



## ***NGV ROADMAP FOR PENNSYLVANIA JOBS, ENERGY SECURITY AND CLEAN AIR***



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## Executive Summary

The natural gas in the Marcellus Shale represents one of the largest energy reserves in the world. This clean-burning resource provides a unique opportunity for the transportation sector to move toward a lower-cost, lower-emission and domestic energy resource to meet our transportation needs in an economically and environmentally responsible manner. The Marcellus Shale Coalition (MSC) was organized by Industry leaders to promote the responsible development of natural gas, and to share best practices while working with, policymakers, business leaders and community partners to promote this use of locally produced natural gas as a transportation fuel. This *NGV Roadmap for Pennsylvania Jobs, Energy Security and Clean Air* report provides a roadmap for how such a transition can begin to take place.

## Recommendations and Next Steps

Effective implementation of this roadmap will require leadership at the state and local level in developing key policies, partnerships, incentive programs and messages to support the proposed Pennsylvania Clean Transportation Corridor (PCTC) program. Given the extremely important direct and indirect benefits that Pennsylvania will derive as a result of the successful development of the PCTC, it is recommended that Pennsylvania adopt a number of policies to support its implementation.

Policy recommendations include:

- Recognize and highlight existing Pennsylvania Natural Gas Vehicle (NGV) success stories;
- Adopt aggressive policy positions which promote NGVs as an economic stimulus for Pennsylvania;
- Modify existing and develop new in-state incentive programs focused on high-fuel use fleet applications and infrastructure development, and encourage the federal government to do the same;
- Allow bi-fuel NGVs certified by the U.S. Environmental Protection Agency to be sold in Pennsylvania as a critical refueling infrastructure and overall market-development strategy;
- Develop strategic partnerships that support effective long-term growth of the regional NGV market via effective outreach, education, programs, policies and strategic coordination.

## Overview

In the transportation sector, natural gas offers the single best opportunity to achieve immediate gains in energy security and reductions in bottom-line fuel expenses while also realizing significant reductions in criteria pollutant and greenhouse gas emissions. In Pennsylvania, expanding the natural gas transportation sector offers the added benefit of increasing the economic and employment potential associated with the Commonwealth's most prolific clean burning energy resource – natural gas from the Marcellus Shale.

A transition to natural gas transportation is both technologically feasible and economically viable. The use of natural gas as a vehicle fuel has experienced a consistent 10-12 percent growth rate in each of the last five years<sup>1</sup>. This is due in large part to the fact that natural gas vehicles offer a proven alternative fuel technology that delivers significant economic, energy security and environmental benefits.

Today's vehicle market – factory built or after-market retrofit/conversion – offers a natural gas vehicle (NGV) option for nearly every transportation application, from compact passenger vehicles such as the Honda Civic to heavy-duty trucks used to haul freight between major metropolitan areas<sup>2</sup>. Not only are NGV technologies readily available, but they offer immediate cost benefits, particularly in fuel-hungry, heavy-duty applications where operators report consistent fuel cost savings over diesel of 30-40 percent.

Because of domestic natural gas from the Marcellus Shale and other gas shale regions throughout North America, fleet operators are increasingly recognizing that natural gas is an abundant, stable and low-cost fuel option for their operations. Pennsylvania is well-positioned to benefit from NGV market growth and can assume a leadership role in the transition to a cleaner energy economy. These initial efforts will build a critical foundation, upon which a regional and multi-state NGV development strategy can be based.

### ***The Growing Natural Gas Vehicle Market***

- NGVs offer the single best opportunity to achieve immediate gains in energy security.
- The use of natural gas as a transportation fuel has been growing at a rate of 10-12 percent since 2006.
- Fleet operators report consistent fuel cost savings of 30-40 percent in their NGV operations compared to traditional fuel sources.
- Heavy-duty fleet operations such as refuse collection, transit, local trucking, municipal and utility, and other markets provide the best opportunities for NGV deployments.

<sup>1</sup> Stephen Yborra, Director of Market Analysis, Education & Communications, Clean Vehicle Education Foundation; Natural Gas Vehicle Market Development Opportunities in Canada: Navigating a Course for Success Lessons Learned/Observations from the US Market; Encana NGV Summit; February 16, 2011.

<sup>2</sup> Please see Appendix B for a comprehensive summary of the multitude of NGV product available in the market for each sector is also included in Appendix B to this roadmap report.

The roadmap uses both short- and long-term goals to provide an economically sustainable plan for long-term NGV market development. The short-term goal when selecting natural gas refueling sites is to support fleet targets whose operations can support cost-effective natural gas operations. These priority targets are likely to be heavy-duty fleets that use high volumes of fuel, that return to a centralized location each day, and that are generally located in urban centers. These fleets – such as those in the refuse, transit, regional goods movement, and other high-fuel-use applications – use enough fuel to quickly see a return on their investment in a refueling station.

This planned refueling infrastructure network will be largely based upon the urban, heavy-duty fleet operations in some of the larger metropolitan parts of Pennsylvania. While the exact location of each fueling station is, in many cases, to be determined, this network will connect Philadelphia, Pittsburgh, Harrisburg, Scranton/Wilkes-Barre, Allentown and neighboring states via key truck corridors such as I-76, I-80 and I-81.

***The Pennsylvania Clean Transportation Corridor is a strategically planned network of natural gas refueling infrastructure connecting:***

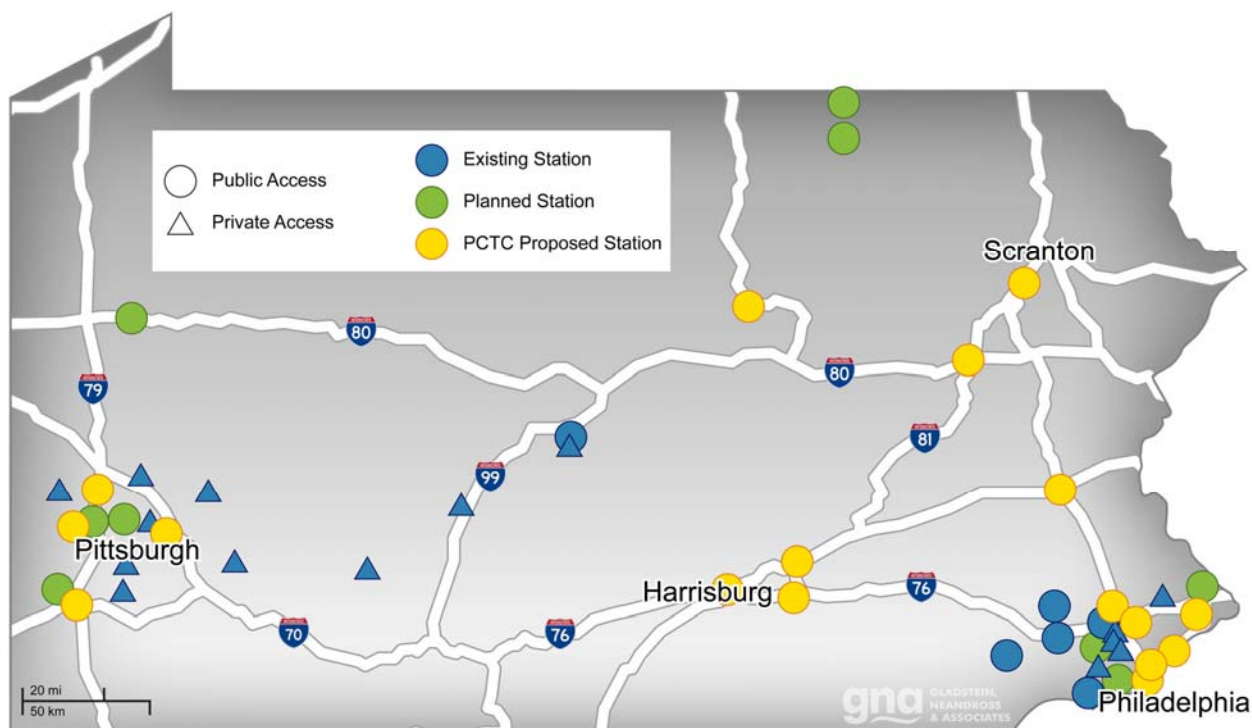
- Philadelphia
- Scranton / Wilkes-Barre
- Allentown
- Harrisburg
- Pittsburgh

***This corridor will serve as the cornerstone of a larger regional clean fueling network throughout the northeastern United States.***

The long-term goal when selecting natural gas refueling sites is to develop a public-access infrastructure corridor that can support NGVs in higher-fuel-consuming regional, intrastate and interstate trucking applications that originate in and pass through Pennsylvania. Therefore, fleet targets along key identified highway routes should be prioritized.

This strategically planned natural gas refueling infrastructure will serve as the foundation for the Pennsylvania Clean Transportation Corridor (PCTC), a fueling network that can then form the cornerstone of larger regional shift to natural gas truck operations in the Northeast United States. This large-scale shift to natural gas operations will rely on lower-cost, lower-emission and locally-produced natural gas.

This report provides a full outline for the PCTC development roadmap and the plan to connect the metropolitan regions of Philadelphia, Harrisburg, Pittsburgh, and Scranton via an economically sustainable natural-gas infrastructure network. The stations will be structured to facilitate the subsequent introduction of additional light-, medium- and heavy-duty natural gas vehicles from both the public and private sectors.



**Figure 1: Map of the Existing and Proposed Natural Gas Refueling Network within the PCTC**

This PCTC roadmap identifies a Foundation Case and a Developed Case development plan. Under the Foundation Case, the PCTC will develop eight new, strategically located and publicly accessible natural gas refueling stations along the identified route, and that will support the deployment of 400 heavy-duty natural gas vehicles (NGVs). Under the Aggressive Case, up to 17 new refueling stations will be established and 850 heavy-duty NGVs deployed. Both cases will provide the foundation to support further NGV deployments, both within the state and beyond its borders, thereby growing the market for natural gas vehicle fuel, supporting key economic sectors in the state, and providing significant environmental and public health improvements via transportation-related emission reductions.

The estimated total project investment is between \$98 million and \$208 million for the Foundation and Developed Case scenarios, respectively. These estimates include the total cost of all NGVs deployed under each scenario, the capital costs of the refueling infrastructure, the capital costs for maintenance facility upgrades that will allow for the indoor storage and repair of NGVs, and expenses related to personnel training and project management.

**Table 1: Pennsylvania Clean Transportation Corridor Project Summary**

	<b>FOUNDATION CASE</b>	<b>DEVELOPED CASE</b>
Total Stations	<b>8</b>	<b>17</b>
Total Trucks	<b>400</b>	<b>850</b>
Total Project Investment (in millions)	<b>\$98</b>	<b>\$208</b>

**Benefits**

The implementation of the PCTC will have significant economic benefits across multiple sectors of the Pennsylvania economy, including: business owners, transportation and logistics providers, the construction industry, Pennsylvania's manufacturing base, and the natural gas production and distribution industries. Under the Developed Case, the PCTC will result in a total investment in Pennsylvania's economy of up to \$208 million, and will have a direct impact on more than 1,350 jobs in Pennsylvania. In addition to the jobs directly tied to the PCTC project, this project will act as a market driver for the NGV industry in the Commonwealth and broader region. Since Pennsylvania is one of the nations' leading hubs for companies involved in the NGV vehicle, engine, fuel and fuel station value chain, the state is well-poised to benefit from both the direct and indirect job impacts and tax revenue benefits of the PCTC initiative.

The PCTC, under the Developed Case, will also displace 9.2 million gallons of diesel fuel with 1.4 billion cubic feet (BCF) of Pennsylvania-produced, lower carbon, and lower cost natural gas each year. Due to the significantly lower cost of natural gas compared to traditional petroleum fuels (gasoline and diesel), the PCTC will save Pennsylvania fleet operators an astounding \$9.2 million in fuel costs annually, savings that can then be reinvested in their business, personnel hiring, and the overall Pennsylvania economy.

In addition to the important job and economic benefits to be provided by the PCTC, the Developed Case will result in the annual reduction of 720 tons of nitrogen oxide (NOx) emissions, nearly 14.5 tons of diesel particulate matter (PM) emissions, and 21,000 metric tons of greenhouse gas (GHG) emissions. Because Pennsylvania already faces a number of air quality challenges, the environmental benefits of the PCTC are of particular significance, especially in the urban centers.

***The Pennsylvania Clean Transportation Corridor will:***

- Result in more than \$200 million in investment in Pennsylvania's economy.
- Have a direct impact on more than 1,350 jobs in Pennsylvania.
- Save Pennsylvania fleet operators nearly \$10 million in fuel costs annually.
- Yield more than \$60 million in tax revenue for the Commonwealth of Pennsylvania.
- Reduce emissions of diesel soot, ozone-causing pollution and greenhouse gas emissions.

**Table 2: Benefit Summary of the Pennsylvania Clean Transportation Corridor**

<b>Case</b>	<b>Foundation</b>	<b>Developed</b>
Total Stations	8	17
Total Trucks	400	850
Diesel Fuel Displaced (millions of gallons over 10 years)	43	92
Natural Gas Fuel Demand (BCF annually)	0.6	13.5
Annual NOx Emission Reductions (tons)	340	720
Annual PM Emission Reductions (tons)	6.8	14.5
Annual GHG Emission Reductions (metric tons)	9,900	21,000
Total Fuel Cost Savings (10 year project in millions)	\$43	\$92
Total Project Investment in Pennsylvania (millions)	\$98	\$208
Incremental Project Investment (millions)	\$58	\$123
Advanced Clean Fuel Technology Jobs	639	1,359

### ***Detailed Recommendations and Next Steps***

The PCTC is a viable plan that provides an economically sustainable pathway for long-term NGV market development in the Northeast and with linkages to developing Canadian NGV freight corridors. The successful development and implementation of the PCTC project is entirely feasible in the near term. All major fleet transportation applications can now be met with NGV models, and adoption of NGV technology is reaching a brisk pace. The growing fuel cost disparity between natural gas and diesel fuel will only continue to drive interest and investment in NGV technology and refueling infrastructure.

Effective implementation of the roadmap will require state leadership in developing key policies and partnerships to support the proposed PCTC program. Given the extremely important direct and indirect benefits that will accrue in the Commonwealth as a result of the successful development of the PCTC, it is recommended that Pennsylvania adopt a number of strategic and aggressive policy measures to support its implementation. Policies should include:

- Recognize and highlight existing Pennsylvania NGV success stories;
- Adopt aggressive policy positions which promote NGVs as an economic stimulus for Pennsylvania;
- Modify existing and develop new in-state incentive programs focused on high-fuel use fleet applications and infrastructure development and encourage the federal government to do the same;
- Allow bi-fuel NGVs certified by the U.S. Environmental Protection Agency to be sold in Pennsylvania as a critical refueling infrastructure and overall market development strategy;

- Develop strategic partnerships that support effective long-term growth of the regional NGV market via effective outreach, education, programs, policies, and strategic coordination;

Strong leadership, existing market momentum, and the realization and recognition of some early Pennsylvania NGV success stories will help to drive interest and enthusiasm in the development of the PCTC project. With continued aggressive action and focus, and under “business as usual” conditions, the PCTC concept can be fully implemented within a five (5) year time frame. However, under the right set of circumstances, the concept could certainly be implemented using a more aggressive 18 to 36 month schedule.

The development of the PCTC will rightly put Pennsylvania at the leading edge of our nation’s effort to address energy security, rising fuel prices, economic recovery and job creation. It will also make Pennsylvania the hub of a clean energy corridor in the Northeast. Framing the PCTC in the broader context of a national and international fuel infrastructure will be critical to successfully illustrating the big-picture objectives of this initial highly focused effort.

### **Incremental Wins**

While the overall size and scope of the PCTC project is quite large and will require tens of millions of dollars in investment, like any large visionary plan, the ability to demonstrate early success will significantly aid in the realization of the big-picture goals. Given the current NGV momentum in Pennsylvania, there is overlap in these existing efforts and the vision of the PCTC. Where such overlap exists, stakeholders must seek to highlight the importance of these NGV projects as they relate to the overall goals of the PCTC. Such a strategy can be particularly effective where the implementation of the PCTC concept is not only already happening, but is being funded by Pennsylvania’s Alternative Fuel Incentive Grant (AFIG) program.

The development of a micro-corridor in the Pittsburgh region – where Waste Management, Giant Eagle and Equitable Gas are currently deploying a natural gas vehicle refueling infrastructure with the assistance of AFIG funding – is an example of where such synergies already exist. These fleets are quintessential return-to-base operations that will help lay the foundation for the PCTC. These companies are using AFIG funding to deploy NGVs in their Pittsburgh area fleets and to construct refueling infrastructure that will service their own operations as well as provide fueling access to outside users. Waste Management’s public access CNG refueling station will be located almost immediately adjacent to I-70 and I-79 intersection, two critical interstate highways. Giant Eagle’s public access CNG refueling station will be located just west of downtown Pittsburgh near the intersection of state highway 22 and I-79 and the Equitable Gas station will be located just east of downtown Pittsburgh. With these projects already in the development phase, this planned fueling infrastructure and subsequent vehicle deployments are expected to take place in 2011, thus providing an excellent opportunity for this project to demonstrate critical near-term wins.

### **Aggressive Policy Positioning**

Through aggressive positioning on important policy issues, the Commonwealth of Pennsylvania will be able to pursue measures that will drive the development of the NGV market in the Northeast. Such action, which can often be taken at minimal or no cost to the state, will result in important long-term economic benefits for Pennsylvania’s economy.

### ***Clear Policy Direction on NGVs as a Local Economic Stimulus***

Given the direct benefits that will take hold in the Commonwealth as a result of the successful development of the PCTC, it is recommended that Pennsylvania adopt a policy platform that

promotes the use of natural gas transportation wherever and whenever possible. This will make it clear to government agencies that the replacement of their respective fleets with NGVs is a priority, and that broad promotion of these kinds of activities needs to be encouraged throughout all levels of government. This can be done via an Executive Order from the Governor or a resolution adopted by the General Assembly. A formal policy will provide clear direction that the replacement of fleet vehicles with NGVs is a priority, and it will provide the direction needed for these public agencies to take the steps necessary to foster the use of NGVs across agencies and the overall transportation infrastructure strategy of the Commonwealth – which will encourage private fleet operations to follow suit.

***Pennsylvania should make it the explicit policy of the state government to promote the use of natural gas vehicles whenever and wherever possible.***

Such direction will then stimulate the development of additional policies, incentives, rules, regulations, and other drivers that will increase the use of NGVs throughout Pennsylvania. Such drivers could include, but are not limited to: incentives to procure NGVs; programs to educate the public about the benefits of NGVs; access to high occupancy vehicle lanes for single occupant NGV drivers; NGV procurement directives for public sector vehicles; the establishment of a select committee on NGV use in the public transportation sector; tax exemptions for NGV fuel; encouragement of Pennsylvania's regulated utilities to more aggressively participate in the NGV market; and the issuance of an NGV project development bonds.

### ***NGV Focused Incentives***

Pennsylvania should further focus and augment its own existing alternative-fuel funding programs, and encourage similar federal incentive programs, aimed at accelerating the transition to natural gas vehicles, especially in high fuel consuming applications and in applications that operate in the urban center. Programs should also seek to develop public-access natural gas refueling infrastructure to support the further proliferation of the NGV market.

To fund this plan, \$58 million to \$123 million would be needed to offset the required Incremental Project Investment<sup>3</sup> for the PCTC relative to the diesel status quo. Given that there is often cost-share and incremental costs associated with such projects, it is feasible that the PCTC project could be implemented with a lower level of incentive funds; perhaps in the \$25 million to \$54 million range<sup>4</sup>. These incentives provide strategic investment in the continued growth of the Pennsylvania job market and economy, and the most effective strategy available by which Pennsylvania and the nation can more effectively enhance energy security with domestically produced clean natural gas.

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<sup>3</sup> The Incremental Project Investment costs include: the full \$2.6 million cost of each fueling station; the \$65,000 incremental cost of each natural gas truck, a \$400,000 allocation for the retrofit of each truck maintenance garage, a small 5% allocation for personnel training and project management considerations, and an overall 10% project contingency.

<sup>4</sup> This lower level assumes a 50% cost-share by others (fuel providers, the fleet owner, etc.) in the fueling infrastructure, vehicle incremental cost and maintenance garage retrofit costs.

The development of new NGV-focused incentive programs should have a particular focus on high-fuel-use applications that operate in the urban core where critical infrastructure is needed to build the PCTC. The recent funding allocation of the AFIG program clearly demonstrates an increased demand of NGVs in the Pennsylvania marketplace. Through dedicated NGV incentive programs, Pennsylvania can continue to support those investments that will ultimately yield the greatest amount of economic benefits.

