

PENNSYLVANIA MARCELLUS SHALE WORKFORCE NEEDS ASSESSMENT



SUMMER 2011

 **Marcellus
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Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment

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Needs assessment conducted by:

Marcellus Shale Education & Training Center (MSETC)

*A collaboration of Pennsylvania College of Technology
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Executive Summary

The Pennsylvania Marcellus Shale Workforce Needs Assessment is intended to supply baseline data to provide individuals, job seekers, communities, businesses, workforce and economic development professionals, and government officials at all levels with the ability to estimate the direct workforce requirements for Marcellus Shale development. Specifically, the assessment can help outline the key occupations associated with unconventional natural gas development and the number of direct jobs required to bring a Marcellus well into production in Pennsylvania between 2011 and 2014.

Over the course of nearly three years, the Marcellus Shale Education & Training Center (MSETC) has developed and refined the method used in this study to estimate the “direct” workforce requirements of the natural gas industry. Given the different development patterns across Pennsylvania, it is important to have a workforce model that is easily adaptable to changing development scenarios. The methodology focuses on analyzing the types and numbers of workers needed to drill a single Marcellus Shale gas well and then uses the direct workforce data to achieve a total workforce requirement based on estimates of future well drilling activity. At the core of the MSETC model is a full-time equivalent (FTE) calculation for each worker associated with drilling a single Marcellus Shale well. The model also incorporates changes in development practices (single vs. multi-well pads), infrastructure development (pipeline), and differing natural gas properties (dry gas vs. high-BTU gas). The flexibility of a per well model significantly increases the predictive power of the model and the usefulness for business and workforce planning. The workforce estimates within the report were created using interviews, an online assessment, publicly available investor reports, and the Pennsylvania Department of Environmental Protection’s permit and well spud reports.

Marcellus Shale is a very large natural gas formation extending across 95,000 square miles and running through roughly two-thirds of Pennsylvania and portions of New York, West Virginia, Virginia, Maryland, and Ohio. In Pennsylvania, development of Marcellus Shale began in Washington County in 2004. Over the next few years, the Marcellus development footprint quickly expanded to include significant portions of northeast Pennsylvania. Today, southwest Pennsylvania is increasingly being selected as a preferred location to establish Appalachian Basin headquarters for exploration and production, service, and supply companies. The hub of drilling activity in Pennsylvania has been more heavily concentrated in the northeast for 2010 and thus far in 2011.

The northeast region of Pennsylvania saw moderate growth during initial stages of Marcellus development with only 76 wells drilled in 2008. In the second half of 2009, development in the area began to ramp up quickly with 332 wells drilled. The core counties of the northeast region have quickly become a major Marcellus Shale development hotspot for the state of Pennsylvania, with 909 wells drilled in 2010, and more than 1,000 expected in 2011.

The Marcellus Shale resource also includes the northwest region of Pennsylvania; however, due to the shallower depth and thinner shale formation, most of the areas are currently considered outside the geologic “Marcellus Fairway”. A number of energy companies have been drilling exploratory wells in the area, and several companies have announced plans to dedicate drilling rigs on the southern and eastern

fronts of the northwest region. Permitting activity has increased in the region over the past few years, and drilling activity in the first four months of 2011 show continued growth and significant potential for commercial quantities of natural gas from the northwest region.

With the recent dramatic increase in interest in high-BTU gas and the premium price commanded for liquids-rich natural gas, the southwest region appears poised for a resurgence in shale gas development related to the Marcellus, Utica, and other Upper Devonian Shale formations. A combination of limited natural gas infrastructure capacity and a need to develop lease holdings in non-traditional natural gas areas of Pennsylvania appear to have resulted in a moderation of development growth in the region over the last few years. Natural gas infrastructure capacity would include a need for additional pipeline and processing facilities required to bring “wet” or high-BTU gas to market. Although the pace of Marcellus development was slower in the southwest from 2008-2010, companies active in the area have made public statements that they intend to dramatically increase activity within the southwest region in 2011 and beyond. In fact, rig counts and permitting within the first four months of 2011 show activity levels should eclipse 2010 development.

The 19 southeast counties of Pennsylvania are currently outside the Marcellus Shale footprint, but represent 28% of all Pennsylvania counties and 58% of the total Pennsylvania population (Census, 2010). Even though outside the core Marcellus development area, the southeast portion of the state will still likely benefit significantly from Marcellus business and workforce opportunities. Without direct Marcellus drilling and completion activities in the southeast region, many of the workforce and business opportunities will likely provide services, support, and supply-chain resources in support of energy exploration and production operations. Most of these support businesses will be able to maintain their primary locations in the southeast region, but company field and operations staff will provide services within the Marcellus footprint. Being outside the Marcellus footprint does change the overall immediate visibility of the workforce impact, but the region will face many of the same challenges as other regions in Pennsylvania in attempting to take full advantage of Marcellus workforce and business opportunities. A few of the key workforce challenges across Pennsylvania include understanding the geographic distribution of the Marcellus industry, developing a basic understanding of natural gas development, developing a diverse network of energy sector contacts, and taking advantage of natural gas safety and training opportunities.

Marcellus Shale development in Pennsylvania is expected to increase in coming years, but the strength of Marcellus growth will continue to depend on the commodity price of natural gas, natural gas inventories, natural gas infrastructure development, natural gas utilization, and the overall health of the economy. Additionally, many areas will likely see increased natural gas activity, but development is expected to continue to be uneven. The current MSETC direct workforce assessment research suggests Pennsylvania drilling activity should increase significantly statewide. On a regional basis, the southwest and northwest portions of the state will see the largest increases with development in the northeast region moderating slightly. Current estimates for 2011-2014 statewide drilling activity include 1,599 Marcellus wells in 2011; 1,888 wells in 2012; 2,009 wells in 2013; and 2,159 wells in 2014. The company drilling projections indicate a rough annual growth rate in drilling activity of 6-18%, with a nearly 60% increase in overall activity by 2014.

To bring a single Marcellus well on line requires about 420 individuals across 150 different occupations. Each phase of natural gas development includes different workforce demands and varies based on the utilization of multi-well pads and the need for additional natural gas infrastructure. Utilizing 260 eight-hour days or 2,080 work hours per year, the first Marcellus well drilled on a well pad will require 13.1-13.3 full-time equivalent (FTE) workers and 9.65-9.85 FTE workers for each well drilled in succession on the same well pad. For development of a single Marcellus well, the initial pre-drilling phase of natural gas development represents about 18% of the entire workforce needed or 2.41 FTEs. The phase of natural gas development when the natural gas wells are drilled and the pipeline infrastructure is put into place is an extremely labor-intensive process and represents about 80% of the workforce for a single well or 10.50 FTEs. Finally, natural gas compression and processing requires about 2% of the overall workforce or 0.2-0.4 FTEs depending on dry, wet, or high-BTU natural gas processing needs.

Based on the Marcellus development in 2010, the MSETC model would project roughly 14,777 direct jobs were required to complete 1,368 wells, an increase of nearly 12,248 new jobs over 2008 job levels. Across the state of Pennsylvania, the total number of direct natural gas development jobs (not indirect or induced jobs) created by wells drilled between 2011 and 2014 is currently estimated to range between **18,596** and **30,684** FTE jobs, creating **9,800** to **15,900** new jobs over 2010 levels, depending on the total number of wells drilled.

This assessment is based solely on the employees *directly* involved in developing a well and placing it into production and **does not consider indirect or induced employment impacts**. The projections are not intended to serve as a measure of the total employment created by Marcellus Shale natural gas development or to estimate the economic impact of such development. The findings of this report, therefore, should not be compared to employment estimates of other studies, which most are intended to project the *overall* employment and economic impact of natural gas drilling in Pennsylvania using “multipliers” to estimate job creation in sectors other than those *directly* associated with the bringing of a Marcellus well into production. This report provides the best estimate currently available of workers needed to bring a Marcellus well into production and projected growth in labor demands around high priority occupations for the oil and gas industry.

The utilization of multi-well pads not only reduces the surface environmental footprint of a well pad, but also increases the efficiency of the natural gas exploration process and reduces the overall workforce needs by roughly 25%. The greatest multi-well pad workforce impacts result from a roughly 73% decrease in the need for pre-drilling occupations and a 16% decrease in drilling and completion jobs when two or more wells are drilled on the same well pad. If all Marcellus wells developed were single well pads, the workforce needs would increase labor demands by thousands of additional workers, but conversely the well pad surface footprint would also increase by six to ten times (depending on well spacing).

In actuality over 98% of natural gas exploration and development jobs are found in the pre-drilling and drilling phase of bringing a well into production, and this segment of the workforce will no longer be needed once the process of drilling gas wells and affiliated infrastructure in an area is completed. In the oil and natural gas industries, this drilling phase period is often referred to as “the boom” as vast

workforces are often suddenly required to perform tasks associated with natural gas development. Conversely, the drilling phase can suddenly decline, which is often referred to as the “the bust”.

The majority of the pre-drilling, drilling, and production phase jobs will be located in the vicinity of the well being drilled. Office workers and some geologic scientists, engineers, and supervisors will be located at energy, service, and support company offices, which may or may not be located near the vicinity of the well site or even within the region. In the development of Marcellus it is important to note that many of the drilling phase jobs will be geographically temporary, meaning a drilling rig moves from location to location, but the drilling phase jobs will continue to be stable jobs across much of the Appalachian Basin for an estimated 30 to 50 years.

In contrast to drilling phase jobs, jobs associated with the production phase are well defined as the management of an operating well, generally serve a fixed geographic area, and will last the lifetime of a producing Marcellus well. Even if drilling were to cease completely, the production phase jobs necessary to manage and maintain Marcellus wells would still be required for decades. In fact, many geologists believe the wells created as part of the Marcellus Shale development will likely produce commercial quantities of natural gas for 30 years or more.

As the Marcellus Play continues to mature, the industry has definitely moved towards hiring more Pennsylvania residents. Early in the development of the Marcellus, the natural gas industry relied heavily on out-of-state employees with experience and knowledge developing high-pressure natural gas. Although Pennsylvania drilled its first oil well in 1859, fluctuations in the commodity market and the prospects of stronger commercial gas fields in other areas drew much of the industry talent to other states. When Marcellus exploration and production began to ramp-up, there was tremendous pressure to find employees with some legacy natural gas knowledge. The early stages of development found as many as 70-80% of the employees from outside Pennsylvania. Although there is still tremendous variability across energy, service, and support companies, this study’s interview and survey data indicates an average of 65-75% of all new Marcellus workers are Pennsylvania residents.

Introduction

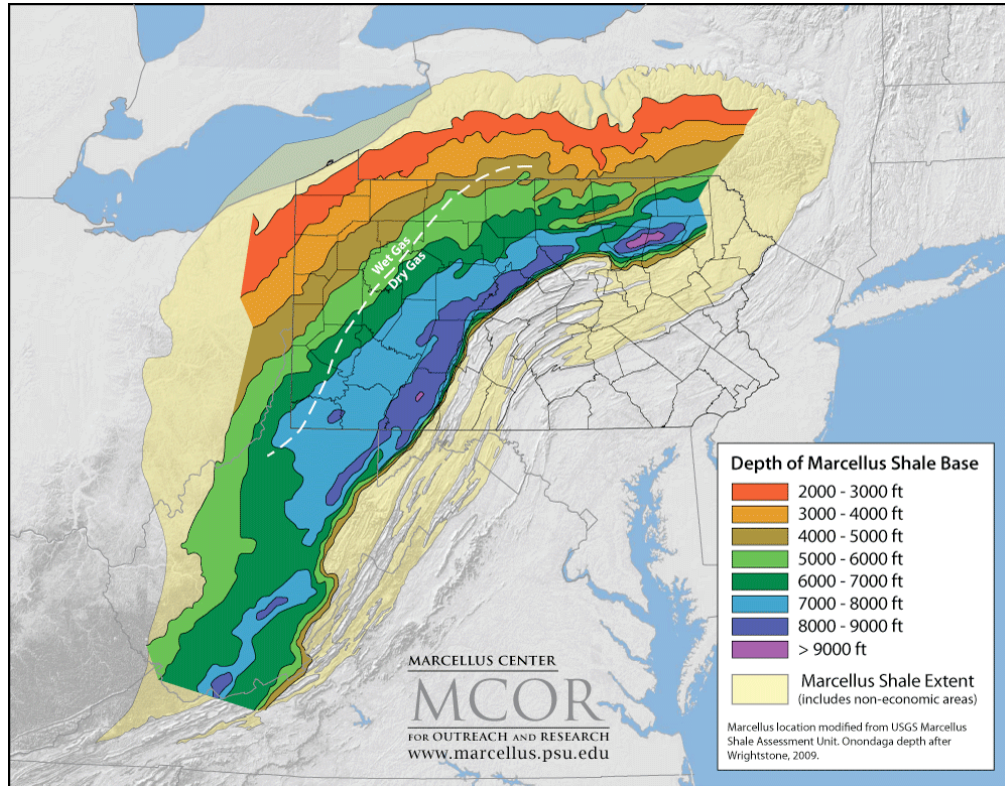
The Pennsylvania Marcellus Shale Workforce Needs Assessment is intended to supply baseline data to provide individuals, job seekers, communities, businesses, workforce and economic development professionals, and government officials at all levels with the ability to estimate the direct workforce requirements for Marcellus Shale development. Specifically, the assessment can help outline the key occupations associated with unconventional natural gas development and the number of direct jobs required to bring a Marcellus well into production in Pennsylvania between 2011 and 2014.

Marcellus Shale Natural Gas Play

Marcellus Shale is a very large natural gas formation extending across 95,000 square miles, running through roughly two-thirds of Pennsylvania and portions of New York, West Virginia, Virginia, Maryland, and Ohio (Figure 1). In Pennsylvania, development of Marcellus Shale began in Washington County in 2004. Over the next few years, the Marcellus development footprint quickly expanded to include significant portions of northeast Pennsylvania. Southwest Pennsylvania is increasingly being selected as a preferred location to establish Appalachian Basin headquarters for exploration and production, service, and supply companies. The hub of drilling activity in Pennsylvania has been more heavily concentrated in the northeast for 2010 and thus far in 2011. Today, more than 2,800 Marcellus wells have been drilled in Pennsylvania (Figure 2).

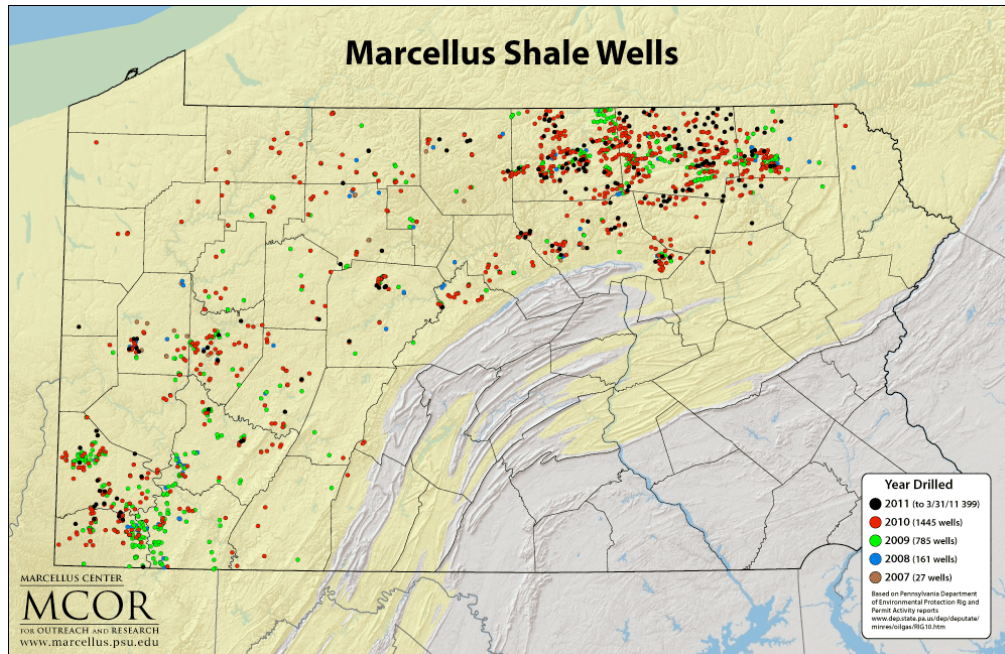
Energy companies continue to invest billions of dollars in exploration and production programs throughout Pennsylvania. Investments by industry include securing mineral rights and land, drilling, production stimulation, pipeline, compressor stations, processing, and a variety of other infrastructure investments necessary to realize the potential of Marcellus Shale. In 2010, two of the world's largest energy firms purchased large stakes in Marcellus Shale, and nearly all of the major firms active in the area continue to plan expansions of their development operations beyond 2011.

The reasons for the planned Marcellus expansion by exploration and production companies are due to a number of factors including, but not limited to, the relative infancy of the play, the close proximity of large consumer markets, proximity to major transmission lines, and the extreme amount of natural gas thought to be recoverable. The amount of total recoverable natural gas located within the formation is currently unknown, although recoverable gas estimates for Marcellus Shale have recently ranged from 262 to 489 trillion cubic feet (EIA, 2011; Englander, 2009). Regardless of the estimates, most geologists place the recoverable gas reserve potential among the largest in the nation and possibly the world.



Source: Marcellus Center for Outreach and Research, Penn State

Figure 1: Map of Marcellus Shale Footprint & Depth



Source: Marcellus Center for Outreach and Research, Penn State

Figure 2: Map of Marcellus Shale Wells as of March 31, 2011

Marcellus Shale development within Pennsylvania first occurred with significant intensity in the southwest region, with the first well drilled by Range Resources LLC in 2004 in Washington County and corresponding gas production in 2005 (Harper, 2008). Shortly after Marcellus development began in southwest Pennsylvania, the hub of drilling activity quickly shifted to the northeast region of Pennsylvania (Figures 3 and 4). With the recent dramatic increase in interest in high-BTU gas and the premium price commanded for liquids-rich natural gas, the southwest region appears poised for a resurgence in shale gas development related to the Marcellus, Utica, and other Upper Devonian Shale formations. A combination of limited natural gas infrastructure capacity and a need to develop lease holdings in non-traditional natural gas areas of Pennsylvania appears to have resulted in a moderation of development growth in the region over the last few years. Natural gas infrastructure capacity would include a need for additional pipeline and processing facilities required to bring “wet” or high-BTU gas to market. Although the pace of Marcellus development was slower in the southwest from 2008-2010, companies active in the area have made public statements that they intend to dramatically increase activity within the southwest region in 2011 and beyond. In fact, rig counts and permitting within the first four months of 2011 show activity levels should eclipse 2010 development. Additionally, Allegheny and Washington Counties also appear to be emerging as a future energy hub on the East Coast with a very high concentration of oil and gas related businesses locating Appalachian Basin operations there.

The northeast region of Pennsylvania saw moderate growth during initial stages of Marcellus development, with only 76 wells drilled in 2008, but expanded dramatically in 2009 and 2010. In the second half of 2009, development in the area began to ramp up quickly with 332 wells drilled. The core counties of the northeast region have quickly become a major Marcellus Shale development hotspot for the state, with 909 wells drilled in 2010 and more than 1,000 expected in 2011.

The southeast region of Pennsylvania is outside the currently defined Marcellus Shale footprint. Given the geographic proximity to the play, location of the Appalachian Basin and regional company headquarters, and a large workforce base, southeast Pennsylvania will experience some workforce demand in key core and ancillary occupations related to shale gas growth. Although, not as easy to quantify, the southeast region will likely see an increased need for construction workers, retail workers, mechanics, engineers, welders, commercial truck drivers, geologists, and more.

