Value Added Opportunities from Natural Gas

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VALUE ADDED OPPORTUNITIES FROM NATURAL GAS

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I. Introduction

Production of natural gas from the Marcellus Shale has lowered the price of natural gas for millions of consumers and greatly increased demand for the commodity. The availability of this resource is transforming markets and will continue to do so. Natural gas is not only a basic commodity. It is also a foundation of numerous value-added products upon which market clusters and economic activity are built. If West Virginia and the broader region, that also includes the similarly extensive Utica Shale, are able to grow regional supply of these value-added products more of the economic benefits of the resource can be retained in the region.

Natural gas and natural gas liquids (NGLs) are used as feedstock for chemical production with the most commonly produced chemicals being methanol, ammonia, and ethylene (Hackworth, Koch and Rezaiyan 1995). The primary constituents of NGLs are propane and ethane which together comprise about 70 percent of all NGLs. Other NGLs are butane, isobutene, pentanes and natural gasoline. Natural gas found to contain methane and NGLs is called "wet" gas. "Dry" gas, on the other hand, is typically at least 95% methane and contains very few NGLs. In West Virginia, wet gas regions are located in the north, primarily in the northern panhandle. Wet gas is "rich" i.e. it has higher energy content than dry gas, with the BTU content measured by gallons of NGLs per thousand cubic feet of gas (National Petroleum Council 2011).

Dry natural gas, or propane processed from NGLs, also has considerable potential for use in transportation and there are multiple initiatives underway in West Virginia and the region to do this. The U.S. Department of Energy (DOE)'s Energy Information Administration considers the transportation sector to have the greatest potential for large-scale substitution of natural gas for petroleum, especially in local fleet vehicles refueled at a central facility.

Marcellus NGLs have garnered much attention due to what is termed "the ethane issue." Ethane is a valuable NGL that has no regional market or infrastructure to deliver it to markets outside of the region. This problem is being alleviated through development of midstream processing and fractionation capacity, although there are very few options to deliver "must recover" ethane that is produced in excess of natural gas pipeline quality standards (Braziel 2011). Marcellus ethane has been shipped out of the region by truck but this is unlikely to be a solution for large volumes.

Propane, butane and natural gasoline already have established markets in the region. The presence of these markets is why much of the existing fractionation capacity only separates these liquids and leaves ethane in the natural gas pipeline stream. The ability to fractionate ethane is currently only a small portion of potential due to the lack of regional demand or takeaway capacity. Separate deethanization facilities are under construction near fractionation plants that could quickly increase the supply of ethane in response to demand. Several firms have made major announcements to build and expand fractionation capacity in the combined Marcellus and Utica region including Williams, Markwest, Chesapeake and Dominion. Some industry analysts expect regional NGL production capacity to triple between 2013 and 2015 (RBN Energy 2012). Given that ethane comprises 50 to 60 percent of the volume of NGLs, the supply of this feedstock will increase considerably.

As supply of ethane grows the potential supply-demand imbalance has spurred extensive discussion of in-region manufacturing opportunities to use ethane as a chemical feedstock. Ironically, pipelines built in the 1920s to ship ethane produced in West Virginia and used in-state

by the chemical industry still exist connecting the Marcellus region with Kanawha County. Although these lines are unlikely to be usable in current condition the right-of-way offers potential for cost savings in project development.

The timing of building and activating NGL production capacity, including separate ethane production capacity, is tied to market conditions. Suppliers evaluate the differential between the price that can be received for natural gas in the region and the price that can be received for ethane as a separate commodity in light of project costs. Construction of NGL separation and fractionation capacity is much quicker than construction of a refinery to be used to crack ethane. Thus, if a cracker were announced there would be ample time to build a supply base.

West Virginia has some of the richest natural gas in the Marcellus region, with liquids comprising nearly nine gallons per thousand cubic feet (mcf) of gas in some areas (Braziel 2011). As the largest component of NGLs by volume, more and more ethane will need to either be recovered as a separate commodity or rejected back into the natural gas pipeline stream. This sets the stage for some potentially very favorable commodity prices in the region. In real dollars, the EIA currently projects industrial natural gas prices to increase by about 1.5 percent per year through 2020 and by about two percent per year through 2040. Nominal natural gas spot prices are projected to be below $5 per mcf on average until sometime between 2020 and 2025. A potentially massive increase in supply of natural gas and NGLs, as represented by production capacity physically capable of becoming available by 2015, could construct an entirely new regional industry based on conversion of these commodities into value-added products.

The development of a broad set of policy alternatives is a key initial step in the formation of a broad and sustainable strategy for maximizing the economic benefits of shale gas in West Virginia. To reap the greatest possible return, this necessarily includes activities beyond drilling, hydraulic fracturing, and cracking. Maximizing the potential yields from the shale gas industry in West Virginia will not occur without significant planning and having forward-looking policies in place in advance of need while providing responsive reaction to opportunities and threats. Policy evaluation and incentive structuring must necessarily balance the development goals of long-term economic growth, infrastructure development and wealth creation with concerns for safety and environmental responsibility.

This document presents information regarding value-added opportunities from natural gas in terms of Manufacturing, Transportation, Electricity Production and a discussion of Policy Considerations.

II. Manufacturing

Methane and NGLs are the building blocks of many products. These raw materials can be manufactured into primary petrochemicals and intermediate products that comprise large shares of the volume and costs of inputs to production for many manufactured goods. Three highly relevant primary petrochemicals upon which numerous chemicals and consumer products are based are methanol (produced from methane), ethylene (produced from ethane) and propylene (produced from propane).

Ethane gets more attention than the other NGLs because it comprises the largest share of the group but is no longer utilized directly in manufacturing processes in the Marcellus region, and thus has no real local market (U.S. EIA 2011). By contrast both propane and butane can be sold in regional marketplaces. Most petrochemical facilities currently capable of utilizing ethane are located along the Gulf Coast of Texas and Louisiana and in Ontario, and there is presently no pipeline infrastructure to efficiently deliver ethane produced in the Marcellus region. Three pipelines have been proposed to serve both of these markets although none are yet operational. An older ethane pipeline built to deliver ethane separated in Wetzel County to chemical manufacturers in the Kanawha County is still in place. However, due to its age and small diameter it would likely require additional investment to be returned to use.

Currently, ethane produced from Marcellus Shale has limited places to go. If it can't be transformed to ethylene in a cracker, whether within or outside of the region, it will go into the natural gas pipeline system as high-btu gas, granted that it does not exceed pipeline restrictions for gas quality that typically require gas not to exceed 1,085 Btu per cubic feet (U.S. EIA 2006). Due to an abundance of wet gas in the region production of ethane is expected to increase steadily over the next several years which will create opportunities for investment.

At expected rates of growth it is believed by some industry analysts that seven new ethane crackers may be needed in North America to take advantage of new supplies of ethane (National Petroleum Council 2011). Where these crackers are located will depend on supply and demand synergies specific to the various NGL producing and consuming areas including not only the Marcellus and Utica region but also the Bakken, Eagle Ford and other shale. Investment will be the result of private sector decision and will be specific to individual firms in the industry. West Virginia and the entire Marcellus region stand to benefit due to resource proximity, but investment decisions will be based on many other supply and demand conditions.

Ethane is not the only NGL that requires cracking to produce a petrochemical. Additional opportunities exist in utilization or production of propane-based products, which are also the foundation of numerous plastics products and polymer materials. Propane supplies have easier access to market compared to ethane however, making utilization of that commodity somewhat less critical in terms of the timeframe for development of capacity in the Marcellus region.

If the West Virginia region were able to retain more of the whole value chain by producing more intermediate or final products from the NGL feedstock instead of exporting the raw materials, more economic value would be retained. This would lead to more employment tied to the resource from clustered economic activity. In economic terms, local sourcing of petrochemical feedstock would increase the regional purchase coefficient for the firm using the materials. The resulting products would be sold in national and global marketplaces.

Other manufacturing-related opportunities due to Marcellus gas are direct fuel savings, including possible large-scale shifts from coal to natural gas in steel production. Several U.S. plants are considering or building facilities that use gas instead of coal to purify iron ore for steel production (Elmquist 2012). This opportunity is simply a matter of taking advantage of the relative price difference between coal and dry gas or between oil and gas. Many discussions of the potential benefits of Marcellus gas do not distinguish between opportunities related to energy and those related to feedstock, although the possible combined benefits of the two are expected by some to amount to one million additional jobs (PricewaterhouseCoopers 2011).

1. Products

The product chain for NGL-based goods is the process of transforming the raw material/feedstock to an intermediate product and eventually to end use product. There are many intermediate products in the petrochemical industry, with many processes requiring multiple intermediate petrochemicals or derivatives as inputs. NGLs are commodities and are traded in national spot markets. Prices for natural gasoline, isobutane, and normal butane more closely track oil prices compared to ethane and propane as they are used in the gasoline refining process (U.S. EIA 2013). Of the five NGLs, ethane is presently the lowest-priced.

The constituents of natural gas liquids are also by-products of, or inputs to, the petroleum refining process. Ethane produced at petroleum refineries is often simply burned along with natural gas as a fuel. Propane is produced during oil refining and may be sold separately or converted into a primary petrochemical such as propylene. Butane is blended with gasoline to meet emissions standards. The volume of NGLs produced from petroleum refineries is expected to be constant through 2035 (National Petroleum Council 2011).

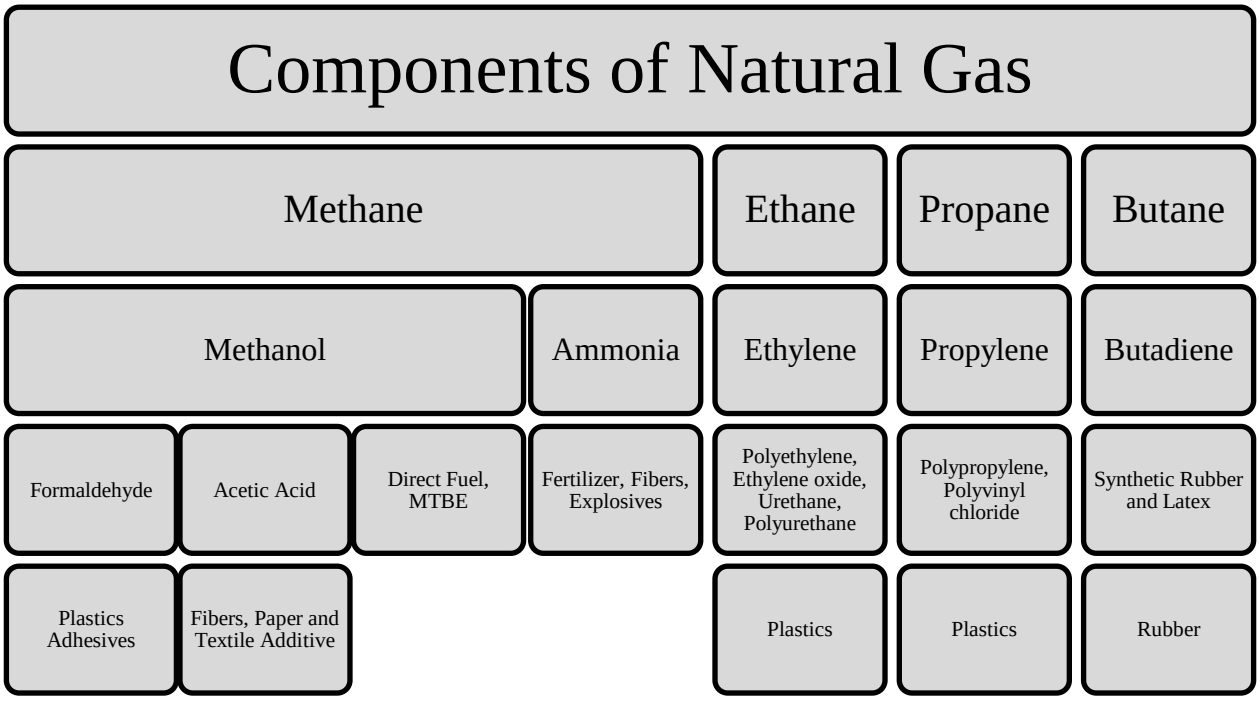
Like commodities, petrochemicals also have regional or near-global pricing. Many intermediate products can be either petroleum-based or natural gas-based and manufacturers can utilize derivatives of both. An example of this is polypropylene (PP), which is expected by some industry analysts to be headed toward global pricing, with North American production playing a larger role due to increased supply of propane and lower propane prices. According to IHS Chemical "use of shale gas has changed the economic profile of PP production and will result in investment in PP production capacity in North America for the first time in a long time," although that investment may not lead to lower product prices in the short-term (Plastics News 2012).

