



# **The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update**

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## Executive Summary

Fully developed, the Marcellus Shale has the potential to be the second largest natural gas field in the world, behind only the South Pars/Asalouyeh field shared between the nations of Iran and Qatar. Converted to British Thermal Units (BTUs), the natural gas found in the Marcellus could be equivalent to the energy content of 87 billion barrels of oil, enough to meet the demand of the entire world for nearly three years.

In Pennsylvania, the development of these historic resources, while still in its infant stages, is credited with the creation of thousands of jobs and billions in annual revenue for the state. Over the next two years, this growth is expected to increase rapidly -- providing the Commonwealth with a steady supply of affordable, clean-burning energy, and creating the potential for a wholesale transformation of the energy landscape both across the state and throughout the nation.

Natural gas development stimulates the economy in two major ways: business-to-business spending and payments to land owners. Exploring, drilling, processing, and transporting natural gas requires goods and services from many sectors of the economy, such as construction, trucking, steelmaking, and engineering services. Gas companies also pay lease and royalty payments to land owners, who also spend and pay taxes on this income. Higher energy production stimulates employment, income, and tax revenues. This study estimates these economic impacts using an input-output model developed by the Minnesota IMPLAN Group, Inc., which is the same model used by the Pennsylvania Department of Labor (2010) in their study of green jobs.

During 2009, Marcellus gas producers spent a total of \$4.5 billion to develop Marcellus shale gas resources. Using the IMPLAN modeling system, we estimate that this spending generated \$3.9 billion in value added, \$389 million in state and local tax revenues, and more than 44,000 jobs (see Table ES1). During 2009, natural gas output averaged 327 million cubic feet per day of natural gas equivalents, which includes dry natural gas and petroleum liquids. Output at year-end 2009 was over 500 million cubic feet per day.

**Table ES1: Summary of Actual, Planned, and Forecast Economic Impacts**

Millions of 2010 Dollars					
Year	Value Added	State & Local Taxes	Employment	Wells Drilled	Output Bcfe / day*
2009	3,877	389	44,098	710	0.3
<i>Planned</i>					
2010	8,039	785	88,588	1,743	1.0
2011	10,129	987	111,413	2,211	2.5
<i>Forecast</i>					
2015	14,415	1,417	160,205	2,903	7.6
2020	18,853	1,872	211,909	3,587	13.5

\* Bcfe is billion cubic feet of natural gas equivalents per day.

Based upon our survey, Marcellus producers plan to spend significantly more this year and next, generating more than \$8 billion in value added in 2010 and another \$10 billion during 2011 (see Table ES1). This higher economic activity generates almost \$1.8 billion in additional state and local tax revenues during 2010 and 2011. Employment in the state expands by more than 88,000 jobs during 2010 and over 111,000 jobs during 2011.<sup>1</sup> This dramatic increase in Marcellus drilling activity has occurred during a period of general economic recession and relatively low natural gas prices. Natural gas production from the Pennsylvania Marcellus will likely average one billion cubic feet per day during 2010 and approach 2.5 billion cubic feet per day during 2011.

The projected economic impact from Marcellus activity in this report is very similar to the forecast made last year at a much earlier stage of Marcellus development. The minor differences can be attributed to a significant decline in natural gas prices and changes in the economy as a whole due to the current nationwide recession.

The Marcellus resource base is large and could support significant levels of drilling in the future. This study estimates a dramatic expansion of Marcellus gas production from slightly over 327 million cubic feet per day during 2009 to over 13 *billion* cubic feet per day by 2020. If this occurs, employment would expand by 200,000 jobs and annual gains in state and local taxes revenues would exceed \$1 billion.

These benefits cannot simply be attributed to nature's bounty. Instead, their realization depends upon the Pennsylvania Marcellus maintaining its relative competitive position. Currently, there are at least five other major shale gas plays competing with the Marcellus, including the Barnett, Haynesville, Fayetteville, Woodford, and Eagle Ford formations as well as several shale formations in Canada. As production from these plays expands, prices for natural gas are likely to remain relatively low and pressures for cost containment will be intense.

Higher gas development costs in Pennsylvania due to regulations, climate conditions, topography, labor costs, and other structural factors are partially offset by city gate prices higher than the national average and the absence of a severance tax in Pennsylvania. The imposition of any significant severance tax on Marcellus natural gas output could induce a redirection of investment flows to other shale plays. Any revenues gained from a severance tax could be offset by losses in sales and income tax receipts resulting from lower drilling activity and natural gas production as producers shift their capital spending to other plays.

The development of the Pennsylvania Marcellus will have economic impacts on Pennsylvania beyond those measured in this report. If the Marcellus is developed to the extent envisioned in this report, the abundance of reliable, low cost natural gas could attract gas intensive manufacturing industries to expand capacity in Pennsylvania. Low cost natural gas also contributes to inexpensive electricity that enhances industrial

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<sup>1</sup> Our previous study forecasted over 107,000 jobs created in 2010. The smaller job gains found here reflect new data in the IMPLAN model that reflects lower employment per unit of output due to the recession. Moreover, the estimates for 2010 and 2011 presented above are based upon a survey that reflects slightly lower spending from the projections last year, which were based upon higher natural gas prices.

development and economic growth. New industries would lead to additional gains in employment, output, and tax revenues. Moreover, developing the Marcellus could reduce the costs of the transition to an economy with lower greenhouse gas emissions.

Marcellus natural gas producers create jobs without direct government subsidies. With rising levels of public debt, this ability to produce domestic energy while generating income and wealth is valuable. In summary, the development of the Pennsylvania Marcellus increases domestic energy production, creates jobs, reduces government deficits, and on balance improves environmental quality.

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## **I. Introduction**

This study provides an update on the economic impacts of the Marcellus shale gas industry in Pennsylvania (Considine, et al., 2009). This update discusses the results of our latest survey of producers to estimate current and planned industry spending, analysis of the economic impacts of this activity, and projections of future drilling, natural gas production, and related economic impacts. The evidence and analysis presented below indicates that the Pennsylvania Marcellus is rapidly emerging as a significant supplier of natural gas to the nation and a major source of jobs, income, and tax revenue to the Commonwealth of Pennsylvania.

For this study, we conducted a survey of producers to estimate drilling activity, spending levels, and production rates. The survey results clearly show a significant ramp-up in activity, with total spending increasing from \$3.2 billion during 2008 to over \$4.5 billion during 2009. Our survey also found that companies plan to increase their investment spending to \$8.8 billion for 2010 and to over \$11 billion in 2011. This evidence confirms that the Pennsylvania Marcellus industry is poised for a substantial take-off in development.

The survey and the findings of this report do not include historical or projected spending to upgrade interstate natural gas transmission pipelines, although it is recognized that Marcellus Shale development will result in significant new construction activity in that sector. Moreover, this report also does not consider development of several other organic shale formations that exist above and beneath the Marcellus.

Capital investments for Marcellus development have significant impacts on the economy of the Commonwealth of Pennsylvania. Producing natural gas requires exploration, leasing, drilling, and pipeline construction. These activities generate additional business for other sectors of the economy. For example, leasing requires real estate and legal services. Exploration crews purchase supplies, stay at hotels, and dine at local restaurants. Site preparation requires engineering studies, heavy equipment and aggregates. Drilling activity generates considerable business for trucking firms and well-support companies now based in Pennsylvania that in turn buy supplies, such as fuel, pipe, drilling materials, and other goods and services. Likewise, construction of pipelines requires steel, aggregates, and the services of engineering construction firms. Collectively, these business-to-business transactions create successive rounds of spending and re-spending throughout the economy. These higher sales generate greater sales tax revenues. Moreover, as businesses experience greater sales they hire additional workers. Greater employment increases income and generates higher income tax revenues.

Natural gas development also affects the economy through land payments. To access land to drill for gas companies negotiate leases with landowners. These agreements often provide an upfront payment or bonus after signing the lease and then production royalty payments during the life of the agreement if production is established. In 2008 alone, natural gas companies paid over \$1.8 billion in these lease and bonus payments to Pennsylvania landowners. What do landowners do with these payments?

