Executive Summary

The Marcellus shale gas industry has grown tremendously in recent years. Dramatic increases in natural gas production coupled with the slowdown of the economy (which reduced demand for natural gas) led to a significant decline in natural gas prices. Low prices have slowed the development of Pennsylvania’s shale gas resources and have been harmful to the state in the short term. This report analyzes four possible options for boosting the natural gas price and supporting locally produced natural gas: increased use of Compressed Natural Gas Vehicles (CNGV), construction of the new Allegheny pipeline, promotion of Plug-in Electric Vehicles (PEV) and exports of Pennsylvania’s shale gas via US Gulf Coast LNG terminals.

The Allegheny pipeline project appears to be the best option. Initial investment will provide a strong boost to employment and GDP growth over the next 3-5 years. After the pipeline is in service, it will help increase natural gas demand somewhere in the neighborhood of 225 MMcf/d, as well as wellhead prices. By encouraging an increase in shale gas production, the pipeline will bring economic benefits to the state.

The increase in natural gas demand due to adoption of dual vehicles is minimal, even in the best-case scenario compared to the boost in demand that would result from the Allegheny pipeline. If the government does partner with American Motors to promote dual fuel vehicles across the state by subsidizing CNGV sales and CNG filling station construction, the best-case scenario shows total number of dual fuel vehicles peaking at less than 300,000. CNGV demand for natural gas be approximately 8,000 MMcf of CNG per annum—around 22 MMcf/d. However, the cost of the CNG filling station infrastructure subsidization alone greatly exceeds revenues that would be accrued from these stations during their lifespan. A more promising alternative would be to target heavy-duty vehicles, instead of passenger vehicles, and follow the model that the state of California used.

Electric vehicles are promising in terms of their energy efficiency. However, given the current state of electric vehicle technology, it is hard to persuade consumers to purchase electric vehicles, due to the high upfront cost, short battery life, and the long recharging time. As a result, even in the highest scenario of our analysis, increased annual demand of natural gas is insignificant: 2.01MMcf/yr in 2013, 3.62MMcf/yr in 2035.

LNG exports from Gulf Coast are not a viable option. The very wide price differentials currently seen in global natural gas markets will not be sustained in the long-run. The high cost of moving gas to the Gulf Coast, liquefying it and shipping it will be more than the average spread between prices, eliminating the profitability of such an endeavor.
Introduction
The Marcellus shale gas industry has grown rapidly in recent years and has had a profound impact on jobs, income and spending in Pennsylvania. According to the Marcellus Shale Coalition, jobs creation between the first quarter of 2008 and the first quarter of 2011 increased by 2075.9%, with 214,000 Marcellus Related Jobs in 2011 Q1. Moreover, the average wage of shale-gas jobs in the Marcellus is $76,036—$29,800 higher than the average of all other industries in the area.

Due to the incredible increases in natural gas supply and mild natural gas demand, prices have dropped from $4 per MMbtu to around $2 since July, 2011. At current 2012 price levels, natural gas prices are below average replacement cost. The EIA projects that natural gas prices will rise with the cost over time, increasing faster than crude oil prices after 2017. Although low natural gas prices should rise to sustainable levels in the long-run, low prices in the near-term will impede the development of the shale gas industry in Pennsylvania, reducing the economic benefit of this incredible resource to the state.

At the request of the Pennsylvania Natural Gas Development Group, this report analyzes four options for boosting demand for locally produced natural gas. These four options would require varying amount of support at the state level and produce different outcomes.

1. CNG Vehicles
2. Allegheny Pipeline
3. Electric Vehicles
4. U.S. LNG exports from Gulf Coat

Prices for natural gas are driven by the interaction of natural gas supply and demand. Demand depends, in large part, on the relative price of other fuels, economic growth and weather, which drives heating demand in the winter and demand for gas-fired generation for cooling in the summer. To increase demand for natural gas in Pennsylvania, there are two options: increasing domestic (in-state) consumption and increasing net exports of gas.

Production = Consumption + (Exports - Imports) + (Injections - Withdrawals) + Losses

Here we assume the annual net storage of natural gas and net loss is stable. The four projects we analyze fit into this framework. To increase consumption, we consider the use of natural gas in transportation sector, more specifically using natural gas through Compressed Natural Gas (CNG) vehicles and electric vehicles. To increase net exports, we examine two options: moving gas to the New York and New Jersey markets and moving gas to the Gulf Coast to be liquefied and sold internationally as LNG.


2 EIA Annual Energy Outlook 2012: http://www.eia.gov/forecasts/aeo/source_natural_gas_all.cfm#marginal
CNG dual fuel vehicle

Passenger Vehicles

According to the American Council for Energy-Efficient Economy, the transportation sector consumes approximately 28% of all end-use energy in the United States. Unlike the production of electricity, energy consumption in the transportation sector heavily depends on imported oil. With much of the world’s petroleum reserves located in politically volatile countries, the U.S. is vulnerable to supply disruptions. U.S. natural gas reserves are abundant; this alternative fuel can be domestically produced and used to offset the petroleum currently being imported for transportation use.