Due to the regional or even global nature of the trade in intermediate products the benefits that may transfer to businesses utilizing intermediate products would not be of the same volume as those that would occur with the spillover effects of a cracker. Actual price reductions will depend on many factors, including supply and demand from outside the U.S., as the region's manufacturers compete in a global market.

The primary or overarching benefit of utilizing the products of natural gas liquids in the region is that more of their economic value is retained. For these industries, the presence of the primary feedstock processor means the presence of other facilities to use the intermediate product, i.e. ethylene, to make another intermediate product. These innate synergies are due largely to the physical volatility of the cracked feedstock. Once cracked, these constituents generally will be

transformed on-site into the form of another intermediate product such as polyethylene, which will eventually become a plastic product, or ethylene oxide which may eventually become a coolant. In the future, transformation of feedstock may be able to skip the cracking step and utilize catalysis instead resulting in a more efficient production process (Hoover 2013).

Table 1: Products from Natural Gas



A. Plastics

Plastics comprise a large subset of products made from natural gas and petroleum feedstock, and there are many different grades of resin used to mold final products. Some of the major volume resin families are polyethylene, polypropylene, polystyrene, polyvinyl chloride and nylon, and are produced by a variety of proprietary processes (Omni Tech International 2010).

Polyethylene (PE) and polypropylene (PP) account for more than 50% of the plastics volume in the United States (Omni Tech 2010). PP is made from propylene which is derived from propane. PE is made from ethylene which is derived from ethane. PP and PE are very transportable products produced in the form of plastic pellets. Many West Virginia manufacturers use PE and PP to produce plastic products for end use markets that include plastic piping, tubing, bottles, bags, packaging and other containers. These firms may be able to obtain PE and PP cheaper than in the past as a result of Marcellus-produced ethane being used in the market. Such cost savings could occur regardless of the location of an ethane cracker being in the region or in the Gulf of Mexico.

The following table shows the number of employees in the U.S. and regional states in key manufacturing industries that use petrochemicals. Also shown is the decline in employment in these industries between 2007 and 2011.

Table 2: Number of Employees in Key Petrochemical-Based Industries

Manufacturing Industry	WV		PA		OH		US	
	2007	2011	2007	2011	2007	2011	2007	2011
Resin, synthetic rubber, and artificial synthetic fibers and filaments	> 2,500	1,844	3,316	3,286	5,754	4,498	96,485	80,219
Plastics & rubber products	3,566	2,732	43,526	35,558	73,651	57,923	848,708	674,690

Ethylene

Current technology employs a two-step process to produce ethylene from ethane. First, ethane is processed using catalytic cracking and hydro-cracking. Then, the product from the first step is thermally cracked with steam, a highly energy intensive process (U.S. DOE 2006). There is research in pursuit of a one-step process to produce ethylene from methane, but this option is not close to being commercially viable at the present time (Black 2012). Approximately 55 to 60 percent of ethylene is used to produce polyethylene, the most common plastic. The outlook for global demand of ethylene is positive, expecting 3.4% growth per year. Global demand for ethylene did experience a downturn in 2008 but it is typically a market that does not experience strong recessionary effects due to use in production of plastic packaging for the stable food industry (IHS 2011).

Propylene

Propylene is a byproduct from the steam cracking of liquid feedstock such as naphtha and liquid petroleum gases, and of off-gases produced in fluid catalytic cracking units in petroleum refineries. Propylene is also produced "on-purpose" via propane dehydrogenation and metathesis to meet demand in excess of that produced as a refinery by-product. Propane dehydrogenation is a relatively high-cost process where propane is converted to propylene at 500-700 degrees Celsius in a reactor containing a noble metal catalyst. Metathesis is the catalytic conversion of ethylene and butene-2 into propylene (ICIS 2010).

B. Chemicals

Nationally, the chemical industry is said to hold the possibility for large-scale switches away from petroleum-based feedstock. Much of the chemical industry produces products based on methane. The advantage of this feedstock is that, compared to ethane, it is readily available. As with the plastics industry, for most chemical manufacturers feedstock accounts for a very high share of total production costs. Establishments could leverage existing access to low-cost natural gas if the cost advantage were believed to be sustainable. It is technically feasible to make most of the crude-based chemicals that are the basics of the industry from natural gas (Roach 2012).

Methanol

Methane, the primary component of natural gas, is converted into synthesis gas, commonly known as syngas, as the first step to methanol and ammonia production. Then, syngas is converted to raw methanol under high pressure at low temperatures using one of several reactor types. The raw methanol is purified by removing water, by-products, and dissolved gases (Aasberg-Petersen, et al.). Formaldehyde is the most common product from methanol, accounting for 27% of worldwide methanol demand. The second largest methanol use is direct fuel applications, accounting for 11% of total methanol. Acetic acid and MTBE (methyl tertiary butyl ether) each account for approximately 10% of worldwide methanol produced (IHS 2011). MTBE production from methanol has decreased continually since 1999 when the U.S. Environmental Protection Agency (EPA) announced that MTBE use could threaten the water supply in the event of leaks, and MTBE is now produced only for export markets (U.S. EPA 1999).

Ammonia

Natural gas is the main input used to produce ammonia (USDA, Economic Research Service 2007). Syngas is cooled slightly and mixed with air and nitrogen in a secondary reformer as the first step to ammonia production. Following the reforming, water, carbon monoxide, and carbon dioxide are removed from the gaseous mixture. The gas mixture is cooled, compressed, and fed into an ammonia synthesis loop where ammonia is removed. Unreacted gases are fed through the loop again at high temperature and pressure with an iron catalyst. This mixture is cooled to allow for easier separation of the liquid ammonia. Finally, any impurities are removed from the liquid ammonia (Copplestone and Kirk). Ammonia's primary use is a feedstock for fertilizers – 80% of worldwide ammonia produced is used for this purpose. Other notable uses of ammonia include 9% for fiber production and 5% for explosives (ammonium nitrate) (Hackworth, Koch and Rezaiyan 1995). The United States is the fourth largest producer of ammonia (USGS 2005).

Fertilizer is a group of chemical products that already uses natural gas as feedstock as much of it is based on ammonia. At the national level manufacturers in this business are evaluating options to increase production in the U.S. to take advantage of low gas prices. A former Sunoco refinery in Philadelphia recently announced that it would restructure its operations, including increased use of natural gas for hydrogen production and potentially add new fertilizer production capacity (Platts 2012). Such investments could reverse increases in imports observed following increases in natural gas prices in the 2000s. These increases caused the share of U.S.-produced ammonia in the U.S. aggregate supply to drop from 80 to 55 percent, while the share from imports increased from 15 percent to 42 percent (USDA, Economic Research Service 2007).

In some countries oil-based naphtha is used to produce fertilizer. Efforts to transfer production away from naphtha to natural gas would allow cost savings for agricultural industries. The U.S. fertilizer industry, producing from a gas-based feedstock, could develop a larger competitive advantage over naphtha-based fertilizers and increase its share of the global market.

2. Opportunities

A revival of manufacturing in the U.S. resulting from access to low-cost NGLs and methane can help reverse job losses in the sector by improving the competitiveness of key industries that rely on petrochemicals. These inputs can reduce overall production costs and allow product expansion and possibly a re-shoring of production capacity that was originally moved out of the U.S. to take advantage of cheap gas and other low-cost inputs to production overseas. The plastics and rubber industry is considered a "tipping point" industry by some market analysts in terms of its ability to re-shore production (Matterhorn Capital Management 2012).

Much emphasis on potential opportunities has focused on an ethane cracker because of the significant spillover effects that would result from locating such a facility in the region. Not only would the facility itself be large and provide jobs and associated business activity but the presence of a cracker would bring about immediate co-location of production capacity for the next-step intermediate petrochemicals that would be made from ethylene. In terms of economic impact, a cracking facility would create the most certain and near-term effects.

Both propylene and ethylene are the foundation of many plastic products that have very stable predicted demand growth. Thus, opportunities also exist to develop a propane cracker for production of propylene for use in production of plastics, although the existing transportation and heating fuel markets for propane as a direct fuel are well-established in the region.

Opportunities also exist for makers and users of downstream NGL-based products but with more uncertain outcomes. Manufacturers who are customers of the intermediate products produced from NGLs may see cost-savings, which would make them more competitive. A partial list of ethane, propane, and butane-based products used by West Virginia manufacturers includes polyethylene, ethylene oxide, urethane, polyurethane, polyvinyl chloride and rubber. These manufacturers use these products to produce an array of other intermediate and final products for businesses and households. Many of the products produced in West Virginia are considered "niche" in that they are largely downstream products tailored to specific manufacturing customers.

Firms are always trying to reduce costs of production by acquiring lower-cost inputs. If a lower-cost supply of domestically-produced intermediate products is made available (enabled by low feedstock prices) that can shorten the supply chain for regional users of those products and lower costs.

Opportunities to take advantage of the low-cost feedstock produced from Marcellus shale are available to both direct users of the feedstock and users of intermediate products. These can be summarized as:

1) Manufacturers in the Marcellus region who can take advantage of proximity to the raw materials produced from the resource. These could be existing facilities that choose to substitute gas for petroleum, or new establishments that select natural gas or NGLs as their feedstock. Construction of an ethane or propane cracker in the region would fall under this type.

2) Manufacturers in the Marcellus region that are users of petrochemicals that may become more competitively priced due to supply of Marcellus gas and its liquids. These opportunities could arise for existing establishments or to new establishments, although the exact nature of the opportunities will be very specific to the individual firms. New establishments may be induced to locate to the region to be closer to their suppliers.
3) Manufacturers in other regions that can import NGLs produced from the Marcellus. The proposed and planned pipeline projects are directed toward both the Gulf of Mexico and Sarnia, Ontario refineries. While supplying these markets would provide an option for producers to get rid of excess ethane, West Virginia and the region would lose the economic benefit of manufacturing value added to the commodity.

A manufacturer will only choose to open a new facility in the Marcellus region if the price advantage of doing so is expected to continue. Global commodity prices will be considered, as ethane produced in the U.S. must be competitive with that produced in other countries (National Petroleum Council 2011).

Specialty chemical products, such as many products made in West Virginia are, can be profitably made further from the source of the raw material. Existing capital investments may be able to leverage experience and know-how and expand production to take advantage of lower-priced inputs to production, such as PP and PE, made outside the region. This would allow the region to benefit in the absence of a cracker, although the impact is likely to be less substantial than upstream NGL processing. Such synergies are very specific to the individual firm and require extensive market analysis. Some manufacturers already have integrated supply chains where they also produce the primary petrochemical from the feedstock, making feedstock switching a whole company decision.