In addition to Pennsylvania-funded efforts, the Commonwealth should also work to use its political power to encourage incentives at the federal levels. The federal tax credits for natural gas vehicles, refueling infrastructure and fuel use that have been in place since 2006 have been particularly important in successfully moving the heavy-duty market towards NGV investments. Similar federal incentives are expected to be proposed in April 2011 and it is recommended that Pennsylvania support proposed federal incentive that will have similar impacts to the tax credit programs that have been in place for the last five years.

In developing a natural gas transportation infrastructure, certainty and clarity in the policy arena is critically important to the long-term success of the PCTC. Programs that only authorize funding for a single year, or that might fund NGVs one year and electric vehicles the next, will only create trepidation and hesitation in moving the market toward natural gas. Large, heavy-duty fleets in particular will often only start down a transition path if they know they will be able to complete the transition, and the process can often take between five and 10 years for a complete fleet turnover. Therefore, unless there is an assurance that funding will be available in future years, a heavy-duty fleet may be extremely hesitant to replace even its first truck with a natural gas vehicle. It is for this reason that Pennsylvania must place a premium on developing and encouraging the federal government to approve dedicated NGV funding programs with a minimum duration of five years.

### ***AFIG Weight Limit***

The AFIG grant program guidelines currently contain conflicting information about the allowable vehicle weight limit that can be funded under the program. The guidelines say that the program will only fund heavy-duty vehicles up to 26,000 pounds gross vehicle weight rating (GVWR), but also state that the program will fund transit buses and refuse trucks, which generally weigh more than 26,000 pounds per vehicle. In conversations with the DEP AFIG staff, they made it clear that the program does in fact fund vehicles above 26,000 pounds and that they do not know how the weight restriction language ever entered the program guidelines. The DEP staff also expressed that the weight restriction language needs to be removed from future program guidelines. It is therefore recommended that PCTC Stakeholders work with DEP staff to update this vestige of the AFIG program.

### ***Allowance of U.S. EPA Certified Bi-Fuel NGVs***

Pennsylvania can significantly accelerate deployment of NGVs – and thus the need for refueling infrastructure and locally-produced natural gas fuel – by modifying the Pennsylvania Clean Vehicle Program requirement to allow for NGVs certified by the U.S. Environmental Protection Agency (EPA). The modification of this program requirement will significantly increase the market penetration of lower-emission natural gas vehicles, thus further driving the development of accessible refueling infrastructure throughout the Commonwealth. Once established, this fueling infrastructure will further encourage the deployment of NGVs throughout all sectors of the Pennsylvania transportation economy.

A major obstacle for the increased proliferation of natural gas light-duty cars and trucks within the Commonwealth is Pennsylvania's Clean Vehicles program that went into effect for model year (MY) 2008 and newer passenger cars and light-duty trucks. This program officially adopted

certain provisions of the California Low Emission Vehicle Program. Vehicles are considered subject to this program if they are MY 2008 or newer, under a gross vehicle weight rating of 8,500 lbs., and have less than 7,500 miles on the odometer. Vehicles subject to this program are required to be certified for emissions by the California Air Resource Board (CARB) in order to be sold, leased, offered for sale or lease, imported, delivered, purchased, rented, acquired, received, titled or registered in Pennsylvania.

Unfortunately, the provisions of the Clean Vehicles program also require that alternative fuel conversion systems (e.g., CNG) for MY 2008 and later passenger cars and trucks must also have received a "Retrofit Conversion Certification" under the "California Certification and Installation Procedures for Alternative Fuel Retrofit Systems for Motor Vehicles Certified for 1994 and Subsequent Model Years." EPA-approved alternative fuel conversion systems may only be used on MY 2007 or older vehicles. These alternative fuel restrictions under Pennsylvania's Clean Vehicles program make it much more difficult and expensive to use CNG in these passenger cars and light-duty trucks for two specific reasons.

***Pennsylvania can accelerate the development of a comprehensive natural gas refueling station network - and thus the use of locally-produced clean natural gas fuel – by allowing bi-fuels natural gas vehicles certified by the U.S. Environmental Protection Agency.***

Because there are very few original engine manufacturers (OEM) light-duty NGVs available, most CNG passenger cars and light-duty trucks tend to be conversions from gasoline. The CARB retrofit certification requirements are much more difficult to comply with than the EPA conversion certification requirements for the rest of the U.S. CARB certification requires more extensive initial durability testing, more extensive onboard diagnostic systems, and ongoing recertification costs annually. Because of this, there are significantly fewer conversion systems available with CARB certification, and the prices of those systems are higher than their EPA-certified counterparts. Right now there are only a limited number of CARB-certified conversion systems for late-model vehicles, and they can be as high as \$5,000 to \$10,000 more expensive than EPA-certified conversions for the same vehicles. Of course, it is extremely important to point out that there are absolutely no emission level differences between the two certifications.

California's retrofit certification process requires manufacturers to essentially certify the converted vehicle as a new product. This means that if the manufacturer wants to certify a bi-fuel conversion system – one that can run on CNG or on the original gasoline fuel system – the manufacturer has to certify it as a new CNG vehicle, as well as re-certify the original gasoline vehicle, which is prohibitively expensive and time consuming. As a result, no CARB-certified bi-fuel conversion systems currently exist in the marketplace. This means that in a fledgling CNG market like Pennsylvania, where infrastructure is limited, potential users will not be able to purchase bi-fuel conversion systems that would allow them to use gasoline part of the time until the CNG infrastructure catches up.

While passenger cars and light-duty trucks are not the primary target for natural gas transportation programs, they nevertheless remain part of the mix of vehicles that consumers and fleets would like to be able to run using CNG. For example, taxicabs and light-duty trucks

can be high-volume fuel users in the right duty cycles, and thus contribute to the growth of natural gas refueling infrastructure and the market overall. The PCTC has identified several markets such as the natural gas industry, airports and utilities that could greatly benefit from expanded light-duty NGV purchase options. However, the CARB retrofit certification requirements present a significant barrier for those applications, and thus inhibit the expedited growth of supporting refueling infrastructure throughout the market.

***Allowing bi-fuel NGVs certified by the U.S. Environmental Protection Agency will:***

- Increase the number of light and medium-duty NGVs available to Pennsylvania drivers by more than two times, from 15 to 36 models.
- Reduce the cost of a light or medium-duty NGV by as much as \$10,000.
- Significantly increase the adoption of NGVs in the Pennsylvania marketplace.
- Provide the demand to allow for increased investment in natural gas refueling infrastructure throughout the state.
- Increase the use of domestically-produced, low-cost and clean burning natural gas.

Given that the base objective of EPA, CARB and other air-quality and energy-focused public agencies is to promote markets for the accelerated use of clean transportation options that use domestic, low-cost and reliable fuel sources, it is strongly recommended that the Commonwealth of Pennsylvania reconsider its mandate to abide by the CARB requirements, and instead work to accelerate the allowance of NGVs that are EPA approved. The EPA is a recognized air-quality regulatory agency, and its protocols and certifications are equally protective of the environment.

The allowance of EPA-certified NGVs, including bi-fuel vehicles, will significantly increase the market penetration of the technology, which will in turn stimulate the growth of a more comprehensive NGV refueling network. The existence of a more robust NGV refueling network will further drive the development of the market, and enhance the economic benefits that will be felt throughout Pennsylvania.

***LNG Fuel Restrictions***

One of the goals of the PCTC is to encourage the use of heavy-duty vehicles in the movement of goods throughout Pennsylvania. This is most likely to be conducted by natural-gas trucks fueled by LNG given the weight and range advantages of LNG when used on heavy-duty trucks, as well as the fact that the only trucks now available in the market to make these long hauls over mountain terrain are the ones powered by the LNG-only ISX engine. Unfortunately, there are restrictions on the use and transportation of LNG in the state of New York, thus limiting the ability of the PCTC to serve trucks that either originate or terminate in this location, and creating another obstacle to the success of the PCTC concept. As part of the recommended outreach to neighboring states, it is recommended that the PCTC stakeholders approach the state of New York on this specific issue and work to remove this market restriction in advance of a more aggressive marketing push for a NY-version of the PCTC (i.e. the "NYCTC").

## **Partnerships**

As Pennsylvania works to implement the stated goals of the PCTC, it is recommended that key strategic partnerships be developed with a range of organizations with similar goals. Pennsylvania officials, public agencies, and private-sector representatives should begin to work with the states that border Pennsylvania in order to encourage the replication of the PCTC project plan. The replication of the PCTC concept in neighboring states will allow for the development of similar accessible natural gas refueling infrastructure, and will thus allow for the replacement of the nation's highest diesel fuel consuming fleet vehicles – over-the-road, Class-8 tractor trailers – with ones that run on Marcellus-produced low-carbon and low-cost natural gas.

There are a number of groups in Pennsylvania – including two Clean Cities Coalitions, the Clean Air Council, and the Philadelphia Diesel Difference Working Group – that are promoting cleaner air, more efficient freight movement, the creation of sustainable jobs, and other positive social objectives. Other potential partners include elements of the supply chain and transportation-logistics industry, such as warehouse and distribution centers, that would like to promote activities that reduce the environmental footprint of their operations. Such partners will include entities that operate in states that neighbor Pennsylvania.

### ***Marcellus Shale Coalition - NGV Committee***

It is recommended that the Marcellus Shale Coalition develop an NGV committee in order to continue to implement the PCTC as laid out in this report, as well as to support the development of a vibrant NGV market in Pennsylvania. This subcommittee can play an important outreach and education role within the state about the multiple benefits of NGVs. It is recommended that this include a wide range of interested stakeholders and partners, including NGV industry participants, fleet operators, and others interested in advancing the use of NGVs in our transportation sector as an effective energy-security and air-quality improvement strategy.

### ***Clean Cities Coalitions (Pittsburgh and Philadelphia)***

In 1993, the U.S. Department of Energy (DOE) launched its Clean Cities Program to assist the nation with displacing petroleum used in the transportation sector. Since its inception, the number of Clean Cities coalitions has grown to nearly 100, and the number of stakeholders has expanded to more than 8,400. Clean Cities coalitions and stakeholders have displaced petroleum at a rate of nearly 3 billion gallons annually, and are on track to displace 2.5 billion gallons of petroleum annually by 2020. Pennsylvania currently has two very successful Clean Cities Coalitions – in Pittsburgh and Philadelphia – which have assisted the Commonwealth with the deployment of hundreds of alternative-fuel vehicles.

The Pittsburgh Region Clean Cities (PRCC) is a nonprofit membership organization whose main objective is to build and support the infrastructure needed for a strong alternative-fuel and alternative-vehicle market in Western Pennsylvania. The PRCC has over 60 active members, including the Allegheny County Airport Authority, Giant Eagle, Federal Express, the Pennsylvania Department of Environmental Protection, and the Pennsylvania Turnpike Commission. The PRCC has the experience and tools in place to help fleets interested in converting to NGV explore the most cost-efficient ways of making the transition. This experience will be invaluable as the PCTC seeks out potential fleet partners who have yet to make the conversion to NGV.

In the coming years, the PRCC will focus its efforts more specifically on CNG as one of Pennsylvania's choices for clean transportation fuel. The PRCC understands the unique opportunity presented by the natural gas resources of the Marcellus Shale and believes the PCTC will help expand the state's NGV network. PRCC will therefore be a strong ally to the

MSC in the development of the PCTC, and the development of a closer working relationship is recommended.

Formed in 1993, the Greater Philadelphia Clean Cities Program (GPCCP) is a 501(c) 3 nonprofit organization comprised of some of the largest governments, utilities, and nonprofit metro-Philadelphia organizations working to promote the use of alternative-fuel vehicles. As one of the founding Clean Cities Coalitions in the United States, the GPCCP has the reputation, knowledge, and track record to successfully implement alternative-fuel infrastructure and vehicle programs. Since a number of GPCCP members have already successfully converted a significant portion of their fleets to natural gas, the GPCCP can be a great resource for stakeholders wishing to accelerate the development of the PCTC in the Philadelphia region.

### ***Clean Air Council***

The Clean Air Council is a member-supported, nonprofit environmental organization based in Philadelphia that works to ensure enforcement of environmental laws through public education, community advocacy and government oversight. Its focus includes transportation, children's environmental health, energy, climate change, waste and recycling. The Clean Air Council works to reduce pollution, and advocates for full implementation of the Clean Air Act, along with related Pennsylvania and local laws, to improve air quality.

The Clean Air Council develops diverse partnerships to pursue clean-fleet programs that include the use of innovative strategies and alternative fuels and market-based approaches – making the Council's support of the PCTC a natural fit. Stakeholders of the organization include community leaders, policy makers, and progressive business leaders.

Most of the organization's efforts focus on diesel emission reductions from return-to-base fleets, such as public transit, school buses and refuse collection, as well as local drayage truck operations at ports. Given the Philadelphia region's non-attainment status for ground level ozone (smog) and fine particulate matter (PM<sub>2.5</sub>) emitted from diesel engines, the Clean Air Council can be a strong ally in the implementation of the PCTC.

### ***Philadelphia Diesel Difference Working Group***

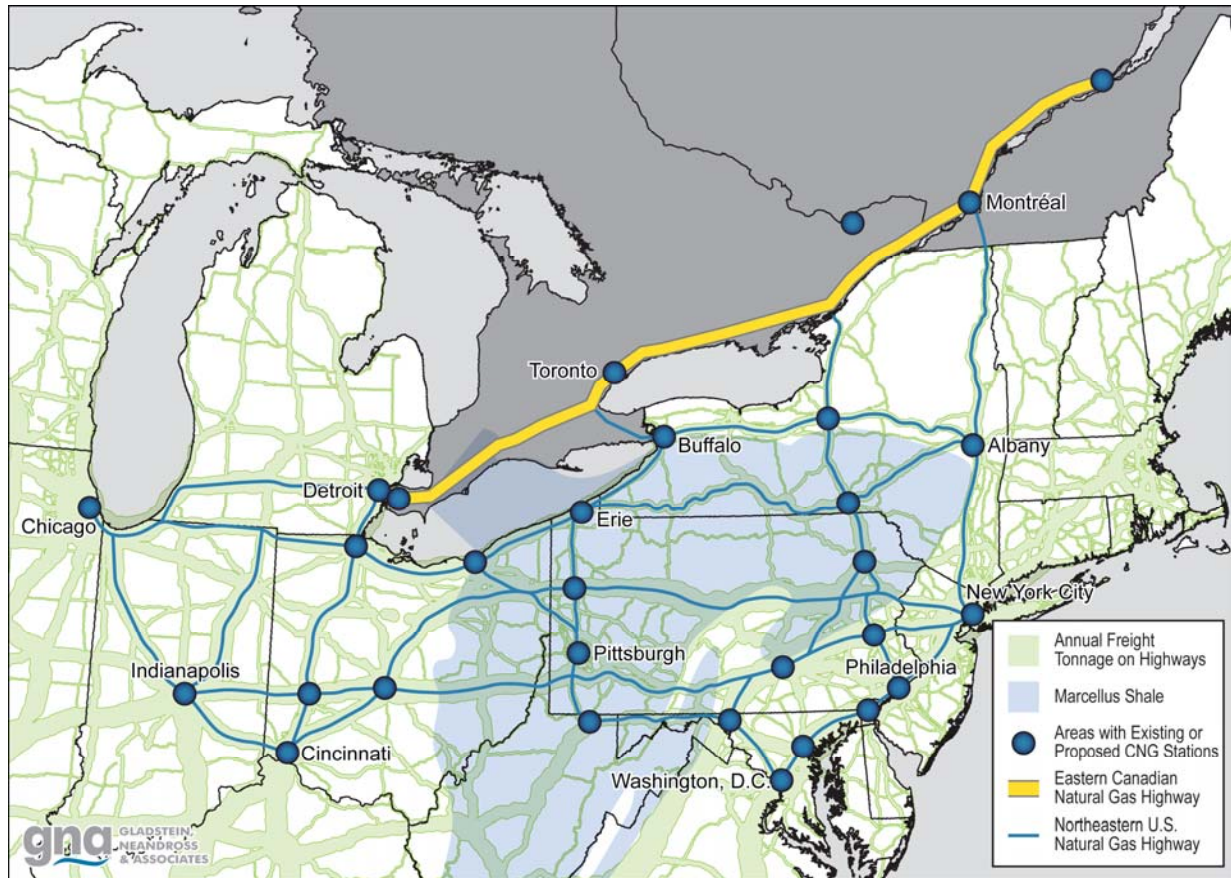
The Philadelphia Diesel Difference Working Group's goal is to initiate the development of voluntary programs and innovative strategies, including market-based approaches, in order to help build a coalition of diverse partners throughout the Philadelphia area with a mutual interest in reducing air pollution from diesel engines.

The Philadelphia Diesel Difference Working Group is an ideal strategic partner for implementing the PCTC in Pennsylvania, especially given its eight-plus years of experience in community engagement and endorsements from local, statewide and national organizations such as the American Lung Association of Pennsylvania, the Clean Air Council, Cummins Power Systems, the EPA, and the City of Philadelphia's Office of Fleet Management.

The Philadelphia Diesel Difference Working Group has had many successes in helping to implement strategies to reduce diesel emissions. By partnering with the Philadelphia Diesel Difference, the PCTC would gain valuable access and visibility within the Commonwealth, and with other private organizations interested in reducing diesel emissions. These types of partnerships are essential for leveraging funding assistance from state and federal agencies. Additionally, the reach of the Diesel Difference Working Group is growing as both New Jersey and Delaware have taken the initial steps of organizing their own Diesel Difference Working Groups.

### ***Neighboring States: PCTC as a Foundation for Goods Movement in the Northeast***

As Pennsylvania works to implement the Foundation and Developed Case scenarios, it is recommended that key stakeholders reach out to neighboring states to encourage them to replicate the PCTC development roadmap in their own states. As the PCTC concept is implemented and similar efforts are successfully developed in neighboring states, a comprehensive, regional natural gas refueling corridor will begin to emerge that will connect major metropolitan regions in the Northeast and eventually the Midwest.



**Figure 2: Map of the Freight Corridors and Potential Natural Gas Fueling in Northeastern North America**

In addition to working in partnership with neighboring states, it is recommended that PCTC stakeholders also establish a partnership with those working to develop a similar natural gas refueling station corridor in eastern Canada along the heavily populated Quebec City-Windsor corridor of Highway 401. Given Windsor's proximity to the continental U.S. – via Detroit – there is a clear link between these international efforts. Such a partnership, while admittedly a longer-term, “Phase II” development effort, can still prove extremely important in the short term as a means to gain greater attention, particularly from elected officials and public agencies responsible for broad, long-term policy planning and development.

## The NGV Roadmap for PA Jobs, Energy Security and Clean Air

Ever since Drake's well was drilled in 1859, the Commonwealth of Pennsylvania has been one of the nation's leaders in the development of U.S. energy resources. Today, 150 years after the petroleum age began here, Pennsylvania finds itself at the forefront of a new energy revolution, this time fueled by natural gas.

Pennsylvania sits atop the Marcellus Shale, a vast underground deposit of shale that's rich in natural gas, the cleanest-burning fossil fuel. This natural gas offers the opportunity to reduce America's dependence on foreign sources of energy, continue to generate tens of thousands of good-paying jobs, and to address important environmental issues such as reducing air pollution and the concentration of greenhouse gases in the atmosphere.

Recognizing the tremendous value of Marcellus Shale gas and the regional trucking industry, MSC seeks to identify ways by which this abundant domestic natural gas resource can play an increased and accelerated role in the state's transportation sector in order to provide for improved economic development, energy security, and air quality in Pennsylvania. MSC has therefore taken a leadership position to develop this roadmap by which Pennsylvania-produced natural gas can be better utilized in the Commonwealth's and the nation's transportation sector.

### ***Economic Importance of Natural Gas and Trucking in Pennsylvania***

Much like Pennsylvania's growing natural gas industry, the Commonwealth's transportation sector provides an important job and economic base for the state. The trucking sector provides approximately 80,000 jobs<sup>5</sup> and generates more than \$10 billion in direct economic output<sup>6</sup> in Pennsylvania. However, as nearly half of the Commonwealth's trucking activity is classified as "through trucking" – i.e., freight that does not commence or terminate in Pennsylvania – the level of economic activity related to the movement of goods is much higher than baseline statistics indicate.

In fact, the natural gas and trucking sectors in Pennsylvania provide more than \$23.3 billion in economic activity<sup>7</sup> in a state with a 2008 gross domestic product of \$555 billion<sup>8</sup>, and employ more than 200,000 Pennsylvanians, or approximately 2% of the state's population<sup>9</sup>. These numbers are expected to grow considerably due to Pennsylvania's warehousing potential, as well as the ample supply of natural gas from Marcellus Shale.

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<sup>5</sup> U.S. Census Bureau, 2007 Economic Census, 2007 Economic Census of Island Areas, and 2007 Nonemployer Statistics.