In order to evaluate whether adopting passenger natural gas vehicles is feasible or not, we analyze American Motors’ business proposal. Since the adoption of the dual fuel vehicles hinges on availability of CNG filling stations, we analyze the profitability of building CNG stations for this target market. According to the Alternative Fuels Data Center, there are currently 36 CNG stations in Pennsylvania and only 13 of them are public. On the other hand, there are approximately 4,500 gasoline stations.

Below are the assumptions used in the analysis:

- 2011 vehicle efficiency standards as estimated by the Energy Information Administration
- Average number of miles driven annually per vehicle is 12,000
- Gasoline price is $3.28/GGE
- CNG price is $2.01/GGE
- Consumers use either fuel half the time
- Average passenger vehicle lifespan is 10 years
- Buyers’ discount rate = 1

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Technology</th>
<th>Efficiency (Miles/GGE)</th>
<th>Annual Demand (GGE)</th>
<th>Fuel Expenditure on Fuel ($)</th>
<th>10-yr Expenditure ($)</th>
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<tr>
<td>Automobile</td>
<td>Gasoline</td>
<td>31.58</td>
<td>380</td>
<td>1248</td>
<td>12480</td>
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<td>CNG Bi-fuel</td>
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<td>1021</td>
<td>10210</td>
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<tr>
<td>Light-duty truck</td>
<td>Gasoline</td>
<td>23.81</td>
<td>504</td>
<td>1655</td>
<td>16550</td>
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<tr>
<td></td>
<td>CNG Bi-fuel</td>
<td>22.92</td>
<td>524</td>
<td>1387</td>
<td>13870</td>
</tr>
</tbody>
</table>

Table 1

Annual fuel demand per vehicle is calculated by dividing number of miles driven in a year by a vehicle’s efficiency. Under the 0% interest rate promotional program for dual fuel vehicles, the total cost of a dual fuel Sentinel would exceed that of a standard model by $900 while the dual fuel Admiral would be $585 more expensive than the standard one. Using the above assumptions, consumers would on average save $227 dollars on fuel expenditure per year when using the dual fuel Sentinel versus the standard Sentinel. Annual fuel expenditure savings from the dual fuel Admiral is $268. Over the lifetime of a

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3 For details see http://aceee.org/portal/transportation.
vehicle, total savings on fuel expenditure would be $2272 and $2684 for the dual fuel Sentinel and Admiral, respectively. The program makes dual fuel vehicles attractive and given an adequate number of CNG filling stations, then buyers would be inclined to purchase dual fuel vehicles over the standard vehicles.

However, since the program is only for two years, when the 4% interest rate is applied across board, the dual fuel vehicles cost $3,000 more than their standard versions, which means that it would be uneconomical for consumers to buy the dual fuel vehicles after the two-year program ends. If American Motors is the only car manufacturer planning to sell dual fuel vehicles in Pennsylvania in the near future, then natural gas consumption in passenger vehicles will be very low, which would make it unprofitable to build CNG filling stations to cater to household demand.

One way to spur demand for the dual fuel vehicles after the expiration of American Motors’ vehicle program would be for the Pennsylvanian government to give a tax credit of approximately $800 to buyers of dual fuel vehicles. In this case, we assume that American Motors sells the vehicles at their fair market price since selling at a price lower than that would require further subsidization. We estimate natural gas demand under different dual fuel vehicle demand scenarios, still assuming that households make their vehicle purchase choice under the belief that they can easily access CNG and gasoline filling stations. We also estimate how much the dual fuel vehicle subsidy would cost the government.

At the fair price, American Motors sells 11,000 Sentinels and 22,000 Admirals per year. The number of dual fuels that will be sold, given different assumption about the share of dual fuel vehicles are given in the table below. Assuming that sales stay similar each year, total number of dual fuel vehicles in Pennsylvania would peak at the 10th year and remain constant thereafter.

<table>
<thead>
<tr>
<th>Share of total sales</th>
<th>Sentinel dual fuel</th>
<th>Admiral dual fuel</th>
<th>Total vehicle subsidy ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>8800</td>
<td>17608</td>
<td>21</td>
</tr>
<tr>
<td>50%</td>
<td>5500</td>
<td>11005</td>
<td>13</td>
</tr>
<tr>
<td>30%</td>
<td>3300</td>
<td>6603</td>
<td>8</td>
</tr>
<tr>
<td>10%</td>
<td>1100</td>
<td>2201</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2
CNG Station Project Analysis

According to our calculations, building CNG filling station infrastructure to target the household sector is not economic for station owners if the state government does not give them grants to help cover costs. This is because catering to passenger vehicle refueling needs would require building enough stations across the state in order to make it enticing for households to buy dual fuel vehicles. Our analysis assumes that 100 regular stations would be built, which is a very low number for a state as large as Pennsylvania. The filling stations are assumed to have a physical lifespan of 20 years. Without
government involvement, cumulative cash flows for the CNG stations are negative for all years and for all scenarios.

The option of assigning municipal bond status to the capital debt that would be incurred by station builders results in negative cumulative cash flows in the 10 and 30 percent adoption scenarios, even when assuming that the debt is serviced at close to 0%. Cumulative cash flow for the 50 percent scenario turned positive only at the 18th year of the project, while the 80 percent case had positive cumulative cash flow at the 14th year of the project. The other alternative considered was exempting CNG filling stations from state tax but this also resulted in negative cumulative cash flows for all scenarios for the assumed lifetime of the stations.

