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Economics of Utica Shale in Ohio: Workforce Analysis

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WORKFORCE ANALYSIS

Center for Economic Development

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About the Center for Economic Development

The Center for Economic Development (the Center) at Cleveland State University's Maxine Goodman Levin College of Urban Affairs provides research and technical assistance to government agencies, non-profit organizations, and private industry. The Center has expertise in studying ecology of innovation, entrepreneurship, performance of economic clusters, industry analysis, economic analysis of cities and regions, economic impact, economic development strategy and policy, workforce development and evaluation of economic development initiatives. The Center has served as a designated Economic Development Administration (EDA) University Center since 1985.

The Center's professional staff includes four full-time researchers, a system analyst, associated faculty, and several graduate research assistants. The Center works with funders, partners, and clients at the national, state, regional, and local levels. All of the Center's research is summarized in publications, including working reports, journal articles, and book chapters. For more information on the Center for Economic Development, use the following link: **http://urban.csuohio.edu/economicdevelopment/**

About the Energy Policy Center

The Energy Policy Center (EPC) is housed within the Maxine Goodman Levin College of Urban Affairs at Cleveland State University. The mission of the EPC is to help overcome social and institutional barriers to the implementation of solutions to energy challenges by providing an objective channel for the free exchange of ideas, the dissemination of knowledge, and the support of energy-related research in the areas of public policy, economics, business and social science. For more information on the Energy Policy Center, use the following link: **http://urban.csuohio.edu/epc/**

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EXECUTIVE SUMMARY

This report presents the findings from research undertaken by Cleveland State that investigated the economic development potential of the Utica and Point Pleasant (together, "Utica") oil and gas shale resources in Ohio. Two other companion reports to this project, *Mapping Opportunities for Shale Development in Ohio* and *Economics of Utica Shale in Ohio: Supply Chain Analysis*, discuss upstream (well field development) and midstream (building the pipeline infrastructure that connects the well field to processing plants) building projections, assesses the potential amount of hydrocarbons that will be extracted and processed regionally and identifies opportunities for local contractors in the Utica industries' supply chain. This report presents labor demand projections created by upstream industries together with certain mid and downstream (the processing of hydrocarbons and the production of related chemical products) industries, specifically those relating to the building and operation of natural gas pipelines, the processing infrastructure, and the construction and management of a petrochemical cracker. To assess the status of applicable skill sets currently available in Ohio, the study examines the labor occupations relevant for the oil and gas industries and those for other industries that employ labor that is transferable to the oil and gas industry. By comparing potential labor demand to the skill sets of the current employment base, the study illustrates what occupations might be in short supply for further development of Utica shale, and informs public policy actions that are needed to ease potential labor shortages.

The future workforce demand from the oil and gas industry in Ohio will be affected by a number of factors, including: the increased complexity of shale drilling and processing, oil and gas commodity and derivative product prices, the volumes of produced oil and gas extracted, access of main producing companies in Ohio to midstream infrastructure, companies' strategies for future upstream and midstream development, and lease acquisition and maintenance in Ohio's portion of Utica play.

The 2014 downturn of hydrocarbon prices increased cost pressure on companies producing in the Utica. A decrease in investment return led to producers reconsidering their investment strategies in 2015, which in turn led to a reduction in drilling rigs in the Utica. It also increased the importance of each company's leasehold locations; those with the best producing Utica acreage and the easiest access to midstream infrastructure will be best positioned to withstand the downturn and create future demand for local labor. A lag in construction of product take-away capacity has led to a regional oversupply of ethane. However this same oversupply invites the construction of ethane crackers in the region. Decreases and delays in investment in upstream, midstream and downstream infrastructure will push back the labor that is expected to be in demand for the next five years in Ohio. However, the shale resource is not going away, and the industry is here for the long term and will be positioned to benefit at the time when prices rebound.

The initial widespread placement of drilling sites, influenced the transience of workers in the industry in the early stages of Utica shale development (2012-2013). This was reinforced by uncertainty of the timing of the development of the play's infrastructure. As the industry has matured in the Utica region, the local workforce has begun to grow. As a result, we can expect that more workers will be hired locally, especially for the long-term maintenance and engineering jobs associated with production and midstream infrastructure.

Workforce projections for future labor force demand in upstream and some midstream operations projected in this report are based on methods developed by the Marcellus Shale Education and Training Center at Pennsylvania State University. Penn State's methodology relies on a survey

administered across a number of companies providing their assessments for the full-time job requirements for upstream and midstream operations. This model provides specific labor requirements on a per-well basis. For the Utica, unlike for the Marcellus, early drilling has been in the wet gas region, where larger volumes of natural gas liquids (NGLs) have been extracted, so the midstream labor force model was adjusted to account for this difference. Moreover, the assessment of labor demand for the construction of the interstate pipelines and increased processing and fractionation infrastructure is not part of the Penn State model. Therefore, the IMPLAN input-output model was used to develop labor coefficients for these activities. An IMPLAN methodology was also used to project the most likely growth path of downstream manufacturing industries.

The workforce estimates assume that the industry's practice of using transient workers for well-field development will continue: many Utica shale workers will be transient residents, especially for the work requiring more skills. Similarly, many operating companies bring with them equipment and drilling rig crews who work shifts and then return home. Likewise, transient workers are also often employed in other oil and gas development construction projects, such as building interstate pipelines. Although the production phase is less labor intensive than the drilling phase, local employment will arise from post-production activities such as well, pipeline and processing plant maintenance.

A number of assumptions were made to project future labor force demand for the next five years in Ohio's portion of Utica upstream, midstream and downstream operations. The typical Utica well pad is assumed to have two units of land of around 750 acres each, with 6 to 8 wells per pad. Early drilling, however, is likely to have fewer wells per pad. This will be the case until operators return to drill the final wells. For purposes of projecting workforce requirements, it was assumed that the average number of wells per pad will increase from 3.0 in 2015 to 4.5 in 2019. For purposes of modeling labor demand for the post-production phase of the play's development, a decline curve of production was estimated at 60% to 65% for the first-year, and the expected ultimate recovery (EUR) for an average well was estimated to be about 3.5 billion cubic feet of natural gas.

The labor demand projections assess jobs in three segments of upstream operations (pre-drilling, drilling, and post-drilling[1]) and in midstream operations. The model assumes that pre-drilling jobs decrease by 73% for every subsequent well drilled on the same well pad. Drilling and completion jobs decrease by about 16% for every additional well on a pad. Workforce demand is modeled for three scenarios: a conservative projection based on drilling 260 new wells a year; a most likely scenario based on drilling 849 wells a year, and an optimistic scenario based on drilling 1,186 wells a year.

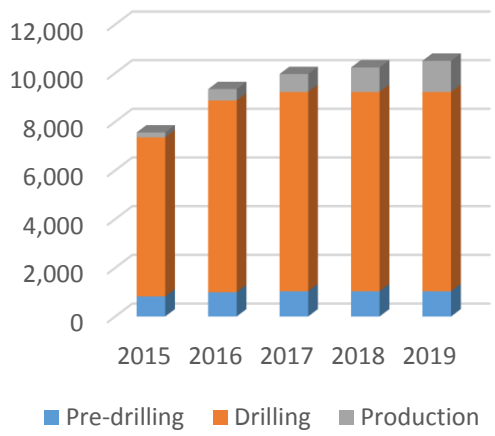
Using these assumptions, the model projected that starting in 2015, the upstream segment of the industry will generate about 10,505 full-time jobs in Ohio from the development of the Utica. Construction and drilling jobs are estimated annually, and they will increase from 7,558 in 2015 to 9,495 in 2019 following the most likely drilling scenario. If drilling in Ohio continues at an annual rate of 700 wells (the number in 2015), and increases to 879 wells per year by 2019, the upstream operations will likely generate 7,558 direct jobs in 2015. This number of direct drilling and midstream jobs is likely to grow to 9,495 and result in more than 1,000 jobs in the production of oil and gas over the five-year period studied.

[1] Post-drilling as defined by Penn State's reports refers to post production activities such as gathering and compressing natural gas for delivery to the processing plant. It also includes cryogenic processing, but no other midstream activities.

Projections of the Workforce Demand for Ohio, 2015-2019

Year	Workforce Demand		
	Pre-drilling & Drilling	Production	Total (annual pre-drilling & drilling and accumulated production jobs)
2015	7,355	203	7,558
2016	8,875	263	9,342
2017	9,223	272	9,961
2018	9,222	273	10,233
2019	9,223	272	10,505

Projected Annual Jobs in the Upstream and Part of the Midstream Industries in Ohio, 2015-2015



With depressed prices, it is likely that the number of wells drilled in 2015 will be slightly below the number used in the model based upon the "most likely scenario." It is reasonable to anticipate prices will gradually improve over time, and that drilling will be on target to reach 850 wells drilled a year by 2019. The detailed estimates of 8,924 jobs in the upstream and partial midstream portions under the most likely scenario are close to our gross projection of 9,138 in 2016. We expect that in the next five years Utica development will follow our most-likely scenario.

2015 Totals of Detailed Job Projections by Development Phase and Scenario

Development Phase/Scenario	Conservative	Most Likely	Optimistic
Total Pre-Drilling Jobs	625	1,876	2,606
Total Drilling Jobs	2,294	6,847	9,501
Total Operating Jobs	62	201	274
Grand Total Jobs	**2,981**	**8,924**	**12,381**

Different phases of upstream development will require different occupational configurations over the next 5 years. In the pre-drilling phase (land acquisition, site preparation and similar activities), the most likely scenario will result in demand for 353 leasing agents, 212 environmental technicians, 149 lease acquisition specialists, and 127 each of biologists, para-legals, and abstract clerks. Out of 1,876 expected jobs for this phase, more than 58% (1,093) will require post-secondary or higher education; of these, some will also require work experience and certification. The more training-intensive jobs tend to be higher paying, and are likely to be the most difficult to fill. Land-leasing and legal will generate the most jobs during this phase. Geological research specialists engaged in

technological processes (environmental scientists, geologists & geophysicists, petroleum engineers, GIS technicians) account for 16% to 18% of total jobs. During this phase, a number of occupations such as lawyers, permitting technicians, civil engineers and cartographers will be employed.

The drilling phase of upstream operations generates the greatest demand for jobs. In the case of the most likely scenario, this phase will require 6,847 full time equivalent (FTE) annually employed people to drill, fracture, complete, and manage water use and construction of gathering lines. Of this total number of jobs (6,847), about 80% will be in drilling and completion operations; and another 20% will be in related midstream construction and operations. Roughnecks — core operators of drilling crews — will be in the highest demand, around 1,270 people. Rig movers (470) and heavy equipment operators (388) will also be in demand. The roughnecks' and operators' jobs require both certification and work experience. Frack crew members (367) and general laborers (194) are two other occupations that rely on physical labor. These jobs typically require workers to be on site for several consecutive days for a number of weeks, operating in 3-shifts a day. Among office jobs will be accountants (382), safety and first aid helpers (353), office and financial managers (308 and 212, respectively), public affairs representatives (212), and other types of clerks/receptionists (180).

Post-drilling operations (including production and processing jobs) will generate another 200 jobs, most of which are permanent and add to a pool of annual operating jobs. Compressor and other operators will generate about 55 jobs; in addition, continuous production will require the work of about 8 petroleum engineers and 8 production foremen. Reclamation triggered by having a well go out of service will require the work of a plugging crew, well tenders, and landscapers. Overall, this phase will generate about 45 jobs that require post-secondary or higher education, and almost all jobs in this phase require work experience or certification.