After paying taxes, lease and bonus income recipients may save a portion or spend the rest on goods and services from other sectors of the economy. For example, a farmer may spend his lease and bonus income to hire a carpenter to remodel his barn, who then buys lumber and supplies, and pays taxes on the net income he earns from the project.

Economists have long recognized these indirect and induced impacts from capital investments and the development of new industries. Countless studies have been conducted on these types of economic impacts arising from the construction of sports stadiums, hospitals, highways, wind turbines, and other capital investments. Nearly all of these studies have been conducted using input-output (IO) models of the economy. Input-output analysis accounts for the flow of funds between industries, households, and governments. These models provide a snapshot of the structure of the economy at a point in time and, thereby, an empirical basis for addressing a variety of questions surrounding economic development. For example, how many jobs are required to support a new industry or project?

These questions are asked so frequently that an economic research and consulting firm called Minnesota IMPLAN Group, Inc. in association with the University of Minnesota has been in business since 1993 providing detailed IO tables at the county and state level. Indeed, a recent study conducted by the Pennsylvania Department of Labor and Industry (2010) used the IMPLAN system to estimate the number of green jobs created in the Pennsylvania. The analysis presented below also uses the same IMPLAN model for Pennsylvania, finding that the \$4.5 billion of spending by Marcellus producers during 2009 generated \$3.8 billion in value added, \$389 million in state and local tax revenue, and more than 44,000 jobs.

The prospects for future Marcellus development in Pennsylvania are promising. For example, the spending planned by Marcellus producers in 2011 could generate more than \$10 billion in value added, nearly \$1 billion in state and local tax revenues, and more than 100,000 jobs. Our forecasting model of future Marcellus natural gas drilling and production suggests that Pennsylvania could be producing more than 13 billion cubic feet of natural gas per day by 2020, which could make the Commonwealth the second largest producer of natural gas in the United States.

Unlike conventional oil and gas development expanding production from shale resources requires continuous drilling activity. Substantial cutbacks in drilling significantly reduce production after a few years because the gas output decline curve is very steep for shale gas reservoirs. Nevertheless, the sheer geographical size of the Marcellus supports significantly higher levels of drilling. Our forecast presented below estimates that more than 3,500 wells could be drilled in 2020, which is about the same level of drilling currently taking place in the Barnett shale play in Texas, which is the largest natural gas producing field in the U.S. This forecast is conservative because the Barnett is only one fourth the size of the Marcellus.

With higher natural gas production from the Marcellus royalty income increases substantially, and combined with greater business activity from additional drilling, significant flows of value added and income for the state are created. Our estimates

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suggest that in 2020 the Marcellus industry in Pennsylvania could be creating more than \$18 billion in value added, generating more than \$1.8 billion in state and local tax revenues, and supporting more than 200,000 jobs. Unlike renewable energy, clean coal, and nuclear power, Marcellus natural gas producers create jobs without government subsidies. With rising levels of public debt, this ability to independently generate income and wealth is essential.

These benefits cannot simply be attributed to nature's bounty. Instead, their realization depends upon the Pennsylvania Marcellus maintaining its relative competitive position. Currently, there are at least five other major shale gas plays competing with the Marcellus, including the Barnett, Haynesville, Fayetteville, Woodford, and Eagle Ford formations as well as several shale formations in Canada. As production from these plays expands, prices for natural gas are likely to remain relatively low and the pressures for cost containment will be intense. The absence of a severance tax in Pennsylvania along with city gate prices higher than the national average offsets higher costs associated with complex regulations, climate conditions, topography, higher labor costs, and other structural factors.

The imposition of any significant tax or other regulation on Marcellus natural gas output could induce a redirection of investment flows to other shale plays. Indeed, investment and production are increasing rapidly in these other shale plays, especially the Haynesville and Eagle Ford regions. Revenues gained from a severance tax could be offset by losses in sales and income tax receipts resulting from lower drilling activity and natural gas production as producers shift their capital spending to other plays. The inefficiencies of severance taxes are well recognized in the economic literature, such as the study by Deacon, Frech, and Johnson (1990), which finds that severance taxes reduce drilling, production, and employment.

The next section of this report describes the results from our survey of Marcellus producers operating in Pennsylvania. Section three discusses the economic modeling methodology and the estimated impacts of Marcellus development on output, employment, and tax revenues. The fourth section of this report discusses the projections of the future level of development and related economic impacts. The study concludes with a summary of our major findings and a brief discussion of the implications for policies that affect the long-term health and vitality of the industry.

## **II. Current Industry Activity**

This project conducted a survey of natural gas producers operating in the Pennsylvania Marcellus. The survey form appears below in Appendix A and has three parts. The first set of questions sought to establish a baseline of economic and drilling activity with an estimate of total spending and wells drilled through year-end 2009. The second section asks for actual spending for 2008 and 2009 and planned spending for 2010-2011 for the following categories:

- Lease and bonus payments,
  - Exploration,
-

- Upstream: drilling and completion,
- Midstream: pipeline and processing, royalties; and
- Other goods and services.

The third and final section requested data on the number of rigs operating, wells drilled to total depth, and production of dry natural gas and petroleum liquids on a quarterly basis for 2009.

To determine the proportion our sample represented of the industry, this project conducted a careful analysis of the inventory of wells started or “spudded” during 2009. The Pennsylvania Department of Environmental Protection (PADEP) publishes a list of well starts. To develop the well count for 2009 we first compiled the monthly spud report issued by the Pennsylvania Department of Environmental Protection (PADEP) into one data set. After this was completed we removed all wells that had duplicate API numbers because this told us that a well had been reported twice as the API number is the unique identifier issued to each well. This double reporting can occur if two separate drilling rigs are used on the same well, which is not uncommon for horizontal wells. The final steps in the process were to then sort the wells that were classified as Marcellus wells by the spud report and check these against Marcellus permits from the PADEP. This process was then repeated two more times to ensure that the same number was reached. The final result was 710 wells drilled during 2009 in Pennsylvania that could be verified as Marcellus Shale wells. A map of the wells drilled during 2009 appears below in Figure 1.