Much of the northwest region of Pennsylvania contains Marcellus Shale, but due to the shallower depth and thinner shale formation most of the areas are currently considered outside the primary geologic “Marcellus Fairway”. However, a number of energy companies have been drilling exploratory wells in the area, and several companies have announced plans to dedicate drilling rigs on the southern and eastern fronts of the northwest region. Permitting activity has increased in the region over the past few years, and drilling activity in the first four months of 2011 show continued growth and significant potential for commercial quantities of natural gas from the northwest region.

Figures 3 and 4 provide a breakdown of the number of wells drilled by region and by county across Pennsylvania.

Historical and Projected Drilling Activity & Median Estimated Workforce Requirements, 2008-2014												
	Southwest			Northeast			Northwest			Pennsylvania		
	Wells	Rigs	FTEs	Wells	Rigs	FTEs	Wells	Rigs	FTEs	Wells	Rigs	FTEs
2008	103	10	1,333	76	8	956	19	2	239	198	20	2,528
2009	370	37	4,319	332	33	3,745	61	6	689	763	76	8,753
2010	358	36	4,032	909	91	9,664	101	10	1,080	1,368	137	14,777
2011	449	37	5,095	1,020	85	10,971	130	11	1,401	1,599	133	17,467
2012	620	52	7,062	1,089	91	11,889	179	15	1,940	1,888	157	20,891
2013	760	63	8,734	1,069	89	11,884	180	15	1,985	2,009	167	22,603
2014	892	74	10,350	1,088	91	12,285	179	15	2,008	2,159	180	24,644

Figure 3: Historical and Projected Activity & Median Estimated Workforce Requirements, 2008-2014

Marcellus Wells Drilled by Region									
Northeast Region					Southwest Region				
County	2011*	2010	2009	2008	County	2011*	2010	2009	2008
Bradford	131	355	113	14	Allegheny	0	1	2	1
Carbon	0	0	0	0	Armstrong	6	29	17	2
Centre	6	38	7	5	Beaver	0	1	0	0
Clinton	6	33	12	3	Bedford	0	1	0	0
Columbia	1	1	0	0	Blair	1	5	0	0
Juniata	0	0	0	0	Butler	17	38	8	10
Lackawanna	0	0	1	0	Cambria	0	0	2	0
Luzerne	0	2	0	0	Fayette	0	19	55	18
Lycoming	68	102	24	13	Fulton	0	0	0	0
Mifflin	0	0	0	0	Greene	16	70	91	18
Monroe	0	0	0	0	Huntingdon	0	0	0	0
Montour	0	0	0	0	Indiana	7	9	8	3
Northumberland	0	0	0	0	Somerset	2	4	3	0
Pike	0	0	0	0	Washington	61	135	138	32
Schuylkill	0	0	0	0	Westmoreland	18	46	46	19
Snyder	0	0	0	0	Total SW:	128	358	370	103
Sullivan	8	18	0	0	Northwest Region				
Susquehanna	37	82	60	32	County	2011*	2010	2009	2008
Tioga	80	261	114	8	Cameron	0	4	1	0
Union	0	0	0	0	Clarion	0	1	4	0
Wayne	0	3	0	1	Clearfield	22	35	27	4
Wyoming	8	14	1	0	Crawford	0	0	0	0
Total NE:	345	909	332	76	Elk	2	8	4	8
					Erie	0	0	0	0
Statewide Totals:	515	1138	763	198	Forest	0	2	5	0
<i>Source: Pennsylvania Department of Environmental Protection. *2011 Data through May 1, 2011</i>					Jefferson	6	4	2	1
					Lawrence	2	0	0	0
					McKean	4	14	10	3
					Mercer	0	0	0	0
					Potter	5	33	8	3
					Venango	1	0	0	0
					Warren	0	0	0	0
					Total NW:	42	101	61	19

Figure 4: Marcellus Wells Drilled by Region (and County) in Pennsylvania

Finally, it should be noted that while the workforce numbers in the assessment reflect the geographic borders of Pennsylvania divided into four regions (northeast, northwest, southeast, and southwest) within the state (Figure 5), Marcellus development does not stop at the state border and encompasses most of the Appalachian Basin. It also should be noted there are no job estimates for the southeast region of Pennsylvania because no wells are being drilled in that region. Marcellus workforce activity in the southeast will be primarily limited to service, support, and supply-chain industries. The majority of the pre-drilling, drilling, and production phase jobs will be located in the vicinity of the well being drilled. Some examples of jobs that may or may not be located near the vicinity of the well site or even within the region could include office workers, geologists, engineers, and supervisors.

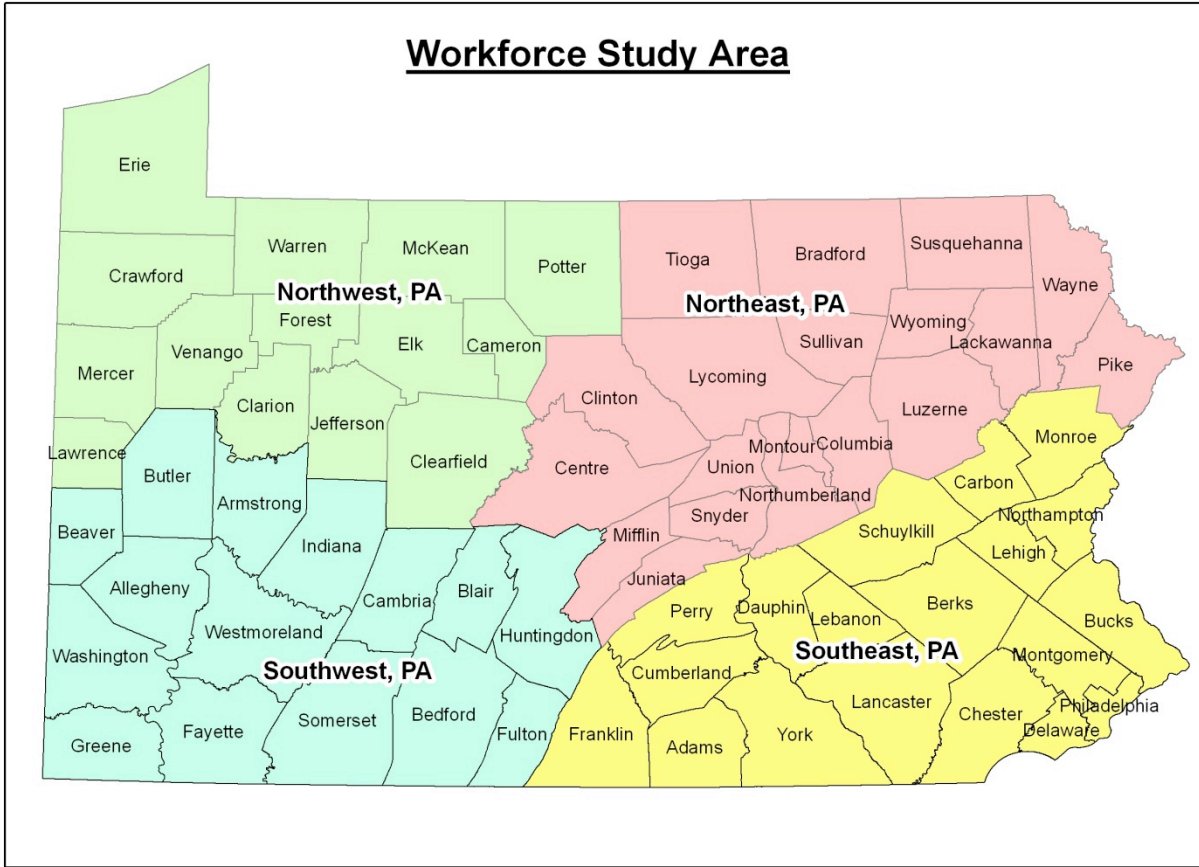


Figure 5: Marcellus Shale Direct Workforce Assessment Study Area

Statewide Development Projections

While region-specific sections are discussed, overall Marcellus Shale development in Pennsylvania is expected to increase in coming years as development growth occurs in the southwest and northwest regions and development in the northeast region remains steady. Based on interviews and survey data from energy companies, as well as from information gleaned from investor statements and public disclosures, current estimates for 2011-2014 statewide drilling activity include 1,599 Marcellus wells in 2011; 1,888 wells in 2012; 2,009 wells in 2013; and 2,159 wells in 2014.

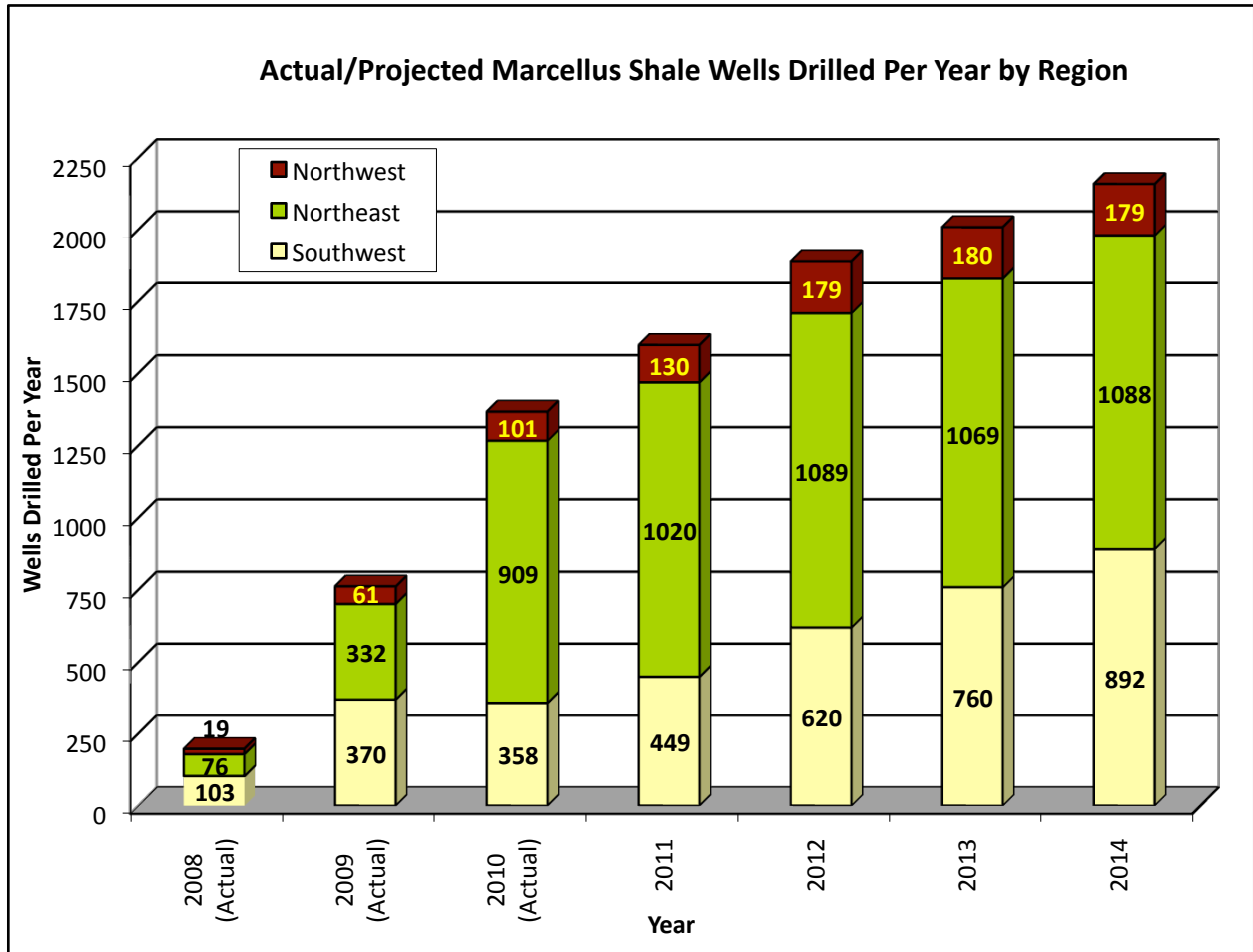


Table 1: Actual/Projected Marcellus Shale Wells Drilled Per Year by Region

Single Well Pads vs. Multi-Well Pads

The direct workforce assessment model used to determine workforce needs is based on the number of occupations and full-time equivalent (FTE) workers needed to bring a single Marcellus well into production. Over the last 18 months, the industry has shown a marked increase in the utilization of multi-well pads. Multi-well pads actually reduce the potential surface footprint of natural gas development and increase the efficiency of the exploration process. While increasing efficiency, the use of multi-well pads does decrease the overall required workforce. The amount of FTE savings really depends on how many wells are drilled consecutively on a single well pad. Wells that are drilled on existing pads require a smaller workforce for land clearing, pipeline construction, and equipment operation on a per well basis.

According to the Department of Environmental Protection’s 2007-2011 spud reports, the total number of wells spudded (started) as of May 15, 2011, included 2,966 wells. After correcting for duplicate well records and eliminating wells where a usable coordinate system could not be identified, 2,824 wells were identified for inclusion in geo-spatial analysis of well pad development in the Marcellus Play. Well pads were identified using a 250-foot buffer around each wellhead, meaning if another Marcellus well was within 250 feet there is a very high likelihood that the wells are on the same well pad (Figure 6).

Based on a geo-spatial analysis of drilling locations performed by the MSETC team for this study, it is estimated no wells drilled in 2007 were within 250 feet of another Marcellus well or on a multi-well pad, but by 2011 upwards of 78% of the wells drilled were on a well pad with at least one other Marcellus well (Figure 6). Sixty-five percent (65%) of wells drilled in 2011 were drilled on new multi-well pads, 13% were drilled on pads created in previous years, and 22% are currently single wells.

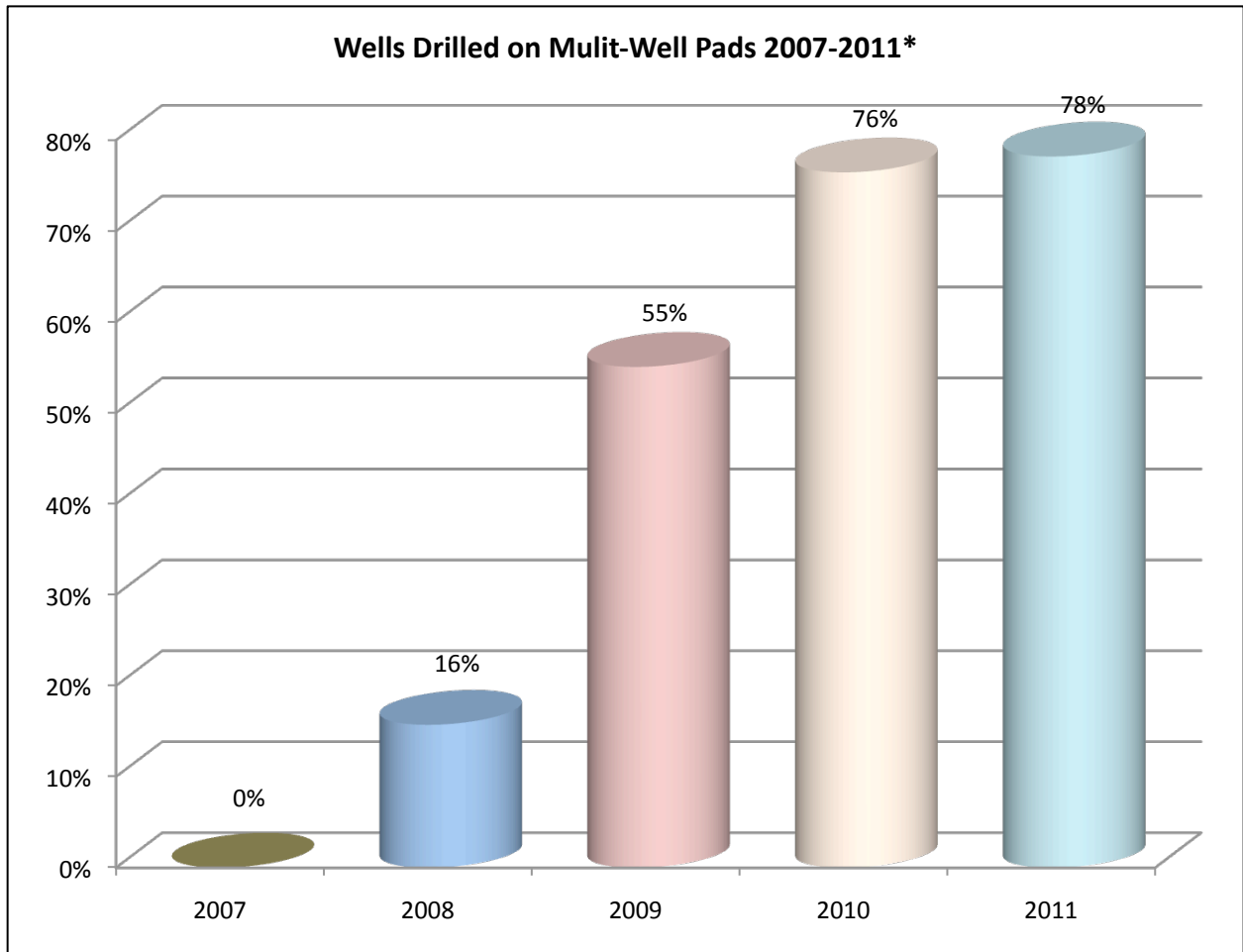


Figure 6: Wells on Multi-Well Pads, 2007-2011*

***2011 data current through May 3.**

If we look at multi-well pad development over time, our research revealed that about 17% of the Marcellus single well pads constructed in 2007 ultimately ended up as multi-well sites. Jumping ahead to 2010, 1,380 total wells were drilled, 126 wells (9%) were drilled on previously constructed well pads, 325 wells (24%) were on new single well pads, and 929 wells (67%) were drilled on newly constructed multi-well pads (Figure 7). If we focus on the 1,254 wells drilled on new well pads constructed in 2010, we find 74% of new wells were drilled on multi-well pads, and 26% of new wells were drilled on a single well pad. In 2010, a total of 580 new well pads were constructed with 56% of new well pads holding only one well (325 wells) and 44% holding two or more wells drilled on the same pad (929 wells) within a calendar year. Several variables can affect the development of multi-well pads; however, under the current development scenarios multi-well pads certainly dominate current production plans.