<sup>6</sup> Economic and Transportation Impact of Warehousing on Rural Pennsylvania Prepared by The Center for Rural Pennsylvania (A Legislative Agency of Pennsylvania General Assembly) (November 2008) [http://www.rural.palegislature.us/Warehousing\\_Report08.pdf](http://www.rural.palegislature.us/Warehousing_Report08.pdf).

<sup>7</sup> IHS Global Insight's analysis on the impact of natural gas concluded that the industry generates \$12.9 billion of value added in Pennsylvania. <http://www.anga.us/media/41016/pennsylvania%20economy.pdf>. \$10.4 billion in direct output from trucking services is per Economic and Transportation Impact of Rural Pennsylvania, Shippensburg University of Pennsylvania and Indiana University, November 2008.

<sup>8</sup> Bureau of Economic Analysis; Gross Domestic Product by State, June 2009. [http://www.bea.gov/scb/pdf/2009/06%20June/0609\\_gdp\\_state.pdf](http://www.bea.gov/scb/pdf/2009/06%20June/0609_gdp_state.pdf)

<sup>9</sup> U.S. Census Bureau, 2009 Population Estimates

### ***Focus on the Heavy-Duty Transportation Sector***

Heavy-duty diesel powered trucks represent only 3-4% of all registered on-road vehicles, yet they are responsible for 25% of all on-highway fuel (both gasoline and diesel) consumption<sup>10</sup>. Of this population, the largest trucks – heavy-duty Class-8<sup>11</sup> trucks – represent only 33% of the total number of registered heavy vehicles in all weight categories (Classes 3<sup>12</sup> to 8), but are responsible for 64% of the total miles traveled and 67% of the total fuel consumed by all commercial vehicles<sup>13</sup>.

With the highest fuel-consumption rates in the transportation industry, and the often centralized and fixed-route nature of their operation, heavy-duty fleet vehicles represent the single best opportunity to realize economic, energy security and environmental gains by transitioning from diesel fuel to a cleaner-burning alternative such as natural gas. In order to realize the greatest gain from the use of Pennsylvania-produced natural gas, it is this sector that is the ultimate target of this roadmap development strategy for the PCTC.

***Heavy-duty fleet vehicles represent the single best opportunity to realize economic, energy security and environmental gains by replacing transitioning to a cleaner burning alternative such as natural gas.***

Within Pennsylvania, as is the case in any state in the nation, the greatest concentration of heavy-duty vehicle use is in the urban centers where a majority of the population is located. Simply put, heavy-duty vehicles support our modern way of life. They are used to deliver goods and services from ports, warehouses and distribution centers to our homes, stores, restaurants and businesses, as well as to transport the population to and from home, school, work and other travel destinations.

Municipal governments are home to a wide variety of heavy-duty fleet vehicles, including refuse collection and transfer vehicles, public works fleets, and vehicles used in a number of utility service applications such as natural gas, electric, water, and communications. It is in these applications that natural gas vehicles have seen the greatest market penetration in the United States. It is also in these applications where there exists a tremendous number of NGV product offerings, and where a single refueling station is able to serve a large and typically uniform fleet of vehicles. In many cases, the refueling infrastructure developed to service vehicles for one of these applications is then made available to other local fleets and outside users.

In addition to the typically urban, heavy-duty fleet operations in Philadelphia, Pittsburgh, Harrisburg, Allentown, and other population centers, all of Pennsylvania's warehousing and distribution centers are also hubs of heavy-duty truck activity. These warehousing and

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<sup>10</sup> U.S. Energy Information Administration, Annual Energy Review 2010. U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, 2007, Table 1-11. (Energy Vision)

<sup>11</sup> 33,001 – 80,000 lbs. GVWR (i.e. tractor trailers, bulk tankers, flat beds, combination trucks)

<sup>12</sup> 10,001 to 14,000 lbs. GVWR. (i.e. vans)

<sup>13</sup> National Research Council, Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles, "Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy- Duty Vehicles," March 2010 . Table 2-1. (Energy Vision)

distribution centers are also located in many of these same urban centers, particularly around seaports and airports, but are also prevalent in places such as Scranton, Wilkes-Barre, and Williamsport.

Pennsylvania ranks second in the country for jobs related to distribution centers and warehousing, and sixth for goods-movement trucking<sup>14</sup>. Approximately 77% of all goods moved within the Commonwealth are moved by truck, and trucking is responsible for transporting nearly \$458 billion in goods to distribution centers, warehouses, and ports throughout Pennsylvania.<sup>15</sup>

Beyond the heavy-duty fleet operations in urban centers and warehousing and distribution centers, Pennsylvania serves as one of the nation's most important corridors for interstate truck traffic. Already within easy reach of the major metropolitan centers throughout the Northeast, Pennsylvania is extremely well-positioned with respect to the nation's interstate highway system, providing excellent north-south access via I-79, I-81 and I-95, and east-west access via the Pennsylvania Turnpike (I-76), I-70, I-80 and I-90. For these reasons, as much as 40% of the freight being moved in Pennsylvania (as measured in ton-miles) is considered through trucking<sup>16</sup>. With an existing distribution and warehousing base, and an incredibly high percentage of goods being moved through the Commonwealth, Pennsylvania is taking strides to capture more of this goods movement by growing its warehouse and distribution infrastructure. As a result, South Central Pennsylvania is expected to see a 79% increase in truck-based goods movement into or out of that region by 2030<sup>17</sup>, and total trucking activity in Pennsylvania is expected to increase by 17% from 2010 to 2020<sup>18</sup>.

#### Target NGV Fleet Applications

- Refuse collection and transfer
- Transit
- Port drayage
- Local trucking and distribution
- Public works (street sweeping, road maintenance, dump trucks, etc.)
- Airport operations (taxi, hotel/parking shuttle bus)
- Utility (natural gas, electric, water and communications)

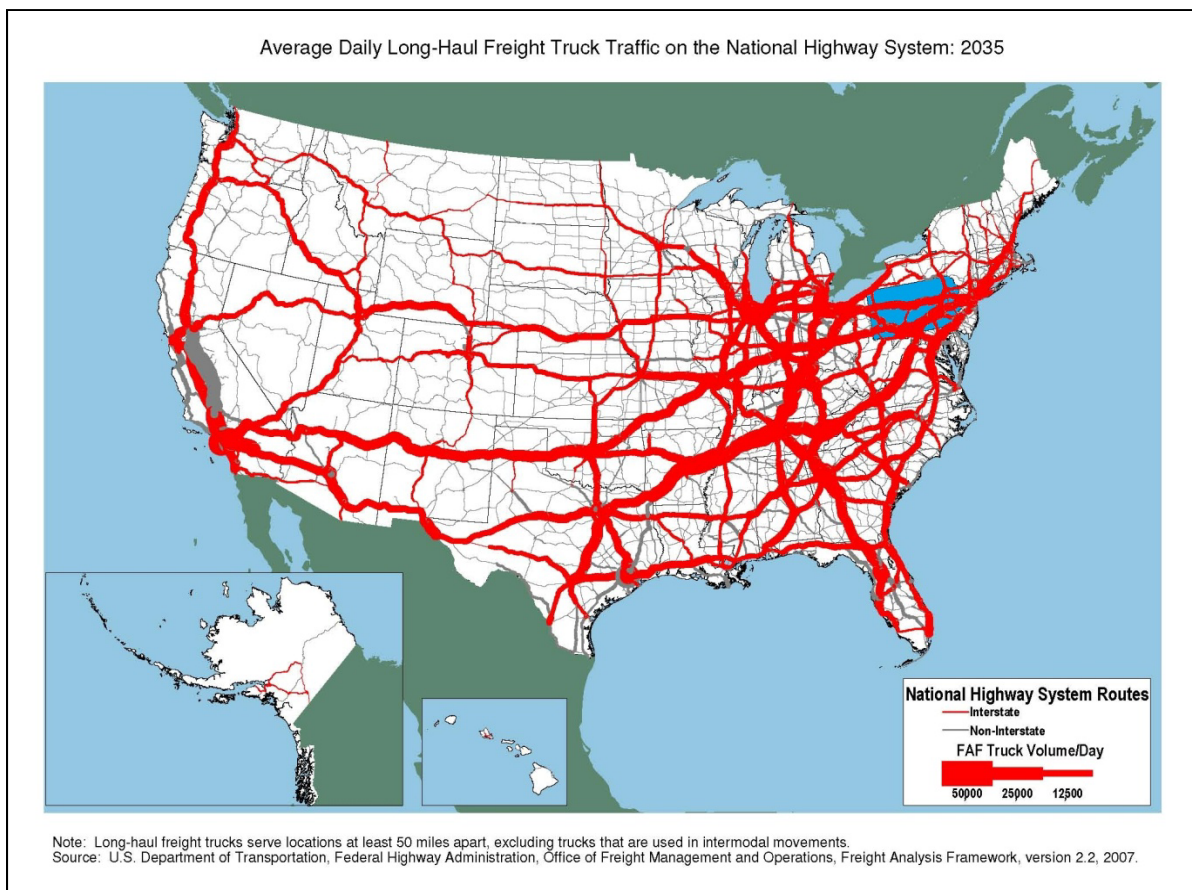
<sup>14</sup> Future Mobility in Pennsylvania, The Condition, Use and Funding of Pennsylvania's Roads, Bridges and Transit System Prepared by TRIP (November 2010); [http://www.rural.palegislature.us/Warehousing\\_Report08.pdf](http://www.rural.palegislature.us/Warehousing_Report08.pdf)

<sup>15</sup> Economic and Transportation Impact of Warehousing on Rural Pennsylvania; prepared by The Center for Rural Pennsylvania (A Legislative Agency of Pennsylvania General Assembly), November 2008. [http://www.tripnet.org/PA\\_TRIP\\_Report\\_Nov\\_2010.pdf](http://www.tripnet.org/PA_TRIP_Report_Nov_2010.pdf)

<sup>16</sup> U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 2.3, August 2009

<sup>17</sup> South Central Regional Goods Movement Study, Final Report, Cambridge Systematics, Inc., July 2006

<sup>18</sup> Ibid.



**Figure 3: Average Daily Long-Haul Freight Truck Traffic on the National Highway System (2035)**

Given the strategic importance of Pennsylvania to the regional movement of goods by truck, the long-term goal of the PCTC is to establish an infrastructure that can ultimately support the regional and national movement of these goods by heavy-duty Class-8 trucks using domestically produced natural gas.

### ***Sitting on a Gold Mine: Pennsylvania Natural Gas for Heavy-Duty Trucking***

Labor and fuel costs consistently represent the top two operating costs for companies operating in the heavy-duty transportation sector. Given the significant fluctuation in the cost of petroleum in recent years – such as the summer of 2008, when diesel fuel reached \$5.00 per gallon in some parts of the country – fuel costs have often risen to be the single largest operating cost for any company that relies heavily on transportation by truck. Not only do these high costs significantly impair the ability for businesses dependent upon truck transportation to be successful, but the escalating and vacillating cost of petroleum-based fuels creates substantial uncertainty and risks that hamstringing business development and growth. These costs, therefore, presents the single biggest opportunity for cost savings and operational stability by way of the displacement of diesel fuel in favor of natural gas – which has consistently yielded savings of 30-40% in heavy-duty fleet operations.

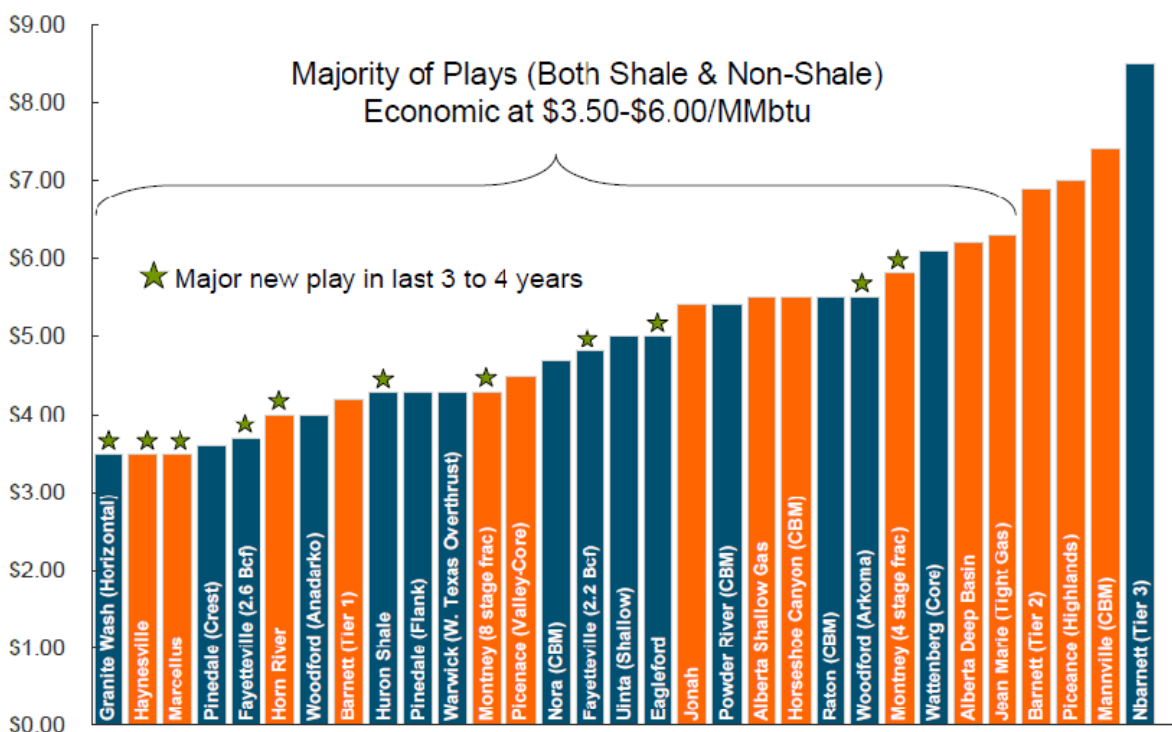
The successful development of the PCTC roadmap represents an extremely important economic development opportunity for Pennsylvania. By providing a network of accessible natural gas refueling stations to the heavy-duty transportation sector both within Pennsylvania and regionally, the PCTC will offer a means by which this sector can significantly reduce

operating costs and be more competitive. This, in turn, will attract a greater share of the transportation market to Pennsylvania.

The Marcellus Shale represents one of the most cost-effective sources of natural gas in North America (see Figure 4). Natural gas from the Marcellus Shale can provide a low-cost fuel at the fueling dispenser given the close proximity between the nozzle and the wellhead. Likewise, the dispensed natural gas will have one of the lowest GHG emission profiles in North America.

## North American Natural Gas Supply Costs

**NYMEX Natural Gas (\$/MMBtu) Price Required for 10% Internal Rate of Return**



**Figure 4: Cost of Natural Gas Supply from Various North American Gas Plays (chart courtesy of Encana; source information from Morgan Stanley, May 2010)**

### **Case Study – Natural Gas Truck Corridors: A Recipe for Success**

GNA has successfully led the development over the last decade of the Interstate Clean Transportation Corridor (ICTC), the nation's most successful planned clean fuel corridor, 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.



**Figure 5: Map of the Interstate Clean Transportation Corridor Natural Gas Refueling Network**

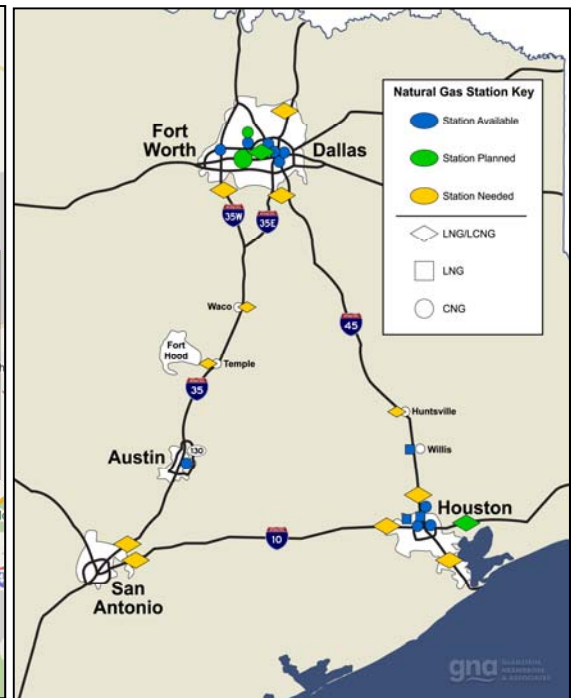
GNA's efforts on this project have demonstrated that independent truckers are able to successfully make their deliveries essentially anywhere in California using natural gas powered trucks and the existing refueling infrastructure established along the ICTC. With natural gas refueling stations now being constructed at truck stop locations in both Las Vegas and Salt Lake City, heavy-duty natural gas powered rigs will, by mid-2011, be able travel these long distances using domestically produced natural gas instead of petroleum based diesel fuel.

As part of the ICTC, GNA has developed a number of sub-level clean-fuel corridors in order to identify and construct specific segments of the larger ICTC within the targeted region. For example, the San Joaquin Valley Clean Corridor Project successfully developed a trio of refueling stations in the Central Valley of California in order to provide an important connection between urban centers in Southern and Northern California. While the Central Valley has few heavily populated metropolitan areas, GNA was able to target selected return-to-base operators

in the region to successfully develop the refueling infrastructure needed to then serve over-the-road trucks traveling through the region. The San Joaquin Valley Clean Corridor Project provides a development model that will likely be replicated in the Philadelphia-Harrisburg-Scranton sub-region and the greater Pittsburgh area, where each sub-region has a triangular network of interstate highways used by a variety regional and local heavy-duty vehicles.



**Figure 6: Map of the San Joaquin Valley Clean Corridor Project**



**Figure 7: Texas Clean Transportation Triangle Map**

Following the successful development of the ICTC, GNA has more recently launched a new clean-fuel corridor effort in Texas – the Texas Clean Transportation Triangle (TCCT). The TCCT will connect the Dallas/Fort Worth, Houston, and San Antonio metropolitan regions with a sustainable network of natural gas refueling stations that will be appropriate for and accessible to heavy-duty trucks traveling these interstates. As the state of Texas is the largest producer of natural gas in North America, the goal of this project – much like the PCTC – is to better utilize this low carbon indigenous resource to promote an alternative fuel transportation strategy that will yield important economic and environmental benefits to the state. Also, much like the PCTC, the development strategy for the TCCT largely focuses on the construction of specific refueling stations to support local return-to-base operations within each of these major urban areas, and in order to yield a connected network of fueling stations along the larger corridor.

## Overview of PCTC

Given the strategic importance of Pennsylvania to the regional movement of goods by way of truck, the long-term goal of the PCTC is to establish an infrastructure that can ultimately support the movement of these goods by heavy-duty Class-8 trucks using Pennsylvania-produced natural gas. While this market sector is the long-term target of the PCTC development plan, the development roadmap will require an initial focus on more localized urban fleet applications so that a sustainable refueling infrastructure can be established. Once established, Pennsylvania – working in concert with its neighboring state and strategic-goods-movement and trade partners – will be able to successfully realize the true vision of the PCTC. Not only do New Jersey, New York, Ohio, West Virginia, Maryland and Illinois all share a strategic alliance with Pennsylvania in terms of the trucking and goods-movement sector, but a good portion of these neighboring states also sit atop the gas-rich Marcellus Shale formation, thus providing an ideal opportunity for the expansion of the PCTC concept beyond Pennsylvania's own borders.

Because long-haul freight truckers are, by their nature, transient in their operation, it is exceptionally difficult to establish a comprehensive and economically sustainable alternative-fuel refueling network to support their operations. At the same time, fleet operators are unwilling to deploy alternative-fuel vehicles unless they are assured of a robust refueling infrastructure to support their operations along any route they may be required to travel. This “Catch-22” is conundrum that the alternative-fuel-vehicle industry has historically faced.

***The “if you build it, they will come” strategy has consistently failed to yield a sustainable alternative fuel vehicle and refueling infrastructure market.***

***Return to base fleet operators such as refuse trucks, transit buses, and other high fuel use applications offer the best opportunity to successfully develop new alternative fuel refueling infrastructure.***

Over the last several decades the “if you build it, they will come” strategy has consistently proven to be an unsuccessful business-development model for alternative-fuel vehicles and refueling infrastructure. Natural gas refueling stations capable of serving the heavy-duty truck market require \$1 million to \$2 million dollars of capital, and investors must be assured of a return on this investment in order that the fueling station is economically viable and to ensure that these stations remain open for business. The return-to-base heavy-duty vehicle sector has been the primary target of the natural gas vehicle industry, as these factors are much more prevalent in these niche applications.

Return-to-base fleet operations such as refuse haulers, transit buses, and other high-fuel-use applications provide two primary advantages when working to develop a refueling station. First, they return to the same location each night, thus ensuring that the refueling station will be used; and second, the high-fuel-use nature of their operations ensures that sufficient fuel throughput is realized and there is thus an opportunity for a return of the initial capital investment in a relative short period of time (typically three, five or 10 years, depending on the business model) without the end-user having to incur a significant fuel cost premium. This development model has proven to be the most successful approach in building sustainable natural gas refueling

infrastructures. Because of these factors, this model should serve as the basis for the development of the PCTC.