While the option of tax credits incentive as envisioned by the Governor’s office does greatly improve the economics of the project for station builders, the cost incurred by the government alone far exceeds revenues generated even in the best case scenario. The credits would cost the government close to $6 billion while the stations would generate approximately $2 billion during the 20 years. Therefore it would not make economic sense to encourage CNG use through tax credit incentives to station builders.

Focusing initial efforts on the cities of Philadelphia and Pittsburgh does not improve the results. The combined population of the two cities is approximately 15 percent of the state population. We adjusted the vehicle sales numbers using this population ratio and assumed that 8 new filling stations would be build. The outcome closely mirrors the national one. It has to be taken into consideration that 100 filling stations for the state or 4 for a city like Philadelphia is too small a number and it would require consumers to travel long distances if they want to access CNG stations. This in itself would deter people from buying dual fuel vehicles because there would be no point in owning these vehicles without convenient access to CNG.

Calculations were also done for the CNG mini stations. While they are cheaper to build than regular stations, they are smaller, and thus more of them would be required to fulfill same fueling needs. If the government plays no role, cash flows for these stations make them unattractive. The best case scenario, 80 percent, has positive cumulative cash flows starting at the 15th year. The other cases have negative cash flows throughout. Results from the different government incentive programs are similar to those obtained for regular stations.

**Heavy-duty vehicles**

According to the “Business Case for Compressed Natural Gas in Municipal Fleets” paper, converting heavy-duty vehicles that consume large quantities of fuel make is a better approach than targeting passenger vehicles. More specifically, the best candidates are refuse trucks, followed by transit buses. According to the same report, using natural gas to fuel certain heavy-duty vehicles made economic sense even without any government subsidies because of a combination of the fuel cost savings and the long life of the vehicles in question (12 years for a refuse truck and up to 15 years for a transit bus).

Although there are challenges to CNG vehicles, there is a good example that State of Pennsylvania can adopt, that is the case of California’s Interstate Clean Transportation Corridor (ICTC) which connects Southern California, Northern California, Salt Lake City, and Las Vegas along more than 1,800 miles of
some of the nation’s most heavily travelled highways. With this project, independent truckers are able to make their deliveries essentially anywhere in California using CNG vehicles by using the refueling infrastructure build along the ICTC. With these stations, CNG vehicles are able to travel long distances using domestically produced natural gas instead of diesel fuel.
Allegheny Pipeline

The Allegheny Pipeline is a proposed pipeline that connects the shale producing regions in north central Pennsylvania to the East Coast pipeline system in New Jersey, providing Marcellus Shale gas producers with improved access to New Jersey and the New York metropolitan area.

Figure 2: The Allegheny Pipeline

The new pipeline project will (1) be profitable to firms without requiring a government subsidy (unlike CNGV), (2) increase the demand for Pennsylvania natural gas, (3) have a positive impact on wellhead prices and (4) provide substantial economic benefit during the initial investment phase and by promoting increased drilling activity.

High transmission costs create a wedge between suppliers and consumers of natural gas. The Allegheny pipeline will significantly lower costs of moving locally-produced gas to hungry markets in New York and New Jersey, effectively increasing the geographic scope of demand for producers who utilize the pipeline. Projected increases in natural gas consumption in the northeast, our low marginal costs for producing gas versus the rest of the country and the presence of capacity constraints mean that the additional pipeline capacity will be utilized.

**The project is profitable to the upstream and midstream producers, and no subsidy is needed from the government.**

Before building a physical pipeline, operators must get a minimum number of gas producers to subscribe to the line’s capacity to guarantee that there will be demand for the infrastructure. This requires suppliers who want to sell gas destined for New York and anticipate demand for it in the market there. Given the advanced stages of the Allegheny pipeline approvals and the considerable costs to pipeline operators to obtain such regulatory approvals, it seems safe to assume that the construction of the pipeline will benefit both upstream producers and the midstream operators.

While profitability of the project is not of direct concern to the governor, it is a sign that the project should create value for the state’s economy and provide jobs. Furthermore, given that firms already want to build the pipeline, there is no need to encourage the investment with tax incentive, so other than political capital and any costs of regulating the pipeline’s operation, the project should cost the
government nothing. The creation of new tax revenue from increased economic activity should mean the pipeline has a positive impact on the state’s budget.

The Allegheny pipeline will allow Pennsylvania to help meet increasing demand for natural gas in the Northeast.

Demand for natural gas in the Northeast should exogenously increase in future years. A 2000 study by the American Gas Association showed that increased conversion to residential natural gas heating substantially boosted residential consumption between 1980 and 1997. The market penetration of gas heating was the lowest in the Northeast out of the entire US, suggesting room for additional increases. Additionally, there have been numerous new EPA regulations on emissions from coal-fired power plants in recent years that will increase the costs of electricity generation from coal. Together with natural gas prices that are forecast to be relatively low for the foreseeable future, this should cause substitution from coal-fired to natural gas fired electricity generation.

Low production costs mean Pennsylvania gas can displace gas supplied to the Northeast by other producing regions.