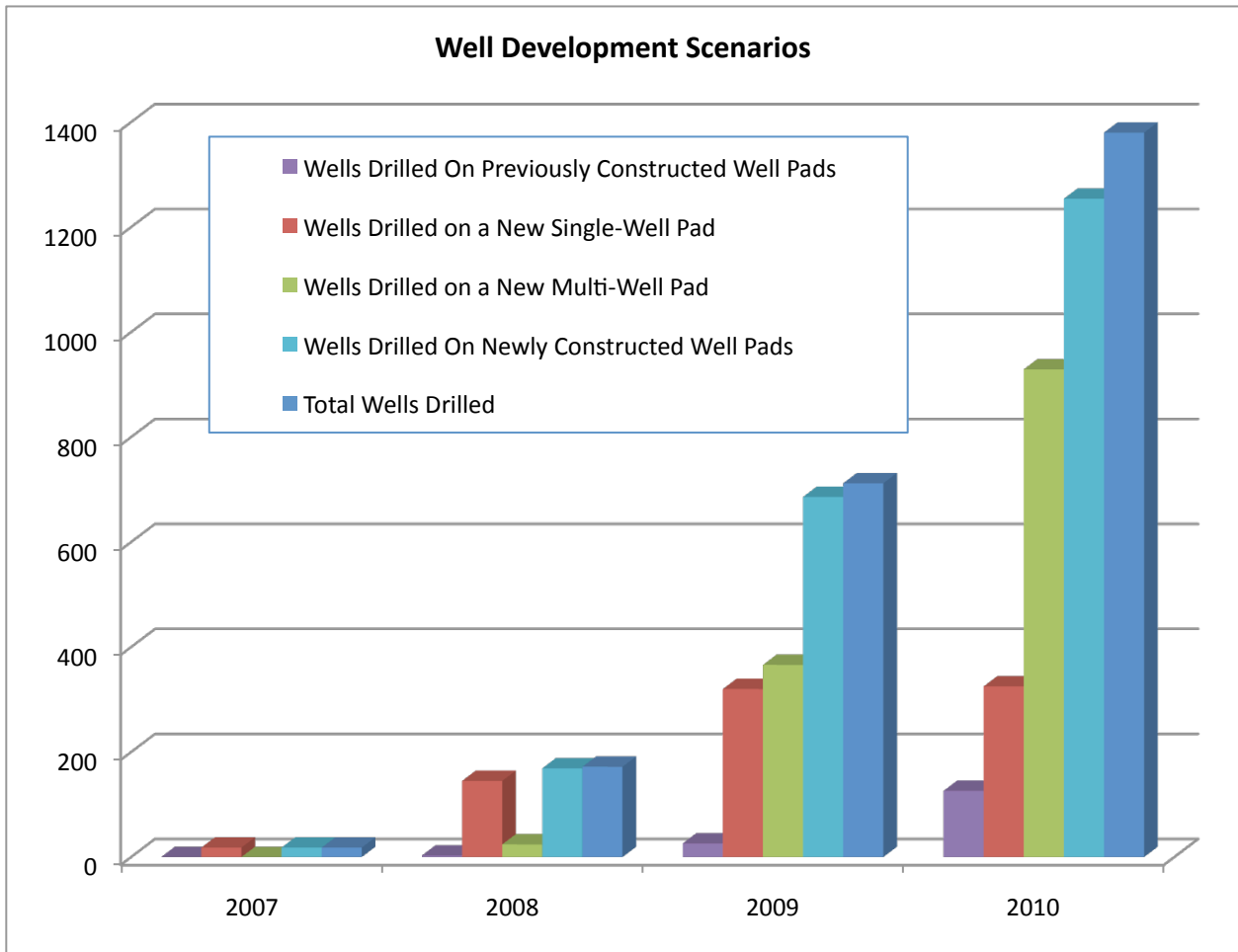


Figure 7: Well Pad Development Scenarios

One other important question to consider when analyzing workforce estimates and the process for developing multi-well pads is how many wells are actually being drilled per well pad in a given year. Rigging up for one well, drilling a well, rigging down, and coming back to the same well pad at a later date is far more labor intensive than drilling and completing multiple wells all at the same time.

Of the 580 well pads constructed in 2010, 255 (44%) were developed as multi-well pads while 325 (56%) had only one well when they were originally constructed. Today, of those same 580 well pads, 271 are multi-well pads, and 309 are still single well pads. Although there were more single well pads constructed in 2010, about 76% of the drilling activity took place on a multi-well pad. Roughly 18% of wells were drilled on a two-well pad, 12% on a three-well pad, 9% on a four-well pad, 7% on a five-well pad, and 31% were drilled on a six-well or more pad (Figure 8).

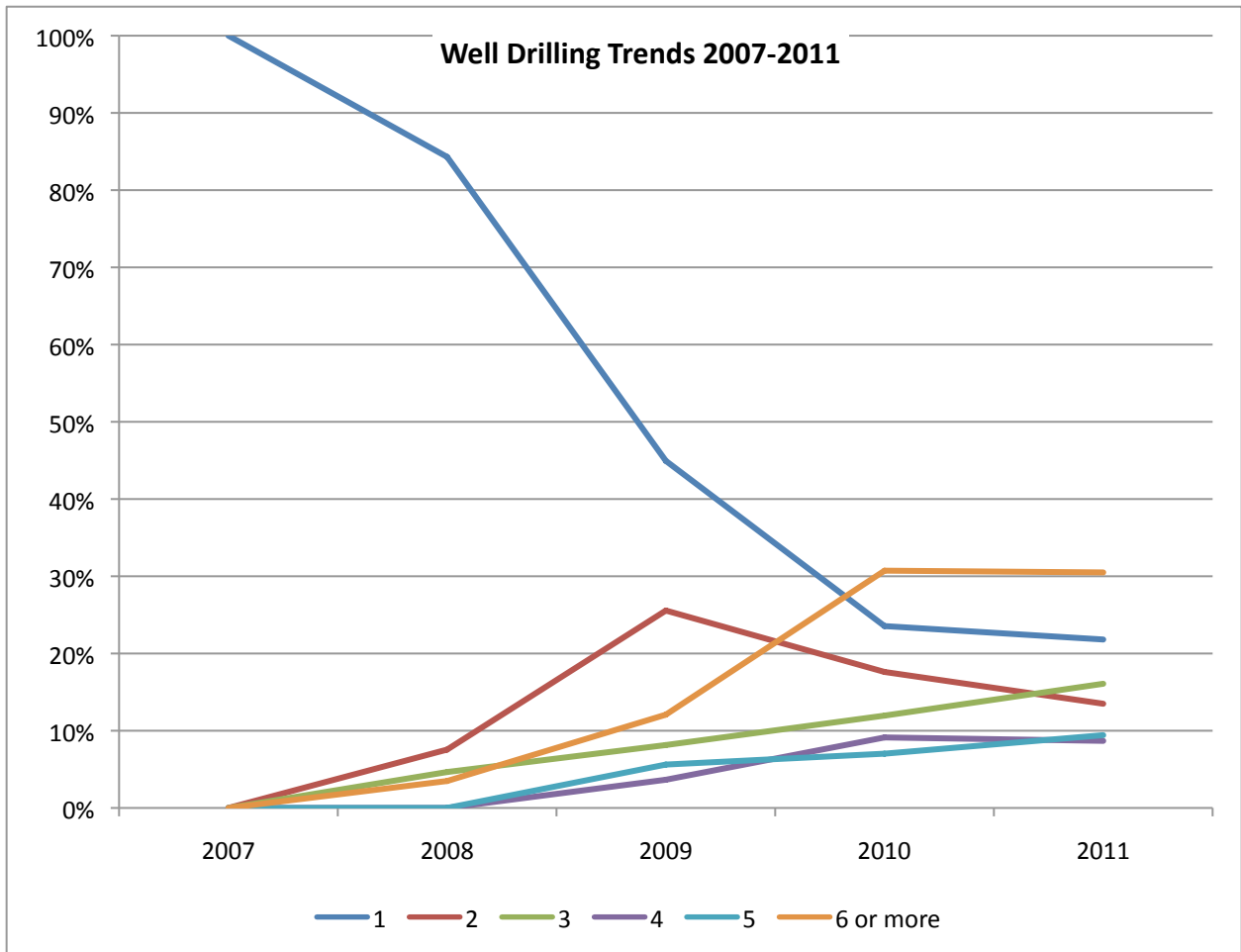


Figure 8: Wells Drilled By Well Pad Type

High-BTU Gas

A big factor in the projected increase of drilling activity in the southwest region is due to the economic attractiveness of liquids-rich, high-BTU gas found in parts of the Marcellus Shale located in southwestern Pennsylvania. High-BTU gas requires large processing facilities to extract liquids such as oil and heavy gasoline and to fractionate other gas compounds found within the produced methane. The result of high-BTU gas processing is a multitude of saleable products that can significantly raise the return on investment and produce potentially higher profits under lower natural gas commodity prices. Some media reports have labeled the attractiveness of high-BTU gas as a “Race to Liquids” as companies devote significant resources to liquid-rich areas (Braziel, 2010). Like many aspects of natural gas

development, the continued attractiveness of high-BTU gas will likely remain variable and dependent on a number of different factors, including commodity price.

The exact boundary of wet vs. dry gas is unclear at this time, although wet/high-BTU gas is understood to be principally found in western Pennsylvania (Figure 1). Projecting development activity that will occur specifically within the high-BTU gas region is more difficult. Permitting activity reported by the Pennsylvania Department of Environmental Protection, as well as discussions with operators in the area, suggest that between 60-75% of the wells drilled in the southwest region within the next several years may be liquids-rich, high-BTU gas that requires additional processing.

Introduction to the Natural Gas Industry Workforce

The Marcellus Shale development process differs significantly from that of Pennsylvania’s long tradition of extracting shallow gas and oil. Due to differences in geology, technology, and energy company practices the extraction of Marcellus Shale requires more employees and significantly greater input and utilization of supplies, materials, and equipment (Figure 9). Marcellus Shale gas is considered “unconventional” because the formation requires directional drilling, production stimulation, and other methods to produce commercial quantities of natural gas. These processes are much more industrial in nature, labor intensive, and technologically advanced than conventional shallow gas development. Unconventional natural gas shales are also known as a continuous geological formation. As a continuous formation, unconventional shale does require higher technology inputs but also reduces the development risk found in conventional formations, which rely on finding pockets of natural gas. Additionally, the energy companies and contractors that initially developed and utilized the unconventional shale drilling and extraction technology were mostly national or international companies and primarily utilized contractors and personnel with legacy shale gas knowledge from around the country and from other parts of the world to begin developing Marcellus Shale.

Extraction Timeline

Lifespan totaling approximately 30-50 years

		Pipeline Construction Construction time depends on pipeline length			
	Permitting Up to 2 mos.		Drilling 30-45 days		Natural Gas Production Wells can be productive over a 30-50 year period
Pre-Drilling			Drilling & Completion	Production/Reclamation	
Geology Studies Up to six months		Staking Well 30-60 days		Production Stimulation 1-2 wks.	Reclaiming 1 month +
Mineral Rights					

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Figure 9: Phases and Timeline of Development of Marcellus Shale Natural Gas Wells

History has shown that predicting future trends of the natural gas industry can be challenging and estimating the workforce requirements of this particular industry represents an even greater challenge. Natural gas development trends can be difficult to predict as commodity prices, technological changes,

new plays develop, and other factors can change the intensity and scope of exploration rather quickly. Additionally, a wide array of energy companies and an even wider array of subcontractors comprise the industry, and the resulting complex web of occupational needs and workforce requirements can be difficult to estimate even under ideal circumstances. Additionally, the industry challenges the general definition of an industry sector and local worker, as employees supporting natural gas development work across a variety of industry sectors and often work in multiple locations within a region to develop hundreds of different wells and infrastructure projects. Furthermore, industry employees will sometimes work 12-hour shifts for weeks at a time and then be afforded several continuous weeks of leave while an entirely new crew takes their place.

Locations and Residency

Due to the inherent uncertainty of development intensity, as well as the need to work at multiple locations, many of the initial Marcellus Shale-related workers remained transient residents of the region and kept their permanent residency at a location hundreds or even thousands of miles away. As the Marcellus Play continues to mature, the industry is moving towards a workforce that contains fewer transient workers and more permanent Pennsylvania residents.

Since many contractors and subcontractors are accustomed to working at multiple and changing locations throughout North America and the world, it is commonplace within the natural gas industry to initially utilize non-local workers and supply-chain services. However, as development moves forward over the course of months and years, contractors and subcontractors will either relocate to the local area, or local businesses will be created to meet industry needs. National and international drilling companies, gas field service companies, and gas field construction firms have already opened regional offices in southwest and northeast Pennsylvania. Many of these companies initially brought an external workforce with them to the area, but are in the process of replacing this workforce with local workers as opportunities arise. In addition, many companies that have historically catered to conventional shallow natural gas and oil field development have significantly augmented their businesses to include work in Marcellus Shale.

As the Marcellus Play continues to mature, the industry has definitely moved towards hiring more Pennsylvania residents. Early in the development of the Marcellus, the natural gas industry relied heavily on out-of-state employees with experience and knowledge developing high-pressure natural gas. Although Pennsylvania drilled its first oil well in 1859, fluctuations in the commodity market and the prospects of stronger commercial gas fields in other areas drew much of the industry talent to other states. When Marcellus exploration and production began to ramp-up, there was tremendous pressure to find employees with some legacy natural gas knowledge, and the early stages of development found as many as 70-80% of the employees were from outside Pennsylvania. Although there is still tremendous variability across energy, service, and support companies, based on recent interviews and survey data the percentage of new industry hires who are Pennsylvania residents today ranges from 50-100% with an approximate average of 65-75% of new Marcellus workers being Pennsylvania residents. A Pennsylvania resident was defined as an employee who has lived in Pennsylvania for at least one year and holds a valid Pennsylvania driver's license. In a separate analysis of residency data using wage and

employment records for workers in the gas and oil industry in Pennsylvania, the Pennsylvania Department of Labor and Industry found that 71% of new hires in 2010 in natural gas core and ancillary industries operating in the Marcellus Shale region were from Pennsylvania (Mukherjee, 2010).

Drilling Phase Jobs vs. Production Phase Jobs

The natural gas development process is such that a large proportion of the total industry workforce will be required during the well drilling phase, while a small minority of the workforce will be required for the long-term production phase. Pre-drilling and drilling phase jobs are grouped together for purposes of this section of the assessment.

Pre-drilling and Drilling Phase Jobs

The phase of natural gas development during which the natural gas wells are drilled and the associated pipeline infrastructure is put into place is an extremely labor-intensive process. In actuality over 98% of natural gas exploration and development jobs are found in the pre-drilling and drilling phase of bringing a well into production, and this segment of the workforce will no longer be needed once the process of drilling gas wells and affiliated infrastructure in an area is completed. In the oil and natural gas industries, this drilling phase period is often referred to as “the boom” as vast workforces are often suddenly required to perform tasks associated with natural gas development. Conversely, the drilling phase can suddenly decline, which is often referred to as the “the bust”. Given the level of mobility required, many employees in the drilling phase of gas development maintain temporary residency in a given area – such as in motels/hotels, RVs, “man camps”, monthly apartment/house leases, etc.

No one can accurately estimate how long the drilling phase will last within Marcellus Shale or within specific areas of the shale formation. Drilling phase estimates have ranged from 10 to 70 years, which in part reflects uncertainty created by future fluctuations in commodity prices, economic conditions, and technological changes, among other variables. A number of drilling scenarios are possible for future Marcellus development, and they include a relatively quick flurry of activity that subsides when drilling moves to another location, high intensity drilling that jumps from hotspot to hotspot, and moderate and sustained drilling across the Appalachian Basin lasting for decades. Each development scenario changes the direct workforce needs, local workforce requirements, and opportunities for business development and entrepreneurship.

Production Phase Jobs

In contrast to drilling phase jobs, jobs associated with the production phase are well defined as the management of an operating well, generally serve a fixed geographic area, and will last the lifetime of a producing Marcellus well. Even if drilling were to cease completely, the production phase jobs necessary to manage and maintain Marcellus wells would still be required for decades. In fact, many geologists believe the wells created as part of the Marcellus Shale development will likely produce commercial quantities of natural gas for 30 years or more.

Within the industry, careers associated with the production phase are often referred to as long-term or even “permanent”. Occupations during the production phase tend to be less labor intensive, with fewer

hazards involved, and more specialization than development phase occupations, while still retaining excellent salary and benefits. Jobs associated with production activities almost always result in local residency and often utilize local workforces.

The duration of the production phase will vary from region to region. In the western part of the state, for example, the high-BTU gas that is present in the majority of the natural gas offers additional opportunities for local production phase jobs. These additional natural gas processing opportunities are not present in other areas of the state. Local high-BTU natural gas processing is needed to fractionate or remove non-methane compounds (non-natural gas such as butane, ethane, propane, etc.) and liquids (oil, water, heavy gasoline, etc.) that naturally occur in the natural gas. Similar to other natural gas production, high-BTU processing facilities and jobs will remain stable for the life of the well and significantly longer than drilling operations. Occupations associated with high-BTU gas production are somewhat similar to other production phase occupations and include compressor operations, pipeline maintenance and technicians, information technology, gauge monitoring, supervisory positions, process engineers, loaders/testers, etc.

The MSETC Workforce Model

Given the complex web of occupations that constitute the natural gas industry workforce, traditional methods of measuring future job creation used in other industries are often inadequate. Many of the industries that participate in the development of a natural gas field are usually not present in the area before the natural gas development process begins; thus capturing their workforce needs using most workforce projection models is ineffective at best given there is no local baseline data. Similarly, given the uncertainty in natural gas development, job estimates predicated solely on posted job openings or industry questionnaires – while providing an accurate snapshot of current demand – are largely inflexible to the constantly changing intensity of development activity. Finally, given the intense use of subcontractors by most exploration and production companies, using a strict definition of “local” as a municipal boundary or “industry” as only a natural gas industry economic code does not accurately reflect the complexity, interconnectedness, and the true scope of natural gas related jobs and opportunities.

Methodology

Over the course of nearly three years, the Marcellus Shale Education & Training Center (MSETC) team has developed and refined the method used in this study to estimate the workforce requirements of the natural gas industry. The methodology focuses on analyzing the types and numbers of workers needed to drill a single Marcellus Shale gas well and then extrapolates that data to achieve a total workforce requirement based on estimates of future well drilling. At the core of the MSETC model is a full-time equivalent (FTE) calculation for each worker associated with drilling a single Marcellus Shale well. An FTE for each worker is 260 eight-hour days or 2,080 hours per year. Many tasks that occur during the well development process may only require a few workdays to complete. Therefore, the “per well” work requirement for most of the occupational categories ranged from 1/10 to 1/100 of an FTE. Some very

labor-intensive occupations such as heavy equipment operation, office staff, and drilling rig operation (roughnecks) constituted an equivalent that ranged between 1/10 to as many as two (2) FTEs per well.

Determining fractional FTE numbers for each worker directly associated with drilling a natural gas well is a complex and time consuming process. FTE numbers for the majority of occupations involve identifying the number of workers in a particular occupation or work crew and then determining the number of days the workers typically spend on a well site or in support of well site development. FTE numbers for a portion of the occupations - including pipeline construction, land clearing, office staff, etc. – are highly variable from company to company based on specific conditions; therefore, rough averages were used to reduce the differences in company development practices.

A critical element in total workforce projection formula used in the MSETC model is the number of wells drilled by a single drilling rig in a given year. In research across both Pennsylvania and Texas, it was determined a large rotary rig drills about 12 wells per year. The efficiency of drilling operations in Pennsylvania has definitely increased by roughly 20% over the last three years. The utilization of multi-well pads, an increase in the number of built-for-purpose Marcellus rigs, and the increase in local drilling knowledge have all contributed to this increased efficiency.

$\frac{(\text{Workers Per Well}) \times (\text{Work Days Per Well})}{260} \times (\text{Drilling Rigs} \times 12) = \text{Workforce Full Time Equivalent (FTE)}$
<p><i>The average number of workdays for one FTE worker is equal to 260. A Marcellus Shale drilling rig will drill 12 wells per year on average, which has increased from 10 wells per year in previous models.</i></p>

Figure 10: General Equation Behind Workforce Model

History of This Workforce Model

In 2009, the MSETC team worked closely with representatives from a number of energy firms, drilling companies, and subcontractors operating in the Northern Tier and Central regions of Pennsylvania to produce a workforce needs assessment for the Central Pennsylvania Workforce Development Corporation, Northern Tier Regional Planning and Development Commission, through Pennsylvania Department of Labor and Industry Partnership funding. During the initial assessment process, nearly 150 occupational categories and/or skill groups were identified.

