A PIPELINE FOR GROWTH

Fueling Economic Revitalization with Marcellus and Utica Shale Gas

A STRATEGY FOR A REGIONAL ENERGY HUB PREPARED BY THE GREATER PHILADELPHIA ENERGY ACTION TEAM

March 30, 2016
Table of Contents

I Executive Summary ..................................................... 2

II Introduction .............................................................. 8

III Overview of Shale Opportunity ..................................... 10

IV Market Analysis .......................................................... 14

Upstream Markets: Supplying Natural Gas ............................... 14

Midstream Market: Transporting Natural Gas ............................ 16

Downstream Market: Creating the Demand Center ....................... 20

V Economic Benefit Analysis ............................................. 32

VI Industrial Land and Infrastructure Available in the Tristate Region ...... 38

VII Environmental Risk Mitigation and Best Practices ....................... 42

VIII Addressing the Challenges: How to Take Advantage of this Opportunity ...... 48

IX Appendix .................................................................... 52

Regulatory Process To Enable Natural Gas Pipeline Development .......... 52

X Glossary of Terms .......................................................... 56

End Notes ....................................................................... 58
The Marcellus and Utica Shale formations that underlie the northern and western tiers of the Commonwealth of Pennsylvania provide the state with extraordinary resources in the form of natural gas reserves locked in the source rock. The gas reserves are so vast that their remaining life is measured in centuries at current production rates, not in years as is typical for hydrocarbon resources.

These potential recoverable shale gas resources present real economic benefit and job creation opportunity for the Commonwealth; however, the economic benefit is literally locked in place, presently out of reach. The Greater Philadelphia region holds the key to unlocking the value in the shale gas resources for the benefit of Pennsylvania, southern New Jersey and northern Delaware.
How can these natural gas resources benefit the region?

1. The natural gas and Natural Gas Liquids (NGLs) producers in the Marcellus and Utica (Marcellus/Utica) regions of the state could produce and sell substantially more hydrocarbons than they do today at profitable prices.

2. Value-added manufacturing could be expanded in the Greater Philadelphia region creating sustainable economic benefit and employment opportunities in southeastern Pennsylvania, southern New Jersey and northern Delaware.

3. Revenue to the Commonwealth of Pennsylvania could be enhanced from the additional production and sales of natural gas and NGLs and from the additional tax base generated by the new industrial development.

This report — “A Pipeline for Growth, Fueling Economic Revitalization with Marcellus and Utica Shale Gas” describes key aspects associated with creating a natural gas and NGLs Energy Hub in the Greater Philadelphia region, and outlines what has to be done to unlock the shale resources to create wealth and prosperity for the region.

The Current Dilemma

The abundant natural gas and NGL resources of the Marcellus/Utica formations cannot presently be extracted at the prodigious rates that the reserves would support without negatively impacting the unit value. The markets to which those fields are connected, through transcontinental natural gas pipelines to the Gulf Coast and to New England, have inadequate pipeline capacity to allow for substantial increases in gas production. Only within the past several years has the transport infrastructure started to be developed to access markets with great potential to take advantage of abundant and stable priced natural gas and NGLs. Presently, the incremental Marcellus production is transported by interstate pipelines to the Gulf Coast in severe price competition with regional Gulf gas supplies, forcing a downward price/value spiral for the Marcellus gas. However, if a new and substantial market for the natural gas and the NGLs could be developed, the rate of monetization of the reserves could bring an amazing influx of economic activity to Pennsylvania, New Jersey and Delaware.

The Natural Resources

For the past eight years, the domestic production of shale natural gas has grown 30% annually; over 42% of this growth came from the Marcellus shale gas reserves, the single largest source of new gas production. (Figure 1)

According to the United States (U.S.) Energy Information Administration (EIA) July 2015 Drilling Productivity Report, the Marcellus/Utica shale reserves have provided 85% of the U.S. shale gas production since the start of 2012.2 Pennsylvania is in the midst of an energy resurgence, and the increase in natural gas production has put this region in the world spotlight.

Figure 1  •  UNITED STATES MONTHLY DRY SHALE GAS PRODUCTION

Source: U.S. EIA February 2016 Natural Gas Drilling Productivity Report

- Rest of US ‘shale’
- Utica (OH, PA & WV)
- Marcellus (PA, WV, OH & NY)
- Haynesville (LA & TX)
- Eagle Ford (TX)
- Fayetteville (AR)
- Barnett (TX)
- Woodford (OK)
- Bakken (ND)
- Antrim (MI, IN, & OH)
Manufacturing and other Industrial Assets

From the 1880s through the first half of the last century, Philadelphia was one of the prominent industrial centers in the U.S. Refineries, textile companies, chemical, pulp and paper companies literally lined the streets of the city that built products for the world. Although it seems like the Greater Philadelphia region has long transitioned from an industrial economy, we have the opportunity to join the world’s prominent energy producers and manufacturers once again.

The Greater Philadelphia region has a unique array of positional assets:

• Close proximity – approximately 100 miles – from the productive Marcellus/Utica fields,
• In the center of the best energy market in the U.S.,
• 100% of the East Coast oil refining is located within a 50 mile radius,
• Access to north/south and east/west interstate highways,
• Direct, deep water access to North Atlantic sea-lanes,
• Access to a world-class and growing airport,
• Excellent rail infrastructure,
• Petroleum pipelines connecting to the best energy market in the country,
• Great access to engineering, banking and other key professional services,
• A skilled, unionized labor force that is vigorous and constructive,
• Federal, state and local elected-officials focused on economic development, and
• A long history of hosting manufacturing and heavy industry.

If the needed energy infrastructure is appropriately developed, the Greater Philadelphia region could achieve worldwide prominence as the home of the next 21st century Energy Hub.

Creating an Energy Hub

In creating an Energy Hub, the goal, first and foremost, is to expand the market for the Marcellus/Utica natural gas and NGLs to increase the economic benefits that will come to the Commonwealth and the Greater Philadelphia region from more vigorous production.

Presently, the natural gas pipeline infrastructure needed to deliver increased volumes of natural gas to the region does not exist and siting new interstate and intrastate pipelines is time consuming and at times challenging. The process of siting new pipelines acts as a barrier to investment in manufacturing facilities that can benefit from either the energy content or the chemical building blocks of natural gas.

Historically, major pipeline projects have not been built “on spec”. To be economically viable, midstream pipeline project developers require a significant portion (over 95%) of the pipeline capacity to be confirmed in a long-term contractual commitment from end-users before the pipeline developer will commit to investing hundreds of millions, if not billions of dollars, in permitting, constructing and operating a pipeline project.

This development model is constraining future development of an Energy Hub in the Greater Philadelphia region. To enable the development of an Energy Hub, other parties may have to support pipeline projects to allow for excess capacity to be built and assigned in the future as new manufacturers and gas users move into the region.

Therefore, the goal in creating an Energy Hub is to incent the development of major, high capacity pipelines with adequate excess capacity to transport natural gas and NGLs to a new hub. The energy hub will serve as a clearing house and a redistribution point for valorizing the natural resources so investors that are interested in building modern manufacturing and processing plants do not have to be concerned with whether the natural gas or NGLs will be available. There will be enough pipeline capacity to get the gas to the market.
How do we get there?

Today, the region consumes approximately 3 Billion cubic feet (Bcf) of natural gas per day. The region’s shared goal is to double the amount of natural gas and NGLs consumed in the Greater Philadelphia region by growing the energy and manufacturing sectors and creating an east coast demand-center that will consume much cleaner fossil fuel. Significantly increasing the demand for natural gas and NGLs in the Greater Philadelphia region will generate thousands of new jobs and fuel economic growth in the tristate area. To achieve this goal, however, we need to expand the existing interstate and intrastate natural gas pipeline infrastructure.

The good news is that we are headed in the right direction. Sunoco Logistics will invest over $3 billion for the next two (2) years to complete Mariner East Pipeline Projects I and II and deliver over 345 MB/pd more NGLs for processing in its Delaware County Pennsylvania facility. Additionally, UGI Energy Services’ PennEast Pipeline project will infuse $1.62 billion into the regional economy and deliver 1 Bcf of natural gas to central and southern New Jersey by the end of 2017. However, to generate substantially more economic benefit to the area and create a sizeable demand-center, the Greater Philadelphia region needs many more pipeline projects like the Mariner and PennEast Pipeline projects.

The economic benefit that could inure to the Greater Philadelphia region from creating the Energy Hub is significant.

Econsult Solutions, Inc. was retained to provide an economic benefit analysis for this report. Econsult’s analysis indicates that natural gas pipeline infrastructure will increase the attractiveness of our region for business activity and new investment. The resulting expansion in energy capacity and reliability could be substantial enough to generate $10 billion in investment in new and retooled manufacturing infrastructure. This would increase direct and indirect regional production by billions of dollars and create upwards of 10,000+ new skilled-labor and professional services jobs.

There are also significant intangible and environmental benefits that would be derived from developing an Energy Hub, including the potential displacement of diesel and marine diesel for transportation, fuel oil for home and business heating, and coal for power generation. The clean burning and efficiency of natural gas can reduce the amount of particulate pollution in the Greater Philadelphia region and reduce the overall emission of greenhouse gases (GHG).

Proposed Strategies to Accelerate Creating the Energy Hub

A consortium of over eighty (80) energy industry, public sector, labor and academic leaders have worked together for the last year to develop the Energy Hub strategy. These energy, environmental and financial industry leaders were asked their perspectives on what factors could unleash the prosperity inherent in the abundant shale gas supply in Pennsylvania, and how can the Greater Philadelphia region capitalize on its proximity to the shale gas reserves as well as its rich history as an industrial center.

Below are some of the suggested strategies to enable this region to leverage its position to be the nation’s next Energy Hub:

One of the barriers to developing additional pipeline capacity is the need to have additional demand in the downstream market. Attracting more energy-intensive manufacturing, more gas-fired electric generation and more liquids processing facilities to southeastern Pennsylvania, southern New Jersey and northern Delaware would increase the demand for gas in the region.

Our region is competing with the Gulf Coast and other industrial centers across the southern tier of the United States. If the three states in the Greater Philadelphia region work together to create an Energy Hub, thousands of new jobs and billions of dollars in economic activity will be created. To attract new manufacturing companies that use a lot of energy, state governments should consider providing more economic incentives.

A stable demand, the potential for load growth and multiple users of significant quantities of gas, all act as beacons for pipelines aiming to connect producers to markets. There needs to be a focus on attracting energy-intensive manufacturing industries like chemical, petrochemical and energy-intensive manufacturing to develop the downstream demand. If state governments can focus their efforts on building a demand-center in the tristate region, then the upstream markets in the Marcellus/Utica regions could increase output, midstream build out could be accelerated, and downstream energy-intensive manufacturing companies could locate in the tristate area and stimulate the economy.
Provide incentives for investment in midstream infrastructure development.

State and local governments should consider providing incentives to improve natural gas transportation, storage and distribution infrastructure. Much like the distribution system improvement charges that exist today for local natural gas distribution companies, Pennsylvania, New Jersey and Delaware could provide a broader system improvement charge. Encouraging the industry to invest in new pipelines and in new distribution system infrastructure improves safety and provides additional capacity for increased volumes of gas.

Expand the funding to the United States Department of Energy’s Clean Cities Program and the states’ natural gas vehicle (NGV) grant programs to accelerate the conversion of fleets to natural gas vehicles.

Many state governments are now providing grants to convert transit buses, school buses, airport vehicles, government agency vehicles, carpooling vans, taxis and fleets from gas and diesel to NGVs. NGVs significantly reduce greenhouse gas (GHG) emissions and other smog producing emissions when compared to similar gasoline and diesel powered vehicles. Not only is natural gas comparatively less expensive than diesel but it is the cleanest burning commercially available fuel for mobile sources today. Reducing greenhouse gas emissions will improve air quality and the health of our citizens in communities throughout the region. Funding for these initiatives can support fleet conversions and provide for more fueling stations.

Streamline and expedite the permitting process for pipeline construction and enhancement projects.

As described in this report, new pipeline projects require federal, regional, state and local regulatory reviews. All of the permitting reviews are public in nature and provide for the communities that are impacted to review and comment on the pipeline proposals. The industry believes these reviews are in the public interest; however, the time it takes to get through the numerous approval processes presents financial and business risks to the developers. To facilitate a more seamless and streamlined process to support or deny a pipeline project proposal, it may be prudent to appoint a single-point of contact in one of the state agencies to ensure the permitting processes are integrated and the pipeline projects are able to meet their respective deadlines.

The successful development of a 21st century Energy Hub will take support from a broad section of government, community and private sector leaders. In addition to the steps we have listed above, we will need to engage leaders from across the region to mobilize and put their full support behind this strategy. Imagine the Greater Philadelphia region as a place that companies from around the world seek out because we have taken advantage of the low-cost and abundant natural gas resources within our commonwealth and are being transported to the region to fuel manufacturing, transportation and many other facilities. There is so much to appreciate about this area and now is the time to shine the world’s spotlight on Greater Philadelphia because we have built the Energy Hub of the 21st century.
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The Greater Philadelphia region, comprised of the communities in the tristate area of southeastern Pennsylvania, southern New Jersey and northern Delaware, is poised to become the nation’s next Energy Hub. Today, this region consumes close to 3 Billion cubic feet (Bcf) of methane gas (natural gas) per day. Refineries, petrochemical companies, electric generators, homes, schools, hospitals and many other consumers of natural gas and NGLs are enjoying the benefits derived from the shale gas revolution that has taken place in the United States (U.S.) for the last eight (8) years. Since 2007, shale gas production has increased over 30% in North America but, more importantly, shale gas production has increased over 1,300% in the Marcellus and Utica (Marcellus/Utica) regions in Pennsylvania.
Enabled by the advances in horizontal drilling and hydraulic fracturing, large deposits of natural gas and oil are being drilled out of the shale formations that traditionally were deemed to be too difficult to extract. In Pennsylvania, shale gas is extracted in communities located in western and northern regions of the state. Resource regions referred to as Marcellus and Utica shale reserves.

There are significant benefits to be derived from these shale reserves. Natural gas and NGLs extracted from the shale reserves can be used downstream as feedstock for manufacturing, heating, and even generating electricity. The increased manufacturing activity and the commensurate revenue generated from producing new products and services with natural gas and NGLs can generate thousands of new jobs, additional direct and indirect economic activity, and new tax revenue for the local and state governments which are home for these new enterprises. Additionally, with the increased supply of natural gas from the shale reserves in the United States, commodity costs have declined considerably, down from $13 per one million British Thermal Units (MMBtu) in 2008 to $2.39 per MMBtu in 2016.9

For the Greater Philadelphia region to benefit from the shale gas reserves in Pennsylvania, however, more interstate and intrastate pipeline capacity is needed to get the methane gas and NGLs to this region. Building the required pipeline capacity could spur an energy and manufacturing boon that could significantly improve the regional economy. In addition to fueling the economic growth for the Greater Philadelphia region, adding new pipeline capacity could improve the long-term viability of the Marcellus and Utica shale area as well. With the current oversupply of gas in the reserves and insufficient infrastructure to get the gas to market, regional prices in the Marcellus and Utica regions remain severely depressed which in turn has resulted in gas producers significantly cutting back their production. Linking the Pennsylvania shale resources more directly to the large energy consuming markets in the tristate region could significantly improve production and increase the revenue generated from gas production in Pennsylvania.

About the Greater Philadelphia Energy Action Team

Over the last two years, the members of the Greater Philadelphia Chamber of Commerce and its affiliates, the CEO Council for Growth and Select Greater Philadelphia, have assembled a multi-industry energy consortium of over eighty (80+) business, public sector, labor and academic leaders to work together to develop a strategy enabling the tristate region to benefit from its proximity to the Marcellus and Utica natural gas reserves. Under the leadership of a number of energy industry experts, the Greater Philadelphia Energy Action Team (GPEAT) was launched in 2013. GPEAT is working together to capitalize on the shale resources and leverage the tristate region’s energy and manufacturing assets to accelerate economic growth in the energy and manufacturing sectors, with the ultimate vision of establishing the Greater Philadelphia region as the nation’s next Energy Hub.

GPEAT’s primary objectives are: (1) to promote pipeline development from Pennsylvania shale gas wells to the Greater Philadelphia region to increase the supply of hydrocarbons used in heating, manufacturing, petrochemical processing and in other industries; (2) to attract more energy-intensive manufacturing companies to southeastern Pennsylvania, southern New Jersey and northern Delaware, and thereby grow demand for natural gas and NGLs and stimulate direct and indirect economic growth and job creation in the region; and (3) ultimately, to build a demand-center by increasing the consumption of natural gas and NGLs in the region, while doing it in an environmentally-responsible fashion and creating long-term economic value to energy consumers.

Purpose of the Energy Hub Strategy

To achieve the stated goal, GPEAT concluded it was imperative to mobilize stakeholders and create a strategy to further the development of pipeline capacity into the Greater Philadelphia region. This report addresses the infrastructure, environmental, economic and regulatory challenges that currently exist in bringing new natural gas and NGLs pipeline capacity to the region. It also highlights the economic and structural benefits that could inure to the tristate area by increasing natural gas supplies.

The Energy Hub strategy was developed under the auspices of the GPEAT Steering Committee and four (4) Working Groups. The Working Groups were organized under the study elements of Economic Framework, Environmental Mitigation and Best Practices, Economic Benefits Analysis and Mapping/Infrastructure Development.
The Greater Philadelphia region, once home to the U.S. Industrial Revolution and birthplace of the country’s refining and petrochemical industries, has embraced and is about to be transformed, yet again, by a new revolution, the “shale revolution.” The abundance of methane gas and NGLs, produced within several hundred miles of the Greater Philadelphia region, provides predictable and sustainable future sources of value added feedstocks for the chemical and petrochemical industries, and fuel for heating and generating electricity. Pennsylvania produced natural gas and NGLs also are available as feedstocks and fuel for domestic and foreign export through the region’s readily accessible and expanded port facilities, national rail network and interstate highway system.

Economic growth and skilled job creation in the Greater Philadelphia region could be transformational for the economy if we can get these hydrocarbons to market through an expanded natural gas interstate and intrastate pipeline system. Increasing access to shale resources within the Greater Philadelphia region could further lead to a resurgence of the region’s chemical, petrochemical and energy intensive manufacturing industries. Figure 2 provides an overview of the upstream production, midstream transmission and downstream consumption of natural gas and NGLs.

The Commonwealth of Pennsylvania and its neighboring states of Ohio, West Virginia, Kentucky, Tennessee and New York are home to the Marcellus and Utica shale formations, one of the largest reserves of natural gas and NGLs in the United States. Upstream supplies of Marcellus/Utica region natural gas and NGLs available to the Greater Philadelphia region are shown in Figure 3.