The timing of opportunities from intermediate products may also be much different than for an upstream facility like a cracker. Price trends that signal an investment opportunity for a new or expanded facility may come sooner than the employment benefits of a cracker, which would take four years to build. Such signals would be the result of significant quantities of Marcellus-produced NGLs hitting the market and the following price declines in associated derivatives.

The opportunities associated with investment in small ethane crackers, rather than a large "world-scale" facility is being explored in the region by Aither Chemical. Aither holds a proprietary, scalable technology to crack ethane and convert it into ethylene, ethylene oxide, ethylene glycol, polyethylene and acetic acid (Aither Chemicals 2012). It has been said that small production facilities are more energy efficient and allow for more supply chain resiliency compared to very large plants, implying that reducing the potential impact of supply chain disruption is more important than economy of scale. Others maintain that scale is significant in this industry and that bigger is better for investment value. Appalachian Resins is considering constructing a smaller scale ethane cracking facility in West Virginia with annual production capacity of 500 million pounds of PE and states that the efficiency advantages from cracking ethane compared to propane and petroleum justify the small size (Plastics News 2013).

3. Markets

The ultimate end use market for downstream products of the plastics and chemical industries is global. The market for plastics products is expected to grow steadily. Global polyethylene demand growth is expected to average 4.7 percent from 2012-17 – above average GDP growth - with northeast Asia growing at above-average rates and North America and Europe at below-average rates (Esposito 2012). Major PE end uses are for film/sheet and injection molding, which IHS expects to average 5 percent growth.

According to industry analysts, North America and the Middle East are becoming the two most cost-advantaged producers of polyethylene in a market that has never had two cost-advantaged regions before (Esposito 2012). Thus, siting decisions in the U.S. will be based in part on response to similar decisions being made in the Middle East or weighing the same opportunities in the Middle East.

An important production location issue concerns capacity at facilities in the Gulf of Mexico and Canada. NGL processing capacity along the Gulf Coast as well as to the north in Sarnia, Ontario is currently underutilized (National Petroleum Council 2011). It is frequently stated that this capacity must become more fully utilized before firms in that region will consider significant investments outside of those areas. The American Chemical Council expects initial investment resulting from use of shale gas to be in established chemical and resin production areas in Texas and Louisiana (Plastics News 2012).

As existing production capacity may need to become more fully utilized before significant investments are made in new capacity, some regional opportunities may be realized in the mid-term (> 5 to 10 years) instead of a short-term. The National Petroleum Council expects use of available ethane processing capacity in these regions to be at maximum in about 2017 (National Petroleum Council 2011). At this point in time, additional cracking capacity will be needed.

Access to markets for downstream products, like polyethylene and polypropylene, and to end use markets is another siting issue affecting the timing of an investment decision. The Marcellus region is partially advantaged due to its proximity to the large demand centers of the Northeastern U.S. This proximity allows a transportation cost advantage over some manufacturing locations. The location of NGL capacity combined with proximity to intermediate products and customers of the next intermediate product will shape investment decisions.

Shipping costs are often a critical cost component, whether via rail, truck or barge. Although pricing of many petrochemicals is nearly global, proximity to a domestic market matters also due to transportation cost volatility and reduced risk from a shorter supply chain.

Any decision to invest in expanded or new production capacity is highly strategic and made with extensive analysis of potential risk from a number of factors, not just feedstock prices. Additional risk factors include development costs, the size of local/regional market, access and proximity to market, transportation costs, the availability of skilled labor and other operations-related issues. The demand for the intermediate products of ethylene and propylene in the Marcellus region is currently small. Larger regional demand for these products would need to be

in place prior to a major investment. These factors are important to West Virginia and the broader region being selected for investment.

In summary there are several conditions needed to fully take advantage of the increasing supply of NGLs that apply to any location. The State of West Virginia is taking steps to address these conditions and private industry is actively pursuing the infrastructure opportunities.

1) The prices for natural gas and NGLs must be believed to be sustainable at levels needed to maintain competition.
2) Midstream gas processing and fractionation capacity must increase in order to handle larger volumes of natural gas and separate the liquids. This growth is already occurring in West Virginia, Ohio and Pennsylvania, and can ramp up more quickly than the time required to build new manufacturing plants.
3) The pipeline infrastructure capable of delivering NGLs to market must be expanded or be seen as expandable in the timeframe needed to serve potential users. Several investments in delivery infrastructure are under construction or have been announced in conjunction with processing and fractionation facilities.
4) Industry must have access to a skilled workforce available to maintain an expanded supply infrastructure, produce higher volumes of goods and manage the supply chain.
5) Suitable sites for facility development must be available with access to water and medium-voltage electricity. Firms may also have a need for ethane storage capability, a factor for which the State of West Virginia has provided evaluation assistance due to unique high-pressure requirements.
6) Multi-model transportation infrastructure to deliver final products must be available that meets the needs of the facility over its expected lifetime. Typically, firms desire a combination of rail and highway access.

If these conditions are believed to be in place West Virginia-based firms will be more likely to position to take advantage of demand and supply trends and make the long-term investments that go along with shale-based supply of natural gas liquids. Regional firms and their parent companies are monitoring the global positioning and use of manufacturing capacity, which will determine the extent of any re-shoring investments.

4. Positioning

As a State West Virginia can try to induce new firms to locate in the State or enable firms already located in the State to take advantage of the opportunities presented directly or indirectly by increased supply of feedstock. Although directly incentivizing use of natural gas-based products is not practical when the market produces identical and competing products from both natural gas and petroleum, other actions can help increase the attractiveness of the State to firms in these industries. Efforts to incentivize location of large-scale natural gas-based feedstock production facilities are logical given the numerous spillover effects that would be felt on a regional basis.

West Virginia can focus on modifying practices and policies that improve the cost of doing business in the State. All firms in general look for a labor force that excels in math, science and

engineering, access to transportation infrastructure that will meet the needs of the establishment for its expected life and access to well-located sites for development. Other policies such as options for property or other taxes to be deferred or substituted for other payments are also seen as providing financial flexibility.

Wet gas continues to be found in large volumes in the Marcellus region and will be available for many years. If the region is not able to capitalize fully on the resource in the short-run there may also be longer-run opportunities as the industry develops further following increased feedstock supply, maximizing of existing processing capacity outside of the region and growing final product demand throughout the world.

III. Transportation

1. West Virginia Initiatives

A. Utilization of Natural Gas for Transportation in West Virginia: 1991 to 2004

- Fleet Vehicles: 1,100
- Infrastructure: 31 stations (26 with public access)

West Virginia's interest in natural gas as a vehicle fuel officially began in 1991. One of the first statewide initiatives was an Executive Order establishing a natural gas vehicle (NGV) test program for the State. Subsequent legislation required state and local fleets to convert portions of their fleets to alternative fuels and instructed the Public Service Commission to develop alternative fuel technology demonstration programs (NREL 1998). At the time well-head and interstate natural gas prices were still regulated by the Federal Energy Regulatory Commission (FERC), the New York Mercantile Exchange (NYMEX) did not yet trade natural gas, and natural gas sales were dominated by marketers. For the early part of the initiative, natural gas and oil prices were relatively stable, although from 1997 to 2001 prices diverged with natural gas prices increasing and gasoline prices largely declining. This price divergence was the primary factor that caused local transportation demand for natural gas to drop.

At the federal level, the Energy Policy Act of 1990 had recently been enacted to encourage adoption of alternative fuel vehicles (AFVs). Like the policies of today, incentives did not favor any specific type of AFV, preferring to let the market sort out the winners. In 1997, the State of West Virginia began to allow tax credits to be received for the purchase of AFVs. The failure to meet both federal and state vehicle adoption goals was a factor in the inability to develop permanent demand for natural gas as a vehicle fuel under these early efforts.

The NYMEX began trading natural gas in 1995 (following removal of price controls on natural gas around 1993) displacing much of the need for natural gas marketers and reducing the margins received by marketers. As it is widely believed that the well-head and interstate prices controls that existed prior to this time suppressed natural gas production, it is not surprising that a lifting of these controls resulted in higher commodity prices.

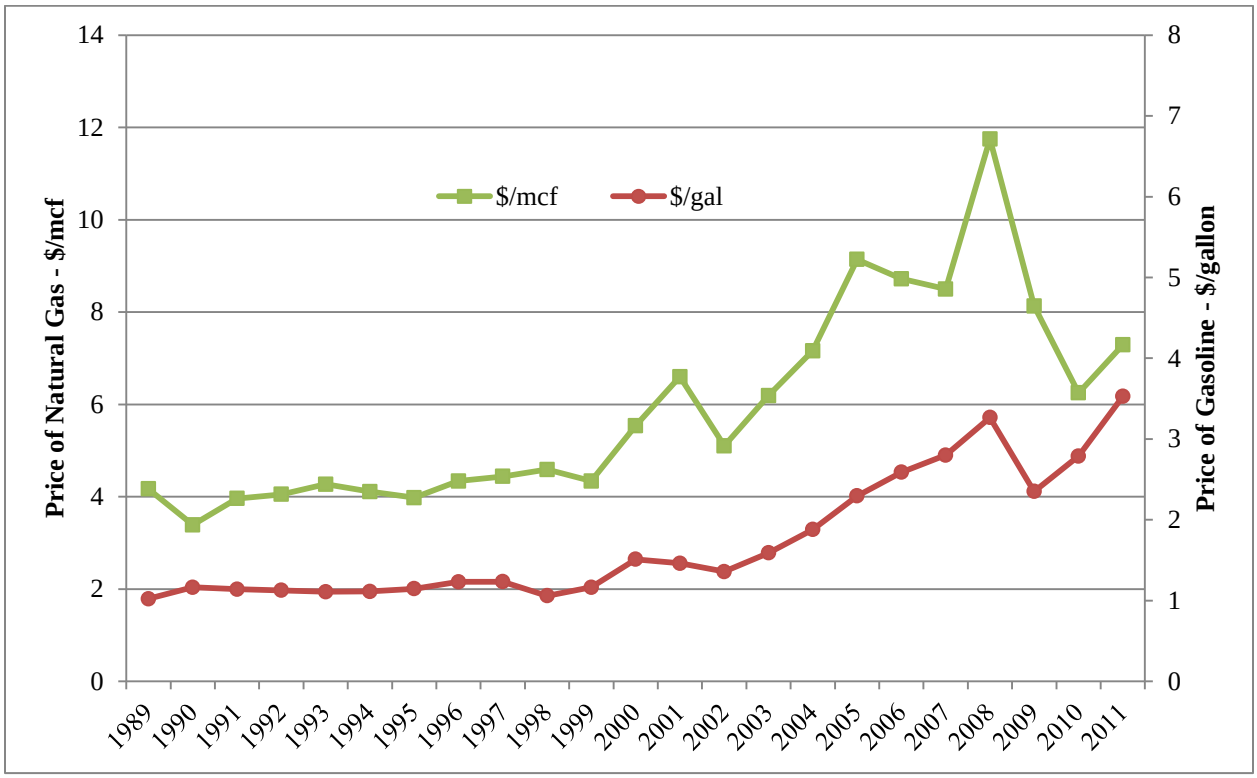
Natural gas fueling infrastructure was developed by four of West Virginia's gas utilities, which were allowed to rate base a combined $11.2 million in infrastructure costs. This allowed multiple natural gas fueling stations to be built without risk to the utilities, and revenues were shared with customers. Some utilities, such as Shenandoah Gas, offered incentives for its customers to build CNG fueling stations (NREL 1998). At the height of the initiative there were about 31 fueling stations installed throughout the State with about 26 of them open for public access.

