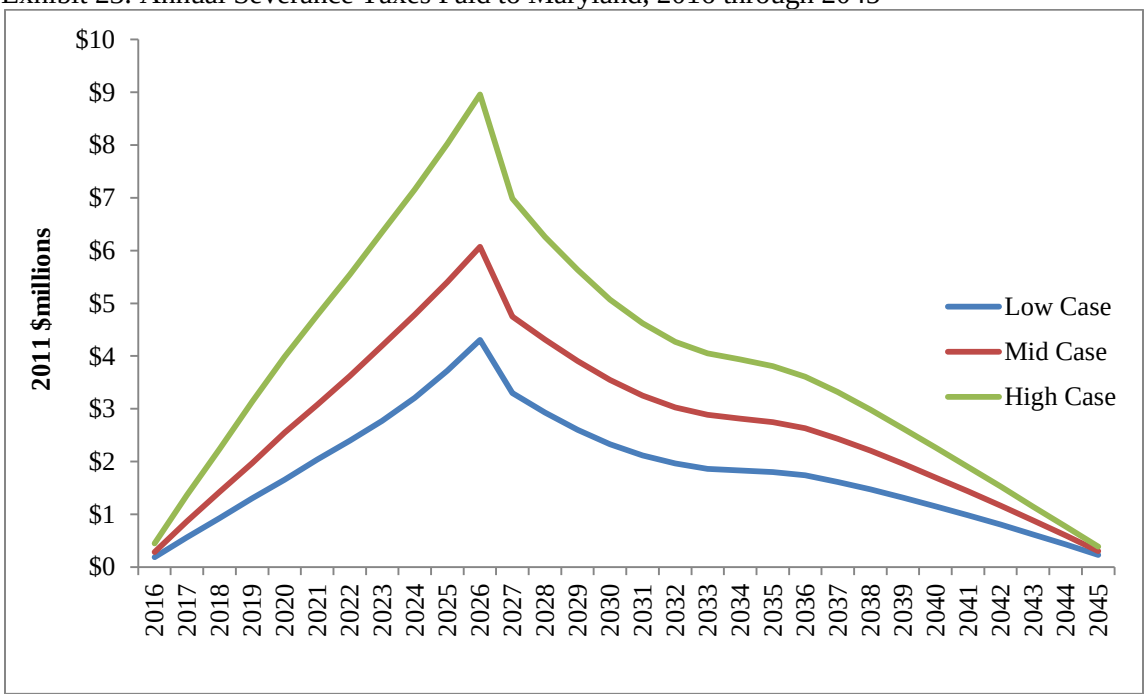
Source: Sage

Exhibit 22: Annual Severance Taxes Paid to Allegany County, 2016 through 2045



Source: Sage

Exhibit 23: Annual Severance Taxes Paid to Maryland, 2016 through 2045



Source: Sage

Exhibit 24: Summary of Results: one year, five year, fifteen year, lifetime

		2016	*Five Years (2016-2020)*	*Fifteen Years (2016-2030)*	*Lifetime of Wells (2016-2045)*
Natural Gas Extracted (billion cubic feet)	Low-Case	1.8	41.7	261.1	387.8
	Mid-Case	3.3	77.0	479.3	710.1
	High-Case	5.8	140.2	877.4	1299.7
Value of Natural Gas Extracted (2011$millions)	Low-Case	$9.4	$231.9	$1,711.7	$2,708.6
	Mid-Case	$14.3	$354.8	$2,538.1	$4,040.1
	High-Case	$22.4	$558.4	$3,796.0	$5,856.6
Royalties Paid to Landowners (2011$millions)	Low-Case	$1.2	$29.0	$214.0	$338.6
	Mid-Case	$1.8	$44.3	$317.3	$505.0
	High-Case	$2.8	$69.8	$474.5	$732.1
Severance Tax Paid to Garrett County (5.5%; 2011$millions)	Low-Case	$0.4	$9.1	$67.3	$106.5
	Mid-Case	$0.6	$14.0	$99.8	$158.9
	High-Case	$0.9	$22.0	$149.3	$230.3
Severance Tax Paid to Allegany County (5.5%; 2011$millions)	Low-Case	$0.1	$3.6	$26.8	$42.4
	Mid-Case	$0.2	$5.6	$39.8	$63.3
	High-Case	$0.4	$8.8	$59.5	$91.8
Severance Tax Paid to Maryland (2%; 2011$millions)	Low-Case	$0.2	$4.6	$34.2	$54.2
	Mid-Case	$0.4	$9.8	$69.4	$155.2
	High-Case	$0.6	$15.3	$103.8	$214.4

Source: Sage

C. Potential Economic and Fiscal Impacts of Marcellus Shale in Maryland

Economic Impacts Associated with Well Construction in Maryland

Before the period of production and severance tax collection, there is a period during which wells are drilled. The drilling of wells also creates economic and fiscal impacts.

Based on a survey of natural gas companies with experience working on Marcellus Shale, the study team estimates that well construction costs are between $5 and $7 million per well. For this study, the Sage study team presumed that each well costs $5.5 million per year. In other words, the study team utilized a fairly conservative estimate. Based on the most recent IMPLAN multipliers, 44.3 percent of total spending on the well would be directly spent in Maryland. Other expenditures would initially be spent off-site beyond state boundaries. With the drilling of a single well in Maryland, $2.44 million direct sales remain in the state. More than 15 jobs are generated with associated labor income of $830,000. Once one accounts for multipliers on direct activity, $3.35 million in business sales are generated.

In the study of drilling activity in Pennsylvania, Considine assumed that 95 percent of the activity was local. While we are not so optimistic in our assumptions, we did try to account for ongoing training of local labor and increased investments in local infrastructure. As such, the study team assumes for each year of drilling local spending increases three percentage points through 2025 where the local spending coefficient of drilling activity is estimated at 75 percent of direct expenditures.

Exhibit 25: Economic Impact of One Well Drilled in Maryland, 2015

Type of Impact	*Jobs*	*Labor Income (2011$millions)*	*Business Sales (2011$millions)*
Direct Impact	9.0	$0.51	$2.44
Indirect Impact	1.9	$0.13	$0.36
Induced Impact	4.3	$0.19	$0.55
Total Impact	15.2	$0.83	$3.35

Source: IMPLAN; Sage

Another source of economic impact to local communities is the increase in spending power of residents due to royalties paid. With the additional income, residents have more money to spend on consumer goods and services. Per $1 million paid out in royalties, 7.8 additional jobs are generated in Maryland with an associated income of $360,000 and business sales of $1.01 million. Per $1 million paid out to Garrett County, 7.3 jobs are generated within the county with associated income of $190,000 and business sales of $760,000. Per $1 million paid out to Allegany County, 7.0 jobs are generated within the County with an associated income of $230,000 and business sales of $760,000.