In the spring of 2010, the MSETC team performed in-depth interviews with many of the major Marcellus Shale energy companies, drilling companies, and service providers operating in the southwest region. The exploration and production companies interviewed represent slightly more than 88% of all permitting activity in 2009-2010. These discussions were designed to revise or reconfirm the data obtained in the 2009 study and to identify differences in industry practices and jobs in the southwest region. To solidify the interview data, the MSETC team created an online workforce needs assessment in the summer of 2010 for gas industry representatives. Thirty (30) respondents completed the online workforce assessment.

For this report, the MSETC team performed interviews in early 2011 with Marcellus Shale energy companies, drilling companies, and service providers throughout Pennsylvania to update previously obtained workforce information and expand the data to include a statewide focus. In-depth interviews

were performed with eight companies. Additionally, an online survey instrument was distributed to 346 individuals across 175 different companies, of which 62 individual responses/46 company responses were returned. Of the 46 industry responses, 13 exploration and production companies returned the survey representing over 76% of all drilling activity in 2010. Other company respondents included 3 service companies, 4 drilling companies, 3 construction companies, and 23 support companies.

In each of the studies, a major step in creating a viable workforce projection model is to estimate future drilling rig activity. For this report, in addition to working with energy operators and subcontractors, the MSETC team reviewed investor statements, press releases, and public statements made by energy company officials regarding their plans for future drilling activity in the region. The results from company interviews and the online workforce assessment helped to confirm the rig/drilling estimates.

Advantages, Limitations, and Key Assumptions of the MSETC Model Methodology

The MSETC model allows the user to identify a projected level of development intensity as measured by wells drilled per year (the input) and project the number of workers based on occupational categories (the output) required for the expected level of development.

For the purposes of assessing potential workforce needs and workforce development capabilities, this type of model is superior to a number of different methods; however, this model still has a number of different limitations. The assessment is based solely on the employees *directly* involved in developing a well and placing it into production and **does not consider indirect or induced employment impacts**. The projections are not intended to serve as a measure of the total employment created by Marcellus Shale natural gas development or to estimate the economic impact of such development. The findings of this report, therefore, should not be compared to employment estimates of other studies, which most are intended to project the *overall* employment and economic impact of natural gas drilling in Pennsylvania using “multipliers” to estimate job creation in sectors other than those *directly* associated with the bringing of a Marcellus well into production. This report provides the best estimate currently available of workers needed to bring a Marcellus well into production and projected growth in labor demands around high priority occupations for the oil and gas industry.

The advantages, limitations, and key assumptions of the model and methodology follow.

Advantages:

- Offers much more specific occupational descriptions than generic “industrial classifications”
- Does not include/exclude based on industrial classifications
- Uses direct worker requirements, not complex imputations of requirements
- Does not include/exclude based on the geographic locations of business offices
- Does not rely primarily on sampling or response rates (such as surveys)
- Can easily be changed as development scenarios fluctuate

- Allows for triangulation of multiple data sources
- Accounts for differences in single well and multi-well pad workforce needs
- Includes differences in high-BTU and dry gas workforce requirements

Limitations:

- Does not (currently) calculate the specific workplace locations of all the occupations; most occupations will occur at the development site, but other occupations may occur elsewhere in the state or country
- Does not (currently) specifically calculate or define indirect or induced economic or workforce impacts of these jobs (e.g. additional jobs created by businesses providing this indirect or supply-chain support, such as for parts and materials, maintenance and repair, equipment, janitorial services, office supplies, etc., and additional jobs created by the workers spending their income)
- Does not differentiate the type of labor force (i.e. corporate, individual business owner, organized labor shops, open shops, etc.)
- Does not include many indirect or supply-chain industries or workforces
- Does not provide business-specific information such as name, size, location, etc.
- Does not include all workers/contractors (such as all contracted legal services)

Key Assumptions:

- Full-time equivalent (FTE) is defined at 260 eight-hour workdays or 2,080 hours per year
- 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)

Key Assumptions of High-BTU Gas Workforce Estimates

The workforce associated with high-BTU gas processing facilities located in portions of western Pennsylvania and West Virginia do not easily conform to a per-well estimate, as these jobs are directly tied to the volume of natural gas production and not numbers of wells developed. As drilling operations expand in an area, the volume of natural gas produced should also increase. Increased volume means an increased need for natural gas processing and associated jobs in high-BTU areas. However, if drilling levels off or declines, the volume of natural gas needing to be processed will also decline potentially

reducing the number of processing jobs. Additionally, Marcellus wells have a relatively steep decline curve, meaning the number of natural gas jobs is not only tied to increases in natural gas volume based on new drilling, but decreases in volume as a well ages. Understanding these somewhat complex volume calculations and using detailed interviews with gas processing companies, the MSETC model based the high-BTU processing workforce estimates on the following assumptions:

- Roughly 60% of wells drilled in southwest Pennsylvania will be located in high-BTU gas areas
- The production facility capacity and staffing is approximately one FTE for every 7.5 million cubic feet of gas processed per day
- Each well will follow an average production curve of Year 1: 4.5MMcf/d; Year 2: 1.1MMcf/d; Year 3: 700Mcf/d; Year 4: 560Mcf/d; Year 5: 470Mcf/d
- The expected ultimate recovery (EUR) for an average Marcellus well will be 3.5 billion cubic feet (BCF) of natural gas

Key Assumptions for FTEs for Multiple Well Pads

Over the last two years, the key exploration and production companies have clearly started to realize the efficiency of constructing and drilling multi-well pads. While the development strategy of multi-well pads does vary significantly from company to company the overall emerging trend is clearly toward multi-well development. In fact, 76% of all wells drilled in 2010 were on a pad with at least one other well (929 wells were drilled on new well pads constructed in 2010, and 126 wells were drilled on well pads constructed in 2008 or 2009). Based on the efficiency of multi-well pads, the MSETC model uses the following workforce assumptions:

- Pre-drilling jobs decrease by 73% for subsequent drilling operations on the same well pad
- Drilling and completion jobs decrease by roughly 16% for subsequent drilling operations on the same well pad
- Production operations workforce remain roughly the same
- Partially developed pads will not have the same workforce efficiency; however, fewer than 8% (224 wells) of all Marcellus wells developed to-date were drilled on previously constructed well pads

Natural Gas Workforce Requirements Interviews, Focus Groups, and Online Workforce Assessment

A comprehensive understanding of the natural gas development exploration and production, service, and support companies is necessary to build an accurate workforce model. Across all three direct workforce studies completed to date, 22 companies were directly interviewed, more than 40 companies participated in three focus group sessions related to the construction and evaluation of the occupational matrix, and more than 100 online assessment responses were returned to help build and confirm the

occupational skills and FTE workers. Again, the purpose of the interviews and online workforce assessment was to obtain projections of drilling activity, re-affirm key occupation and FTE assumptions of the workforce model, and provide a basis to triangulate different data sources.

In general, the results of the online workforce assessment confirmed much of the interview data regarding well development projections, workforce development, and assumptions about workforce needs. While the respondents to the online workforce assessment remained anonymous, respondent estimates of well development activity within the next five years were very similar to published reports and in-person interviews with operators.

Online workforce assessment results regarding questions about workforce development and hiring practices revealed similar results to the 2009 MSETC report and historical data from other natural gas plays. Companies indicated finding individuals with the proper work ethic, general mechanical aptitude, and general experience within the industry remained the largest barriers to finding local workers (Figure 11). Most respondents indicated they used some type of training programs, with the vast majority indicating a need for industrial certifications, vocational training, or technical college (Figure 12). These findings are consistent with the occupational matrix that shows over 75% of the Marcellus workforce will need a high school diploma or a specialized certification such as API 1104 downhand welding or a commercial driver's license.

Biggest Challenges to Finding New Workers

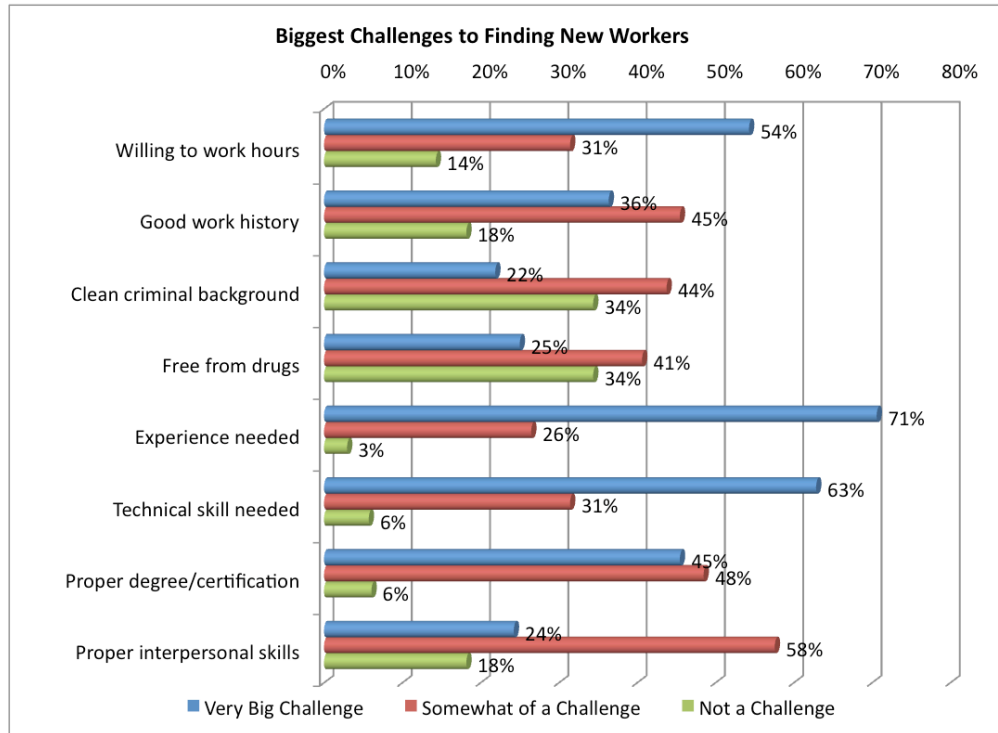


Figure 11: Biggest Challenges to Finding New Workers

Education and Training Programs Most Needed

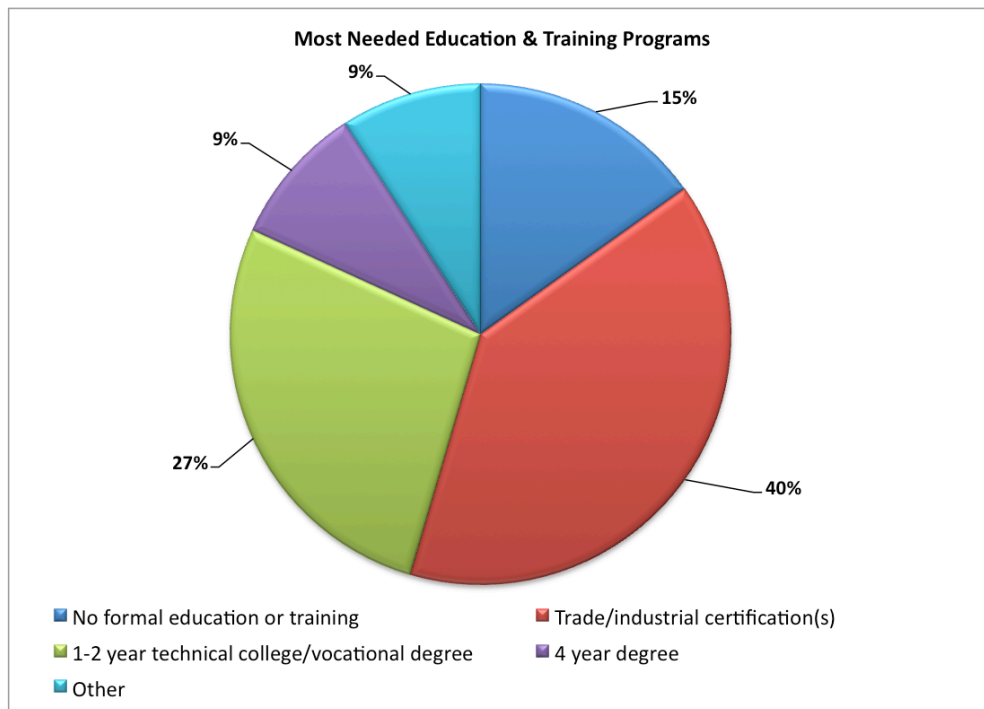


Figure 12: Education and Training Programs Most Needed

Specific occupational areas that have shown the greatest demand include general and semi-skilled office staff, engineering and geology-related occupations, and supervisory roles throughout a range of different types of companies.

Workforce Model Results

Full-Time Work Equivalent (FTE) to Drill One Marcellus Shale Well

The MSETC model reveals that over 420 individuals working across nearly 150 different occupations are needed to perform all the operations required to complete and produce gas from a single Marcellus Shale well. The total hours worked by these individuals are the equivalent of 13.10 FTE direct jobs over the course of a year for dry gas wells. Of these FTEs, 12.9 are required during the pre-drilling and drilling phase, while 0.19 are required during the production phase. For additional wells drilled on a previously constructed well pad, the total FTEs required drops to 9.64. Of the 9.64 FTEs, 0.65 are required during pre-drilling, 8.81 during drilling, and 0.19 during production phase. As is discussed in the following section, the FTE for high-BTU gas wells will change over time.

FTE 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	0.20	0.20
Dry Gas Total	13.09	9.65
High-BTU Gas Total	13.29	9.85
¹ Dry Gas Calculation ² High-BTU Gas Calculation ³ Includes Pipeline Construction		

Figure 13: FTE by Phase and Type of Well

It is important to note that pre-drilling and drilling phase jobs for each well do not compound year after year. These workers are required only while wells are being drilled and are a function of the number of wells being drilled each year. For example, if 100 single wells are drilled per year, then the total drilling phase workforce will be 1,290. If 100 single wells are drilled per year for 10 straight years, the total drilling phase workforce will still remain very close to 1,290. Although these jobs follow the drilling development and the true length of activity remains uncertain, drilling jobs, while geographically short-term, may still be long-term Pennsylvania jobs depending on the development scenario (sustained, hotspot, or flurry development outlined previously).

The vast majority of jobs directly associated with the staking, scoping, permitting, engineering, logging, clearing, drilling, moving, finishing, cementing, completing, and producing a well are included in the estimate, as well as the majority of jobs required to clear, dig, and construct collector pipeline and compressor station infrastructure for the well. The workforce estimate includes the vast majority of occupations directly associated with the drilling and completion process, but does not include many of the indirect jobs that will be created in a variety of occupations ranging from legal advice to gravel quarrying to steel pipe fabrication.

Production Phase FTEs

While the vast majority of jobs associated with the natural gas industry occur during the pre-drilling and drilling phase, a number of jobs are associated with monitoring the long-term health and production capability of a natural gas well. These production jobs will be required for as long as wells are producing commercial quantities of natural gas, which is currently estimated by university scientists and the exploration and production companies in Marcellus Shale to be over a 30 to 40 year period. The workforce model estimates that 0.19 of these long-term, full-time jobs are created for each dry gas well drilled in a given field (or approximately one worker for every five wells drilled), and 0.39 jobs for every high-BTU well drilled over the next five years. Production jobs do compound each year as more wells are drilled, while processing jobs will be influenced by the volume of natural gas produced. For example, if 100 dry gas wells were drilled per year for 10 years, 19 of these long-term jobs would be created each year, for a total of 190 long-term jobs created after 10 years. In addition to being long-term in nature, these jobs typically retain the excellent salary and benefits found in natural gas development but are generally less hazardous and less labor intensive than jobs associated with the drilling phase.

Jobs associated with high-BTU gas processing also increase as the volume of natural gas increases; however, the amount of required workers per well will decrease over time as the volume of gas that is produced from a well also decreases. Approximately 0.20 processing jobs are created per high-BTU gas well for the first five years of production from a well, while over the 30-year life of a well the average FTE calculation for gas processing on a per well basis may be closer to 0.02. However, since this report is limited to a 2014 time horizon, 0.2 FTEs per well are used to extrapolate total workforce estimates. During the drilling phase of development, new wells will continue to be drilled; therefore, even though the amount of production for each well is decreasing, the total gas production within a region may continue to increase and thus require a larger workforce until drilling activity slows.

“Direct” Job Creation

As previously noted, the jobs projected in this assessment are only those directly associated with drilling and completing a Marcellus Shale natural gas well and related pipeline construction. Jobs that are not directly associated with the industrial process are not included in this model and are outside the scope of this report. Since the analysis focuses on the specific jobs required for drilling and production without regard to formal industry sectors, it would be illogical to apply workforce or economic multipliers to it, which typically are based upon specific industry sectors.

Statewide Direct Workforce Requirements

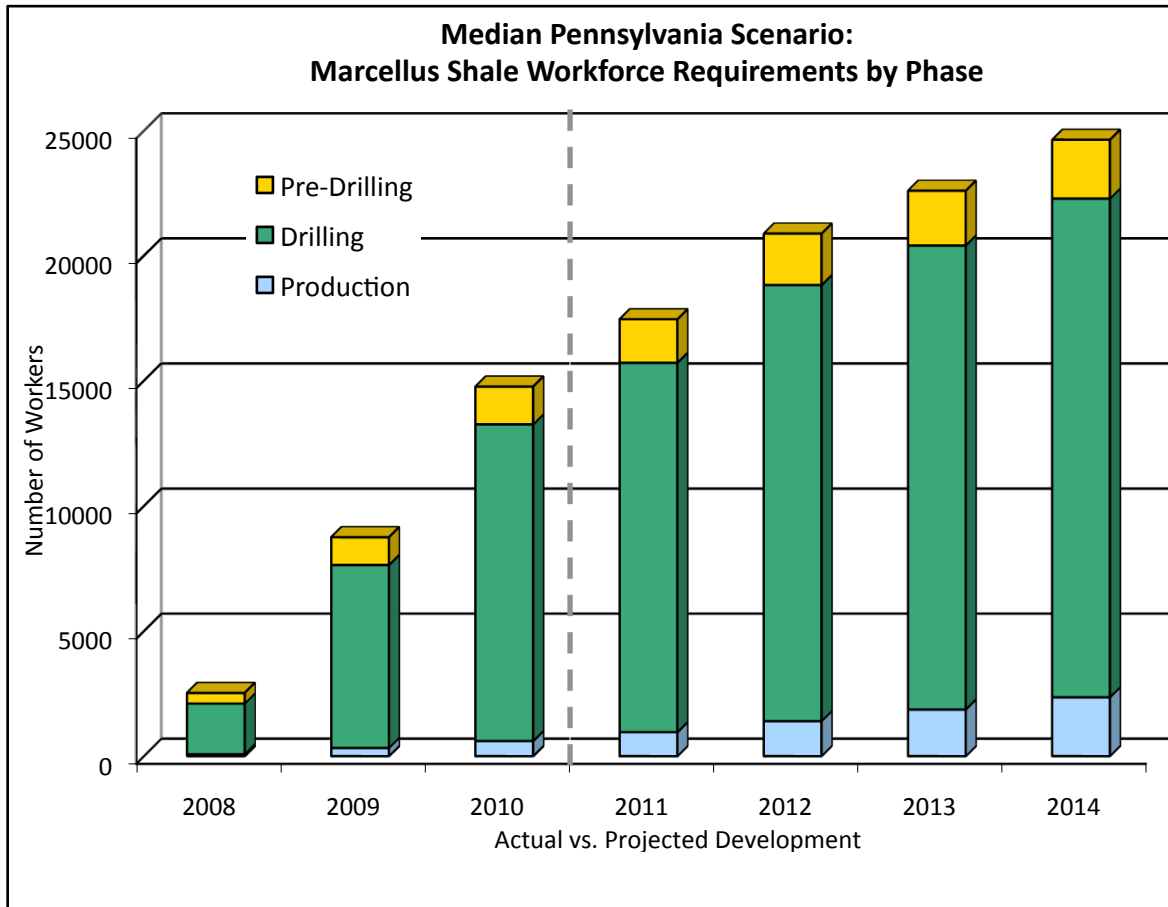


Figure 14: Median Pennsylvania Scenario Marcellus Shale Workforce Requirements by Phase

Previous and Current Workforce Requirements

Applying the MSETC workforce projection model to the previous and current levels of development in Pennsylvania shows an estimated equivalent of **2,528** direct jobs (or FTEs) created throughout Pennsylvania in 2008, increasing to **14,777** FTEs in 2010. Using the well development projections discussed in previous sections, it is estimated that between **13,224** and **21,710** FTE jobs would be required in 2011, with approximately **17,467** FTE jobs being the median workforce development estimate based on development projections given by energy companies. The number of production phase jobs created between 2008 and 2011 is estimated from **843** to **1,075**, with **959** being the median estimate, depending on drilling activity during the remainder of 2011.