Despite historically low natural gas prices in the United States, the Marcellus/Utica region continues to exceed production forecasts which indicate the country and our region now have their own indigenous supply of potentially recoverable hydrocarbons for the next 100 years, thus rendering the United States and much of North America energy independent. The discovery and development of natural gas and NGLs within the Marcellus/Utica region has been an economic resurgence for Pennsylvania, West Virginia and Eastern Ohio, where the shale wells are generally located.
Figure 2 • OVERVIEW OF NATURAL GAS TRANSMISSION FROM WELL HEAD TO END USERS

Source: DTE Energy

Figure 3 • UPSTREAM UNCONVENTIONAL PRODUCTION WELLS IN THE APPALACHIAN BASIN

Map provided by Langan Engineering and Environmental Services 2016
The chemical characteristics of the gas being produced in each of these areas are very different. Production in the Pennsylvania Northern Tier\textsuperscript{14} (primarily Bradford, Susquehanna, and Tioga counties) is predominantly methane or “dry” natural gas; requiring only minor processing in order to be delivered into the system of natural gas pipelines. Marcellus gas production in most areas of the Pennsylvania Southwest Tier (primarily Fayette, Greene, and Washington counties) including parts of West Virginia and eastern Ohio has a richer stream and contains “heavier” NGLs in addition to methane. In Figure 3, a wet/dry gas line is shown on the map to indicate these two regions. These heavier hydrocarbons need to be processed out of the gas stream and collected before being delivered into the pipeline system. These NGLs can be further processed, separated and ultimately sold to both domestic and foreign markets as petrochemical feedstocks and for other products. In addition to Marcellus Shale assets, there are other high value shale resources; Utica/Point Pleasant Shale and Lower Devonian Shale are also located in the Marcellus/Utica region and both contain significant quantities of future natural gas and NGLs.

Shale gas production provides downstream benefits providing fuel for the production of electricity and energy-intensive manufacturing, as well as industries that heavily rely on natural gas and NGLs as a fuel or feedstock like pulp and paper, synthetic resins, fertilizer, iron, steel and petrochemicals, to name a few. Attracting these industries to the Greater Philadelphia region can only happen if we improve our region’s access to the shale resources. Building the required interstate and intrastate pipeline capacity to transport the natural gas and NGLs from areas in southwestern and northern Pennsylvania to heavily populated southeastern Pennsylvania, southern New Jersey and northern Delaware could spur an energy and manufacturing boom for this region’s economy.

Expanding the natural gas pipeline capacity to the Greater Philadelphia region could be a catalyst for a petrochemical and energy intensive manufacturing renaissance, providing transitional fuel for clean electric power generation, establishing new markets for liquefied natural gas (LNG) and compressed natural gas (CNG), and creating enhanced economic activity along with new highly-skilled and high paying jobs. The Greater Philadelphia region could transform into the nation’s next Energy Hub.

Despite having historically low market prices for natural gas in 2016, five (5) publically announced natural gas pipeline projects are currently in the planning stages or under construction in our region. The foundation for the Greater Philadelphia region becoming a future Energy Hub is already being laid. Despite having historically low market prices for natural gas in 2016, five (5) publically announced natural gas pipeline projects are currently in the planning stages or under construction in our region. The new natural gas pipeline projects combined could bring an additional 3.094 Bcf/d\textsuperscript{15} of natural gas into the Greater Philadelphia region. As discussed below, these pipeline projects along with future pipeline projects could provide additional natural gas to the region that would significantly exceed the region’s projected modest growth for local gas distribution companies (LDCs), and open up the tristate area to potential new markets for natural gas fired electric generation, energy intensive manufacturing, and the sale of LNG and CNG.

Once fully operational, Sunoco Logistics’ Marcus Hook Industrial Complex (MHIC) located in Marcus Hook, Delaware County, Pennsylvania and its two (2) new Mariner
East pipelines are projected to carry 750,000 barrels per day (bpd) of low-cost NGLs and condensates into the Greater Philadelphia region. This substantial increase of NGLs into the region further supports newly proposed petrochemical operations at the MHIC including ethane cracking, propane dehydrogenation and derivatives operations for both domestic markets and export markets. The proximity of MHIC to the adjacent and expanding chemical and refining operations at Braskem, Philadelphia Energy Solutions (PES), and Monroe Energy further signals a resurgence of the petrochemical production and oil refining in the region.

Although the current MHIC expansion signals a significant introduction of new NGLs into the area and the development of a world-class petrochemical facility, there is limited pipeline capacity to move more NGLs from the Marcellus shale reserves to the Greater Philadelphia region.

Developing the Greater Philadelphia region into a sustainable future Energy Hub fueled by the Marcellus/Utica region’s expansive reserves will take time. Current and future petrochemical, manufacturing, power generation and LNG/CNG projects will likely take a decade or more to complete assuming the required additional pipeline capacity is developed along with concomitant increases in demand for natural gas and NGLs. The substantial economic impact on the Greater Philadelphia region from these developments is discussed in greater detail in this report along with the current environmental regulatory requirements and industry best practices.

However, “time and tide wait for no man.” No truer statement can be made than in connection with the future increased consumption of natural gas and NGLs within our region. Make no mistake, the tristate is in a “winner take all” race against the established petrochemical dominant states of Texas and Louisiana (“Gulf Region”) and with other states capturing the treasures of the Appalachian Basin (Marcellus/Utica shale plays). Of the total NGLs currently produced in the Appalachian Basin, more than 90% is exported or is planning to be exported away from Pennsylvania for further value added processing and distribution to domestic and foreign markets.

There currently are three (3) existing operational interstate natural gas pipelines transporting product to demand centers; two of which transport products to other regions in the United States. Moreover, there are four (4) NGLs pipeline projects under construction or being developed from the Marcellus/Utica reserves and three (3) of these projects plan to transport product to the Gulf Region and the other project will transport product to other locations outside of Pennsylvania. Current forecasts indicate that the vast majority of the NGLs will be transported to areas outside of Pennsylvania and the resulting economic benefit and job creation will go to these areas outside of Pennsylvania, as well.

GPEAT has developed this report to encourage law makers and policy makers to address the economic, regulatory and environmental challenges for natural gas and NGL pipeline development within the region. GPEAT strongly encourages state officials to take action and ensure the Commonwealth of Pennsylvania does not run the risk of exporting the lion’s share of its undeveloped natural resources to other states where our feed stocks will be processed into value added products for domestic and export markets. If we do not act quickly, the economies of PA, NJ and DE will lose the resulting economic benefits for decades to come.
MARKET ANALYSIS:
Requirements For Expansion Of Natural Gas And Natural Gas Liquids Into The Greater Philadelphia Region

Upstream Markets Supplying Natural Gas and Natural Gas Liquids to the Tristate Region

U.S. EIA estimates that the country has technically recoverable natural gas of 388.8 Tcf in 2014 (including natural gas and NGLs), representing a record-high level of proved reserves for the second consecutive year. Pennsylvania shale resources experienced the greatest gain of natural gas proved reserves additions in 2014, with operators adding a net 10.4 Tcf, largely as a result of development in the Marcellus shale region.18

According to the EIA, in 2014 the total U.S. dry natural gas content of the proved reserves was 368.7 Tcf. The estimated volume of natural gas liquids that may be extracted from the natural gas reserves was 15.0 billion barrels. According to the EIA by February 2015, the Marcellus/Utica region is currently yielding about 19 Bcf of natural gas per day.19
Beginning in 2007, the combined dry natural gas production from the Marcellus/Utica region has experienced exponential growth as detailed in Figure 4.

Since 2007, Marcellus/Utica shale gas production has increased over 1,300% (Figure 4). United States shale gas production has driven down the Henry Hub price of U.S. Natural Gas from $13 per MMBtu in June 2008 to approximately $2.39 per MMBtu, as of January 2016. As noted by the EIA, projections of future natural gas and NGLs pricing are influenced by assumptions about oil prices, resource availability and demand for natural gas and NGLs.

In addition, wells in the Pennsylvania Southwestern Tier near the Pennsylvania-Ohio border, are yielding substantial quantities of high value NGLs and small amounts of oil. While production has been tempered by the recent price declines, the EIA forecasts production and pricing trends in natural gas and NGLs will escalate through at least 2035.

Based on reference case predictions in the EIA’s Annual Energy Outlook for 2015, the Henry Hub Natural Gas spot price (in 2013 dollars) may rise to $4.88 per MMBtu by 2020 and to $7.85 per MMBtu by 2040. Projections for NGLs (EIA defined as NGLs plant liquids) will rise from $15.36 per MMBtu in 2020 to $27.41 per MMBtu by 2035.

Current pricing of natural gas and NGLs within Pennsylvania signals future economic development opportunities for the Greater Philadelphia region. Wholesale pricing at the three key interstate transmission pipeline pricing points within the Marcellus/Utica region (TETCO M2, Transco Leidy and Dominion SP) have been trading at an increasing discount to Henry Hub, providing shippers with economic incentive to bring the natural gas to market. The price spread between the marker (Henry Hub) and NYMEX pricing for the three major hubs in Pennsylvania are shown in Figure 5.

In summary, the plentiful future supply of natural gas and NGLs within the geographically favorable Marcellus/Utica region, when combined with positive price differentials between this region and established trading hubs, provides the building blocks for future natural gas-driven industrial expansion within the Greater Philadelphia region. This expansion is predicated on significant new pipeline investment in the region linked with increased downstream demand.
Midstream Markets Moving Natural Gas and NGLs: Pipeline Transportation and Storage of Natural Gas and NGLs into the Tristate Region

For many years, the Greater Philadelphia region’s demand for natural gas has been met by deliveries from a strong interstate pipeline system (Figure 6). There are three (3) major interstate pipelines that deliver into the Greater Philadelphia region: Transco (a Williams company); Texas Eastern (a Spectra Energy company); and Columbia (a Columbia Pipeline Group company), as shown in Figure 6. Collectively, these pipeline systems currently deliver approximately 3.0 Bcf/d of natural gas into the Greater Philadelphia region. Transco has the largest position delivering approximately 60% of the gas to the Greater Philadelphia region with Texas Eastern delivering 30% and Columbia delivering the remaining 10%.24

Historically, natural gas pipelines within the Greater Philadelphia region have been expanded incrementally to meet the region’s increased demand from LDCs and from electric power generation. However, these systems are currently running at full capacity, and they now restrict deliveries of interruptible natural gas services during seasonal peak demand periods.

Major interstate pipeline companies have publicly proposed and/or are currently constructing five (5) new projects to provide the Greater Philadelphia region with access to natural gas from the Marcellus/Utica region. (Figure 7)

As detailed in Table 1, these new interstate pipeline projects will bring natural gas either directly into or to the fringes of our region.

These proposed projects are expected to meet the regional LDCs’ current residential and commercial peak demand. Based upon current market demand, existing LDC natural gas networks within the Greater Philadelphia region are expected to experience modest growth. However, if new energy-intensive manufacturing, electric generation or LNG/CNG projects are added, then these proposed pipeline projects will be insufficient. Regional LDCs like Public Service Electric and Gas (PSE&G) are working with state government to build new demand centers in areas like Camden, NJ where thousands of square feet of commercial and industrial space are under development. LDCs with active economic development efforts partnered with state governments are spurring business growth and contributing to the development of the demand centers.

As compared to the current nominal growth in the tristate region for methane gas, NGL processing in the region grew six-fold from 2011 to 2013. Producers are building processing plants to extract NGLs and pipelines to transport them to domestic and Canadian markets, and to
**Table 1 • PUBLICLY PROPOSED NATURAL GAS PROJECTS IN/NEAR THE GREATER PHILADELPHIA REGION**

<table>
<thead>
<tr>
<th>Project</th>
<th>Exp.In-Service</th>
<th>Exp. Quantity</th>
<th>Near/or Into Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>PennEast Pipeline</td>
<td>2017</td>
<td>1,107,000 Dth/day</td>
<td>Near</td>
</tr>
<tr>
<td>TETCO Marcellus to Market</td>
<td>2017</td>
<td>200,000 Dth/day</td>
<td>Near</td>
</tr>
<tr>
<td>Transco Diamond East</td>
<td>2018</td>
<td>1,000,000 Dth/day</td>
<td>Near</td>
</tr>
<tr>
<td>TETCO Greater Phila. Expansion</td>
<td>2018</td>
<td>475,000 Dth/day</td>
<td>Into</td>
</tr>
<tr>
<td>Transco Grand Passage Project</td>
<td>2019</td>
<td>N/A</td>
<td>Into</td>
</tr>
</tbody>
</table>

*Source: Company Websites*
### Table 2 • CURRENT AND PROPOSED NGLS PROJECTS IN THE APPALACHIAN BASIN REGION

<table>
<thead>
<tr>
<th>Owner</th>
<th>Name</th>
<th>Capacity</th>
<th>Cost</th>
<th>In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinder Morgan</td>
<td>Utopia East</td>
<td>50 MB/pd ((\text{expandable to 75 MB/pd}))</td>
<td>$0.5 B</td>
<td>1Q 2018</td>
</tr>
<tr>
<td></td>
<td>Utopia west</td>
<td>95 MB/pd</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UMTP</td>
<td>430 MB/pd</td>
<td>$4.0 B</td>
<td>4Q 2018</td>
</tr>
<tr>
<td>Enterprise</td>
<td>ATEX</td>
<td>125 MB/pd ((\text{expandable to 225 MB/pd}))</td>
<td>$1.4 B</td>
<td>In-service</td>
</tr>
<tr>
<td></td>
<td>Mariner East I</td>
<td>70 MB/pd</td>
<td>$3 B</td>
<td>In-service</td>
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<tr>
<td>ETE (Sunoco Logistics)</td>
<td>Mariner East II</td>
<td>275 MB/pd</td>
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<td>1Q 2017</td>
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<tr>
<td></td>
<td>Mariner West</td>
<td>50 MB/pd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marathon/ MarkWest</td>
<td>Cornerstone</td>
<td>25 MB/pd</td>
<td>$0.14 B</td>
<td>2H 2016 - 1H 2017</td>
</tr>
</tbody>
</table>

*Source: EIA, Company and industry websites*

### Table 3 • NGLS SPOT PRICING AT MONT. BELVIEU

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural Gas ($/MMBtu)</th>
<th>Ethane ($/Bbl)</th>
<th>Propane ($/Bbl)</th>
<th>Normal Butane ($/Bbl)</th>
<th>Iso Butane ($/Bbl)</th>
<th>Natural Gasoline ($/Bbl)</th>
<th>Extraction Margin ($/Bbl)</th>
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<tbody>
<tr>
<td>2008</td>
<td>8.88</td>
<td>36.60</td>
<td>59.29</td>
<td>70.55</td>
<td>72.24</td>
<td>87.64</td>
<td>25.10</td>
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<tr>
<td>2009</td>
<td>3.93</td>
<td>25.36</td>
<td>43.21</td>
<td>55.00</td>
<td>61.82</td>
<td>67.49</td>
<td>20.21</td>
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<tr>
<td>2010</td>
<td>4.38</td>
<td>25.27</td>
<td>49.07</td>
<td>62.88</td>
<td>66.58</td>
<td>77.12</td>
<td>28.06</td>
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<tr>
<td>2011</td>
<td>3.99</td>
<td>31.93</td>
<td>61.39</td>
<td>77.25</td>
<td>85.75</td>
<td>98.30</td>
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<td>2012</td>
<td>2.75</td>
<td>16.96</td>
<td>42.37</td>
<td>69.68</td>
<td>75.60</td>
<td>90.32</td>
<td>31.68</td>
</tr>
<tr>
<td>2013</td>
<td>3.73</td>
<td>10.84</td>
<td>41.80</td>
<td>58.72</td>
<td>60.26</td>
<td>89.49</td>
<td>26.40</td>
</tr>
<tr>
<td>2014</td>
<td>4.34</td>
<td>11.22</td>
<td>44.00</td>
<td>51.38</td>
<td>52.50</td>
<td>83.52</td>
<td>23.10</td>
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<tr>
<td>2015</td>
<td>2.78</td>
<td>8.23</td>
<td>19.79</td>
<td>25.44</td>
<td>25.55</td>
<td>45.24</td>
<td>9.93</td>
</tr>
</tbody>
</table>

*Source: PIRA Energy Group Price Portal*
ports on the East Coast and Gulf Coast for export. The Marcellus/Utica region is seeing unparalleled production of NGLs including substantial new quantities of ethane, propane, butane and condensates.25

As with the dry natural gas, there are new NGLs pipeline projects under construction/consideration to move these valuable liquid streams to market. Figure 8 details a map of the current and contemplated NGLs pipelines within Pennsylvania.

The most notable projects currently under development in the Greater Philadelphia region are the Sunoco Logistics Mariner East I, II and II Expansion (proposed and in open season) pipelines. The Mariner East projects are being developed to move propane and ethane from the liquid-rich areas of Western Pennsylvania to Marcus Hook, Pennsylvania for further chemical feedstock processing or as commodities that will be shipped to world markets.

Sunoco Logistics has constructed a pipeline from MarkWest Energy Partners L.P.’s Houston, Pennsylvania processing and fractionation complex to an interconnection with an existing Sunoco Logistics pipeline at Delmont, Pennsylvania. The NGLs will then be transported to the Marcus Hook facility where Sunoco Logistics has constructed new facilities to process, store, chill, and distribute propane and ethane to local, regional and international markets.

Sunoco Logistics has further developed the Mariner West project, which commenced operations in 2013, and now transports ethane from processing and fractionation areas in Western Pennsylvania to the Sarnia, Ontario petrochemical market. Table 2 details current and proposed NGLs pipeline projects within the Appalachian Basin (Pennsylvania, Ohio and West Virginia).

NGLs production continues to expand due to increases in wet gas production as producers seek to supplement revenue from historically low natural gas prices with NGLs netbacks. However, with the rise in propane and ethane supplies, prices over the last several months have eroded the NGLs premiums for gas producers, resulting in a rationalization of wet gas production within the Marcellus region. It is projected that Marcellus wet gas and NGLs production plateaued in 2015, as prices for these products remain low. Unless and until the price for natural gas increases, NGL production could slowly approach a flat growth trajectory in future years. A summary of historic NGLs pricing is shown in Table 3.
Fundamentals of Midstream Development

Historically, major pipeline projects have not been built “on spec.” To be economically viable for the pipeline project sponsors to proceed, sufficient long-term contractual commitments from shipper(s) of these hydrocarbons must be secured. Sponsors of pipeline projects need to obtain sufficient economic support (including a return on investment) before they will invest substantial capital to develop, permit, construct and operate a pipeline system.