Historically, the Northeast has imported large quantities of gas from the Southeastern and Central US and Canada, as well as costly LNG from around the world to meet demand. Local Pennsylvania gas should be able to displace gas from these far-away regions because of its low production and transportation costs. According to the energy investment bank Tudor, Pickering and Holt, of all of the US gas-bearing shale formations, the Marcellus has the lowest production costs—lower even that Gulf Coast gas. Rice University’s Baker Institute estimates for production costs by shale place the Marcellus Tier One shale as the third-least expensive out of over two dozen other formations. Furthermore, Pennsylvania’s proximity to the Northeast means that distances from production to market are much shorter, reducing transportation costs. Thus, even if demand in the Northeast does not grow extremely fast, Pennsylvania producers should have a market for their production.

The Allegheny line will reduce bottlenecks in a constrained transmission system that has and will prevent Pennsylvania producers from selling their gas in the areas of most demand.

According to EIA data from the State Energy Data System (SEDS), natural gas production in PA averaged 0.56 Bcf/d in 2008. A recent EIA estimate placed monthly gas production at over 10 times that in June 2012 (over 5.6 Bcf/d). Forecasts for 2015 production by BENTEK and the 2011 Pennsylvania State

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University report on the impact of shale gas in Pennsylvania⁸ are 10 and 12 Bcf/d, respectively—roughly double that of 2012. Pennsylvania’s production in 2015 should be enough to satisfy the vast majority of its in-state demand (2.4 Bcf/d in 2010) plus New England⁹ (7.6 Bcf/d in 2010), particularly if natural gas consumption only grows at 2%—the approximate annual growth rate in national gas consumption projected by the EIA for the next several years.

Much of this new supply could be transported through existing interstate transmission system that runs through Pennsylvania (TGP, Transco, Texas Eastern, to name a few), displacing gas from the West and South. Some of it will also displace Canadian gas, which enters the Northeast through pipelines that have a combined capacity of 4.4 Bcf/d. If these pipelines are utilized at just 60%, and Pennsylvania displaces 50% of the imports (some forecasters predict it will displace 100% of this production), transmission lines from Pennsylvania will need to handle an additional 1.6 Bcf/d of completely new demand, which is 78% of the capacity to be added by the three new Pennsylvania pipelines. As a point of reference, average pipeline volumes in the Northeast were 78% of capacity in winter 2011, resulting in price spikes and capacity constraints¹⁰.

The additional capacity represented by the Allegheny pipeline is relatively modest compared to net interstate pipeline capacities, which are currently a constraint on the market. EIA data show that in 2011, New York and New Jersey’s combined total net inflow pipeline capacity was 8.7 Bcf/d, and the gross inflow capacity from Pennsylvania was 11.5 Bcf/d¹¹. Currently, there appear to be only two major projects that will increase Pennsylvania transmission capacity to New York and New Jersey: the new Constitution Pipeline (.65 Bcf/d) and an expansion to the Tennessee Gas Pipeline Company’s relatively new 300 Line (.64 Bcf/d). Together with the .75 Bcf/d increase in capacity from the Allegheny line, the additional capacity will be 2.0 Bcf/d. Even though the .35 Bcf/d 300 line is quite new, an expansion to it is still needed to reduce capacity constraints.

**Recent price spreads are evidence of pipeline constraints.**

In 2012, prices along the new 300 Line connecting new Marcellus shale production in Pennsylvania to the Tennessee Gas Pipeline Company’s routes into New Jersey and New York have been significantly lower than national benchmarks for a number of months, evidence of an insufficient transmission infrastructure in Pennsylvania. A recent article by Platts pointed out that though there will be a  

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⁹ Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont

¹⁰ [http://www.eia.gov/todayinenergy/detail.cfm?id=170](http://www.eia.gov/todayinenergy/detail.cfm?id=170)

¹¹ [http://www.eia.gov/naturalgas/data.cfm#pipelines](http://www.eia.gov/naturalgas/data.cfm#pipelines)
significant increase in pipeline capacity to serve Marcellus production, little of the increase will actually address the bottlenecks between production and urban demand in the Eastern seaboard\textsuperscript{12}.

**Impact: Increased production**

Assuming that the pipeline achieves a 60% utilization and that 50% of this is marginal production which would not occur without the lower transportation costs provided by the pipeline, Pennsylvania production will increase by 225 MMcf/d when the pipeline is completed—2% of an 11 Bcf/d 2015 production forecast. If the pipeline achieves a 75% utilization and all of this gas is marginal production (production that would not happen without the pipeline), demand will increase by 563 MMcf/d—5% of 2015 production.

\textsuperscript{12} “New Northeast gas pipeline projects may not breach traditional bottlenecks.”
http://www.platts.com/newsfeature/2012/naturalgas/uspipelines/index
Impact: Increased wellhead prices and profits

Gas in New York and New Jersey (the target markets for the Allegheny pipeline) trades at a premium to national benchmarks, which more closely reflect our wellhead prices. It is commonly known that very cold winters can cause demand for gas in the Northeast to exceed pipeline capacity during particularly cold winter days. This leads to large spikes in the difference between national benchmarks at the Henry Hub in Louisiana or Dominion South Point Hub in central-southwest Pennsylvania. While these spikes are related to particularly extreme weather, there is still a persistent premium during low demand season. The producers served by the Allegheny pipeline hope to capture some of this differential as profit.