Figure 8: Concentric Circle Approach for Corridor Development

By focusing on the heavy-duty return-to-base fleet operations in Pennsylvania's urban centers, multiple refueling stations can be established in strategic locations within each of the major metropolitan regions of the Commonwealth. To serve the broader trucking market, all infrastructure developed as part of the PCTC should be constructed in order to serve the primary base fleet user, as well as outside fleet-vehicle operators and the general public. This type of "open access" refueling-infrastructure development has proven to be a very successful model in helping to stimulate the deployment of additional alternative-fuel vehicles within a local market. Subsequently, as multiple, publicly-accessible natural gas refueling stations are developed along a set corridor, they begin to support the use of natural gas trucks in longer-haul applications. This development model is often referred to as the "concentric circle" approach – i.e. stations are developed to service vehicles that operate in a fixed return-to-base circle, and as multiple circles are developed along set routes, refueling infrastructure corridors begin to emerge.

This development strategy has also proven to be the single most effective way in which the "chicken and the egg" challenge can most successfully be circumvented. This approach

eliminates the inertia that so often impedes the development of alternative fuels. It also sets the PCTC up to accomplish two important objectives: creating a commercially viable and economically sustainable clean-fuel corridor in Pennsylvania that can be accessed by both public and private fleets throughout the Commonwealth; and laying the foundation for the region's first interstate clean-fuel corridor.

***When faced with the classic “chicken and the egg” conundrum, the alternative fuels industry has most often found success by cooking both!***

### ***Natural Gas Fuel Stations and Vehicles***

Given the multiple large urban areas within Pennsylvania, and considering the strategic importance of Pennsylvania's distribution and warehousing sectors, GNA has determined that a minimum of eight publicly accessible natural gas refueling stations will be required to provide sufficient fueling coverage to support the development of the PCTC concept. Looking at a more aggressive case, up to 17 publicly accessible natural gas refueling stations could be developed as part of the PCTC. A summary of the general conceptual locations for this infrastructure network is as follows:

***Table 3: Potential Natural Gas Refueling Stations (Conceptual)***

	FOUNDATION	DEVELOPED
Philadelphia	3	6
Pittsburgh	3	4
Harrisburg	1	3
Scranton	1	2
Allentown	0	1
Williamsport	0	1
<b>Total</b>	<b>8</b>	<b>17</b>

While there are already more than 20 natural gas refueling stations within Pennsylvania, few of these sites are accessible to outside users, and those that are accessible are often meant to support light-duty vehicles (such as pickup trucks and sedans), not the heavy-duty vehicles that are the focus of the PCTC. However, in some cases, this existing infrastructure can be leveraged as part of the PCTC roadmap.

For the purposes of this report, it is assumed that each natural gas refueling station – appropriate for the refueling of heavy-duty natural gas vehicles – will be capable of refueling at least 50 heavy-duty trucks each day. With 50 trucks a day as the minimum, each station able to fairly easily accommodate up to 100 to 125 heavy-duty trucks each day, as well as the additional of a few hundred of light-duty natural gas vehicles. Therefore, the projected PCTC infrastructure, under the Foundation and Developed Case plans, will be able to support a base of 400 to 850 heavy-duty natural gas vehicles respectively and up to 1,000 to 2,215 heavy-duty trucks and thousands of light-duty natural gas vehicles. The 400 and 850 truck number is

therefore considered the minimum required to justify the investment of the refueling infrastructure under each respective plan.

While the size, shape and cost of natural gas vehicles vary greatly, for the purpose of this PCTC roadmap, it is estimated that each heavy-duty vehicle will carry a total cost of approximately \$165,000, thus requiring a total of \$66 million to \$140 million in capital expenditures under the two respective plans.

Constructing a publicly accessible natural gas refueling station capable of supporting 50 heavy-duty vehicles each operating day will require an estimated \$2.6 million per station, or \$21 million to \$45 million for all stations under the two respective scenarios.

In addition to the refueling infrastructure, it will be required that modifications be made to maintenance garages in order to properly repair and maintain these heavy-duty natural gas vehicles and keep them up to code. For the purpose of this PCTC roadmap report, it is assumed that one maintenance garage will be retrofit for this purpose for each natural gas fueling station constructed. Based upon industry experience, it is estimated that each garage will require approximately \$400,000 for retrofitting, yielding a total of \$3.2 million to \$6.8 million in capital expenditures in order to retrofit anywhere from eight to 17 maintenance garages under the two respective plans.

The total investment required for the incremental cost of the natural gas trucks, refueling stations and maintenance garage modifications proposed as part of the PCTC under the Foundation and Developed Case scenarios – the Incremental Project Investment – is \$50 million to \$107 million. In addition to these costs, as well as the base diesel cost of the trucks, a 5% budget line item for personnel training and project management is proposed, as is an overall 10% cost contingency, thus bringing the total potential investment in Pennsylvania as a result of the successful implementation of the PCTC roadmap to \$98 million to \$208 million.

**Table 4: Pennsylvania Clean Transportation Corridor - Station and Truck Summary**

	FOUNDATION	DEVELOPED
Total Stations	8	17
Total Trucks	400	850
Total Investment in Pennsylvania (in millions)	\$98	\$208

## Benefits of the PCTC

An investment of this magnitude will bring significant benefits to Pennsylvania in the form of jobs, economic activity, tax revenues, lower operating costs for business, environmental benefits, and a more sustainable and more energy-secure transportation sector.

### *The PCTC: A Pennsylvania Job Stimulus*

The implementation of the PCTC roadmap will stimulate local investments in natural gas fleets and refueling infrastructure, thus providing a boost to advanced clean-fuel technology jobs. The construction of natural gas refueling stations and maintenance facility upgrades will result in important local construction jobs, and sales of new natural gas trucks will provide needed stimulus to in-state manufacturers and truck dealerships. Local truck drivers and mechanics will be exposed to advanced technologies and alternative-fuel-vehicle maintenance and repair, thus broadening their skill sets and providing the Pennsylvania workforce with the professional expertise that will be required in the 21<sup>st</sup> century.

***The Pennsylvania Clean Transportation Corridor will help to equip Pennsylvania's workforce with the tools and expertise needed for the 21<sup>st</sup> century economy.***

The PCTC project, as defined in this analysis, will create or sustain 639 full-time jobs in the advanced clean fuel technology field under the Foundation Case, and 1,359 full-time jobs under the Developed Case<sup>19</sup>. A breakdown and summary of these jobs is provided in the table below, followed by more detailed explanations.

**Table 5: Jobs Summary for the Pennsylvania Clean Transportation Corridor**

	FOUNDATION	DEVELOPED
Advanced Clean Fuel Technology Jobs (Trucks)	516	1,096
Advanced Clean Fuel Technology Jobs (Stations)	50	107
Advanced Clean Fuel Technology Jobs (Facilities)	20	43
Advanced Clean Fuel Technology Jobs (E&P)	53	113
<b>Advanced Clean Fuel Technology Jobs (TOTAL)</b>	<b>639</b>	<b>1,359</b>

<sup>19</sup> Job numbers were calculated using a GNA calculator that was developed in response to the 2009 U.S. Department of Energy Clean Cities Program grant solicitation. This job calculator accounts for employment hours per truck per year in various categories. We consulted with major natural gas truck manufacturers, dealers and fleets to confirm hourly estimates for each step of natural gas product roll-out, including production, training, service, parts, delivery, administrative support, and truck operation services. The total hours required for each truck was then multiplied by the total number of trucks and divided by 2,000 hours in order to determine how many full time equivalent (FTE) jobs can be directly attributed to the trucks ordered for this project. It should be noted that these responsibilities could be spread over several companies, several employees and several years.

### **Manufacturing Jobs**

In addition to the direct economic impact attributed to the responsible development of the Marcellus Shale, Pennsylvania's manufacturing sector has also experienced a renewal. The growth of the NGV market will have a number of immediate and direct job impacts on major Pennsylvania manufacturing companies that are involved in the NGV and equipment industry.

Pennsylvania is home to some of the world's leading natural gas truck manufacturers and refueling-station equipment manufacturers. Among the most recognizable brand of NGVs are Mack Trucks, one of North America's leading suppliers of natural gas powered refuse-collection trucks. Below are additional examples of Pennsylvania-based companies that are leaders in the NGV industry, and that will benefit from the expansion of the NGV market via the PCTC and other similar efforts.

**Mack Trucks (Allentown, Pa.)** is a Pennsylvania truck manufacturer and one of the nation's leading natural gas truck providers. Mack Trucks manufactures its entire product line in its 1-million square-foot plant in Macungie, Pennsylvania, just outside of Allentown. This facility employs over 800 people.

Mack Trucks first started making heavy-duty natural gas trucks and engines over 10 years ago, and was the first truck manufacturer in the U.S. to have a completely vertically integrated natural gas truck platform. The company continues to offer natural gas refuse-collection truck products, with its TerraPro model – one of the most popular refuse-collection trucks in America – now available from the factory as a natural gas powered unit.



Figure 9: Mack TerraPro NG Refuse Truck

As the natural gas vehicle usage in Pennsylvania and throughout North America grows, especially in the refuse-collection sector, and via the development of the PCTC project and other efforts, Mack Trucks and its employees will be directly and positively impacted by that growth. For example, if it is assumed that all 850 trucks under the Developed Case were to pass through the Pennsylvania manufacturing facility over a three year timeframe, Mack would see an increased build rate of around 24 trucks per month, which would necessitate the equivalent of 28 full-time workers each year.

**PC McKenzie/Ingersoll Rand (Pittsburgh, Pa.)** is one of the largest equipment suppliers in the compressed natural gas (CNG) fuel station business. The company supplies Ingersoll Rand natural gas compressors for the NGV market, as well as dehydration systems, filter separators, pilot operated relief valves, air-cooled heat exchangers and compressor systems for the natural gas pipeline industry. Ingersoll Rand is the only American Fortune 500 company manufacturing NGV compressor packages. Its CNG compressor packages are assembled in Pittsburgh, and are ideal for fleets with between 10 and 100 CNG vehicles.

**Knox Western (Erie, Pa.)** is one of the world's premier CNG compressor manufacturers, with more than 200 of its units already in service around the world. The company designs,

manufacturers and builds several natural gas compressor packages. Its manufacturing facilities are all located in Erie,, which is also the location of the company's headquarters and home to more than 50 corporate employees.

**CP Industries (McKeesport, Pa.)** is the world leader in the manufacturing of large seamless steel pressure vessels for high-pressured gases. With more than 100 employees, CP Industries has built pressure vessels for CNG refueling stations around the country.

**PSB Industries (Erie, Pa.)** specializes in the design and fabrication of compressed air, gas, and liquid dehydration and purification systems. The company produces single- and dual-tower regenerative or non-regenerative natural gas dryers for CNG fuel stations of all sizes. PSB Industries employs more than 100 people.

**Air Products and Chemicals, Inc. (Allentown, Pa.)** serves customers in industrial, energy, technology and healthcare markets all around the world with a unique portfolio of atmospheric gases, process and specialty gases, performance materials, and equipment and services. The company makes remote natural gas economical to transport with liquefied natural gas heat exchangers, as well as hydrogen fueling infrastructure. With the company's corporate headquarters located in Allentown, Air Products employs 18,300 people throughout the United States, and has additional operations in more than 40 countries around the world.

**Cryostar (Bethlehem, Pa.)** is an industry leader in the design and manufacturing of cryogenic equipment. Over the last decade, Cryostar has increasingly focused on extending its offerings to process plants in the fields of natural gas and clean energy. Cryostar has been extremely proactive in partnering on the development of natural gas refueling stations in California, and is a strong advocate for accelerated market penetration of NGVs. The Bethlehem facility is home base for Cryostar's East Coast sales and technical field service operations.

#### **Vehicle Related Jobs**

Large numbers of vehicle-related jobs will be created due to development of the PCTC, including those related to production, training, service, parts manufacturing, delivery and truck operation. Local maintenance and service-support jobs will be created in order to service and support natural gas trucks; special training will be provided to fleet-maintenance personnel and fleet drivers so they will have the skills to maintain and service the low-emission natural gas engines and tanks, as well as to operate the trucks. Fleet drivers will also be trained to understand the basic operation of the on-board natural gas fuel tank and the methane detection system, if applicable, so they are well-prepared in the event of an accident and/or emergency situation.

The net impact is the equivalent of 516 additional full-time equivalent (FTE) jobs as a result of the Foundation Case of the 400 vehicle rollout, and 1,096 FTE jobs as a result of the 850 Developed Case vehicle rollout.

#### **Station Construction Jobs**

The range of jobs involved in a station construction project include: specification engineer; estimator; bid writer; project manager; purchasing agent; design engineer; drafter; cryogenic engineer; plan checker; site foreman; equipment operator; laborer; electrician; electrician assistant; mechanic; mechanic assistant; carpenter; pipe fitter; and administrative support personnel. A large majority of these jobs will be local.

Each of the large refueling stations in the PCTC project will require approximately 277 weeks of full-time man hours, or 5.3 FTE jobs. Under the Foundation Case scenario, eight large stations

will result in 42 FTE jobs. Under the Developed Case scenario, 17 large natural gas refueling stations will be constructed, resulting in 90 FTE local jobs.

### **Station Fueling Jobs**

For each refueling station in operation, at least one full-time job will be created to support ongoing station maintenance and operation efforts, parts-supply efforts and other support functions. Therefore, this project will require an additional eight to 17 FTE jobs for station maintenance and operations<sup>20</sup>.

### **Facility Modification Jobs**

The retrofitting of an existing vehicle-maintenance facility to permit the indoor maintenance of vehicles fueled by natural gas is required by code. It is difficult to accurately project a job creation/maintenance figure associated with this project, but for the purposes of this analysis, a \$400,000 maintenance-garage upgrade must be completed. However, GNA has calculated that approximately 20 construction jobs will be created under the Foundation Case and 43 construction jobs will be created under the Developed Case.

### **Natural Gas Production Jobs**

The Marcellus Shale industry currently employs over 80,000 Pennsylvanians.<sup>21</sup> There are numerous local companies that are involved in these functions and that benefit directly from the gas production efforts: Eaton Corp, Mine Safety Appliances, Cleveland Brothers, United States Steel, GE Transportation Systems, CSX Transportation, Air Products, PPG, and Caterpillar are just a few of the Pennsylvania companies that are benefiting from the development of this extremely important energy resource.

The Marcellus Shale is eventually expected to produce more than 13 times the amount of gas that it is producing right now; production at such an increased level will require another 120,000 employees in the gas production industries<sup>22</sup>.

The successful implementation of the PCTC project will result in the additional demand for natural gas by approximately 2.0 BCF to 5.4 BCF over the next 10 years. Given that the most favorable economic model for natural gas use is one that relies upon local resources, it is assumed that this gas demand will be met by local production from the Marcellus Shale. For this level of gas production, it is estimated that the PCTC will require an additional 53 to 113 jobs in the Marcellus Shale exploration and production value chain.

### ***Pennsylvania Tax Revenue***

In addition to jobs, environmental and user benefits, natural gas infrastructure development, and NGV deployment, the development and production of natural gas in Pennsylvania will also bring in increased tax revenues. In total, \$29.6 million in sales, excise taxes and fuel taxes would be generated by the trucks, infrastructure development and fuel use projected under the Foundation Case, and \$62.9 million would be generated under the Developed Case.

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<sup>20</sup> These numbers are included in the “stations” row of the summary table.

<sup>21</sup> The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Plan: An Update, The Pennsylvania State University, College of Earth and Mineral Sciences, Department of Energy and Mineral Engineering, May 2010

<sup>22</sup> The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Plan: An Update, The Pennsylvania State University, College of Earth and Mineral Sciences, Department of Energy and Mineral Engineering, May 2010

**Table 6: Tax Revenue from the Pennsylvania Clean Transportation Corridor**

	FOUNDATION CASE	DEVELOPED CASE		FOUNDATION CASE	DEVELOPED CASE
	Taxable Units (\$ millions)			Tax Rate	Tax (\$ millions)
Sales Tax on Truck Sales	\$ 66	\$ 140	6%	\$ 4.0	\$ 8.4
Truck Sales FET	\$ 66	\$ 140	12%	\$ 7.9	\$ 16.8
Infrastructure Development	\$ 15	\$ 31	6%	\$ 0.9	\$ 1.8
Facility Modifications	\$ 2	\$ 5	6%	\$ 0.01	\$ 0.03
Fuel (gallons over 10 years)	44	93	38.1	\$ 16.7	\$ 35.5
TOTAL (millions)				\$ 30	\$ 63

Natural gas development in Pennsylvania, while a relatively young industry, has already created thousands of jobs and billions in annual revenue. State and local tax dollars from natural gas during 2009 include vehicle license fees, income taxes paid on laborers employed by the natural gas industry, sales taxes on natural gas vehicles and property taxes. Pennsylvania State University modeling of the economic impacts from the Marcellus Shale concluded that the \$4.5 billion Marcellus gas producers spent in Pennsylvania to develop shale resources in 2009 generated \$3.9 billion in value added, \$389 million in state and local tax revenues, and more than 44,000 jobs. By 2020, natural gas could generate more than \$18 billion in value added.<sup>23</sup>

The production of natural gas contributes to the development of the economy in two significant ways. The first is expenditures by gas companies in the form of lease and royalty payments to land owners, which in turn generate higher income and property tax revenues.

The second is through business-to-business spending. Producing natural gas entails exploration, leasing, drilling and pipeline construction; total spending from these activities in 2008 and 2009 was estimated at \$3.2 billion and \$4.4 billion, respectively<sup>24</sup> Natural gas operations also increase business activity in areas such as real estate and legal services, construction, steelmaking, engineering services, heavy-equipment leasing or purchasing, trucking..

Furthermore, these activities require studies, support firms, the purchase of supplies, aggregates, and other goods and services from discretionary spending stemming from the increased purchasing power of workers to employee lodging and dining at local hotels and restaurants. Overall, these business-to-business expenditures create additional spending and re-spending throughout the economy, leading to higher sales tax revenues, as well as additional jobs.

The development of natural-gas-infrastructure and low-emission-vehicle projects also increases local revenue from the permitting and licensing fees, as well as the attraction of federal funding

<sup>23</sup> The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Plan: An Update, The Pennsylvania State University, College of Earth and Mineral Sciences, Department of Energy and Mineral Engineering, May 2010.

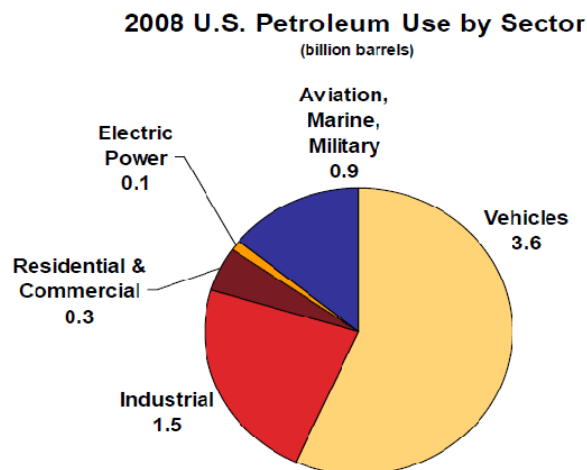
<sup>24</sup> Ibid.

and grants through programs such as U.S. Department of Energy (DOE) Clean Cities, and U.S. Environmental Protection Agency (EPA) Diesel Emission Reduction Act.

### **Domestic Energy Security**

Given the political volatility inherent in the Middle East, and the direct relationship to the increasing cost of a barrel of oil, it has never been more important to increase the use of alternative fuels in our transportation sector. As the transportation sector is responsible for 3.6 billion barrels of petroleum use every year – out of a total of approximately 6.4 billion barrels per year – the sector represents the single best opportunity to put a dent in the approximately \$1 billion that the U.S. exports every day for more than 65% of its needed petroleum <sup>25</sup>.

<b>Table 7: 2010 U.S. Oil Imports (billion bbls)<sup>26</sup></b>	
Canada & Mexico	1.56
OPEC & Persian Gulf	2.45
Other	0.44
<b>Total</b>	<b>4.5</b>



**Figure 10: U.S. Petroleum Use by Sector**

In addition to being the cleanest fossil fuel, natural gas has the benefit of being a domestically abundant and secure fuel source – especially given new sources of natural gas, such as the Marcellus Shale – thereby significantly enhancing the nation's energy and national security.

The PCTC is expected to displace at least 4.3 million gallons of diesel per year under the Foundation Case scenario, and 9.2 million gallons per year under the Developed Case scenario. Over the expected 10-year vehicle life, this will translate into petroleum displacement of between 43.3 million and 92.1 million gallons of petroleum diesel fuel under the two scenarios, which is also equivalent of 4.2 million to 8.9 million barrels of oil, respectively, being displaced.