About one-third (33% or 2,900 jobs) of all of the jobs generated in pre-drilling, drilling, and post-drilling and operating phases also have higher education requirements. This contradicts the notion that local people with low-skills or minimal training will be the principal employees in the shale development industry. In addition, before oil and gas companies hire, they often require applicants to have had previous experience in the industry, be drug-free, and be available to work more than 40 hours a week.

An anticipated $4.7 billion of investment will be made over the next 5 years in interstate pipelines and natural gas processing plants that will generate an additional 5,000 annual FTEs in construction jobs in Ohio. This number does not include any new downstream industries, such as a cracker plant. If a petrochemical complex including a cracker plant and consecutive polyethylene plants will be built in Ohio, every $1 billion of construction cost will generate approximately 7,400 annual FTE construction jobs and another 1,570 jobs in supplier industries (crackers typically cost $5 billion or more). Beside the construction trades, the largest demand will be created in the wholesale industries (280 FTE jobs); manufacturing (200 FTE jobs); professional, scientific and technical services (247 FTE jobs); administrative and waste services (207 FTE jobs); and transportation and warehousing (192 FTE jobs) (all per billion spent). Among individual industries, the highest FTE labor demand will be for wholesale trade clerks (273), truck drivers (142), employment services employees (96), architects and engineers (96), back office employees (44) and lawyers (38) (per billion spent). The demand for these jobs will be annual and will continue for about five years.

Increased labor demand will also be generated by the operation of an assumed chemical complex. A petrochemical complex costing about $5-7 billion in investment will employ about 400 people

directly. Besides the 400 engineers, technicians, and support staff in the Basic Organic Chemistry industry, the demand for labor in its supply chain will require full-time employment of 160 workers for administrative and support services, 300 clerks in wholesale and retail trades, 127 workers in transportation and warehousing, and more than 70 workers across other manufacturing industries. These estimates represent permanent jobs that will likely be created if a cracker is built in Ohio. However, since any cracker that is built in Ohio (or West Virginia) will likely be built on the Ohio River for logistical reasons, there is likely be a significant number of workers who will cross state boundaries.

A number of positions will likely be in occupations for which Ohio already has a large number of skilled employees, such as administrative, managerial and clerical positions. However there are few incumbent workers in the many of the more highly specialized occupations, such as those found for drilling and oil and gas extraction employment.

The largest occupational demand will be for truck drivers, with 92,096 jobs. Truck driving is hardly a skill set new to Ohio. Nevertheless, it is also an occupation that is often cited in interviews with shale development companies and their suppliers as suffering from chronic shortages of available workers. Occupations that are essential for the operation of drilling rigs are estimated to have the smallest available numbers of workers in Ohio. Oil and gas roustabouts (775), riggers (259), rotary drill operators (193) and derrick operators (183) are at the top of the list of projected occupational needs for the drilling phase of upstream development. To meet the anticipated demand for these positions with local labor, training programs need to be established. The pattern of 2014 employment by occupation should not be proffered as evidence of the available labor supply in the future, but it does demonstrate that Ohio has a large potential pool of workers available for the oil and gas drilling and extraction industries.

The greatest challenge facing the oil and gas industry over the next 5 to 7 years nationally is the 'great crew change,' which highlights the large gap in knowledge between baby boomer-generation managers and the young workers who will replace them. Once the baby boom generation retire, the industry could face a leadership and skills crisis. This challenge has prompted the industry to create stronger connections with high schools, community colleges, and higher education institutions to provide a skilled workforce that is prepared to help the industry make this employment shift.

To capture the new jobs, it is essential to create connections in Ohio. Direct involvement of industry management in creating the training for middle-skilled oil and gas occupations is necessary. However, training should not be confined to oil and gas field operations. If Ohio wishes to capture some of the more highly compensated occupations in the oil and gas industry, including the downstream petrochemical industry, it is also necessary to provide education that supports highly skilled occupations. Positions in chemical, petrochemical, mechanical, process and environmental engineering will be crucial for the expansion of downstream industries. Ohio will realize the greatest value from its hydrocarbon production by retaining NGL and oil processing derivatives within the Ohio petrochemical industry, including plastics production and other manufacturing. The greatest number of jobs will be created in Ohio when Ohio production being used by Ohio-based manufacturing of polyethylene and other products that are then supplied to Ohio-based compounding and chemical companies.

1. INTRODUCTION

This is the second of three reports on the findings of a research project investigating the economic development potential of Utica and Point Pleasant (together, "Utica") oil and gas shale resources in Ohio. This project was funded by the Greater Cleveland Growth Association and is intended to provide actionable intelligence for the Regional Economic Competitiveness Strategy (RECS) committee of Northeast Ohio and for Ohio's statewide economic development organization, JobsOhio. While the development of Utica Shale resources has slowed with the 2014 downturn of oil and gas prices, the hydrocarbons have proven to be economically recoverable and the industry is here to stay. It will continue to draw on local talented and skilled labor. Two other reports of this project, *Mapping Opportunities for Shale Development in Ohio* and *Economics of Utica Shale in Ohio: Supply Chain Analysis*, deliberate on upstream and midstream building projections, assess the potential amount of hydrocarbons that will be extracted and processed regionally, and identifies opportunities for local contractors in the oil and gas industry supply chain. The two reports also present a special case for the extraction of ethane as a valuable product for petrochemical crackers and deliberate on factors affecting the opportunity to develop a petrochemical cluster of companies and their suppliers within the tri-state region of Ohio, Pennsylvania, and West Virginia.

This report presents projections for the labor demand created by the upstream industries, portions of the midstream industries (natural gas pipelines and processing infrastructure) and certain potential downstream industry (construction and management of a petrochemical cracker). The Study then looks at the likely available Ohio-based labor supply over the next five years, and compares it to potential upstream, midstream and downstream labor force demands in Ohio.

2. PROJECTION OF WORKFORCE FOR FUTURE UTICA DEVELOPMENT

2.1. Introduction to the Oil and Natural Gas Industry Workforce

Economic development of shale formations requires horizontal drilling, together with intense reservoir stimulation accomplished in completion zones ranging from 3000 to 10,000 feet. These technologies greatly increase the difficulty of the drilling and completion process over most conventional oil and gas operations. Higher technological complexity dictates the engagement of a larger and often more sophisticated labor force than conventional natural oil and gas drilling. Like other shale formations in the U.S., Utica shale drilling uses multiple high-intensity methods to extract and process natural gas in large quantities. Besides the increased complexity of drilling, four other factors influence labor demand for the local upstream industries: (1) oil and gas commodity prices, (2) the nature and amount of production, (3) access of a producing company to midstream infrastructure and (4) land leasing strategies and unitization procedure.

Being a horizontally contiguous deposit of oil and natural gas, the Utica shale, as do all organic shale formations, provides drillers with a reduced risk of failure to discover hydrocarbons. The hydrocarbons are there in predictable volumes; the only question will be whether they can be recovered economically, given existing technology. This simplifies the decision to drill: each well decision may be determined by its projected rate of return on investment. This is in turn determined by expenditures for drilling, completion and post-production infrastructure build out

compared to projections for the nature, volume and pricing of production, along with other factors, such as the accessibility of midstream gathering and processing infrastructure. The status of the Utica midstream infrastructure was explained in the companion report *Mapping the Opportunities for Shale Development in Ohio.* However that report did not analyze the position that a producing company may find itself within available midstream infrastructure. In particular, two factors will be important to the producer: (1) how accessible gathering trunk lines and processing facilities are to the well and (2) whether the company has reserved transportation and processing capacity within these lines and facilities. These are important to getting the production to the best markets – the matter of heightened importance in times of low hydrocarbon prices.

The drilling decision is usually about picking a location and designing a drilling plan that maximizes the economic return to the company. If a producing company already has one or a few wells in close proximity to prospective wells, it can better assess producing capacity of a future well and therefore more accurately assemble financial indicators and future plans for drilling and engaged labor. The pace of future drilling also depends on lease acquisition and requirements to maintain leases. After the first well is drilled in a drilling multi-well pad, the drilling site is hold to production. In this case the construction cost of each well and the pre-drilling (primarily construction) labor demand is incremental, while the drilling , production and post production demand for labor stays constant with each new well. Overall, the predictability of drilling strategies in shale formations allow for easier planning on how to deploy drilling rigs, develop midstream infrastructure, and plan for the resulting labor demand.

Other factors controlling the pace of development and, therefore, the future demand for labor include oil and gas commodity prices and related company investment strategies and international trade agreements on the export of hydrocarbons. Over the last 3-4 years, natural gas prices departed from the direct correlation with oil prices. However, since the most of Utica wells produce combination of products (natural gas liquids (NGLs) and dry gas, dry gas and oil or all three – dry gas, NGLs and oil) the dry gas and NGLs' prices fluctuate depending on oil commodity pricing. Movement in the sale price of natural gas and its derivative products influence the depth and breadth of exploration and the pace of field development.

The uncertain nature of the timing of Utica shale development, paired with the initial widespread placement of drilling sites, has influenced the transience of workers in the industry at the beginning period of Utica shale development, 2012-2013. As the industry continues to mature in the Utica region, the local workforce is growing. As contractors and sub-contractors move into the Utica region, the demand for basic goods and services is increasing. Local businesses will also ramp up to meet both business and residential demands. Many drilling, producing, and supply-field companies of all sizes have opened regional offices in the region.[2] While most employees of these companies were initially attracted from outside the region, now local workers are filling open positions. The recent assessment in Pennsylvania shows that after more than 10 years of Marcellus development, the employment of local residents in the shale gas industry and service companies has reached about 70% in the state.[3]

[2] For many companies the region covers both within the Marcellus and Utica shale basins.
[3] UpStream PA 2015 Conference, April 16, 2015. State College, PA.

The development of the Utica shale formation in Ohio has been projected to last anywhere from 20 to 70 years. The longevity of a producing well will inevitably increase as better fracking and reservoir management techniques are developed. Moreover, efforts to re-frack producing wells and the identification of other existing organic shale and tight sand formations in the same geography will likely extend the life of the Appalachian basin. The high cost of building a midstream and downstream infrastructure will also extend the length of time for drilling, as companies will seek to avoid decommissioning assets. The gradual maturation of the industry within the state will certainly lead to the engagement of local workers.

The demand for a skilled workforce depends on a number of factors, including, among others: technology changes, final demand for products, commodity prices, a midstream capacity to take produced products to the markets, the availability of capital, and how individual companies make their investments across multiple basins. Since shale gas development is more predictable than traditional oil and gas development, it will require a locally sourced, skilled workforce.

2.2. Methodology of Workforce Demand Assessment

Workforce projections for upstream and some midstream operations are based upon methods developed by Marcellus Shale Education and Training Center, a joint effort of Penn State University Extension and Penn College of Technology.[4] Penn State's methodology relies on a survey administered across a number of companies providing their assessments for the full-time job requirements for upstream and midstream operations. The model provided specific labor requirements on a per-well basis. These assessments also account for labor required to construct gathering lines, compressor stations, and some natural gas processing facilities. The research team then modified the Penn State model. Rather than use the per-well labor requirements directly, we provide three estimates, or scenarios, that use varying assumptions about scale economies and the adoption of labor-saving technologies.[5]

Penn State's model of projecting upstream and midstream labor force demand was based on the dry gas drilling in the Marcellus, and as such, it does not fully account for workforce demands that result from wet gas. For the Utica, early drilling has been in the wet gas region, where larger volumes of NGLs have been extracted. Also, assessment of labor demand for the construction of interstate pipelines are not part of the Penn State model. Therefore, we used the IMPLAN input-output model to develop labor coefficients for these activities.