Exhibit 26: Economic Impact of $1 million in Royalties Paid in Local Jurisdictions

Area	*Jobs*	*Labor Income (2011$millions)*	*Business Sales (2011$millions)*
Maryland	7.8	$0.35	$1.01
Garrett County	7.3	$0.19	$0.76
Allegany County	7.0	$0.23	$0.76

Source: IMPLAN; Sage

Severance tax revenues for the State and local government also mean increased spending by these government entities. Most states allocate the largest share of severance tax revenues to the general fund or for general government purposes. States often also transfer a share of revenues to local governments, designate some of the taxes collected for specific projects such as conservation programs, place a portion in a permanent fund, or do all three.

Fifteen states allot a portion of severance tax revenues to local governments, including Colorado, Florida, Kansas, Kentucky, Louisiana, Mississippi, Montana, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Tennessee, West Virginia, and Wyoming.[51,52] West Virginia transfers more than 6 percent of severance tax revenues to counties and municipalities, seventy-five percent of which goes to oil and gas producing counties and twenty-five percent being divided among counties and municipalities based on population.[53] In FY 2008, West Virginia collected $525 million in severance tax revenues and transferred $35 million to local governments.[54] Some states allocate a larger portion of severance tax collections to local governments. For example, in 2009 Montana split approximately 48 percent of total oil and gas production tax revenues among counties and school districts.[55]

Ten states also earmark severance tax revenues for environmental cleanup or conservation. These include California, Colorado, Florida, Louisiana, Montana, New Mexico, Ohio, Oklahoma, West Virginia, and Wyoming.[56] After paying for debt and distributing revenues to state parishes, Louisiana deposits a portion of severance tax revenues and state oil and gas revenues in the state's Coastal Protection and Restoration

[51] Pennsylvania Budget and Policy Center. (June 15, 2009). "Shared Costs, Shared Resources-State Distribution of Severance Tax Revenues."
[52] Judy Zelio and Lisa Houlihan. (June 2008). *State Energy Revenues Update*, National Conference of State Legislatures.
[53] West Virginia State Treasury, *Tax Distribution Site*, http://www.wvsto.com/Tax+Distribution/DefaultTD.htm
[54] Pennsylvania Budget and Policy Center. (June 15, 2009). "Shared Costs, Shared Resources-State Distribution of Severance Tax Revenues."
[55] North Dakota Legislative Council staff for the Taxation Committee. (October 2008). "Oil-producing States' Funding Allocation to Political Subdivision."
[56] See footnote 76.

Fund.[57] This amount varies depending on total oil and gas revenues received by the state, ranging from $7 million to $25 million.[58]

Alaska, New Mexico, and Wyoming place some severance tax revenues into permanent funds. States typically only draw from the interest earned on permanent funds, leaving the principal untouched, which can alleviate the need for states to levy higher sales or income taxes to support public services.[59]

For every $1,000,000 worth of natural gas extracted in the state, state and local governments would have an addition $75,000 to spend on goods and services supplied by the community. Moreover, for every $1 million spent by state and local government, 14.8 jobs are generated in the state with associated income of $820,000.

Exhibit 27: Economic Impact of $1 million in Severance Taxes Paid in Maryland

Type of Impact	*Jobs*	*Labor Income (2011$millions)*	*Business Sales (2011$millions)*
Direct Impact	9.9	$0.59	$0.87
Indirect Impact	0.7	$0.04	$0.10
Induced Impact	4.2	$0.19	$0.54
Total Impact	14.8	$0.82	$1.51

Source: IMPLAN; Sage

Typically, field personnel stay within the local area to maintain the wells. Periodic maintenance of wells occurs once every eighteen months and could cost between $50,000 and $75,000 per visit. Industry experts estimate that there will be roughly one field worker per twelve wells going on line. For instance, in year eight of the **mid-case** scenario, when there are 196 wells on line, there will be sixteen field workers providing maintenance.

There are also operational impacts associated with water disposal that have been estimated to cost between $2.50 and $4.00 per barrel of water disposed. Finally marketing costs associated with operations are not reflected in these impacts. Marketing costs include extracting liquids and compressing gas and sending it to distribution sites. Even without these impacts included, under the mid-case scenario, the study team estimates that more than 1,800 Marylanders will have jobs due simply to the impacts of well drilling and royalty payments.

[57] Coastal Protection and Restoration Authority of Louisiana, CPRA statute, http://www.lacpra.org/index.cfm?md=pagebuilder&tmp=home&nid=28&pnid=4&pid=10&fmid=0&catid=0&elid=0.
[58] See footnote 76.
[59] Ibid.

Exhibit 28: Economic Impact of One Field Worker in Maryland

Type of Impact	*Jobs*	*Labor Income (2011$millions)*	*Business Sales (2011$millions)*
Direct Impact	1	$0.13	$0.27
Indirect Impact	0.5	$0.03	$0.08
Induced Impact	1.1	$0.05	$0.14
Total Impact	2.6	$0.21	$0.49

Source: IMPLAN; Sage

When one considers the economic impacts of the acts of drilling the wells, the royalties paid out for the wells, and state and local government spending related to severance tax revenues impacts on local jurisdictions are significant. Note that the impacts provided below in Exhibit 29 do not include costs associated with water disposal, and marketing costs such as liquid extraction and gas compression and distribution. In other words, the impacts in these exhibits are understated. This is because many services would initially be purchased from neighboring jurisdictions such as Pennsylvania and West Virginia.