Since January 2002, the average monthly spread between Dominion South Point and NYC prices has been $0.66/MMbtu, and it has climbed somewhat over time. Rarely has this basis differential fallen
below $0.10, even during off-peak summer months, especially since 2008. Instead, it has remained in the $0.15 to $0.53 range (the middle 50% of the distribution) for a significant portion of the year. The added Allegheny pipeline capacity may reduce the price spikes but it seems unlikely to completely eliminate the baseline differential.

The table below breaks out a variety of scenarios for the annual, marginal increase in state revenue that could result from the Allegheny pipeline. The main assumptions are:

- The Allegheny pipeline bypasses the main bottlenecks in New York, allowing producers to capture the majority of the price differential.
- Average price differentials for the past 10 years will continue, except for the largest ones in wintertime. These will top out at $0.50, due to additional pipeline capacity being built.
- The past 10 years of New York and New Jersey’s combined gas consumption are representative of monthly pipeline flows.
- The tariff that matters is the *marginal* tariff (i.e., the tariff rate over and above an older pipeline that has depreciated its capital and charges a lower rate).

A reasonably conservative range for the additional profit for gas producers that is attributable directly to the Allegheny pipeline seems to be $33 to $70 million per year, due to an average boost in wellhead prices between $0.24 to $0.34. While total additional profit number seems small, it is simply the *marginal increase* in profit to producers over and above a counterfactual world where the gas is sold at the Dominion South Point, not New York City.
### Marginal Profit to Gas Producers due to Allegheny Line

<table>
<thead>
<tr>
<th>Month</th>
<th>Share of Annual Flows</th>
<th>Historical Spread</th>
<th>Post Allegheny Spread</th>
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<tbody>
<tr>
<td>January</td>
<td>13%</td>
<td>$3.02</td>
<td>$0.50</td>
</tr>
<tr>
<td>February</td>
<td>12%</td>
<td>$1.21</td>
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</tr>
<tr>
<td>March</td>
<td>11%</td>
<td>$0.43</td>
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</tr>
<tr>
<td>April</td>
<td>8%</td>
<td>$0.18</td>
<td>$0.18</td>
</tr>
<tr>
<td>May</td>
<td>6%</td>
<td>$0.11</td>
<td>$0.11</td>
</tr>
<tr>
<td>June</td>
<td>6%</td>
<td>$0.19</td>
<td>$0.19</td>
</tr>
<tr>
<td>July</td>
<td>6%</td>
<td>$0.31</td>
<td>$0.31</td>
</tr>
<tr>
<td>August</td>
<td>7%</td>
<td>$0.28</td>
<td>$0.28</td>
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<tr>
<td>September</td>
<td>6%</td>
<td>$0.22</td>
<td>$0.22</td>
</tr>
<tr>
<td>October</td>
<td>6%</td>
<td>$0.22</td>
<td>$0.22</td>
</tr>
<tr>
<td>November</td>
<td>8%</td>
<td>$0.24</td>
<td>$0.24</td>
</tr>
<tr>
<td>December</td>
<td>11%</td>
<td>$1.56</td>
<td>$0.50</td>
</tr>
</tbody>
</table>

Capacity (MMcf/yr) 750  
MMbtu/ MMcf 1000  
Days/year 365  

| Marginal Tariff | $0.00 | $0.05 | $0.10 |
| Wellhead price: Vol-wtd marginal increase | $0.34 | $0.29 | $0.24 |

Utilization | Additional Profit from increased wellhead prices |
75% | $70,348,355  
60% | $56,278,684  
50% | $46,898,903  

<p>| | |</p>
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### Table 3

**Impact: Sustained increases in production boost economic activity**

The economic benefit to the State of Pennsylvania could be much higher if the pipeline makes it profitable for firms to drill new wells, significantly boosting economic activity. If average flows from additional wells are 3 MMcf/d for the first 4 years, a 75% utilization rate that produced a 33% increase in the number of wells drilled would mean 62 new wells created. Assuming a 100% success rate (far too high) a drilling cost of $10 million per well, would mean $620 million of new investment in Pennsylvania—over half of the cost of the pipeline itself.

Without more detailed data on the exact geography of existing pipeline transmission infrastructure, bottlenecks in the system and future locations of gas production, it is impossible to give a precise, rigorous estimate of the difference in gas production and wellhead prices with and without the

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Allegheny pipeline. However, given the eagerness of producers to see the Allegheny pipeline built, the price differentials that suggest current capacity constraints, the limited number of new pipelines being built, the enormity of the future production increases and the increased capacity needed to displace Canadian gas, it seems very likely that the Allegheny pipeline will be heavily utilized. The economic impact of the pipeline is not so much in the increased profit existing producers will get from an increased wellhead price, but the entry of marginal wells permitted by the decrease in transportation costs.

Impact: Initial Investment

The construction of the pipeline will be a significant positive demand shock for both New Jersey and Pennsylvania during the construction period 2013-2015 (expected). Depending on the total expenditures involved in the construction of the pipeline, initial investment should boost employment, labor income, GDP and state and local tax revenues.

Estimation of the pipeline’s cost requires a number of assumptions:

- **Type**: Transport line\(^{13}\). The different types of pipelines usually have different size and right-of-way, and thus different cost.