These long-term commitments usually come in the form of binding agreements where the shipper agrees to provide the pipeline project sponsor with a firm revenue stream for a period of time (usually 10 to 20 years) in exchange for the obligation of the pipeline to provide firm natural gas or NGLs transportation services on behalf of the shipper. Shippers can be demand side players: LDC’s, electric power generators, industrials, LNG/CNG producers, and/or marketing companies. Additionally, shippers can be supply side players: natural gas and NGLs producers, pipelines, and/or energy marketing companies.

Before making the long-term commitment in a natural gas or NGL pipeline project, project sponsors must identify sufficient downstream market demand (for example, a new gas-fired power plant, a LNG project, or a new petrochemical operation) that is currently underserved. Users of natural gas and NGLs correspondingly are looking for the pipeline to provide access to firm, liquid and competitively priced supplies of the product over a significant time period. Similarly, upstream shippers of natural gas and NGLs require access to demonstrated downstream end-use market opportunities; access to multiple downstream pipeline options or to a liquid trading point that has price transparency where they can sell their commodity on a long-term basis.


Producing low-cost and geographically accessible natural gas and NGLs within Pennsylvania has the potential to spur a manufacturing resurgence in the Greater Philadelphia region. This resurgence includes the revitalization of the region’s storied petrochemical past, along with future construction of new energy-intensive manufacturing within the aluminum, fertilizer, paper, glass and food industries to name a few.

Electric power production within the region is likewise undergoing mass disruption and replacement. Natural gas-fired electric generation is now replacing coal as the fuel of choice for future electric power demands within the region’s residential, commercial and industrial sectors. Plentiful natural gas has further propelled new and previously unthinkable production opportunities to address expanding LNG and CNG markets.

The Greater Philadelphia region’s proximity to a significant supply of hydrocarbon feedstocks and low-cost electric power is only surpassed by its accessibility to a skilled workforce, substantial petrochemical storage, electric transmission infrastructure, and an efficient transportation hub. Manufacturers can better control their supply and distribution chains through newly expanded Delaware River port facilities, multiple Class 1 railroads, and an interstate highway system leading to the nation’s largest northeast regional markets and expanding export markets within Europe, Asia, and South America.

An Energy Hub within the Greater Philadelphia region is already developing for liquids with additional pipelines bringing more NGLs from the Marcellus/Utica reserves into expanded operations in Marcus Hook and elsewhere in the tristate area. However, this region can only harness its full economic potential from unconventional oil and gas resources if current bottlenecks are removed by adding additional natural gas and NGLs pipeline infrastructure to support new value-added manufacturing and hydrocarbon exports.

The Greater Philadelphia Region: Home to a Petrochemical Renaissance

Over the years, the natural gas pipeline system within the U.S. was developed to move natural gas and processed liquids from established production supply centers in the Gulf Coast to demand centers along the East Coast. A new paradigm is emerging. Substantial new supplies of natural gas and NGLs produced in the Marcellus region now requires new pipeline infrastructure to move product to emerging and expanding petrochemical production facilities within our region and elsewhere. In February 2014, the American Chemical Council reported 148 chemical and plastics projects within the U.S. totaling $100 billion in potential new investment.

By all accounts, the petrochemical industry stands to significantly benefit from the increased availability of affordable natural gas and NGLs. As noted above, the prices for the product within the U.S. have substantially decreased over the past ten years. Chemical producers within the U.S. have taken advantage of these historically low prices for...
natural gas feedstocks, resulting in the U.S. becoming one of the lowest cost chemical producers outside of the Middle East. According to a recent report from Harvard Business School and Boston Consulting Group, the United States has an enormous 15 year, first-to-market advantage in unconventional natural gas development with approximately 101,117 hydraulic fractured wells, followed by Canada’s 16,990. In contrast, China has developed approximately 258 unconventional wells, and it continues to rely heavily on foreign suppliers of natural gas and NGLs to support its petrochemical industry.

In a 2014 University of Michigan report entitled “Shale Gas: A Game Changer for U.S. Manufacturing,” analysts with Resources for the Future concluded that a domestic expansion of petrochemical production (especially ethylene) “could likely boost production and have positive impacts on the entire manufacturing industry.” Many more international petrochemical producers who previously relocated domestic operations overseas are now exploring the re-shoring of their operations to exploit the long-term supplies of low cost feedstocks. As noted in the above study, “the shale boom has already reversed the U.S. trade balance for the chemical industry from a $9.4 billion deficit in 2005 to a $3.4 billion surplus in 2013.”

By way of example, a focus on recent ethylene and ammonia markets demonstrates the extraordinary economic benefits derived from access to inexpensive domestic feedstocks produced in the Marcellus region and other shale producing regions within the U.S. As a feedstock, ethylene drives much of the U.S. chemical industry. Ethylene is produced by cracking ethane a major component in the suite of NGLs extracted from wet gas production. Unlike their U.S. competitors, European and Asian petrochemical producers do not have access to substantial quantities of locally produced natural gas. They must, therefore, rely on imported ethane and produced ethylene for chemical production, or use naphtha as a chemical feedstock derived from more expensive imported crude oil. The U.S. chemical industries’ proximity to plentiful shale gas deposits and ethane crackers provides these domestic producers with lower cost feedstocks such that “the ethane supply in the U.S. has increased fourfold.”

Ammonia is a key ingredient used in the production of fertilizer and other agricultural products. “Between 70-90% of the cost of producing ammonia...is the cost of natural gas — as both a feedstock and fuel.” Until recently, more than half of the nitrogen fertilizer used in the U.S. was imported. A number of new domestic ammonia plants have been announced and/or are under construction, thus lowering the substantial production and transportation costs of domestic fertilizer production.

In its Annual Energy Outlook for 2015, EIA projects that continued lower prices for natural gas and NGLs will increase domestic petrochemical consumption of these feedstocks by more than 50% from 2013–2040. The EIA notes, “With sustained low HGL prices (another term for NGLs), the feedstock slate continues to favor HGL at unprecedented levels.”

The Greater Philadelphia region’s proximity to steady long-term supplies of NGLs (ethane, propane, and butane) is a key building block for expanding petrochemical, chemical, fertilizer and plastics manufacturing within our region. These NGLs serve as initial feedstocks in petrochemical manufacturing. They are converted into manufactured plastics, fibers, adhesives, coatings, cleaning agents and other value-added materials used in the manufacturing supply chain.

The refining and petrochemical industries have solid roots in our region’s history. Marcus Hook, positioned along the Delaware River in Delaware County, Pennsylvania,
just south of Philadelphia, has a long history of hydrocarbon processing dating back to Joseph N. Pew’s development of one of the region’s first oil refineries in 1901. Sunoco Logistics continues that tradition today with its expanding world-class NGLs hub at the Marcus Hook Industrial Complex.

The refining and petrochemical industries have solid roots in our region’s history.

The Marcus Hook Industrial Complex (MHIC) is located about 90 miles up the Delaware River from the Atlantic Ocean. As previously discussed, the MHIC and surrounding area bounded by the Pennsylvania/New Jersey river front is home to the Greater Philadelphia region’s petrochemical and refining corridor. Current and former petrochemical and refining operations include: Sunoco Logistics; Braskem; Monroe Energy; Philadelphia Energy Solutions; PBF’s refineries in Paulsboro, NJ and in Delaware City, DE; the former Eagle Point refinery; the Marcus Hook Tank Farm; the Fort Mifflin storage terminal; and additional port and potential petrochemical manufacturing facilities at Philadelphia’s Southport Terminal.

These locations contain existing and newly developing petrochemical and refining infrastructure including combined power and steam generation, product and raw materials storage, an inter-facility pipeline network, world-class ports, Class 1 rail and proximity to the I-95 highway serving East Coast markets.

New and expanding NGLs pipeline capacity from the Marcellus region to the MHIC and the surrounding area’s petrochemical operations further signals the emergence of the Greater Philadelphia region as an Energy Hub. The MHIC and surrounding refining and petrochemical operations are depicted in Figure 9.

As detailed above, the first phase of Sunoco Logistics’ Mariner East NGLs pipeline projects began operating in late 2014, delivering propane to the Marcus Hook Complex. Sunoco Logistics continues to increase its capacity to process NGLs from the Marcellus/Utica region with the build out of an additional Mariner East II pipeline which collectively will carry 750,000 bpd of NGLs. Sunoco Logistics’ NGLs expansion includes the construction of multiple storage facilities including two propane storage tanks with a 1.5 million barrel capacity, plus a 600,000 barrel butane tank and a 300,000 barrel ethane tank.

As a result of the closure of the Marcus Hook refinery in 2012/13, Delaware County commissioned IHS, a global consulting firm, to examine potential options for the facility’s reuse. The study highlighted the following petrochemical development options for the facility: (1) natural gas liquids processing and fractionation; (2) gas-to-liquids production and storage facility; (3) liquid natural gas liquefaction; (4) refined petroleum products import terminal; (5) natural gas driven power generation; (6) ethane cracking and derivatives; and (7) propane dehydrogenation (PDH).

The initial success of the MHIC and surrounding facilities may well be the tipping point for the addition of new NGLs pipelines leading to the further expansion of value-added petrochemical manufacturing in the Greater Philadelphia region.

As recently completed update, IHS Marcus Hook Industrial Complex Reuse Study: Update 2015, a Regional Analysis, issued in October 2015, reports that Sunoco Logistics has undertaken the construction of NGLs processing and fractionation facilities, and it is committed to the development of a PDH plant to feed the growing demand for propylene, a feedstock for the areas polypropylene production (including possible expansion of the existing Braskem facility). IHS estimates the PDH plant would produce up to 400,000 metric tons per year with the ability to increase production for additional petrochemical customers. These Marcus Hook projects, along with possible future investments in an ethane cracker and expansions at Braskem’s polypropylene facility and Philadelphia Energy Solution and Monroe Energy’s refining facilities, signals the start of a petrochemical renaissance within the Greater Philadelphia region.

It is important to note that the economic benefit to the region from the development of a PDH plant could be significant. IHS estimates that the PDH plant Sunoco Logistics plans to add to its Marcus Hook Industrial Complex will have a capital cost of $1 billion to $2 billion and total employment of about 100 people. This is comparable to other propane dehydrogenation facilities currently under development throughout the world with capacities in the range of 500,000 metric tons per year and capital costs of $1 billion or more.

The initial success of the MHIC and surrounding facilities may well be the tipping point for the addition of new NGLs pipelines leading to the further expansion of value-added petrochemical manufacturing in the Greater Philadelphia region. The IHS Study further notes, however, that “competing pipelines could reduce Marcellus/Utica NGLs flows to Delaware County by moving products to the Gulf Coast to make higher value petrochemicals for exports.”

The initial NGLs pipeline capacity into our region from the Mariner East projects is in large measure already spoken for, and it alone cannot provide the catalyst needed to maximize the economic opportunities from shale gas and liquids processing.
Figure 9 • THE MARCUS HOOK INDUSTRIAL COMPLEX (MHIC) AND SURROUNDING ENERGY CORRIDOR

Source: IHS's Marcus Hook Industrial Complex Reuse Study: Update 2015
### Table 4 • ECONOMIC IMPACT FOR ENERGY INTENSIVE MANUFACTURING

<table>
<thead>
<tr>
<th></th>
<th>Capital Cost ($ million)</th>
<th>Construction Jobs (man-years)</th>
<th>Direct Operational Jobs (FTEs)</th>
<th>Indirect Operational Jobs (FTEs)</th>
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<tbody>
<tr>
<td>NGL Processing</td>
<td>$350</td>
<td>1,750</td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>PDH Facility</td>
<td>$1,000</td>
<td>5,000</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>CCGT Power Plant</td>
<td>$500</td>
<td>2,500</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Small Scale LNG</td>
<td>$80</td>
<td>400</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Ethane Cracker</td>
<td>$5,000</td>
<td>25,000</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Gas to Liquids</td>
<td>$5,000</td>
<td>25,000</td>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>Methanol</td>
<td>$1,000</td>
<td>5,000</td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>Ammonia</td>
<td>$2,000</td>
<td>10,000</td>
<td>200</td>
<td>400</td>
</tr>
</tbody>
</table>

Source: KPMG

### Figure 10 • EXISTING ELECTRIC POWER PLANTS WITHIN THE GREATER PHILADELPHIA REGION

Map provided by Langan Engineering and Environmental Services 2016
Economic Impact for Energy-Intensive Manufacturing

With the development of shale gas, access to low-cost natural gas is having a positive impact on many energy-intensive manufacturing industries by reducing costs and improving the manufacturing process. Energy-intensive manufacturing often includes sectors like fertilizers, paper, glass, petroleum refineries, and bulk chemicals. Not only are these sectors able to keep operation costs down with low natural gas prices but they are also realizing a savings in their electric costs.

Table 4 provides an economic analysis completed by KPMG of the construction jobs, direct jobs and indirect job benefits of energy-intensive manufacturing plants and facilities that are commonly developed in areas that offer access to low cost natural gas.

KPMG’s analysis is based upon publicly-available information and other inputs. It estimates the construction cost, direct construction employment, and direct and indirect operating employment for each of the facilities. Construction employment estimates are based on the assumption that five man-years of construction employment are generated by every million dollars of capital cost. Indirect operating employment is estimated based on the assumption that two indirect full time jobs are generated by each direct full time job.

The construction and operation for a selection of facilities of this type could be expected to generate well over $10 billion of capital expenditures and tens of thousands of man-years of direct and indirect construction employment. The direct employment impact of the on-going operations of these facilities could be 1,000 or more jobs.

Increased Use of Natural Gas for Power Generation in the Greater Philadelphia Region

Electric power generation within the Greater Philadelphia region and the broader wholesale market administered by PJM Interconnection LLC (PJM) continues to increasingly be dominated by natural gas. As discussed above, the combination of abundant supplies from the Marcellus Shale, lower natural gas prices, and increased retirements of coal generating plants have led to natural gas being the fuel of choice for new generating capacity. However, electric markets in eastern Pennsylvania are subject to higher priced natural gas primarily “caused by a lack of pipeline capacity to transport the glut of supply to the markets where it is most needed.”

PJM has historically had a diverse mix of generation resources. However, its base load energy requirements are served primarily by nuclear and coal-fired generation. At December 2015, almost 55% of the installed generating capacity of the entire PJM market was comprised of nuclear and coal resources. Gas-fired combined cycle and combustion turbine capacity account for a total of approximately 34% of the installed capacity. The mix of resources in the PJM market causes coal and natural gas to be the marginal fuels in the market. Figure 10 shows a map of the current and proposed electric power plants within southeastern Pennsylvania, southern New Jersey and northern Delaware region.

There is no indication that natural gas as the fuel of choice for power generation in PJM is abating. PJM maintains an “interconnection queue” by which it tracks those electric generating facilities desiring to interconnect proposed generation with the existing electric transmission system. While on average only 25% of the projects in the interconnection queue ever get built, as of December 2015 about 58,948 megawatts (MW), or 87% of the total of the proposed projects in the queue, were from new natural gas-fired electric generating capacity. (Figure 11)

Figure 11 • QUEUED INTERCONNECTION REQUESTS BY FUEL TYPE (MW) AS OF DECEMBER 31, 2015

Source: PJM Presentation dated February 18, 2016

- Natural Gas: 58,948 MW
- Nuclear: 1,663 MW
- Other: 163 MW
- Solar: 2,203 MW, Nameplate Capacity, 3,769 MW
- Wind: 2,352 MW, Nameplate Capacity, 14,914 MW
- Biomass: 45 MW
- Wood: 66 MW
- Coal: 1,863 MW
- Methane: 97 MW
- Hydro: 209 MW
- Storage: 0 MW, Nameplate Capacity, 866 MW
The emergent role of natural gas as a dominant fuel source in PJM is the result of two primary factors: (1) increased supply and favorable pricing of natural gas from nearby Marcellus/Utica region shale gas resources, and (2) the retirement of coal-fired generation as a result of new environmental requirements and changing economics.

Environmental regulations, such as the Mercury and Air Toxic Standards (MATS), aging coal production infrastructure, along with historically low gas prices and robust supply of natural gas, have resulted in over 20,000 MW of coal-fired electric generation capacity being announced for retirement in PJM since 2012. (Table 5)

Continued low natural gas prices and the increasing amount of time that natural gas is on the margin setting prices in the wholesale power markets like PJM, will put greater pressure on older coal-fired power plants, and will likely lead to the region adding new gas-fired generation as well as extending the licenses on existing nuclear plants.

With two of the largest shale reserves, Marcellus and Utica, located in the PJM region, this increased gas availability has driven down gas prices and made gas competitive with coal for power generation. For example, over 11,000 MW of existing generation resources (4,000 MW of which was nuclear capacity) did not clear in the 2017/2018 capacity auction held by PJM in May 2014.43

Another reason why coal plants are retiring in the PJM region is their age. Approximately 85% of the current installed coal-fired capacity is greater than 30 years old. In comparison, a little over half of all installed capacity in PJM is over 30 years old. Of the approximately 42,000 MW of coal-fired capacity in PJM that is over 40 years old, 23,600 MW is not equipped with any SO2 or mercury controls that are needed to comply with current environmental rules. Many of these older less efficient generating units have found it difficult to justify the significant capital investment required to continue operating, let alone competing with often lower cost natural gas generating facilities.44

Of course, changing economics and age do not only impact coal-fired generating facilities. Table 5 shows the capacity, average size and average age of the generating units retiring in PJM from 2011 – 2019.45 Coal-fired units account for 77.4% of the 26,679.8 MW of retiring capacity during this time period.46 These units have an average age of 56.4 years.

Moreover, the natural gas-fired combined cycle gas turbine (CCGT) power plant is a very common and very well developed power plant technology. Such plants can operate as dedicated electricity generating facilities under power generating contracts or as merchant plants selling power into the local grid. Either way they are reliable consumers of natural gas over their expected lives of more than 40 years.

A CCGT power plant with a typical operating capacity of 400 megawatts would require capital investment of approximately $400 million.47 While the capital expenditures and employment impacts of a typical sized CCGT are not as large as some of the refining and manufacturing opportunities, the indirect benefits of fuel diversity and environmental benefits could be significant. These indirect benefits will be discussed in the Economic Benefits section of this report.