Exhibit 29: Economic Impact of Well Drilling, Well Maintenance, Royalties Paid to Local Residents, and Increased State and Local Government in Maryland, through 2025

		Employment Impact			*Labor Income (2011$millions)*			*Business Sales (2011$millions)*		
		Low-case	*Mid-case*	*High-case*	*Low-case*	*Mid-case*	*High-case*	*Low-case*	*Mid-case*	*High-case*
2015	Direct	45	81	144	$2.5	$4.6	$8.1	$12.2	$22.0	$39.1
	Indirect	10	17	30	$0.7	$1.2	$2.1	$1.8	$3.3	$5.8
	Induced	22	39	69	$1.0	$1.8	$3.1	$2.8	$5.0	$8.8
	Total	**76**	**137**	**243**	**$4.2**	**$7.5**	**$13.3**	**$16.8**	**$30.2**	**$53.8**
2016	Direct	127	227	411	$6.8	$12.3	$22.4	$32.3	$58.9	$107.0
	Indirect	26	47	86	$1.7	$3.2	$5.7	$4.8	$8.8	$15.9
	Induced	70	123	219	$3.0	$5.4	$9.6	$8.6	$15.3	$27.4
	Total	**222**	**398**	**716**	**$11.6**	**$20.9**	**$37.8**	**$45.7**	**$83.0**	**$150.3**
2017	Direct	179	326	586	$9.3	$17.1	$31.1	$43.4	$80.6	$146.4
	Indirect	35	65	118	$2.3	$4.3	$7.9	$6.5	$12.0	$21.8
	Induced	114	199	349	$4.8	$8.5	$14.9	$13.8	$24.3	$42.7
	Total	**328**	**591**	**1,053**	**$16.4**	**$30.0**	**$53.9**	**$63.6**	**$116.9**	**$210.9**
2018	Direct	224	399	730	$11.3	$20.5	$38.1	$52.5	$95.3	$177.7
	Indirect	45	81	150	$2.8	$5.1	$9.6	$7.9	$14.3	$26.6
	Induced	153	262	461	$6.4	$11.0	$19.5	$18.3	$31.5	$55.9
	Total	**423**	**741**	**1,341**	**$20.6**	**$36.6**	**$67.2**	**$78.7**	**$141.0**	**$260.2**
2019	Direct	262	476	838	$13.0	$24.2	$43.1	$59.3	$111.2	$199.0
	Indirect	51	94	168	$3.2	$6.0	$10.8	$9.0	$16.7	$30.0
	Induced	190	326	559	$7.9	$13.6	$23.4	$22.6	$39.0	$67.2
	Total	**503**	**896**	**1,565**	**$24.1**	**$43.8**	**$77.4**	**$90.9**	**$167.0**	**$296.1**
2020	Direct	299	533	960	$14.6	$26.7	$49.0	$66.3	$121.6	$224.6
	Indirect	57	103	189	$3.6	$6.6	$12.2	$10.0	$18.4	$33.9
	Induced	225	383	662	$9.3	$15.9	$27.6	$26.6	$45.5	$79.1
	Total	**581**	**1,019**	**1,811**	**$27.5**	**$49.2**	**$88.9**	**$102.9**	**$185.4**	**$337.6**
2021	Direct	340	602	1,073	$16.5	$30.0	$54.6	$73.8	$135.7	$248.2
	Indirect	63	115	209	$4.0	$7.4	$13.6	$11.2	$20.6	$37.7
	Induced	264	443	757	$10.8	$18.3	$31.4	$31.0	$52.4	$90.2
	Total	**667**	**1,160**	**2,038**	**$31.3**	**$55.7**	**$99.6**	**$116.0**	**$208.7**	**$376.1**
2022	Direct	379	674	1,201	$18.2	$33.4	$61.0	$81.4	$150.5	$276.2
	Indirect	72	131	238	$4.4	$8.2	$15.1	$12.4	$22.9	$42.0
	Induced	301	506	859	$12.2	$20.8	$35.6	$35.2	$59.7	$102.1
	Total	**752**	**1,311**	**2,297**	**$34.9**	**$62.5**	**$111.7**	**$129.0**	**$233.0**	**$420.3**
2023	Direct	422	750	1,322	$20.2	$37.0	$67.0	$89.6	$165.9	$302.0
	Indirect	79	144	260	$4.9	$9.1	$16.6	$13.7	$25.3	$46.1
	Induced	340	572	959	$13.8	$23.4	$39.7	$39.8	$67.3	$113.8
	Total	**841**	**1,465**	**2,541**	**$38.9**	**$69.6**	**$123.3**	**$143.1**	**$258.5**	**$461.9**
2024	Direct	468	829	1,462	$22.2	$40.8	$74.2	$98.2	$182.1	$333.1
	Indirect	86	157	285	$5.4	$10.0	$18.4	$15.0	$27.8	$50.9
	Induced	384	639	1,070	$15.6	$26.2	$44.2	$44.8	$75.2	$126.8
	Total	**938**	**1,625**	**2,817**	**$43.2**	**$76.9**	**$136.7**	**$158.0**	**$285.0**	**$510.8**
2025	Direct	565	920	1,597	$27.0	$45.3	$80.9	$120.0	$201.5	$362.1
	Indirect	107	178	317	$6.6	$11.1	$20.0	$18.3	$30.8	$55.5
	Induced	457	716	1,180	$18.5	$29.2	$48.7	$53.3	$84.0	$139.7
	Total	**1,129**	**1,814**	**3,094**	**$52.1**	**$85.6**	**$149.5**	**$191.7**	**$316.4**	**$557.2**

Source: IMPLAN; Sage

While infrastructure is already in place in neighboring jurisdictions it is possible that over the duration of drilling activity in Maryland that infrastructure would be constructed within the state thereby generating a greater economic impact in the local economy. Therefore, Sage's impact estimates should be viewed as conservative.

The year 2025 marks the final year of drilling activity according to study team estimates. It also marks the highest number of job creation for drilling activity as 1,814 annual jobs are projected to be created under the mid-case scenario Severance payments to local governments, well maintenance, and royalty payments to mineral rights owners continue through the lifetime of the wells. The study team projects that well usage will continue through 2045. Exhibit 30 summarizes the total economic impacts of activity through 2045. Between 2015 and 2045, the study team estimates that under the mid-case scenario, total cumulative labor income of $916.8 million and local business sales of $2,907 million will be produced.