Estimated Future Workforce Requirements

The model indicates that the number of jobs will increase between 2011 to 2014 along with increased levels of drilling activity. Based on the Marcellus development in 2010, the MSETC model would project roughly 14,777 direct jobs were required to complete 1,368 wells, an increase of nearly 12,248 new jobs over 2008 job levels. The FTE direct workforce is expected to increase by 1,000 to 11,000 new jobs over 2010 levels by the end of 2012, and using the median and high estimates the model projects between 9,800 and 15,900 new jobs by the end of 2014. The total direct workforce needed to meet current 2012

drilling predictions will likely fall between **15,788** and **25,994** total workers. By 2014, the total direct workforce number is expected to range from **18,596** to **30,684** depending on the development activity, with **24,644** representing a median direct workforce estimate.

The total number of production phase jobs (including gas processing) created by wells drilled between 2011 and 2014 will total between **1,879** and **2,822** FTE jobs, depending on the total number of wells drilled.

Northeast Region

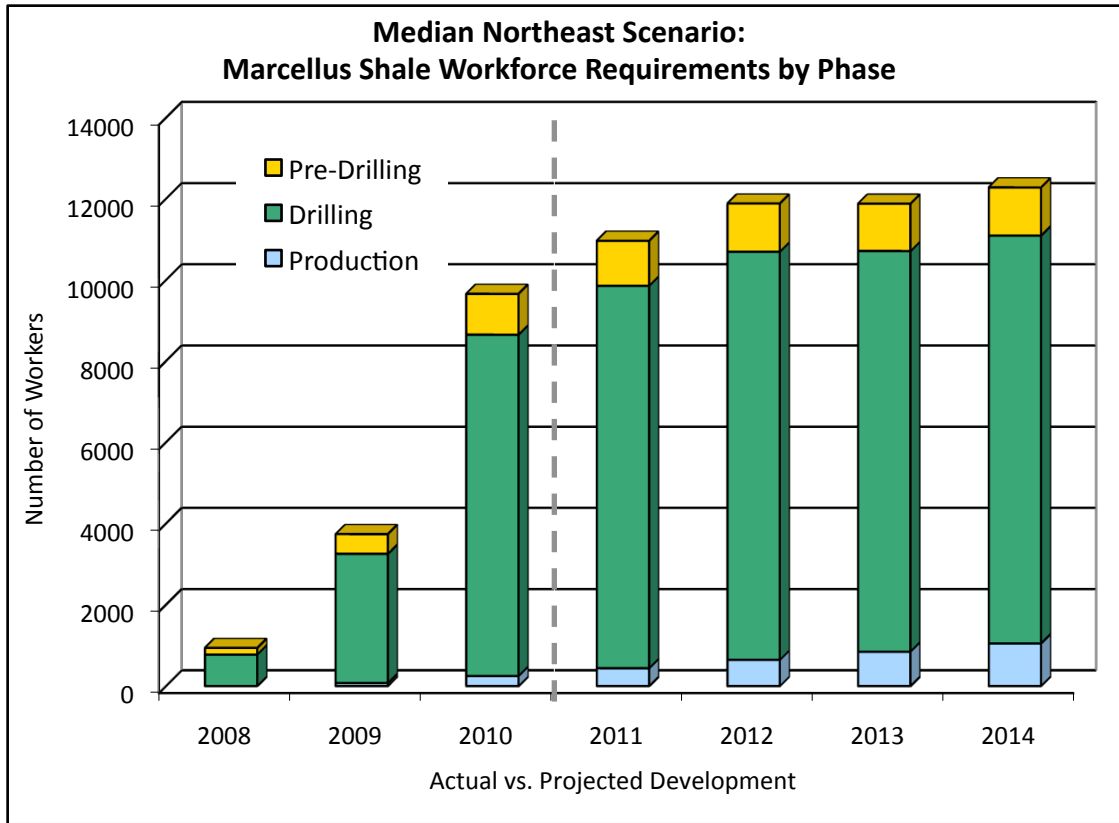


Figure 15: Median Northeast Region Scenario Marcellus Shale Workforce Requirements by Phase

Previous and Current Workforce Requirements

Applying the MSETC workforce projection model to the previous and current 2011 well drilling activity in Bradford, Carbon, Centre, Clinton, Columbia, Juniata, Lackawanna, Luzerne, Lycoming, Mifflin, Monroe, Montour, Northumberland, Pike, Schuylkill, Snyder, Sullivan, Susquehanna, Tioga, Union, Wayne, and Wyoming Counties indicated that approximately **956** FTE direct jobs were created in 2008 and that number increased to **9,664** by 2010. In 2011, it is estimated that between **8,290** and **13,652** FTE direct jobs would be required, with 10,971 FTE jobs being the median workforce estimate. It is estimated that the number of long-term production phase jobs created between 2008 and the end of 2010 was likely around 248 jobs.

Estimated Future Workforce Requirements

The model indicates the number of jobs will increase over the four-year period from 2011 to 2014. The FTE direct workforce is expected to increase slightly as drilling in the region stabilizes over the next few years and will require between **8,979** and **14,799** workers by 2012, with **11,899** required workers being the median estimate. By 2014, the total direct workforce requirements may range from **9,276** to **15,294** depending on the development activity, with **12,285** workers being the likely workforce estimate.

The total number of production phase jobs (including gas processing) created by wells drilled between 2011 and 2014 will total between **603** and **928** FTE jobs, depending on the total number of wells drilled.

Southwest Region

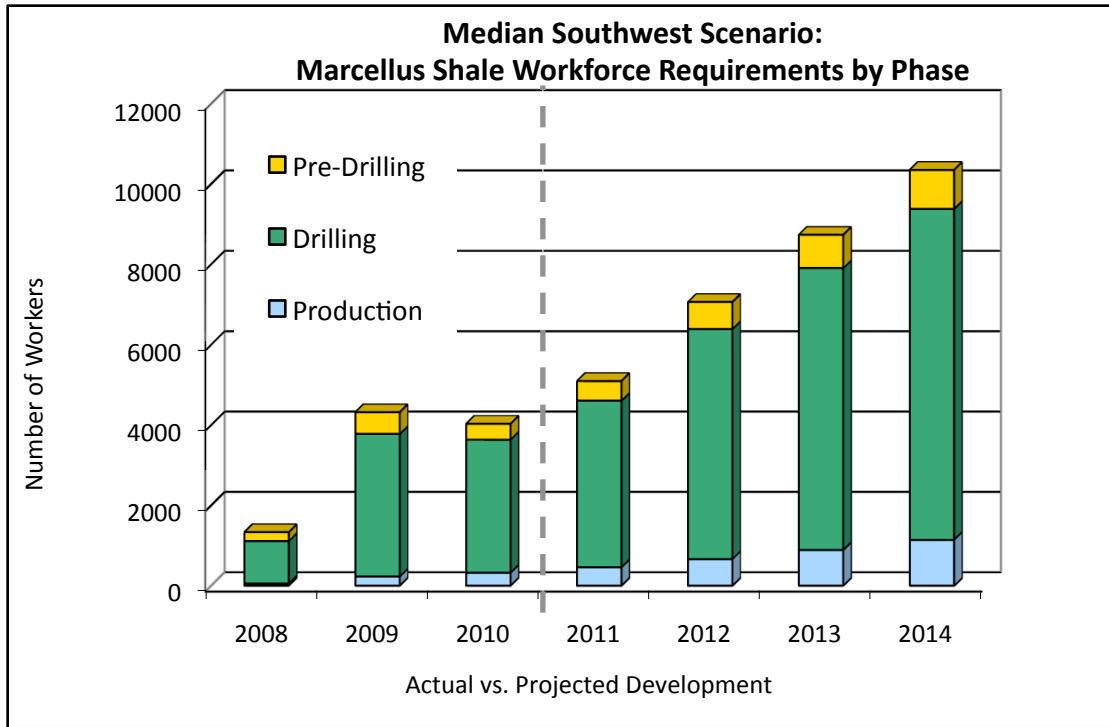


Figure 16: Median Southwest Region Scenario Marcellus Shale Workforce Requirements by Phase

Previous and Current Workforce Requirements

Applying the MSETC workforce projection model to the previous and current 2011 well drilling activity in Allegheny, Armstrong, Beaver, Bedford, Blair, Butler, Cambria, Fayette, Fulton, Greene, Huntingdon, Indiana, Somerset, Washington, and Westmoreland Counties indicated that approximately **1,333** FTE direct jobs were created in 2008, and that number increased to roughly **4,032** in 2010. In 2011, it is estimated that between 3,875 and 6,316 FTE direct jobs would be required, with 5,095 FTE jobs being the median workforce estimate based on development projections. Of these jobs, the number of long-term production phase jobs created between 2008 and 2011 will be between **398** and **521**, with **460** being the median estimate based on 2011 development information and an assumption of 60% of the wells drilled will require gas processing.

Estimated Future Workforce Requirements

The model indicates the number of jobs will increase over the three-year period from 2011 to 2014. The FTE direct workforce is expected to increase as drilling in the region increases within the next few years to between **5,346** and **8,779** workers required by 2012, with 7,062 required workers being the median estimate. By 2014, the number may range from **7,806** to **12,888** depending on the development activity, with **10,350** workers being the likely workforce needed.

The total number of production phase jobs (including gas processing) created by wells drilled between 2011 and 2014 will total between **575** and **1,053** FTE jobs, depending on the total number of wells drilled.

Northwest Region

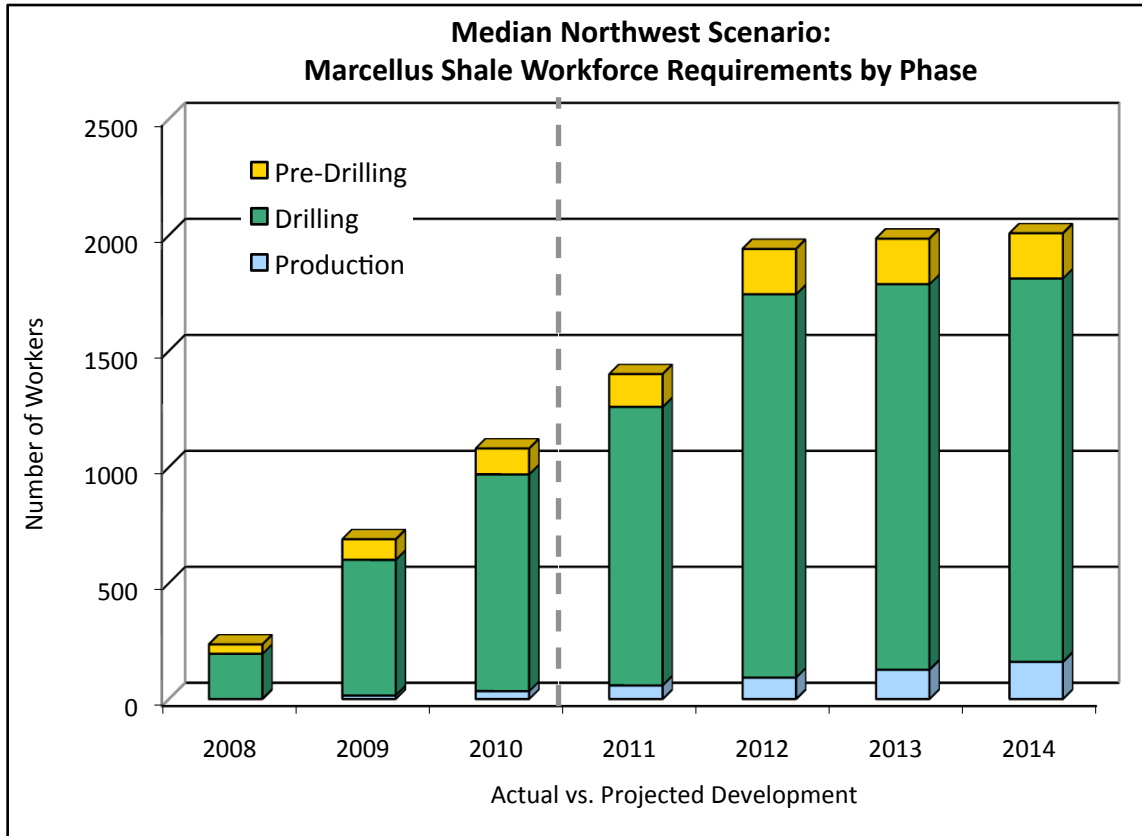


Figure 17: Median Northwest Region Scenario Marcellus Shale Workforce Requirements by Phase

Previous and Current Workforce Requirements

Applying the MSETC workforce projection model to the previous and current 2011 well drilling activity in Cameron, Clarion, Clearfield, Crawford, Elk, Erie, Forest, Jefferson, Lawrence, McKean, Mercer, Potter, Venango, and Warren Counties indicated that approximately **249** FTE direct jobs were created in 2008, and that number increased to **1,080** by 2010. In 2011, it is estimated between **1,059** and **1,338** FTE direct jobs would be required, with **1,080** FTE jobs being the median workforce estimate based on current development projections. Of the direct jobs, the number of production phase jobs created between 2008 and 2011 will likely fall between **53** and **65** based on drilling in 2011 thus far.

Estimated Future Workforce Requirements

The model indicates that the number of jobs will increase over the four-year period from 2011 to 2014. As drilling in the region continues to increase, the FTE direct workforce is expected to increase to between **1,464** and **2,417** workers required by 2012 and remains relatively stable through 2014, based on current drilling projections. These projections may change or increase significantly if drilling shifts strongly to the northwest.

The total number of production phase jobs (including gas processing) created by wells drilled between 2011 and 2014 will total between **94** and **157** FTE jobs, depending on the total number of wells drilled.

Occupational Categories within the Natural Gas Industry

The model and related research found the majority of the occupations in the direct workforce associated with Marcellus Shale natural gas development are comprised of relatively low-skilled or semi-skilled occupations. These occupations account for roughly 70-80% of the workforce (Figure 18). Industry representatives, online workforce assessment respondents, and additional research indicated that most of these occupations require no formal post-secondary education and only a few (such as CDL, welding, X-ray, etc.) require a specialized license or trade certification; however, nearly all of them require the skills and knowledge unique to the natural gas industry; skills and knowledge that are usually learned through on-the-job experience. Workers within all occupations of the natural gas industry are additionally praised for their hard work ethic and willingness to work very long hours in unfavorable conditions. Many of the remaining 25% of workers are in occupations that are white collar in nature, including supervisors, lawyers, realtors, engineers, and geologists that usually require post-secondary education.

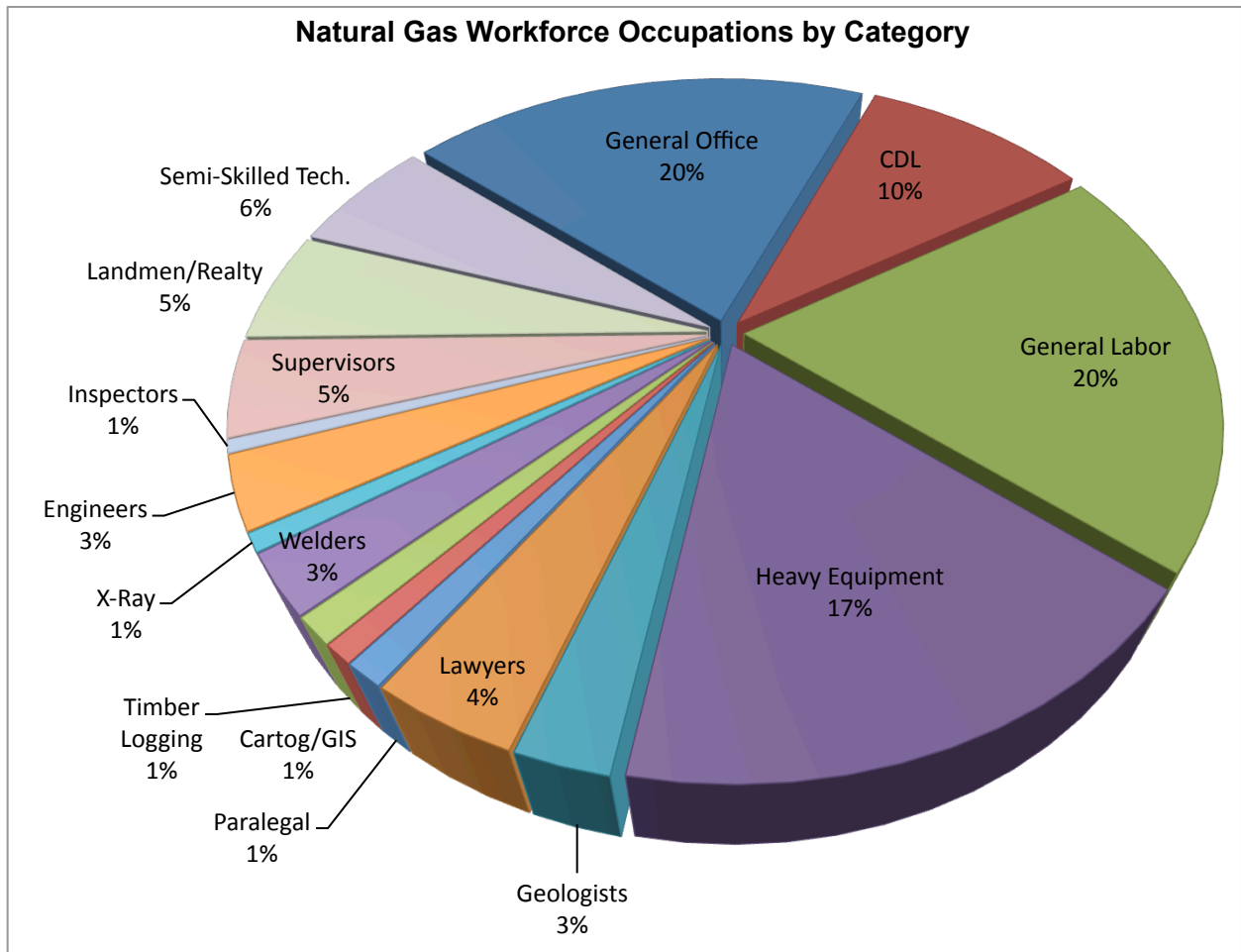


Figure 18: Occupational Composition of Natural Gas Workforces

Summary

The Pennsylvania Marcellus Shale Workforce Needs Assessment is intended to supply baseline data to provide individuals, job seekers, communities, businesses, workforce and economic development professionals, and government officials at all levels with the ability to estimate the direct workforce requirements for Marcellus Shale development. Specifically, the assessment can help outline the key occupations associated with unconventional natural gas development and the number of direct jobs required to bring a Marcellus well into production in Pennsylvania between 2011 and 2014.