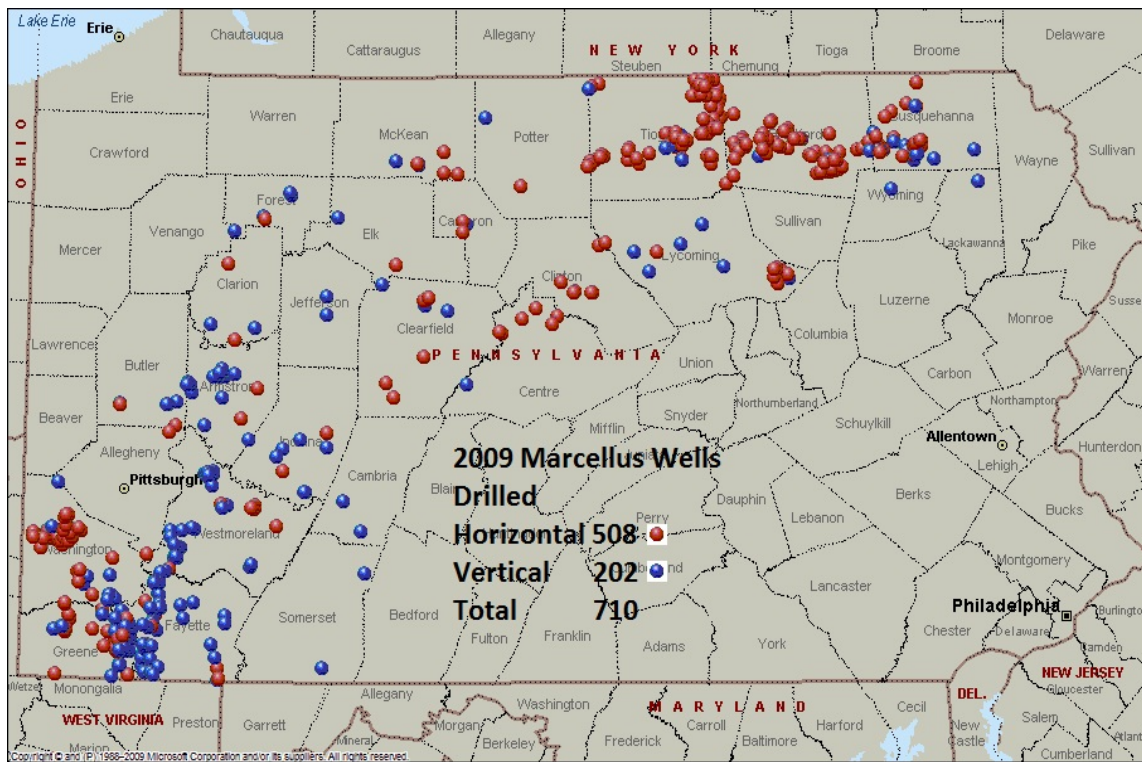


Figure 1: Marcellus wells started during 2009

Of the 710 wells drilled, 508 were horizontal and 202 were vertical wells. There was a noticeable increase in drilling activity in the northeastern counties of Susquehanna, Bradford, and Tioga with 282 wells drilled during 2009 from approximately 63 wells drilled during 2008. As Figure 1 above suggests, most of the wells drilled in these three northeastern counties were horizontal. Our estimate of 710 wells drilled in the Pennsylvania during 2009 should be considered conservative because the PADEP reports 763 wells started during 2009. The PADEP estimate was not used for this study because 53 wells could not be matched with a permit.

Our survey was distributed to members of the Marcellus Shale Coalition in early February 2010. Responses from twelve firms were completed during mid-April 2010. Based upon the well inventory analysis discussed above, these 12 firms drilled 528 during 2009, or more than 74 percent of the total wells started during 2009. Hence, to estimate the industry aggregates reported below, we multiplied all values from our survey by the ratio of 710 to 528. Clearly, using the 763 estimate of well starts reported by PADEP would lead to an over-estimate of the size of the Marcellus industry and the associated economic impacts.

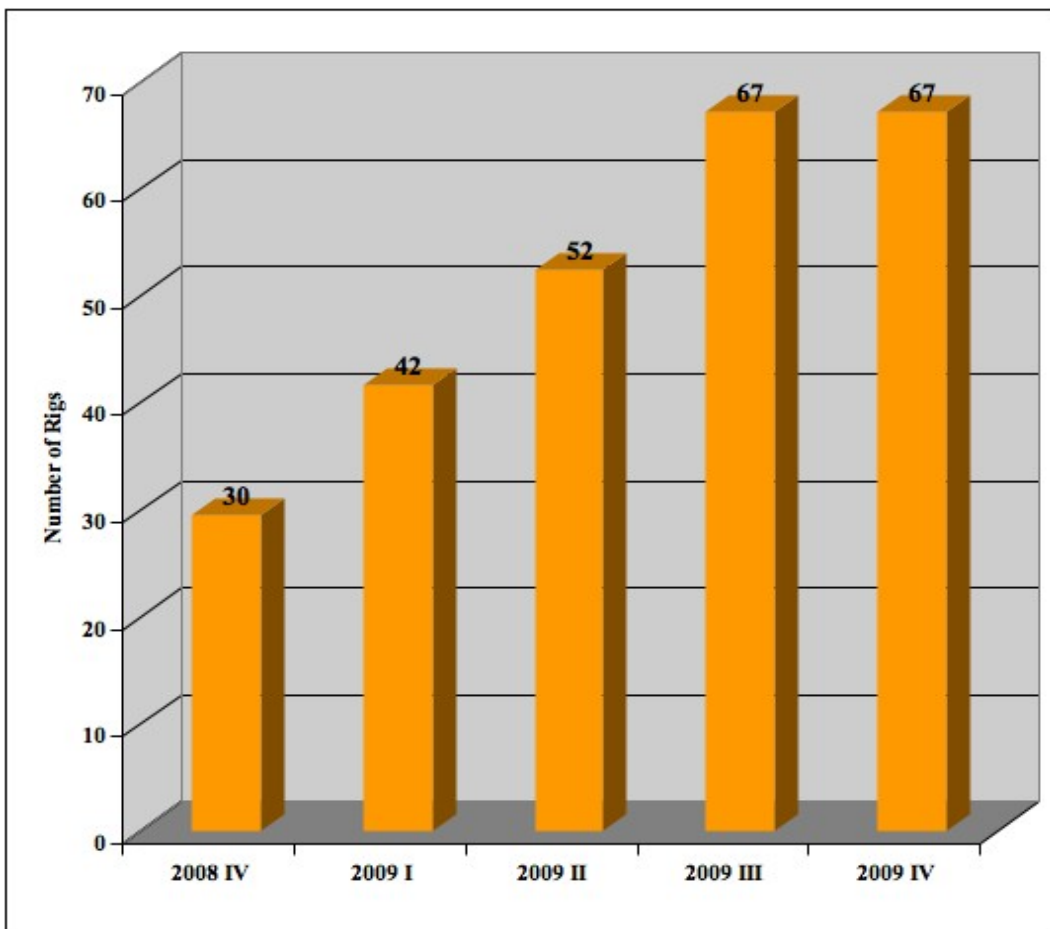
The analysis now turns to the results of the survey on spending, drilling, and production. The estimated spending by Marcellus producers in Pennsylvania during 2008 and 2009 appears below in Table 1. Total spending increased from \$3.2 billion during 2008 to more than \$4.5 billion during 2009. Most of the increase came from higher expenditures on exploration, drilling, and pipeline and processing plant investments (see Table 1). Lease and bonus payments, which were the largest category at over \$1.8 billion during 2008, declined slightly to \$1.7 billion during 2009. The next largest expenditure category is upstream drilling and completion of wells, which amounted to over \$857 million during 2008 and then over \$1.7 billion during 2009. Mid-stream expenditures on pipelines and natural gas processing plants are the next largest category with over \$329 million of spending during 2008 and approaching \$700 million during 2009. The planned expenditures for the upstream and mid-stream segments of the industry discussed below will double yet again in 2010 and increase roughly 50 percent in 2011. As previously mentioned, this report does not include expenditures for any “downstream” activities such as expansion of interstate natural gas transmission, natural gas distribution or new businesses that may be created in Pennsylvania due to an abundant supply of reasonably priced natural gas.

**Table 1: Spending in thousands of nominal dollars, 2008-2009**

	2008	2009
Total Spending	3,224,577	4,535,304
Lease & Bonus	1,837,734	1,728,765
Exploration	121,940	243,831
Upstream: Drilling & Completion	857,751	1,700,435
Midstream: Pipeline & Processing	329,437	695,801
Royalties	22,183	54,683
Other	55,531	111,787

Not all of this spending occurred within Pennsylvania given that some supplies are imported from other regions and land income recipients may spend money outside the state. Our expenditure analysis from last year, however, indicated that 95 percent of this spending occurred within Pennsylvania during 2008. This indicates that a sizable well support industry has developed in Pennsylvania, particularly as corporations from the world oil and gas service business establish local headquarters in the Commonwealth.

Our survey asked producers for the number of rigs they were operating at the end 2008 and at the end of each quarter during 2009. The survey results appear below in Figure 2. At the end of 2008, 30 rigs were drilling in the Pennsylvania Marcellus (see Figure 2). By the end of the third quarter of 2009, the rig count more than doubled to 67 (see Figure 2). The leveling of the rig count during the fourth quarter of 2009 probably reflects seasonal factors, since operating during winter weather is more difficult.