As coal-fired generating facilities continue to be retired, natural gas is likely to remain the fuel source of electric power generation in significant portions of PJM wholesale market and in the Greater Philadelphia region for years to come.
Increased use of Natural Gas for the Production of Compressed Natural Gas and Liquefied Natural Gas in the Greater Philadelphia Region

Natural Gas fuel comes in two forms: Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG). The economic and environmental benefits of using natural gas are realized when using either form, each has a unique advantages that make it better suited for specific applications.48

### Table 5 - PJM RETIREMENTS BY FUEL TYPE, 2011 THROUGH 2019

<table>
<thead>
<tr>
<th>Source</th>
<th>Number of Units</th>
<th>Avg. Size (MW)</th>
<th>Avg. Age at Retirement (Years)</th>
<th>Total MW</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>124</td>
<td>166.6</td>
<td>56.4</td>
<td>20,659.6</td>
<td>77.4%</td>
</tr>
<tr>
<td>Diesel</td>
<td>7</td>
<td>11.0</td>
<td>43.9</td>
<td>77.2</td>
<td>0.3%</td>
</tr>
<tr>
<td>Heavy Oil</td>
<td>4</td>
<td>68.5</td>
<td>57.3</td>
<td>274.0</td>
<td>1.0%</td>
</tr>
<tr>
<td>Kerosene</td>
<td>20</td>
<td>41.4</td>
<td>45.5</td>
<td>828.2</td>
<td>3.1%</td>
</tr>
<tr>
<td>LFG</td>
<td>15</td>
<td>76.6</td>
<td>43.8</td>
<td>1,148.7</td>
<td>4.3%</td>
</tr>
<tr>
<td>Light Oil</td>
<td>4</td>
<td>6.5</td>
<td>14.8</td>
<td>26.1</td>
<td>0.1%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>50</td>
<td>59.9</td>
<td>46.4</td>
<td>2,996.50</td>
<td>11.2%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>1</td>
<td>614.5</td>
<td>50.0</td>
<td>614.5</td>
<td>2.3%</td>
</tr>
<tr>
<td>Waste Coal</td>
<td>1</td>
<td>31.0</td>
<td>20.0</td>
<td>31.0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Wood Waste</td>
<td>2</td>
<td>12.0</td>
<td>23.5</td>
<td>24.0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Total</td>
<td>228</td>
<td>117.0</td>
<td>50.8</td>
<td>26,679.8</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

CNG and LNG Domestic Demand Drivers

CNG is made by compressing natural gas to approximately 3,600 psi, which is then stored in high-pressure cylinders. For many applications especially short-haul and intra-city deliveries, CNG is the preferred fuel of choice. For heavy-duty, high-mileage applications, LNG is often the fuel of choice due to its high energy density. LNG is produced by cooling natural gas to -260°F, which is then stored in insulated tanks. At that temperature, natural gas becomes a liquid and is 600 times more energy-dense than in its gaseous form.

Fleet owners and operators across the nation rely on a wide variety of vehicles powered by domestically produced natural gas that is both economical and clean-burning. Natural gas vehicles (NGV) use proven, reliable technology to take advantage of our country’s abundant natural gas reserves. NGVs use both CNG and LNG as a fuel source. The low cost of natural gas, combined with public and private investment, has led to significant market growth for this emerging fuel in the transportation sector.

The positive economics of NGVs are here to stay. With the development of shale gas resources in the Marcellus/Utica region and across the country, the price of natural gas has decoupled from the price of crude-derived transportation fuels. Recent independent studies now forecast that NGVs will capture a significant market share of both light and heavy-duty vehicle markets in the near future. Another advantage, natural gas is the cleanest burning commercially available alternative fuel, and its use as a transportation fuel is improving the air quality and the health of communities across the country. NGVs significantly reduce greenhouse gas emissions and other smog producing emissions when compared to similar gasoline and diesel powered vehicles.

To stimulate interest in and promote acceptance of natural gas as a transportation fuel, the U.S. Department of Energy’s (DOE) Clean Cities Program and the Pennsylvania Department of Environmental Protection’s (PA DEP) Natural Gas Vehicle Grant Programs, along with other agencies, are working to accelerate the use of alternative fueled vehicles throughout the Commonwealth. The DOE and PA DEP programs have expanded the use of NGVs in a variety of applications, such as school buses, transit buses, airport vehicles, taxis, and delivery fleets. Grants have also been used to build out fueling infrastructure to further increase the number of vehicles using natural gas in the private sector.

The Federal Transit Administration (FTA) also awarded about $100 million in funding in fiscal years 2014–15 for more cities to switch to natural gas buses. The FTA programs will result in: (1) 3,000 new natural gas vehicles, and 600 heavy duty trucks powered by LNG; (2) more than 200 new natural gas powered buses, and the refurbishing of more than 400 existing natural gas buses, and (3) 140 new fueling stations across the country, including 10 LNG for heavy-duty trucks.

Another advantage, natural gas is the cleanest burning commercially available alternative fuel, and its use as a transportation fuel is improving the air quality and the health of communities across the country.
Fleet owners and operators across the nation are now seeing contracts maintained or awarded based on their use of NGVs or their willingness to implement green programs. The increased use of NGVs satisfies the emission targets of many public and private fleets, as well as the green initiatives of many corporations that rely on the trucking firms for shipment of their goods.

A growing number of trucking fleets — including ATT, Verizon, Frito-Lay, Coca-Cola, UPS, and Federal Express are switching to natural gas, and that is helping to raise the number of natural gas fueling stations available to consumers. There are now over about 1,000 natural gas fueling stations located across the country with 34 CNG stations located in Pennsylvania, 11 CNG stations in New Jersey, and 1 CNG station in Delaware.53

Recent independent studies now show NGVs capturing significant market share of both the light and heavy duty vehicle markets. The National Petroleum Council (NPC), under an “aggressive” scenario, predicts NGVs will capture 50% of the light-duty market, upwards of 35% of the light duty truck market, and almost 50% of the heavy-duty long haul truck market by 2050.52 The Clean Cities Annual Report, published in 2013, also supports this forecast showing LNG and CNG accounting for 61% of total conversions from petroleum derived fuels to alternative sources. (Figure 12)53

The reduced operating costs of NGVs are directly related to the price for natural gas which makes up a relatively small portion of the price for CNG and LNG at the pump. For example, a $1.50 per MMBtu increase in the natural gas pricing only translates to a $0.25 increase per diesel gallon equivalent (DGE) at the pump. On the other hand, diesel pricing is tied to crude oil, as the raw material cost makes up a much larger portion of the price at the pump. As history has shown, the price of crude oil can far exceed the actual supply-demand market economics due to volatility and instability in the marketplace.

An accelerated adoption of LNG in the marine industry may also follow the passage of the North American Emissions Control Area regulations.54 This new rule supports LNG market growth as the marine transportation sector transitions from high sulfur marine diesel and bunker fuels to cleaner sources to achieve the mandated emissions. With natural gas being inherently cleaner and costing less than other low sulfur alternatives, the transition to LNG presents an attractive option to the marine transportation sector.

Another potential market for LNG adoption is the railroad sector; there are three Class 1 freight railroads (line-haul freight) and numerous short haul railroads operating within the Greater Philadelphia region. These freight lines consume significant volumes of diesel fuel that can be readily replaced by price advantage LNG. The current price spread between natural gas and liquid fuels will provide a relatively quick recapture of the $1 million incremental cost of an LNG powered locomotive. The lower fuel cost (23% of operating costs) translates to tremendous long-term savings for the operator. Every day, 1.5 million children in Pennsylvania ride school buses to get to and from school. This presents a tremendous growth opportunity for CNG fuels, which are well suited for this application. Several of the districts have taken advantage of PA DEP Programs to fund the conversion of their fleets to NGVs. According to the 2015 Annual Report for the Pennsylvania Natural Gas Development Program, the Rose Tree Media School District in Delaware County, PA boasts a “healthy” project status for their Natural Gas Bus Project. Awarded through the FY 2014 – 2015 NGEDP Projects, Lower Merion School District in Montgomery County, PA was awarded over $150,000 to assist in the purchase and deployment of 8 CNG school buses.55 These school districts are now enjoying reduced fuel and maintenance costs with buses that have proven to be comparable to diesel buses in terms of their durability, performance, and safety.

Transit agencies across the country are also transitioning to natural gas. Today, approximately 11,000 natural gas buses operate across the country, and about 35% of new transit buses on order are powered by natural gas.56 In October 2015, South-eastern Pennsylvania Transportation Authority (SEPTA) announced the proposal of a new natural gas power plant to generate energy for its regional rail system. Located in North Philadelphia, the combined heat and power plant would serve regional rail lines and SEPTA buses. If the proposed plan is determined feasible and can be self-funded under the Pennsylvania Guaranteed Savings Act, the plant could be operational by 2017.57
Increasing LNG Production in the Greater Philadelphia Region

There are currently two sites in the Greater Philadelphia Region where natural gas is converted into LNG and stored. These sites, operated by Philadelphia Gas Works (PGW) in Philadelphia (Richmond LNG Facility) and by PECO in West Conshohocken, PA have been safely operating for many years and are primarily being used to provide peak-shaving services for the two utilities in the winter months. Traditionally these facilities receive liquefied natural gas supplies during the summer months and store the LNG in tanks in order to be re-gasified into the distribution networks or trucked as liquid to other satellite LNG storage tanks to meet peak winter loads.

With the growth of natural gas production from the Marcellus/Utica region and its proximity to the Greater Philadelphia region, there has been increased discussion about the Port of Philadelphia or the Delaware River Corridor (including Delaware and Chester Counties) becoming the site of large scale LNG export facilities.

There is no question that a facility of this magnitude, similar to Dominion Energy’s Cove Point LNG export project currently under construction in Maryland, would represent a significant demand for natural gas in the Greater Philadelphia region.

The siting of a large-scale LNG facility in this region may be challenging given: (1) the high population density; the number of bridges, and urban nature of the river corridor and port; (2) the number of proposed LNG export facilities already under consideration in the U.S. (including Cove Point and a number of proposed LNG export facilities in the Gulf Coast), and (3) the softening in demand for LNG in both Asian and European markets. While these obstacles may be daunting, they have not deterred some investors who currently are exploring an LNG export facility in the Greater Philadelphia region.

As discussed above, properly scaled LNG facilities could play a role in developing an Energy Hub in the region. There are a number of small to mid-sized LNG applications that are under consideration. In June 2015, PGW issued a Request for Information from third-parties seeking recommendations for increasing the liquefaction capabilities at its existing Richmond LNG facility and developing non-traditional services that could be offered to the Greater Philadelphia region. These services could include supplies of LNG to be used as a fuel to power truck fleets and buses and for marine use in the Port of Philadelphia. LNG represents an attractive lower emissions alternative to diesel and/or Bunker C fuel in trucks, barges and vessels. In addition, LNG could become an attractive back-up fuel source for gas-fired power generators as they try to comply with PJM’s recent “pay-for-performance” standards.

In addition to enhancements to existing LNG facilities, there are a number of independent companies that are looking to establish small to mid-sized liquefaction facilities all along the Delaware River Corridor at suitable sites in Pennsylvania, New Jersey and Delaware. The tristate region has positioned itself to take advantage of LNG processing and transport to other regions by partnering with the federal government to deepen the Delaware River’s navigational channel from 40 feet to 45 feet, making the ports in the three (3) states more attractive to the shipping industry.

While it is not likely that the Greater Philadelphia region will develop into a major international export point for LNG, the production, storage and transport of a limited amount of LNG is be important to the overall energy strategy. LNG production facilities can be built in modular scalable units. For example, a LNG production unit with a capacity of 12 mcf/d could be built for approximately $80 million and would have an operating staff of approximately ten employees. This facility could be scaled up and multiple facilities of this type could be developed along the Delaware River corridor.
Econsult Solutions, Inc. was retained by GPEAT to evaluate and assess whether there are economic benefits for the region by pursuing the development of an Energy Hub strategy. Econsult’s findings are as follows:

As noted throughout this report, expanding natural gas pipeline infrastructure linking the Marcellus/Utica regions to the Greater Philadelphia region could generate significant economic benefits, both tangible and intangible. Cleaner air quality from fuel conversions, possible expansion of energy research and development, and enhancing our energy services support infrastructure are three examples of very attractive intangible benefits.

Tangible (quantifiable) economic benefits would accrue in two ways: (1) in a “one-time” sense, during the construction of the pipeline infrastructure or construction of large-scale manufacturing or trans-shipment facilities, and (2) in an “ongoing” sense (indeed the primary benefits, and the ultimate reason for promoting the infrastructure development), generated by the expanded economic activity resulting from the increased manufacturing activity, and greater supply and reliability of natural gas and NGLs to the tristate market.

These economic benefits are typically measured by the following variables: (1) greater economic activity (gross metropolitan product/GMP), (2) increased employment and wages, and (3) fiscal impacts, as in additional tax revenues for local governments, as well as for the state treasuries.
Some of the potential benefits would be derived from midstream activities, but the bulk of the benefits would come from various downstream opportunities. While there may be some connections, we do not examine any benefits associated with upstream activity in this report. The specific midstream and downstream benefits are:

**Midstream** - Capital infrastructure investment, building and maintaining the pipelines and any related transportation infrastructure.

**Downstream** - Creating a more attractive future business environment for certain industries (existing or new) with large-scale energy input needs that would be most advantaged by the increase in and reliability of natural gas supply (comparative advantage).

- These could include refinery operations, PDH plants, an ethane cracker plant, petrochemical manufacturing and other energy-intensive manufacturing.
- Trans-shipment opportunities, and
- Gas and electric utility customer savings generated by the increased supply of gas and electricity.

Since building an Energy Hub based upon expanding natural gas and NGLs pipeline infrastructure is a relatively new and not-yet-existing concept, it is difficult to predict which of these downstream activities might be induced, with the exception of the utility customer savings. Further, since we have not witnessed this potential for comparative advantage in many decades, we do not have any direct empirical data with which to estimate the potential economic impacts of large industry expansions using standard econometric models.

Still, the potential for significant downstream activities is enhanced, and the potential economic impacts could be quite significant, and in this section we provide some “order-of-magnitude” estimates based on illustrative, assumptions about business responses to the increased and more reliable supply of natural gas to the metropolitan markets.

Econsult’s approach to estimating the potential benefits is threefold: First, the team identified the various ways in which the expanded pipeline capacity could provide direct economic benefits. Second, the GPEAT team constructed and analyzed several examples of the kinds of energy-intensive businesses that could theoretically take advantage of the additional supply of hydrocarbons. We then estimated the direct capital investment and ongoing operations’ requirements. Third, these estimates were used to generate economic and employment impact forecasts.

**Potential Economic Benefits Generated by Pipeline Infrastructure Investment**

Pipeline infrastructure development requires large capital investment, and generates significant employment in the construction and support services industries. Additionally, pipeline development typically provides for one time or ongoing payments to land owners for the use of the right of way. Several studies have estimated the potential economic impacts of pipeline development for announced projects.

Sunoco Logistics planned to invest approximately $3 billion in Pennsylvania for the Mariner East projects to transport NGLs from western Pennsylvania, West Virginia and eastern Ohio to the Marcus Hook Industrial Complex. The multi-year project, which is expected to be completed in 2017, included the development of a 50-mile pipeline that connects with an existing pipeline; construction of a new 350-mile pipeline, and the repurposing of its MHIC to store and process NGLs.

Econsult estimates significant potential statewide economic impacts associated with the construction of Sunoco Logistics’ two Mariner East pipeline projects, with a total statewide economic impact of $4.2 billion over the construction period.24 The projects could potentially support between 300 to 400 permanent direct and indirect jobs and between $800,000 and $1.2 million in tax revenues to the Commonwealth per year once operational.

The economic impact of construction and ongoing operations from the Mariner East projects were estimated within the Commonwealth of Pennsylvania. Therefore, it is expected that a portion of the potential Commonwealth impacts will take place in the Greater Philadelphia region due to operations at MHIC. However, most of the new pipeline mileage will be outside of the Greater Philadelphia region, and hence the local economic impact from the pipeline construction is likely to be relatively small. By accounting for specialized construction services and material availability within the Commonwealth and the Greater Philadelphia region, the portion of economic impact within the region was calculated. We estimate that the regional economic impact of the construction of both Mariner East pipelines and the facilities at Marcus Hook will be about $1.3 billion over the entire construction period.
**Potential downstream industry growth**

The greatest potential dividends to be generated by pipeline infrastructure build out could come from the growth of industries with large, reliable energy needs. These include industries that (1) refine or transform certain types of energy, (2) engage in trans-shipment activities, and (3) use large quantities of natural gas or NGLs for fuel or as feedstock.

One characteristic of those industries is that they are very capital-intensive, and therefore use less labor than standard industries. In this section, we examine only two of these potential facilities as an example, and estimate the construction and ongoing employment impacts for each.

There are a number of additional impacts that are not being considered at this time. We are not modeling an LNG export facility nor are we including the manufacture of components for the facilities as it is likely that this will take place, to a substantial degree, outside of the region. We have not estimated potential property taxes and fees because it is difficult to predict what incentives would be offered to the developers of these facilities in the region. The long term impact of revitalizing the region’s energy and manufacturing base is likely to be the biggest payoff but is not yet amenable to detailed analysis.

**Refineries and other large energy transformation facilities**

To determine the economic impact of potential refineries and other large energy-consuming facilities, the estimated construction budgets of a theoretical energy manufacturing facility was developed and analyzed.

In total, it is estimated that the construction of a large energy manufacturing facility will require an investment of $950 million. The investment includes costs for engineering, equipment, and construction. Of the total $950 million expenditure, $470 million is estimated to be spent in the Greater Philadelphia region (Table 6). Due to the highly specialized nature of constructing this type of facility, a significant portion of the equipment and building material will be sourced outside of the Greater

<table>
<thead>
<tr>
<th>Table 6 • ILLUSTRATIVE CONSTRUCTION EXPENDITURE INPUTS FOR A LARGE ENERGY MANUFACTURING FACILITY ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure Category</td>
</tr>
<tr>
<td>Engineering, Soft</td>
</tr>
<tr>
<td>Equipment</td>
</tr>
<tr>
<td>Construction, start up</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Source: Econsult Solutions

<table>
<thead>
<tr>
<th>Table 7 • POTENTIAL ECONOMIC IMPACT FROM A LARGE ENERGY MANUFACTURING FACILITY IN THE GREATER PHILADELPHIA REGION ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Type</td>
</tr>
<tr>
<td>Direct Output</td>
</tr>
<tr>
<td>Indirect &amp; Induced Output</td>
</tr>
<tr>
<td>Total Output</td>
</tr>
<tr>
<td>Employment Supported</td>
</tr>
<tr>
<td>Labor Income Supported</td>
</tr>
</tbody>
</table>

Source: IMPLAN (2013), Econsult Solutions
Additionally, a portion of the engineering and construction expenditures will be sourced from companies outside of the region.