An IMPLAN methodology is also used to project a prospective growth of downstream manufacturing industries if an ethylene cracker is going to be built in Ohio. The downstream demand is assessed in units scaled to $1 billion of an annual investment in the petrochemical industry and does not reflect the whole amount of actual investment even in a single cracker-related petrochemical complex project. Out downstream labor demand calculations show the fraction of potential demand created

[4] *Marcellus Shale Workforce Needs Assessment*, Marcellus Shale Education & Training Center, Penn State University, Summer 2009, http://www.shaletec.org/docs/NeedsAssessmentwithcover.pdf and *Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment*, Marcellus Shale Education & Training Center, Penn State University, June 2011, http://www.shaletec.org/docs/StatewideWorkforceNeedsAssessment.pdf.

[5] Increases in labor force demand is not proportional to increases in the number of drilled wells.

by a unit of investment and can be scaled to actual proposed investments in Ohio.[6] All models in this report estimate statewide Ohio labor demand. Midstream and downstream labor demand in the tri-state region of OH, PA, and WV is the subject of another forthcoming report.[7]

To analyze the supply side of Ohio's labor force, this study examines the existing pools of skills available in the region for four segments of the oil and gas industry: (1) drilling, (2) pipeline construction and operation, (3) extraction and (4) petrochemical manufacturing.

2.3. Modeling Assumptions

Projections for labor force demand in Ohio are based on a number of assumptions. The methodology for projecting labor force demand uses a conceptual timeline of the overall well extraction process. It builds on the Pennsylvania workforce studies, adjusting it to fit the Utica drilling and production experiences (Figure 1). The model includes four phases related to the drilling and production processes and two phases of the midstream infrastructure – construction and operation. For purposes of this analysis, upstream refers to the pre-drilling, drilling, and production phases (see Well Extraction timeline in Figure 1). And midstream refers to the transportation and processing segments of the oil and gas business (see Midstream Construction in Figure 1). The relevant oil and gas downstream segments to this analysis refer to manufacturing industries including basic chemicals manufacturing; resin, synthetic rubber and artificial synthetic fibers manufacturing; plastic products and other chemical products manufacturing; and pesticide, fertilizer, and other agricultural products manufacturing.

Figure 1. Well Extraction Timeline

Well Extraction Timeline			
Management of Mineral Rights			
Pre-Drilling **4-6 months**	**Drilling and Completion** **4-6 weeks**	**Production** **10-50 years**	**Reclamation** **1-2 months**
Geological research Land leasing Permitting Pre-drilling construction (well pads, roads, water supply)	Drlling Stimulaion Completion Interim reclamation	Production Re-stimulation Production (maintenance and well monitoring)	Plugging Reclamation Restoration

Midstream Construction, Operation, and Maintenance	
Pipeline Construction **6 months to 3 years**	
Gathering Pipelines Temp flax water lines Take-away interstate pipelines (gathering and transportation; pipeline maintenance and monitoring)	**Building Gas Processing Capacity** **4 months to 5 years** Compressing facilities Fractionation/Cryogenic/De-ethanization plants Refining plants (processing and maintenance)

[6] IMPLAN calculations are based on linear model and does not account for economy of scale. At the time of this research there were no reliable projections of actual amount of investment in Ohio cracker. Moreover, to accurately project labor demand, a number of assumptions need to be made on pace of investment across multiple years and actual costs of investments in capital and labor.

[7] *Opportunities and Challenges of Downstream Development in Marcellus-Utica Region: Ohio, Pennsylvania and West Virginia*. Center for Economic Development & Energy Policy Center. Cleveland State University. 2015. Forthcoming.

The pre-drilling, drilling, production and reclamation phases overlap in time with the construction of interstate pipelines and natural gas processing facilities. All of the drilling-related phases are technologically advanced and unevenly spread across the extraction timeline. Pre-drilling may last from 4 to 6 weeks and requires only fractions of full-time equivalent (FTE) jobs. Drilling and completion activities also last for 4 to 6 weeks for a well, but during this time a drilling crew is sometimes employed for 50-60 hours a week. The production phase of the process takes the longest time – essentially the commercial life of the well and generates minimal direct employment. No commercial Utica wells have been plugged and abandoned yet, so the life expectancy of the wells is uncertain. However, assuming 10 to 15 years of commercial production are reasonable, setting aside technological advances that might extend that time to 20 or 50 years. After the well is taken out of production, it is plugged and abandoned. Under most lease terms, the land is also reclaimed and restored to its original condition. The process of midstream construction and operation runs parallel with the drilling-related phases. While well-connecting gathering lines are constructed usually within weeks or months, building gas processing plants takes at least 4 months to a year.[8]

The workforce estimates assume that the industry's practice of using transient workers for well-field developments will continue: many Utica shale workers will be transient residents, especially the engineering personnel. Similarly, companies coming to Ohio to drill, bring their equipment and assigned crews for drilling rigs. Companies providing drilling services commonly assign two crews to each drilling rig. Crew shifts work about 10-14 days each and travel with the rig from basin to basin. While the drilling rig crews tend to be rig-specific rather than region-specific, with time, more and more local workers can be included in the rig crews, thereby reducing company travel and relocation costs. Transient workers are often employed in other large field development construction projects, such as building interstate pipelines.

Although the production phase is less labor intensive, local workers are typically employed. Furthermore, wet gas development offers more job opportunities than does dry gas field development due to additional processing needs. Examples of some common wet-gas, add-on production jobs include: processing and fractionation plant technicians, chemical and process engineers, and equipment service and maintenance specialists. In addition, many midstream jobs are also those found in upstream work, such as compressor operators, pipeline maintenance and technicians, information technology specialists, gauge monitoring technicians, supervisory positions, civil engineers, loaders and testers.

The model developed in Pennsylvania used data gathered from producers and service companies developing Marcellus wells from 2009 to 2011. All projections are Full-Time Equivalents (FTE) and require 260 eight-hour days or 2,080 hours of work per year for each worker. The model assumes that the large rotary rigs used in the Utica drill about 12 wells per year. The first well drilled on a pad requires, on average, one mile of gathering pipeline construction; additional wells on a multi-well pad do not require construction beyond making a connection. Projecting the number of jobs

[8] *Marcellus Shale Workforce Needs Assessment*, Marcellus Shale Education & Training Center, Penn State University, Summer 2009, http://www.shaletec.org/docs/NeedsAssessmentwithcover.pdf and *Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment*, Marcellus Shale Education & Training Center, Penn State University, June 2011, http://www.shaletec.org/docs/StatewideWorkforceNeedsAssessment.pdf.

generated in a wet gas play is also tied to the volume of natural gas production due to required natural gas liquid processing. We assume that 50% to 60% of Utica wells are drilled for wet gas. The percentage of wells drilled for wet gas in Utica will be proportionately larger than that drilled in the Marcellus during the time of developing this model by Penn State. Therefore, the coefficients for phases of a single well development (Table 1) used by the Ohio Study Team for wet gas wells are higher than that developed for Marcellus study. The higher coefficients per single wet gas well in the Utica is the result of an anticipated need for more midstream infrastructure for Utica wet gas processing compared to Marcellus dry gas processing (if any). These increased midstream coefficients are intended to account for a larger required processing capacity infrastructure. However they do not include construction of interstate gas or pure product (liquid) large diameter pipelines.

The decline curve of production in Utica wells is similar to that of the Marcellus wells (60% to 65% for the first-year) and therefore allows for modeling of labor for the maintenance and production-phase in a manner similar to the Marcellus model. The expected ultimate recovery (EUR) for an average well is assumed to be 3.5 bcf (billion cubic feet) of natural gas.[9]

As with the Marcellus, the typical early Utica well pad is located on 640 acres and is built with 6 slots with the intention of drilling 3 to 4 wells. Since 2014, a more common strategy has been to build a single pad that can access two land units of around 750 acres each, and to drill 3 to 4 wells per unit, resulting in 6 to 8 wells per pad. Projections of the average number of wells per pad in the future will increase from 3.0 in 2015 to 4.5 in 2019.[10]

The projections based on the Pennsylvania model assess jobs in three segments: pre-drilling, drilling, and post-drilling operation of wells and midstream operations. The last phase also includes the workforce demand for well reclamation and closing. Pre-drilling jobs decrease by 73% for every subsequent well drilled on the same well pad. Drilling and completion jobs decrease by about 16% for every additional well on a pad. The production operations workforce for dry gas and wet gas remains the same for every well drilled.

The majority of pre-drilling and drilling jobs are not additive; meaning that annual FTE equivalents are estimated. The calculations include only direct jobs created for drilling and production and do not include indirect jobs required in supply services or induced jobs resulting from increased consumer spending. Production jobs do compound over years (0.19 FTE jobs per dry well and 0.39 FTE jobs per wet well) as long as the wells are operational, and they will increase proportionally with the growth in the well output. An additional 0.20 FTE for gas processing per wet well is calculated as diminishing to 0.02 FTE as production declines over time (Table 1).

[9] *Id*. These EURs are decidedly outdated in 2015 due to the longer laterals being drilled, dramatically improving production per well. However they remain a useful if conservative estimate for purposes of workforce analysis.

[10] Methodology of development drilling projections are discussed in the report *Mapping the Opportunities for Shale Development in Ohio*. Center for Economic Development & Energy Policy Center. Cleveland State University. September 2015.

Table 1. Workforce Required per Average Utica Well (annual FTE Equivalent)

Phase of Development	First/Single Well		Additional Well	
	Dry Gas	Wet Gas	Dry Gas	Wet Gas
Pre-drilling	2.41	2.41	0.65	0.65
Drilling and Pipeline (GL)	10.49	10.49	8.81	8.81
Production	0.19	0.19	0.19	0.19
Wet Gas Processing		0.20		0.20
Total	**13.09**	**13.29**	**9.65**	**9.85**

2.4. Assessment of Ohio Upstream and Midstream Labor Demand

Using the assumptions developed for the Penn State model and adjusted for Utica drilling conditions and product, it is estimated that over the next five years, starting in 2015, the upstream segment of the industry will generate about 10,505 full-time jobs in Ohio from the development of the Utica (Table 2, Figure 2). Construction and drilling jobs are estimated annually, and they will increase from 7,558 in 2015 to 9,495 in 2019 following the most likely scenario of drilling discussed in another report of this study.[11]

If drilling in Ohio continues at an annual rate of 700 wells (the number in 2015), and increases to 879 wells per year by 2019, the downstream operations will likely generate 7,558 direct jobs in 2015. This number of direct jobs is likely to grow to 9,495 direct drilling and midstream jobs and result in over 1,000 jobs in the production of oil and gas over a five-year period (Table 2, Figure 2).

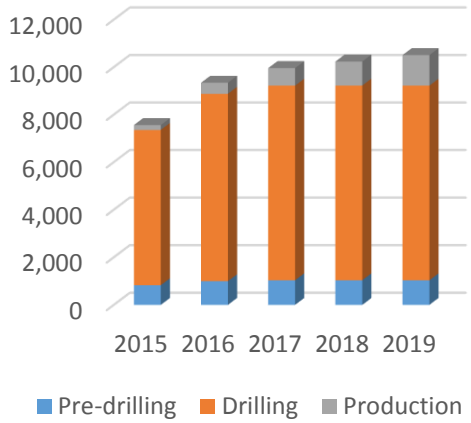
These projections of overall demand for downstream and part of the midstream operations is complemented with detailed projections of specific occupations in each phase of drilling and production. Small discrepancies between the overall projections and the detailed projections discussed later in this chapter are likely because it is impossible to update the detailed occupational workforce coefficients to accommodate Utica's higher drilling rate for wet gas wells. Despite this limitation, the detailed projections are valuable for assessing the future labor force demand related to Utica development.

[11] Methodology of development drilling projections are discussed in the report *Mapping the Opportunities for Shale Development in Ohio*. Center for Economic Development & Energy Policy Center. Cleveland State University. September 2015.