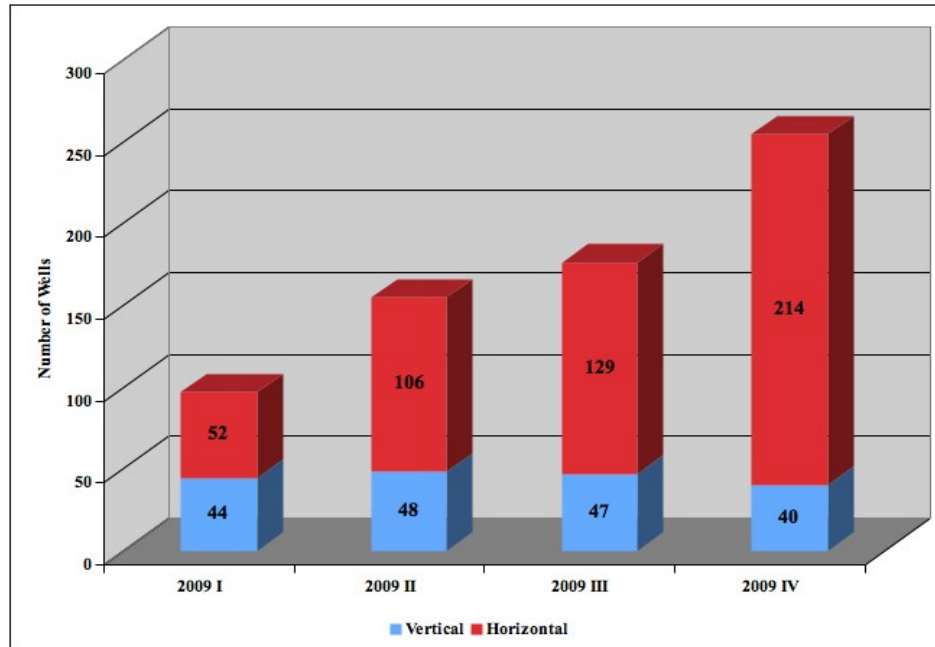


**Figure 2: Marcellus Rigs operating in Pennsylvania by quarter, 2008-2009**

This increase in rig capacity translated to more wells drilled. Charted below in Figure 3, are wells drilled to total depth. During 2009, 682 wells were drilled to total depth, which is consistent with our finding of 710 wells started. At the beginning of 2009, 54 percent of wells drilled to total depth were horizontal wells and by the end of the year

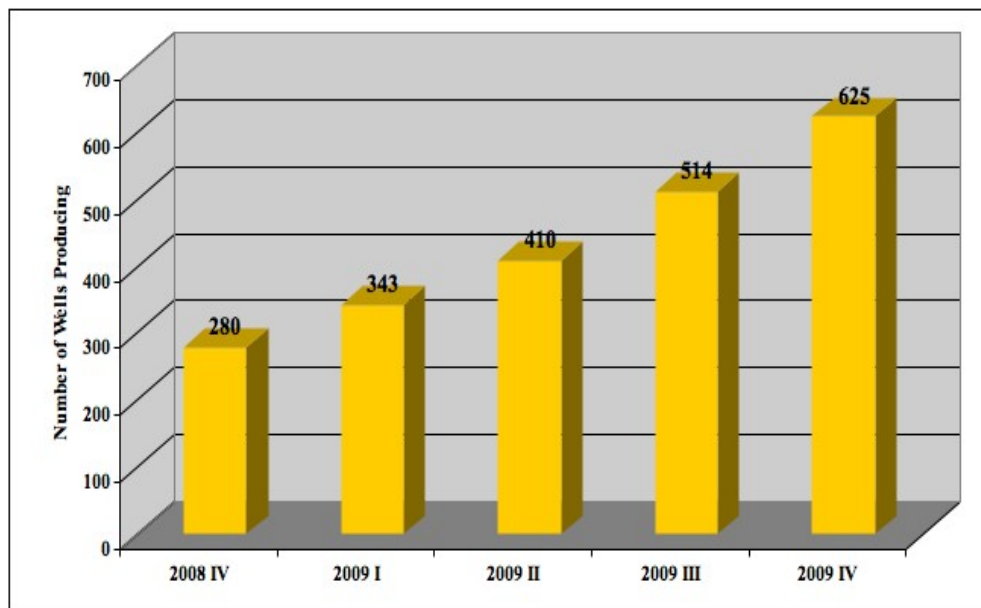
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that percentage increased to 84% (see Figure 3). On average 3.5 wells were drilled per operating rig, which implies that each rig took 25.5 days to drill a well to total depth.



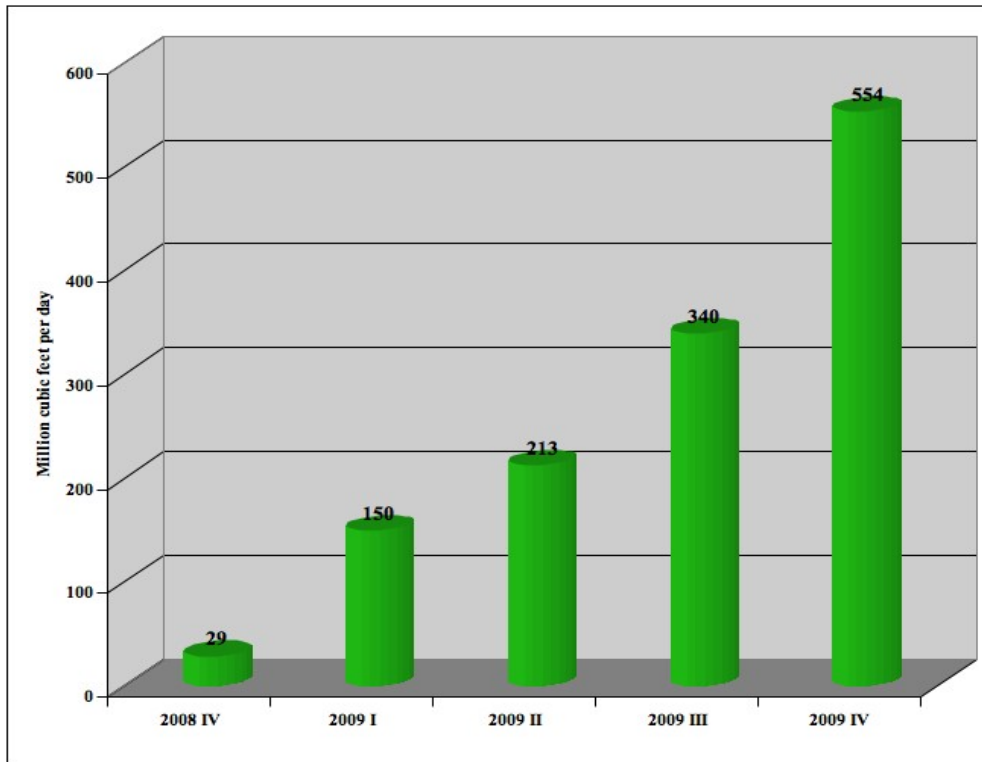
**Figure 3: Marcellus Wells drilled to total depth during 2009**

This drilling effort led to a steady increase in the number of operating wells. Figure 4 plots the number of producing wells. At the end of 2008, our sample suggests 280 wells were in production. One year later, 625 wells were operating (Figure 4).



**Figure 4: Marcellus wells producing in Pennsylvania**

As these wells went into production, total natural gas production increased steadily. Figure 5 below reports quarterly average production of dry natural gas and natural gas liquids. During the last quarter of 2008, the Marcellus industry produced roughly 29 million cubic feet (mmcf) of natural gas equivalents per day. As Figure 5 illustrates, total production accelerated sharply, exceeding 200 mmcf per day by July and surpassing 550 mmcf per day by the end of the fourth quarter of 2009. Average annual production during 2009 was 327.7 million cubic feet per day.



**Figure 5: Quarterly production of natural gas equivalents**

### **III. Economic Impacts**

While the drilling rig may be the most widely associated symbol of natural gas development, there are many activities before and after drilling that generate significant economic impacts. Many people are required to identify lease properties, write leases, and conduct related legal and regulatory work. Seismic surveys also require manpower, local business services, and other provisions. Once a prospective site is identified, site preparation and drilling begins and with it the need for services, labor, and other locally supplied activities. If natural gas is found in commercial quantities, infrastructure, such as well production equipment and pipelines are installed, which again stimulates local business activity. Finally, as production flows from the well, royalties are paid to landowners and taxes paid to local governments. These expenditures stimulate the local economy and provide additional resources for community services, such as health care, education, and charities.