**Table 8: Diesel Fuel Displacement & Increased Domestic Natural Gas Demand**

	<b>FOUNDATION</b>	<b>DEVELOPED</b>
Diesel Fuel Displaced (million gallons over 10 Years)	<b>43</b>	<b>92</b>
Barrels of Oil Displaced (millions-10 Years)	<b>4</b>	<b>9</b>
Natural Gas Fuel Demand (BCF - 10 Years)	<b>6</b>	<b>14</b>

<sup>25</sup> Data from U.S. Energy Information Administration showing 18.771 bbl/day of U.S. petroleum and 12.345 bbl/day of petroleum imports. [http://www.eia.doe.gov/energyexplained/index.cfm?page=oil\\_home#tab2](http://www.eia.doe.gov/energyexplained/index.cfm?page=oil_home#tab2)

<sup>26</sup> Data based upon January 2011 averages as reported by U.S. Energy Information Administration, U.S. Imports by Country of Origin. [http://www.eia.doe.gov/dnav/pet/pet\\_move\\_impcus\\_a2\\_nus\\_ep00\\_im0\\_mbbbl\\_m.htm](http://www.eia.doe.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbbbl_m.htm)

Of course, all of these numbers do not account for any additional natural gas vehicle deployments over the 10-year term of the PCTC, and that are likely to occur once Pennsylvania fleet operators see the economic benefits of transitioning to natural gas and as additional refueling infrastructure is developed. Therefore, these results should be viewed as the benefit floor, as additional natural gas trucks and fueling stations are very likely to be built during the first 10 years of the PCTC Project.

### ***Fleet Fuel Cost Savings and Re-Investment in Pennsylvania's Economy***

Natural gas is less expensive than diesel. The current spread between diesel fuel and an equivalent volume of natural gas is now more than \$1.00 per diesel gallon, and in some cases even greater than \$1.50 per diesel gallon<sup>27</sup>. This significant advantage is expected to continue for the foreseeable future, particularly as increased tensions in the Middle East drive the cost of petroleum even higher, and the further development of domestically abundant natural gas resources continues to stabilize the price of natural gas.

A truck that is driving 65,000 miles a year will consume approximately 10,800 gallons of diesel (assuming a fuel economy of 6 MPG). Assuming the current difference between diesel and natural gas averages \$1.00 per diesel-equivalent gallon, that vehicle will save \$10,800 a year in reduced fuel costs. Over five years, that vehicle will save \$54,200, while over 10 years the natural gas truck will save \$108,400. In total, through the PCTC project there is the potential to save participating Pennsylvania fleet operators between \$43.3 million and \$92.1 million in reduced fuel costs over a 10-year project period.

***Table 9: End User Fuel Cost Savings Resulting from the PCTC***

	<b>FOUNDATION</b>	<b>DEVELOPED</b>
Total Trucks	<b>400</b>	<b>850</b>
Annual Fuel Cost Savings (millions)	<b>\$4.3</b>	<b>\$9.2</b>
Fuel Cost Savings Over Expected 10-Year Life of Initial Truck Deployments (millions)	<b>\$43</b>	<b>\$92</b>

Given the single-digit margins on which the heavy-duty trucking sector operates, the ability to recognize such significant fuel cost savings is exceptionally important. With such an opportunity to reduce one of the top operational expenses via the use of lower-cost natural gas, Pennsylvania-based fleet operators will be provided with an important economic stimulus. The significant operational cost savings that will be realized will allow Pennsylvania businesses to make important reinvestments in their companies in the form of new equipment, the retraining and hiring of personnel, and/or other strategic investments in their operations; thus further strengthening one of the more important sectors of Pennsylvania's economic base (i.e., the trucking sector) and Pennsylvania's economy overall.

### ***Air Quality***

Pennsylvania suffers from the 8<sup>th</sup> worst air quality in the nation in terms of health risk from diesel soot. While diesel vehicles provide critically needed transportation services, conventional diesel trucks are one of the leading sources of both smog-forming nitrogen oxide (NOx) and these toxic diesel particulates.

<sup>27</sup> [http://www.afdc.energy.gov/afdc/pdfs/afpr\\_oct\\_10.pdf](http://www.afdc.energy.gov/afdc/pdfs/afpr_oct_10.pdf)

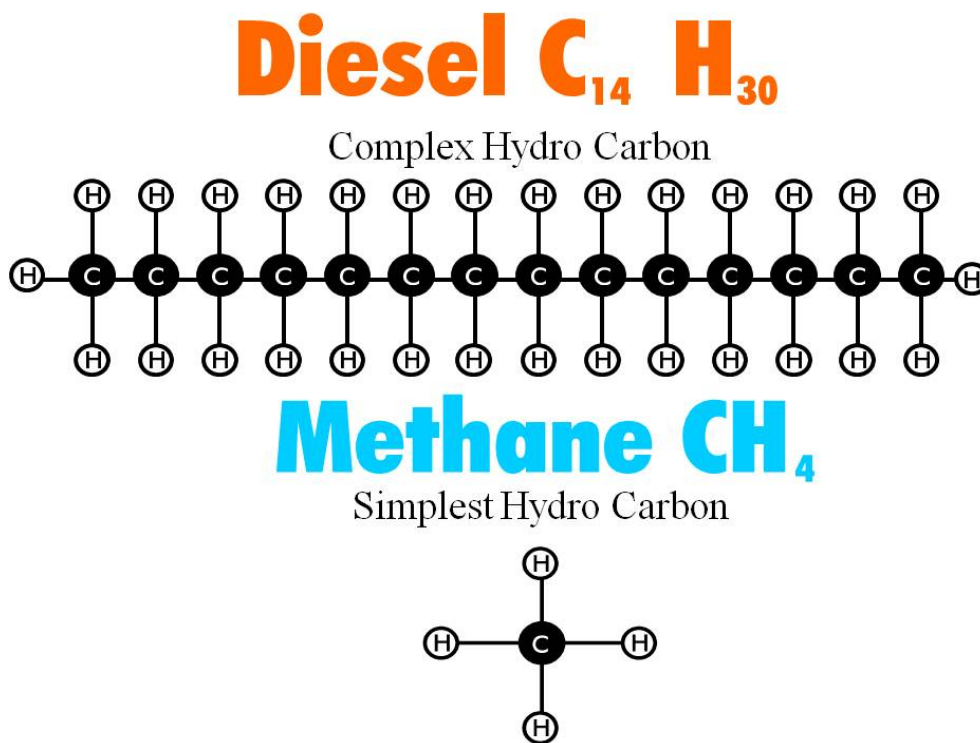
Leadership throughout Pennsylvania agrees that the reduction of air pollutants and toxic contaminants from diesel engines is a high priority. Natural gas is an extremely important transportation fuel for reducing smog-forming compounds, mitigating public exposure to toxic diesel soot, and curbing the effects of climate change.

The PCTC Project will displace more carbon-intensive fuel burned by heavy-duty trucks with cleaner-burning and domestically produced natural gas. This will result in significant air quality benefits, including the annual reduction of 340 tons of NOx, 6.8 tons of PM, and 9,900 metric tons of GHG emissions under the Foundation Case, and the reduction of 720 tons of NOx, 14.5 tons of PM, and 21,000 metric tons of GHG emissions under the Developed Case.

**Table 10: Emission Benefits of the Pennsylvania Clean Transportation Corridor**

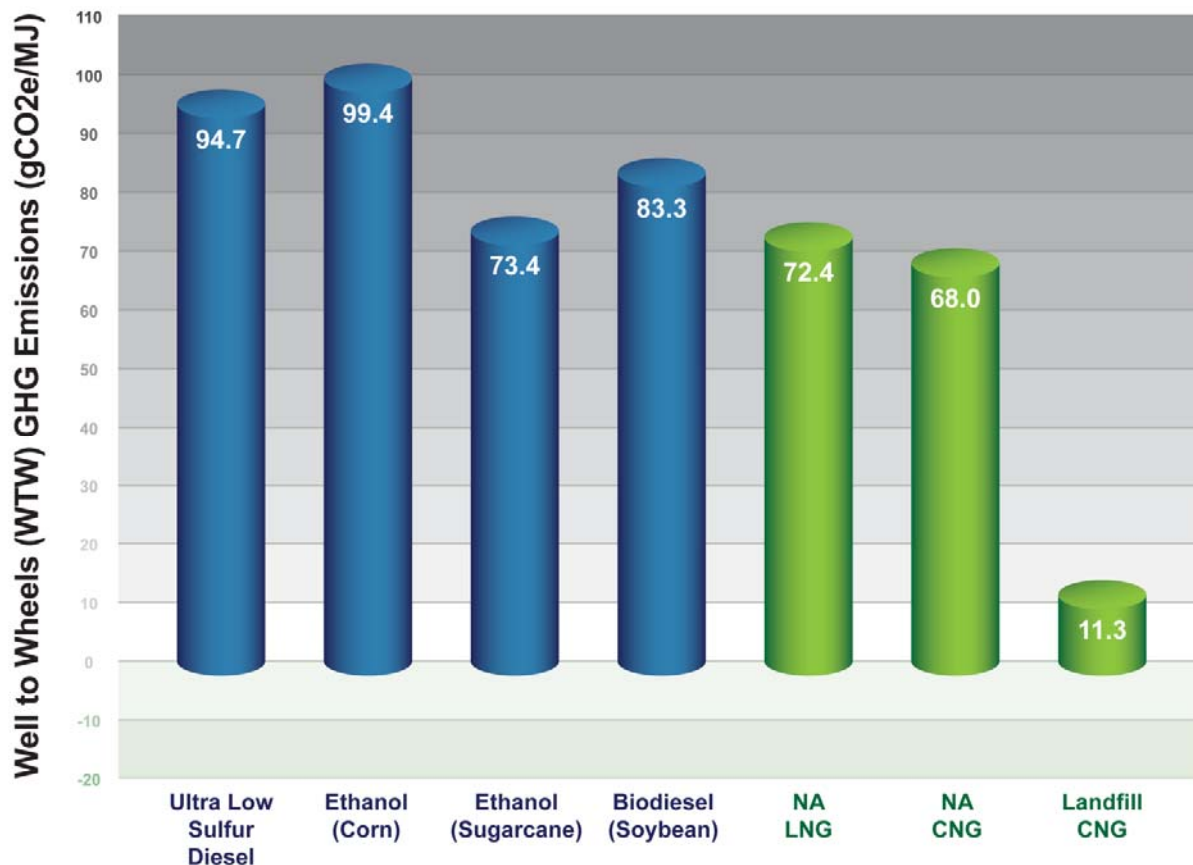
	FOUNDATION	DEVELOPED
Annual NOx Emission Reductions (tons)	<b>340</b>	<b>720</b>
Annual PM Emission Reductions (tons)	<b>6.8</b>	<b>14.5</b>
Annual GHG Emission Reductions (MT)	<b>9,900</b>	<b>21,000</b>

Natural gas is the cleanest of all commercially available transportation fuels for Class 6 to 8 vehicles, even when factoring in emissions from production and transportation. Composed mainly of methane, the primary byproducts of the combustion of natural gas are carbon dioxide (CO<sub>2</sub>) and water vapor. Given the simplicity of the methane molecule, natural gas engines produce a fraction of the soot created by diesel engines.



**Figure 11: Diesel and Methane (Natural Gas) Molecule Structure**

Natural gas trucks deployed throughout the PCTC Project will have an estimated 90% fewer NOx and PM emissions, 100% fewer SOx emissions, and up to 30% fewer GHG emissions than the 5-7-year-old diesel trucks they are replacing. Furthermore, diesel soot is specifically classified as a Toxic Air Contaminant (TAC) due to the health hazard posed by the chemical composition of the particles. The lower emissions from natural gas use in trucks will provide significant public health benefits.



**Figure 12: CARB Well to Wheel Greenhouse Gas Emissions Analysis of Various Transportation Fuels**

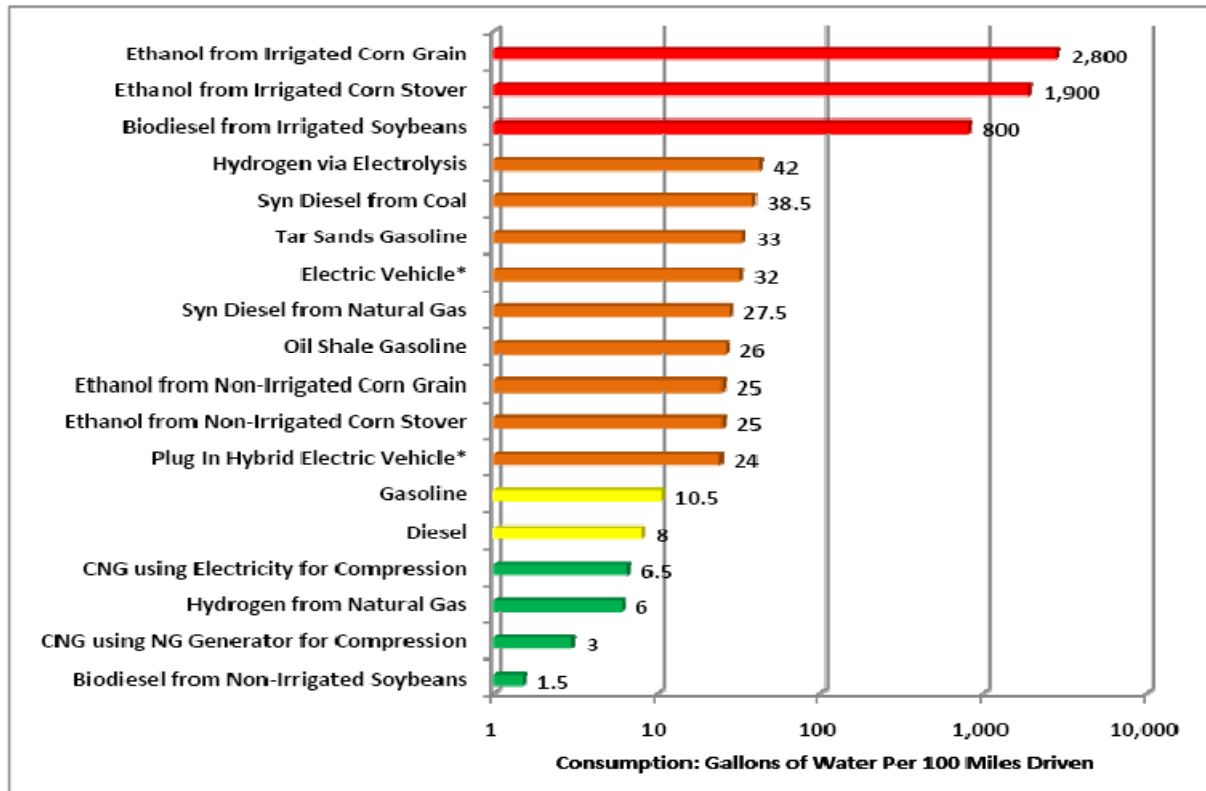
With the development of the foundation natural gas refueling infrastructure along the PCTC, additional NGV deployments in all sectors are expected to eventually surpass the figures presented within this report's Foundation and Developed Case scenarios. These additional deployments will yield incremental benefits for Pennsylvania, including: increased petroleum displacement levels; the increased use of clean, domestically produced fuels; and important reductions in the criteria-pollutant and greenhouse-gas emission levels.

### ***Natural Gas: A Water-Efficient Transportation Fuel***

As the world continues to seek alternative to traditional gasoline and diesel fuel sources, the issue of water use has often been a focal point when completing a holistic environmental review of the benefits associated with these alternatives. Recent data<sup>28</sup> on this subject indicate that the

<sup>28</sup>King, C.W., and M.E. Webber, 2008a, The water intensity of the plugged-in automotive economy: Journal of Environmental Science and Technology, v. 42 (12), p. 4305–4311.

use of compressed natural gas as a motor fuel is one of the most water-efficient alternative fuel technologies available.



Source: Adapted from King and Webber 2008a; \*Adapted from King and Webber 2008b

**Figure 13: Water Intensity of Transportation Fuels (graphic courtesy of ANGA; source information adapted from King and Webber 2008<sup>29</sup>)**

King, C.W., and M.E. Webber, 2008b, The Water Intensity of Transportation: Journal of Environmental Science and Technology, v. 42 (21), p.7866-7822.

<sup>29</sup> King, C.W., and M.E. Webber, 2008a, The water intensity of the plugged-in automotive economy: Journal of Environmental Science and Technology, v. 42 (12), p. 4305–4311; and, King, C.W., and M.E. Webber, 2008b, The Water Intensity of Transportation: Journal of Environmental Science and Technology, v. 42 (21), p. 7866-7822.

### Existing Natural Gas Fuel Stations in Pennsylvania

***Pennsylvania is already one of the nation's leaders in the development of NGV projects, with over 20 natural gas fueling stations already operating in the state.***

**Figure 14: Map of the Existing Natural Gas Fueling Stations in Pennsylvania**

The PCTC will build upon Pennsylvania's existing natural gas vehicle infrastructure to provide continual access to existing NGVs, and to expand that infrastructure network to meet the larger goals of the project.

### ***PCTC Layout Recommendations: Foundation Case***

To provide for accessible natural gas refueling coverage for light-, medium- and heavy-duty vehicles operating along the PCTC – and thus create a baseline for this project – a minimum of eight natural gas refueling stations must be established in very strategic locations. Under this “Foundation Case” scenario, fueling stations would be strategically located in Pittsburgh, Harrisburg, Philadelphia and Scranton. These stations would primarily serve the return-to-base fleet operations for which they were built while being capable of serving broader base of trucks traveling between these major urban areas. The Foundation Case is generally viewed as a starting point for a more comprehensive network of natural gas refueling stations that can serve all of Pennsylvania, as well as connect to neighboring cities and states that are strategically important to Pennsylvania’s goods-movement sector.

#### ***The Pennsylvania Clean Transportation Corridor will have:***

- *8 stations under the Foundation Case*
- *17 stations under the Developed Case*

***Final station locations will depend upon the actual locations of the base fleet operators each site will serve.***

Under the Foundation Case scenario, it is recommended that three natural gas stations be developed in the Philadelphia region, three stations in the Pittsburgh region, one station in the Scranton/Wilkes-Barre area, and one station in Harrisburg. It is recommended that the stations be developed in the general vicinity of major interstate highway intersections in order to provide long-term fueling access to the greatest possible number of heavy-duty vehicles. Of course, the ultimate location of each new natural gas refueling station will depend upon the location of the targeted return-to-base fleet operator that will allow for the development of each site. Conceptually, however, the roadmap recommends stations be targeted in the following areas:

#### **Philadelphia**

- I-95/I-276 on the northeast entrance to Philadelphia as approached from New York, New Jersey and the ports.
- I-76/I-476 on the northwest side of the city, which is the crossroads when heading west to Harrisburg and Pittsburgh or north when heading to Allentown and Scranton/Wilkes-Barre.
- I-95/I-76 just south of downtown Philadelphia, and very near the Philadelphia International Airport, Delaware Bay waterway, naval yard and intermodal yards.

**Pittsburgh**

- I-76/I-376/US-22 near downtown Pittsburgh and the airport. This location would be a major entry point to the downtown community from the east.
- I-79/I-279, a highly trafficked intersection on the north side of the city with convenient access to many parts of Pittsburgh. Giant Eagle's proposed public access is located within this targeted region.
- I-79/I-70, which constitutes a major goods-movement corridor traversing the state from east to west, and passing through Philadelphia, Harrisburg and Columbus, Ohio. I-79 is a significant interstate freeway running from north to south and passing closely through downtown Pittsburgh. The Waste Management station, which is currently undergoing permitting in Washington, Pennsylvania will fill this strategic location.

**Scranton/Wilkes-Barre**

- I-81/I-476, the major freeway intersection where the two main interstate highways entering Scranton from the south coincide.

**Harrisburg**

- I-76/I-283/PA-283 by the Harrisburg International Airport; the main point of entry to the region from Philadelphia. Also near I-78, I-81 and I-83.

***PCTC Layout Recommendations: Developed Case***

In order to provide for more comprehensive fueling coverage, as well as to better support the deployment of heavy-duty natural gas trucks within the PCTC, the large geographic size and high population concentration of the metropolitan areas of Pittsburgh and Philadelphia can easily accommodate more fueling stations than are recommended in the Foundation case. Additionally, other locations within Pennsylvania and that are smaller and have fewer residents could support non-trucking natural gas vehicles. Therefore, a more enterprising and "Developed Case" plan is recommended as part of the roadmap in order to provide 17 strategically located natural gas fueling stations along the PCTC.

This Developed Case plan provides for a more comprehensive fueling station network within and between the cities of Pittsburgh, Harrisburg, Philadelphia, Wilkes-Barre, Scranton, Allentown, and Williamsport. Not only that, it will also serve to connect to Pennsylvania's neighboring states, metropolitan areas and strategic trading partners.