Table 2. Projections of the Workforce Demand for Ohio, 2015-2019

Year	Workforce Demand		
	Annual Pre-drilling & Drilling Jobs	Annual Production Jobs	Total (annual pre-drilling & drilling and accumulated production jobs)
2015	7,355	203	7,558
2016	8,875	263	9,342
2017	9,223	272	9,961
2018	9,222	273	10,233
2019	9,223	272	10,505

Figure 2. Projected Annual Jobs in the Upstream and Part of the Midstream Industries in Ohio, 2015-2015



A set of detailed workforce demand coefficients was applied to estimate the types of jobs that will be in demand in Ohio as a result of the Utica play.[12] Since detailed coefficients were derived from interviews with individual companies that were drilling Marcellus shale, the coefficients could not be tailored for current Utica conditions. The main difference in detailed workforce projections and gross estimates presented in Table 2 is that the length of the gathering lines is shorter in Marcellus shale drilling (1 mile per well) compared to Utica drilling (about 3 miles) and the ratio of wet gas wells to total wells drilled is smaller in the Marcellus than that in the Utica basin (about 20% in Marcellus vs. 50%-60% in Utica).

Workforce demand is also modelled across three scenarios of Utica drilling: a very conservative projection based on drilling 260 wells a year; the most likely scenario, based on drilling 849 wells a year, and an optimistic scenario based on drilling 1,186 wells a year.[13] The conservative projections are based upon assumptions that oil and gas prices will continue to be significantly depressed for the next 5 years and would not stimulate an increased number of wells drilled in the Utica. However indications based upon permitting activity in Ohio suggest that notwithstanding sustained low prices, a more optimistic projection based upon assumptions of growing oil and gas prices, is the more likely scenario to be realized over the next five years.

[12] Detailed methodology on development of FTE coefficients on per well bases is described in reports *Marcellus Shale Workforce Needs Assessment*, Marcellus Shale Education & Training Center, Penn State University, Summer 2009, http://www.shaletec.org/docs/NeedsAssessmentwithcover.pdf and *Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment*, Marcellus Shale Education & Training Center, Penn State University, June 2011, http://www.shaletec.org/docs/StatewideWorkforceNeedsAssessment.pdf.

[13] The methodology of development drilling projections are discussed in the report *Mapping the Opportunities for Shale Development in Ohio*. Center for Economic Development & Energy Policy Center. Cleveland State University. September 2015.

In 2015, Ohio had a total of 1,541 horizontal wells drilled and 1,980 permits granted in the Utica.[14] However with depressed prices, it is likely that the total number of wells drilled in 2015 will be slightly below the number used in the most likely scenario. However drilling is likely to be back on target by 2019, reaching 850 wells drilled a year. The detailed estimates of the most likely scenario of 8,924 jobs in the upstream and partial midstream portions are close to our gross projection of 9,138 in 2016.

Table 3. 2015 Totals of Detailed Job Projections by Development Phase and Scenario

Development Phase/Scenario	Conservative	Most Likely	Optimistic
Total Pre-Drilling Jobs	625	1,876	2,606
Total Drilling Jobs	2,294	6,847	9,501
Total Operating Jobs	62	201	274
Grand Total Jobs	**2,981**	**8,924**	**12,381**

We expect that in the next five years Utica development will be close to that projected in our most-likely scenario. These are the estimates that are discussed in detail below (Table 4).

2.4.1 Expected Pre-Drilling Job Creation

The most likely scenario of drilling and connecting new wells to the growing midstream infrastructure will create demand for 353 leasing agents, 212 environmental technicians, 149 lease acquisition specialists, and about 127 each of biologists, para-legal, and total-abstract clerks during the pre-drilling phase of development. These are annual estimates of the number of jobs created in developing the well filed over the next five years in case of most likely scenario of drilling. Out of a total of 1,876 jobs for this phase, more than 58% (1,093) jobs require post-secondary or higher education; of these, some will also require work experience and certification. The more training-intense jobs are high-paying and are likely to be in great demand. Most will be created in land-leasing and legal companies. Geological research specialists engaged in this phase of the technological process (geologists & geophysicists, petroleum engineers, GIS technicians) account for 16%-18% of total jobs. During this phase, a number of occupations such as lawyers, permitting technicians, civil engineers and cartographers will be engaged. Some companies questioned during the survey listed additional occupational requirements to perform pre-drilling operations that go beyond the types of jobs illustrated in Table 4 (See Appendix Table A-1 – jobs listed in the left column in bold).

[14] Ohio Department of Natural Resources, Oil & Gas Resources Division, updated June 8, 2015. http://oilandgas.ohiodnr.gov/shale

Table 4. Highest Demand Pre-Drilling Jobs Projections

Associated Jobs	Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	Scenario		
				Conservative	Most Likely	Optimistic
Leasing Agents (Right-of-Way)		x		120	353	492
Environmental Technicians		x	x	72	212	296
Geologists & Geophysicists			x	58	170	237
Lease Acquisition				51	149	208
Biologist				43	127	178
Para-legal	x	x	x	43	127	178
Title-Abstract	x	x	x	43	127	178
Surveyors		x	x	36	106	149
Lawyers		x		29	85	119
Petroleum Engineers			x	25	79	104
Civil Engineer			x	22	67	94
Heavy Equipment Maint Tech		x	x	20	62	86
Cartographer			x	14	47	63
GIS Technicians		x	x	14	47	63
Landmen-for drilling/leasing		x		14	47	63
Lawyers			x	7	24	33
Lease Admin				7	24	33
Permitting Technicians			x	7	24	33

2.4.2. Expected Drilling Phase Job Creation

The drilling phase generates the greatest demand for jobs. In the case of the most likely scenario, this phase will require 6,847 FTE annually employed people to complete drilling, fracturing, completion, water management and construction of the required midstream infrastructure of gathering lines, compressors, and processing plants. These are annual estimates of the number of jobs created in developing the well filed over the next five years in case of most likely scenario of drilling. Of this total number of jobs, about 80% will be in drilling and completion operations and another 20% will be in the related midstream construction and operations. (Table 5 and Appendix Table A-2).

Table 5 includes the 30 highest demand jobs during the drilling phase. Each of these 30 occupations generate at least 20 jobs annually in the case of the most likely scenario of Utica development in

Ohio. All jobs generated at this phase are listed in the Appendix Table A-2. Roughnecks – core operators of drilling crews -- will be in the highest demand, totally around 1,270 people. Rig movers (470) and heavy equipment operators (388) will also be in demand. The roughnecks' and operators' jobs require both certification and work experience. Frack crew members (367) and general laborers (194) are two other types of physical labor jobs that will be in demand. These jobs typically have long work-week assignments, and operate on 3-shifts a day. Among high demand office jobs, the most needed will be accountants (382), first aid helpers (353), office and financial managers (308 and 212, respectively), public affairs representatives (212), and other types of clerks/receptionists (180).

Table 5. Highest Demand Drilling Jobs Projections

Associated Jobs	Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	Scenario		
				Conservative	Most Likely	Optimistic
Roughnecks	x	x		500	1470	2053
Rig Move				160	470	657
Heavy Equipment Operators		x	x	132	388	542
Accountants	x			130	382	534
Frack Crew				125	367	513
First Aid		x		120	353	492
Office Management		x		105	308	430
Financial/Business Management			x	72	212	296
Public Affairs				72	212	296
General Labor	x			66	194	271
Clerks/data entry/reception			x	61	180	252
Directional Drilling				56	165	230
Roustabouts		x		50	147	205
Pipe Fitters		x	x	44	130	181
Field Representatives			x	43	127	178
Welder Helpers				33	97	136
Roustabouts		x		33	97	136
Flowback Analyzer	x	x		30	93	123
Commercial Driver's License		x		29	89	119
Finishing Rig				28	85	115
Company Man/Geologist		x	x	25	78	103
Tool Pushers		x		25	78	103
Mudmen	x	x	x	25	78	103
Superintendent				22	68	90
Petroleum Engineers			x	22	67	94
Boring Crew	x	x	x	21	66	91
Electricians		x	x	20	62	86
Logging				20	62	86
Weld Inspectors		x	x	17	51	71
Welders		x	x	17	51	71

The drilling phase requires significantly more labor with work experience and lower educational attainment than is required for the pre-drilling phase; only 25% of all occupations require post-secondary or higher education. However, lack of experience in directional drilling operation among local labor is the main impediment to hiring local workers.

2.4.3. Expected Post-Drilling Job Creation

The last phase consists of post-drilling operations. These will generate about 200 jobs, most of which are permanent and add to a pool of annual operating jobs (Table 6 and Appendix Table A-3). These are annual estimates of the number of jobs created in developing the well filed over the next five years in case of most likely scenario of drilling.

Table 6. Highest Demand Operating/After-Drilling Jobs Projections

Associated Jobs	Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	Scenario		
				Conservative	Most Likely	Optimistic
Landscapers-architect	x	x		15	49	65
Operator		x		12	38	50
Well Tenders/Roustabout		x		10	34	47
Plugging Crew		x	x	8	26	36
Compressor Operator				5	17	24
Heavy Equipment Maint Tech		x	x	3	11	15
Service Rig Operator		x		3	9	13
Petroleum Engineers			x	3	8	12
Production Foreman	x	x		3	8	12

Compressor and other operators will generate about 55 jobs; in addition, continuous production will require the work of about 8 petroleum engineers and 8 production foremen. Reclamation triggered by having a well go out of service will require the work of a plugging crew, well tenders, and landscapers. Overall, this phase will generate about 45 jobs that will require post-secondary or higher education, and almost all jobs in this phase require work experience or certification.

About one-third (32.5% or 2900 jobs) of all of the jobs generated in pre-drilling, drilling, and post-drilling and operating phases will have higher education requirements. This contradicts the notion that local people with low-skills or minimal training will be the principal employees in the shale development industry. In addition, oil and gas companies often require previous experience in the industry, require their workers be drug-free, and require that they be available to work more than 40 hours a week.

In addition to the modeled upstream and midstream jobs, projections for interstate pipeline projects and additional capacity in wet gas processing were generated using IMPLAN Ohio data tables, which reflect the structure of Ohio's economy in 2013.[15] Based on information received from midstream companies and an inventory of Ohio investments tracked and published by Bricker & Eckler LLP,[16] this study assumes that an additional $4.7 billion of investment will be made in Ohio over the next 5 years in interstate pipelines and in natural gas processing plants. Employment projections for the midstream industry accounted for in drilling labor force projections do not include the labor demand for the construction of interstate pipeline and processing plants. Because of unknown annual investment in the interstate pipelines construction, the study team assumed that interstate pipeline projects will be constructed over the five-year period and every year 1/5 of the total investment for the project will be spent. The completion of large midstream infrastructure projects will require 5,000 FTE annual construction jobs in Ohio. These jobs will be created in addition to the midstream jobs projected in the drilling phase.

2.5. Labor Supply in Drilling, Oil and Gas Extraction, and Midstream Construction Occupations

To identify shortages in the local labor supply, the study looked at the occupational employment in oil and gas industries across Ohio in 2014.[17] We examined the pattern of the largest occupational groups (Table 7) and those that have smallest employment (Table 8) in 2014.[18]

While the number of positions in the largest Ohio occupations suggest that Ohio has ample supplies of skilled labor in administrative, managerial and clerical positions, there are fewer incumbent workers in the more highly specialized drilling and oil and gas extraction occupations. Also, truck drivers are listed as a very large occupational group with 92,096 jobs. However, it is also one of the occupations that is often cited in interviews with shale development companies and their suppliers as having chronic shortages.