Exhibit 30. Total Economic Impact of Well Drilling, Well Maintenance, Royalties Paid to Local Residents, and Increased State and Local Government in Maryland, 2015-2045

Type of Impact	*Low-Case*	*Mid-Case*	*High-Case*
Labor Income ($millions)	$547.0	$916.8	$1,533.8
Business Sales ($millions)	$1,701.1	$2,907.1	$4,974.6

Source: IMPLAN; Sage

Summary of Fiscal Impacts

Drilling activity produces fiscal impacts for all levels of government. These impacts include property tax revenues, income tax revenues, sales tax revenues for the State, and other special tax revenues such as severance taxes. The study team calculated the severance tax and permit fees, income tax, and sales tax revenues expected to be generated by drilling activity and royalty payments. The exhibit below reflects the fiscal impacts of drilling in Allegany and Garrett counties for both county governments and for the State of Maryland. The tax rates used to estimate these fiscal impacts are embedded in the text. Under the mid-case scenario, the two counties and the State of Maryland could expect to collect roughly $4,441 million in additional revenues (2011 constant dollars) over the course of three decades.

Exhibit 31: Fiscal Impacts: one year, five year, ten year, lifetime

		2016	*Five Years (2016-2020) $millions*	*Ten Years (2016-2025) $millions*	*Lifetime of Wells (2015-2045) $millions*
Severance Tax Paid to Allegany County (5.5%)	Low-Case	$0.1	$3.6	$26.8	$42.4
	Mid-Case	$0.2	$5.6	$39.8	$63.3
	High-Case	$0.4	$8.8	$59.5	$91.8
Income Tax Paid to Allegany County (3.05%)	Low-Case	$0.0	$0.1	$0.3	$1.0
	Mid-Case	$0.0	$0.1	$0.5	$1.6
	High-Case	$0.0	$0.2	$0.7	$2.3
Total Taxes Paid to Allegany County	Low-Case	$0.1	$3.7	$27.1	$43.4
	Mid-Case	**$0.2**	**$5.7**	**$40.3**	**$64.9**
	High-Case	$0.4	$9.0	$60.2	$94.1
Severance Tax Paid to Garrett County (5.5%)	Low-Case	$0.4	$9.1	$67.3	$106.5
	Mid-Case	$0.6	$14.0	$99.8	$158.9
	High-Case	$0.9	$22.0	$149.3	$230.3
Income Tax Paid to Garrett County (2.65%)	Low-Case	$0.0	$0.2	$0.7	$2.4
	Mid-Case	$0.0	$0.3	$1.0	$3.5
	High-Case	$0.0	$0.5	$1.6	$5.1
Total Taxes Paid to Garrett County	Low-Case	$0.4	$9.3	$68.0	$108.9
	Mid-Case	**$0.6**	**$14.3**	**$100.8**	**$162.4**
	High-Case	$0.9	$22.5	$150.9	$235.4
Severance Tax Paid to Maryland (2%)	Low-Case	$0.2	$4.6	$34.2	$54.2
	Mid-Case	$0.4	$9.8	$69.4	$155.2
	High-Case	$0.6	$15.3	$103.8	$214.4
Income Tax Paid to Maryland (4.75%)	Low-Case	$0.4	$3.3	$10.0	$15.2
	Mid-Case	$0.7	$6.0	$17.6	$24.9
	High-Case	$1.3	$10.8	$31.5	$42.4
Sales Tax Paid to Maryland (2%)	Low-Case	$0.4	$3.8	$12.0	$20.4
	Mid-Case	$0.7	$6.8	$20.7	$33.7
	High-Case	$1.3	$12.1	$36.1	$55.7
Total Taxes Paid to Maryland	Low-Case	$1.0	$11.7	$56.2	$89.8
	Mid-Case	**$1.8**	**$22.6**	**$107.7**	**$213.8**
	High-Case	$3.2	$38.2	$171.4	$312.5

NOTE: Income tax revenues for counties only reflect income derived from royalty payment and severance tax revenues. Income taxes paid to Maryland also include impacts from well drilling and maintenance from 2015-2025

Source: Sage

D. Conclusion

The utilization of Marcellus Shale formation in Western Maryland in order to produce natural gas would have transformative economic and fiscal impacts. Under the study's mid-case scenario, Western Maryland would produce $316.4 million in output during the peak-year of drilling activity. In 2025, 1,814 jobs would be generated for Marylanders directly related to well drilling and maintenance, the payment of royalties to landowners/mineral rights owners and expanded state and local government spending activity. Importantly, Sage's estimates do not encompass jobs that would ultimately be associated with the marketing and distribution of natural gas (e.g., pipeline construction and maintenance activity).

Exhibit 32: Summary of Findings

Economic Impact of Drilling Activity in 2025, Annual Impact			
	Low-Case	*Mid-Case*	*High-Case*
Jobs	1,129	1,814	3,094
Labor Income ($millions)	$52.1	$85.6	$149.5
Business Sales ($millions)	$191.7	$316.4	$557.2
Total Impacts 2015 through 2045			
	Low-Case	*Mid-Case*	*High-Case*
Natural Gas Extracted (billion cubic feet)	387.8	710.1	1299.7
Value of Natural Gas Extracted ($millions)	$2,708.6	$4,040.1	$5,856.6
Royalties Paid to Landowners ($millions)	$338.6	$505.0	$732.1
Fiscal Revenues for Allegany County ($millions)	$43.4	$64.9	$94.1
Fiscal Revenues for Garrett County ($millions)	$108.9	$162.4	$235.4
Fiscal Revenues for State of Maryland ($millions)	$89.8	$213.8	$312.5

Note: All Dollar Figures are in constant $2011

Nearly all occupations involve knowledge and skills that are specific to the natural gas industry and usually learned through on-the-job experience. In other words, the industry is particularly good at putting blue collar workers back to work and teaching them industry specific skills. The remaining 25 percent of the Marcellus Shale workforce are associated with white collar occupations that require post-secondary education, including engineers, geologists, realtors, supervisors and attorneys.[60]

Over the course of developing the Marcellus Shale play (2015-2045), the State of Maryland would collect *$213.8 million* in additional revenues under the mid-case scenario. Garrett County would collect *$162.4 million* and Allegany County more than

[60] Ibid.

$64.9 million in 2011 dollars. This translates into total positive fiscal impacts of roughly $441 million over the course of the Marcellus Shale development.

These figures do not embody associated property tax collections, nor are they associated with potentially higher tax rates. Moreover, these estimates do not contemplate improvements in technology, which could increase the rate of return on investment through more efficient drilling methods and increased amounts of natural gas extraction. They also do not encompass the possible emergence of related manufacturing and other sectors that presently do not exist in Maryland. Many services would initially be purchased from neighboring jurisdictions such as Pennsylvania and West Virginia — increasing activity levels in the general regional economy. This was not taken into account in this analysis. In other words, the analysis presumes that much of the equipment to be purchased to drive investment in Marcellus Shale capacity will be purchased from companies operating in other parts of the nation or world. To the extent that Maryland is able to birth new companies and industries, this analysis understates potential impact.