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Expenditures at all stages of production generate indirect economic impacts as the initial stimulus from expenditures on natural gas development is spent and re-spent in other business sectors of the economy. For example, in developing mineral leases natural gas drilling companies employ the services of land management companies that in turn purchase goods and services from other businesses. These impacts are known as *indirect economic impacts*. The wages earned by these employees increase household incomes, which then stimulates spending on local goods and services. These impacts associated with household spending are called *induced impacts*. The total economic impacts are the sum of the direct, indirect, and induced spending, set off from the expenditures by Marcellus producers. These economic impacts are estimated by comparing gross output, value added, tax revenues, and employment in the local economy with and without Marcellus development.

Regional economic impact analysis using input-output (IO) tables and related IO models provide a means for measuring these economic impacts. Input-output analysis provides a quantitative model of the inter-industry transactions between various sectors of the economy and, in so doing, provides a means for estimating how spending in one sector affects other sectors of the economy. IO tables are available from Minnesota IMPLAN Group, Inc. based upon data from the Bureau of Economic Analysis in the US Department of Commerce.<sup>2</sup> This project uses these tables to estimate the economic impacts from the Marcellus industry outlays for natural gas exploration, development, and production. This study also identifies the specific economic sectors affected by the stimulus generated from natural gas development.

The Pennsylvania Marcellus is less than five years old and, therefore, is not included in the last update of the IO accounts for Pennsylvania. Accordingly, this study uses a technique proposed by Miller and Blair (2009) for introducing new industries into an input-output model of a regional economy. This approach requires estimating the input requirements of the new industry, which in our case are the purchases made by Marcellus gas producers from other sectors of the economy. Our previous report collected detailed accounting data from Marcellus producers to determine these inter-industry transactions. The location of firms supplying inputs to Marcellus producers and their respective industrial sector codes were determined from business database directors.

Like our previous report, the economic impacts reported below uses the IMPLAN system. This update, however, will not involve collecting detailed accounting information. Nevertheless, the detailed information collected last year is utilized for this update to link the data for spending categories above with the more disaggregated spending streams in the state level input-output system. In other words, our original study serves as a benchmark for our subsequent economic impact estimates. This benchmark approach is widely used by U.S. government agencies when they estimate economic activity.

The first set of estimated economic impacts reported in Table 2 involves gross output, which is equivalent to gross sales. The Marcellus gas industry provides a direct

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<sup>2</sup> <http://www.implan.com/index.html>

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economic stimulus of \$3.77 billion dollars to the local economy. This spending then leads to subsequent rounds of spending and re-spending by other firms on goods and services, which adds another \$1.56 billion to total state gross output. These direct and indirect business activities generate additional income in the region, which then *induces* households to purchase \$1.84 billion in additional goods and services. The sum of these direct, indirect, and induced impacts is more than \$7.17 billion in 2009.

**Table 2: Impacts on Gross Output by Sector during 2009 in millions of 2010 dollars**

Sector	Direct	Indirect	Induced	Total
Ag, Forestry, Fish & Hunting	13.5	11.8	6.3	31.6
Mining	991.9	19.4	3.8	1,015.1
Utilities	42.2	43.7	38.3	124.2
Construction	829.2	18.6	14.0	861.9
Manufacturing	139.4	239.3	123.1	501.9
Wholesale Trade	455.7	102.2	84.8	642.7
Retail trade	228.2	16.3	197.7	442.2
Transportation & Warehousing	90.0	77.7	39.7	207.4
Information	22.1	129.5	92.9	244.5
Finance & Insurance	44.3	159.6	214.4	418.4
Real estate & rental	220.6	143.9	315.8	680.3
Professional- scientific & tech services	174.0	310.9	87.1	572.1
Management of companies	0.0	84.1	19.5	103.6
Administrative & waste services	26.6	93.0	43.0	162.5
Educational services	87.9	1.7	39.2	128.8
Health & social services	190.8	3.3	290.9	484.9
Arts- entertainment & recreation	35.3	6.0	34.1	75.5
Hotel & food services	87.6	26.1	81.0	194.7
Other services	63.3	39.0	83.8	186.2
Government & Misc.	25.8	30.9	34.5	91.2
<b>Total</b>	<b>3,768.6</b>	<b>1,557.2</b>	<b>1,843.8</b>	<b>7,169.6</b>

So for every \$1 that the Marcellus industry spends in the state, \$1.90 of total economic output is generated. This estimate is considerably above the 1.34 multiplier found by Baumann et. al (2002) in their study of the impacts of oil and gas activities on the Louisiana economy. In a study of the economic impacts of the natural gas industry in New Mexico, Walker and Sonora (2005) assume an output multiplier of 1.43. The study by Snead (2002) finds an output multiplier of 1.55 for Oklahoma. This study’s higher multiplier probably reflects our detailed expenditure analysis in our benchmark year 2008 based upon company accounting data, which provide a more accurate measurement of inter-industry purchases.

A more meaningful estimate of economic impacts is value added, which subtracts inter-industry purchases from gross output and measures the returns to labor and capital (see Table 3). Using this measure, the Marcellus gas industry in Pennsylvania directly added over \$1.98 billion to the economy of Pennsylvania, which then generated indirect and induced impacts that increased the total value added generated in the Commonwealth by \$3.87 billion. In other words, the total economic impact of the Marcellus industry measured by valued added was \$3.87 billion during calendar year 2009.

**Table 3: Impacts on Value Added by Sector during 2009 in millions of 2010 dollars**

Sector	Direct	Indirect	Induced	Total
Ag, Forestry, Fish & Hunting	3.7	3.9	2.2	9.8
Mining	501.0	11.0	2.4	514.4
Utilities	29.9	28.4	27.4	85.8
Construction	330.1	10.7	8.4	349.2
Manufacturing	34.4	62.1	29.0	125.5
Wholesale Trade	306.0	68.6	56.9	431.5
Retail trade	152.0	11.1	133.0	296.1
Transportation & Warehousing	49.5	48.3	22.9	120.7
Information	9.2	51.6	37.4	98.2
Finance & Insurance	23.8	92.6	112.2	228.7
Real estate & rental	163.1	96.9	232.8	492.8
Professional- scientific & tech services	91.2	178.2	50.9	320.3
Management of companies	0.0	50.6	11.8	62.4
Administrative & waste services	14.9	59.0	26.6	100.5
Educational services	50.2	0.9	23.0	74.2
Health & social services	119.1	2.0	179.8	300.9
Arts- entertainment & recreation	14.9	3.2	14.8	32.9
Hotel & food services	44.7	12.7	39.4	96.9
Other services	33.0	20.8	42.1	95.9
Government & Misc.	11.2	15.1	13.8	40.1
<b>Total</b>	<b>1,982.0</b>	<b>828.0</b>	<b>1,066.5</b>	<b>3,876.5</b>

Like the impacts on gross output by sector, the increases in value added by sector generated by the Marcellus industry are broad based. Value added generated in the mining, real estate and rentals, and wholesale trade sectors are \$514, \$493, and \$431 million dollars respectively (see Table 3). Marcellus development generates value added in excess of \$300 million in the construction, scientific and technical services, health and social services. The retail trade and finance and insurance sectors are also stimulated more than \$200 million dollars of value added (see Table 3). Overall, the Marcellus gas industry generates a rather widespread increase in value added across many sectors of the Pennsylvania economy.

This broad based increase in value added stimulates employment in the region. The Marcellus industry purchases of goods and services, their royalties to landowners, and tax payments directly create more than 21,000 jobs in Pennsylvania. Indirect and induced impacts create even more jobs so that total jobs created by the Marcellus industry is estimated at 44,098 (see Table 4). An estimated 5,934 jobs are created in retail trade, 5,272 in construction, 4,943 in health and social services, 3,219 in professional services, 3,195 in wholesale trade, and 2,937 in mining. Like our estimated impacts on gross output and value added, these diverse job gains reflect the widespread stimulus to the Pennsylvania economy from the supply chain required to develop Marcellus Shale gas.