- **Size**: Transport lines vary in size, generally ranging from 24 to 36 inches in diameter.

- **Length**: In general, the cost-per-mile within a given diameter decreases as the number of miles rises. Given that the width of Pennsylvania is 280 miles, the map appears to show that the pipeline is 189 miles long. 151 of these miles are in Pennsylvania.

- **Construction period**: Pipeline construction is usually completed within 18 months and sometimes in as little as 6 months. Given the substantial economic benefits to the state, we expect that the governor can help reduce the timeframe of the DBRC review to 2. An 18-month construction period would mean the pipeline would be in service in approximately 2015.

We looked up all new pipeline projects in Pennsylvania with completion dates during 2010-2015 (Appendix A). The first, Constitution Pipeline, is a very similar project to the Allegheny pipeline, taking new Marcellus production to urban markets in the Northeast. It has similar length, capacity and service date as the Allegheny Pipeline. We take its cost as our baseline scenario. The last two projects in the table have a short length and large diameters (42in), which make them representative of a high cost scenario. The average cost per mile of the eight projects gives a low scenario. The following table breaks out these three scenarios.

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\(^{13}\) Natural gas transportation infrastructure consists of gathering lines which take the gas from each well to a transport line which takes the gas either to another transport line or directly to.
Table 4: Estimated costs of the Allegheny pipeline

For all three scenarios, the expected cost is over $1 billion. However, only part of the investment will be spent on the local inputs. Here we follow a report by Rutgers issued in 2011 and assume 36% will be spent in New Jersey and Pennsylvania, which is about $412 million to $580 million.

A standard way to estimate the economic impact of an initial investment to a region is with a regional Input-Output (IO) model. Authors at Rutgers University estimated the regional economic benefits of Kinder Morgan’s Northeast pipeline upgrade project in New Jersey and Pennsylvania using the Rutgers Economic Advisory Service Input-Output Model. Given the similarities in region, time period and type of investment, it is appropriate to use the multipliers from Rutgers’ report as our base scenario. Assuming that investment is spread uniformly along the length of the pipeline, 80% of the investment impact should take place in Pennsylvania. The table below presents the estimated increases in Pennsylvania jobs, labor income, GDP, and tax revenue generated during the initial investment phase of the Allegheny line (2013-2015).

Table 5: Increased economic activity due to initial investment phase (million dollars)

Spending for the Allegheny Pipeline project in PA and NJ will generate large economic benefits for PA. During the two core years of project (2013-2015, expected), approximately 189 miles of pipeline will be installed. Under the baseline scenario, the project is expected to cost approximately $1.2 billion. While part of this will be paid to firms and workers outside of the state, about $336 million will be spent in Pennsylvania. This large, initial investment will create approximately 4,933 jobs, increase labor income by $205 million, boost state GDP by $279 million and generate $104 million in local and state tax revenue.

Electric Vehicles

Starting from 2008, the share of natural gas in Pennsylvania’s power generation has increased. In 2011, Pennsylvania generated 44% of its net electricity from coal, 33% from nuclear and 18% from natural gas. According to report on Pennsylvania’s combined heat and power (CHP) baseline assessment, power generation capacity mix is more likely to shift towards natural gas-fired combined cycle and combustion turbine.

To understand the demand for natural gas from electric vehicles, we use the EIA’s projections on total new car sales by technology type in Mid-Atlantic.\(^\text{15}\) We assume that the power for newly sold electric vehicles is generated from natural gas-fired combined cycle power plant and use this as upper bound for natural gas demand derived from electric vehicles.

![Projected natural gas demand from new electric vehicles sold in PA](image)

**Figure 5**

Based on EIA’s projections expected demand\(^\text{16}\) of natural gas from 100 mile electric vehicle sales in 2013 is 2.01 MMcf and it is expected to increase to 48.29 MMcf by 2022.\(^\text{17}\)

\(^{15}\) According to 2008 estimates, population of Mid-Atlantic States is 57,303,316 and the population of Pennsylvania is 12,743,000, which is roughly 22% of the total population of Mid-Atlantic states. We assume that 1/5 of total new vehicles in Mid-Atlantic will be sold in Pennsylvania.

\(^{16}\) EIA reports light-duty vehicle energy consumption in trillion BTU for past and future years for vehicle stock by technology type. However, their analysis considers the energy consumption by end-user and does not include the energy losses during production and transmission. These losses are significant especially in electricity generation. Thus, we calculate the energy consumption for electric vehicle on kWh by using the heat content of delivered electricity which is 3412 BTU per kWh. We assume that all electricity for the electric vehicle is generated by using natural gas combined cycle power plants with a heat rate of 7000 BTU per kWh. The heat rate of 7000 BTU per kWh is equivalent to a thermal efficiency of about 48%. Considering that a modern NGCC plant has a thermal efficiency of about 53% our assumption compensates for average line losses in transmission about 3-5%.
More realistic demand estimates would require using the electric generation composition in Pennsylvania. If we assume that 18 percent of 2.01 MMcf is generated by natural gas combined cycle then the demand for natural gas in 2013 is projected to be 0.36 mcf.