The current MSETC direct workforce assessment research suggests Pennsylvania drilling activity should increase significantly statewide; however, there will likely be variation in development patterns across the state. Additionally, the strength of Marcellus growth will continue to depend on the commodity price of natural gas, natural gas inventories, natural gas infrastructure development, natural gas utilization, and the overall health of the economy. On a regional basis, the northeast region is currently a drilling hotspot with nearly 75% of all drilling activity, but growth is expected to slow somewhat in the coming years. The northwest region has been slow to develop, but over the coming years a likely uptick in activity is projected for the southern and eastern portions of the region. In the southwest region, the most dramatic drilling increases are projected to take advantage of high-BTU gas and natural gas liquids options. Finally, the southeast region is currently outside the Marcellus footprint, but exploration and production activities will likely draw on the workforce expertise of the southeast across a wide range of occupations. Current estimates for 2011-2014 statewide drilling activity include 1,599 Marcellus wells in 2011; 1,888 wells in 2012; 2,009 wells in 2013; and 2,159 wells in 2014. The company drilling projections indicate a rough annual growth rate in drilling activity of 6-18%, with a nearly 60% increase in overall activity by 2014.

The MSETC model reveals that over 420 individuals working within nearly 150 different occupations are needed to perform all the operations required to complete and produce gas from a single Marcellus Shale well. The total hours worked by these individuals is the equivalent of 13.10 FTE direct jobs over the course of a year for dry gas areas and 13.3 FTE in high-BTU gas areas. Of these FTEs, in both dry gas and high-BTU gas areas, 12.9 FTEs are required during the pre-drilling and drilling phase while 0.19 are required during the production phase. An additional 0.20 FTEs are required to process high-BTU natural gas. Across the state of Pennsylvania, the total number of direct natural gas development jobs (not indirect or induced jobs) created by wells drilled between 2011 and 2014 is currently estimated to range between **18,596** and **30,684** FTE jobs, creating **9,800** to **15,900** new jobs over 2010 levels, depending on the total number of wells drilled.

As the Marcellus Play continues to mature, the industry has definitely moved toward hiring more Pennsylvania residents. Early in the development of the Marcellus, the natural gas industry relied heavily on out-of-state employees with experience and knowledge developing high-pressure natural gas.

Although there is still tremendous variability across energy, service, and support companies, this study's interview and survey data indicates an average of 65-75% of all new Marcellus workers are Pennsylvania residents.

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Appendices

High Pennsylvania Scenario Marcellus Shale Workforce Requirements by Phase

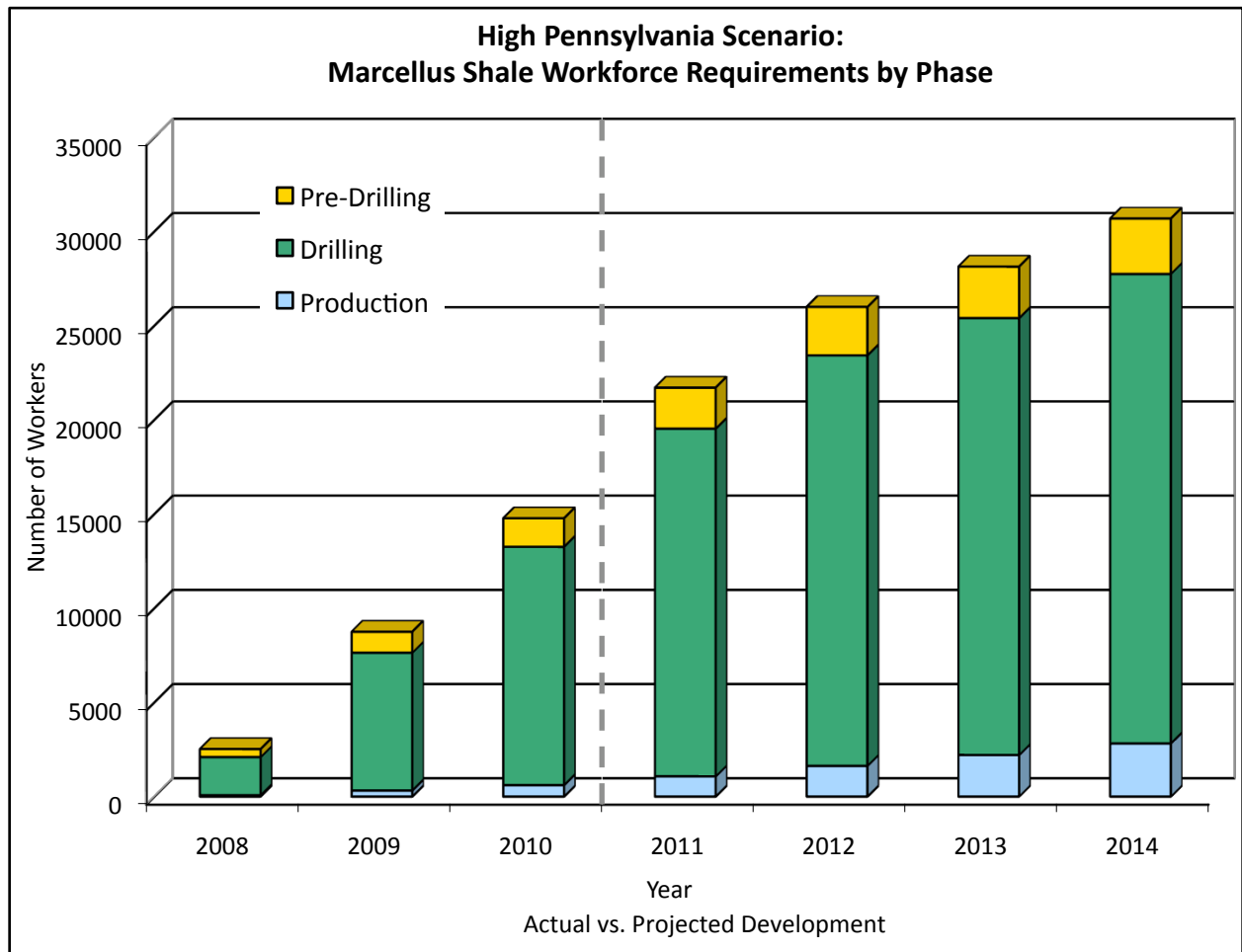


Figure 19: High Pennsylvania Scenario Marcellus Shale Workforce Requirements by Phase

High Northeast Region Scenario Marcellus Shale Workforce Requirements by Phase

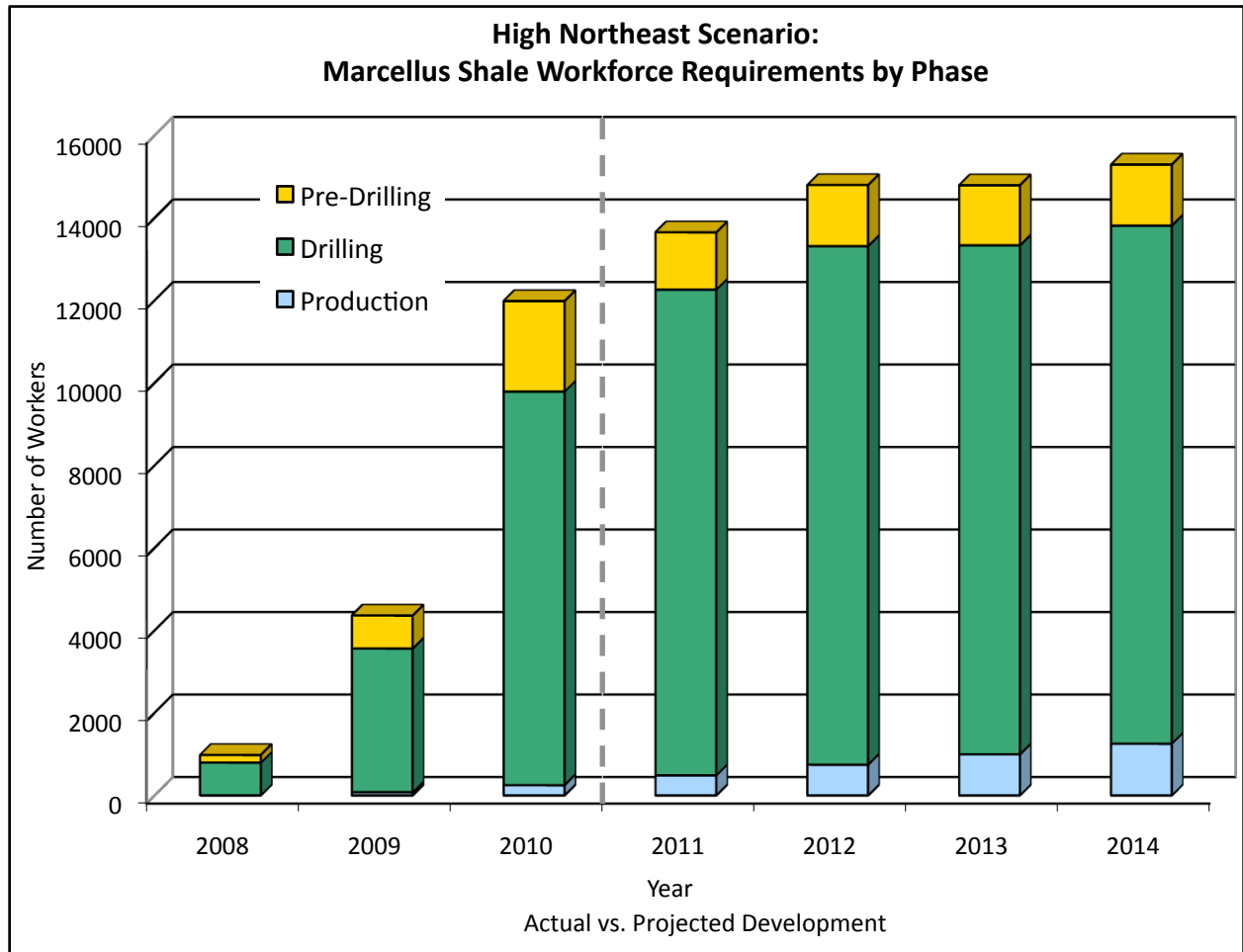


Figure 20: High Northeast Region Scenario Marcellus Shale Workforce Requirements by Phase

High Southwest Region Scenario Marcellus Shale Workforce Requirements by Phase

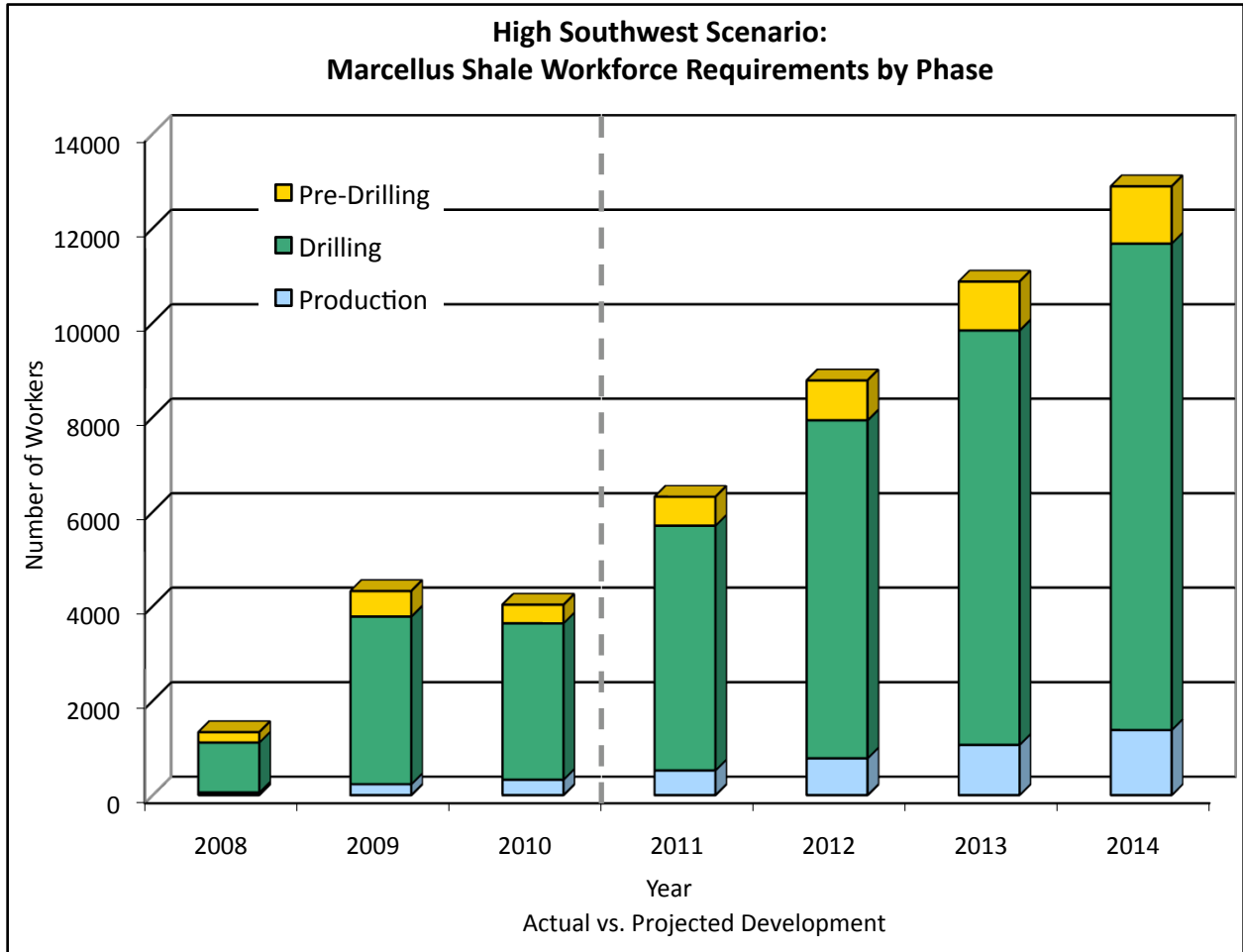


Figure 21: High Southwest Region Scenario Marcellus Shale Workforce Requirements by Phase

High Northwest Region Scenario Marcellus Shale Workforce Requirements by Phase

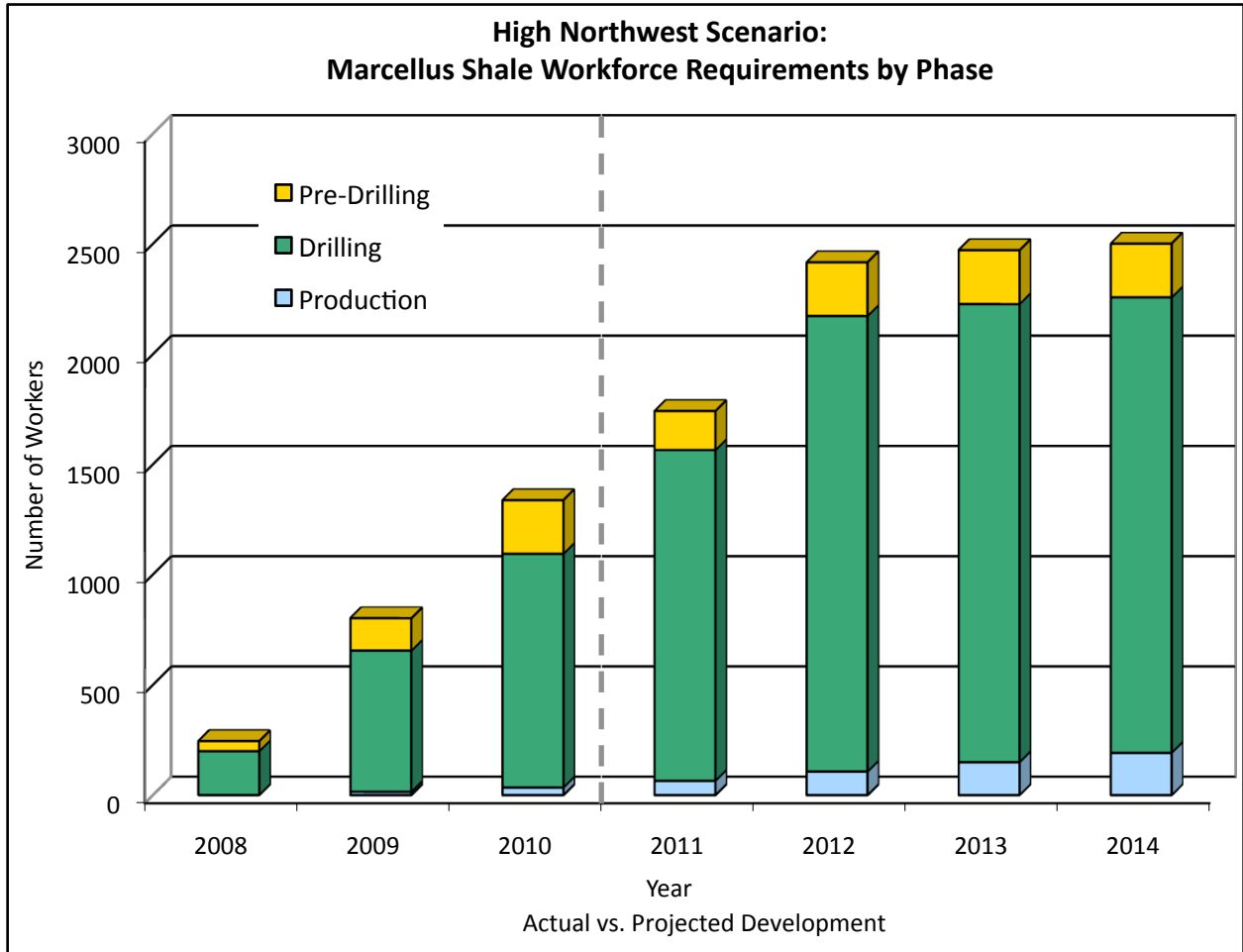


Figure 22: High Northwest Region Scenario Marcellus Shale Workforce Requirements by Phase