Under the Developed Case scenario, it is recommended that a total of six natural gas stations be developed in the Philadelphia region, four stations in the Pittsburgh region, two stations in the Scranton/Wilkes-Barre area, three stations in Harrisburg, one station in Allentown, and one station in Williamsport. Building upon the conceptual recommendations presented in the Foundation case, the roadmap recommends the following additional stations be targeted under the Developed Case:

**Philadelphia**

- I-276/I-476 near I-76/PA-309.
- I-76/I-676, west of downtown near an intermodal yard and the University of Pennsylvania.
- I-95/Betsy Ross Bridge, northeast of downtown near an intermodal yard and several large trucking companies; the Betsy Ross Bridge provides easy access to New Jersey.

**Pittsburgh**

- US-22/US-30 by the Pittsburgh International Airport and west of downtown Pittsburgh.

**Harrisburg**

- I-81/I-83, northeast of the region ; the access point when travelling from Scranton/Wilkes-Barre, Allentown, and when travelling east to the ports of New York and New Jersey.
- I-76/I-81, west of Harrisburg on the highway corridor from Pittsburgh and the Midwest; also very close to Carlisle, the other significant city in the Harrisburg region.

**Scranton/Wilkes-Barre**

- I-81/I-80 on the south side of Wilkes-Barre; two major goods movement freeways.

**Allentown**

- I-78/I-476/US-22; the convergence point for all major goods-movement roads from Harrisburg, Philadelphia, Scranton/Wilkes-Barre and New York and New Jersey.

**Williamsport**

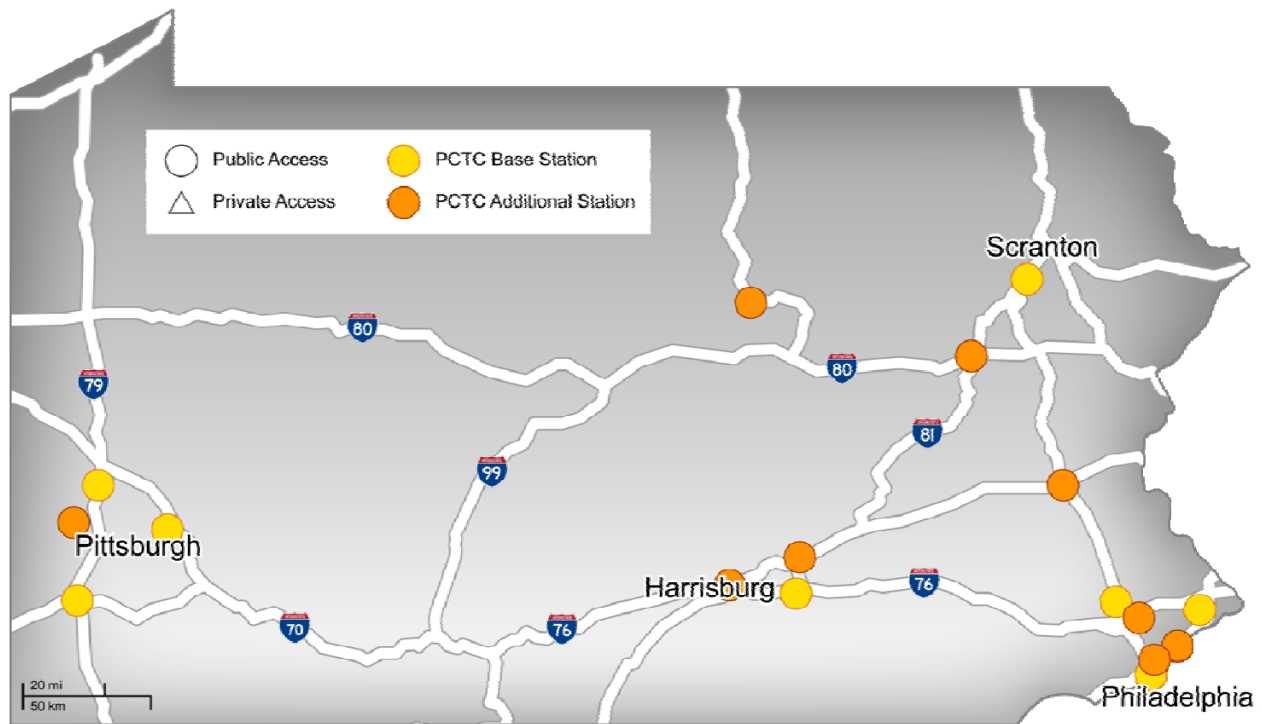
- US-220/US-15, just west of Williamsport; near the two largest highways in the area and very near an intermodal yard and multiple warehousing and distribution centers.

***Station Development within the PCTC: Summary***

Under the Foundation case and Developed Case scenarios of the PCTC development roadmap, a total of eight to 17 stations can be developed in strategic locations within Pennsylvania. This network of accessible refueling stations will provide the basis by which the state can make a transition to lower-cost and domestic fuels in the heavy-duty transport sector. A summary of the new natural gas refueling infrastructure that will be developed under the Foundation and Developed Case scenarios is provided below, together with a map showing these overall locations.

***Table 11: Potential Natural Gas Refueling Stations (Conceptual)***

	FOUNDATION	DEVELOPED
Philadelphia	3	6
Pittsburgh	3	4
Harrisburg	1	3
Scranton	1	2
Allentown	0	1
Williamsport	0	1
<b>Total</b>	<b>8</b>	<b>17</b>



**Figure 15: Map of the Natural Gas Fueling Station Locations Proposed for the PCTC**

While both the Pittsburgh and Philadelphia metropolitan areas are similar in geographic size, the population density is considerably greater in Philadelphia, which has a population of about 6 million versus Pittsburgh's 2.4 million. The Foundation case scenario calls for three natural gas fueling stations around the Pittsburgh area and three stations around the Philadelphia area. The Developed Case adds an additional three stations to Philadelphia (for a total of seven), and one additional station to Pittsburgh (for a total of four).

Scranton, with a population of more than 500,000, is one of the only heavily populated areas in northern Pennsylvania with close proximity to upstate New York and New England. With major goods-movement corridors running through the region, Scranton is well-situated for heavy-duty natural gas vehicle use; as a result, the Foundation Case calls for one station, while the Developed Case calls for two stations.

The relatively moderate distances between major cities in the PCTC – Pittsburgh and Philadelphia are approximately 300 miles apart, and Pittsburgh and Scranton/Wilkes-Barre a little more than 300 miles apart – is one of the important features of this project. Although a properly equipped heavy-duty truck should be able to travel from one city to another city without refueling, it is strongly recommended that fueling stations be developed between the major cities in order to provide for a much more robust infrastructure along the PCTC. Appropriate locations must therefore also be identified between the major metropolitan areas.

A critical element for the successful development of fueling stations in these gap locations will be locating sufficient local fueling demand that can provide the base load that will justify the infrastructure investment and cost of ongoing operations. As these intermediate locations are likely to have fewer heavy-duty fleet operations to serve as anchor tenants for a fueling station, it is projected that fewer fueling stations will be developed in these gap locations.

Harrisburg is a likely candidate for an intermediate location along the corridor from Philadelphia to Pittsburgh and would be a good site for the eighth natural gas fueling station within the Foundation Case. Additionally, Harrisburg is also a logical midway point for goods movement between the Scranton/Wilkes-Barre region and Pittsburgh. Harrisburg is located on major freeways that are essential for goods movement throughout the region. Together with Philadelphia, it connects New York, New Jersey and New England with southern destinations. Harrisburg is also the interconnecting city when heading west from those same East Coast states into Ohio, Indiana and beyond (via I-70). Because of its location, Harrisburg has considerable warehousing and distribution sectors, and is critical to several goods-movement corridors. This region has over 186 million square feet of warehousing space, and is one of the fastest growing warehousing and distribution regions in the U.S.<sup>30</sup> The Developed Case calls for the addition of two stations in the Harrisburg region.

A natural gas fueling station in Allentown is also recommended as part of the Developed Case. The Allentown metropolitan area is the largest metropolitan area in Pennsylvania outside of Pittsburgh and Philadelphia. Even though the area is more populated than Harrisburg or Scranton, it's more of a bedroom community with less emphasis on goods movement and other industries than other areas. Still, with almost 800,000 people in the area, there is significant truck use for refuse collection, transit, and food/beverage/package delivery, thus providing the opportunity for natural gas fuel-station development in this strategically important region.

Finally, Williamsport is another good candidate city for natural gas fueling infrastructure. Near I-80 in the northern part of Pennsylvania, Williamsport is a relatively small community but one that has experienced significant growth in recent years due to the expansion of the warehousing and distribution sectors, as well as the Marcellus Shale gas-exploration industry. In the last two years, 70 companies have opened in the area as a direct result of Marcellus Shale development.<sup>31</sup> A natural gas fueling facility in Williamsport will provide for fueling bases for both the goods-movement sector, as well as exploration and production related companies operating in the area. This station will be the 17<sup>th</sup> station proposed under the Developed Case scenario.

### ***Natural Gas Vehicle Fueling Stations***

The natural gas vehicle refueling stations proposed as part of the PCTC roadmap development plan must be suitable for the fueling of large, heavy-duty fleet vehicles that consume large volumes of fuel. Unlike a typical passenger car, pickup truck or van that may need 10 to 20 gallons of fuel every few days, heavy-duty vehicles require 50-100 gallons or more at each refueling, and are often refueled each day. Therefore, the stations that are developed as part of this project must be capable of meeting these commercial fueling needs.

Natural gas as a commercial transportation fuel is available in two different forms: either as a compressed natural gas (CNG) or as liquefied natural gas (LNG). Both forms are simply natural gas, the only difference is the means by which it is fueled and stored in the vehicle.

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<sup>30</sup> South Central Regional Goods Movement Study, Final Report, Cambridge Systematics, Inc., July 2006.

<sup>31</sup> Quote from Vincent J. Matteo, president and CEO of the Williamsport-Lycoming Chamber of Commerce, as reported by John Beauge, The Patriot-News, "In Little League's home, gas drilling is huge", August 24, 2010.

In a general sense, CNG fueling stations are more common in light- and medium-duty vehicle applications, while LNG fueling stations more often serve heavy-duty vehicle fleets. While either type of fuel station is used to store and dispense natural gas vehicle fuel, LNG and CNG refueling technologies are different from one another.



**Figure 16: Typical CNG Refueling Station Equipment**

CNG fuel stations are high-pressure systems that receive gas from the local utility pipeline network. The pipeline gas is then pressurized using large compressors with motors generally between 250-600 horsepower. The gas is compressed and stored in high-pressure storage tubes (or spheres) at 5,000 psi until it is dispensed via pressure transfer into an on-board vehicle fuel storage system; this transfer is completed through traditional looking fuel dispensers under “fast fill” fueling operations similar to the way traditional diesel and gasoline are fueled. The on-site high-pressure CNG storage capacity in a fast-fill station is typically between 100-200 useable gasoline equivalent gallons (GGE). This allows for the rapid transfer of CNG fuel to vehicles without the use of the compressor in volumes up to the available useable stored CNG fuel. When this on-site useable fuel storage capacity is nearing depletion, the CNG compressor will be activated and will begin to fuel vehicles directly. After vehicle fueling is complete, the compressor will refill the on-site storage and turn off.

CNG fuel systems also have the capability to provide time-filling of vehicles while they are parked overnight. A time-fill operation allows for a vehicle, or a fleet of vehicles, to be “plugged

in” to a CNG fueling hose to refuel over a set period of time (typically overnight). While “plugged in” a small CNG compressor will dispense fuel to the vehicle at a slow rate so the on-board CNG storage tank is full in the morning (or at the end of a set period of time). A time-fill refueling station can provide significant savings in labor costs and equipment costs, as operators are not required to wait the few minutes required to fast fill a vehicle. Instead, they simply park the vehicle at the end of the shift, attach the fueling hose, and leave the vehicle until the start of the next shift. Additionally, much smaller compressors can be used (100-250 horsepower), thereby reducing both up-front capital costs and ongoing operations and maintenance costs, particularly power costs via the ability to often use “off-peak” power when time-filling a fleet at night. Time-fill fueling is the typical method of fueling refuse and other transit vehicles that are housed overnight in central fleet yards.



**Figure 17: CNG Time Fill Refueling for Refuse Trucks**

LNG fuel stations, on the other hand, are liquid-based systems that use large bulk cryogenic (extremely cold) storage tanks to store fuel on site. LNG is delivered to the site from the point of production by 10,000-gallon capacity tanker trucks (much like diesel and gasoline is delivered to traditional fueling stations with 5,000-12,000-gallon underground or above-ground storage tanks). From the bulk storage tanks, the LNG fuel is then dispensed to vehicles through small 50-horsepower liquid pumps and LNG fuel dispensers. Fuel is dispensed into vehicle on-board fuel tanks as a liquid in a fast-fill application, usually at a rate of around 25 gallons of LNG per minute (equivalent to approximately 15 diesel gallons per minute).



**Figure 18: Typical LNG Refueling Station Layout (graphic courtesy of Chart)**

As there is no active refrigeration within an LNG refueling station, the thermal efficiency of the double-walled vacuum-insulated storage tanks used to contain the fuel is relied upon to keep the fuel from warming too quickly. While these storage systems are generally very good at maintaining the proper temperature, they cannot completely stop the LNG fuel inside the tank from gradually warming. As this LNG warms, it transitions from a liquid state back to its natural vapor state. The boiling of LNG takes place in exactly the same fashion as boiling water; the only difference is that ambient temperatures are sufficient to cause the cryogenic liquid to reach a boiling state. As LNG housed inside a storage tank boils, the vapor pressure inside of the storage tank will also increase. Ultimately, if the pressure becomes too great, a safety relief valve will activate and the pressure will be allowed to escape. Of course, it is not just pressure that is allowed to escape to the atmosphere; fuel (which costs money) escapes, as well.

One distinct advantage of LNG fuel stations is their ability to supply CNG from LNG, better known as “LCNG”. LCNG is produced by compressing the liquid fuel and vaporizing it under high pressure. The LCNG pumps used to compress the liquid fuel utilize 25-75-horsepower electric motors and have very few moving parts. The advantage, therefore, offered by LCNG when compared to traditional CNG, is that the compressed gas (i.e., the CNG) can be produced with significantly lower energy inputs compared to a traditional CNG compressor requiring several hundred horsepower to accomplish the same goal. More importantly, the cost of a natural gas fueling station that can fuel up to 50 heavy-duty vehicles is on the order of \$2 million, whether it be traditional CNG or LNG. For an additional \$500,000, an LNG station can also dispense CNG fuel at a rate acceptable for heavy-duty LNG or CNG trucks. A station that has the capacity to dispense both LNG and LCNG is commonly referred to as an “LNG/LCNG station.”



**Figure 19: LNG/LCNG Fueling Station with Public LNG and CNG Dispensing Capabilities**

When considering what kind of fueling stations will be required to support the concept of the PCTC, the number required, the potential locations, and the estimated cost, one must first consider whether the vehicles will be equipped with either CNG or LNG fuel storage tanks. Unfortunately, there is no single correct answer, as heavy-duty natural gas transportation in the U.S. has successfully used both kinds of on-board fuel storage. Since the exact fleets that will be converted to natural gas fleets have not yet been determined, choosing either LNG or CNG as the preferred on-board fuel system for this project is not possible, nor recommended.

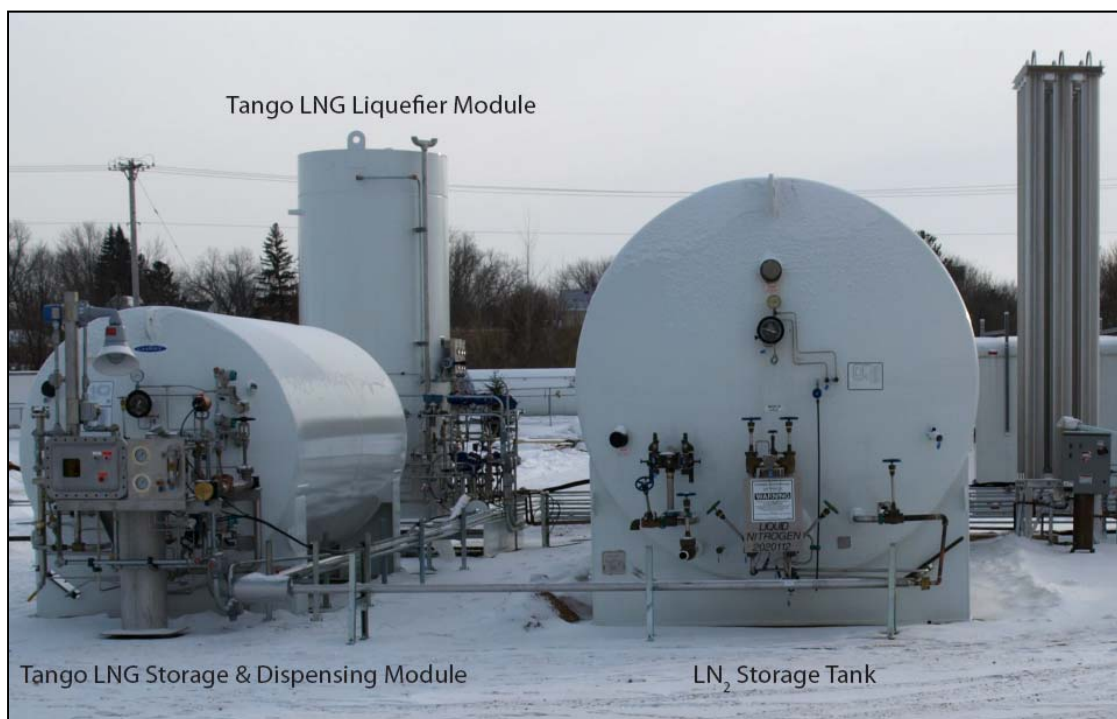
A single LNG/LCNG station can fuel LNG heavy-duty vehicles while simultaneously fueling light-, medium- and heavy-duty CNG vehicles. It is therefore recommended that LNG/LCNG fueling stations be considered at this point in the development of the PCTC. As a starting point and for planning purposes, this will ensure that both kinds of natural gas vehicle fuel are available to fleet operators looking to deploy either LNG or CNG trucks along the PCTC. All stations should be publicly accessible and have the capability to fuel any vehicle within 15 minutes. However, it is recognized that the proponents of this project will not always be able to exert such influence, and high volume CNG fuel stations will be constructed within the PCTC. An example is the Waste Management CNG refueling station in Washington at the intersection of I-79 and I-70. While this station will only offer CNG fueling, it is a strategically located fueling facility at a key truck corridor intersection, and will thus play an important role in the overall PCTC.

By recommending the placement of LNG/LCNG stations throughout the PCTC, LNG supply becomes critical to the success of such a plan. Fortunately, UGI, a Pennsylvania-based company, has an LNG peak-shaving operation near Reading in eastern Pennsylvania with ample LNG product available to service the vehicle market.



**Figure 20: UGI LNG Peak Shaving Facility near Reading, Pennsylvania**

In addition to UGI's large-scale LNG-production and truck-loading facility, there is the potential to site new micro-scale LNG production throughout the project area. One new technology recently introduced into the market is a micro-scale LNG production facility that can be located within a fleet yard. The system uses cryogenic nitrogen to liquefy natural gas from a standard utility natural gas line. With the ability to produce approximately 4,000 gallons of LNG per day, this size LNG plant – which is also equipped with an LNG fueling station – is ideally suited for the startup of a moderately sized LNG fleet operation consisting of approximately 50 heavy-duty vehicles. In addition to this specific example, there are a number of other companies and similar technological approaches that can provide this kind of micro-scale LNG production.



**Figure 21: Tango LNG Production Facility (photo courtesy of Chart)**

### ***Fuel Station Sizing***

Because LNG fuel is in a constant state of boiling when stored and used as a vehicle fuel, it is generally required that a fueling station have a minimum daily fuel capacity of approximately 1,200 LNG gallons. This is to ensure that the boil-off (the portion of the fuel that returns to a vapor state) does not cause fuel venting due to increased pressures within the storage tank. With the use of 1,200 gallons or more of LNG per day, bulk loads of LNG are delivered to the station once every week or so, if not more often. These bulk deliveries of fresh and “cold” LNG tend to collapse vapors that build up inside the storage tank, converting them back to liquid fuel. More frequent deliveries reduce overall boil-off and help to eliminate fuel venting. Because of the need to “use or lose the fuel,” LNG fuel dispensing and vehicle systems are generally used in applications with high daily fuel demands.