Using the input-output model and estimated construction costs associated with the Greater Philadelphia region, the upfront construction of a large energy manufacturing facility will have a one-time economic impact within the region. The estimated total impacts include direct output, employment, and labor income, along with the corresponding indirect and induced impacts. In the Greater Philadelphia region, it would potentially generate an approximate $819 million in one-time total economic impact, supporting about 5,320 jobs with $393 million in earnings over the entire construction period (Table 7).

In addition, the ongoing operations of such a facility could be expected to directly support 250 FTEs while an additional 230 indirect and induced jobs for a total annual impact supporting 480 jobs.

**Specialty Petrochemical**

A similar approach was used to determine the economic impact of potential specialty petrochemical facilities. The estimated regional economic impact was calculated by developing and analyzing the estimated capital investment of a theoretical petrochemical manufacturing facility.

We estimate that the construction of a petrochemical manufacturing facility will require an investment of $350 million. The investment includes costs for engineering, equipment, and construction. Of the total $350 million expenditure, $150 million is estimated to be spent in the Greater Philadelphia region (Table 8).

The upfront construction of a petrochemical manufacturing facility will have a one-time economic impact within the region. In the Greater Philadelphia region, it would potentially generate an approximate $247 million in one-time total economic impact, supporting about 1,600 jobs with $118 million in earnings over the entire construction period (Table 9).

The ongoing operations of such a facility could be expected to directly support 150 FTEs while an additional 140 indirect and induced jobs for a total annual impact supporting 290 jobs.

---

**Table 8 • ILLUSTRATIVE CONSTRUCTION EXPENDITURE INPUTS FOR A PETROCHEMICAL MANUFACTURING FACILITY ($ million)**

<table>
<thead>
<tr>
<th>Expenditure Category</th>
<th>Project Capital Costs</th>
<th>Purchased from Greater Philadelphia Expenditure Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering, Soft</td>
<td>$20</td>
<td>$10</td>
</tr>
<tr>
<td>Equipment</td>
<td>$200</td>
<td>$20</td>
</tr>
<tr>
<td>Construction, start up</td>
<td>$130</td>
<td>$120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$350</strong></td>
<td><strong>$150</strong></td>
</tr>
</tbody>
</table>

*Source: Econsult Solutions*

**Table 9 • POTENTIAL ECONOMIC IMPACT FROM A PETROCHEMICAL MANUFACTURING FACILITY IN THE GREATER PHILADELPHIA REGION ($ million)**

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Greater Philadelphia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Output</td>
<td>$121</td>
</tr>
<tr>
<td>Indirect &amp; Induced Output</td>
<td>$126</td>
</tr>
<tr>
<td><strong>Total Output</strong></td>
<td><strong>$247</strong></td>
</tr>
<tr>
<td>Employment Supported</td>
<td>1,600</td>
</tr>
<tr>
<td>Labor Income Supported</td>
<td>$118</td>
</tr>
</tbody>
</table>

*Source: IMPLAN Econsult Solutions*
Residential and business gas and electric utility customers have already benefitted from reduced prices generated by the massive expansion of natural gas production from the Marcellus/Utica shale gas, and some argue that there really are no additional savings to accrue. However, the expanded pipeline infrastructure contemplated with the Energy Hub could generate significant customer savings primarily by providing customers in the Greater Philadelphia region access to lower cost natural gas from the Marcellus/Utica reserves which “consistently trade(s) below prices for natural gas produced along the Gulf coast.”

Large energy consumers will not be the only beneficiaries of an upgraded pipeline infrastructure. All users of energy will benefit; indeed the broadest distribution of Marcellus benefits to the region’s citizens and small businesses will come via this path. Every person and entity receiving a utility bill will reap the reward of lower energy costs than would have otherwise been imposed without the new pipeline infrastructure. This is one of the few opportunities we have to make our region more competitive.

Our estimates are based on analysis undertaken by Concentric Energy on behalf of the proposed PennEast Pipeline project. They estimated the customer savings from an additional 1 Bcf/d of pipeline capacity would have generated over a recent one year period in eastern PA and NJ. They identified four avenues for savings to the residential and commercial customers:

1. Gas-fired power generation savings
2. Oil-fired generation displacement savings
3. Industrial transport customer savings
4. Natural gas distribution company gas supply savings

We adjusted their numbers to reflect the smaller geographical boundaries of the Greater Philadelphia region, and we estimated the residential and business components.

We estimate that residents would save approximately $220 million each year, which would generate $304 million in economic impact and support 1,920 jobs with $107 million in earnings (Table 10).

We also estimate that businesses would annually save approximately $330 million, which would generate $584 million in total economic impact and support 3,330 jobs with $217 million in earnings (Table 11).

Combined, the new savings to residents and businesses will generate $888 million each year, supporting 5,250 jobs with $324 million in earnings (Table 12).

These economic impacts lead to fiscal impacts for the region, through both wage/local EIT tax and local sales tax. In total, the savings for residents and businesses generate approximately $4.4 million in tax revenues within the Greater Philadelphia region (Table 13).

Forecasting changing business behavior in response to changed circumstances is always challenging. A successful pipeline infrastructure investment program will unambiguously make our region more attractive for economic activity that relies on energy.

The economies of Pennsylvania, New Jersey and Delaware all have an opportunity to be bolstered by business growth, investment in new infrastructure, and the creation of hundreds of new jobs for its citizens. Moreover, the budgets for the three (3) states can be bolstered by new tax revenue being collected from the new businesses and from new citizens working and paying taxes. We recognize that public policy decision requires a careful assessment of aggregate costs and aggregate benefits. The significant economic benefit associated with the efficient expansion of the states’ energy infrastructure clearly should factor positively in the public policy decision.
### Table 10 • POTENTIAL ECONOMIC IMPACTS OF RESIDENTIAL SAVINGS TO GREATER PHILADELPHIA

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Greater Philadelphia Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Savings ($M)</td>
<td>$220</td>
</tr>
<tr>
<td>Indirect &amp; Induced Output ($M)</td>
<td>$304</td>
</tr>
<tr>
<td>Total Output ($M)</td>
<td>$304</td>
</tr>
<tr>
<td>Employment Supported</td>
<td>1,920</td>
</tr>
<tr>
<td>Labor Income Supported ($M)</td>
<td>$107</td>
</tr>
</tbody>
</table>


### Table 11 • POTENTIAL ECONOMIC IMPACTS OF BUSINESS SAVINGS TO GREATER PHILADELPHIA

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Greater Philadelphia Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added Business Revenue ($M)</td>
<td>$330</td>
</tr>
<tr>
<td>Margin on Retail ($M)</td>
<td>($9)</td>
</tr>
<tr>
<td>Direct Output ($M)</td>
<td>$321</td>
</tr>
<tr>
<td>Indirect &amp; Induced Output ($M)</td>
<td>$263</td>
</tr>
<tr>
<td>Total Output ($M)</td>
<td>$584</td>
</tr>
<tr>
<td>Employment Supported</td>
<td>3,330</td>
</tr>
<tr>
<td>Labor Income Supported ($M)</td>
<td>$217</td>
</tr>
</tbody>
</table>


### Table 12 • COMBINED POTENTIAL ECONOMIC IMPACTS TO GREATER PHILADELPHIA

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Greater Philadelphia Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Output ($M)</td>
<td>$321</td>
</tr>
<tr>
<td>Indirect &amp; Induced Output ($M)</td>
<td>$567</td>
</tr>
<tr>
<td>Total Output ($M)</td>
<td>$888</td>
</tr>
<tr>
<td>Employment Supported</td>
<td>5,250</td>
</tr>
<tr>
<td>Labor Income Supported ($M)</td>
<td>$324</td>
</tr>
</tbody>
</table>


### Table 13 • POTENTIAL FISCAL IMPACTS TO GREATER PHILADELPHIA

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Greater Philadelphia Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Wage/EIT tax (aggregate @ 1.5%)</td>
<td>$4.2</td>
</tr>
<tr>
<td>Local Sales tax for Philadelphia portion (@ 2%)</td>
<td>$0.2</td>
</tr>
<tr>
<td>Total Fiscal Impact ($M)</td>
<td>$4.4</td>
</tr>
</tbody>
</table>

INDUSTRIAL LAND AND INFRASTRUCTURE IN THE GREATER PHILADELPHIA REGION

As outlined in the Economic Benefits of Developing the Energy Hub section, the region’s greatest potential for economic gain from pipeline infrastructure development will come from the build out of industries that are heavy energy-users. These industries, that use large amounts of natural gas and process liquids, often require transportation infrastructure nearby to meet their shipping or transport needs to get their products to market. The Greater Philadelphia region boasts numerous available industrial land sites and redevelopment parcels that are close to the required transportation infrastructure, and are ready for immediate development.

A number of these sites are in industrial parks, some have existing manufacturing operations and others are idled heavy-industrial sites. Many of these properties are in close proximity to rail-service by Class 1 freight railroads, CSX and Norfolk Southern, and have the required electric, gas, water and sewer infrastructure in place. These industrial areas tend to be clustered along or near the Delaware River with excellent access to strategic transportation infrastructure along interstate highways I-95, I-76, I-295, I-495 and the PA and NJ Turnpikes.

Additionally, the Greater Philadelphia region has strategic access to key export markets in Europe and other markets via its shipping ports. The Delaware River’s 45-foot channel deepening project will be completed in 2017 and will allow the larger, more modern ships to pass through the Panama Canal and to get from Asia to East Coast ports. The Port of Philadelphia has experienced five consecutive years of double-digit cargo growth and is poised for expansion with the development of the 196 acre Southport Terminal currently seeking requests for qualifications.
The Port of Paulsboro in New Jersey is currently being constructed and is the first new marine terminal to be built in South Jersey in the last 50 years. When completed, it is expected to cover 190 acres of waterfront land, with an approximately 3,000 feet wharf. It will provide 1,500 linear feet of deep-water berths and be available for companies to use in shipping a multitude of products down the Delaware River and into the global marketplace.

In November 2015, recognizing the growth and development of the region’s port infrastructure and availability of land and major distribution centers nearby, CBRE identified Greater Philadelphia as one of the top 20 emerging global logistics hubs, one of only 3 U.S. regions to make the list.

The Port of Paulsboro in New Jersey is currently being constructed and is the first new marine terminal to be built in South Jersey in the last 50 years. When completed, it is expected to cover 190 acres of waterfront land, with an approximately 3,000 feet wharf.

In addition to the movement of goods and liquid bulk, the region’s connectivity is heightened by its airport and passenger rail assets. Philadelphia International Airport (PHL), the international hub for American Airlines, is undergoing a substantial Capacity Expansion Plan with more than $2 billion in capital improvements including runway extensions, terminals expansions/renovations and added capacity for its carriers. PHL also serves as the home of a robust United Parcel Service (UPS) hub. There also are eight additional international airports located within a 90-minute drive north and south of Philadelphia increasing the convenience and connectivity for domestic and international travel.

From Philadelphia, Amtrak offers access to New York and Washington, D.C. in approximately 1.5 hours as well as service between international airports in Philadelphia, Baltimore and Newark. Philadelphia is the 3rd busiest Amtrak station in the U.S. Amtrak’s Northeast Corridor is the busiest railroad in North America with 1,700 trains running daily.

The draw to the tristate region for energy-related manufacturing projects also stems from its strategic location in the heart of the largest U.S. mega market — the northeastern U.S. between Boston and Washington D.C. The Greater Philadelphia region is in the center of the largest population concentration in the U.S. with 47 million people located within 200 miles and 40% of the U.S. population within a day’s drive.

Moreover, the region is rich in intellectual human capital with more than 100 colleges and universities training a constant pool of talent with business, management and STEM (Science, technology, engineering and math) degrees. Traditionally a research powerhouse, Greater Philadelphia’s 36 academic research institutions annually rank in the top 10 for federal research grants.

Greater Philadelphia also benefits from a strong presence of the chemical industry in the northeast, including petrochemicals, pharmaceuticals, organic and polymer chemistries. Anchored by worldwide leaders in the chemicals industry — DuPont, Dow Chemical, Honeywell, Ashland, BASF and others; this industry provides key suppliers and/or customers for natural gas related projects.

Over the past three years, the region has seen an increase in interest from site selectors, investment bankers, private equity firms and project developers, eager to learn more about how their individual projects could take advantage of the Greater Philadelphia’s strategic location, existing infrastructure and available industrial land sites located in the 11-county, tristate region.
Industrial Real Estate Sites in the Tristate Region

Described below are seven examples of industrial sites presenting opportunities for manufacturing development due to their size, location, infrastructure and current or former use. Additional industrial land sites of varying sizes are available throughout the region and can be found at SelectGreaterPhiladelphia.com.

Philadelphia Energy Solutions Refining Complex

The Philadelphia Energy Solutions (PES) Refining Complex in South Philadelphia is owned by the private equity fund, The Carlyle Group, a subsidiary of Energy Transfer Partners, L.P., and is the largest oil refinery on the eastern seaboard with a production capacity of over 335,000 BPD. Three unit trains of Bakken crude oil from North Dakota arrive daily. The refining complex produces a wide range of fuels for markets in the northeastern United States, including gasoline, low-sulfur diesel, jet fuel, kerosene, butane, propane, home heating oil and the petrochemical. PES also utilizes ethanol and biodiesel components in its products.

PES currently operates on approximately half of its 1,440 acre site presenting a significant opportunity for new development on the remaining 700+ acres. The site has exceptional infrastructure including access to a natural gas pipeline, dock facility, rail, and I-95 and I-76 highways.

The company is actively seeking development projects, especially those that use natural gas as a feedstock and that are synergistic with its operations. This co-location allows both parties to gain efficiencies by leveraging PES’ exceptional infrastructure and process operations, such as steam or hydrogen, and other byproducts resulting in a more cost-effective opportunity.

Southport Marine Terminal Complex

Philadelphia Regional Port Authority’s (PRPA) Southport Marine Terminal Complex has issued a Request for Qualifications to seek formal development proposals during the first half of 2016 with work to start the following year. The 194-acre complex is located at the eastern tip of the Philadelphia Navy Yard in South Philadelphia and includes three waterfront sites along the Delaware River: the Southport Marine Terminal site (119 acres); Southport West (75 acres); and Pier 124 North Berth, a 1,132-foot finger pier. All are primed for development with state-funded early construction and permitting work.

Approximately $30 million has already been spent on pre-development work. Current infrastructure includes an existing container terminal permit, direct access to the newly deepened Delaware River Main Channel, immediate access to major rail (CSX and Norfolk Southern Intermodal Yards) and road infrastructure (I-95 and I-76).

PRPA is seeking to partner with one or more private developers who will: (1) design and build industrial/commercial revenue-generating facilities on the Southport sites; (2) finance all or substantial portion of the initial capital costs of the project through private equity and debt and use revenues to fund the O&M period; and (3) operate and maintain the facilities (including all lifecycle work) under a long-term leased-based contract.

Marcus Hook Industrial Complex

Sunoco Logistics’ Marcus Hook Industrial Complex (MHIC) in Marcus Hook, PA is an 800 acre site on the banks of the Delaware River near Philadelphia, PA. It is a LPG, refined products and crude terminal as well as a fully functioning process complex. There are approximately 2 million barrels of NGLs storage capacity in underground caverns, and approximately 3 million barrels of refrigerated above ground NGLs storage capacity with Mariner East 1 and 2.

MHIC is becoming a world-class NGLs energy hub. The Mariner East 1 and 2 pipeline projects deliver NGLs from the Marcellus/Utica region in Western Pennsylvania, West Virginia and Eastern Ohio to the MHIC. Mariner East 1 commenced initial operations in the fourth quarter 2014 and now delivers 70,000 BPD of NGLs. Mariner East 2 is expected to commence operations in early 2017 and expand total takeaway capacity to 345,000 BPD. This should eventually grow to 700,000 BPD when Mariner East 3 comes online.

The facility can receive NGLs via marine vessel, pipeline, truck and rail, and can deliver via marine vessel, pipeline and truck. In addition to providing NGLs storage and terminal services to both affiliates and third-party customers, MHIC also provides its customers with the use of industrial space and equipment at the facility, as well as logistical, utility and infrastructure services.

The terminal has the capability to receive, store, blend, and distribute: crude oil, gasoline, gasoline components, Naphtha, ULSD, jet fuel, and has the capability to distribute chemicals. The docks match the Delaware River capacity with drafts up to 40 feet and can accommodate vessels as large as a VLCC tanker.

With its significant infrastructure and renewed availability of land due to the dismantling of older operations, opportunities exist for new development projects to take advantage of the propane, ethane and butane, similar to Braskem’s polypropylene plant located at MHIC.

Keystone Industrial Port Complex

The Keystone Industrial Port Complex (KIPC) in Fairless Hill, PA is a 2,400 acres site primarily owned and operated by United States Steel Corporation (U.S. Steel) which still operates a small steel galvanizing operation on site. U.S. Steel currently
EAGLE POINT
The Sunoco Logistics Eagle Point terminal, located in Westville, NJ on 1,000 acres on the banks of the Delaware River near Philadelphia, PA is a 6 million barrel refined product and crude oil terminal including a dock facility, a truck rack, pipeline access, gasoline blending manifold, and rail access. The terminal receives, stores, blends, and distributes: crude oil, ethanol, gasoline, gasoline components, Naphtha, ULSD, heating oil, jet fuel, distillate components, and vacuum gas oil, and have the capability to distribute chemicals. The docks match the Delaware River capacity with drafts up to 40 feet and can accommodate vessels as large as a typical Suezmax tanker.

The rail capabilities at Eagle Point can off-load 66 cars per day by utilizing 22 off-load positions or a unit train every 2 days. The terminal’s off-loading capacity continues to be expanded. In addition, the site has crude barge capacity outbound and can supply the following refineries: Philadelphia Energy Solutions (Philadelphia), PBF (Delaware City, DE and Paulsboro, NJ), Monroe Energy (Trainer, PA) and Phillips 66 (Bayway, NJ).

Sunoco Logistics is continually upgrading the terminal’s infrastructure and operational flexibility to meet market needs. This site presents potential opportunities to leverage Sunoco Logistics’ terminal and storage capacity.

EDGEMOOR ON THE DELAWARE
The 112 acre industrial parcel is a prime redevelopment opportunity located on the banks of the Delaware River north of the City of Wilmington, Delaware in the Edgemoor section of New Castle County. It is a recently idled chemical manufacturing facility where Chemours, a global chemical company, produced titanium dioxide (TiO2) announced its closing in August 2015.