West Virginia was able to deploy natural gas-capable vehicles by leveraging funding from the U.S. DOE's Clean Cities program, which was used to purchase a number of compressed natural gas (CNG) vehicles. Overall, it is reported that around the year 2000 more than 1,100 dedicated or bi-fuel natural gas vehicles were in use in West Virginia, the large majority being bi-fuel (U.S.

EIA 2012).[1] These included vehicles within state fleets as well as the fleets of several utilities, West Virginia University, and local governments and school districts. At the time, more than 80 percent of Hope Gas's corporate fleet was capable of running on natural gas. Some utilities, including Hope, offered technical assistance for converting vehicles to run on natural gas.

Beginning around 1997, falling gasoline prices[2] combined with already rising natural gas prices caused demand for natural gas as a vehicle fuel to decline, and pipeline customers became more lucrative for gas suppliers. For the previous ten years natural gas and gasoline prices had maintained a fairly stable relationship, but the relative prices trended largely in opposite directions until 2001. These price conditions are considered to be the primary reason for the failure of the earlier adoption efforts.

Figure 1: Gasoline and Natural Gas Price Trends

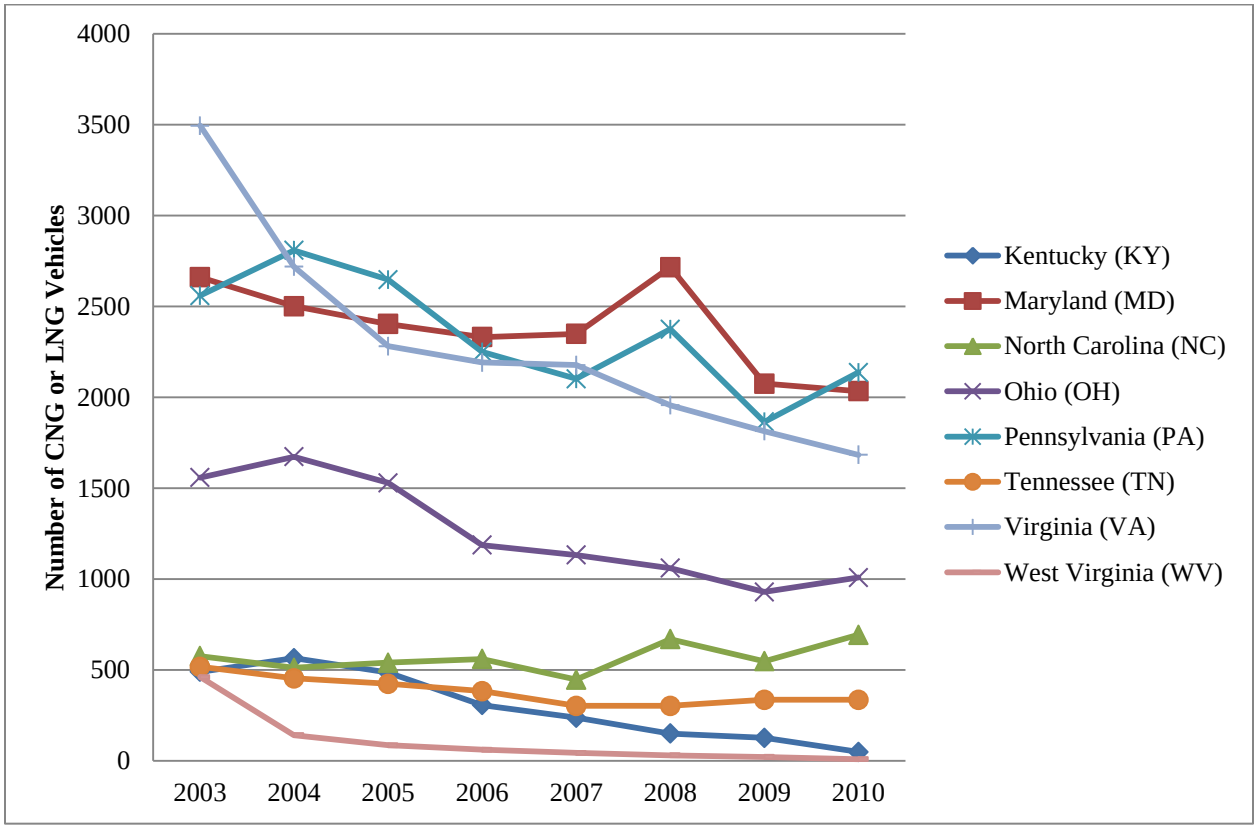


Source: (U.S. EIA 2012).

Between 2003 and 2004, the U.S. DOE reports that the number of dedicated or bi-fuel CNG vehicles in West Virginia's fleet dropped from 461 to 134. This decline in demand caused a mass dismantling of natural gas fueling stations in 2004. Trends were largely the same for other states in the region, as shown in Figure 2.

[1] In 2003, only 4 out of 461 NGVs were dedicated. Dedicated vehicles do not have the option to use gasoline.
[2] In 1997 and 1998, real gasoline prices were lower than they had been in over 20 years.

Figure 2: Natural Gas Vehicles, 2003-2010



Source: (U.S. EIA 2012).

Overall, the earlier investment in fueling infrastructure was based on an expectation of growth in demand for gas that did not occur. The small size of the natural gas fleet in West Virginia, combined with the dispersion of that fleet, was not able to support the stations. Neither federal nor State entities adopted NGVs at the rate that the legislative language suggested would occur.

Today, there still exists some ability to leverage on both the experience and investment that occurred in the 1990s. Some pipeline infrastructure is still in place that could allow some savings on capital equipment. Former employees of the firms that installed the original fueling equipment are still in the area and maintain extensive knowledge of the earlier efforts.

In addition, today the structure of natural gas markets is not in transition as it was in the mid-1990s, although this does not mean prices will not be volatile. Technology is also improved, both for CNG tanks, which are rated for higher pressure and have a longer life and for dispensers, which are much faster than in the 1990s.

B. Kanawha Converts

- Population (Charleston, WV): 51,400
- Population Density: 1,690 persons/square mile
- Fleet Vehicles: 1 bi-fuel pickup, 2 CNG buses
- Infrastructure: Fuelmaker CNG fueling unit, planning a permanent fueling station

The Kanawha Converts consortium was organized in 2012 to assess the feasibility of utilizing natural gas in existing transportation fleets in the Kanawha County area. An overall goal of the consortium is to make Kanawha County a regional leader in adoption of natural gas as a vehicle fuel. More explicit goals of the project are to make services available to support vehicle conversion, to provide education, to coordinate information and necessary steps to proceed, and to encourage adoption of dedicated NGVs and bi-fuel conversion in preparation for more widespread availability of CNG at filling stations.

The consortium has undertaken tasks related to identifying education and training needs, fuel cost comparisons, emission reductions, infrastructure development costs, tax incentives, and maintenance facility modifications that could eventually service large numbers of fleet conversions. The group has also enabled the conversion of one county vehicle to be bi-fueled and has acquired federal funding to purchase two dedicated CNG buses.

The primary partners of the Kanawha Converts effort are the Kanawha County Commission, the Charleston Area Alliance, Bridgemont Community and Technical College and the Charleston Chamber of Commerce. Many other private and public sector organizations have contributed time and expertise to the initiative and are stakeholders in the success of the effort.

Kanawha Converts has completed action items related to three primary goal areas, Education and Training, Public Policy, and Markets. In education, the initiative has identified a curriculum that it would like to see implemented in the area to train workers to inspect and install bi-fuel conversion kits on vehicles. This effort includes an inventory of skills needed to do the conversions. On the policy side, members of the group helped introduce tax credit legislation that would allow governmental entities to take advantage of AFV tax credit now available only to households and businesses by allowing it to pass through to dealerships. On the market side, Kanawha Converts is currently working on its goal to develop an inventory of AFV candidates. This is a continuing effort that supports the primary goal of promoting NGVs to fleet owners, thus developing interest and building demand. As part of this work, a database of potential fleets that could convert to natural gas was developed, combined with estimated annual gas usage and supplementary data on budget constraints and fleet turnover.

The group's market research also included site location analysis that resulted in a Kanawha Rapid Transit (KRT) location being selected as the initial location for a fueling station to service two KRT-operated CNG buses that will be ordered for delivery in late 2013. KRT has received $2 million for the buses from the EPA's Diesel Emissions Reduction Act Grants via the National Clean Diesel Funding Assistance program.

Kanawha Converts also helped the Kanawha County Commission convert a Chevy Tahoe to a bi-fueled vehicle that will begin running on CNG once fueling equipment is installed at the Kanawha County courthouse. A Fuelmaker CNG fueling unit (one GGE/hour – one gasoline

gallon equivalent/hour) was donated to Kanawha County by IGS Energy, a private developer of CNG fueling stations. The unit is expected to be installed in February 2013.

The group's next steps are to issue an RFP for a private investor to build a CNG fueling station to service the KRT's dedicated CNG buses. Currently the group's partners are helping determine whether a fast-fill or slow-fill station would be optimal given the needs of the KRT. The type of station selected will also depend on the type and size of the station IGS announced it will build on Spring Street in Charleston and the timing of its availability. Two other stations along I-79 were announced by IGS as well (Associated Press 2013). Kanawha Converts is in discussions with IGS to determine what is best for KRT.

C. Governor's Natural Gas Vehicle Task Force

- Fleet Vehicles: potential for 6,000 in State fleet and 12,000 additional in private and local fleets
- Infrastructure: identification of desirable infrastructure locations

Governor Earl Ray Tomblin announced the creation of the Natural Gas Vehicle Task Force as a group dedicated to assessing the feasibility of improving the state fleet to include natural gas vehicles and supporting infrastructure initiatives. The task force is also to develop a means of communicating the benefits of NGVs to the state. The 24-member group met for the first time on July 12, 2012.

The Task Force has adopted a pledge within a Memorandum of Understanding (MOU) initiated by Pennsylvania, Oklahoma, Colorado, and Wyoming in November 2011. This effort was created to encourage automobile original equipment manufacturers (OEMs) to produce a functional and affordable natural gas fleet vehicle. West Virginia as well as Kentucky, Louisiana, Maine, Mississippi, New Mexico, Ohio, Texas, and Utah joined the MOU in the following months. On April 27, 2012, the governors from the MOU states sent a letter to 19 major automobile manufacturers expressing their desire to purchase OEM NGVs (Christensen and Myers 2012). While this initiative was joined prior to the creation of the task force, it was regularly reported and discussed by the group. The MOU is a vehicles-only initiative currently. Oklahoma is in the process of completing a cost-benefit analysis of implementing NGVs that will be available to all states active in the MOU. Currently, only 2 of the 13 states involved in the MOU have purchased vehicles off this contract. These states are those that already had natural gas infrastructure established.

On July 24th, subcommittees for the task force were announced: Finance, Legislative and Communications, and Infrastructure Development. The Finance Committee was tasked with analyzing the costs and benefits of using natural gas as a fuel source for the state fleet. One method used was a sensitivity analysis of savings from the use of natural gas based on various potential gasoline prices. The state currently spends $19 million annually on fuel; the committee believes that savings of $1.9 million annually could result from full implementation of NGVs in the state fleet (a 12 year cycle). The committee recommended that natural gas vehicles from OEMs be added to the state RFP (request for proposal) for the 2013 model year fleet purchase. Ten types of vehicles to run on CNG have been included in the RFP. A pre-bid conference was held on August 22, 2012 and the bid opened September 6th (Governor Tomblin Announces

Natural Gas Vehicles for State Fleet Out to Bid 2012). All bids were received by November 20th and will be presented in 2013. The Department of Education, Higher Education system, and municipalities will be able to purchase vehicles on the state RFP.