The pattern of 2014 employment by occupation cannot be proffered as the available labor supply of the future, but it does demonstrate that Ohio is a state with a large potential pool of workers that are potentially available for all oil and gas drilling and extraction industries.

[15] The latest data available at the time of modeling.
[16] Latest report claiming more than $28 billion in shale-related investments in Ohio. May 4, 2015, http://www.bricker.com/documents/resources/shale_economic_development_chart.pdf.
[17] EMSI data were used to assess occupational employment in the oil and gas-related industries.
[18] Detailed tables of occupational employment in Drilling and Extraction Industries are presented in Appendix Tables A-4 and A-5.

Table 7. Occupations with the Largest Number of Jobs that are Relevant to the Drilling, Oil and Gas Extraction, and Midstream Construction Industries in Ohio, 2014

Occupations	2014 Employment
Laborers and Freight, Stock, and Material Movers, Hand	106,659
Janitors and Cleaners, Except Maids and Housekeeping Cleaners	104,496
Office Clerks, General	102,588
Real Estate Sales Agents	101,345
Heavy and Tractor-Trailer Truck Drivers	92,096
First-Line Supervisors of Retail Sales Workers	74,972
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	72,839
Bookkeeping, Accounting, and Auditing Clerks	68,353
General and Operations Managers	66,427
Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	58,765
Managers, All Other	52,685
Accountants and Auditors	52,522
Construction Laborers	52,467
Maintenance and Repair Workers, General	52,294
First-Line Supervisors of Office and Administrative Support Workers	45,835
Personal Financial Advisors	45,509
Property, Real Estate, and Community Association Managers	38,955
Management Analysts	37,095
Sales Representatives, Services, All Other	33,269
Machinists	29,390
First-Line Supervisors of Production and Operating Workers	29,272
Computer Systems Analysts	29,007
Executive Secretaries and Executive Administrative Assistants	28,777
Financial Managers	27,512
Lawyers	27,219
Business Operations Specialists, All Other	26,419
Inspectors, Testers, Sorters, Samplers, and Weighers	26,341
Electricians	25,587
First-Line Supervisors of Construction Trades and Extraction Workers	23,525
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	22,999
Helpers--Production Workers	20,422

Essential occupations for operating drilling rigs are listed as having the smallest available numbers of workers in Ohio (Table 8). Oil and gas roustabouts (775), riggers (259), rotary drill operators (193) and derrick operators (183) are at the top of the list of projected occupational needs for upstream development. To meet the anticipated demand of Utica shale development and enable producers to hire local labor, significant training positions will need to be established to meet projected demand.

Table 8. Occupations with the Smallest Number of Jobs that are Relevant to the Drilling and Oil and Gas Extraction Industries in Ohio, 2014

Occupations	2014 Employment
Maintenance Workers, Machinery	4,465
Mobile Heavy Equipment Mechanics, Except Engines	4,107
Engineering Technicians, Except Drafters, All Other	3,638
Title Examiners, Abstractors, and Searchers	3,367
Environmental Scientists and Specialists, Including Health	2,955
Helpers--Installation, Maintenance, and Repair Workers	2,319
Wellhead Pumpers	1,880
Crane and Tower Operators	1,691
Petroleum Pump System Operators, Refinery Operators, and Gaugers	1,510
Excavating and Loading Machine and Dragline Operators	1,476
Geoscientists, Except Hydrologists and Geographers	1,104
Helpers--Extraction Workers	1,051
Roustabouts, Oil and Gas	775
Service Unit Operators, Oil, Gas, and Mining	661
Pump Operators, Except Wellhead Pumpers	612
Earth Drillers, Except Oil and Gas	499
Petroleum Engineers	383
Gas Compressor and Gas Pumping Station Operators	332
Riggers	259
Geological and Petroleum Technicians	254
Rotary Drill Operators, Oil and Gas	193
Derrick Operators, Oil and Gas	183
Extraction Workers, All Other	183

The incumbent workforce does not fully reflect the supply of labor. In case of increased demand for oil and gas-related occupations, middle-skilled qualified workers from other industries will be attracted to the oil and gas-related jobs by higher wages and opportunities of better careers. The less qualified workers will have opportunities to fill the labor gap created in industries that lost some workers to the oil and gas industry. These less qualified workers will move from unemployment or under-employment to full employment, reducing the number of unemployed. Another supply of qualified labor will come from the educational pipeline. Since Utica development is projected to last from 20 to 70 years, educational institutions should align their programs with occupations that are in highest demand for the local oil and gas development, processing and potentially downstream manufacturing.

In addition, those employed in occupations that pipeline construction companies can draw from are in large supply in Ohio. The construction of pipelines and gas processing facilities, which are needed

for Utica midstream infrastructure, will need to compete with construction for drilling and extraction and all other industries, including downstream manufacturing projects (Table 9 and Appendix Table A-6).

Table 9. Occupations with the Largest Number of Jobs that are Relevant to the Pipeline Construction Industry in Ohio, 2014

Occupations	2014 Employment
Laborers and Freight, Stock, and Material Movers, Hand	106,659
Office Clerks, General	102,588
Heavy and Tractor-Trailer Truck Drivers	92,096
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	72,839
Bookkeeping, Accounting, and Auditing Clerks	68,353
General and Operations Managers	66,427
Managers, All Other	52,685
Accountants and Auditors	52,522
Construction Laborers	52,467
Maintenance and Repair Workers, General	52,294
Carpenters	47,992
Unclassified Occupation	41,637
First-Line Supervisors of Production and Operating Workers	29,272
Executive Secretaries and Executive Administrative Assistants	28,777
Business Operations Specialists, All Other	26,419
Inspectors, Testers, Sorters, Samplers, and Weighers	26,341
Electricians	25,587
First-Line Supervisors of Construction Trades and Extraction Workers	23,525
Helpers--Production Workers	20,422
Construction Managers	18,969
Industrial Machinery Mechanics	17,798
Welders, Cutters, Solderers, and Brazers	17,558
First-Line Supervisors of Mechanics, Installers, and Repairers	16,280
Plumbers, Pipefitters, and Steamfitters	16,023
Operating Engineers and Other Construction Equipment Operators	13,926
Bus and Truck Mechanics and Diesel Engine Specialists	12,298
Cost Estimators	10,398

The current pool of 52,467 construction laborers will be available for all construction projects in Ohio. Workers of specific occupations, such as welders, cutters, solderers, and brazers (17,558) and plumbers, pipefitters, and steamfitters (16,023) are available in Ohio and could be engaged in construction of pipeline projects for midstream companies. Individual interviews with midstream companies, local government representatives in the core Utica development counties, and

producers indicate that companies prefer to hire local labor and have not yet seen any shortage in construction labor. Moreover, some companies prefer to contract unionized labor because of their members' heightened skills, work ethic, and discipline. Union laborers are required to be drug free, which makes this labor supply very attractive to oil and gas construction companies, which value both skill and safety.

2.6. Projected Labor Demand from the Construction and Operation of a Cracker

Based on the prospects for development of the petrochemical downstream cluster in the Mid-Ohio Valley,[19] this study assessed the workforce that is required to construct a cracker complex. Usually, a cracker is built as part of a petrochemical complex, which besides the cracker plant includes two or three polymerization plants. We project the annual workforce need during the construction of a petrochemical complex that spends $1 billion in a given year. We also assume that the complex will require an annual operating workforce of 400 workers.[20]

Annual construction operations will account for 7,400 FTE construction jobs[21] and approximately another 1,570 jobs in supply industries. Beside the construction trades, the largest demand will be created in the wholesale industries (280 FTE jobs); manufacturing (200 FTE jobs); professional, scientific and technical services (247 FTE jobs); administrative and waste services (207 FTE jobs); and transportation and warehousing (192 FTE jobs). Among individual industries, the highest FTE labor demand will be in the fields/categories of wholesale trade clerks (273), truck drivers (142), employment services employees (96), architects and engineers (96), back office employees (44) and lawyers (38). The demand for these jobs will be annual and continue for about five years.

Increased demand will also be generated by the operation of a cracker and polymerization plans. The petrochemical complex worth about $5-7 billion will directly employ about 400 people. Besides the 400 engineers, technicians, and support staff in the Basic Organic Chemistry industry, the demand for labor in its supply chain will require full-time employment of 160 workers in the Administrative and Support Services industry, 300 clerks in wholesale and retail trades, 127 workers in transportation and warehousing, and more than 70 workers across other manufacturing sectors. These estimates represent permanent job opportunities that should be created if a cracker is built in Ohio.[22]

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[19] In details discussed in Chapter 4 of the report *Mapping the Opportunities for Shale Development in Ohio*. Center for Economic Development & Energy Policy Center. Cleveland State University. September 2015.

[20] Multiple newspaper announcements and policy briefs quoted Shell and Braskem projects in PA and WV estimating a demand for about 10,000 construction jobs to build an ethane cracker and consecutive polyethylene plants and creation of 350-400 permanent jobs to run these facilities. For example, The Intelligencer, March 28, 2015: http://www.theintelligencer.net/page/content.detail/id/629069.html; *The Business Journal*, March 15, 2012: http://archive.businessjournaldaily.com/economic-development/shell-chemical-selects-beaver-county-pa-cracker-plant-2012-3-15; Pennsylvania Budget and Policy Center, June 8, 2012: http://pennbpc.org/cracker-plant-tax-credit-expensive-taxpayers-while-promising-few-permanent-jobs.

[21] These assessments are based on IMPLAN estimates for direct and indirect jobs triggered by increased annual demand of construction industry by $1 billion. Industrial FTE IMPLAN coefficients were used to estimate full-time jobs requirements.

[22] The detailed and more precise analysis of the downstream demand will require inclusion in the modeling of the specific data for the proposed Ohio cracker and could be a subject to a separate study.

2.7. Shale Development Middle-Skilled Workforce Challenges

The greatest challenge facing the oil and gas industry over the next 5 to 7 years is the 'great crew change,' which highlights the large gap in knowledge between baby boomer-generation managers and the young workers who will replace them. Once the baby boomers retire, the industry could face a leadership and skills crisis. This challenge has prompted the industry to create stronger connections with high schools, community colleges, and higher education institutions to provide a skilled workforce that is prepared to help the industry make this employment shift. To successfully complete this task, the industry needs to define the core knowledge, skills and abilities for all rig-related positions. The industry is being pressed to increase efficiency, especially with depressed oil and gas prices, and to continue improving the efficiency of its production processes. For example, new "cyber rigs" are more technologically advanced than traditional rigs and require a workforce with a new set of skills. Both industry and community colleges might benefit from developing programs to prepare trained and prequalified entry-level workers and offer learning opportunities for more sophisticated skills for higher level operators and first-line managers.[23]

Additionally, workers and potential workers for many of the low- and middle-skilled occupations need a streamlined screening and testing process to evaluate basic computational and logical skill sets. These are sometimes called "soft skills" and are vitally important for an industry where any unwise decision can cause significant damage. Related to this need for screening is an emphasis on environmental awareness for workers, who need to understand why they are faced with strict environment-related procedures and protocols.[24]

In addition to the training the workforce for the 'great crew change,' increased workers safety became one of priorities for producing companies requiring additional training to be provided to the oil and gas industry workers. In a rapidly changing industry such as shale gas development, the collaboration of many companies and crews across many locations can make developing a clear safety protocol difficult. Producing companies typically contract many crews, including rig operators, drilling fluid/mud handlers, mud loggers, and casing operators. Many crews like working for different companies because it ensures improved job stability. This fragmentation of the natural gas industry requires a common safety system, where every crew involved in shale exploration and drilling understands the same protocols and procedures. Each crew needs to understand how they fit into the network, and respond to the safety needs of others accordingly. More cooperation between the industry and educational institutions can improve this understanding, but much work needs to be done within the industry.