Between 2010 and 2015, employment in the shale drilling industry nationally is expected to expand at an annual rate of 7.7 percent. IHS forecasts that by 2035, the shale drilling employment base will have nearly tripled, surpassing 1.66 million jobs. This type of growth is consistent with the notion that more states will see fit to allow the industry to expand. In other words, the IHS Global Insight researchers do not anticipate that environmental or other considerations will prevent the industry from continuing to expand natural gas production. That said, the study team has not shied away from frankly discussing environmental, infrastructure and other considerations regarding Maryland's Marcellus Shale play. Along this dimension, Maryland is fortunate to be able to learn from the experience of earlier state adopters.

Based on drilling activity in the Pennsylvania Marcellus Shale between 2008 and 2010, a study published by the Manhattan Institute estimated that the environmental impacts from a typical Marcellus Shale well generated $14,000 in economic damages. This is substantially lower than the $4 million in economic impacts the study concludes can be attributed to the typical Marcellus well.[61] Based on these estimates, the ratio of economic benefit to environmental damage associated with a typical Marcellus Shale well is 286 to 1.

Policymakers should note that though Maryland has an opportunity to participate in the Marcellus Shale play, its allure to the natural gas industry is somewhat limited. Maryland

[61]Timothy J. Considine, Robert W. Watson & Nicholas B. Considine. (May 2011). "The Economic Opportunities of Shale Energy Development," Center for Energy Policy and the Environment at the Manhattan Institute.

is home to only about 1 percent of the Marcellus Shale play and could therefore be easily overlooked. There are at least 22 states that have shale plays and Maryland is competing with all of them for investment. Given current low natural gas prices ($2.60/MM/btu as of this writing), Maryland is even more likely to miss the opportunity if it creates an exceedingly regulated and expensive environment. There is also some belief that Maryland is more associated with dry gas and the industry is more drawn to wet gas (liquids). With oil prices well over $100/barrel, investors are also more drawn to crude oil than natural gas generally.

Perhaps most importantly, the Marcellus Shale play in Maryland would benefit Western Maryland, a part of the state that suffered deeply during the economic downturn. Allegany County continues to be associated with among the state's lowest incomes and highest unemployment rates. Marcellus Shale development represents a way for both Allegany and Garrett counties to secure a key driver of business investment and future job creation.

Appendix

Exhibit A1. Activities Included and Excluded from Study's Economic Impact Estimates

Impacts Included in Estimates	*Impacts Not Excluded in Estimates*
Well Drilling	Water Disposal
Well Maintenance	Marketing Costs/Gas Distribution
Royalty Payments	Pipeline Construction
Expanded State and Local Government Spending Capacity	Pipeline Maintenance

Discussion Regarding Additional Fiscal Impacts

Sage did not calculate the impacts associated with property taxes. As the Maryland Department of the Environment (MDE) indicates, the Maryland statute regarding property taxes provides: "If minerals and mineral rights are owned separately from the land in which they are located, the supervisor may assess the minerals and mineral rights separately from the land." Md. Tax-Property Code Ann. Section 8-229. According to the State Department of Assessment and Taxation, this provision has not been used, mainly because it is so difficult to estimate the value of mineral rights when minerals are still in the ground.

Moreover, while Maryland does not impose personal property tax revenues, local jurisdictions do. According to MDE, "if natural gas were considered a mineral or earthen material, the machinery and equipment used to extract it would be considered manufacturing property under Md. Tax-Property Code Ann. §1-101(r), which is generally exempt under Md. Tax-Property Article Code Ann. §7-225." At this time, neither Allegany nor Garrett Counties taxes manufacturing property, although such taxation is authorized by State law. MDE notes that several states that produce oil or gas assess personal property taxes on the value of equipment or other assets used for production ranging from 2 percent in Alaska, 6.2 percent in Wyoming, and 27 percent in New Mexico.

MDE also highlights the potential fiscal value associated with permit fees. A permit fee is assessed to defray the costs of regulatory review and enforcement. In Maryland, a law passed in 2010 requires a person to obtain a permit from MDE's Minerals, Oil, and Gas Division before drilling a well for the exploration, production, or underground storage of gas or oil in Maryland.[62] MDE is required to set and collect permit and production fees related to oil and gas well drilling. Fees must be set at a rate necessary to cover all costs incurred by the State to (1) review, inspect, and evaluate monitoring data, applications, licenses, permits, and other reports; (2) perform and oversee assessments, investigations, and research; (3) conduct permitting, inspection, and compliance activities; and (4)

[62] Maryland General Assembly, House Bill 72, 2010 Regular Session. Available at http://mlis.state.md.us/2010rs/billfile/hb0072.htm.

develop and implement regulations to address the risks to public safety, human health, and the environment from oil and gas well drilling and development. Unlike most taxes, permit fees generate revenue in advance of the actual gas production; however, the fees would be assessed only against those who apply for permits." Pennsylvania recently enacted comprehensive legislation that provides for enhanced environmental protections for the development of unconventional natural gas resources; to authorize the imposition, collection and distribution of an impact fee on the development of unconventional natural gas resources and to provide for municipal ordinances and zoning standards related to oil and gas development.[63]

Review of Economic Impact Studies

Most of the impact studies regarding shale drilling to date have relied upon input-output modeling. In these analyses, direct economic impacts stem from the purchases made by natural gas companies from other sectors of the economy. Indirect impacts result from transactions taking place deeper along the supply chain. Induced impacts are the series of purchases of goods and services made by workers or by landowners' spending of lease, bonus, and royalty payments.[64]

Timothy J. Considine of Natural Resources Economics, Inc. has authored several studies in conjunction with Penn State University evaluating the economic impacts of Marcellus Shale drilling. For example, Considine analyzed the implications of Marcellus shale drilling in New York, Pennsylvania, and West Virginia in a 2010 report.[65] He has also produced a series of reports focused more closely on Marcellus drilling in Pennsylvania.[66,67,68] The most recent study reported that in Pennsylvania, the Marcellus natural gas industry supported 60,168 jobs in 2009 and 139,889 in 2010.[69]