A task force member from the WV Department of Education has provided the task force with information on the school transportation system. The Department of Education operates 3,000 school buses daily using 6.2 million gallons of diesel fuel annually. Due to heavy regulation of school buses, the Department thinks OEM vehicles will be most appropriate, and both CNG and propane fueled buses have been considered. CNG technology is limited to large capacity school buses which are less commonly used in the state. The Department reported that the premium on CNG buses of between $40,000 and $50,000 combined with the expenses to install CNG stations would be a challenge. In contrast, a variety of school buses are available using propane as fuel and the engine premium is only $10,000. Infrastructure is available from propane suppliers for an additional $0.05 or $0.10 per gallon, making the cost savings over the life of the bus equate to a 2 to 3 year pay back for propane. Based on this information, a propane bus has been added to the state RFP.

The Legislative and Communications Committee was created to provide options for adapting the West Virginia motor fuels excise tax and to develop a strategy to communicate the benefits of natural gas. The committee recognizes that the motor fuel excise tax is an important source of revenue for road construction and maintenance and is trying to identify an appropriate method to include natural gas when used as vehicle fuel. It is anticipated that this committee will have a review of the taxation situation for consideration in 2013.

The Infrastructure Development Committee was slated with the task of evaluating the infrastructure necessary to adequately supply the state fleet and potential private fleets and customers. The committee has used information from the state's early attempts to adopt NGVs to guide the infrastructure discussion. There has been a particular emphasis on identifying areas where infrastructure development would be most beneficial: heavily populated areas and regions with large state fleets. Such areas include portions of Berkeley, Cabell, Harrison, Kanawha, Mercer, Monongalia, Putnam, and Wood counties. Maps were developed by the committee as a way to locate intersections of natural gas pipelines, population centers, and state and private fleets. In total, 18,000 fleet vehicles statewide are represented on the map: 6,000 in state fleets, 2,000 in municipal fleets, and 10,000 in private fleets. The committee expects that lateral pipelines will be necessary for infrastructure development in the desired areas, but believes utilities will be interested in this endeavor if costs can be recouped.

The Natural Gas Vehicle Task Force delivered its final report to the governor in February 2013.

D. West Virginia Clean Cities

The W.Va. Clean State Program is West Virginia's Clean Cities coalition, one of nearly 90 nationwide. Sponsored by the U.S. DOE's Vehicle Technologies Program, Clean Cities is a government-industry partnership designed to reduce petroleum consumption in the transportation sector.

The program is currently involved in advancing natural gas as a transportation fuel. Recent activities include:

- Co-sponsorship of "Compelling Case for Natural Gas Vehicles" workshop on Feb. 16, 2012, in Charleston, WV, with nearly 170 in attendance, 17 tabletop displays and seven NGVs on display.
- Sponsorship of State Employee Natural Gas Vehicle Workshop on Sept. 12, 2012, in Charleston, WV, with nearly 40 in attendance and seven alternative fuel vehicles on display including the Kanawha County Commission's CNG bi-fuel Chevrolet Tahoe, Chesapeake Energy's CNG-powered pickup and CleanFUEL USA's propane-powered pickup, driven to the expo from Texas.
- Participation in the Governor's Natural Gas Vehicles Task Force, which began its work in June 2012. Tasked with exploring natural gas transportation options for vehicles and infrastructure, the group will present its recommendations to the 2013 session of the W.Va. Legislature, which begins in February. A major milestone supporting the effort is the announcement by IGS Energy of an Interstate 79 CNG fueling corridor with stations announced for Charleston, Jane Lew and Bridgeport in WV and at Mt. Morris, PA in partnership with Chesapeake Energy, EQT and Anterro Resources.

The program is also a co-sponsor of the 2013 Appalachian Basin NGV Expo and Conference May 13-15, 2013, in Charleston, WV. The conference will gather stakeholders to discuss strategy for using natural gas as a transportation fuel.

The W.Va. Clean State Program was established in 1994. During the late 1990s, the program sponsored an alternative fuel grant program that enabled units of local government to pay 50 percent of the incremental costs associated with alternative fuel vehicle conversions. These funds were used to convert a number of vehicles to operate on natural gas. Although the U.S. DOE occasionally offers competitive grant funding that allows for infrastructure or vehicle costs, the program's current funding does not allow these costs.

2. Regional Case Studies

A. City of Dublin, Ohio

- Population: 41,751
- Population Density: 1,709 persons/square mile
- Fleet Vehicles: 44
- Infrastructure: 1 "fast fill" station open to the public

In June 2012, Dublin, Ohio expanded its city vehicle fleet with the addition of CNG vehicles and a fueling station. This project had a cost totaling $4.2 million. The city states several reasons for this interest in CNG vehicles including natural gas as an abundant, American, clean fuel source that saves money. The city cites a 90% reduction in carbon emissions when using CNG vehicles rather than gasoline and diesel vehicles. Currently, CNG is retailing for $1.99 per GGE at the Dublin station (CNG Now! 2013). The city further expects to see a $30,000 savings per year in fuel cost with its new CNG fleet.

Dublin's city fleet contains 44 dedicated CNG vehicles. The fleet is comprised of one Ford Transit, two Ford Fusions, 17 Ford F-150s, 23 Ford F-250s, and one Ford F-350. All were

purchased as new gasoline-fueled vehicles from Ford and then converted to run on CNG using EPA-certified kits. The total cost for this vehicle purchase was $967,000, an expense that was previously calculated into Dublin's capital replacement fund. The city plans to acquire additional CNG vehicles as existing gasoline fleet vehicles are retired. To manage this conversion process, all six of the city's maintenance technicians became ASE (National Institute for Automotive Service Excellence) certified in CNG conversion kit installation. Additionally, two city technicians are ASE certified in CNG vehicle maintenance and repair.

The remaining $3.2 million of project costs was incurred in design, equipment, station construction, and building modifications related to the new CNG fueling station. The station is a "fast fill" type that operates similarly to an average gasoline station. Fill time at this CNG station is about the same as at a gasoline/diesel fueling station. The station services the city's existing 44 vehicle fleet and is also open to corporate fleets and the public. To use the station, customers enroll in a program and receive an account and access card to use in fueling their CNG vehicles. To expand the city's CNG opportunities, Dublin, as a suburb of Columbus, has an agreement for reciprocity between the two cities for fueling, fleet maintenance, and training (City of Dublin 2012).

R.W. Setterlin was hired as the general contractor for the City of Dublin's fueling station. The company's responsibilities included site work, concrete, process piping, steel, HVAC, electrical, and paving work as well as installation of the compressors and dispensers. The city used a site adjacent to its existing gasoline/diesel fueling station for the new CNG station. However, since CNG was a completely new endeavor for Dublin, several challenges had to be overcome. Construction of the CNG station required several new utilities to the area including power, gas, high pressure piping, and electrical. One challenge faced in construction was incorporating these new utilities with existing underground utilities. Gasoline and diesel fuel islands already existed at the city's adjacent fueling station. These fueling options needed to be extended to the same location as the new CNG dispensers without interrupting the city's ability to use the gasoline and diesel pumps during construction. Contractors were responsible for installing all of the specialized CNG equipment: compressors, dispensers, and storage units. This equipment required a crane for placement at the site. However, the weight of the crane was a concern for the careful network of underground utilities and piping. The placement of the equipment had to be carefully planned and executed as to not risk damage to this network. Throughout the construction process, work and inspections had to be coordinated with state officials, the fire marshal, project engineers, and the building department. The complexity of this new installation brought construction costs, excluding equipment, to $1.7 million (R.W. Setterlin Building Company 2012).

Station construction and equipment was funded in part by a U.S. DOE/Clean Cities grant administered through Clean Fuels Ohio that covered half of the station cost ($1.5 million). IGS Energy, a retail supplier of natural gas with Platinum LEED certification, was also a partner in building the station by contributing $275,000 as assistance in covering project costs. IGS Energy remains involved in the Dublin station as the retail operator and bills customers. Columbia Gas supplies the natural gas.

City of Dublin's example and infrastructure development has encouraged local companies to consider CNG fleets of their own. Stanley Steemer and Smith Dairy have both begun to convert some vehicles to run on CNG (R.W. Setterlin Building Company 2012).

B. City of Asheville, North Carolina

- Population: 83,393
- Population Density: 1,856 persons/square mile
- Fleet Vehicles: 32
- Infrastructure: 1 "fast fill" station open to the public

The City of Asheville began its use of CNG in 2005 with the construction of a city-owned fueling station. The city also made vehicle purchases between 2008 and 2009 and retains eight CNG vehicles from that initial purchase. These vehicles include two CNG OEM Hondas and a mix of Ford and Chevy pickups that were converted to run on CNG. The high fueling volume at this initial station wore the compressors out, and by 2012, the City of Asheville was looking to upgrade both its fueling infrastructure and vehicle fleet.

The fleet upgrade included the purchase of 25 new Ford vehicles of varied passenger and pickup models. The vehicles were purchased as gasoline vehicles from the manufacturer and converted to run on CNG at a local Ford dealership. Since the conversion was completed at the Ford dealership, vehicle warranties (3 years / 36 months) remain valid. Maintaining these warranties through a certified conversion process was a requirement to be eligible for grant funding. Each vehicle conversion cost $10,800 with a total fleet upgrade cost of $350,000. The city has several ASE-certified CNG mechanics to service fleet vehicles.

Asheville has plans to expand this fleet including CNG refuse trucks that are on order. The fleet manager believes these heavy duty trucks will provide the greatest cost savings to the city. The city's current refuse trucks run on diesel and achieve approximately two miles per gallon. CNG is currently selling for $2.11 per GGE at the Asheville station (CNG Now! 2013).

The upgrade to the fueling station totaled another $350,000. This included several improvements but at a much lower price tag than new station construction due to the presence of all necessary utilities. The city purchased two 58 CFM (cubic feet per minute) compressors, a new inlet gas dryer, and a second 3600 psi dispenser. The station's storage was doubled as part of this upgrade from 300 dge (diesel gallon equivalent) to 600 dge. The station is a "fast-fill" type, so with the storage enhancements, many customers can utilize the station with the same fill time as a standard gasoline fueling station. Natural gas is currently provided by Public Service of North Carolina (PSNC). The city does have the option to purchase gas from other suppliers and pay a small fee to use the PSNC fuel line but has not investigated this possibility yet.

The complete vehicle and infrastructure upgrade cost was $700,000. The city received a matching grant that covered half the cost of the upgrade: $350,000. The grant was part of a larger $12 million grant supported by the American Recovery and Reinvestment Act and administered and distributed through the Carolina Blue Skies and Green Jobs Initiative (led by the Triangle J Council of Governments). This undertaking funded 40 alternative fuel projects across the states of North Carolina and South Carolina. After the grant, $350,000 remained as the city's responsibility, but this amount had already been programed into the city's budget as a capital expense to replace aging fleet vehicles. Due to careful capital planning, Asheville was able upgrade its fleet without any additional out-of-pocket costs.

The City of Asheville's initial 2005 installation of a CNG station encouraged local businesses to invest in CNG vehicles for their fleets. The 2012 station upgrade has maintained this local CNG investment and increased it. Mission Health, a not-for-profit independent community hospital system based in Asheville, has approximately 18 CNG vehicles. Five of these vehicles, including two new shuttles, were purchased in reaction to the city's recent station upgrade (City of Asheville 2012). Buncombe County's Mountain Mobility program has six CNG vehicles that it uses to transport individuals that live outside Asheville without personal transportation. The local AT&T branch utilizes 12 CNG vans. Other business customers include the Land of Sky Regional Council and University of North Carolina – Asheville. In addition to the city and local commercial fleets, the station receives 150 individual credit card sales per month from private consumers.