Our demand projections for natural gas are based on EIA’s new light-duty vehicle sales by technology type. Next, we relax EIA’s assumptions and assume that federal government gives a big tax credit for electric cars and the number of 100 mile electric vehicles sales are going to be 80%, 50% and 30% higher than EIA’s sales projections. Under this scenario, demand for natural gas in 2013 would be 0.65 MMcf, 0.54 MMcf and 0.47 MMcf, for the respective scenarios. We assume that electric generation composition in Pennsylvania stays the same until 2035. (The share of natural gas in power generation is assumed to be 18%).

![Projected natural gas demand of newly sold Electric Vehicles (EVs) in PA (18% of power is generated from natural gas combined cycle power plant)](image)

If we assume that power is generated by natural gas combined cycle power plant, then demand for natural gas will be 3.62 MMcf in 2013 in high electric vehicle demand scenario. When we look at the power capacity of Pennsylvania, we see that existing capacity\(^\text{18}\) in 2010 is sufficient to meet 2013 demand from electric vehicles sales.\(^\text{19}\)

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\(^{17}\) We assume that all the power needed is generated by natural gas combined cycle power plant.

\(^{18}\) In 2010, total electric power industry (from all sources) capacity in Pennsylvania is 49650 Megawatt-hours.

\(^{19}\) We look at the scenario of 80% higher sales of electric vehicles than EIA’s reference case projections. Under this scenario, demand for power is 1708.7 Megawatt-hours.
Electric vehicles are promising in terms of their energy efficiency. However, with current technology, there substantial challenges to their increased adoption. The upfront cost of electric vehicles is higher than gasoline vehicles due to the high cost of the battery. According to EIA’s report, the current incremental consumer purchase cost of a battery electric vehicle relative to a comparable conventional gasoline vehicle is $20,000 before accounting for Federal and State tax incentives. According to EIA’s calculations, although consumers may value high-cost battery electric vehicles for a variety of reasons, it is unlikely that they can achieve wide-scale market penetration while their additional purchase costs remain significantly higher than the present value of future fuel savings.

Also, the battery of an electric vehicle has a five year life time which increases the life time cost of electric vehicle. Duration of recharging the battery is significantly longer than filling the tank with gasoline. For instance, typical 120-volt outlets can take up to 20 hours for a full EV battery to recharge; a 240-volt outlet can reduce the recharging time to about 7 hours.\(^\text{20}\)

Considering these challenges, it is hard to persuade consumers to purchase electric vehicles. That is why even in high demand scenario in 2013, demand for natural gas will be insignificant.

\(^{20}\) For details see http://www.eia.gov/forecasts/aeo/pdf/0383%282012%29.pdf page 35.
U.S. LNG Exports from Gulf Coast

Per Dr. Frank’s request, we analyze adding export capability to existing Gulf Coast import terminals. In general, future U.S. exports of LNG depend on a number of factors that are difficult to anticipate and thus are highly uncertain.

According to analysis by Medlock (2012), which is based on Rice World Gas Trade Model (RWGTM), the spreads between the Japan/Korea Marker, Henry Hub and UK National Balancing Point prices are not sufficient to cover liquefaction and transport costs and support long-term baseload LNG exports from the US Gulf Coast to these regions.

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2011-2020</th>
<th>2021-2030</th>
<th>2031-2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed gas cost ($/mcf)</td>
<td>$3.80</td>
<td>$3.98</td>
<td>$4.69</td>
<td>$5.26</td>
</tr>
<tr>
<td>Liquefaction ($/mcf)</td>
<td>$2.92</td>
<td>$2.92</td>
<td>$2.92</td>
<td>$2.92</td>
</tr>
<tr>
<td>Transport cost ($/mcf)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>$1.07</td>
<td>$1.07</td>
<td>$1.07</td>
<td>$1.07</td>
</tr>
<tr>
<td>Japan</td>
<td>$2.15</td>
<td>$2.15</td>
<td>$2.15</td>
<td>$2.15</td>
</tr>
<tr>
<td>Landed cost ($/mcf)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>$7.79</td>
<td>$7.97</td>
<td>$8.67</td>
<td>$9.25</td>
</tr>
<tr>
<td>Japan</td>
<td>$8.87</td>
<td>$9.05</td>
<td>$9.75</td>
<td>$10.33</td>
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<tr>
<td>Market price ($/mcf)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>NBP</td>
<td>$8.84</td>
<td>$7.47</td>
<td>$7.44</td>
<td>$8.09</td>
</tr>
<tr>
<td>JKM</td>
<td>$11.73</td>
<td>$8.08</td>
<td>$7.98</td>
<td>$8.46</td>
</tr>
<tr>
<td>Export margin ($/mcf)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>$1.06</td>
<td>$(0.49)</td>
<td>$(1.23)</td>
<td>$(1.16)</td>
</tr>
<tr>
<td>Japan</td>
<td>$2.86</td>
<td>$(0.56)</td>
<td>$(1.77)</td>
<td>$(1.87)</td>
</tr>
</tbody>
</table>

Table 6: The Prospect of LNG Exports (LNG Exports Margin - Averages)

Medlock (2012) compares the “landed” cost of natural gas to the spot market price, simulated by RWGTM, to examine the margin on exports. According to his analysis, profitable trade including a return to capital is in the very near term only. The simulation results indicate that as current capacity constraints are alleviated, the export margin turns negative, indicating trade becomes unprofitable. Based on these results, LNG exports from Gulf Coast is off the table.