While the upstream workforce challenges are typical of oil and gas industry, the shortages in supply of oil and gas downstream industries are more typical to the rest of manufacturing base. Interviews with some chemical, petrochemical and plastics companies that currently operate in the Mid-Ohio Valley suggest the existence of a shortage of available workforce for low-paid entry-level positions. These concerns were expressed primarily by smaller companies that operate on a small-scale economy of output, and offer lower wages and modest-if-any benefit packages to their employees.

[23] Workshop "Opportunities for the Gulf Research Program. Middle-Skilled Workforce Needs." The National Academies Press. Washington, D.C. www.nap.edu

[24] Pennsylvania Marcellus Shale Workforce Needs Assessment. Marcellus Shale Education and Training Center. Summer 2011. www.msetc.org.

Companies with better pay and more generous benefits usually attract workers from the smaller companies where these workers have acquired some experience and knowledge on industry standards and operations.

3. Conclusions and Future Research

Utica shale deposits will be developed in Ohio over the next 20, 50, or even 100 years. However fostering upstream, midstream and downstream industries around Utica play will require skilled labor to produce and transform dry gas, NGLs and oil locally. Projected future labor demand identified occupations that need to be trained in upstream and midstream operations and examined the expansion of necessary skills needed to facilitate a downstream petrochemical complex.

Even the conservative scenario illustrated that about 20,000 direct jobs in construction and maintenance of upstream and midstream infrastructure will require training of leasing agents, environmental technicians, para-legal, GIS technicians, cartographers, roughnecks, rig movers, heavy equipment operators, frack crew members and general laborers. In addition to field-related jobs, office occupations will be in high demand, including accountants, first aid helpers, office and financial managers, public affairs representatives and other types of clerks/receptionists. Most highly-paid positions will be created in maintenance and oil and gas processing and manufacturing operations. These activities will require additional managers, civil, petroleum, chemical engineers, process technicians, environmental engineers and clerks, lawyers, geologists and related technical and support staff.

Additional research would further support economic development analysts looking to better understand workforce shortfalls. The Study could be supplemented by a careful assessment of occupations needed for building and operating petrochemical complexes (with chemical cracker(s) in their core) and further expansion of downstream chemical and petrochemical companies in Ohio. Interviews conducted in this Study with industry representatives identified existing shortages of skilled labor in Mid-Ohio Valley. This labor shortage tends to be most problematic for companies at the lower end of product pricing and profit margins. Many of these companies are small businesses that lose their workers to larger counterparts that pay higher wages and better benefits. Separate downstream industry segments could also be studied in detail to better understand the needs of companies within each downstream segment. This would better inform policy makers who are considering strategies for training to support industry.

Other knowledge useful for creating educational strategies could be obtained by studying existing training capacity at Ohio educational institutions and available training programs in occupations relevant to upstream, midstream and downstream industries. Helping the education institutions and training programs to form close connections with the oil and gas industry and developing shale-related training programs might stimulate local employment in already existing or new jobs in upstream and downstream industries.

APPENDIX A

Table A-1. Pre-Drilling Education/Job Matrix

	Associated Jobs	Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	FTE 260 wells/ year	FTE 849 wells/ year (2015)	FTE 1,186 wells/ year (2019)
Geological Studies	Geologists & Geophysicists			x	58	189	263
	Hydro Geologist			x	0	0	0
	Petroleum Engineers			x	25	83	115
	Petroleum Chemists			x	0	0	0
	Cartographer			x	14	47	66
	GIS Technicians		x	x	14	47	66
Seismic	Project Management		x	x	0	0	0
	CDL Drivers		x		0	0	0
	Landman						
	Helicopter Pilot/Crew	x	x		0	0	0
	Seismic Crew		x	x	0	0	0
Public Land Only	Water Management			x	0	0	0
	Forester	x	x	x	0	0	0
	Lawyers				0	0	0
	Archeology				0	0	0
	Biologist				43	141	198
Mineral Rights	Landmen-for drilling/leasing		x		14	47	66
	Lawyers			x	7	24	33
	Para-legal	x	x	x	43	141	198
	Title-Abstract	x	x	x	43	141	198
	Lease Acquisition				51	165	231
	Lease Admin				7	24	33
Permitting Process	**Archeologist**						
	Biologist						
	Community Affairs						
	Corporate Development						
	Environmental Technicians[1]		x	x	72	236	329
	Lawyers		x		29	94	132
	Permitting Tech			x	7	24	33
	Public relations Division						
Staking the Well	Roadman		x		0	0	0
	Surveyors		x	x	36	118	165
	Civil Engineering Tech			x	0	0	0
	Civil Engineer			x	22	71	99
	Lawyers						
	Leasing Agents (Right-of-Way)		x		120	392	547
	Land Clearing		x	x	0	0	0
	Heavy Equipment Operators	x	x	x	0	0	0
	Heavy Equipment Maint Tech		x	x	20	65	91
	Logging		x		0	0	0
Water Management	**Electricians**						
	Environmental Coordinator						
	Water transfer/Driver CDL		x		0	0	0
	Hydrologist (stream monitoring)			x	0	0	0
	Mechanics						
	Private water Supply Testing Coord.						
	Water Management Technician						
	Welders						
Overall	**Human Resources**						

Table A-2. Drilling Education/Job Matrix

Associated Jobs		Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	FTE 260 wells/ year	FTE 849 wells/ year (2015)	FTE 1,186 wells/ year (2019)
Pipeline Construction	**Environmental Coordinator**						
	Environmental Tech-monitor reclamation			x			
	Foreman	x	x	x	11	36	50
	Superintendent				22	72	100
	Petroleum Engineers		x	x	0	0	0
	Mechanical Engineering						
	Pipe Fitters		x	x	44	144	201
	Safety Coordinator						
	Welders		x	x	17	54	75
	Welder Helpers				33	108	151
	Weld Inspectors		x	x	17	54	75
	Heavy Equipment Operators		x	x	132	431	602
	X-Ray			x	11	36	50
	X-Ray Tech				11	36	50
	General Labor	x			66	216	301
	Boring Crew	x	x	x	21	69	96
	Environmental Tech-monitor reclamation			x	0	0	0
	Operational landmen	x	x		0	0	0
	Surveyors			x	4	13	18
	Civil Engineering			x	14	47	66
	Logging				20	65	91
Compressor Construction	Construction Managers				2	7	10
	Welders				9	29	41
	Welders Helpers				9	29	41
	X-ray				2	7	10
	X-Ray Tech				2	7	10
	General Labor				14	44	62
	Land Clearing				6	20	27
	Foreman				2	7	10
	Pipeline Inspection				2	7	10
Facility Construction (Hi Btu Gas)	**Electricians**						
	Engineers						
	General Construction						
	Pipeline						
	Welders						
	Well head						

	Associated Jobs	Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	FTE 260 wells/ year	FTE 849 wells/ year (2015)	FTE 1,186 wells/ year (2019)
Drilling	Company Man/Geologist		x	x	25	82	114
	Drilling Engineer				7	24	33
	Drilling Superintendent		x	x	3	8	11
	Tool Pushers		x		25	82	114
	Roughnecks	x	x		500	1633	2281
	Roustabouts		x		33	108	151
	Safety Coordinator						
	Security						
	Surveyors						
	Diesel Technicians		x	x	3	8	11
	(Rig Move)				160	522	730
	Heavy Equipment Operators	x	x	x	0	0	0
	CDL Drivers		x		0	0	0
	Mudmen	x	x	x	25	82	114
	Welders		x	x	3	10	14
	CDL Drivers		x		15	49	68
	Electricians		x	x	3	8	11
	Environmental Coordinator						
	Flaggers						
	Light truck delivery						
	Machine Shop						
	Pilot drivers						
Fracking and Completion	Cement Pumpers		x		10	33	46
	Well Logging			x	3	10	14
	CDL Drivers		x		0	0	0
	Directional Drilling				56	183	255
	Finishing Rig				28	91	128
	Supervisors		x	x	12	39	55
	Safety				0	0	0
	Foremen		x	x	0	0	0
	Site Management		x	x	0	0	0
	e-techs						
	Petroleum Engineers			x	22	71	99
	Frac Crew				125	408	570
	Heavy Equipment Operators		x	x	0	0	0
	Heavy Equipment Maint Tech		x	x	0	0	0
	CDL Drivers	x	x		0	0	0
	Mechanics						
	Perforators						
	Safety Coordinator						
	Roustabouts		x		50	163	228
	Heavy Equipment Operations		x	x	0	0	0
	Crane Operations		x	x	0	0	0
	Electricians		x	x	20	65	91
	Engineers						
	Environmental Coordinator						
	Environmental Inspection		x		16	52	73

	Associated Jobs	Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	FTE 260 wells/ year	FTE 849 wells/ year (2015)	FTE 1,186 wells/ year (2019)
Water Management	Flowback Analyzer	x	x		30	98	137
	CDL Drivers/Water Haulers			x	3	10	14
	Hydrologist/water supervisor		x		0	0	0
	Completion-xaferers						
	Engineers						
	Environmental Compliance		x	x	0	0	0
	Water Testing/Quality						
	Safety Coordinator						
	Water Re-use Supervisor						
	Water Re-use Technician		x		0	0	0
	Flowback				0	0	0
Overall	Road Crews				0	0	0
	Heavy Equipment				0	0	0
	CDL		x		29	94	132
	Local Liaison						
	Lunch Wagon						
	MSHA Compliance						
	MSHA Training						
	Noise Abatement						
	Human Resources						
	Fleet Managers						
	Environmental Coordinator						
	Field Representatives			x	43	141	198
	Safety/ OSHA		x		0	0	0
	First Aid		x		120	392	547
	Security		x	x	0	0	0
	Calibration Technician						
Overall	**Safety Coordinator**		x	x	0	0	0
	Office Management		x		105	342	478
	clerks/data entry/reception			x	61	200	280
	Financial/Business Management			x	72	236	329
	Accountants	x			130	424	593
	Office support - admin assist.						
	OSHA Compliance						
	OSHA Training						
	Public Affairs				72	236	329
	IT/Computer		x	x	14	47	66
	Purchasing						
	State Law Compliance						
	State Law Training						
	Surveyors						
	Trainers for on-the-job training						

Table A-3. Operating/Post-Drilling Education/Job Matrix

Associated Jobs		Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	FTE 260 wells/ year	FTE 849 wells/ year (2015)	FTE 1,186 wells/ year (2019)
Natural Gas Production	Petroleum Engineers			x	3	8	12
	Heavy Equipment Maint Tech		x	x	3	11	15
	Well Tenders/Roustabout		x		10	34	47
	Operator		x		12	38	53
	Gas Control Center						
	Gas Dispatcher						
	Gathering Operations						
	Compressor Operator				5	17	24
	Service Rig Operator		x		3	9	13
	Production Engineer			x	0	0	0
	Equipment calibration		x	x	0	0	0
	Communications Tech offsite monitoring		x	x	0	0	0
	Production Foreman	x	x		3	8	12
Reclamation	Plugging Crew		x	x	8	26	36
	CDL Drivers	x	x		0	0	0
	Site Management		x	x	0	0	0
	Landscapers-architect	x	x		15	49	68
	Environmental Inspection		x	x	0	0	0
	General Construction						
	Heavy Equipment Operator						
	Civil Engineer		x		0	0	0
	Government officials		x		0	0	0
Overall	Inspectors	x	x		0	0	0
	Sewage treatment		x	x	0	0	0
	Lobbying		x	x	0	0	0
	Community Affairs/PR			x	0	0	0
	Calibration Officials		x		0	0	0
	Corrosion Technicians			x	0	0	0
	Business Development/Sales						
	CDL Drivers						
	Fleet Managers						
	Human Resources						
	Marketing						
	Noise Abatement						
	Environmental Health & Safety			x	0	0	0
	Purchasing		x	x	0	0	0
	IT Tech			x	0	0	0
	Local Liaison		x		0	0	0
	Office Management		x	x	0	0	0
	Office support-admin-non tech	x			0	0	0
High Btu Gas/Gas	**Bi-product Marketing/Sales**						
	Bi-product Transportation						
	Compressor Operator						
	Facility Construction						
	Gathering Operations						