The site which is surrounded by industrial, power generation, commercial and waterfront uses, is zoned heavy industrial with access to I-95 access, including a dedicated highway exit, a Norfolk Southern rail line with close proximity to Edgemoor yard, and close to the Port of Wilmington.

The property features a number of industrial assets and substantial infrastructure that may be of value to future users. The decision to decommission and dismantle these assets will be made based upon market interest. On-site heating system includes two (2) Clever Brook Water D-Class Boilers which were installed three years ago. The 300,000 lb. saturated steam system is powered by natural gas. An on-site wastewater treatment system with a 5.2 million gallon per day capacity is used to treat process discharge and storm water. An above ground pipe bridge supports the distribution of process chemicals and materials through an above-ground-piping network.

The property is served by natural gas provided by Delmarva Power, nitrogen is currently supplied to the property through a direct feed line from Claymont, Delaware and maintains a Department of Natural Resources and Environmental Control (DNREC) Allocation Permit and a Delaware River Basin Commission (DRBC) Withdrawal Docket that allows a 14.4 million gallon per day draw from the Delaware River.

FIRST STATE CROSSING
First State Crossing is the former Evraz Steel Mill in Claymont, Delaware on a 425-acre waterfront property now being redeveloped. The concept plan envisions a mix of uses to capture the value created by the highways (I-95 and I-495), railroads, and Delaware River. Proposed uses include “First State Corporate Center” offices on the high profile northern gateway; “First State Employment Center” with research, office, manufacturing, and warehouse users in the center area; “First State Transit Center” for rail, bus, auto, bike, and pedestrians to serve existing and stimulate new development; and “First State Logistics Center” for multi-modal truck, rail, and river users. A total of 58 acres will focus on manufacturing, warehouse, and logistics uses.

For nearly a century, this property was home to steel manufacturing operations for rail, infrastructure and other industrial applications. In 2007, the property was acquired and operated by Evraz Steel until it closed in 2013. The owners, a brownfield redevelopment company, have been actively engaged in environmental remediation to prepare the site for the First State Crossing redevelopment plan. The expected timeline to complete environmental remediation is 2 years and the First State Crossing redevelopment plan can begin during remedial activities.

Additional industrial land sites of varying sizes are available throughout the region and can be found at SelectGreaterPhiladelphia.com.
The impact of shale development, of transporting the hydrocarbons, and of increasing consumption of natural gas and NGLs in the Greater Philadelphia region can all be done in an environmentally-responsible fashion. Pennsylvania has developed a nationally-recognized oil and gas environmental protection program for both the upstream production and midstream product delivery process to ensure safe and protective delivery of hydrocarbons in the Commonwealth and into other states. Both New Jersey and Delaware have environmental regulators that have also developed environmental protection programs and rules to ensure that infrastructure build out does not have any deleterious impact on their communities. This section of the report will highlight the environmental regulations that the upstream and midstream industry participants must comply with and the best practices they employ to ensure the environment is protected.
Upstream Natural Gas Market: Managing the Impact of Drilling and Methane Emissions

The unconventional wells drilled within Pennsylvania have drastically increased the availability of natural gas the Greater Philadelphia region. According to Pennsylvania Department of Environmental Protection (PA DEP) reports, the issuance of new well permits reached a peak in 2008 at nearly 9,000 permits per year (both unconventional shale wells and conventional production wells). The state records show the 1,207 unconventional wells were drilled in 2013 and 1,372 unconventional wells were drilled in 2014. It is noteworthy that the unconventional well gas recovery figures are significant — up to 3 Tcf in natural gas in 2013 and 4 Tcf in 2014.60

The two areas the public has voiced the most concern about unconventional well drilling are: (1) impacts to water and sensitive areas, and (2) emissions of methane gas at the well head. Ground and surface water protection starts with a robust regulatory program governing the proper design, construction and operation of the wells.

Protecting Water and Environmentally Sensitive Areas

In order to ensure these production wells are safely constructed, Pennsylvania has a variety of design, operation and enforcement regulatory programs pertaining directly to the development of natural gas supplies. These standards both at the federal and state level are the principle reason why the EPA was able to conclude in its May 2015 report, entitled Review of Well Operator Files for Hydraulically Fractured Oil and Gas Production Wells: Well Design

Pennsylvania’s Residual Waste regulations are among the most comprehensive and stringent in the nation, yet retain sufficient flexibility and practicality to allow for continued commercial and industrial development. Recently, both the U.S. Environmental Protection Agency (EPA) and the PA DEP have sought to further enhance the environmental protection standards at the well site and at midstream operations. Protection of water resources and more stringent air emission standards at the well head, and on pipelines and compressor stations have been a focal point of the EPA and PA DEP initiatives.

and Construction,61 that robustly regulated and designed wells had multiple levels of protection against any impacts to nearby surface and groundwater resources. In that regard, Pennsylvania has a litany of critical laws that impact well design and operation, with Chapter 78 leading the way. Chapter 78 rules are being revised, and it is anticipated that the new rules will enhance environmental protection and provide the region with one of the strongest and most comprehensive set of regulations in the nation.

Although new Chapter 78 regulations are still being finalized at this time, they address key issues of concern to the public and to well operators. First, there is a uniform setback requirement of 100 feet from the edge of the drilling pad, which creates essential buffer from sensitive resources that could be adversely impacted from daily well-related activities. Secondly, the regulations modify the means by which drillers store and treat wastewater from drilling, retaining a preference for recycling that water, and putting greater restrictions on site storage. The regulation also provides for centralized waste water treatment, and adopts Pennsylvania’s comprehensive Residual Waste program requirements on treatment to better document the processing of this waste material.

Pennsylvania’s Residual Waste regulations are among the most comprehensive and stringent in the nation,62 yet retain sufficient flexibility and practicality to allow for continued commercial and industrial development. In addition, these new standards make it clear that the well operator must disclose any potential impacts to nearby sensitive environmental areas, as well as schools, playgrounds, and water wells. These are well-developed standards to which many other successful industries in Pennsylvania, most notably the solid waste industry, have had to comply with for decades with no meaningful decrease in development.

These new Chapter 78 standards also require that well developers proactively demonstrate noise mitigation techniques during construction activities, which is a permitting element for many other large industrial and commercial projects that need to demonstrate to local communities that they will comply with local noise ordinances.

These new requirements provide the opportunity for the developer to highlight the protectiveness of their systems, and affirmatively demonstrate the safety of their project. Developers will be in a position to provide data that their projects are not negatively impacting the environment by compiling protective data in its application.
Minimizing Methane Emissions at the Well

In April 2015, PA DEP released data regarding its 2013 air emissions inventory of the natural gas industry. The data shows that methane emissions decreased 13% and carbon monoxide emissions decreased by 10% in Pennsylvania since 2012, while natural gas production has increased. This is due to the practice of using green completions to improve emissions at well sites. However, the EPA is ramping up the protective nature of these standards, and while the need for additional regulatory provisions is debatable, the new standards would enhance requirements with respect to:

- Well completions: revising the current New Source Performance Standard (which governs new wells to regulate both methane and VOC emissions from well completions of all hydraulically fractured wells (i.e., gas wells and oil wells));
- Fugitive emissions: proposing standards to reduce methane and VOC emissions from fugitive emission components at well sites and compressor stations;
- Pneumatic pumps and controllers, and compressors: proposing methane and VOC standards;
- Equipment leaks at natural gas processing plants: proposing to add new methane standards.

Both water and emissions issues at the point of natural gas extraction have been comprehensively addressed at both the federal and state level. Ultimately, a careful review of the EPA Report discloses that there are in fact no widespread impacts to water as a result of unconventional drilling, and nothing in the new air regulations refutes the industries achievements in already dramatically reducing methane emissions.

As noted by information from the U.S. Energy Information Agency and the EPA (as reported in the Wall Street Journal):

Since 2005, domestic oil production has nearly doubled and natural-gas production has risen by about 50%, according to the U.S. Energy Information Administration. Methane emissions from the sector dropped roughly 15% between 2005 through 2012, according to EPA data, but the agency estimates that these emissions will rise 25% over the next decade if steps aren’t taken to reduce them.

In short, these new regulatory programs protect the public for many years to come while acknowledging a remarkable decrease in methane emissions in the face of drastic increases in the production market.

The data shows that methane emissions decreased 13% and carbon monoxide emissions decreased by 10% in Pennsylvania since 2012, while natural gas production has increased.

Midstream Pipeline Market:
Bringing Natural Gas to Market

Between the upstream well sites and the energy consumer lies the midstream market dedicated to delivering natural gas and its products to market through a carefully engineered network of interconnected pipelines. Depending upon whether the contents are liquid or gas, the transmission line will have a series of pumping or compressor stations to keep the materials flowing and at a uniform pressure. These pipelines typically end at a storage facility, such as a cavern (storing gas in an underground cave-like formation), liquid natural gas tanks, and/or former oil and gas reservoirs. Public concerns surrounding midstream projects include the impacts caused by large rights of way associated with pipelines, as well as pipeline leaks and leak detection.

Because of its prime location within the Marcellus/Utica shale formations, Pennsylvania has a strong presence of midstream assets crossing the Commonwealth, both gathering lines as well as the interstate pipelines in which they feed.

The general regulatory programs include:

- **Federal** – Siting and construction of interstate pipelines regulated primarily by the Federal Energy Regulatory Commission (FERC), which will analyze whether the proposed pipeline is economically needed and appropriately routed with all necessary environmental issues identified and addressed. FERC requires that the developer comply with the Endangered Species Act (to protect threatened and endangered plants and wildlife impacted by developments), the National Environmental Policy Act, and document the impacts and decision-making process associated with the need for and location of the pipeline itself. If FERC issues a Certificate of Public Convenience and Necessity, the pipeline developer will receive the power of condemnation.
- **Regional** – a pipeline may also be subject to jurisdiction of regionally-specific bodies established via interstate compact, such as the Delaware River Basin Commission. These entities generally are designated to ensure a project is constructed and operated in a manner that does not impair the water quality within a particular water basin.
- **State** – if an intrastate pipeline transports natural gas or petroleum liquids to the public for compensation it is considered a “public utility,” subject to the jurisdiction of a state utility commission. The pipeline owner will be required to file an application with the utility commission to obtain a certificate of public convenience to provide such service and approval of its rates charged for service. The pipeline owner must also obtain any
other state authorization required to construct and operate a pipeline, such as environmental approvals. In Pennsylvania, the Pennsylvania Public Utility Commission also has jurisdiction to oversee pipeline safety as an agent of the U.S. Department of Transportation.

- **Local** – unless a utility is deemed exempt from local regulation, the pipeline may also be subject to regulation from township or municipalities, such as local zoning and land use requirements.

The most detailed environmental standards for pipeline development are imposed at the state level, which is vested with implementing some of the most important federal standards under both the Clean Air Act (with respect primarily to compressor or pump stations along the route) and Clean Water Act (with respect to pipeline construction and is most focused on the impacts to streams, wetlands and other bodies of water under the Clean Water Act). In Pennsylvania, these pipelines are subject to the full range of state environmental statutes including the Clean Streams Law, which prohibits unpermitted pollutants from entering into waters of the Commonwealth, and implements many of the features of the Clean Water Act.

Pennsylvania also implements other permitting programs under that Act, including under Section 102, its own general permit for erosion and sedimentation, stringent anti-degradation provisions, and comprehensive storm water management. Under Section 105, the Department of Environmental Protection oversees regulation of streams and wetlands crossings.

Developers can adopt certain best management practices to minimize or mitigate these impacts. For examples, maximizing the use of subsurface pipelines removes the physical barriers. Minimizing the width of the pipeline can help mitigate the loss of trees and vegetation, and post-development replanting can carefully replicate the presence of pre-existing species. The loss of trees during development can be offset by re-establishing tree growth post-construction with the use of carefully selected species that do not compromise the subsurface pipeline development. Many of the ongoing pipeline projects are utilizing pre-existing rights of way that are typified by a lack of tree growth, as they have been maintained to prevent damage to pipelines from tree roots.

The construction process brings with it the potential for erosion and stream degradation. These potential impacts can arise from excavation, machinery impacts to streambeds and wetlands, stability issues, and sedimentation releases to fisheries, sensitive waterways and trout streams. The aforementioned Chapter 102 and 105 permitting processes incorporate comprehensive provisions and requirements to minimize and/or eliminate these impacts.

Applicants must carefully describe tree and vegetation removal practices, stream bank stability measures, and methods to reduce or eliminate the potential for sedimentation release. Machinery impacts can be substantially reduced by using tree mats that absorb and distribute the weight of heavy equipment, and substantially eliminate the direct contact between the equipment wheels and sediment. Aesthetic impacts can also be largely eliminated by carefully evaluating the setting in question, and mimicking the natural surrounding environment.

Wetland and stream impacts can be strategically mitigated by the use of horizontal directional drilling. Especially with respect to wetlands, a careful inventory of pre-existing vegetation and wildlife can be of great assistance in post-construction reconstruction of these ecosystems, and midstream developers are frequently required to ensure the efficacy of wetlands re-establishment. Wetlands can also be carefully identified and mapped to maximize the developer’s opportunities to bypass such features, or to ensure that construction does not interfere with important breeding seasons.
Along the pipeline route itself the compressor and pump stations may impose both noise and air contaminant emissions. The impacts associated with noise can be mitigated with sufficient buffering from receptors, and more importantly by the use of baffling and dampening technologies to reduce the decibel level emitted by the facility. The emission of volatile organic compounds and oxides of nitrogen, which can in great concentration contribute to smog are carefully permitted under the Pennsylvania Air Pollution Control Act. Emissions from such facilities rarely exceed regional non-attainment zone standards under the Clean Air Act, and therefore typically are subject to more flexible minor source requirements.

All of the permitting processes described above are public in nature and not only can members of the public both review and comment upon the applications themselves, but to the extent a regulatory agency errs in approving a permit, there are very broad rights of third parties to appeal these permits and require more stringent review. Thus, a final best practice is for the regulated party to coordinate carefully with the PA DEP to ensure that decision making is both well documented and reasoned to avoid any environmental impacts.

**Downstream Market: Managing the Build Out of New Manufacturing**

Since the economic performance of many chemical industries is driven primarily by raw material costs, the Greater Philadelphia region possesses a unique opportunity to attract new industrial and manufacturing businesses with its offer of abundant local raw materials.

Of course, certain risks exist when developing any new industrial activity. Risks to the environment must be carefully evaluated and mitigated for the successful development to occur. In most cases, such risks fall into the broad categories of potential air, water and land use impacts. Operations posing such risks are regulated under existing federal, state and local regulations, with a well-established permitting process that involves all stakeholders in identifying and minimizing adverse impacts.

In particular, the Pennsylvania Air Pollution Control Act (which implements the federal Clean Air Act) ensures that before construction commences on any project that proposes any significant amount of air emissions undergo a thorough and publicly vetted analysis of how best to control such impacts. The Pennsylvania Clean Streams Law, and other regulatory standards, govern how such facilities manage their water emissions, storm water runoff and any impacts to sensitive environmental areas, such as streams and wetlands. Moreover, any wastes produced at such facilities are carefully governed by the Commonwealth’s comprehensive solid waste regulations. Pennsylvania also carefully examines the potential impacts to diverse or poor communities to ensure that they are not being disproportionally impacted by industrial facilities.

As a result, new industries and manufacturing concerns will be required to utilize best available control technologies to minimize air emissions in accordance with strict but fair regulatory standards. Similarly, the transportation of NGLs using pipelines, railroads, trucks and waterborne vessels introduces the potential for accidental spills and releases, but well-established rules, regulations and best practices will be required to be employed to ensure the safe handling of these materials to minimize such risks.

As is the case with all industrial and manufacturing operations, refineries have the potential to negatively impact the environment. With respect to air emissions and potential adverse impacts to local air quality, such risks are limited significantly by stringent applicable permitting requirements, ever-improving technology and a regulatory environment that has consistently driven down acceptable concentration limits for regulated substances. Existing facilities are constantly being upgraded to meet these new requirements.

Like most manufacturing plants, refineries also require freshwater intake and water discharge facilities. As with potential impacts from air emissions, these risks are significantly mitigated by an established permitting process, stringent regulations on discharge parameters, and imposed requirements to implement best practices for spill prevention, control and containment, and the implementation of the latest technologies.

Environmental risks to land from refinery operations stem mainly from the potential for accidental releases. Potential release points include pipelines, railcars, and trucks transporting feedstock and products in and out of the refinery. The migration of such releases has been significantly mitigated in recent years by ever-increasing environmental regulatory standards and best management practices. Notably, extensive research data shows that pipelines are in fact the safest mode of transportation for these materials.

Refinery operations in the United States today are some of the most regulated activities in the world, and often work to protect the environment. For instance, the water discharged from refinery cooling systems is often cleaner than the water that comes into the refinery via river intake. Applicable federal and state environmental regulations are stronger in the United States than in many other countries, making American refining better for the overall global environment than refining conducted elsewhere in the world.

As with any manufacturing process, certain risks do exist with the development of LNG and CNG manufacturing plants. Natural gas compression and/or liquefaction must be balanced against the benefits from cleaner emissions associated with the transition from oil based fuels to natural gas, and the associated reduction on NOx and SOx pollution from vehicular emissions. Potential adverse impacts are regulated under existing state and local regulations, with established permitting processes that impose requirements to install best available control technologies and best management practices to limit emissions and reduce the threat of accidental releases and environmental impacts.