**Table 4: Employment Impacts during 2009 in number of Jobs**

Sector	Direct	Indirect	Induced	Total
Ag, Forestry, Fish & Hunting	103	130	79	311
Mining	2,878	51	8	2,937
Utilities	73	45	41	159
Construction	4,989	161	122	5,272
Manufacturing	239	574	222	1,034
Wholesale Trade	2,266	508	421	3,195
Retail trade	2,938	225	2,771	5,934
Transportation & Warehousing	613	617	303	1,533
Information	61	322	239	621
Finance & Insurance	164	700	847	1,711
Real estate & rental	446	586	596	1,629
Professional- scientific & tech services	738	1,938	543	3,219
Management of companies	0	302	70	372
Administrative & waste services	326	1,340	600	2,266
Educational services	1,070	23	574	1,667
Health & social services	1,984	22	2,938	4,943
Arts- entertainment & recreation	401	113	403	917
Hotel & food services	1,368	445	1,393	3,206
Other services	968	427	1,238	2,633
Government & Misc.	154	203	180	538
<b>Total</b>	<b>21,778</b>	<b>8,732</b>	<b>13,587</b>	<b>44,098</b>

These employment impacts are within the range reported in the literature. The results of this study indicate that for every \$1 million of output created by natural gas production in the Pennsylvania Marcellus, 6.9 jobs are created. This metric is within the range of employment multipliers of 3.0, 6.7, and 7.7 found by Walker and Sonora, Baumann et. al, and Snead et. al. respectively but more than the estimates reported by Perryman (2009).

The higher economic output and greater employment by the Marcellus gas industry generate additional tax revenues for federal, state and local governments. These impacts are reported below in Table 5. State and local tax revenues for Pennsylvania increase slightly over \$389 million with the bulk of that coming from indirect business taxes of \$289 million. Federal taxes paid by Pennsylvania increase by \$1.05 billion from Marcellus development with most of the increase coming from higher social security taxes and personal income taxes paid as more people are working and receiving income.

The Allegheny Conference (2009) recently found that Pennsylvania’s pre-Marcellus oil and gas industry in total generated \$7.1 billion in economic impacts. Oil and gas producers drilled a total of 4,189 wells in Pennsylvania during 2007. Hence, according to their estimates every well drilled generates \$1.7 million in economic impacts. In contrast, our study finds that each Marcellus well generates \$6.2 million in economic impacts. This difference reflects the higher cost of Marcellus wells and the greater resource requirements for the supply chain.

**Table 5: Tax Impacts during 2009 in millions of 2010 dollars**

Description	State and Local Taxes					Total
	Employees	Proprietor	Business	Households	Corporations	
Dividends					22.38	22.38
Social Insurance						
Employee Contr.	0.76					0.76
Employer Contr.	3.26					3.26
Indirect Business						
Sales			117.85			117.85
Property			124.32			124.32
Motor Vehicle Lic.			2.59			2.59
Other			36.37			36.37
S/L Fees			8.16			8.16
Corporate Profits					14.95	14.95
Personal Income						
Income				47.14		47.14
Fines & Fees				6.89		6.89
Motor Vehicle Lic.				2.25		2.25
Property				1.09		1.09
Other (Fish/Hunt)				1.06		1.06
Total State & Local	4.02		289.28	58.43	37.33	389.06
			Federal Taxes			
Social Insurance						
Employee Contr.	241.96	50.54				292.51
Employer Contr.	244.70					244.70
Indirect Business						
Excise			35.79			35.79
Custom Duty			16.67			16.67
Fed Fees			27.52			27.52
Corporate Profits					124.61	124.61
Personal Income				315.02		315.02
Total Federal	486.66	50.54	79.98	315.02	124.61	1,056.81

#### IV. Planned Industry Spending and Economic Impacts for 2010 and 2011

Our survey of Marcellus natural gas producers operating in Pennsylvania also asked for estimates of planned industry spending for 2010 and 2011, which are reported below in Table 6. Producers plan to spend more than \$8.7 billion during 2010. While lease and bonus payments decline slightly from 2009 levels, producers expect that they will remain more than \$1.5 billion for the next two years. The big increase over this year and next are for the upstream and mid-stream segments of the industry, with spending increasing from \$2.4 billion during 2009 to \$6.3 and \$8.1 billion for 2010 and 2011 respectively.

The economic impacts from this planned spending are likely to be significant. To estimate these possible impacts, this study ran the IMPLAN model for Pennsylvania for these two years, adjusting for the effects of inflation on real value added. Below is a summary of the total economic impacts on value added and employment by sector. The economic contribution of the Marcellus gas industry as measured by value added rises to

\$8 billion in 2010 and to over \$10 billion in 2011. In other words, the Marcellus industry increases the gross state product of Pennsylvania.

**Table 6: Planned Marcellus Spending in thousands of nominal dollars, 2010-2010**

	2010	2011
Total Spending	8,773,731	11,010,602
Lease & Bonus	1,602,187	1,577,748
Exploration	493,910	486,972
Upstream: Drilling & Completion	4,468,292	6,489,792
Midstream: Pipeline & Processing	1,785,878	1,586,278
Royalties	252,463	633,135
Other	171,001	236,677

Higher gross state product implies greater employment. For example, our estimates suggest that the level of employment in the state could increase over 88,000 due to Marcellus industry activity during 2010 and well over 100,000 during 2011. As a result of higher real output and employment, state and local tax revenues could be \$785 and \$987 million higher during 2010 and 2011 respectively. In short, the Marcellus shale gas industry adds true, real value to the economy and in the process creates jobs and improves the fiscal health of the Commonwealth.

**Table 7: Value Added and Employment Total Impacts from Planned Spending**

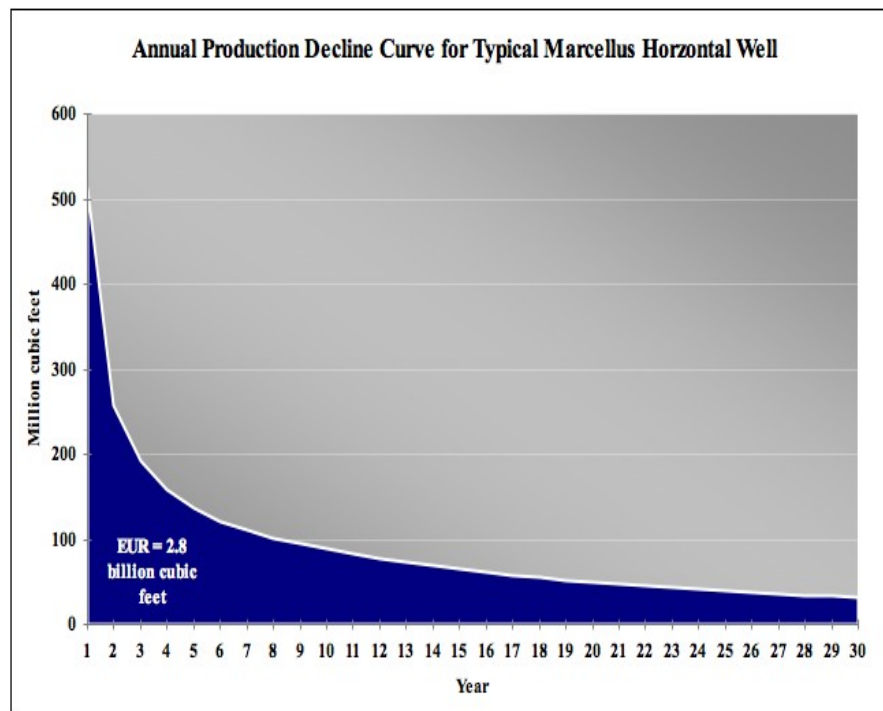
Sector	Value Added in Millions of 2010 Dollars		Employment Gains in Number of Jobs	
	2010	2011	2010	2011
Ag, Forestry, Fish & Hunting	19.3	24.2	590	740
Mining	1,287.8	1,637.5	7,367	9,369
Utilities	157.9	197.5	312	391
Construction	864.9	1,099.3	13,061	16,601
Manufacturing	247.8	311.4	2,113	2,660
Wholesale Trade	1,012.7	1,283.9	7,499	9,507
Retail trade	544.0	680.7	10,748	13,435
Transportation & Warehousing	261.2	329.9	3,293	4,156
Information	194.9	244.9	1,224	1,538
Finance & Insurance	447.5	562.0	3,364	4,226
Real estate & rental	855.9	1,067.0	2,851	3,556
Professional- scientific & tech services	723.9	916.0	7,229	9,145
Management of companies	135.9	171.7	812	1,025
Administrative & waste services	211.0	266.0	4,761	6,002
Educational services	105.3	129.3	2,441	3,006
Health & social services	511.5	636.8	8,438	10,507
Arts- entertainment & recreation	54.4	67.6	1,540	1,915
Hotel & food services	158.8	197.1	5,355	6,658
Other services	169.2	211.2	4,567	5,693
Government & Misc.	75.5	94.6	1,024	1,284
<b>Total</b>	<b>8,039.5</b>	<b>10,128.6</b>	<b>88,588</b>	<b>111,413</b>