Considine's studies estimate economic impacts based on surveys of expenditures by Pennsylvania natural gas companies and an IMPLAN input-output model. The same

[63] Commonwealth of Pennsylvania. Report of the Committee of Conference House Bill 1950, Act 13 of 2012.
http://www.legis.state.pa.us/cfdocs/billinfo/billinfo.cfm?syear=2011&sind=0&body=H&type=B&BN=1950.
[64] Ibid.
[65] Considine, Timothy J. (July 2010). The Economic Impact of the Marcellus Shale: Implications for New York, Pennsylvania, and West Virginia, Natural Resource Economics.
[66] Considine, Timothy, et al. (July 2009). "An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play", Penn State.
[67] Considine, Timothy J., Robert W. Watson, Seth Blumsack. (May 2010). The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update, Penn State.
[68] Considine, Timothy J., Watson, Robert., Blumsack, Seth. (July 2011). "The Pennsylvania Marcellus Natural Gas Industry: Status, Economic Impacts and Future Potential."
[69] Ibid.

model employed by Considine has been applied to analyses of economic impacts of development in other energy sectors. The Pennsylvania Department of Labor used the model to estimate the economic impacts of green jobs in renewable energy and energy efficiency in 2010.[70] Natural gas exploration, drilling, processing, and transportation involve multiple sectors of the economy. Considine's analyses estimate Marcellus Shale impacts on the sectors detailed in the exhibit below.

Exhibit A2: Pennsylvania Marcellus Shale: Impacts on Value Added by Sector during 2010 (millions of 2010 dollars)

Sector	Direct	Indirect	Induced	Total
Ag, Forestry, Fish & Hunting	10.6	6.9	4.7	22.2
Mining	1,311.3	94.0	5.7	1,411.00
Utilities	52.0	66.4	75.6	194
Construction	1,386.8	19.7	25.3	1,431.80
Manufacturing	66.2	211.5	93	370.7
Wholesale Trade	941.7	221.8	175.4	1,338.80
Retail trade	387.2	27.2	424.9	839.3
Transportation & Warehousing	128.5	155.6	69.9	354
Information	17.5	136.9	120.3	274.6
Finance & Insurance	36.2	218.1	410.4	664.7
Real estate & rental	212.2	257.9	722.2	1,192.30
Professional-scientific & tech services	356.1	527.9	174.1	1,058.10
Management of companies	0.0	156.6	38.5	195.2
Administrative & waste services	44.0	141.4	82.7	268.2
Educational services	67.6	2	82.4	152.1
Health & social services	151.7	1.9	582.4	736.1
Arts-entertainment & recreation	29.9	11.2	50.5	91.6
Hotel & food services	62.0	31.2	136.7	229.9
Other services	52.1	55.9	146.4	254.5
Government & Misc.	19.4	31.5	31	81.9
Total	*5,333.00*	*2,375.50*	*3,452.30*	*11,160.80*

Source: Timothy J. Considine, Robert W. Watson & Nicholas B. Considine, "The Economic Opportunities of Shale Energy Development," Center for Energy Policy and the Environment at the Manhattan Institute, May 2011. Table 4.

Other studies analyzing shale drilling have deployed similar input-output methods. Several of these impact analyses are listed below:

- Higginbotham, Pellillo, Gurley-Calvez, Witt, "The Economic Impact of the Natural Gas Industry and the Marcellus Shale Development in West Virginia in 2009", December 2010;

[70] Ibid.

- The U.S. Department of Energy, "Projecting the Economic Impact of Marcellus Shale Gas Development in West Virginia: A Preliminary Analysis Using Publicly Available Data," March 31, 2010;
- Weinstein, B., and T. Clower. "Potential Economic and Fiscal Impacts from Natural Gas Production in Broome County, New York", July 2009;
- Dean A. Bangsund, "Petroleum Industry's Economic Contribution to North Dakota in 2009";
- Center for Community and Business Research and The University of Texas at San Antonio Institute for Economic Development, "Economic Impact of the Eagle Ford Shale," February 2011;
- The Perryman Group. "Bounty from Below: The Impact of Developing Natural Gas Resources Associated with the Barnett Shale on Business Activity in Fort Worth and the Surrounding 14-County Area", May 2007;
- The Perryman Group, "The Impact of the Barnett Shale on Business Activity in the Surrounding Region and Texas: An Assessment of the First Decade of Extensive Development," August 2011;
- The Center for Business and Economic Research, "Projecting the Economic Impact of the Fayetteville Shale Play for 2008-2012," March 2008; and
- Loren Scott and Associates. "The Economic Impact of the Haynesville Shale on the Louisiana Economy in 2008", 2009.

The exhibits below provide rich detail regarding the economic implications of shale drilling activity, including upon employment. The Sage study team took great pains to ensure that its estimates fell neatly within the four corners of the findings of other researchers along various dimensions, including with respect to value-added calculations and the overall economic multiplier.

Exhibit A3: Selected Studies: Estimates of Employment from Shale Drilling Activity

Study	State/Play	Year	Direct	Indirect	Induced	Total Employment
U.S. Department of Energy, "Projecting the Economic Impact of Marcellus Shale Gas Development in West Virginia," March 31, 2010	West Virginia	2008	1466	334	447	2247
The Center for Business and Economic Research, "Projecting the Economic Impact of the Fayetteville Shale Play for 2008- 2012," March 2008	Arkansas	2007	3,776	1,904	3,852	9,533
Considine, Timothy J., Watson, Robert., Blumsack, Seth., "The Pennsylvania Marcellus Natural Gas Industry: Status, Economic Impacts and Future Potential," July 2011	PA	2010	67,739	26,234	45,916	139,889
Center for Community and Business Research and The University of Texas at San Antonio Institute for Economic Development, "Economic Impact of the Eagle Ford Shale," February 2011	Eagle Ford	2010	6,769	2,579	3,254	12,601

Exhibit A4: Selected Studies: Estimates of Output from Shale Drilling Activity ($millions)