Low Pennsylvania Scenario Marcellus Shale Workforce Requirements by Phase

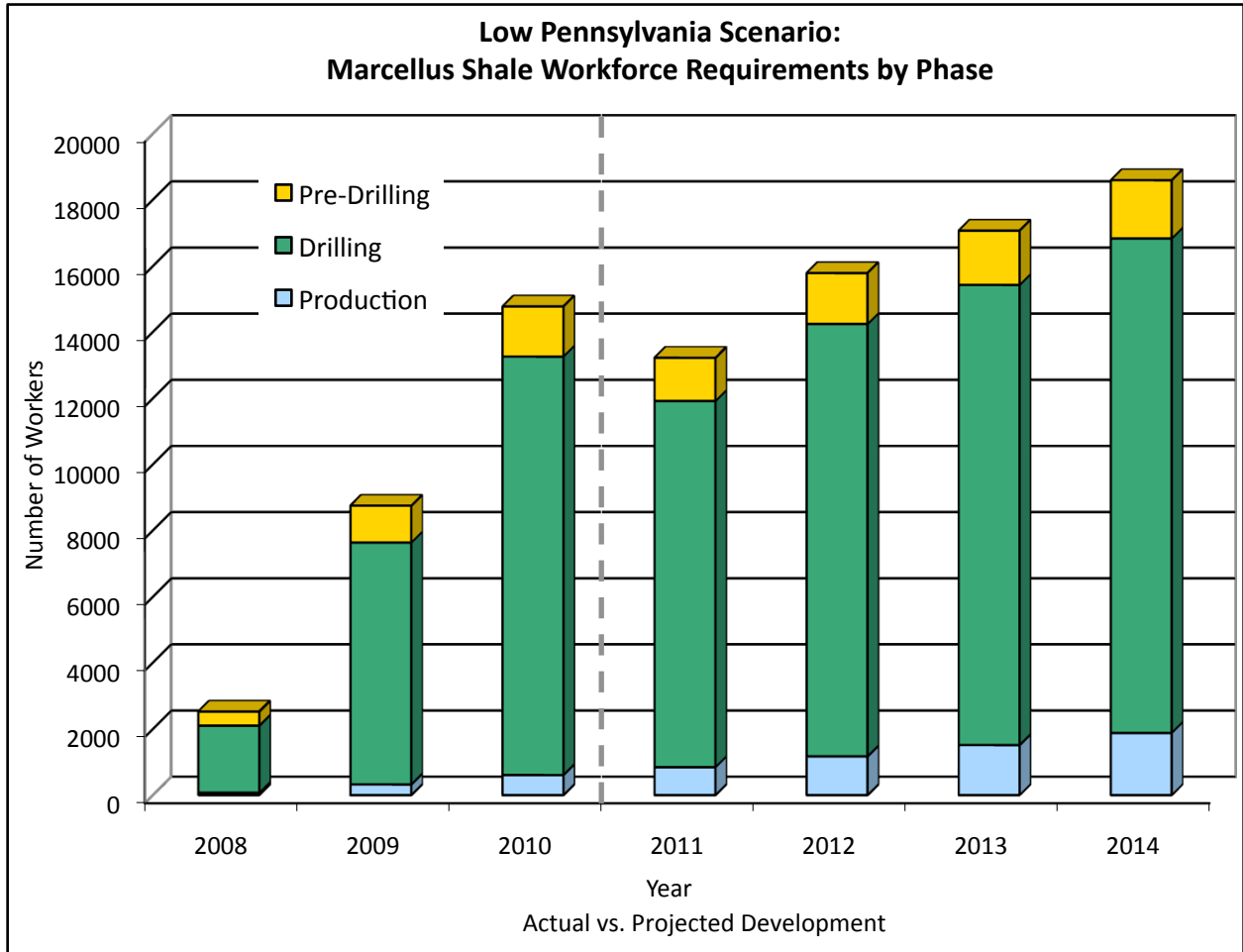


Figure 23: Low Pennsylvania Scenario Marcellus Shale Workforce Requirements by Phase

Low Northeast Region Scenario Marcellus Shale Workforce Requirements by Phase

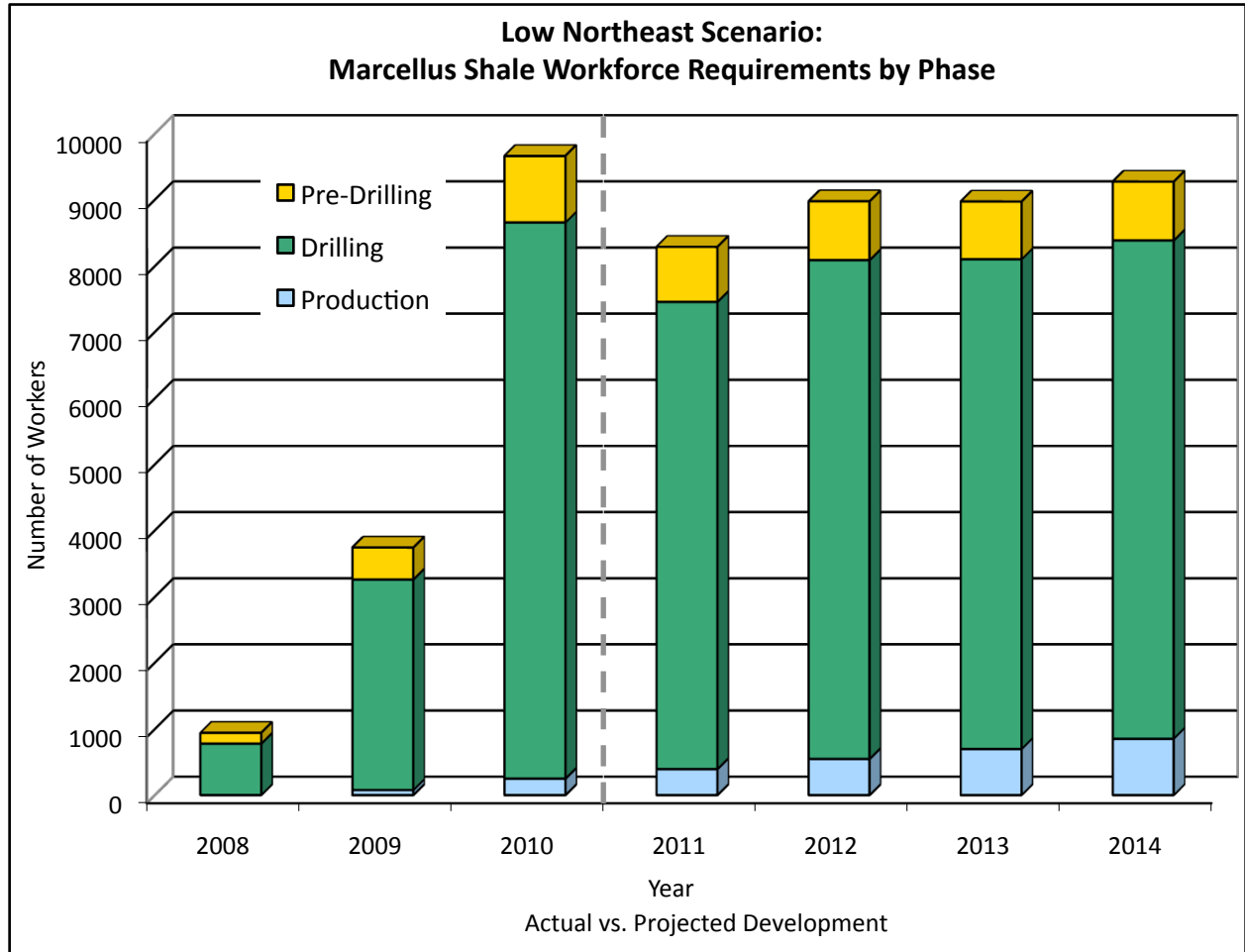


Figure 24: Low Northeast Region Scenario Marcellus Shale Workforce Requirements by Phase

Low Southwest Region Scenario Marcellus Shale Workforce Requirements by Phase

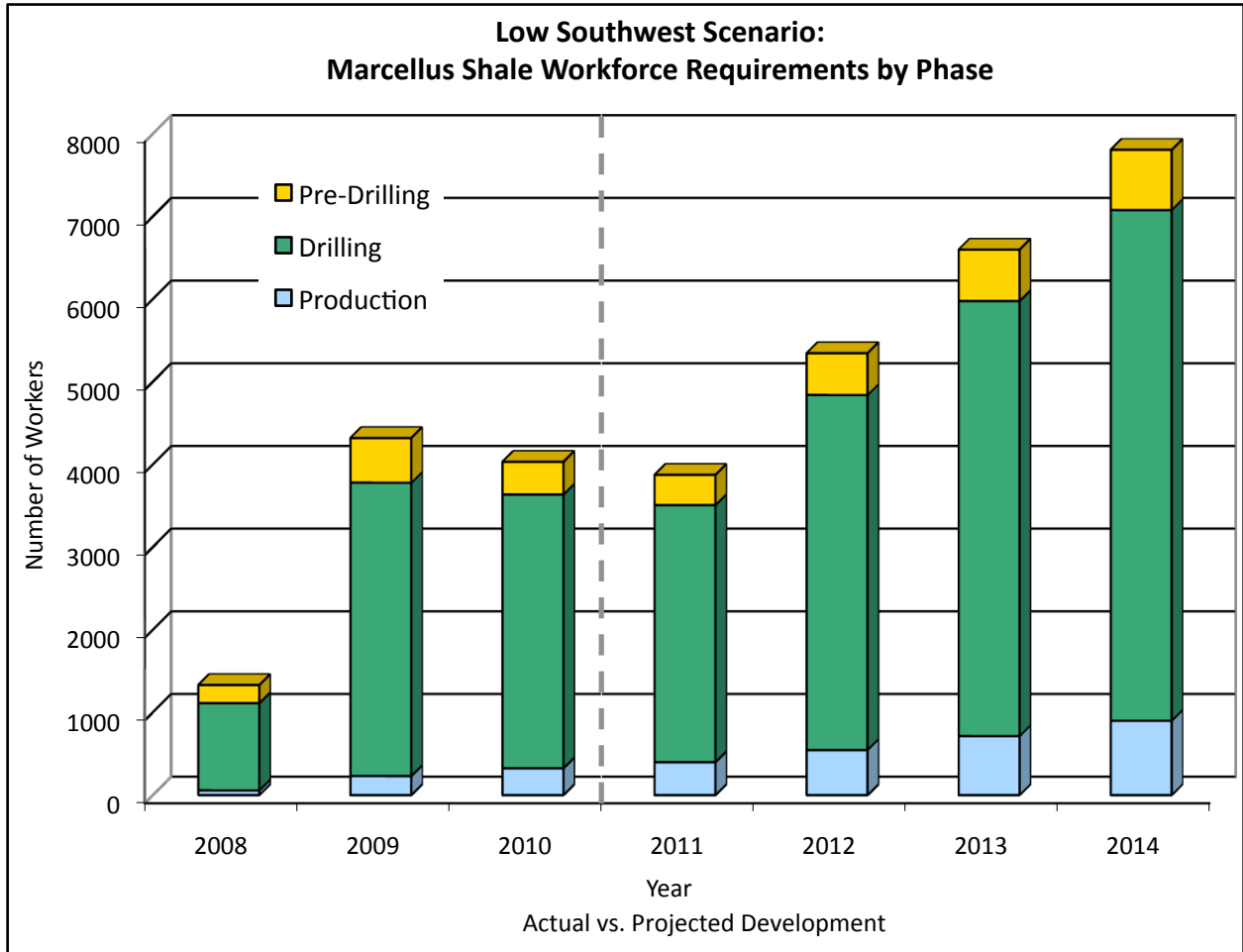


Figure 25: Low Southwest Region Scenario Marcellus Shale Workforce Requirements by Phase

Low Northwest Region Scenario Marcellus Shale Workforce Requirements by Phase

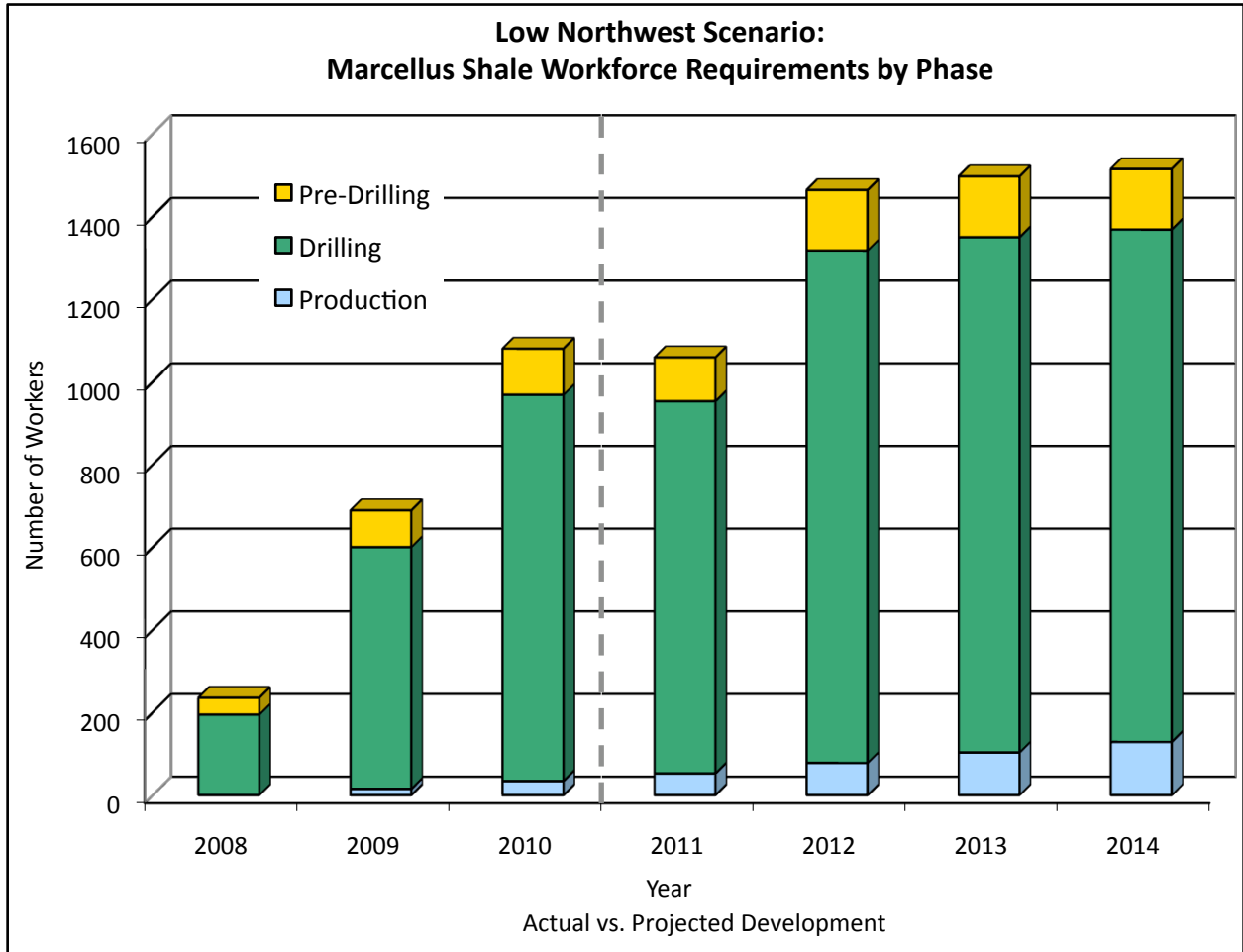


Figure 26: Low Northwest Region Scenario Marcellus Shale Workforce Requirements by Phase

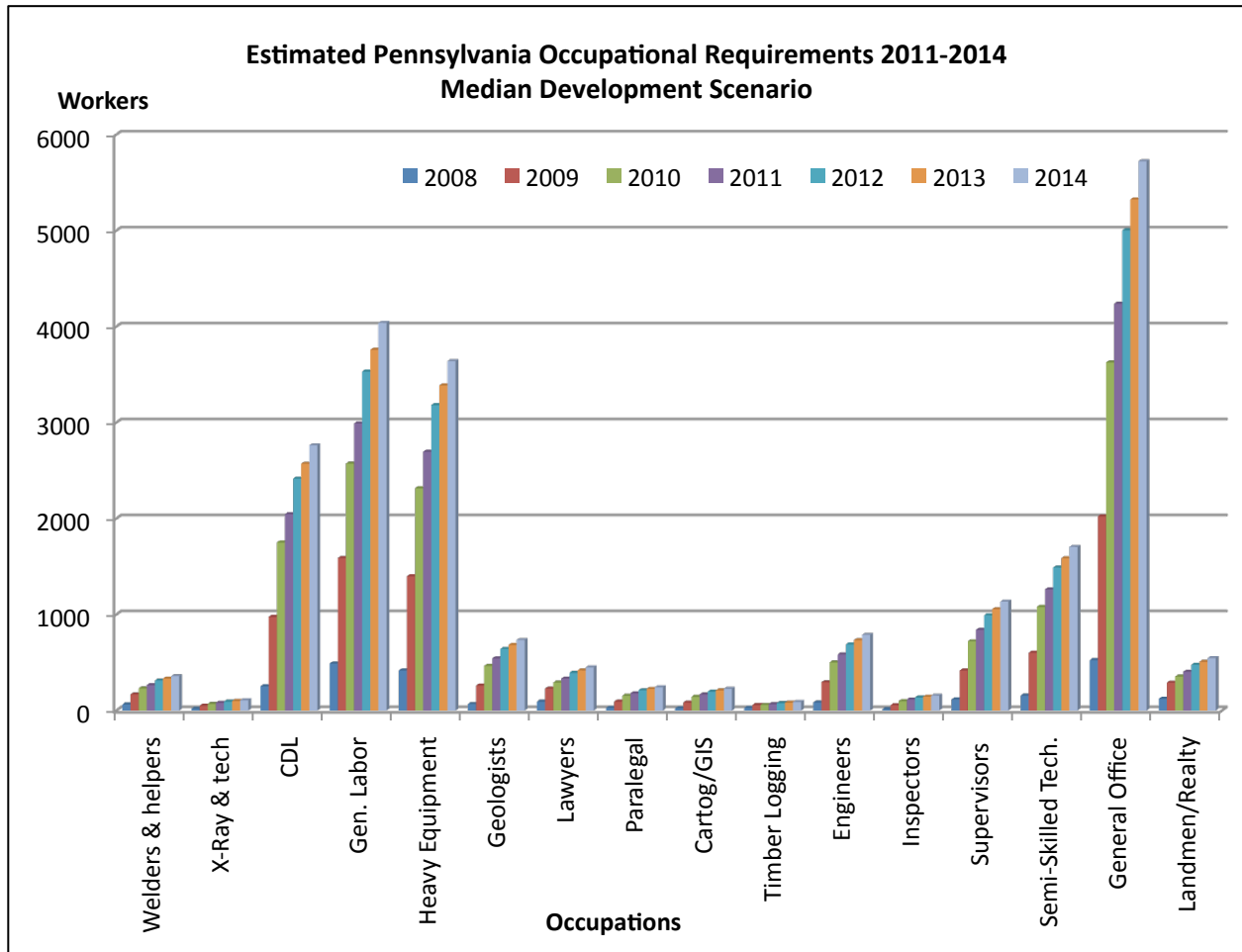


Figure 27: Estimated Statewide Occupational Requirements 2011-2014 Median Development Scenario