C. Pennsylvania Turnpike

- Fleet Vehicles: no vehicles
- Infrastructure: 17 potential service plaza sites, 2 privately-owned stations (1 additional announced station)

The Pennsylvania Turnpike has taken steps to consider LNG (Liquefied Natural Gas) as a fuel option for those who travel the toll road. LNG is created by cooling natural gas vapor to 260 degrees below zero. The cooled liquid is stored in cryogenic tanks. Vehicles that are capable of using LNG (typically commercial long-haul trucks) have an engine premium of $70,000 (Turner 2012). High diesel prices in recent years have caused private truck fleets to consider LNG as a potential fuel source yielding annual fuel savings up to $50,000 per truck.

In early 2011, the Pennsylvania Turnpike Commission (PTC) created an LNG Committee of natural gas industry experts. The committee meets quarterly to discuss the feasibility of natural gas as a turnpike fuel (Christensen and Myers 2012). The turnpike maintains 17 service plazas that it considers potential sites for future LNG fueling stations. The construction of LNG stations has become increasingly considered following the completion of an LNG production facility. The production facility is owned by UGI Energy Services in Ontelaunee Township and has the potential to store 1 Bcf (billion cubic feet) of natural gas on site (Speraw 2012). In 2012, Clean Energy Fuels announced plans for three LNG fueling stations in Pennsylvania. Stations are planned to be built at Flying J Travel Centers in Carlisle, Mill Hall, and Smithton. All stations are under construction but were not completed by the end of 2012 (Clean Energy 2012).

Figure 3: Travel Plazas on the Pennsylvania Turnpike

Source: (F&F 2012).

In March 2012, the PTC approved plans for a feasibility study to be researched by Penn State Facilities Engineering Institute. The LNG study was commissioned to address many related topics: optimum LNG station location, station logistics, station business models, and construction costs (Christensen and Myers 2012). The findings of the study were presented to the PTC in October 2012 in the paper "Feasibility Study for the Liquefied Natural Gas Utilization for Commercial Vehicles on the Pennsylvania Turnpike." The authors found the implementation of LNG on the Pennsylvania Turnpike to be a feasible option due to continual increase in demand and technological improvements. Depending on the number of fuel tanks, a truck can safely travel up to 600 miles between fueling.[3] The authors created a mathematical model that utilized traffic and travel information from the turnpike combined with safe traveling distance between fueling. From the turnpike's 17 travel plazas, four locations were identified as optimal: Allentown, Sidling Hill, Oalmont/Plum, and King of Prussia. These four stations could cover 5,972,866 truck trips annually. This is an effective coverage of 51.7% (percentage of all trucks that could be covered if LNG stations were installed at every travel plaza). A second tier of four plazas were identified as the next best LNG fueling site locations: Peter J. Camiel, New Stanton, and North and South Midway. LNG can be transported economically 500 miles from production station to fueling station, so all optimal station locations could consider purchasing LNG from the newly constructed production facility run by UGI Energy Services.

The Penn State paper authors also identify a business model to be used by the PTC. LNG is cryogenic fuel that will degrade with time. Since the fuel is perishable if not consumed in an appropriate time period, guaranteed customers need to exist so spoiled fuel is not discarded at a loss. The authors recommend that PTC find anchor customers to agree to purchase minimum fuel amounts at specific stations. This would reduce fuel waste. The mathematical model used to find optimal station sites considers traffic and travel patterns; however, anchor customers could influence the permanent LNG station locations. Before anchor customers are defined, the PTC could install mobile LNG stations. These mobile stations cost $400,000 to $500,000 to install, and some companies offer leasing options. These stations have a small footprint to easily

[3] A truck with one fuel tank can travel 300 miles while a truck with two fuel tanks can travel 600 miles.

fit with existing infrastructure. The disadvantage to this type of station is the capacity; LNG storage is only 6,000 gallons which an anchor customer could consume in a few days. While the frequency of re-supplying these stations is not ideal in the long run, mobile stations can provide a lower commitment scenario to evaluate a station's potential success. After successful locations are identified, permanent stations can be installed.

Two options exist for the PTC when planning permanent LNG station construction: independent sites or expansion of existing travel plazas. Independent sites offer the ideal traffic flow and station design as each site has no existing buildings or fueling stations to consider. These independent sites would require the construction of acceleration and deceleration lanes as well as the addition of necessary utilities. Infrastructure would be the primary cost driver. For LNG stations added to existing travel plazas (such as those identified by the mathematical model), adequate space and traffic flow, not infrastructure, would be most costly. Stations that require significant additions and traffic flow changes, such as Allentown, Sidling Hill, and New Stanton, have price tags reaching $3.95 million. Other less expensive sites (Oakmont/Plum, King of Prussia, North and South Midway, and Peter J. Camiel) have costs as low as $1.8 million. In addition to these costs, the authors recommend that all employees "from janitors to executives" receive at least basic LNG training on physical properties and safety procedures.

The authors detour from the paper's primary directive to discuss the possibility of installing LCNG (LNG and CNG) combined stations. Building an LCNG station would add $750,000 to the above prices; however, this possibility provides many benefits. LCNG provides the widest fueling potential with access to natural gas fuel for long-haul trucks as well as cars and light trucks. The potential emission reductions would be greater as well.

Finally, funding possibilities are suggested to the PTC. The Federal Clean Cities Program is mentioned with local initiatives in both Pittsburgh and Philadelphia. The Congestion Mitigation Air Quality Improvement Program (CMAQ) can be used along the turnpike portions that abut metro areas with ozone and carbon monoxide problems. The Diesel Emission Reduction Program will provide 75% of the cost of retrofitting a diesel vehicle to run on LNG or 50% of the cost of a new LNG truck. The Alternative Fuels Incentive Grant (AFIG) offers funds for either vehicle conversion or infrastructure plans. Finally, the Department of Environmental Protection (DEP) was suggested as a potential investment partner (Myers, et al. 2012).

IV. Natural Gas in Electricity Generation

Most new demand for natural gas has been for power generation, and the U.S. has more natural gas-fired power generation capacity than any other resource. Over half of natural gas-fired capacity has been built since the year 2000. As reported by the EIA, amount of electricity generated by natural gas grew by 40 percent between 2000 and 2011. Regionally, new natural gas capacity is concentrated in Pennsylvania and Ohio, although every state saw some additions.

Figure 4: U.S. Electricity Production by Fuel (MWh)

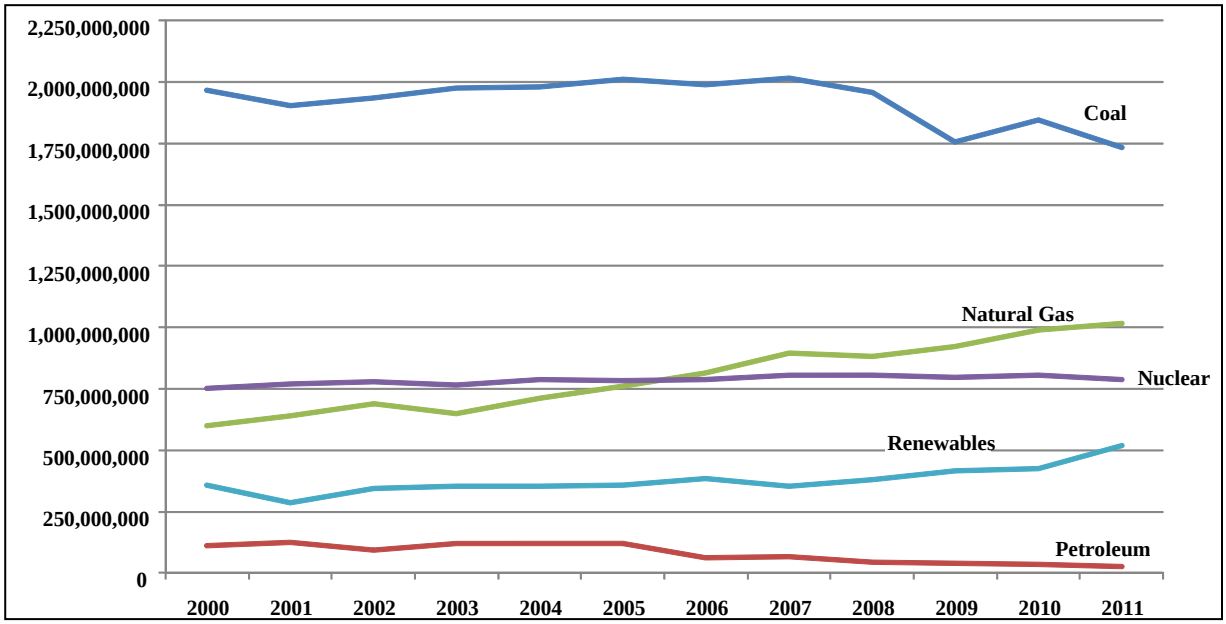
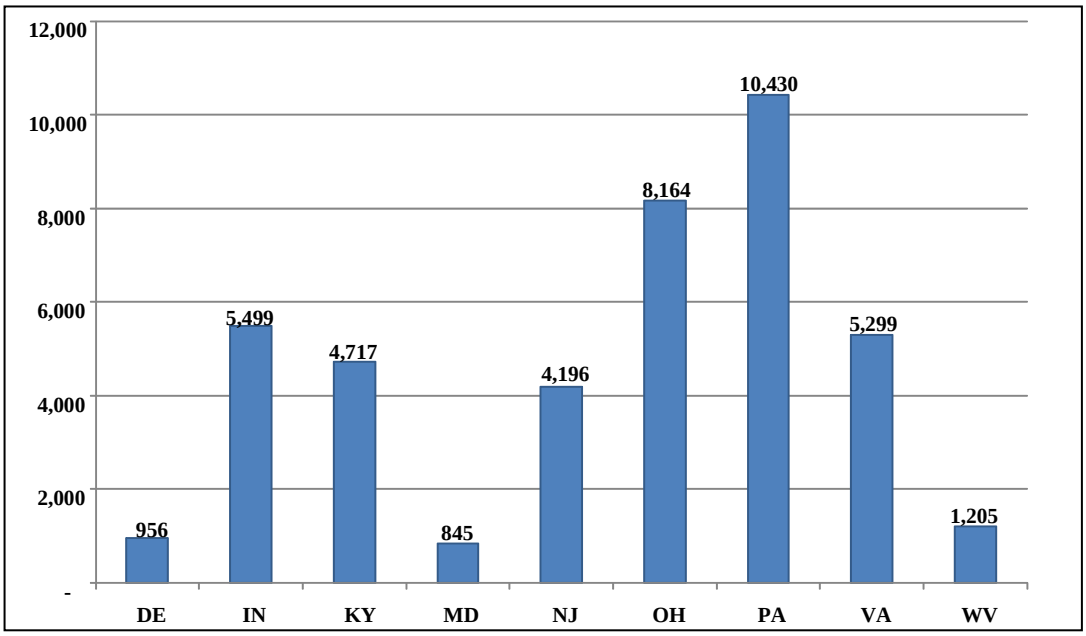
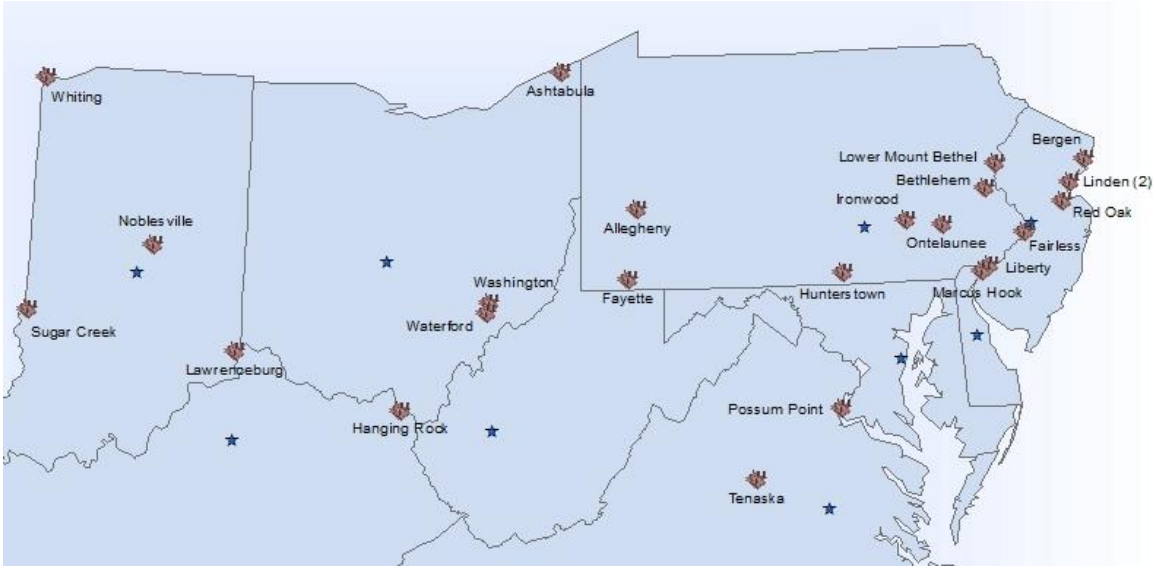