A typical heavy-duty LNG vehicle will use 40-80 LNG gallons per operating day; with an average of 50 gallons; therefore, the minimum 1,200 gallon-per-day threshold typically needed for the construction of a non-venting LNG station can be achieved with a minimum fleet of 25 vehicles, depending on each vehicle’s daily fuel requirements. It is important to note, however, that even when an LNG station does vent to relieve pressure, the total volume of GHG emissions that result from such venting are less than the amount emitted by common dairy cows, vented landfill gas, and other such sources. The contribution to total U.S. GHG emissions from the LNG transportation sector can almost be considered irrelevant compared to other, much larger and more common sources of similar emissions.

The turnkey installation of an LNG/LCNG station with a 15,000-gallon LNG storage tank that can accommodate an average of 50 heavy-duty trucks per day (as well as some light- and medium-duty vehicles) will cost approximately \$2.6 million for all equipment, engineering, site work, project management, installation and start-up.

An LNG/LCNG station can be easily scaled to accommodate demand growth via the installation of additional LNG or CNG dispensers and/or additional storage tanks. It is common to see an LCNG station installation where the tank pad and dispenser islands are provided for additional equipment in the future, as demand on the station increases with additional natural gas vehicle deployments. Where feasible, such planning is recommended for any station developed as part of the PCTC project. But even with this scalability, the initial construction projects and introduction of new LNG/LCNG stations should be sized to accommodate the expected growth of vehicles using that station in the first two to three years; thus the reason for this report assuming a station that can support a fleet of 50 heavy-duty vehicles.

***Table 12: Total Natural Gas Refueling Station Costs for the PCTC***

	<b>FOUNDATION</b>	<b>DEVELOPED</b>
Natural Gas Stations	8	17
Cost Per Natural Gas Station (millions)		\$2.6
<b>Total Natural Gas Fuel Station Cost (millions)</b>	<b>\$21</b>	<b>\$45</b>

### ***NGV Maintenance and Repair***

When considering the development of a new natural gas vehicle-deployment project, the vehicle and fueling infrastructure costs are not the only expenses that must be considered. One must also consider the cost required to properly retrofit the garage facilities per code requirements,

and to allow for the indoor maintenance and repair of these natural gas vehicles. Such costs can run several hundred thousand dollars or more for each fleet-maintenance facility.

Retrofitting of an existing vehicle maintenance facility (often referred to as “garage modifications”) to permit the indoor maintenance of vehicles fueled by natural gas is required by several codes and ordinances. The National Fire Protection Association (NFPA) Code 30A (*Code for Motor Fuel Dispensing Facilities and Repair Garages*) 2008 Edition provides the basic requirements and specifications. Other information can be found in NFPA 52 (*Vehicular Gaseous Fuel Systems Code*) 2010 Edition, the National Electric Code, various state fire codes, and some local ordinances. In most cases, the local fire department is responsible for the inspection of the garage shop and determination of which codes or regulations may apply. It is important to work closely with the local fire inspector when converting a fleet to the use of natural gas and some variation occurs due to the heavy influence of a local system of inspection and code interpretation.

***A minimum 1,200 LNG gallon-per day-fuel throughput – that of about 25 heavy-duty trucks – is typically required for a new LNG fuel station to be developed.***

The purpose of conducting garage modifications is to render the maintenance area safe from accidental fire or explosion resulting from the release and ignition of either LNG or CNG within the building structure. Essentially, only three classes of work are required, but depending upon the configuration of the existing facility, as well as appurtenances located within it, the work required for garage modifications can range from simple to very complex. The three classes of work include ventilation, ignition sources, and gas monitoring and alarm, and all are discussed in more detail in Appendix A.

Given the extraordinary diversity in the design and function of existing vehicle-maintenance facilities, it is not possible to project the total cost for the maintenance facility modifications that will be required to support this overall PCTC project. Therefore, an estimated \$400,000 per garage has been used for the purposes of including an estimate in this report. This estimate is based upon GNA’s experience and some recent actual maintenance-facility modification costs for several heavy-duty truck projects now under development. It is important to note that the \$400,000 estimate is for the basic upgrade of a small- to medium-size fleet-maintenance garages. Costs can be significantly higher depending upon the size of the maintenance shop and the complexity of the modifications required.

For the purpose of this report, it is assumed that each fueling station located along the PCTC will be associated with a single-anchor fleet tenant. It is, therefore, estimated that for each fleet tenant, a \$400,000 maintenance-garage upgrade must be completed.

**Table 13: Estimated Maintenance Facility Update Costs for the PCTC**

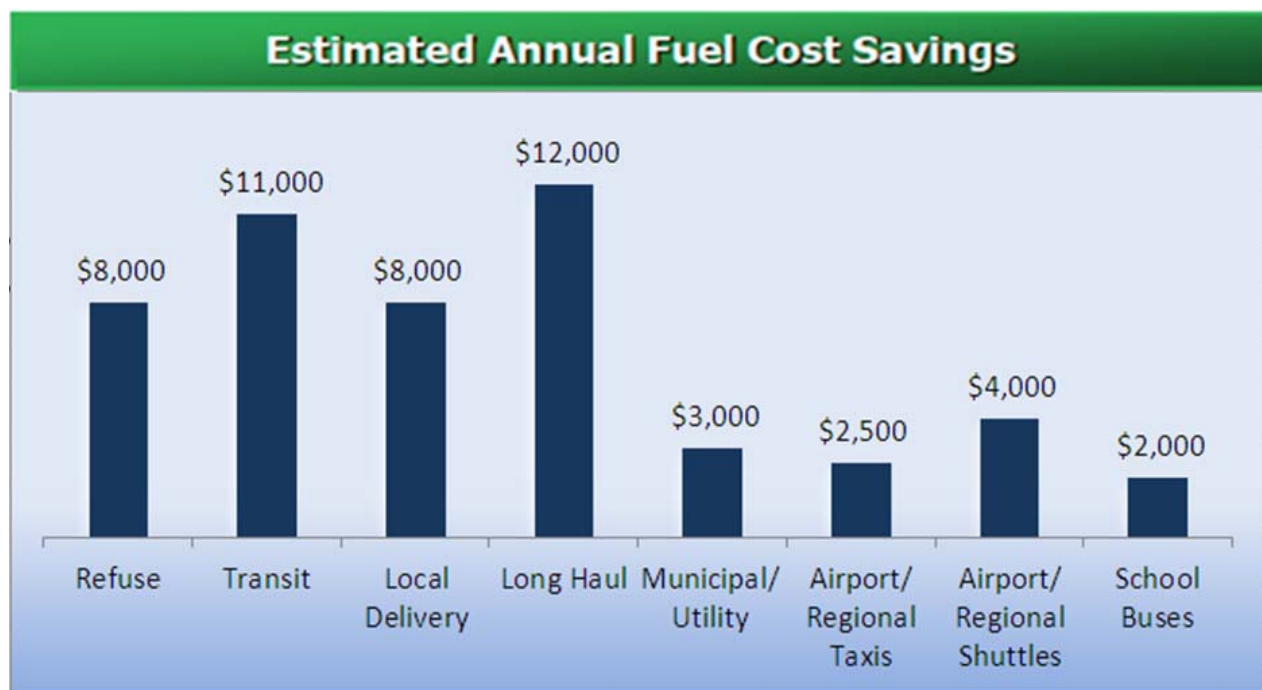
	<b>FOUNDATION</b>	<b>DEVELOPED</b>
Total Maintenance Facility Upgrades	8	17
Cost Per Facility Upgrade (millions)		\$0.4
<b>Total Facility Upgrade Costs (millions)</b>	<b>\$3.2</b>	<b>\$6.8</b>

## Market Sector and Vehicle Targets

The most effective approach to sustainable growth in the alternative-fuels industry is to deploy vehicle and refueling infrastructure in tandem, targeting prime fleet candidates. Because return-to-base heavy-duty fleet operators present the best opportunities for the successful implementation of an alternative-fuel program, selecting viable fleet vehicle partners will play a critical role in the successful development of the PCTC. The development of publicly accessible refueling infrastructure around these “anchor” fleet operations will then allow for the growth of the NGV market on an expanded local, regional, statewide and ultimately interstate basis.

Because heavy-duty trucks consume such copious amount of fuel and often return to base each night or operate along fixed routes, they offer an excellent opportunity to quickly build fueling demand around focused infrastructure development projects. A typical heavy-duty truck will travel 50,000-100,000 miles per year and consume 8,500-17,000 gallons of diesel fuel. Refuse, transit, grocery store delivery fleets, and package delivery are therefore perfect candidates to build infrastructure while creating the clean transportation corridor. In comparison, a typical light-duty passenger vehicle will consume 500-600 gallons of gasoline per year, and even a high mileage light-duty or medium-duty commercial truck (such as the service support vehicles in E&P or other utility fleets) will only burn 1,000-1,500 gallons of fuel per year. With such copious fuel consumption, and given the extremely low cost of natural gas transportation fuel compared to diesel, these heavy-duty applications provide for one of the greatest opportunities for fuel cost savings within the transportation sector.

Due in part to the significant fuel cost savings of NGV fleet operations, the heavy-duty vehicle niche markets that have proven to be the most viable for NGV deployment include refuse, transit buses, and regional goods-movement activities such as freight hauling and local food and beverage delivery. Medium-duty truck fleets have also proven to be excellent partners for NGV operations, including municipal vehicles, package delivery, airport shuttles, utility vehicles, and smaller-scale transit operations. Some light-duty fleets with numerous vehicles, such as taxis and shuttles, can also achieve reasonable fueling volumes to support a station. Each of these sectors, analyzed in additional detail below, represent opportunities to commence the development of the PCTC. A comprehensive summary of the multitude of NGV products available in the market for each sector is included in Appendix B.



	Refuse	Transit	Local Delivery	Long Haul	Municipal/Utility	Airport/Regional Taxis	Airport/Regional Shuttles	School Buses
<b>Annual Fuel Cost Savings</b>	\$ 8,000	\$11,000	\$ 8,000	\$12,000	\$3,000	\$2,500	\$4,000	\$2,000
<b>Incremental Cost</b>	\$45,000	\$40,000	\$45,000	\$65,000	\$40,000	\$ 7,000	\$20,000	\$40,000
<b>Annual Fuel Usage (Gallons)</b>	8,000	11,000	8,000	12,000	3,000	2,500	4,000	2,000
<b>Comparison Fuel</b>	Diesel	Diesel	Diesel	Diesel	Diesel	Gasoline	Gasoline	Diesel

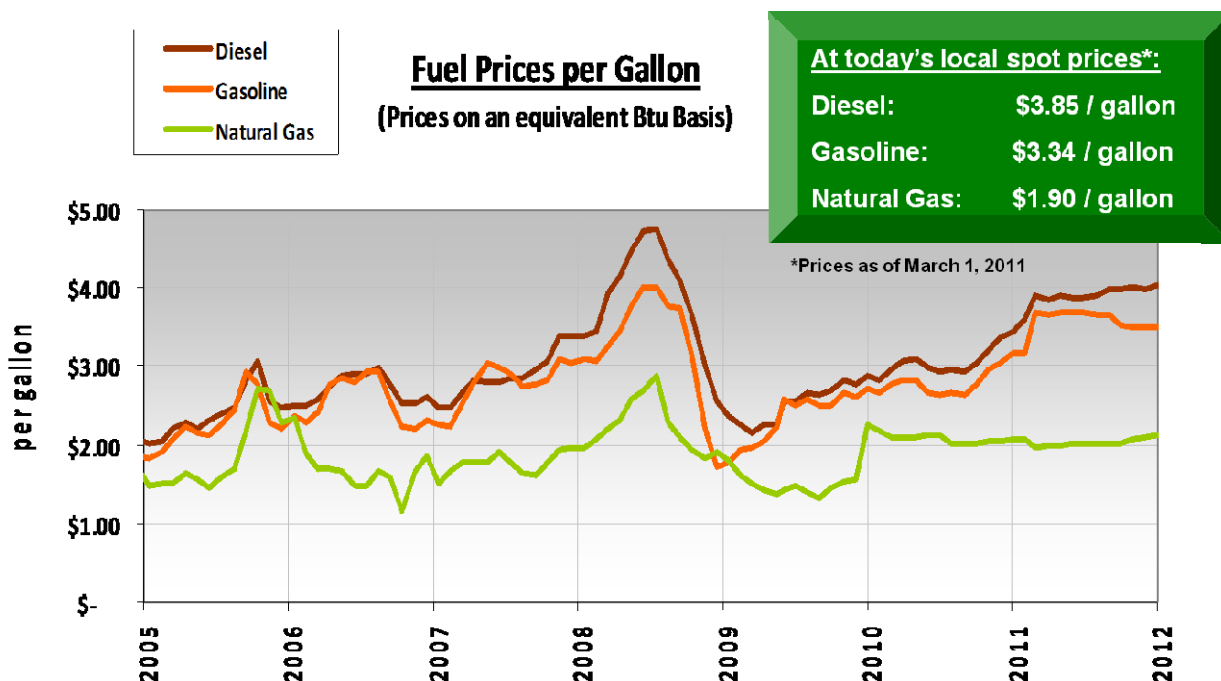
**Figure 22: Estimated Annual Fuel Cost Savings for NGVs**

### ***In Focus: Refuse Industry***

The refuse-collection industry has been one of the most successful market segments in the transition of large volumes of heavy-duty fleet vehicles to cleaner and domestically produced natural gas. Nearly all the major heavy-duty vehicle manufacturers – including Autocar, Crane Carrier, Freightliner, Mack, and Peterbilt – offer natural gas powered refuse-collection vehicles for residential and commercial-bin operations. These companies provide refuse trucks for both CNG and LNG operations, using the industry leading 9-liter, 320-horsepower ISL G engine from Cummins Westport

Due to their fixed-route return-to-base operation, the availability of natural gas product from all major refuse truck manufacturers and, above all, the fuel cost savings versus diesel in a very fuel intensive operation, this market has quickly become the fastest growing segment of the NGV industry in the United States. Refuse-collection vehicles all have a GVWR of over 33,000

pounds and operate in a very fuel-inefficient stop-and-go cycle. Their heavy-heavy weight class and unique operations mean each conventionally fueled truck can easily use between 5,000 and 10,000 gallons of diesel each year. When replaced with units that instead burn natural gas that has an equivalent per-diesel-gallon fuel cost of approximately \$2.00 (compared to approximately \$3.50 per gallon for diesel fuel), annual fuel-cost savings are tremendous. In addition, natural gas refuse-collection trucks have historically offered significant emission reductions that are achieved “at street level.” The combination of superior economic and environmental performance has resulted in the prolific growth of natural gas refuse-market vehicle use across the United States in recent years.



**Figure 23: Transportation Fuel Price Comparison (chart courtesy of Equitable Gas)**

Pennsylvania is home to multiple natural gas refuse and refueling infrastructure development projects. In fact, one of the nation's very first natural gas refuse projects was launched in 1997 by Waste Management at their Washington, Pennsylvania fleet location. Since that time, Waste Management has continued to aggressively grow its national natural gas fleet operations. It now operates more than 1,000 natural gas trucks, making it the largest natural gas refuse fleet operator in the nation. Waste Management has realized significant economic benefits from its natural gas fleet programs, and is thus moving forward with a national natural gas fleet plan.

Additionally, Waste Management is now in the process of purchasing 30 new CNG refuse-collection trucks, and is building a new public access CNG refueling station at its Ardent Landfill location in Washington. This CNG fuel-station project is being supported by a \$700,000 AFIG grant from the Pennsylvania Department of Environmental Protection (DEP). This CNG refueling station, expected to be in operation by the end of 2011, will allow Waste Management to convert the rest of its fleet in this location to CNG over the next several years. In addition to the growth of its own natural gas fleet, this public access CNG station – located less than two miles from the intersection of I-70 and I-79 – is in an absolutely ideal location for heavy-duty fleet operators in the southwest section of Pittsburgh, and for those vehicles traveling these interstate routes.

Waste Management has completed other similar public-access fueling stations in Seattle and California. This large-scale and replicable success story demonstrates that refuse fleets can be important anchor fleets for the development of strategic infrastructure with a public access component.



**Figure 24: Waste Management Public Access CNG Station in Seattle, Washington (note the \$1.85 / GGE cost)**

Beyond Waste Management's strategic NGV project just outside of Pittsburgh, several other natural gas refuse truck and refueling infrastructure projects are now being implemented in Pennsylvania. Through a \$361,534 grant, Lycoming County is working to develop a natural gas refueling station to support the deployment of natural gas trucks in its Resource Management Services operation. Likewise, the Northern Tier Solid Waste Authority (NTSWA) in Northampton County recently partnered with Clean Energy Fuels Corp. to design and install a CNG fueling station in Burlington Township, and to repower four diesel refuse trucks to run on natural gas. This project is being supported through a \$900,000 AFIG award made in 2010. The CNG refueling station will be located at the entrance to the NTSWA Integrated Waste Management Facility along U.S. Route 6, and will provide public fueling access for other local vehicle users.

With approximately 2,500 registered refuse-hauling companies in t Pennsylvania<sup>32</sup>, and a proven pattern of success for both the refuse sector and local public access fleet users, the

<sup>32</sup> Pennsylvania Department of Environmental Protection, Waste Haulers with Authorization Status

refuse sector is a prime target for the development of the PCTC roadmap. In fact, four of the 100 largest fleets in Pennsylvania are refuse-collection fleets, including Waste Management, Solid Waste Services, York Waste Disposal, and Vogel Disposal Services, all of which are prime targets for PCTC targets.

The greater Philadelphia area is the fifth largest population center in the United States, and Pittsburgh is the 22<sup>nd</sup> largest, according to U.S. census data<sup>33</sup>. There are nearly 6 million people living in the greater Philadelphia area, with approximately 3.8 million in Pennsylvania (the balance live in New Jersey)<sup>34</sup>. The greater Pittsburgh area has a population of nearly 2.4 million people<sup>35</sup>. Using an industry metric that one refuse truck is required to service every 4,000 people in a given population, it becomes clear that the refuse-fleet operators in Philadelphia and Pittsburgh – two of Pennsylvania's larger population centers – are ripe opportunities for conversion to natural gas.

It is estimated that approximately 1,000 refuse-collection trucks are required to service the Pennsylvania counties within the greater Philadelphia area, with approximately 370 of these units for the City of Philadelphia proper. Likewise, it is estimated that approximately 600 refuse-collection units are required to serve the greater Pittsburgh area. With such large fleet sizes, and assuming that a typical refuse collection fleet has a 10% annual rate of turnover (i.e., 10% of its fleet is replaced each year with new trucks), it is clear that even a single year's worth of replacement trucks purchased as natural gas vehicles will allow for the economically sustainable development of a sizeable refueling station in each region.

***The refuse fleet operators in Philadelphia and Pittsburgh – two of the state's larger population centers – are ripe opportunities for conversion to natural gas. The refuse market should be a core focus of the PCTC project development effort.***

Although the city of Philadelphia's Greenworks Sustainability Plan identifies as a priority the construction of a CNG station to support refuse-truck fueling<sup>36</sup>, the city has been unable to make progress, despite securing a \$750,000 grant from the U.S. Environmental Protection Agency. This grant was slated to assist in the development of a refueling facility and the purchase of 15 CNG refuse trucks. However, the city was unable to secure the cost-share necessary to initiate the project, and had to return the grant. The city is clearly interested in natural gas refuse operations and would be a valuable PCTC partner, particularly if more funding were available or if partnerships could be developed to help share station facilities or upfront expenses.

Given the history of success due to the ideal operating conditions of this industry, wide range of available product – including natural gas refuse-trucks made by Pennsylvania-based Mack Trucks – and the tremendous opportunities for conversion in the major urban centers within

<sup>33</sup> <http://www.census.gov/popest/metro/tables/2005/cbsa-01-fmt.csv>.

<sup>34</sup> "Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Economy at a Glance". Bureau of Labor Statistics. December 22, 2009. [http://www.bls.gov/eag/eag.pa\\_philadelphia\\_msa.htm](http://www.bls.gov/eag/eag.pa_philadelphia_msa.htm). Retrieved January 2, 2010.

<sup>35</sup> Based upon a population of 2.4 million; Table 1. Annual Estimates of the Population of Metropolitan and Metropolitan Statistical Areas: April 1, 2000 to July 1, 2009 (CBSA-EST2009-01). 2009 Population Estimates. [United States Census Bureau](http://www.census.gov/popest/metro/tables/2009/CBSA-EST2009-01.csv), Population Division. 2010-03-23. <http://www.census.gov/popest/metro/tables/2009/CBSA-EST2009-01.csv>. Retrieved 2010-03-26.

<sup>36</sup> [http://www.phila.gov/green/greenworks/pdf/Greenworks\\_OnlinePDF\\_FINAL.pdf](http://www.phila.gov/green/greenworks/pdf/Greenworks_OnlinePDF_FINAL.pdf).