## V. Forecasts of Marcellus Industry Activity and Economic Impacts out to 2020

As the above analysis demonstrates, the economic impacts of the Marcellus gas industry are driven by inter-industry spending to support drilling activity and payments to land owners. As the Marcellus is developed, royalties will dominate payments to land owners, eventually exceeding lease and bonus payments. Therefore, to project future royalties a forecast of natural gas production is required.

Natural gas production in any period is the sum of production from current and all previous vintages of producing wells. 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. Since the play is so new, with very few wells having more than even a one year producing history, companies estimate reserves on the basis of early life production results, reservoir models, and comparisons with longer term well performance in more mature shale plays.

The production decline curve used in this study is displayed below in Figure 6, which is the basis for the production forecast below. This curve is on the low end of publicly released decline curve information released by five major Marcellus Shale operators during the second half of 2009. The estimated production over the first 30 years is 2.8 billion cubic feet, after 50 years the yields is 3.5 bcf. Given this decline curve, average annual production from a Pennsylvania Marcellus horizontal well is over 500 mmcf during the first year, about 250 mmcf during the second, after 8 years about 100 mmcf, and roughly 30 mmcf per year after 30 years of production.

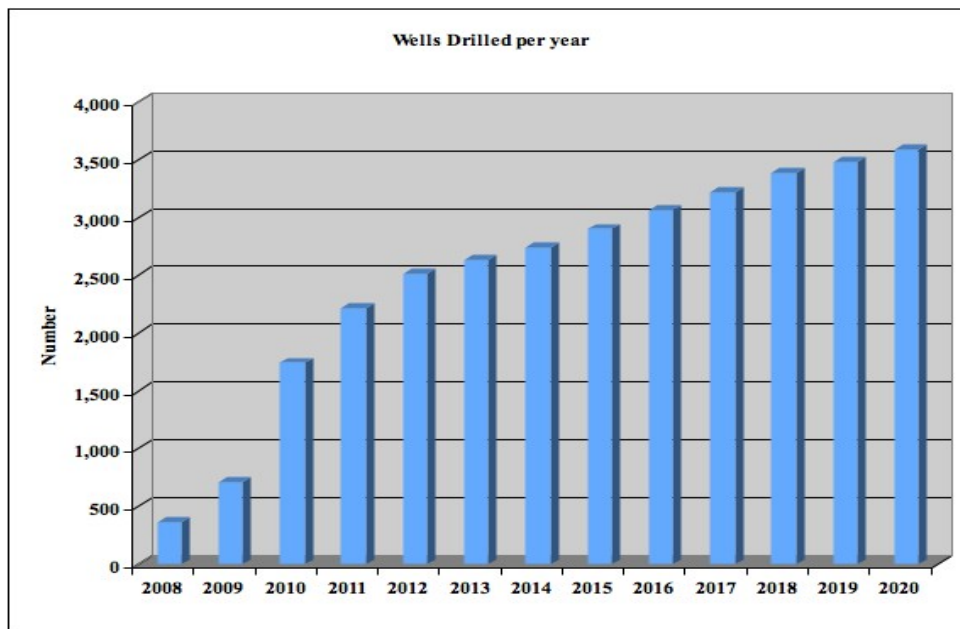


**Figure 6: Marcellus Production Decline Curve**

As the discussion above demonstrates, not all wells drilled in the Marcellus are horizontal. Vertical wells have a similar decline curve but substantially lower output. Accordingly, this study assumes that annual production from a vertical Marcellus well is slightly less than 30 percent of the output from a horizontal well.

Bottlenecks in infrastructure development are another feature of the industry that must be considered in projecting future production. There are widespread reports of producers drilling wells to secure leases and then capping them until pipeline infrastructure can be built to carry the gas to market. Given time lags in constructing pipeline gathering systems and connections to major interstate pipeline networks, this study assumes a one-year lag between the time a well is drilled and when it is producing marketable gas.

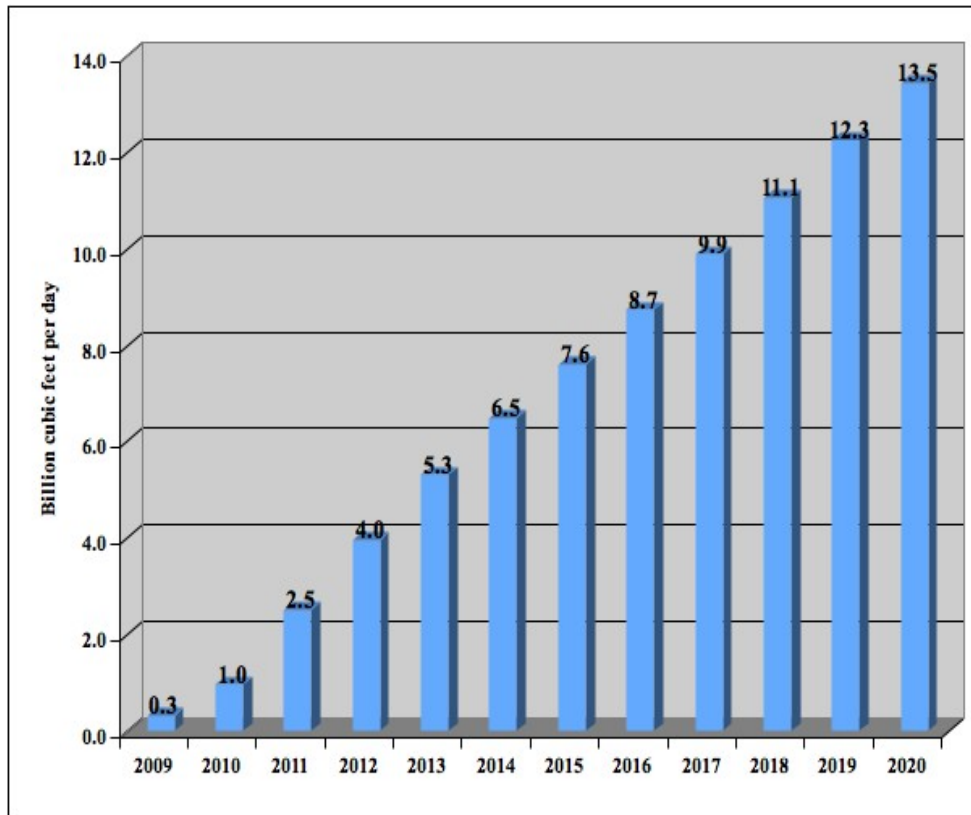
The planned level of spending by Marcellus producers, suggests that over 1,700 wells could be drilled during 2010. This estimate is based upon an average expenditure for exploration, upstream, and downstream production of over \$3.8 million for wells drilled to total depth observed during 2009. Similarly, spending plans suggest over 2,200 wells could be drilled during 2011. Between 2012 and 2020, this study uses the drilling forecast equation developed by Considine, et. al. (2009) that predicts drilling activity based upon natural gas prices. The prices used in this study are futures prices for natural gas from the New York Mercantile Exchange reported on April 15, 2010 adjusted for inflation. These real, inflation adjusted prices in 2010 dollars are \$5.42 per thousand cubic feet (mcf) in 2010 and gradually increase to over \$6 per mcf by 2020 for an average annual real rate of increase of two percent. Given these assumptions, our projection of future Marcellus gas drilling is displayed below in Figure 7. Drilling activity increases from 2,500 wells drilled during 2012 to over 3,500 wells drilled during 2020.