Figure 5: Total Natural Gas Capacity (MW) Additions in Regional States, 2000-2011



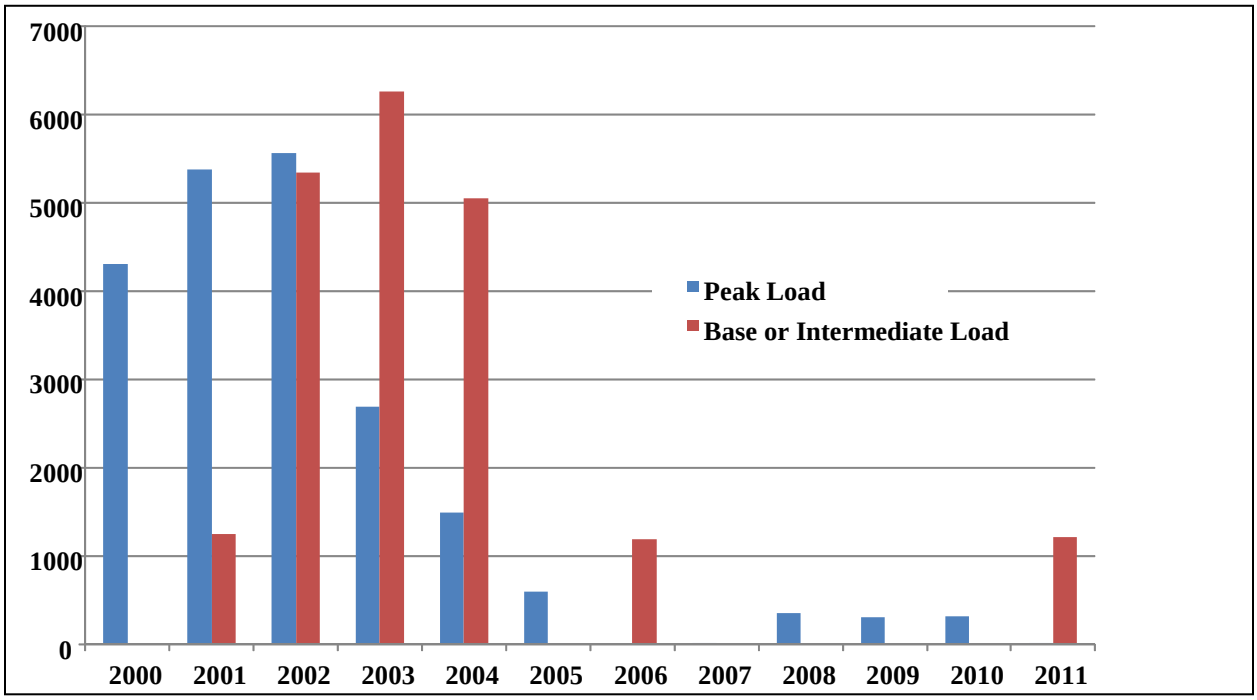
The type of generating capacity differs throughout the region. All of West Virginia's capacity is in generators designed to supply peak load, as opposed to combined-cycle plants that are designed to supply base or intermediate load. Combined-cycle plants operate more frequently and consume more natural gas. Significant capacity of both types of generators was added throughout the region but combined-cycle plants are of special interest due to high gas consumption rates. These plants are located to take advantage of proximity to large demand centers and associated higher prices for generation.

Figure 6: Combined-Cycle Natural Gas Plants Built from 2001 to 2010



There are several reasons why the location of natural gas plants is concentrated in eastern Pennsylvania and New Jersey. For one, a coal-dominated capacity mix, as is in place in West Virginia, Kentucky and much of Ohio and Virginia has historically produced lower wholesale power prices, thus giving fewer incentives to build new capacity. Wholesale power prices in the large metropolitan areas of the Atlantic coast are higher due to large demand and the presence of transmission constraints, meaning there will be a higher "spark spread" between the price of natural gas and the selling price of any electricity generated. As natural gas has also been available in large quantities in northeast Pennsylvania, supply has not been a constraint to plant development. Pennsylvania and New Jersey have also been "restructured" electricity markets for several years, allowing non-utility generators to pursue retail customers. Ohio only recently began allowing retail choice, and West Virginia, Kentucky and Virginia are still fully integrated.

Figure 7: Regional Natural Gas Capacity Adds by Generator Type (MW), 2000 - 2011



Source: (U.S. EIA 2012).

In West Virginia, the Public Service Commission (PSC) has required utilities to submit plans to acquire additional generating capacity to meet in-state needs. To date additional power has been purchased from regional power pools or via purchase power agreements. Both American Electric Power/Appalachian Power (ApCo) and FirstEnergy (FE), via its subsidiaries Monongahela Power Company and The Potomac Edison Company, have submitted proposals to acquire additional coal-fired capacity from plants in West Virginia that are not presently in the rate base for their West Virginia-based customers.

The PSC required ApCo and FE to present alternative options to purchasing the existing coal-fired capacity, including the option to purchase new natural gas-fired capacity. Both utilities presented comparisons of costs from buying existing coal vs. buying new combined-cycle gas

and selected existing coal as their proposed plans. The plans have not yet been approved and are currently being reviewed by the PSC and interveners.

There are several interveners in the cases representing various citizen and industry groups including the Independent Oil & Gas Association (IOGA). Current case activity includes various requests for information of the utilities by the interveners. Information requests cover a broad range of topics, many of which regard the physical characteristics of the plants targeted for acquisitions, financial projections of their operating costs and details about efforts to acquire power from other sources. The final orders for the cases will be issued by the PSC in August or September of 2013.

V. Policy Considerations

This portion of the report is designed to provide a discussion of incentives and policies to encourage manufacturing (with or without a focus on natural gas-related downstream products) that are currently available in West Virginia as well as examples of those found in other states. This discussion should not be considered exhaustive, but rather a sampling of potential alternatives. A brief description of the policy space and incentive structure in West Virginia is followed by a short discussion of efforts in other states.

1. West Virginia

This section briefly outlines the business taxation environment, a sampling of tax credits and recent developments in legislation that have occurred in West Virginia having direct impacts upon manufacturing and natural gas-related firms operating in the state.

A. Business Taxation Environment

There are two primary business taxes in the State of West Virginia: the Corporation Net Income Tax (CNIT) and the Business Franchise Tax (BFT), with additional industry-specific taxes also levied. Two additional taxes that have impacts on natural gas-related industries in West Virginia are the Severance Tax and the Business and Occupation (B&O) Tax. The Severance Tax is imposed on the production of natural resources, including natural gas, while the Business and Occupation Tax is imposed upon public utilities, electric power producers, and gas storage operators. Reductions to the CNIT and the complete elimination of the BFT are scheduled to occur over the next few years pending reserves in the State Rainy Day Fund[4]. These four taxes are briefly outlined below.

[4] WV State Code §11-24-4 (referring to rate reductions in CNIT) and §11-23-6 (referring to rate reductions in BFT).

Table 3: Primary Business Taxes Related to Manufacturing and/or Natural Gas in WV[5]

Tax	Description	Rate
Corporation Net Income Tax	Imposed on taxable corporation income as defined by federal law and as adjusted by State law	7.00% beginning January 1, 2013[6] 6.50% beginning January 1, 2014[7]
Business Franchise Tax	The greater of $50 or the product of apportioned net equity times the applicable tax rate	7.00% beginning January 1, 2013[8] 6.50% beginning January 1, 2014[9] Eliminated beginning January 1, 2015
Severance Tax	Gross receipts tax levied on businesses that sever, extract, and/or produce natural resource products	5.00% on natural gas[10]
Business and Occupation Tax	Only applies to public utilities, electric power producers, gas storage businesses, and the production of synthetic fuel from coal	Lesser of 1) average monthly tax paid during a five-year period or 2) 5 cents multiplied by either the net number of dekatherms of gas injected into or withdrawn from such gas storage reservoirs during a tax month

B. West Virginia Business Tax Credits

Although West Virginia Code provides for the application of multiple tax credits against various business and personal taxes, this brief review will focus upon five main credits as they relate to manufacturing and natural gas-related activity in West Virginia. This section is not intended to represent an exhaustive list of tax credits at play in West Virginia. For a detailed description of such credits, please refer to the *Biennial Report of the Tax Commissioner of West Virginia*[11].

Manufacturing Investment Tax Credit[12]

Designed to encourage the location of new industry in the state (as well as the expansion, growth and revitalization of existing industrial facilities), the credit may be used to offset up to 50 percent of the taxpayer's annual liability for Severance Tax, BFT and CNIT for a period of ten years. This calculation is subject to limitations[13] and applies to those entities having business activity in North American Industry Classification System (NAICS) code sections 31, 32, 33 and 211112 (Note: 211112 was added via the Marcellus Gas and Manufacturing Development Act further described below).

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[5] For a detailed description of taxes in the State, please refer to the *Biennial Report of the Tax Commissioner of West Virginia*. http://www.state.wv.us/taxrev/publications/taxLawReport.pdf
[6] WV State Code §11-24-4(7).
[7] WV State Code §11-24-4(8).
[8] WV State Code §11-23-6(b)(10).
[9] WV State Code §11-23-6(b)(11).
[10] Subject to exemptions; also subject to a tax to reduce the unfunded Workers' Compensation liability.
[11] http://www.state.wv.us/taxrev/publications/taxLawReport.pdf
[12] WV State Code §11-13S
[13] WV State Code §11-13S(4)(b)

Economic Opportunity Tax Credit[14]

The Economic Opportunity Tax Credit is available to businesses that make an investment in a new or expanded business which results in the creation of at least 20 new jobs (although lower requirements apply for small businesses and corporate headquarters relocation). The pro-rated credit is calculated by applying the applicable percentage allowance (based upon created employment levels) and the applicable percentage of the qualified investment (based upon useful life of the asset). The creation of 20 new jobs provides a credit equal to 20 percent of its qualified investment, while creating at least 280 or 520 new West Virginia jobs provides higher credit percentages (25 and 30 percent respectively). The amount of the tax offset is determined via a payroll factor. Taxpayers may use the credit to offset up to 80 percent of specific taxes or up to 100 percent of those taxes if the new employment compensation exceeds the statewide average non-farm payroll wage. Firms must be engaged in the activities associated with manufacturing, information processing, warehousing, non-retail goods distribution, research and development or destination-oriented recreation and tourism.