Study	State/Play	Year	Direct	Indirect	Induced	Total
U.S. Department of Energy, "Projecting the Economic Impact of Marcellus Shale Gas Development in West Virginia," March 31, 2010	West Virginia	2008	$266.65	$52.65	$51.87	$371.17
The Center for Business and Economic Research, "Projecting the Economic Impact of the Fayetteville Shale Play for 2008- 2012," March 2008	Arkansas	2007	$1,797	$416	$387	$2,601
Considine, Timothy J., Watson, Robert., Blumsack, Seth., "The Pennsylvania Marcellus Natural Gas Industry: Status, Economic Impacts and Future Potential," July 2011	PA	2010	$10,407	$4,318	$5,741	$20,467
Center for Community and Business Research and The University of Texas at San Antonio Institute for Economic Development, "Economic Impact of the Eagle Ford Shale," February 2011	Eagle Ford	2010	$2,134	$367	$366	$2,868

Exhibit A5: Output Multipliers (Economic Output per $1 Natural Gas Industry Spending)

Source	Output Multipliers
Considine (2010) (PA)	1.94
Considine (2011)	2.00
Baumann et. al (2002) (Louisiana)	1.34
Walker and Sonora (2005) (New Mexico)	1.43
Snead (2002) (Oklahoma)	1.55
U.S. Department of Energy, "Projecting the Economic Impact of Marcellus Shale Gas Development in West Virginia," March 31, 2010	1.39
Bangsund (North Dakota in 2009)	1.58
The Center for Business and Economic Research, "Projecting the Economic Impact of the Fayetteville Shale Play for 2008- 2012," March 2008	1.45

Exhibit A6: Employment Multipliers (Jobs created per $1 million of gross output)

Source	Employment Multipliers
Considine (2010) (PA)	6.2
Considine (2011) (PA)	6.8
Walker and Sonora (2005) (New Mexico)	3
Baumann et. al (2002) (Louisiana)	6.7
Snead (2002) (Oklahoma)	7.7

Environmental Considerations

Some negative externalities of drilling are arguably unavoidable, including those associated with congestion from increased truck traffic, noise, dust, and the clearing of land for well pads. Some more severe side effects can occur as a result of drilling, and are important to be aware of. However, it should be emphasized that these are very rare occurrences, and have grown even less so as the shale drilling industry has matured.

Drilling

The most serious violations associated with drilling in the Marcellus Shale include major spills, cement and casing violations, blowouts and venting, and stray gas. A major spill is defined as being a spill of more than 100 gallons of hazardous chemicals, fuel or produced drilling fluids. When a well casing is not properly cemented into place, cement and casing violations can occur. Blowouts and venting occur when a well begins to uncontrollably expel gas and natural gas can migrate to layers closer to the surface.

The environmental impacts of major spills primarily take the form of reductions in water quality and in certain cases impacts on fish. In Pennsylvania, spills have, on average,

released around 760 gallons of fluid, but also have been typically contained on site.[71] Cement and casing violations typically do not have direct environmental impacts, but can indirectly impact water through stray gas and flows of fluid resulting from the cement or casing breach. In considering these types of incidents, it is important to note that drilling activity occurs *far* below the level at which groundwater aquifers for drinking water are located. Blowouts most often result from design flaws of a well or equipment failure, and thus are preventable.[72]

Drilling violations like these, along with time and experience, have led to strengthened operational protocols in the Pennsylvania Marcellus and improved industry drilling practices.[73] Maryland is fortunate to be in a position to learn from Pennsylvania's experiences along this dimension. In fact, if drilling in the Pennsylvania Marcellus shale is any indication, the majority of environmental violations are minor. Between 2008 and 2010, 1,924 violations occurred of which only 152 were serious. As technology improves and industry drilling experience matures, the incidence of drilling violations declines. Indeed, in Pennsylvania the number of serious violations per 100 wells declined from 9 in 2009 to 6.8 just one year later. It is important to note that while serious violations are defined as those that present the greatest threat to health and human safety[74], they do not necessarily, and almost never, affect entire towns or large numbers of people. Half of the minor violations were administrative. Many of these incidents can be avoided by careful management, fastidious site preparation and maintenance, and drilling best practices.

Land Impacts

Drilling involves clearing land and building access roads and can result in disturbance of plants and animals or require trees to be cut. However these disturbances can be mitigated in a number of ways. Foresters, conservancies, and lawyers who specialize in shale natural gas extraction can provide guidance for minimizing negative impacts on land. Owners of land can insist that drilling companies use lumbering roads already in place or specify where access roads can be built. Additionally, if trees must be cut, owners may be compensated for the lumber. Endangered species or unique habitats may also be protected by local ordinances and federal/state regulations.[75]

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[71] Timothy J. Considine, Robert W. Watson & Nicholas B. Considine. (May 2011). "The Economic Opportunities of Shale Energy Development," Center for Energy Policy and the Environment at the Manhattan Institute.
[72] Ibid.
[73] Ibid.
[74] Ibid.
[75] Ibid.

Water & Water Management

An important water-resource issue related to Marcellus Shale gas extraction is securing a sufficient supply of water for well construction without impacting local water resources.[76] Well operation requires large amounts of water – 50,000 to 100,000 or more gallons for drilling and 4 to 5 million for hydraulic fracturing. While these are substantial quantities, they are small compared to residential water use and represent a small fraction of total water resource use in a basin. Water use by all Pennsylvania households exceeds 300 billion gallons annually and the water needed for shale operations ranges from 0.1 to 0.8 percent by basin.[77,78] Drilling and hydraulic fracturing of Marcellus Shale wells typically rely on surface waters from bodies such as lakes and rivers, but can also use ground water, municipal water, private water sources and recycled frac water. Competing water use demands can also be addressed through a number of actions. When seasonally available, river water can be captured and stored. Drilling companies can do as companies in the Barnett Shale area of Texas did and form cooperatives to coordinate available water supplies with drilling needs. Water management plans can be required of drilling companies as part of the permitting process or water withdrawals can be otherwise regulated. These types of guidelines exist in Pennsylvania and both the Delaware River Basin Commission (DRBC) and the Susquehanna River Basin Commission (SRBC) maintain similar regulations.[79]

Air Quality

Although natural gas can boast lower emissions levels than other fossil fuels and alternative fuel sources, some degree of emissions can still result from the production of natural gas. Natural gas extraction from Marcellus Shale releases greenhouse gases and impacts air quality differently depending upon the drilling phase. Temporary emission sources exist during site preparation and the drilling and fracking phase. Drilling rigs and fracking engines used in early stages of extraction are usually fueled by diesel or gasoline. Similarly, trucks must haul hundreds of loads of water to the well site and carry wastewater away. During well completion, venting and flaring can occur and chemicals may also evaporate from pit water. Occasional leaks from drilling equipment can also occur as a result of improper installation, over-pressurization of gases or liquids in