**Figure 7: Forecast for Marcellus Natural Gas Drilling, 2009-2020**

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Following recent trends, this study assumes that the share of vertical wells in total well drilled will decline to 10 percent by 2020. Given this and previous assumptions, this study projects a trajectory of natural gas production for the Pennsylvania Marcellus that is displayed below in Figure 8. During 2010, average annual production could approach one billion cubic feet per day. Given planned drilling during 2010, production could exceed 2.5 bcf per day by 2011, exceeding Pennsylvania’s natural gas consumption and making the Commonwealth a natural gas exporter. Pennsylvania could be producing over 7 billion cubic feet of gas per day by 2015, which is more than Wyoming’s production during 2008. Production could reach 13 bcf per day by 2020, which would make Pennsylvania the second largest producer of natural gas behind Texas.



**Figure 8: Forecast for Marcellus Natural Gas Production, 2010-2020**

Change in Pennsylvania’s regulatory and tax policies that would raise the relative cost of Marcellus development could reduce the pace of drilling and, hence, future natural gas production and other economic impacts discussed in this report. If the current tax and regulatory policies remain in place, there are several reasons why the above forecast could be conservative. First, the productive capacity for a typical Marcellus well could be greater than indicated by the type curve used in these projections. Second, the level of drilling could be substantially higher than the levels projected here. At 3,500 wells by 2020, drilling density would remain quite low compared to other shale gas plays. If these projections are borne out, the Pennsylvania Marcellus could have a profound effect on the U.S. natural gas market.

This level of future drilling and development activity will significantly stimulate the Pennsylvania economy. Estimates of these future economic impacts are summarized in Table 8. During 2015, the Marcellus gas industry could be generating more than \$14 billion in value added, \$1.4 billion in state and local tax revenues, and increasing state employment by 160,000. In 2020, the impacts grow even larger with over \$18 billion in value added, over \$1.8 billion in state and local tax revenue, and a workforce 200,000 larger.

**Table 8: Forecast Economic Impacts**

Millions of 2010 dollars			
Year	Value Added	State & Local Taxes	Jobs
2015	14,415	1,417	160,205
2020	18,853	1,872	211,909

## VI. Summary and Conclusions

This study provides an update of the impacts of the Marcellus gas industry on the economy of the Commonwealth of Pennsylvania. This update was accomplished by conducting a survey of natural gas producing companies drilling the Marcellus play in Pennsylvania. The companies responding to our survey accounted for more than 74 percent of the Marcellus wells drilled during 2009. Our survey results reveal that the industry spent over \$4.5 billion on Marcellus development during 2009. By the end of 2009, our estimates suggest that there were over 625 producing Marcellus wells in Pennsylvania producing over 500 million cubic feet of natural gas equivalents per day.

Our estimated economic impacts for 2008 and 2009 are quite close to our estimates from last year. The estimates for 2008 changed slightly since this update uses revised and updated economic data for 2008. The estimated impacts for 2009 are also very similar to the projections from last year’s report. During 2009, the Marcellus gas industry increased Pennsylvania’s value added by \$3.8 billion, generated \$389 million in state and local taxes, and created more than 44,000 jobs.

Our survey also asked Marcellus natural gas producers how much they planned to spend for 2010 and 2011. Based upon the results from this survey, the near term outlook for the Marcellus gas industry in Pennsylvania is even more robust than we anticipated last year. Based on these spending plans, the Marcellus industry in Pennsylvania could generate more than \$8 billion in value added during 2010. This economic activity would generate more than \$785 million in state and local taxes and would cause job gains to double yet again to over 88,000 (see Table 9). The rate of growth tapers somewhat in 2011. Nonetheless, the economic impacts are impressive with nearly \$1 billion in additional tax revenues for the state and 100,000 plus jobs.

Looking beyond the planning horizon and employing some conservative assumptions about drilling and production profiles, the outlook for Marcellus production is remarkable. By 2015, the Pennsylvania Marcellus could be producing over 7 billion cubic feet per day, substantially exceeding all gas output from offshore federal waters.

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Marcellus natural gas production could nearly double again by 2020, with more than 13.5 billion cubic feet per day, which would make Pennsylvania second only to Texas in natural gas production. The economic impacts of this level of production are very significant, dramatically improving the fiscal position and job market in the Commonwealth of Pennsylvania.

**Table 9: Summary of Estimated, Planned, and Forecast Economic Impacts**

Millions of 2010 dollars			
Year	Value Added	State & Local Taxes	Jobs
2008	2,556	265	30,137
2009	3,877	389	44,098
<i>Planned</i>			
2010	8,039	785	88,588
2011	10,129	987	111,413
<i>Forecast</i>			
2015	14,415	1,417	160,205
2020	18,853	1,872	211,909

Large-scale development of the Marcellus is reshaping the economic landscape of Pennsylvania. Strategies and policies that encourage growth of the Marcellus gas industry will generate significant economic and environmental benefits for the Commonwealth of Pennsylvania, transforming the Pennsylvania to a net natural gas exporter while creating hundreds of thousands of jobs and generating billions of dollars in additional output, income, and tax revenues.

There are additional economic impacts not estimated in this report. The availability of low cost natural gas supplies could stimulate the expansion of manufacturing capacity in the Commonwealth of Pennsylvania, such as steel, glass, foundries, chemicals, fertilizers, and other natural gas intensive industries. Such an expansion would further stimulate the supply chain and generate additional job and tax revenues gains. Abundant gas supplies also could reduce the cost of achieving reductions in greenhouse gas emissions as well as emissions of NO<sub>x</sub>, SO<sub>2</sub>, and other pollutants. Thus, the additional natural gas produced from the Marcellus would propel Pennsylvania's economy forward while reducing greenhouse gas emissions.

Despite the enormous potential of the Marcellus, Pennsylvania policy makers need to understand that the Marcellus competes for scarce investment capital with other shale plays around North America. Policies that raise the costs of developing the Marcellus relative to these other shale plays could reduce Marcellus production, job creation, and tax revenue growth.

Many people believe clean, domestic energy production need not impinge upon economic growth. Marcellus shale gas producers are transforming this belief into a new reality.

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**Appendix A: Survey Form**

**Table A1: Survey Form for Measuring Marcellus Shale Activity**

**Confidential Survey: Pennsylvania Marcellus Shale Gas Activity**

Company: \_\_\_\_\_  
 Contact Name: \_\_\_\_\_  
 Phone Number: \_\_\_\_\_  
 Email Address: \_\_\_\_\_

*Note: All values should be for the Pennsylvania Marcellus on a calendar year basis  
 Data should pertain to wells operated by the company (Gross Operated Basis)*

**Cumulative as of year end 2009 (inception to date)**

<i>Total Spending 1,000\$</i>						
<i>Wells drilled to total depth, #</i>						
<i>Vertical</i>						
<i>Horizontal</i>						
		Actual		Planned		
	Units	2008	2009	2010	2011	
<b>Total Spending</b>	1,000 \$					
<i>Lease &amp; Bonus</i>	1,000 \$					
<i>Exploration</i>	1,000 \$					
<i>Upstream: Drilling &amp; Completion*</i>	1,000 \$					
<i>Midstream: Pipeline &amp; Processing*</i>	1,000 \$					
<i>Royalties</i>	1,000 \$					
<i>Other</i>	1,000 \$					
		Year End		2009 end of quarter		
<b>Rig &amp; Well Count</b>	Units	2008	I	II	III	IV
<i>Rigs Operating</i>	#					
<i>Wells producing</i>	#					
		2009				
<b>Drilling &amp; Production</b>	Units	2008	I	II	III	IV
<i>Wells Drilled to total Depth</i>	#					
<i>Vertical</i>	#					
<i>Horizontal</i>	#					
<i>Production that you operate</i>						
<i>Gross Dry Natural Gas</i>	mcf					
<i>Petroleum Liquids</i>	mmbtu					