Strategic Research and Development Credit[15]

The Strategic Research and Development Tax Credit, designed to encourage research and development relating to manufacturing processes before commercial sales have begun, may be used to offset up to 100 percent of the taxpayer's annual liability for BFT, CNIT and Personal Income Tax in that order. The calculation of qualified investment for determining the credit is based upon the useful life for investments in depreciable property or the percentages of investment for other qualified expenses.

Natural Gas Industry Jobs Retention Credit[16]

This credit, which may offset up to 100 percent of the B&O taxes for natural gas storage operators, is calculated by multiplying the number of qualified employees by $1,000. This credit became effective on October 1, 1996 and was established to encourage natural gas storage operators to maintain employment levels.

Manufacturing Property Tax Adjustment Credit[17]

Designed to provide a measure of tax relief to manufacturers without directly reducing revenue for local governments, the Manufacturing Property Tax Adjustment provides a credit equal to the amount of West Virginia ad valorem property tax paid on the value of manufacturing inventory against the CNIT and BFT for a given tax year. These inventories are limited to raw materials, goods in process, and finished goods for firms engaging in manufacturing activities only.

[14] WV State Code §11-13Q
[15] WV State Code §11-13R
[16] WV State Code §11-13L
[17] WV State Code §11-13Y

C. Marcellus Gas and Manufacturing Development Act

WV Senate Bill 465 (2011), creating the "Marcellus Gas and Manufacturing Development Act" was passed during the 2011 Regular Session of the West Virginia Legislature (Legislature) and its provisions became effective July 1, 2011. Among those were provisions to revise property tax valuations of oil and natural gas drilling rigs, to create tax credits for alternative-fuel motor vehicles and related infrastructure, the reallocation of portions of excess severance taxes on oil and gas, revisions to the Strategic Research and Development Tax Credit, the inclusion of natural gas extraction in the Manufacturing Investment Tax Credit and amendment of what is commonly known as the 'five for ten' property tax program for manufacturing businesses.

Legislative Findings

Included among the provisions of SB 465 was an addition to the Economic Development Act of 1985 (contained in Chapter 5B of West Virginia Code). The Legislature found that the development of the Marcellus shale provides "the opportunity for economic development in related areas of the economy including, but not limited to, manufacturing, transmission of natural gas and related products and the transportation of manufactured products".[18] As such, the Legislature declared that "facilitating the development of business activity directly and indirectly related to development of the Marcellus shale serves the public interest of the citizens of this state by promoting economic development and improving economic opportunities for the citizens of this state".[19]

Alternative-Fuel Motor Vehicles

Modifications to §11-6D include changes to alternative-fuel motor vehicles tax credit and the creation of an alternative-fuel infrastructure tax credit. The definition of alternative-fuels in code was modified to include "natural gas hydrocarbons and derivatives" (as well as hydrogen) while removing specific references to methanol, ethanol and other alcohols.[20] Definitions for qualified alternative fuel vehicle and home refueling infrastructures are also provided. Tax credits for any person, corporation, limited liability company or partnership subject to the tax against liability for personal income, business franchise and corporate net income tax liabilities were provided should they purchase or convert a dedicated or bi-fueled alternative-fuel motor vehicle or construct or purchase infrastructure "capable of dispensing alternative fuel for alternative-fuel motor vehicles".[21] The credits are available for tax years beginning after January 1, 2011, but no credits are available for vehicles or infrastructure purchases occurring after December 31, 2021. Each of the credits is briefly described below.

[18] WV State Code §5B-2H-2(a)(2).
[19] WV State Code §5B-2H-2(b).
[20] WV State Code §11-6D-2.
[21] WV State Code §11-6D-4(a) through §11-6D-4(c).

Table 4: Alternative-Fuel Motor Vehicles and Infrastructure Tax Credits

Credit	Description	Credit	Cap
Alternative fuel motor vehicle purchases	Vehicles weighing <26,000 lbs.	35% of purchase price	$7,500
	Vehicles weighing >26,000 lbs.	35% of purchase price	$25,000
Alternative fuel motor vehicle conversions	Vehicles weighing <26,000 lbs.	50% of conversion cost	$7,500
	Vehicles weighing >26,000 lbs.	50% of conversion cost	$25,000
Credit	**Description**	**Credit**	**Cap**
Qualified alternative fuel vehicle refueling infrastructure	Not generally accessible for public use	50% of direct construction or purchase and installation costs	$250,000[22] $200,000[23] $150,000[24]
	Generally accessible for public use	50% of direct construction or purchase and installation costs multiplied by 1.25	$312,500[5] $200,000[6] $187,500[7]
Qualified alternative fuel vehicle home refueling infrastructure		50% of direct construction or purchase and installation costs	$10,000

Special Method for Appraising Qualified Capital Additions to Manufacturing Facilities

§11-6F of West Virginia Code originally provided for a reduction in the valuation of capital additions to manufacturing facilities for property tax purposes. Here, a qualified capital addition would be assessed at 60 percent of its salvage value, which is equal to five percent of the original cost for the period of ten years.[25] As part of WV SB465 (2011), the definition of "manufacturing" (with regard to this method) was expanded to include the six-digit NAICS 211112 - Natural Gas Liquid Extraction.[26] This industry contains establishments "engaged in the recovery of liquid hydrocarbons from oil and gas field gases" (United States Census Bureau 2012). In addition to modifying the definition, this change reduced the additional investment required from $50 million (on the original investment of $100 million) to just $10 million (on an original investment of $20 million) and also removed the land valuation from the capital addition value. The eligibility for this special valuation is subject to application with and certification by the Tax Commissioner.[27]

[22] For taxable years beginning on and after January 1, 2011 but prior to January 1, 2014.
[23] For taxable years beginning on and after January 1, 2014, but prior to January 1, 2016.
[24] For taxable years beginning on and after January 1, 2016, but prior to January 1, 2022.
[25] WV State Code §11-6F-3.
[26] WV State Code §11-6F-2(b).
[27] A full description of the requirements can be found in WV State Code §11-6F.

Manufacturing Investment Tax Credit

The West Virginia Manufacturing Investment Tax Credit Act provides tax credits for any person, corporation, limited liability company or partnership subject to the tax against liability for Severance, BFT and CNIT liabilities equal to five percent of a qualified manufacturing investment.[28] This investment is calculated by applying a percentage to the cost of a property purchased for manufacturing investment based upon its anticipated useful life.[29] As with the 'Special Method for Appraising Qualified Capital Additions to Manufacturing Facilities', the definition of "manufacturing" (with regard to this method) was expanded to include the six-digit NAICS 211112 - Natural Gas Liquid Extraction.[30]

D. Other considerations

Although this report is primarily concerned with policies and incentives that involve the use of natural gas and NGL components as feedstock commodities in manufacturing processes, the State has several other credits and programs in place designed to improve the economic competitiveness of the business climate. In addition to tax credits such as the Strategic Research and Development Tax Credit and the High-Tech Manufacturing Credit, the West Virginia Development Office (WVDO) provides several workforce development training programs. Among these are the Governor's Guaranteed Work Force Program (GGWFP), the Competitive Improvement Program and the Small Business Work Force Program (SBWF). The GGWFP provides State dollars to firms for training that provides wage upgrades, portable credentialing, job upgrading or regarding new technology. The Competitive Improvement Program provides Federal dollars through the Appalachian Regional Commission to assist small or medium-sized businesses on a 50 percent support toward training to support worker competencies. The SBWF reimburses costs of pre-approved technology, technical and regulatory compliance training for small businesses up to 75 percent of training costs with a $5,000 maximum grant.[31]

2. Policies and Incentives in Other States

Business tax credits, incentives and policies that both directly and indirectly affect manufacturing and value-added opportunities related to the natural gas supply chain vary widely across states. Neighboring and other gas producing states offer targeted credits related to capital investment in the manufacturing of ethylene but also broader programs and incentives designed to create jobs, train workers accelerate technology transfer and commercialization and to assist manufacturers and other firms that require significant capital investments, specifically new or used machinery and equipment acquisition/upgrades directly related to the business process. Such credits and incentives can be useful policy tools to enhance the business climate of a state, but must be considered within the full tax, policy and competitive space. Many of these initiatives require the demonstration of specific levels of investment, employment or return on public dollars.

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[28] WV State Code §11-13S-5.
[29] WV State Code §11-13S-5(b).
[30] WV State Code §11-6F-2(b).
[31] http://www.wvcommerce.org/business/default.aspx

Pennsylvania, for example, has the Pennsylvania Resource Manufacturing (PRM) Tax Credit in place to encourage manufacturers purchasing ethane for use in the manufacturing of ethylene to make large capital investments to construct a facility within the Commonwealth valued at least $1 billion and creates a minimum of 2,500 full-time jobs during the facility's construction phase (Pennsylvania Department of Revenue 2013). Utah and Massachusetts, more broadly, employ tax increment financing programs that provide refundable tax credits or property tax exemptions based upon capital investment, job creation and/or workforce training expenditures with the Utah Economic Development Tax Increment Financing (Utah Governor's Office of Economic Development)and Massachusetts Manufacturing Workforce Training Tax Increment Financing Plan (The Massachusetts Register Issue: 1106 2008) respectively. Other states employ programs that create specialized innovation or development zones aimed at boosting particular industries, technologies or geographic areas.

Such credits and incentives can be useful policy tools to enhance the business climate of a state, but must be considered within the full tax, policy and competitive space.

VI. Discussion

The significant reserves and resulting production of natural gas (and ultimately the NGL components) from the Marcellus Shale has lowered the price of, and increased the demand for, the commodity. Substantial regional and market impacts are underway and are likely to continue. As such, the consideration of approaches to grow regional supply, infrastructure and capacity for value-added natural gas products is necessary to preserve more of the economic benefits of the resource in the region. As part of this discussion, several points are worth noting:

- The selection of policies that grow manufacturing has the potential to produce jobs, additional tax revenues and improve communities that have grown stagnant during recent declines.
- Infrastructure improvements, including (but certainly not limited to) natural gas transmission infrastructure, transportation access and refueling infrastructure for the use of natural gas in transportation, will require significant up-front investments. The risk of these investments has the potential to be spread out through the use of public-private partnerships. Failure to produce this infrastructure likely limits the potential to employ value-added opportunities to niche or regionally-bound markets.
- There are substantial energy and/or feedstock costs savings that may arise for U.S. manufacturers due to increased supply of shale gas, particularly in the chemical and refining industries. Although the many competing end uses for both wet and dry natural gas make future prices uncertain, many in the energy industry believe the price advantage of shale gas will remain in place for several years. Investments will ultimately be market driven and specific to individual firms.
- Any consideration of economic benefits to be derived from the additional activity resulting from expanded hydraulic fracturing of the Marcellus Shale cannot ignore the likely and continued scrutiny drilling will receive from the courts, regulators and various environmental stakeholders.

Although the implementation of direct financial incentives has served as a popular component of economic development strategies, these incentives are not alone a panacea and are fraught with unintended consequences. Improving (and reaping the maximum benefit from) the value-added opportunities from natural gas requires a careful and thorough suite of policies that encourages broad investment in manufacturing, infrastructure and education and workforce training. Ultimately it is necessary to consider a strategy that accounts for the full effects of policies, incentives and financial supports to ensure that Marcellus Shale development leads the State along a sustainable path a regional wealth creation and revitalization.

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