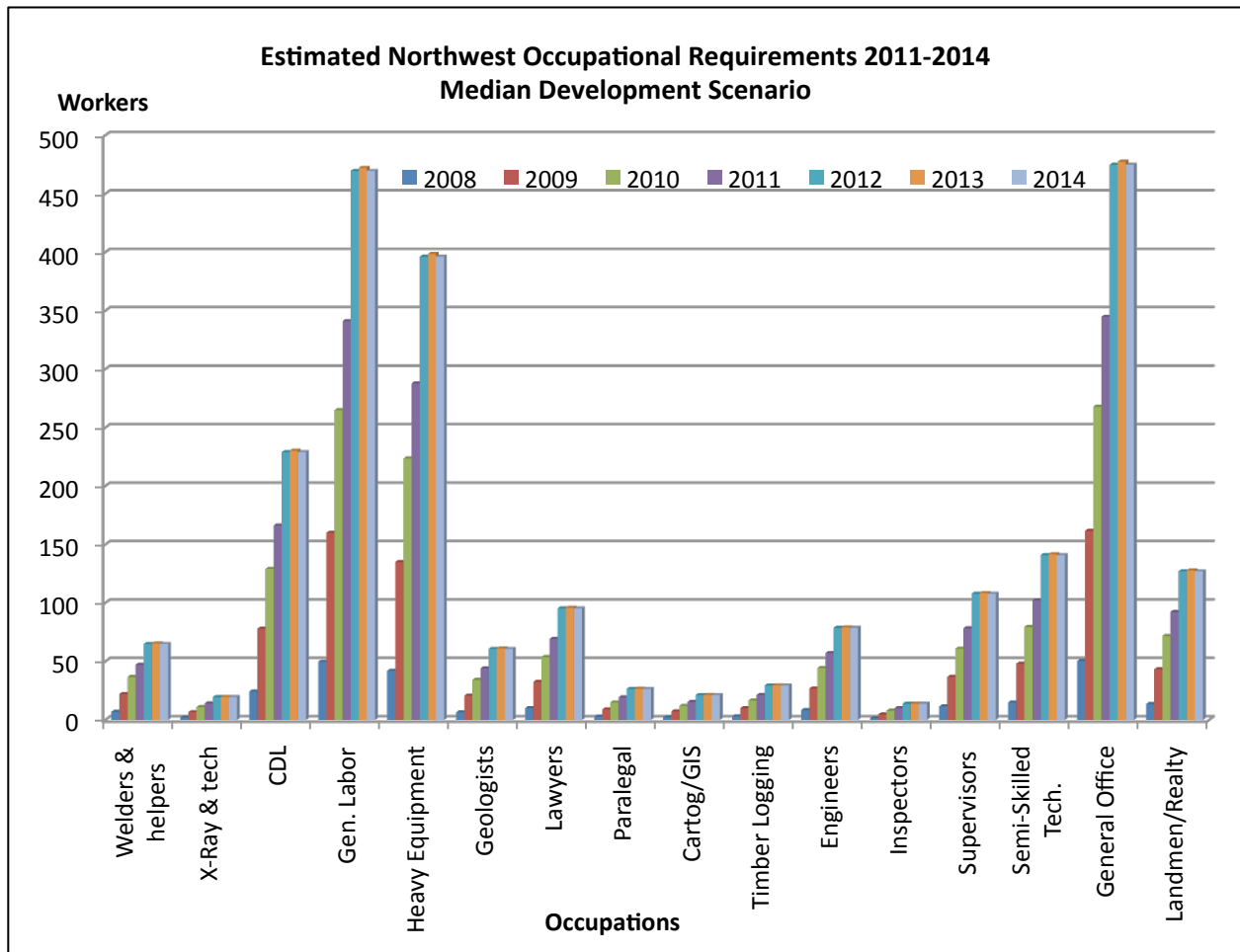


Figure 28: Estimated Northwest Occupational Requirements 2011-2014 Median Development Scenario

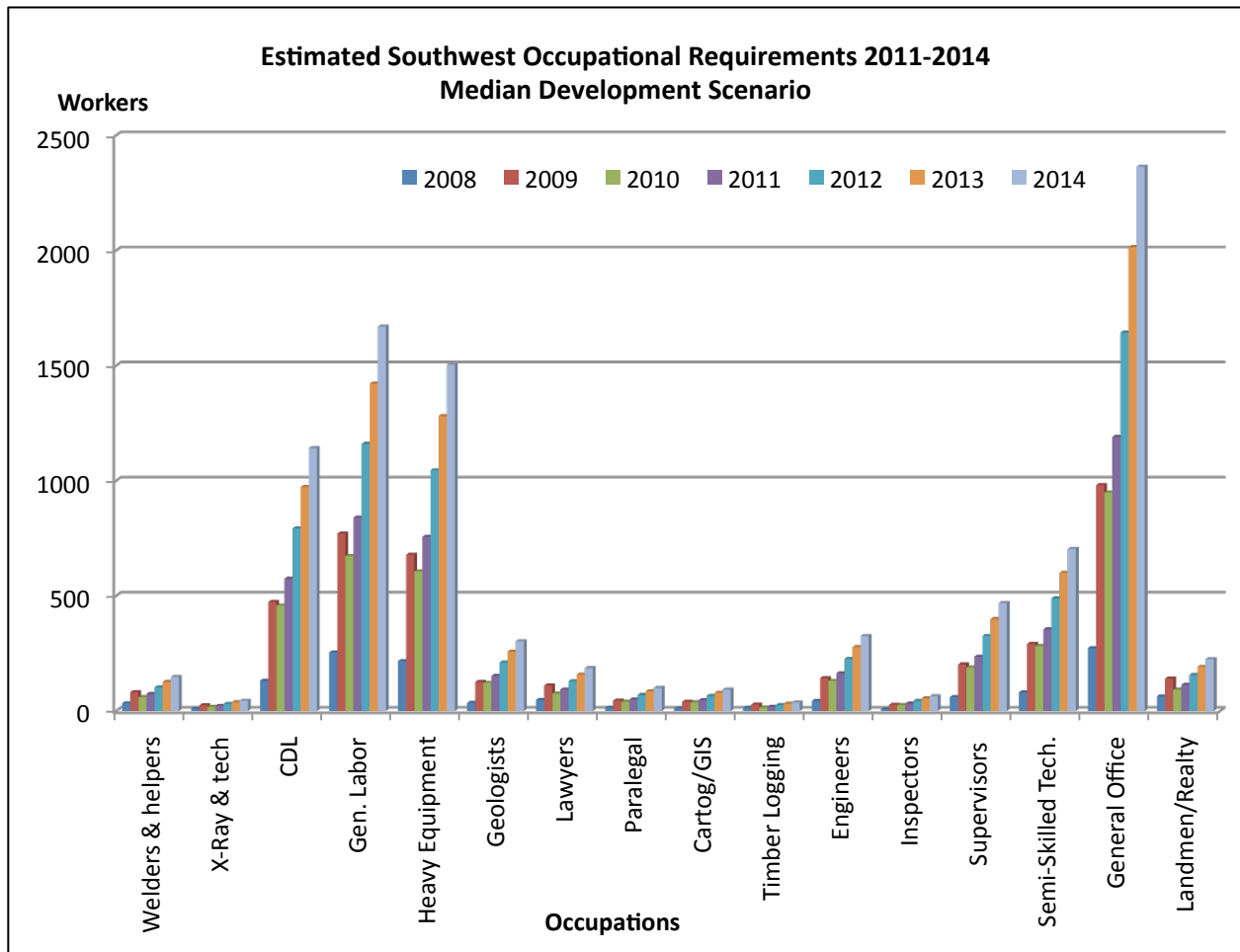


Figure 29: Estimated Southwest Occupational Requirements 2011-2014 Median Development Scenario

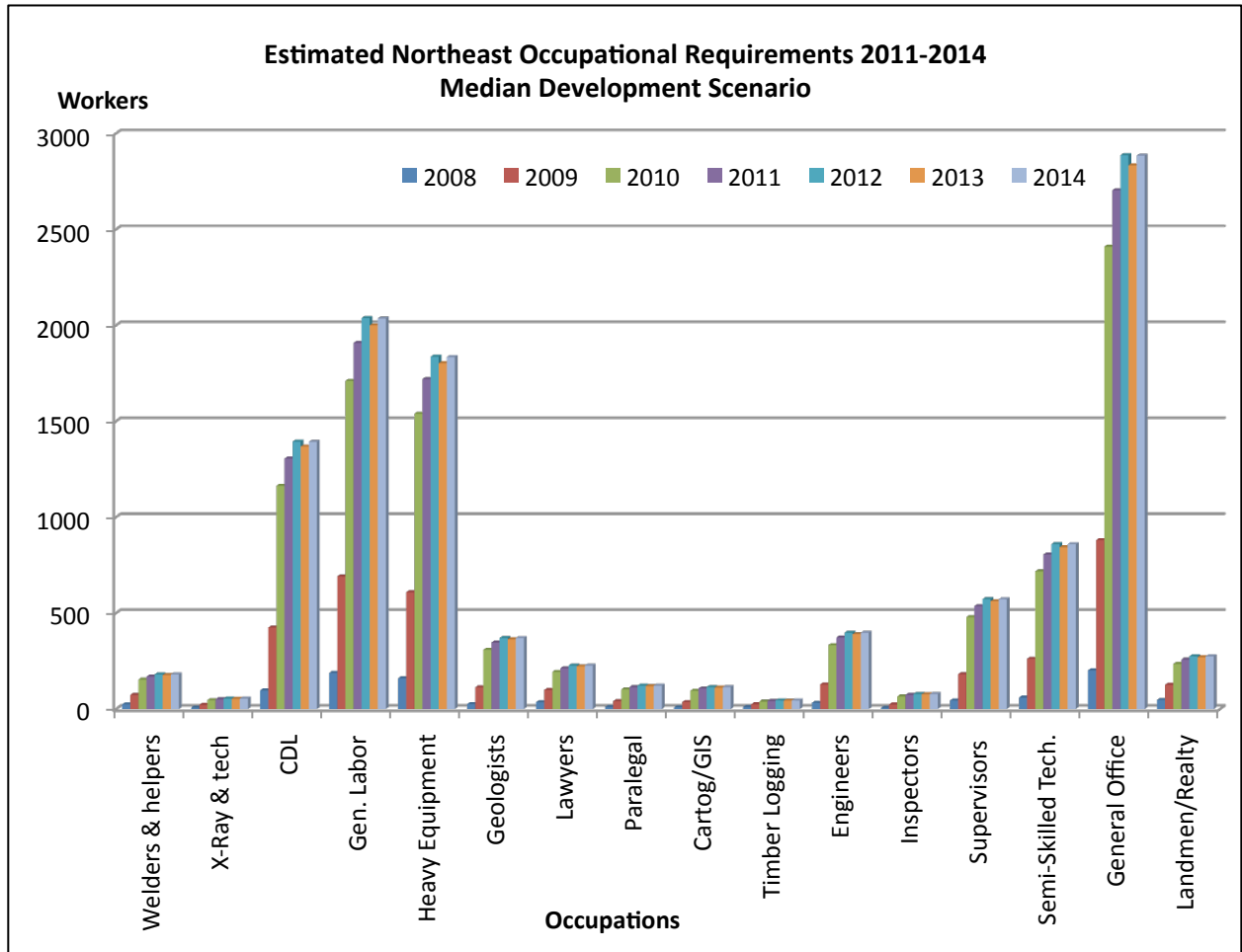


Figure 30: Estimated Northwest Occupational Requirements 2011-2014 Median Development Scenario

History of the Marcellus Shale Education & Training Center

As a primary provider of education and technology resources in the region, the Marcellus Shale Education & Training Center (MSETC) was an early pioneer in efforts to determine the potential impact of an emerging oil and natural gas industry as the Marcellus Shale Play has developed in Pennsylvania.

In November 2008, Penn College (through its Workforce Development & Continuing Education unit) and Penn State Extension partnered to form the Marcellus Shale Education & Training Center (now headquartered on the Penn College campus in the Center for Business & Workforce Development in Williamsport, PA).

Among the first initiatives undertaken by the MSETC team was to research and publish a document assessing workforce needs for the developing Marcellus-related oil and natural gas industry. The workforce assessment document and more information about MSETC initiatives are available online at www.msetc.org. Since the initial assessment, MSETC has been contracted to perform three additional assessments utilizing their successful workforce projection model.

These workforce assessments made it clear that significant new employment opportunities are emerging and that there is a need for more training and education related to the industry needs throughout the Appalachian Basin.

In addition to the multiple research projects, the MSETC team has developed several short-term, noncredit, workforce training programs that meet specific industry needs and provide opportunities for local residents to train for positions in the industry. To date, more than 2,500 individuals have participated in noncredit training programs developed by the MSETC team and offered at locations in Williamsport, Wellsboro, and areas across the Appalachian Basin. Classes offered include:

- Defensive Driving
- Fit 4 Natural Gas Pre-employment Training (Roustabout)
- Commercial Driver Training
- API 1104 Downhand Welding
- SafeLand USA
- Certified Operations Technician
- OSHA Rough Terrain Forklift Training
- Natural Gas Development and Production Overview
- OSHA 10-Hour Construction

MSETC has delivered training for current employees of companies working in the Marcellus industry and for companies positioning for work in the region. Specialized client training has been offered in welding,

commercial driving, and safety to help area companies gain a competitive advantage in securing work related to Marcellus Shale. To date, MSETC has trained workers from more than 180 companies.

Programs also have been offered to the area's dislocated and unemployed workers who may be looking to enter careers associated with the industry. MSETC, in partnership with regional One-Stop offices (CareerLinks) and regional workforce investment boards (WIBs), offers a three-week, pre-employment program to help these individuals gain entry-level positions in the industry. The program – called Fit 4 Natural Gas – provides entry-level technical and job-readiness skills.

Fit 4 Natural Gas has been offered in communities across the Marcellus Shale region in central, northcentral, and northeastern Pennsylvania (including Tioga, Bradford, Lycoming, Clinton, and Susquehanna Counties). The model of integrating CareerLink services with technical training is being replicated, expanded, and disseminated across a multi-state region through a collaboration of education and training providers known as ShaleNET. Additional pre-employment noncredit training will soon be available for floorhands, production technicians, and welder helpers through certified ShaleNET training providers across the region.

An additional 20 companies have pledged cash and equipment to support the future development of a MSETC Natural Gas Applied Technology and Safety Training facility at Penn College. This facility is scheduled to open in October 2011 and will provide hands-on training for Pennsylvania's first responders and emergency responders as well as other training programs that require the installed equipment.

MSETC has participated in originating Federal and State grants totaling \$17.6 million and more than \$6 million has already been awarded to support the natural gas industry's training and workforce development needs. Other major initiatives to support the industry include sponsoring a semi-annual Marcellus Career Expo (over 2,500 attended the first event) and an annual ShaleNET Workforce Forum that brings together industry, education, and public sector organizations involved in workforce development initiatives across the Marcellus Play.

Pre-Drilling Matrix

Natural Gas Extraction Job Matrix
Pre-Drilling Phase *(continued on next page)*

Pre-Drilling	Associated Jobs	
	Geological Studies	Geologists & geophysicist
	Hydro Geologist	
	Petroleum Engineers	
	Petroleum Chemists	
	Cartographer	
	GIS Technicians	
Seismic	Project Management	
	CDL Drivers	
	Landman	
	Helicopter Pilot/Crew	
	Seismic Crew	
Public Land Only	Water Management	
	Forester	
	Lawyers	
	Archeology	
	Biologist	
Mineral Rights	Landmen-for drilling/leasing	
	Lawyers	
	Para-legal	
	Title-Abstract	
	Lease Aquisition	
	Lease Admin	
Permitting Process	Archeologist	
	Biologist	
	Community Affairs	
	Corporate Development	
	Environmental Technicians	
	Lawyers	
	Permitting Technician	
	Public relations Division	
Staking the Well	Roadman	
	Surveyors	
	Civil Engineering Tech	
	Civil Engineer	
	Lawyers	
	Leasing Agents (Right-of-Way)	
	Land Clearing	
	Heavy Equipment Operators	
	Heavy Equipment Maint Tech	
	Logging	

Natural Gas Extraction Job Matrix
Pre-Drilling Phase *(continued)*

Pre-Drilling	Water Mgmt	Electricians
		Environmental Coordinator
		Water transfer/Driver CDL
		Hydrologist (stream monitoring)
		Mechanics
		Private water Supply Testing Coord.
		Water Management Technician
		Welders
		Overall

Drilling & Completion Matrix

Natural Gas Extraction Job Matrix

Drilling Phase *(continued on next page)*

		Associated Jobs
		Drilling
Environmental Tech-monitor reclamation		
Foreman		
Superintendent		
Petroleum Engineers		
Mechanical Engineering		
Pipe Fitters		
Safety Coordinator		
Welders		
Welder Helpers		
Weld Inspectors		
Heavy Equipment Operators		
Weld Inspectors		
X-Ray Tech		
General Labor		
Boring Crew		
Environmental Tech-Monitor Reclamation		
Operational Landmen		
Surveyors		
Civil Engineering		
Logging		
Construction Managers		
Welders		
Welders Helpers		
Weld Inspectors		
X-Ray Tech		
General Labor		
Land Clearing		
Foreman		
Pipeline Inspection		
Electricians		
Engineers		
General Construction		
Pipeline		
Welders		
Well head		

Natural Gas Extraction Job Matrix
Drilling Phase *(continued on next page)*

Drilling	Drilling	Roustabouts
		Safety Coordinator
		Security
		Surveyors
		Diesel Technicians
		Rig Move
		Heavy Equipment Operators
		CDL Drivers
		Mudmen
		Welders
		CDL Drivers
		Electricians
		Environmental Coordinator
		Flaggers
		Light truck delivery
		Machine Shop
Pilot drivers		

Natural Gas Extraction Job Matrix
Drilling Phase *(continued on next page)*

Drilling	Fracing and Completion	Well Logging
		CDL Drivers
		Directional Drilling
		Finishing/ Service Rig
		Supervisors
		Safety
		Foremen
		Site Management
		Electronics Technicians
		Petroleum Engineers
		Frac Crew
		Heavy Equipment Operators
		Heavy Equipment Maint Tech
		CDL Drivers
		Mechanics
		Perforating Crews
		Safety Coordinator
		Roustabouts
		Heavy Equipment Operations
		Crane Operations
		Electricians
		Engineers
		Environmental Coordinator
		Casing Crew
	Water Management	Environmental Inspection
		Flowback Analyzer/ Well Testing
		CDL Drivers/Water Haulers
		Hydrologist/water supervisor
		Completion-chemists
		Engineers
		Environmental Compliance
		Water Testing/Quality
		Safety Coordinator
Water Re-use Supervisor		
Water Re-use Technician		

Natural Gas Extraction Job Matrix
Drilling Phase *(continued)*

Drilling	Overall	Flowback/ Well Testing
		Road Crews
		Heavy Equipment
		CDL
		Local Liaison
		Catering
		MSHA Compliance
		MSHA Training
		Noise Abatement
		Human Resources
		Fleet Managers
		Environmental Coordinator
		Field Safety Representatives
		First Aid
		Security
		Calibration Technician
		Safety Coordinator
		Office Management
		Clerks/Data entry/Reception
		Financial/Business Management
		Accountants
		Office support - admin assist.
		OSHA Compliance
		OSHA Training
		Public Affairs
		IT/Computer
		Purchasing
		DOT Law Compliance
		DOT Law Training
		Surveyors
OJT Trainers		
Accountants		

Production Phase Matrix

Natural Gas Extraction Job Matrix
Production Phase *(continued on next page)*

Production	Associated Jobs	
	Natural Gas Production	Petroleum Engineers Heavy Equipment Maint Tech Well Tenders/Roustabout Operator Gas Control Center Gas Dispatcher Gathering Operations Compressor Operator Service Rig Operator Production Engineer Equipment calibration Communications Tech offsite monitoring Production Foreman
Reclamation	Plugging Crew CDL Drivers Site Management Landscapers-architect Environmental Inspection General Construction Heavy Equipment Operator Civil Engineer Government officials	

Natural Gas Extraction Job Matrix

Production Phase *(continued)*

Production	Overall	Inspectors
		Sewage treatment
		Lobbying
		Community Affairs/PR
		Calibration Officials
		Corrosion Technicians
		Business Development/Sales
		CDL Drivers
		Fleet Managers
		Human Resources
		Marketing
		Noise Abatement
		Environmental Health & Safety
		Purchasing
		IT Tech
		Local Liaison
	Office Management	
	Office support-admin-non tech	
	High BTU Gas/Gas Processing	Bi-product Marketing/Sales
		Bi-product Transportation
		Compressor Operator
		Facility Construction
		Gathering Operations
		Information Science Technology
		Instrumentation/Reader Techs
		IT Technicians
		IT Trainers
		Pigging Technicians
		Pipeline operators
		Pipeline Techs
		Processing Engineers
		Processing Loader/Testers
Processing Maintenance/Mechanics		
Processing Operators		
Processing Supervisors/Managers		