[76]Soeder, D. and Kappel, W. (May 2009). Water Resources and Natural Gas Production from the Marcellus Shale. U.S. Geological Survey. Available at http://geology.com/usgs/marcellus-shale/.
[77] Timothy J. Considine, Robert W. Watson & Nicholas B. Considine. (May 2011). "The Economic Opportunities of Shale Energy Development," Center for Energy Policy and the Environment at the Manhattan Institute.
[78] The League of Women Voters of Pennsylvania, Marcellus Shale Natural Gas Extraction Study 2009-2010, Study Guide II: Marcellus Shale Natural Gas: Environmental Impact.
[79] Ibid.

piping, wear and rust, or insufficient maintenance, creating additional sources of emissions.[80]

However, air emissions can be reduced and avoided by deploying certain technologies. Based on suggestions made by Amendariz (2008) and The United States Department of Energy, the League of Women Voters of Pennsylvania compiled a set of practices to reduce emissions:

- According to the EPA, new, low bleed pneumatic devices exist that can reduce methane emissions by nearly 90 percent;
- Installing flash tank separators, or vapor recovery units, on condensate tanks can recover 90-99 percent of methane that would otherwise be vented or flared;
- Infrared cameras can be used in the field to visually identify fugitive hydrocarbon leaks;
- Using portable equipment to process and direct extracted natural gas into pipelines or tanks rather than venting or flaring the gas can recover approximately 53 percent of the gas for that would have been combusted or lost in the atmosphere;
- Internal combustion engines can be replaced with electric motors for compression power; and
- Aggressive inspection and maintenance procedures can be developed and implemented.

Offsetting Environmental Benefits

Although some environmental concerns surround natural gas extraction, it is also associated with several valuable benefits. Burning natural gas rather than coal results in substantially lower emissions levels than alternative fuel sources and is actually the cleanest burning of all fossil fuels.[81] Used for electricity, natural gas emits approximately half as much carbon dioxide as coal and 30 percent less than oil. Accordingly, natural gas is often considered central to energy plans designed to reduce greenhouse gases.[82] Exhibit A7 provides relevant statistical detail.

[80] Ibid.
[81] U.S. Department of Energy. (April 2009). "Modern Shale Gas Development in the United States: A Primer."
[82] The League of Women Voters of Pennsylvania, Marcellus Shale Natural Gas Extraction Study 2009-2010, Study Guide II: Marcellus Shale Natural Gas: Environmental Impact.

Exhibit A7: Combustion Emissions (Pounds/Billion BTU of Energy Input)

Air Pollutant	Combusted Source		
	Natural Gas	Oil	Coal
Carbon dioxide (CO2)	117,000	164,000	208,000
Carbon monoxide (CO)	40	33	208
Nitrogen oxides (NO x)	92	448	457
Sulfur dioxide (SO2)	0.6	1,122	2,591
Particulates (PM)	7	84	2,744
Formaldehyde	0.75	0.22	0
Mercury (Hg)	0	0.007	0
Sources: EIA, 1998			

Drilling for natural gas is also cleaner than mining for coal. Relevant statistics are provided in Exhibit A8.

Exhibit A8: Air Emissions from Coal and Natural Gas Drilling in Electric Power Generation

	Emissions Factors (lbs/MMBtu)	
Emission	Coal	Natural Gas
Carbon dioxide	215.0632	130.5527
Sulfur dioxide	0.6682	0.0007
Nitrous oxides	0.2135	0.1014
Particulate matter (under ten microns)	0.01168	0.0011
Carbon monoxide	0.02227	0.00428
Mercury	2.74E-09	0
Source: Timothy J. Considine, Robert W. Watson & Nicholas B. Considine, "The economic opportunities of shale energy Development," Center for Energy Policy and the Environment at the Manhattan Institute, May 2011. (Table 8)		

Horizontal drilling in the Marcellus Shale requires less land surface than vertical drilling and placing multiple wells on a single pad further reduces the surface environmental footprint of a well pad. Vertical drilling on a single square mile of ground requires approximately sixteen separate well pads. Moreover, fewer access roads, well pads, pipelines, and production facilities are needed to drill a horizontal well. Although an array of piping remains underground, following fracking and drilling, a site that measures four to six acres during initial drilling can be reduced to the size of a two car garage and only water tanks remain above ground on site.[83]

Based on drilling activity in the Pennsylvania Marcellus Shale between 2008 and 2010, a study published by the Manhattan Institute estimated that the environmental impacts from

[83]Ibid.

a typical Marcellus Shale well generate $14,000 in economic damages. This is substantially lower than the $4 million in economic impacts the study concludes can be attributed to the typical Marcellus well.[84] Based on these estimates, the ratio of economic benefit to environmental damage associated with a typical Marcellus Shale well is 286 to 1.

Exhibit A9: Summary of Considine Economic Cost Benefit Analysis (PA)

	2010 Dollars per well		
	Minimum	Average	Maximum
Economic value added	2,791,549	3,957,746	5,459,859
Environmental benefits of coal displacement:			
Avoided air pollution	4,420	17,132	50,061
Avoided community health impacts from coal	14,555	29,111	43,666
Subtotal	18,976	46,243	93,727
Economic and environmental benefits	2,810,525	4,003,989	5,553,586
Environmental costs:			
Air impacts from upstream life-cycle emissions	1,089	2,796	7,173
Air impacts from diesel use during hydraulic fracturing	2,091	7,245	20,329
Water pollution using household values	102	193	312
Forest disruption	1,394	3,943	6,493
Subtotal	4,676	14,178	34,307
Economic and environmental net benefits	2,805,849	3,989,811	5,519,279
Without benefits from avoided health impacts from coal	2,791,294	3,943,569	5,425,552
Using Dimock settlement to value water-pollution damages	2,699,878	3,787,941	5,193,317
Without health impacts from coal and using Dimock settlement	2,685,322	3,758,830	5,149,651

Source: Timothy J. Considine, Robert W. Watson & Nicholas B. Considine, "The economic opportunities of shale energy Development," Center for Energy Policy and the Environment at the Manhattan Institute, May 2011. (Table 12)

[84]Timothy J. Considine, Robert W. Watson & Nicholas B. Considine. (May 2011). "The Economic Opportunities of Shale Energy Development," Center for Energy Policy and the Environment at the Manhattan Institute.