In 2010, the United States imported 11 percent of its total natural gas supply. In the EIA Annual Energy Outlook 2012, U.S. natural gas production grows faster than consumption, so that U.S. LNG exports will begin in 2016 at 1.1 Bcf/d, doubling to 2.2 Bcf/d by 2019.

Based on EIA projection, LNG exports cannot help our case at least by 2016. Even after LNG exports starts, the long distance from Marcellus shale to Gulf coast will make the cost uncompetitive to the gas

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22 Table 1 is borrowed from Medlock (2012).
from Texas and Louisiana. It is reasonable to assume that LNG from Pennsylvania is only a small percent of the total export (less than 20%), which would be less than 225MMcf/d demand increased by the new pipeline.
Summary and Conclusions

This report analyzes four possible options for boosting the natural gas price and supporting locally produced natural gas: increased use of Compressed Natural Gas Vehicles (CNGV), construction of the new Allegheny pipeline, promotion of Plug-in Electric Vehicles (PEV) and export of Pennsylvania’s shale gas via US Gulf Coast LNG terminals.

<table>
<thead>
<tr>
<th>Impact</th>
<th>CNGV</th>
<th>Allegheny Pipeline</th>
<th>PEV</th>
<th>LNG Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG Production levels</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Wellhead prices</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Government Revenue</td>
<td>Highly negative</td>
<td>Positive</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>Economic activity</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 7: Economic impacts of four natural gas price boost options

Based on our analysis, the Allegheny pipeline project appears to be the best option. More than $1 billion initial investment will provide about $336 million local spending, create approximately 4,933 jobs, increase labor income by $205 million, boost state GDP by $279 million and generate $104 million in local and state tax revenue. After the pipeline is in service, it will be heavily utilized. Its presence will increase demand for local natural gas in the neighborhood of 225-563 MMcf/d and boost wellhead prices between $0.24 and $0.34. This will result in increased shale gas production, which, given the investment required to drill new wells, should be another significant boost to the local economy.

The increase in natural gas demand due to adoption of dual vehicles is minimal, even in the best-case scenario, compared to the boost in demand that would result from the Allegheny pipeline. With the magnitude of the state subsidy that Dr. Bryant, of the Governor’s Office mentioned in the letter, the best-case scenario shows total number of dual fuel vehicles peaking at less than 300,000, and consuming approximately 22 MMcf/d of natural gas.

The last two options (electric vehicles and LNG exports) were not promising. Given the current state of electric vehicle technology, it is hard to persuade consumers to purchase electric vehicles. In the highest scenario, increased demand of natural gas is 2.01MMcf in 2013, and 3.62MMcf in 2035. LNG exports from Gulf Coast also cannot help much especially in the near future.

In conclusion, the new pipeline project is highly recommended in order to boost the natural gas demand in the short term. Although the pipeline may not offer the Governor as much high-profile publicity or appear to burnish a green image, its positive economic impact on the state is far greater than the other options. While a CNGV project may seem fashionable, the benefits to the natural gas industry are
minimal, and the costs are enormous. We hope Governor will make advocating for the Allegheny pipeline a priority. The use of political capital will pay off handsomely.
Appendix

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Year In Service</th>
<th>Stat es</th>
<th>Costs (million $)</th>
<th>Length (miles)</th>
<th>Additional Capacity (MMcf/d)</th>
<th>Pipeline Diameter (Inches)</th>
<th>costs/mile</th>
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</thead>
<tbody>
<tr>
<td>Constitution Pipeline</td>
<td>2015 PA, NY</td>
<td>750</td>
<td>121</td>
<td>650</td>
<td>30</td>
<td>6.20</td>
<td></td>
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<tr>
<td>Transco Rockaway Delivery</td>
<td>NY</td>
<td>12</td>
<td>3</td>
<td>530</td>
<td>26</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td>Iroquois NY Marc</td>
<td>2014 NJ, NY</td>
<td>500</td>
<td>66</td>
<td>200</td>
<td>36</td>
<td>7.58</td>
<td></td>
</tr>
<tr>
<td>AES Mid-Atlantic Express</td>
<td>2013 MD, PA</td>
<td>225</td>
<td>88</td>
<td>1500</td>
<td>30</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>Sunrise</td>
<td>2012 PA, WV</td>
<td>272</td>
<td>50</td>
<td>314</td>
<td>24, 20, 16</td>
<td>5.44</td>
<td></td>
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<tr>
<td>Appalachian Gateway</td>
<td>2012 WV, PA</td>
<td>635</td>
<td>110</td>
<td>484</td>
<td>30, 24, 20</td>
<td>5.77</td>
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<tr>
<td>N/A</td>
<td>2010 PA</td>
<td>35</td>
<td>4</td>
<td>42</td>
<td></td>
<td>8.81</td>
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<tr>
<td>N/A</td>
<td>2010 PA</td>
<td>17</td>
<td>1.93</td>
<td>42</td>
<td></td>
<td>8.32</td>
<td></td>
</tr>
</tbody>
</table>

Data Source: EIA and Oil & Gas Journal special reports

Table 8: Pipeline cost in Northeast Area

Figure 8