Associated Jobs		Secondary/ Career and Technical Centers	Work Experience/ Certification	Post-Secondary/ Higher Education	FTE 260 wells/ year	FTE 849 wells/ year (2015)	FTE 1,186 wells/ year (2019)
	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						

Table A-4. Ohio Drilling Occupations in All Industries, 2009-2014

SOC	Description	2014 Jobs	2009 - 2014 Change	2009 - 2014 % Change	2014 Location Quotient	Median Hourly Earnings	Pct. 90 Hourly Earnings
11-1011	Chief Executives	15,880	2,116	15%	0.83	$55.07	$89.74
11-1021	General and Operations Managers	66,427	2,090	3%	0.86	$41.92	$86.97
11-9021	Construction Managers	18,969	(1,861)	(9%)	1.04	$24.90	$38.80
11-9141	Property, Real Estate, and Community Association Managers	38,955	8,189	27%	0.76	$16.15	$22.84
11-9199	Managers, All Other	52,685	3,437	7%	0.90	$21.17	$30.42
13-1199	Business Operations Specialists, All Other	26,419	1,218	5%	0.72	$29.35	$46.06
13-2011	Accountants and Auditors	52,522	1,308	3%	0.86	$27.15	$42.51
17-2171	Petroleum Engineers	383	(127)	(25%)	0.27	$47.46	$88.57
19-2042	Geoscientists, Except Hydrologists and Geographers	1,104	(206)	(16%)	0.51	$36.23	$45.13
19-4041	Geological and Petroleum Technicians	254	(220)	(46%)	0.42	$25.61	$42.90
41-3099	Sales Representatives, Services, All Other	33,269	846	3%	0.97	$21.75	$43.61
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	58,765	4,002	7%	0.93	$23.49	$46.03
43-1011	First-Line Supervisors of Office and Administrative Support Workers	45,835	740	2%	0.85	$22.62	$34.48
43-3031	Bookkeeping, Accounting, and Auditing Clerks	68,353	3,642	6%	0.97	$16.60	$24.30
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	72,839	2,622	4%	0.84	$15.08	$21.69
43-9061	Office Clerks, General	102,588	2,416	2%	0.95	$13.48	$20.75
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	23,525	(1,145)	(5%)	0.84	$21.23	$29.46
47-2061	Construction Laborers	52,467	6,163	13%	0.93	$14.87	$21.08
47-2073	Operating Engineers and Other Construction Equipment Operators	13,926	366	3%	1.02	$20.82	$33.38
47-2111	Electricians	25,587	1,882	8%	1.03	$22.15	$31.81
47-2152	Plumbers, Pipefitters, and Steamfitters	16,023	1,517	10%	0.99	$21.69	$31.60
47-5011	Derrick Operators, Oil and Gas	183	45	33%	0.21	$16.20	$22.30
47-5012	Rotary Drill Operators, Oil and Gas	193	32	20%	0.18	$14.46	$24.89
47-5013	Service Unit Operators, Oil, Gas, and Mining	661	199	43%	0.28	$20.45	$35.33
47-5021	Earth Drillers, Except Oil and Gas	499	80	19%	0.64	$16.52	$24.32

SOC	Description	2014 Jobs	2009 - 2014 Change	2009 - 2014 % Change	2014 Location Quotient	Median Hourly Earnings	Pct. 90 Hourly Earnings
47-5071	Roustabouts, Oil and Gas	775	96	14%	0.28	$13.95	$25.47
47-5081	Helpers--Extraction Workers	1,051	63	6%	0.75	$15.01	$21.28
47-5099	Extraction Workers, All Other	183	(14)	(7%)	0.42	$20.15	$23.84
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	16,280	675	4%	1.00	$27.46	$41.87
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	12,298	803	7%	1.23	$19.89	$27.20
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	4,107	575	16%	0.74	$18.54	$25.13
49-9041	Industrial Machinery Mechanics	17,798	2,577	17%	1.37	$21.32	$31.72
49-9043	Maintenance Workers, Machinery	4,465	466	12%	1.33	$20.53	$28.11
49-9071	Maintenance and Repair Workers, General	52,294	2,504	5%	1.06	$17.14	$26.30
49-9096	Riggers	259	27	12%	0.38	$18.68	$26.21
49-9098	Helpers--Installation, Maintenance, and Repair Workers	2,319	67	3%	0.48	$12.55	$21.51
51-1011	First-Line Supervisors of Production and Operating Workers	29,272	1,412	5%	1.29	$25.04	$38.32
51-4041	Machinists	29,390	4,419	18%	1.93	$18.04	$27.62
51-4121	Welders, Cutters, Solderers, and Brazers	17,558	1,896	12%	1.16	$16.70	$23.54
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	1,510	75	5%	0.95	$26.92	$34.67
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	26,341	2,813	12%	1.34	$16.90	$25.89
51-9198	Helpers--Production Workers	20,422	2,448	14%	1.27	$12.05	$18.11
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	8,511	375	5%	1.13	$24.36	$35.41
53-3032	Heavy and Tractor-Trailer Truck Drivers	92,096	3,326	4%	1.11	$17.05	$24.66
53-7021	Crane and Tower Operators	1,691	142	9%	1.06	$18.89	$29.86
53-7032	Excavating and Loading Machine and Dragline Operators	1,476	(49)	(3%)	0.66	$16.05	$23.08
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	106,659	11,377	12%	1.16	$11.01	$18.15
53-7072	Pump Operators, Except Wellhead Pumpers	612	(145)	(19%)	0.65	$21.17	$25.04
53-7073	Wellhead Pumpers	1,880	(635)	(25%)	0.89	$18.82	$21.69
	Total	1,237,558	74,644	6%		$20.18	$32.43

Source: EMSI

Table A-5. Ohio Oil and Gas Extraction Occupations in All Industries, 2009-2014

SOC	Description	2014 Jobs	2009 - 2014 Change	2009 - 2014 % Change	2014 Location Quotient	Median Hourly Earnings	Pct. 90 Hourly Earnings
11-1011	Chief Executives	15,880	2,116	15%	0.83	$55.07	$89.74
11-1021	General and Operations Managers	66,427	2,090	3%	0.86	$41.92	$86.97
11-2021	Marketing Managers	7,029	373	6%	0.81	$45.46	$72.12
11-2022	Sales Managers	16,433	444	3%	1.01	$44.59	$84.82
11-3031	Financial Managers	27,512	2,084	8%	0.98	$41.96	$72.62
11-3051	Industrial Production Managers	12,036	1,019	9%	1.84	$39.72	$67.75
11-9041	Architectural and Engineering Managers	7,137	496	7%	1.02	$53.81	$79.47
11-9141	Property, Real Estate, and Community Association Managers	38,955	8,189	27%	0.76	$16.15	$22.84
11-9199	Managers, All Other	52,685	3,437	7%	0.90	$21.17	$30.42
13-1023	Purchasing Agents, Except Wholesale, Retail, and Farm Products	13,434	789	6%	1.13	$27.84	$41.91
13-1111	Management Analysts	37,095	1,411	4%	0.86	$31.47	$46.77
13-1199	Business Operations Specialists, All Other	26,419	1,218	5%	0.72	$29.35	$46.06
13-2011	Accountants and Auditors	52,522	1,308	3%	0.86	$27.15	$42.51
13-2051	Financial Analysts	14,383	712	5%	0.88	$31.20	$45.34
13-2052	Personal Financial Advisors	45,509	11,671	34%	0.80	$28.25	$37.98
13-2099	Financial Specialists, All Other	6,519	508	8%	0.83	$28.14	$39.27
15-1121	Computer Systems Analysts	29,007	2,965	11%	1.31	$36.53	$53.19
15-1142	Network and Computer Systems Administrators	15,084	238	2%	1.07	$31.71	$45.15
17-2112	Industrial Engineers	11,471	1,032	10%	1.33	$35.26	$54.14
17-2171	Petroleum Engineers	383	(127)	(25%)	0.27	$47.46	$88.57
17-2199	Engineers, All Other	8,819	918	12%	1.42	$37.71	$57.20
17-3029	Engineering Technicians, Except Drafters, All Other	3,638	266	8%	1.44	$27.46	$40.63
19-2041	Environmental Scientists and Specialists, Including Health	2,955	76	3%	0.82	$32.75	$42.98
19-2042	Geoscientists, Except Hydrologists and Geographers	1,104	(206)	(16%)	0.51	$36.23	$45.13
19-4041	Geological and Petroleum Technicians	254	(220)	(46%)	0.42	$25.61	$42.90
23-1011	Lawyers	27,219	285	1%	0.79	$42.16	$75.47
23-2093	Title Examiners, Abstractors, and Searchers	3,367	61	2%	0.95	$19.30	$26.40
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	104,496	5,810	6%	1.00	$10.39	$16.89
41-1011	First-Line Supervisors of Retail Sales Workers	74,972	(615)	(1%)	0.94	$13.90	$20.93
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	22,999	1,346	6%	1.57	$31.68	$65.52

SOC	Description	2014 Jobs	2009 - 2014 Change	2009 - 2014 % Change	2014 Location Quotient	Median Hourly Earnings	Pct. 90 Hourly Earnings
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	58,765	4,002	7%	0.93	$23.49	$46.03
41-9022	Real Estate Sales Agents	101,345	14,689	17%	0.72	$13.03	$15.76
43-1011	First-Line Supervisors of Office and Administrative Support Workers	45,835	740	2%	0.85	$22.62	$34.48
43-3031	Bookkeeping, Accounting, and Auditing Clerks	68,353	3,642	6%	0.97	$16.60	$24.30
43-6011	Executive Secretaries and Executive Administrative Assistants	28,777	(257)	(1%)	0.96	$21.42	$30.04
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	72,839	2,622	4%	0.84	$15.08	$21.69
43-9021	Data Entry Keyers	9,452	(386)	(4%)	0.92	$16.42	$20.56
43-9061	Office Clerks, General	102,588	2,416	2%	0.95	$13.48	$20.75
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	23,525	(1,145)	(5%)	0.84	$21.23	$29.46
47-5011	Derrick Operators, Oil and Gas	183	45	33%	0.21	$16.20	$22.30
47-5012	Rotary Drill Operators, Oil and Gas	193	32	20%	0.18	$14.46	$24.89
47-5013	Service Unit Operators, Oil, Gas, and Mining	661	199	43%	0.28	$20.45	$35.33
47-5071	Roustabouts, Oil and Gas	775	96	14%	0.28	$13.95	$25.47
47-5081	Helpers--Extraction Workers	1,051	63	6%	0.75	$15.01	$21.28
47-5099	Extraction Workers, All Other	183	(14)	(7%)	0.42	$20.15	$23.84
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	4,107	575	16%	0.74	$18.54	$25.13
49-9041	Industrial Machinery Mechanics	17,798	2,577	17%	1.37	$21.32	$31.72
49-9099	Installation, Maintenance, and Repair Workers, All Other	7,003	(1,340)	(16%)	0.91	$14.77	$22.76
51-1011	First-Line Supervisors of Production and Operating Workers	29,272	1,412	5%	1.29	$25.04	$38.32
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	1,510	75	5%	0.95	$26.92	$34.67
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	26,341	2,813	12%	1.34	$16.90	$25.89
51-9199	Production Workers, All Other	13,481	1,806	15%	1.43	$14.97	$23.11
53-3032	Heavy and Tractor-Trailer Truck Drivers	92,096	3,326	4%	1.11	$17.05	$24.66
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	106,659	11,377	12%	1.16	$11.01	$18.15
53-7071	Gas Compressor and Gas Pumping Station Operators	332	(36)	(10%)	1.08	$28.68	$31.73
53-7072	Pump Operators, Except Wellhead Pumpers	612	(145)	(19%)	0.65	$21.17	$25.04
53-7073	Wellhead Pumpers	1,880	(635)	(25%)	0.89	$18.82	$21.69
	Total	1,561,361	98,242	7%		$21.91	$34.87