Pipelines are a safe and efficient mode of transporting natural gas and NGLs. If properly planned and executed, the environmental benefits associated with natural gas transport and the industries that can use natural gas can contribute to job growth and economic growth while mitigating any environmental risks.
Environmental Best Practices

As with all aspects of all sources of energy, natural gas pipeline developers in the region have adopted certain best management practices (BMPs) to minimize or mitigate environmental impacts. Below you find examples of some of the successful BMPs being employed during midstream development:

- The use of subsurface pipelines to avoid the physical barriers, such as mountains or streams. Minimizing the width of the pipeline can help mitigate the loss of trees and vegetation, and post-development replanting can carefully replicate the presence of pre-existing species.
- Applicants must carefully describe tree and vegetation removal practices, stream bank stability measures, and methods to reduce or eliminate the potential for sedimentation release.
- Machinery impacts can be substantially reduced by using tree mats that absorb and distribute the weight of heavy equipment, and substantially eliminate the direct contact between the equipment wheels and sediment.
- Wetland and stream impacts can be strategically mitigated by the use of horizontal directional drilling. Especially with respect to wetlands, a careful inventory of pre-existing vegetation and wildlife can be of great assistance in post-construction reconstruction of these ecosystems.
- Developers can mitigate noise impacts with baffling and dampening technologies.
- Manage pipelines for shrub cover rather than grass, and create forested linkages at intervals across rights-of-way to facilitate wildlife crossings.
- Avoid crossings of wetland and riparian areas and crossings that bisect movement pathways (e.g., between wetlands), unless the crossing can be implemented with limited and managed disturbance.
- Locate and construct structures crossing intermittent and perennial streams such that they do not decrease channel stability or increase water velocity.
- Avoid dust suppression activities near the ordinary high-water mark of wetlands and waterbodies.
- Design road crossings of streams to allow fish passage and to minimize the generation of sediment.
- Schedule construction in stream courses to avoid critical spawning times.
- Provide proper road drainage and erosion control.
- In wetlands, only the topsoil on the trench line would be removed and segregated before digging and removing the subsoil (double-ditching method). Topsoil removal in wetlands can range between 12–18 inches.
- Install mats in wetlands to support equipment and prevent soil compaction.
- Cut shrubs and trees in the construction area at grade level to leave the root systems intact.
- Do not import foreign material into the wetland to stabilize the working area.
ADDRESSING THE CHALLENGES:
How to Take Advantage of the Shale Gas Opportunity

As a part of developing this report, GPEAT conducted a market survey of industry thought leaders to obtain their insights into the economic, regulatory and policy challenges faced when trying to develop additional natural gas and NGLs pipeline capacity. We engaged 16 business and regulatory leaders who provided unvarnished insight into the fundamental challenges that the Greater Philadelphia region faces in expediting pipeline development. They represent upstream natural gas and NGLs producers, midstream natural gas and NGLs pipeline and storage companies, and downstream beneficiaries like petrochemical, energy-intensive manufacturing, electric power generation, local distribution companies, LNG producers, and exporters/shippers of NGLs.
Additionally, these thought leaders were asked what steps needed to be taken to enable infrastructure development across the Commonwealth and throughout the Greater Philadelphia region. Many of the thought leaders reinforced the market requirement that natural gas pipelines are not built “on spec” but rather require sufficient long-term downstream demand, multiple downstream options and positive pricing signals to warrant an investment of billions of dollars in pipeline development and construction costs. Conversely, downstream purchasers of natural gas and NGLs reinforced the market requirement that predictable access to long-term supplies of competitively priced natural gas and NGLs is necessary before an energy-intensive manufacturer will invest billions of dollars in a new facility in our region. One does not get built without the other.

In addition to these market dynamics, participants identified state and federal regulatory requirements, permitting delays and insufficient state economic incentives as major impediments to further the development of an Energy Hub in the Greater Philadelphia region. Moreover, developing natural gas pipeline capacity in densely populated urban settings requires increased cooperation with local government and the affected communities; consequently, an ongoing dialogue between industry and government will be necessary to fully develop an Energy Hub in the Greater Philadelphia region.

Below are some of the suggested strategies to enable this region to leverage its position to be the nation’s next Energy Hub:

**One of the barriers to developing additional pipeline capacity is the need to have additional demand in the downstream market.** **Attracting more energy-intensive manufacturing, more gas-fired electric generation and more liquids processing facilities to southeastern Pennsylvania, southern New Jersey and northern Delaware would increase the demand for gas in the region.**

Our region is competing with the Gulf Coast and other industrial centers across the southern tier of the United States. If the three states in the Greater Philadelphia region work together to create an Energy Hub, thousands of new jobs and billions of dollars in economic activity will be created. To attract new manufacturing companies that use a lot of energy, state governments should consider providing more economic incentives.

A stable demand, the potential for load growth and multiple users of significant quantities of gas, all act as beacons for pipelines aiming to connect producers to markets. There needs to be a focus on attracting energy-intensive manufacturing industries like chemical, petrochemical and energy-intensive manufacturing to develop the downstream demand. If state governments can focus their efforts on building a demand-center in the tristate region, then the upstream markets in the Marcellus/Utica regions could increase output, midstream build out could be accelerated, and downstream energy-intensive manufacturing companies could locate in the tristate area and stimulate the economy.
Provide incentives for investment in midstream infrastructure development.

State and local governments should consider providing incentives to improve natural gas transportation, storage and distribution infrastructure. Much like the distribution system improvement charges that exist today for local natural gas distribution companies, Pennsylvania, New Jersey and Delaware could provide a broader system improvement charge. Encouraging the industry to invest in new pipelines and in new distribution system infrastructure improves safety and provides additional capacity for increased volumes of gas.

Expand the funding to the United States Department of Energy’s Clean Cities Program and the states’ natural gas vehicle (NGV) grant programs to accelerate the conversion of fleets to natural gas vehicles.

Many state governments are now providing grants to convert transit buses, school buses, airport vehicles, government agency vehicles, carpooling vans, taxis and fleets from gas and diesel to NGVs. NGVs significantly reduce greenhouse gas (GHG) emissions and other smog producing emissions when compared to similar gasoline and diesel powered vehicles. Not only is natural gas comparatively less expensive than diesel but it is the cleanest burning commercially available fuel for mobile sources today. Reducing greenhouse gas emissions will improve air quality and the health of our citizens in communities throughout the region. Funding for these initiatives can support fleet conversions and provide for more fueling stations.

Streamline and expedite the permitting process for pipeline construction and enhancement projects.

As described in this report, new pipeline projects require federal, regional, state and local regulatory reviews. All of the permitting reviews are public in nature and provide for the communities that are impacted to review and comment on the pipeline proposals. The industry believes these reviews are in the public interest; however, the time it takes to get through the numerous approval processes presents financial and business risks to the developers. To facilitate a more seamless and streamlined process to support or deny a pipeline project proposal, it may be prudent to appoint a single-point of contact in one of the state agencies to ensure the permitting processes are integrated and the pipeline projects are able to meet their respective deadlines.

Encourage innovative financing arrangements that involve multiple stakeholders in Greater Philadelphia region to share in the development costs (and share in the risks) to get pipeline infrastructure built.

In other regions of the U.S., shale gas producers are sharing in the capacity requirement to get the pipeline constructed. Producers are willing to commit drilling and transportation resources when they can be assured that most of the capacity on a new pipeline has firm commitments for ten (10) to twenty (20) years. To further the effort to create a demand-center in the Greater Philadelphia area, we will need a diversity of end-users and potentially some producers to contract for long-term gas supply. Producers cannot finance the entire infrastructure needed to get their product to market but multiple stakeholders in the region can share in the development costs (and risks) to get the infrastructure built.

Downstream developers should consider taking advantage of the current — unusually low price forecasts for natural gas to secure long-term supply contracts and support the construction of transport and distribution infrastructure.

Producers believe that while periods of low prices may make infrastructure investment challenging, the low natural gas price forecasts may incent longer-term contracts to supply and support the build out of infrastructure. From the midstream developer’s perspective, customers that can commit to a long-term supply arrangement for natural gas or NGLs are an important element in shaping where pipelines will be constructed.

Continue to explore natural gas-fired power generation to increase demand for natural gas.

Natural gas-fired power generation will significantly increase the demand for the fuel in the Greater Philadelphia region. With the introduction of the EPA’s Clean Power Plan regulations and the on-going environmental efforts to reduce carbon emissions by converting existing oil and coal plants to gas-fired generation, real opportunity exists for increased gas consumption and for new gas pipeline capacity. As oil and coal plants in the Greater Philadelphia region retire, new gas-fired power plants will replace them and require more natural gas to be consumed in the region.

The successful development of a 21st century Energy Hub will take support from a broad section of government, community and private sector leaders. In addition to the steps we have listed above, we will need to engage leaders from across the region to mobilize and put their full support behind this strategy. Imagine the Greater Philadelphia region as a place that companies from around the world seek out because we have taken advantage of the low-cost and abundant natural gas resources within our Commonwealth and are being transported to the region to fuel manufacturing, transportation and many other facilities. There is so much to appreciate about this area and now is the time to shine the world’s spotlight on Greater Philadelphia because we have built the Energy Hub of the 21st century.
Regulatory Process to Enable Natural Gas Pipeline Development

INTERSTATE GAS PIPELINES – FEDERAL ENERGY REGULATORY COMMISSION

Under Section 7(c) of the Natural Gas Act of 1938 (NGA), the Federal Energy Regulatory Commission (FERC) is authorized to issue certificates of “public convenience and necessity” for “the construction or extension of any facilities... for the transportation in interstate commerce of natural gas.” Thus, entities seeking to build interstate natural gas pipelines must first obtain certificates of public convenience and necessity from FERC. FERC’s regulatory process for interstate (i.e., located between two or more states) gas pipeline certification consists of several steps, which may vary somewhat depending upon whether a pipeline developer elects to use a voluntary “pre-filing” process with FERC before formally applying for a pipeline certificate.

PRE-FILING AND ENVIRONMENTAL REVIEW

Prior to applying to FERC for a certificate of public convenience and necessity, pipeline developers may file a request with FERC to use its pre-filing procedures. FERC established the pre-filing process to encourage the pipeline industry to engage with the public and relevant government agencies as early as possible in the development of interstate pipeline projects. Through this process a developer notifies all stakeholders — including state, local, and other federal agencies, and potentially affected property owners — about a proposed project so that the developer and FERC staff can hear stakeholder’s concerns about a proposed project. The pipeline developer can then attempt to incorporate proposed environmental mitigation measures into the project design, taking into account the input from the various stakeholders. The goal of the pre-filing is to improve a developer’s proposal, hopefully avoiding mitigating problems during the subsequent formal review of FERC certificate application.

The pre-filing process involves a set of specific activities by the developer, including studying potential project sites, identifying stakeholders, and holding an open house for stakeholders to discuss the project. At the conclusion of pre-filing, the developer conducts pipeline route studies and field surveys to develop a final application and submit it to FERC. Concurrent with the developer’s activities, FERC staff participate in the open house and publish in the Federal Register a Notice of Intent for Preparation of an Environmental Assessment or an Environmental Impact Statement in accordance with the regulations at 40 CFR §1508.22, opening a scoping period to seek public comments. During this period, FERC consults with interested stakeholders, including government agencies, and also holds public scoping meetings and site visits in the proposed project area.

Although the pre-filing process precedes the filing of the formal certificate application with FERC, it is, nonetheless, part of the regulatory process and requires a written request to FERC’s Office of Energy Projects. Pipeline developers wishing to begin the pre-filing process must do so seven to eight months prior to filing a certificate application. If FERC approves pre-filing, it will issue to the developer a pre-filing docket number establishing an official public record associated with the proposed pipeline project.
APPLICATION FOR FERC CERTIFICATE

To formally initiate the interstate pipeline siting process, a pipeline developer formally files an application with FERC for a certificate of public convenience and necessity. Among other requirements, the application must contain a description of the proposed pipeline, route maps, construction plans, schedules, and a list of other statutory and regulatory requirements, such as permits needed from other agencies. The application must also include environmental reports analyzing route alternatives and studies of potential environmental impacts (e.g., on water, plants, and wildlife), cultural resources, socioeconomics, soils, geology, aesthetic resources, and land use. Upon receiving an application, FERC issues a public Notice of Application for authorization to construct and operate a new pipeline in the Federal Register and begins the formal application review process.

FERC’s decision whether to grant or deny a pipeline certificate is based upon its determination whether the pipeline project would be in the public interest. FERC considers several factors, including a project’s potential impact on pipeline competition, the possibility of overbuilding, subsidization by existing customers, potential environmental impacts, avoiding the unnecessary use of eminent domain, and other considerations. FERC may also take into account safety concerns, but generally defers to the Department of Transportation, which has primary authority to regulate pipeline safety under the Natural Gas Pipeline Safety Act of 1968 and subsequent acts. Of the factors above, environmental review typically comprises the bulk of FERC’s review.

ENVIRONMENTAL REVIEW

Among other factors, FERC’s review of certificate applications requires examination of environmental impacts of the action in compliance with the National Environmental Policy Act (NEPA) and associated regulations promulgated by the Council of Environmental Quality (CEQ). NEPA requires federal agencies to consider the potential environmental impacts of an action (e.g., granting a pipeline certificate) and to inform the public of those potential impacts before proceeding with that action. The Energy Policy Act of 2005 (P.L. 109-58, EPAct) designates FERC as the lead agency for coordinating NEPA compliance and “all applicable Federal authorizations” in reviewing pipeline certificate applications (§313(b)).

If the pipeline applicant did not pre-file, FERC begins the environmental review process by publishing a Notice of Intent for Preparation of an Environmental Assessment or an Environmental Impact Statement. In reviewing environmental impacts associated with a pipeline project, FERC typically prepares an environmental assessment (EA), which is “a concise public document” intended to “briefly provide sufficient evidence and analysis” to determine whether a finding of no significant impact can be issued. If the EA determines impacts are significant, a more extensive and detailed environmental impact statement (EIS) must be prepared. If FERC determines a project falls within a category of activities that has already been found to have no significant environmental impact, FERC may classify it as a “categorical exclusion.” For example, one of FERC’s categorical exclusions allows certain pipeline construction and modification projects under “blanket” certificate applications and prior notice filings. As such, they are categorically excluded from the requirement to prepare an EIS or EA.

When an EIS is required, it is generally prepared in two stages: a draft and final EIS. Among other requirements, the EIS must include a statement of the purpose and need for the proposed project, a description of all reasonable alternatives to meet that purpose and need, a description of the environment that would be affected by those alternatives, and an analysis of the direct and indirect effects of the alternatives, including cumulative impacts. In preparing an EIS, FERC is the “lead agency” required to obtain input from other...
“cooperating agencies” with jurisdiction by law or with special expertise regarding any environmental impact associated with the project.79 Cooperating agencies for a pipeline project often include the Environmental Protection Agency; the Department of Transportation’s Pipeline and Hazardous Materials Safety Administration; the Department of the Interior’s Bureau of Land Management, Fish and Wildlife Service, and National Park Service; and the Army Corps of Engineers, among others.

After FERC staff completes its environmental analysis and completes consultations with cooperating agencies regarding a certificate application, FERC issues a draft EIS that will include its initial recommendations for approval or denial of the pipeline certificate. Issuance of the draft EIS also begins a public comment period of at least 45 days, during which FERC will hold public meetings in the proposed project area. Notice of the availability of the draft EIS for public comment and the times and locations of public meetings are published in the Federal Register.

Although FERC considers all public comments in its application review, filing comments does not make a commenter a party to the certificate proceeding. Only intervenors to the proceeding have the right to file briefs, attend hearings, and appeal FERC’s decision regarding the certificate. Intervenors may also challenge final commission actions in the U.S. Circuit Courts of Appeal. Any person seeking to become a party to the proceeding must file a motion to intervene under FERC’s rules.82 Intervenors receive the certificate applicant’s filings and other FERC documents related to the case, as well as materials filed by other interested parties.

After the end of the public comment period for the draft EIS, FERC reviews the comments it received and revises its draft EIS as necessary in response to comments. When these revisions are completed, FERC issues a final environmental statement with final recommendations for approval or denial of the certificate. Under NEPA, a final agency record of decision—in this context a FERC order—cannot be issued until at least 30 days after FERC publishes a notice of availability of the final EIS.83 However, there is no additional opportunity for public comment after the final EIS is issued. After the 30-day period is over, the FERC may issue an order approving or denying the pipeline certificate application.

**FINAL FERC ACTION ON CERTIFICATE**

If FERC grants a pipeline certificate, its order will state the terms and conditions of the approval, including the pipeline route that has been authorized, as well as any construction or environmental mitigation measures required for the project. A FERC certificate confers on the developer eminent domain authority.84 Also, federal law preempts any state or local law that duplicates or obstructs that federal law (e.g., siting or zoning) relevant to the interstate pipeline project. A FERC certificate provides a pipeline developer with the authority to secure property rights to lay the pipeline if the developer cannot secure the necessary rights-of-way from landowners through private negotiation. In practice, however, eminent domain authority is considered a last resort and is seldom used by developers.

Although a FERC certificate authorizes a pipeline under the Natural Gas Act, it cannot preempt other federal laws that may apply—such as the Endangered Species Act, the Coastal Zone Management Act, or the Clean Water Act—so any requirements under other federal statutes must still be met by the pipeline developer. These may include, for example, securing authorizations for water crossings from the Army Corps of Engineers, permission to cross federal lands from the Bureau of Land Management, and other federal approvals. A developer must secure these other federal approvals before proceeding with pipeline construction.

**THE SITING OF PUBLIC UTILITY NATURAL GAS PIPELINE FACILITIES**

Unlike interstate pipelines, there is no specific regulatory process or framework administered by the PA PUC for the planning and siting of intrastate public utility pipelines. This is in contrast to the rather detailed regulatory regime established by the PA PUC for the siting and construction of electric high voltage transmission lines.86 Public utilities possess two significant business advantages only associated with entities that have obtained a
certificate of public convenience from the PA PUC. (1) They have the power of eminent domain, and (2) their facilities are exempt from municipal zoning requirements. Natural gas utilities have a further advantage relative to electric public utilities. Under the Business Corporation Law, an electric public utility must obtain PA PUC approval of need for a facility before condemning property for electric overhead facilities. In contrast, a natural gas public utility may pursue condemnation of property without a PA PUC finding of need.

The utility exemption from local zoning is longstanding in Pennsylvania. It is well settled under the law that the PA PUC has exclusive regulatory jurisdiction over the implementation of public utility facilities that overrides local regulation of utility equipment. Reasons cited by the Courts for conferring the exemption from local zoning regulation on utilities include reference to the “twisted and knotted” regulation by a multitude of jurisdictions that would otherwise harm the general public. The statewide authority over public utilities and the exclusive authority over certain utility functions wielded by the PA PUC have been recognized as a legislative preference for state-wide regulation of utility facilities rather than a myriad of local governments with different regulations.

One limited exception to the historic prohibition of zoning public utility facilities is Section 619 of the Municipalities Planning Code. This provision allow for local zoning with respect to the present or proposed situation of a utility “building”. Even here, however, a public utility may obtain relief from this exception and obtain an exemption from the local zoning of buildings if the PA PUC determines that the present or proposed situation of the building is reasonably necessary for the convenience or welfare of the public.

Unlike with respect to the PA PUC’s regulation of electric transmission facilities, there is no existing public utility pipeline siting process that could be applied to new, lengthy intrastate natural gas transmission projects. Non utilities are dependent on meeting local permitting and zoning requirements in each of the municipalities the pipeline will cross, as well as the demands of local property owners. Utilities have an exemption from local zoning and access to condemnation procedures, but they focus on distribution facilities and have geographically limited service territories. Unlike their electric utility counterparts, natural gas utilities do not have access to a single consolidated siting process administered by an entity with state-wide authority within which concerns about the need for the project, route alternatives, impact on the environment and assorted local interests can be examined, evaluated and brought to conclusion with finality. In the absence of such a process, challenges to a proposed multi-county natural gas transmission project can arise in individual contests with landowners, in multiple municipal zoning forums and in multiple state county courts.

**CONDEMNATION PROCEDURE**

Whether or not it is a public utility, a company planning to construct a pipeline will prefer to negotiate private right of way with affected property owners for the speed and efficiency inherent in a mutually acceptable agreement. If re-routing is not feasible and the property owner will not agree to allow the right of way or finds that the offered compensation is inadequate, condemnation may be the only alternative.

Interstate pipelines that have received FERC approval of a proposed interstate pipeline and have access to the federal courts can use either Federal or State condemnation procedures. Once in Federal court, the interstate pipeline condemner can use either the condemnation procedures outlined in Rule 71A of the Federal Rules of Civil Procedure or the applicable state law. In Pennsylvania, the applicable state law for condemnation is Title 26 of the Eminent Domain Code or Section 1511(g) of the Business Corporation Law. Of course a natural gas public utility pursuing condemnation can rely on Pennsylvania state law in state court. In Pennsylvania, the state law governing condemnation is preferred even by interstate pipelines because it allows the condemnation to be perfected by the tendering of “just compensation”, an option not available under the condemnation procedures of the Federal Rules.
BCF: One billion cubic feet of natural gas at standard distribution pressure of 14.73 pounds per square inch and 60° Fahrenheit.

Butane: A hydrocarbon substance consisting of molecules composed of four atoms of carbon and ten atoms of hydrogen, used primarily for blending in high-octane gasoline, for residential and commercial heating and in manufacture of chemicals and synthetic rubber.

Butylene: A hydrocarbon substance consisting of molecules composed of four atoms of carbon and eight atoms of hydrogen, used primarily for blending in high-octane gasoline, for residential and commercial heating and in manufacture of chemicals and synthetic rubber.

Demand: The rate at which natural gas is delivered to or by a system at a given instant or averaged over a designated period, usually expressed in kilowatts or megawatts (electric); Mcfs or MMBrus (natural gas).

Distribution Line: Network-like pipeline that transports natural gas from a transmission line to an end-user’s service line or to other distribution lines. Generally, large pipelines are laid in principal streets, with smaller lateral lines extending along side streets and connected at their ends to form a grid; sometimes lateral lines are brought to a dead end.

Ethane: A hydrocarbon molecule consisting of two carbon atoms and six hydrogen atoms, used as petrochemical feedstock in production of chemicals and plastics, and as a solvent in enhanced oil recovery processes.

Ethylene: A hydrocarbon molecule consisting of two carbon atoms and four hydrogen atoms, used as petrochemical feedstock in production of chemicals and plastics, and as a solvent in enhanced oil recovery processes.

Federal Energy Regulatory Commission (FERC): An independent federal agency that regulates the interstate transmission of natural gas, oil and electricity. FERC also regulates the storage of natural gas and the importation of liquefied natural gas. The commission is composed of up to five sitting commissioners that are appointed by the President and must be confirmed by the Senate. The commission is staffed by economists, engineers, attorneys, policy experts and administrative law judges who analyze filings made by industry participants and advise the commission on its decisions.

Henry Hub: A major pipeline interconnect point located in Louisiana. The Henry Hub is operated by Sabine Pipe Line, LLC and interconnects with 16 separate interstate and intrastate pipelines. The Henry Hub is the designated delivery point for the NYMEX Natural Gas futures contract. The Henry Hub is also a highly liquid trading point, with numerous buyers and sellers of both physical natural gas and financial derivatives. Platts publishes both a monthly and a daily index price for the Henry Hub in Inside FERC and Gas Daily, respectively.

Hydrocarbon: Organic compound made up of carbon and hydrogen atoms. Heavier fossil fuels, such as coal, have a large ratio of carbon to hydrogen, while natural gas (methane) is the lightest hydrocarbon, with one atom of carbon and four atoms of hydrogen (CH₄). Natural gas liquids are heavier than methane but lighter than crude oil. Crude oil is a complex of many hydrocarbons.

Interstate Pipeline: A pipeline located between two or more states

Intrastate Pipeline: A pipeline located within one state

Liquids, Natural Gas (LNG): Those liquid hydrocarbon mixtures that are gases at reservoir temperatures and pressures, but can be recovered by condensation or absorption. Natural gasoline and liquefied petroleum gases fall in this category.

Local Distribution Company (LDC): The entity responsible for receiving natural gas or power from the wholesale transmission system and distributing it to end use customers. LDCs are state-jurisdictional entities whereas most transmission providers are federal jurisdictional. In addition to local delivery of energy, the LDC is typically also responsible for providing metering and billing services.
In the electric power industry, LDCs are often called “Distribution Companies” or “DISCos” for short.

**Marcellus Region:** See Figure 2 within report

**Mcf:** One thousand cubic feet of natural gas, a standard measurement for natural gas

**Mont Belvieu:** The pricing point for North American NGL markets located in Mont Belvieu, TX. Underground storage facility 30 miles east of of Houston

**MW – Megawatt:** A megawatt is a unit of electrical power equal to one million watts. One megawatt of generation capacity can provide enough electricity to power 800 average North American homes.

**Natural Gas:** A naturally occurring mixture of hydrocarbon and non-hydrocarbon gases found in porous geological formations beneath the earth’s surface, often in association with petroleum. The principal constituent is methane, CH4.

**Natural Gas Liquids:** A general term for liquid products separated from natural gas in a gas processing plant. These include propane, butane, ethane and natural gasoline.

**NYMEX - New York Mercantile Exchange:** A major trading exchange for commodities futures and options. The NYMEX is the largest commodity exchange in the world. Natural gas, petroleum products, electric power, coal and precious metals are all traded. NYMEX is owned by the Chicago Mercantile Exchange.

**Petrochemicals:** Organic and in organic compounds and mixtures that include but are not limited to organic chemicals, cyclic intermediates, plastics and resins, synthetic fibers, elastomers, organic dyes, organic pigments, detergents, surface active agents, carbon black, and ammonia.

**Petrochemical feedstocks:** Chemical feedstocks derived from refined or partially refined petroleum fraction, principally for use in the manufacturing of chemicals, synthetic rubber, and a variety of plastics.

**PJM Interconnection:** A regional transmission organization (RTO) that coordinates the generation and transmission of electric power in all or part of the states of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

**Propane:** A hydrocarbon substance consisting of molecules composed of three carbon atoms and eight hydrogen atoms, used primarily in residential and commercial heating and cooling, and as transportation fuel and petrochemical feedstock.

**Propylene:** A hydrocarbon substance consisting of molecules composed of three carbon atoms and six hydrogen atoms, used primarily in residential and commercial heating and cooling, and as a transportation fuel and petrochemical feedstock.

**Refinery:** An installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and oxygenates.

**Regional Transmission Organization (RTO):** An independent governing body that coordinates power generation and transmission within an integrated regional market. The RTO projects the hourly load requirements for the markets it serves, collects bids from generators, and dispatches plants to provide energy, reserve capacity and power regulation services. Based on the bids received, the RTO determines an hourly price for each service. The market-clearing price is charged to all net users of the service and paid to all net suppliers. The RTO also serves as a clearinghouse for payments between generators, utilities and end users.

**Spot Purchases:** A short-term single shipment sale of a commodity, including gas, purchased for delivery within one year, generally on an interruptible or best effort basis. Spot purchases are often made to fulfill a certain portion of energy requirements, to meet unanticipated energy needs, or to take advantage of low prices.

**Transco - Transcontinental Gas Pipeline:** A major interstate natural gas pipeline system that transports natural gas from producing regions along the U.S. gulf coast to major markets in the U.S. Northeast. Transco zone 6 is divided into two distinct markets: zone 6 New York includes New York City delivery points as well as Public Service Electric & Gas in New Jersey; zone 6 Non-New York includes delivery points in New Jersey and eastern Pennsylvania. Transco is owned by The Williams Companies.

**TETCO - Texas Eastern Transmission Pipeline:** A major interstate gas pipeline system that transports natural gas from the Gulf Coast to Northeast United States. Ownership is Spectra Energy Partners, LP and Operator is Spectra Energy. The pipeline is 9,098 miles and capacity is 10.38 billion cubic feet (Bcf/d); approximately 74 Bcf of natural gas storage.

**Transmission (Trunk) Line:** Pipeline transporting natural gas from principal supply areas to distribution centers, large volume customers or other transmission lines. Transmission lines generally have a linear configuration, may be quite large in diameter, operate at relatively high pressure, and traverse long distances.

**Utica Region:** See Figure 2 within report

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**Sources:**

- [https://www.spragueenergy.com/natgas/additional-resources](https://www.spragueenergy.com/natgas/additional-resources)
- [http://www.eia.gov/tools/glossary/index.cfm](http://www.eia.gov/tools/glossary/index.cfm)
End Notes

1. Greater Philadelphia is comprised of 11 counties in 3 states: New Castle County in Delaware, Burlington, Camden, Gloucester, Mercer, and Salem Counties in New Jersey; and Bucks, Chester, Delaware, Montgomery, and Philadelphia counties in Pennsylvania.


3. Company filings with regulatory agencies.


5. PennEast Pipeline Project Economic Impact Analysis p. 3.4, February 9, 2015, Eonsolut Solutions Inc. and Drexel University School of Economics

6. Company filings with regulatory agencies.


10. University of Pennsylvania Professor Mark Alan Hughes, and his co-author Elise Harrington discussing Philadelphia as a next energy hub noted that: “In 1847...[Philadelphia’s] enormous energy infrastructure of mines, coal breakers, railroads, freight yards, and docks helped generate the industrial base that made Philadelphia the ‘workshop of the world’ in the half-century that followed...In 1907, the Atlantic Refinery burned 550,000 tons of coal to produce oil and oil derivatives that accounted for nearly one-fourth of Philadelphia exports, including half the world’s lamp oil.” Hughes, Mark Alan and Elise Harrington, The Philadelphia Inquirer, November 13, 2013.

11. This report treats the generic term “natural gas” as separate commodity markets for (i) dry gas or methane (“natural gas”) and (g) natural gas liquids or (“NGLs”). Our analysis will cover the production (“upstream”), pipeline transportation, treatment and storage (“midstream”) and productive use (“downstream”) of both natural gas and NGLs. NGLs include ethane, propane, butane, isobutene, and pentane. The U.S Energy Information Administration (“EIA”) notes that NGLs are used in nearly all sectors of the economy including as feed stocks for petrochemical plants and electric power generation, burned for space heat and cooking, and blended into vehicle fuel. As a counterpart to recent generally low natural gas prices, high value NGLs continue to provide major economic incentives for producers to drill in the liquids-rich “wet gas” areas of Southwestern Pennsylvania and into Ohio.


14. Drilling activity within Pennsylvania thus far has been concentrated in two general areas of the state: dry Natural Gas production in Bradford, Susquehanna, and Tioga counties in the “Pennsylvania Northern Tier”; and wet gas production in Fayette, Greene, and Washington counties in the “Pennsylvania Southwestern Tier”. The range in distances from the Pennsylvania Northern Tier to the Greater Philadelphia Region approximately totals between 150 miles to 250 miles. The range in distances from the Pennsylvania Southwestern Tier to the Greater Philadelphia Region approximately totals between 280 miles and 345 miles.

15. Table 1, Company websites


17. Quote by English poet Geoffrey Chaucer, Prologue to the Clerk’s Tale, (1395).


24. Company filings with regulatory agencies.


27. Shale Gas: A Game Changer for U.S. Manufacturing, University of Michigan, p. 6 (2014)


37. PJM is a regional transmission organization (“RTO”) that coordinates the movement of wholesale electricity in all or parts of 13 states (including Pennsylvania, New Jersey and Delaware) and the District of Columbia.


40. Base load power sources are electric power stations that can consistently generate the electricity needed to satisfy minimum demand. That demand is called the base load requirement, which is the minimum level of demand on an electric grid over 24 hours.

41. In a combined cycle gas turbine, a gas turbine generator generates electricity and waste heat is used to make steam to generate additional electricity via a steam turbine. In combined cycle mode, the waste heat is recovered in waste heat boilers, and the steam is used to produce additional electricity.

42. www.pjm.com Queued Interconnection Requests by Fuel Type (MW) As of 12/31/15


44. 2014 State of the Market Report for PJM

45. 2014 State of the Market Report for PJM, Section 12, Planning, p. 22

46. 2014 State of the Market Report for PJM, Section 12, Planning, p. 22


49. The amortized cost of the compression equipment, the electricity to operate it, and its maintenance/repair adds between 50 cents per gasoline gallon equivalent and $1.15 per gge to the wholesale price of natural gas to make it available for use as fuel. A third-party vendor would also include a profit margin to arrive at the retail price. Argonne National Laboratory, “Natural Gas Vehicles: Status, Barriers, and Opportunities,” August 2010, p 8.


56. Transit agencies across the country are transitioning to natural gas. Natural gas buses offer environmental and economic advantages over diesel and other alternative fueled buses. Natural gas transit buses have a track record of clean, reliable, and cost-effective service in major metro markets and dozens of small communities. Today, approximately 11,000 natural gas buses operate across the country, and about 35% of new transit buses on order are powered by natural gas. Argonne National Laboratory, “Natural Gas Vehicles: Status, Barriers, and Opportunities,” August 2010, p 8.

57. Southeastern Pennsylvania Transportation Authority Media Release Http://www.septa.org/media/releases/2015/10/22/22.html

58. Econsult Solutions, The Economic Impact of Sunoco Logistics’ Mariner East Projects in Pennsylvania p iii (Executive Summary) (February 5, 2015)


60. https://www.paoilandgasreporting.state.pa.us

61. U.S. Environmental Protection Agency “Review of the Well Operator Files for Hydraulically Fractured Oil and Gas Production Wells: Well Design and Construction


67. FERC is also required to approve the abandonment of gas facilities and services. It has no similar siting authority over oil pipelines or over natural gas pipelines located entirely within a state’s borders not involved in interstate commerce. As noted further below, siting of oil and intrastate (i.e., located within a single state) is regulated by the states.

68. 18 CFR §1572.21.


72. Pipeline safety regulations are covered in Title 49 of the Code of Federal Regulations. In granting pipeline certificates, FERC requires that developers comply with DOT pipeline safety standards for design, construction, operation, and maintenance. For further analysis, see Congressional Research Service Report R41536, Keeping America’s Pipelines Safe and Secure: Key Issues for Congress, by Paul W. Parfomak.

73. 42 U.S.C. § 42321 et seq.

74. 40 CFR §41500-1508.

75. 40 CFR §41508.9.


77. 18 C.F.R. §380.44.

78. 18 C.F.R. §380.44.

79. 40 C.F.R. §41508.

80. 18 C.F.R. §385.214.

81. 40 C.F.R. §1506.10(b)(2).


83. An intrastate pipeline that: 1) did not serve the public, 2) met local zoning/ordination requirements, 3) obtained all state and local environmental permits and approvals, 4) met federal gas pipeline safety standards and requirements, and 5) obtained easements for the entire route of the pipeline without the need for eminent domain, could theoretically operate in Pennsylvania as either a FERC regulated pipeline or a state public utility. Pipelines close enough to the wellhead to be considered “production” related pipelines fall into this category. Gathering lines for the most part are outside FERC jurisdiction and currently are not regulated as state public utilities. However except for the most rural gathering pipelines, they service federal gas safety requirements implemented at the state level. Most transmission gas pipelines in Pennsylvania are either part of a FERC regulated interstate pipeline, owned by a state public utility as part of its distribution system or certified as an intrastate transmission line public utility subject to the jurisdiction of the Pennsylvania Public Utility Commission (“PaPUC”).

84. Both “person” and “corporations” have broad legal definitions under the Public Utility Code, which is the codification of the law under which the PaPUC regulates public utilities. 66 Pa.C.S. § 101 et seq.

85. 53 Pa.C.S. § 102.

86. Both PaPUC regulations and written guidelines in the form of a policy statement govern the siting of electric transmission lines. 52 Pa.Code § 57.71-57.77; 52 Pa.Code § 69.3102-3107.

87. 15 Pa.C.S. § 1511(c).

88. 15 Pa.C.S. § 1511(a).


92. 53 P.S. § 10619.

93. 53 P.S. § 10619.

Map Sources

Figure 3: Upstream Unconventional Production Wells in the Appalachian Basin
- Unconventional well locations obtained from The Pennsylvania Spatial Data Clearinghouse (PASDA) and the National Energy Technology Laboratory (NETL) part of the U.S. Department of Energy (DOE).
- Wet/dry gas line digitized from a map created by Penn State Marcellus Center for Outreach & Research (MCOR).
- Extent of Marcellus and Utica Shale obtained from PASDA.
- Service Layer Credits: Esri, Delorme, GEBCO, NOAA NFDC, and other contributors.

Figure 6: Existing Natural Gas Transmission Pipeline Systems Into or Near the Greater Philadelphia Region
- Existing natural gas transmission pipelines provided by Platts.com.
- Extent of Marcellus and Utica Shale obtained from PASDA.
- Service Layer Credits: Esri, Delorme, GEBCO, NOAA NFDC, and other contributors.

Figure 7: Existing and Proposed Natural Gas Transmission Pipeline Systems Into or Near the Greater Philadelphia Region
- Existing natural gas transmission pipelines provided by Platts.com.
- Proposed pipeline routes digitized from information obtained on the respective pipeline owners’ web pages.
- Extent of Marcellus and Utica Shale obtained from PASDA.
- Service Layer Credits: Esri, Delorme, GEBCO, NOAA NFDC, and other contributors.

Figure 8: Existing and Proposed Natural Gas Liquids Pipeline Systems Into or Near the Greater Philadelphia Region
- Existing natural gas liquids transmission pipelines provided by Platts.com.
- Proposed pipeline routes digitized from information obtained on the respective pipeline owners’ web pages.
- Extent of Marcellus and Utica Shale obtained from PASDA.
- Service Layer Credits: Esri, Delorme, GEBCO, NOAA NFDC, and other contributors.

Figure 10: Existing Electric Power Plants Within the Greater Philadelphia Region
- Electric provider information obtained from U.S. Energy Information Administration (EIA) webpage.
- Extent of Marcellus and Utica Shale obtained from PASDA.
- Service Layer Credits: Esri, Delorme, GEBCO, NOAA NFDC, and other contributors.
**GPEAT Member Companies** *(as of 3/9/16)*

<table>
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