Source: EMSI

Table A-6. Ohio Pipeline Occupations in All Industries, 2009-2014

SOC	Description	2014 Jobs	2009 - 2014 Change	2009 - 2014 % Change	2014 Location Quotient	Median Hourly Earnings	Pct. 90 Hourly Earnings
11-1021	General and Operations Managers	66,427	2,090	3%	0.86	$41.92	$86.97
11-9021	Construction Managers	18,969	(1,861)	(9%)	1.04	$24.90	$38.80
11-9041	Architectural and Engineering Managers	7,137	496	7%	1.02	$53.81	$79.47
11-9199	Managers, All Other	52,685	3,437	7%	0.90	$21.17	$30.42
13-1051	Cost Estimators	10,398	647	7%	1.27	$26.01	$41.31
13-1199	Business Operations Specialists, All Other	26,419	1,218	5%	0.72	$29.35	$46.06
13-2011	Accountants and Auditors	52,522	1,308	3%	0.86	$27.15	$42.51
17-2051	Civil Engineers	8,402	428	5%	0.76	$33.59	$47.81
17-3023	Electrical and Electronics Engineering Technicians	3,926	46	1%	0.73	$26.81	$35.88
43-3031	Bookkeeping, Accounting, and Auditing Clerks	68,353	3,642	6%	0.97	$16.60	$24.30
43-6011	Executive Secretaries and Executive Administrative Assistants	28,777	(257)	(1%)	0.96	$21.42	$30.04
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	72,839	2,622	4%	0.84	$15.08	$21.69
43-9061	Office Clerks, General	102,588	2,416	2%	0.95	$13.48	$20.75
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	23,525	(1,145)	(5%)	0.84	$21.23	$29.46
47-2011	Boilermakers	1,128	(6)	(1%)	1.92	$30.76	$36.90
47-2031	Carpenters	47,992	986	2%	0.96	$16.09	$21.36
47-2051	Cement Masons and Concrete Finishers	3,999	25	1%	0.69	$18.74	$26.77
47-2061	Construction Laborers	52,467	6,163	13%	0.93	$14.87	$21.08
47-2071	Paving, Surfacing, and Tamping Equipment Operators	1,561	13	1%	0.77	$20.50	$32.33
47-2073	Operating Engineers and Other Construction Equipment Operators	13,926	366	3%	1.02	$20.82	$33.38
47-2111	Electricians	25,587	1,882	8%	1.03	$22.15	$31.81
47-2151	Pipelayers	2,526	105	4%	1.02	$15.81	$20.02
47-2152	Plumbers, Pipefitters, and Steamfitters	16,023	1,517	10%	0.99	$21.69	$31.60
47-2221	Structural Iron and Steel Workers	2,301	14	1%	0.99	$25.49	$32.88
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	831	57	7%	0.45	$11.14	$17.59
47-5021	Earth Drillers, Except Oil and Gas	499	80	19%	0.64	$16.52	$24.32
47-5071	Roustabouts, Oil and Gas	775	96	14%	0.28	$13.95	$25.47
47-5081	Helpers--Extraction Workers	1,051	63	6%	0.75	$15.01	$21.28

SOC	Description	2014 Jobs	2009 - 2014 Change	2009 - 2014 % Change	2014 Location Quotient	Median Hourly Earnings	Pct. 90 Hourly Earnings
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	16,280	675	4%	1.00	$27.46	$41.87
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	12,298	803	7%	1.23	$19.89	$27.20
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	4,107	575	16%	0.74	$18.54	$25.13
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	1,477	2	0%	0.98	$26.40	$34.96
49-9041	Industrial Machinery Mechanics	17,798	2,577	17%	1.37	$21.32	$31.72
49-9071	Maintenance and Repair Workers, General	52,294	2,504	5%	1.06	$17.14	$26.30
49-9099	Installation, Maintenance, and Repair Workers, All Other	7,003	(1,340)	(16%)	0.91	$14.77	$22.76
51-1011	First-Line Supervisors of Production and Operating Workers	29,272	1,412	5%	1.29	$25.04	$38.32
51-4121	Welders, Cutters, Solderers, and Brazers	17,558	1,896	12%	1.16	$16.70	$23.54
51-8092	Gas Plant Operators	256	(22)	(8%)	0.50	$30.90	$35.72
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	1,510	75	5%	0.95	$26.92	$34.67
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	26,341	2,813	12%	1.34	$16.90	$25.89
51-9198	Helpers--Production Workers	20,422	2,448	14%	1.27	$12.05	$18.11
53-3032	Heavy and Tractor-Trailer Truck Drivers	92,096	3,326	4%	1.11	$17.05	$24.66
53-7021	Crane and Tower Operators	1,691	142	9%	1.06	$18.89	$29.86
53-7032	Excavating and Loading Machine and Dragline Operators	1,476	(49)	(3%)	0.66	$16.05	$23.08
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	106,659	11,377	12%	1.16	$11.01	$18.15
53-7071	Gas Compressor and Gas Pumping Station Operators	332	(36)	(10%)	1.08	$28.68	$31.73
99-9999	Unclassified Occupation	41,637	5,122	14%	0.82	$12.83	$14.59
	Total	1,164,138	60,744	6%		$19.51	$30.24

Source: EMSI

Table A-7. Ohio Petrochem Industry Occupations in All Industries, 2009-2014

SOC	Description	2014 Jobs	2009 - 2014 Change	2009 - 2014 % Change	2014 Location Quotient	Median Hourly Earnings	Pct. 90 Hourly Earnings
11-1021	General and Operations Managers	66,427	2,090	3%	0.86	$41.92	$86.97
11-2022	Sales Managers	16,433	444	3%	1.01	$44.59	$84.82
11-3051	Industrial Production Managers	12,036	1,019	9%	1.84	$39.72	$67.75
11-3071	Transportation, Storage, and Distribution Managers	5,743	596	12%	1.32	$36.49	$62.92
13-1199	Business Operations Specialists, All Other	26,419	1,218	5%	0.72	$29.35	$46.06
13-2011	Accountants and Auditors	52,522	1,308	3%	0.86	$27.15	$42.51
15-1121	Computer Systems Analysts	29,007	2,965	11%	1.31	$36.53	$53.19
17-2041	Chemical Engineers	1,354	52	4%	1.08	$40.11	$58.75
17-2112	Industrial Engineers	11,471	1,032	10%	1.33	$35.26	$54.14
17-2141	Mechanical Engineers	12,139	1,084	10%	1.22	$33.96	$51.39
17-2171	Petroleum Engineers	383	(127)	(25%)	0.27	$47.46	$88.57
17-3029	Engineering Technicians, Except Drafters, All Other	3,638	266	8%	1.44	$27.46	$40.63
19-2031	Chemists	3,679	175	5%	1.13	$30.86	$51.85
19-4031	Chemical Technicians	3,710	245	7%	1.56	$20.19	$31.23
41-1012	First-Line Supervisors of Non-Retail Sales Workers	26,961	2,403	10%	0.90	$18.79	$29.95
41-2011	Cashiers	117,182	(1,069)	(1%)	0.92	$9.02	$12.47
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	22,999	1,346	6%	1.57	$31.68	$65.52
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	58,765	4,002	7%	0.93	$23.49	$46.03
43-1011	First-Line Supervisors of Office and Administrative Support Workers	45,835	740	2%	0.85	$22.62	$34.48
43-3021	Billing and Posting Clerks	24,498	1,526	7%	1.25	$15.94	$21.70
43-3031	Bookkeeping, Accounting, and Auditing Clerks	68,353	3,642	6%	0.97	$16.60	$24.30
43-4051	Customer Service Representatives	82,574	3,799	5%	0.89	$15.03	$23.63
43-5032	Dispatchers, Except Police, Fire, and Ambulance	7,989	541	7%	1.08	$18.01	$26.67
43-5061	Production, Planning, and Expediting Clerks	13,835	678	5%	1.26	$19.59	$29.52
43-5071	Shipping, Receiving, and Traffic Clerks	36,143	1,996	6%	1.41	$13.67	$20.47
43-5081	Stock Clerks and Order Fillers	78,076	(1,270)	(2%)	1.15	$11.04	$17.84
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	72,839	2,622	4%	0.84	$15.08	$21.69

SOC	Description	2014 Jobs	2009 - 2014 Change	2009 - 2014 % Change	2014 Location Quotient	Median Hourly Earnings	Pct. 90 Hourly Earnings
43-9061	Office Clerks, General	102,588	2,416	2%	0.95	$13.48	$20.75
47-2071	Paving, Surfacing, and Tamping Equipment Operators	1,561	13	1%	0.77	$20.50	$32.33
47-2111	Electricians	25,587	1,882	8%	1.03	$22.15	$31.81
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	16,280	675	4%	1.00	$27.46	$41.87
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	12,298	803	7%	1.23	$19.89	$27.20
49-9041	Industrial Machinery Mechanics	17,798	2,577	17%	1.37	$21.32	$31.72
49-9071	Maintenance and Repair Workers, General	52,294	2,504	5%	1.06	$17.14	$26.30
51-1011	First-Line Supervisors of Production and Operating Workers	29,272	1,412	5%	1.29	$25.04	$38.32
51-2092	Team Assemblers	67,673	10,512	18%	1.65	$14.66	$25.35
51-4041	Machinists	29,390	4,419	18%	1.93	$18.04	$27.62
51-8091	Chemical Plant and System Operators	1,929	(65)	(3%)	1.33	$20.70	$28.73
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	1,510	75	5%	0.95	$26.92	$34.67
51-9011	Chemical Equipment Operators and Tenders	3,014	30	1%	1.33	$24.08	$31.65
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	8,055	569	8%	1.84	$17.14	$25.98
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	26,341	2,813	12%	1.34	$16.90	$25.89
51-9111	Packaging and Filling Machine Operators and Tenders	19,563	1,777	10%	1.41	$13.69	$21.98
51-9198	Helpers--Production Workers	20,422	2,448	14%	1.27	$12.05	$18.11
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	8,511	375	5%	1.13	$24.36	$35.41
53-3031	Driver/Sales Workers	22,297	1,441	7%	1.35	$9.22	$19.86
53-3032	Heavy and Tractor-Trailer Truck Drivers	92,096	3,326	4%	1.11	$17.05	$24.66
53-3033	Light Truck or Delivery Services Drivers	37,857	1,822	5%	1.07	$13.33	$26.83
53-6031	Automotive and Watercraft Service Attendants	5,090	217	4%	1.20	$9.68	$14.12
53-7051	Industrial Truck and Tractor Operators	25,003	1,899	8%	1.29	$14.95	$21.66
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	106,659	11,377	12%	1.16	$11.01	$18.15
53-7072	Pump Operators, Except Wellhead Pumpers	612	(145)	(19%)	0.65	$21.17	$25.04
	Total	1,634,711	88,496	6%		$18.68	$30.43

Source: EMSI