Pennsylvania, the refuse market should be one of the core focal points of the development of the PCTC. Waste Management's project in Washington, Pennsylvania is an ideal example of how this sector will allow for the development of strategically located public access refueling infrastructure that will be available to other heavy-duty vehicles operating within Pennsylvania's urban areas and along key interstates that make up the PCTC. Conversion of the refuse collection fleets in Philadelphia, Pittsburgh and other larger metropolitan regions will undoubtedly provide similar refueling infrastructure-development opportunities along the PCTC.

### ***In Focus: Public Transportation***

Natural gas already powers 18% of all transit buses in America, accounting for about 66% of all vehicular natural gas use in the United States, and one out of every five new transit bus orders are for units powered by natural gas<sup>37</sup>. Transit applications are one of the true natural gas success stories and are extremely well-suited to natural gas operations because they operate on fixed routes and schedules, and are centrally located, fueled and maintained. In addition, transit buses also have high daily fuel-use needs due to their stop-and-go, daylong operations, meaning they can achieve expedited payback periods on their natural gas program investments with fuel-price benefits. With over 11,000 transit vehicles on the road in the United States, every transit bus manufacturer in North America offers a natural gas model. These vehicles come with a factory warranty, powered by the 9-liter, 320-horsepower ISL G engine from Cummins Westport. While transit vehicles can run on either CNG or LNG, most agencies utilize CNG.



**Figure 25: Metro CNG Bus (CNG Bus # 2,221)**

With so many CNG-powered transit agencies across the U.S., there are numerous examples of the viability and success of transit bus natural gas programs. One of the leading examples is the Los Angeles County Metropolitan Transportation Authority (Metro),

which retired its last diesel vehicle in January 2011 and is now running 2,221 CNG buses that have collectively traveled more than 1 billion revenue-generating miles. Although its CNG buses cost about \$50,000 more than diesel buses, Metro has realized significant cost savings with CNG through lower operational and fuel costs, saving 50% per mile over its previous diesel operations.

Pennsylvania has also seen success with some CNG transit fleets, notably Centre Area Transportation Authority (CATA), the Area Transportation Authority of North Central Pennsylvania, Berks Area Reading Transportation Authority (BARTA), and Erie Metropolitan Transit Authority. Although none of these fleets are located along a prime PCTC route, their pioneering efforts have helped bring CNG operations into Pennsylvania and give passengers and fleet operators first-hand familiarity with the benefits of CNG. These early programs have

<sup>37</sup> 2009 data found at [http://www.ngvc.org/about\\_ngv/index.html](http://www.ngvc.org/about_ngv/index.html) and <http://www.ngvc.org/mktplace/index.html>.

also helped train mechanics and local personnel in CNG vehicle maintenance and operations, thereby supporting development of long-term support and maintenance resources for a long-term transition to natural gas.

CATA is a prime example of a local CNG-powered transit agency. CATA is the mass transit agency for the town of State College and surrounding areas, and for Pennsylvania State University itself. In 1996 CATA introduced its first CNG buses. By the following year, CATA had already phased out the remaining diesel-powered buses to replace them with CNG buses. The agency has received approximately \$3.5 million in grant assistance, including a \$1 million grant from Pennsylvania's AFIG program. CATA now operates 52 CNG buses for its fixed route and four paratransit mini-buses, burning about 521,000 gasoline-gallon equivalents (GGE) of CNG each year (approximately 43,000 gallons per month). CATA's station also supplies fuel for a nearby Uni-Mart convenience store, demonstrating that public-access stations and partnerships are critical to expanding natural gas fuel use.

In order to target cost-effective transit agencies for CNG transitions, this report identifies five PCTC target fleets with large enough numbers of vehicles and high volumes of fuel that are located in four key corridor locations: Philadelphia, Pittsburgh, Allentown, and Harrisburg. Based on 2008 data from the Federal Transit Administration's National Transit Database, there are transit fleets in these areas that would make good targets for conversions to natural gas.

Southeastern Pennsylvania Transportation Authority (SEPTA), serving the Philadelphia area, uses 15,759,000 gallons of diesel each year in its 1,400 buses. The fleet is currently pursuing a hybrid purchase plan in order to reduce diesel emissions and help the city achieve its sustainability goals. SEPTA has already demonstrated its commitment to sustainability via a hybrid purchase program, and could completely from diesel fuel use to locally-sourced, sustainable natural gas operations instead. Given SEPTA's size, prominence, location, and significant long-term cost savings from a switch to natural gas operations, Philadelphia's transit fleet should be a prime target for initial PCTC outreach efforts. On December 10, 2010, State Senator Jake Corman reintroduced a resolution directing the Legislative Budget and Finance Committee (LBFC) to conduct a study on the feasibility and effectiveness of converting the SEPTA bus system to natural gas fuel, and the PCTC should work to build on this initial momentum.

The Port Authority of Allegheny County, serving the Pittsburgh area, uses 8,160,000 gallons of diesel each year. With its high-volume fuel use, and its location in the Pittsburgh region of the PCTC, this agency should be a key target for PCTC initiatives.

Allentown is unique in that there are two possible bus-related opportunities for the PCTC: one involving the local transit agency, and one involving commuter bus operations. The Allentown Lehigh and Northampton Transportation Authority consumes 713,000 gallons of diesel each year and could support a CNG transition on its own. However, it might be able to co-locate a CNG station with Trans-Bridge Lines, Inc., a commuter bus provider that uses 874,000 gallons of diesel each year. Trans-Bridge isn't a typical transit agency, but instead provides motorcoach service from the Allentown area to New York City, JFK Airport, Jersey City, and other locations. Since each of these fixed routes are less than 300 miles roundtrip, and because buses return to Allentown to park and fuel, Trans-Bridge could transition to natural gas, particularly if the transit agency and coach company could share a refueling station facility.

Capital Area Transit, serving the Harrisburg area, uses 478,000 gallons of diesel each year. Harrisburg is located along the PCTC route, meaning Capital Area Transit could be a key partner in local CNG fueling partnerships or efforts.

***In Focus: Goods Movement***

Commercial heavy-duty trucking offers an excellent opportunity to build natural gas infrastructure along the state's busiest highways, and is the ultimate long-term target of the PCTC efforts. Pennsylvania ranks second in the country<sup>38</sup> (to California) for jobs related to goods movement, distribution centers and warehousing. The goods movement industry in the state is very reliant on trucking, with the Federal Highway Administration noting that close to 80% of the state's freight is transported by trucks.<sup>39</sup> These trucks transport nearly \$458 billion in goods, and from 2010 to 2020, it is projected that trucking in Pennsylvania will increase by 17%<sup>40</sup>.

There are two primary types of goods movement trucking operations: long-haul trucking and local / regional delivery. In general, long-haul trucks operate out of warehouses, distribution facilities, and other locations where goods movement cargo originates. These vehicles often do not have fixed routes, instead hauling their loads for delivery at end-points throughout the state and even across the country. However, this trend has been changing recently with an increased emphasis on point to point trucking and the use of intermodal freight movement; both of these developments are conducive to the increased use of natural gas for truck transportation.

Local goods movement trucks have different operations that focus around daily delivery routes for a wide variety of industries. Examples of local package delivery operations, beverage distributors, uniform and linen companies and food service and supermarket delivery are a few good applications for local delivery goods movement operations using natural gas.

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<sup>38</sup> The Center for Rural Pennsylvania, a legislative agency of the Pennsylvania General Assembly, "Economic and Transportation Impact of Warehousing on Rural Pennsylvania," November 2008.

<sup>39</sup> <http://www.ops.fhwa.dot.gov/freight>.

<sup>40</sup> Future Mobility in Pennsylvania, The Condition, Use and Funding of Pennsylvania's Roads bridges and Transit System, TRIP, November 2010 [http://www.tripnet.org/PA\\_TRIP\\_Report\\_Nov\\_2010.pdf](http://www.tripnet.org/PA_TRIP_Report_Nov_2010.pdf).



**Figure 26: Freightliner M2 Natural Gas Tractor for Regional Goods Movement Applications**

Pennsylvania has significant business interests and traffic associated with both these goods movement sectors. For years, warehousing in Pennsylvania was focused in suburban counties around Philadelphia and Allentown in the eastern portion of the state. However, warehousing has shifted from these suburban counties to more rural locations primarily straddling the I-81 corridor from the Scranton/Wilkes-Barre area to the Harrisburg area. Cumberland County, which entails the Harrisburg metropolitan area, employs more people in warehouse-related jobs than any other county in Pennsylvania<sup>41</sup>. Cumberland County also employs more people in the trucking sector than any other county in the state<sup>42</sup>. Pennsylvania's Port of Philadelphia also received a lot of cargo for distribution with and outside the region. The Port hosts several food importation clients, with Del Monte as one of its large tenants.

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<sup>41</sup> The Center for Rural Pennsylvania, a legislative agency of the Pennsylvania General Assembly, "Economic and Transportation Impact of Warehousing on Rural Pennsylvania," November 2008.

<sup>42</sup> Ibid.

Pennsylvania also hosts a much of the goods movement traffic passing through from neighboring states to other East Coast, Mid-Atlantic, and Great Lakes/Midwest destinations. It is also located nearby other major warehousing and distribution regions like Binghamton, which supports a large warehousing and distribution center in New York and lies along I-81, connecting to a major goods movement artery in Pennsylvania. All of these adjacent regions should be targets for eventual PCTC expansion, in order to support a transition to NGVs for these varied multi-state long-haul operations. In fact, PCTC development will be an important catalyst in spurring these areas to support natural gas station development that links with Pennsylvania's, thereby extending the corridor and availability of natural gas fueling.



**Figure 27: Kenworth T800 Natural Gas Tractor for Long Haul Goods Movement Applications**

Pennsylvania's local delivery sector offers a prime opportunity to immediately grow PCTC participation, especially with so many successful fleet operations that already use natural gas, such as UPS and Sysco. Delivery vehicles tend to range from medium-duty class 4 vehicles up to heavy-duty class-8 trucks. Fuel consumption is varied across such a varied group of local delivery operators, but in general these vehicles are used on daily routes with some stop-and-go operations, and therefore burn enough fuel to justify a transition to natural gas, based on long-term fuel economics.

The recent development of a multitude of factory-direct natural gas truck products by Freightliner, Kenworth, International, Peterbilt and other brand-name heavy-duty manufacturers has helped support a significant expansion of natural gas goods movement operations. A full listing of available products is available in Appendix B. All of these products are powered by one of three engines: the 9-liter 320 horsepower ISL G engine from Cummins Westport, the 7.6 liter 280 horsepower Phoenix engine from Emission Solutions Inc. (ESI), or the 15-liter 400 horsepower Westport ISX engine. Goods movement fleets will generally have to choose between a less expensive engine that is well suited to local delivery (the ISL G and Phoenix) or a heavy-heavy-duty engine that is equipped for heavy hauling (Westport ISX.)

The ISL G and the Phoenix engine have similar characteristics. Both of these engines can power either a CNG or LNG vehicle. These engines are ideally suited for urban freight applications in which their operating speed remains below 65 mph for the majority of the time and total weight is limited to 65,000 pounds or below. They are not intended to be used in tractor trailer applications on interstate highways where speed limits and typical truck speeds exceed 65 mph for sustained periods.

***The recent development of a multitude of factory-direct natural gas truck products by Freightliner, Kenworth, International, Peterbilt and other brand-name heavy-duty manufacturers has helped support a significant expansion of natural gas goods movement operations.***

The Westport ISX engine product will be the default product for those looking to haul 80,000 pounds of freight over long distances or up steep terrain on the PCTC and in interstate operations. The Westport ISX comes in either a Peterbilt or Kenworth tractor and is ideally suited for moving heavy-duty freight. It is a high horsepower LNG-powered truck capable of easily making these routes while maintaining the speeds necessary on the Pennsylvania interstate system and in the Appalachian Mountains. It is important to note that the Westport ISX engine is an LNG-fueled engine only; it cannot use CNG.

In addition to the Westport ISX engine product, recent announcements indicate that additional heavy-duty natural gas engines will soon be available from both Cummins Westport and Navistar. Cummins Westport is developing an 11.9 liter dedicated natural gas engine that will have a peak power rating of 400 horsepower and 1,350 lb.-ft of torque; it is expected that this engine will be available in a variety of truck chassis offered by Freightliner, Kenworth, Peterbilt and likely others. Likewise, Navistar is developing a similar natural gas engine product. At the 2011 Mid America Truck Show, Navistar unveiled a prototype International ProStar tractor powered by the MaxxForce 13 Dual-Fuel natural gas engine that will offer 430 horsepower and 1,550 lb.-ft of torque. While specific milestones are not available at the time of this report, it is anticipated that both the Cummins Westport 11.9 liter and Navistar MaxxForce 13 Dual-Fuel engine products will be available in the next 12 to 36 month time period. Together with the existing Westport ISX product, these heavy-duty platforms are expected to significantly increase market penetration of natural gas vehicle fuel in the over-the-road truck sector.

Large goods movement companies have started to take note of the benefits of natural gas. UPS, Sysco, Ryder, Robert Transport (a large Canadian trucking company), and many other companies are investing in natural gas goods movement operations. In California, momentum for natural gas operations has grown as more and more infrastructure has become publicly available. One major recent catalyst came from The Ports of Los Angeles and Long Beach, which funded a variety of vehicle and infrastructure projects for local port operations, ultimately supporting the deployment of 882 natural gas trucks, many of which serve local cargo sorting operational needs, and two stations. Ryder Trucks is currently implementing a 202 vehicle deployment throughout Southern California that was specifically designed to utilize the variety of public access sites throughout the region. Ryder is also investing in two natural gas fueling stations of its own, to help support operations in regions without robust public fueling options, demonstrating that successful natural gas corridors drive NVG market growth and further corridor infrastructure investments.

These Port and Ryder truck projects were possible due to the groundbreaking natural gas efforts of fleets like Sysco and UPS back in the early 2000s. Sysco has long used LNG in its Southern California and Houston and Dallas operations. Its public-access station in Walnut, California provides a key opportunity for other local fleets to utilize LNG. Similarly, UPS' station in Ontario, CA was one of the first public access stations in Southern California. Located on the high-traffic I-10, this is one of the most heavily utilized natural gas stations in the state, supporting UPS's delivery and long-haul natural gas operations as well as a variety of other local refuse operators and goods movement trucks. UPS recently expanded its natural gas operations with an investment in 48 long-haul trucks and a Las Vegas fueling station. This station is particularly noteworthy because it will provide a crucial link between Utah and Southern California's extensive natural gas infrastructure networks, thereby enabling interstate natural gas goods movement operations for UPS' natural gas operations and others.



**Figure 28: LNG Port Drayage Truck**

In Canada, which also has large and economical supplies of natural gas, Robert Transport just placed an order for 180 Peterbilt LNG trucks with the ISX engine. Robert is one of Canada's largest for-hire trucking companies with 1,100 tractors and 2,300 employees. Its new trucks will be used on line haul routes between Montréal and Québec City, and Montréal to Toronto. Gaz Métro, a distributor of natural gas in Quebec, plans to install three refueling sites to support the initiative, thereby installing the first LNG fueling infrastructure in the area. With the development of this natural gas goods movement corridor in eastern Canada, there is the potential to ultimately link to the growth of the PCTC throughout the greater northeastern U.S.

## **The ICTC: Case Study in Natural Gas Fuel Station Corridor Development**

The Interstate Clean Transportation Corridor (ICTC) is the nation's most successful planned clean-fuel corridor development project. It is a model of how natural gas fueling corridors focused on serving long-haul truck markets can be developed, often by focusing on the development of multiple aligned return-to-base fleet operators. A recent example of this successful business development model can be seen with the city of Barstow, UPS' February 2011 order of 48 heavy-duty natural gas trucks, and the development of new natural gas refueling infrastructure along Interstate 15 in Las Vegas and Salt Lake City.

The city of Barstow sits approximately half way between Los Angeles and Las Vegas. While Barstow is a relatively small city (with a population of approximately 25,000), it is an extremely important hub for the heavy-duty trucking market moving goods between these locations. Recognizing its importance in this regard, and with a comprehensive network of natural gas refueling infrastructure already in Southern California, the city of Barstow set a goal to establish a publicly accessible natural gas refueling station.

By focusing on the replacement of its local refuse and transit operations with natural gas vehicles, the city was able to develop a sufficient enough natural gas fuel demand to justify the investment in a new natural gas refueling station, a station that was developed not in the city's own municipal fleet yard, but on an industrial piece of property (owned by the city) and with convenient access to the interstate highway. The station was opened in 2005.

With the development of this station, natural gas fleet operators have been encouraged to deploy their vehicles along this route. United Parcel Service (UPS) has been running a fleet of natural gas powered trucks from Southern California to Las Vegas, a high-mileage route that has yielded significant fuel-cost savings for UPS. The success of this deployment project has encouraged UPS to deploy additional natural gas trucks in this route and ultimately, work to construct a public access natural gas fueling station to support its Las Vegas operations.

A new publicly accessible natural gas refueling station now being built in Las Vegas is the most telling signal of the success of the city of Barstow's project. The Las Vegas station is being developed primarily to serve UPS' 48 natural gas powered trucks that will make daily trips between its Southern California and Las Vegas distribution centers. While UPS is the primary "anchor tenant" of this new station in Las Vegas, it will be accessible to the general public and other fleet operators.

In addition to the strategic infrastructure developed in Barstow and Las Vegas, a similar development effort is now underway in Salt Lake City. A new publicly accessible natural gas refueling station was opened in March 2011 at a Flying J truck stop in the city. This fueling serves a number of local fleet operators involved in local city pickup and delivery operations. While the primary focus of this fueling facility is to serve these local users, the station, when linked with the Barstow and Las Vegas stations, will allow for a long-haul truck – such as operated by UPS – to now travel between Southern California and Salt Lake City. Seeing what is happening, others are now working to build similar publicly accessible infrastructure in Grand Junction, Colorado and Denver, thus extending the Interstate Clean Transportation Corridor to points further east.

The growth of this natural gas goods-movement corridor was only made possible by the development of the natural gas station first in the city of Barstow; a station that was built to serve the city's local return-to-base fleet operations.

This natural gas goods movement momentum includes local Pennsylvania companies as well. Giant Eagle Inc. is one of the nation's largest food retailers, with stores in Pennsylvania, Ohio, West Virginia and Maryland. The vast majority of Golden Eagle's stores are located in Pennsylvania, including 99 in western Pennsylvania and 122 in central, northeastern and eastern Pennsylvania. To service its stores, Giant Eagle operates a private fleet of 232 heavy-duty trucks and 700 trailers. It recently launched an aggressive program to deploy a large number of heavy-duty CNG delivery trucks within its fleet. Giant Eagle's efforts are specifically driven by the recognition that Pennsylvania's domestic natural gas resources offer the company a more reliable and lower-cost energy source for its operations, along with the added environmental benefits.

***Giant Eagle will complete the construction of its first publicly accessible natural gas refueling station by June 2011.***

To assist in the implementation of its CNG plan, Giant Eagle applied for and was the successful recipient of a \$900,000 AFIG grant for the purchase of 10 CNG-powered trucks, and the installation of a public CNG refueling station in Allegheny County. In 2010 Giant Eagle was awarded an additional \$750,000 in AFIG funding for the purchase of 29 compressed natural gas and electric/plug-in vehicles. Its new CNG refueling station will be located in Crafton, Pennsylvania – a strategic location in southwest Pittsburgh near the intersection of I-376 and I-79. Giant Eagle aims to complete the construction of this publicly accessible CNG station by June 2011.



Figure 29: Typical "Get Go" Retail Fueling Station (operated by Giant Eagle)

With growing interest in natural gas cost savings and domestic fuel benefits, and a large local-goods-movement economy, this market sector should be a key focus for the PCTC's natural gas

fleet and station development efforts. The best initial targets include local delivery companies in urban areas and other return-to-base fleets, particularly those along key PCTC and warehousing routes. The major metropolitan areas within Pennsylvania each offer ripe opportunities for the conversion of local, return-to-base fleet operations. Pennsylvania should start out by assisting national companies with demonstrated interest in natural gas fleet programs to identify local project efforts, such as Giant Eagle, UPS, Sysco, Ryder, HEB, and Coca Cola. Beyond simply demonstrating an interest in natural gas operations, these fleets have been actively working to *expand* their natural gas operations. Pennsylvania could easily be the focal point for that interest, especially with implementation of the PCTC concept. The PCTC would greatly benefit from developing partnerships with nationally recognized fleets that have expertise, commitment, and proven success with NGV operations.

### ***In Focus: Natural Gas Industry***

The natural gas industry provides a vital and growing component of the world's supply of energy. In the natural gas industry, there are generally two kinds of companies that maintain large vehicle fleets, and that are good targets for NGV deployment: the exploration and production (E&P) sector, and the local distribution company (LDC) sector. As the name implies, E&P companies are involved in the mining of natural gas from the earth. Once the gas is produced, it is distributed by pipeline companies to the LDC. The LDC is then responsible for owning, maintaining and operating the natural gas pipelines that deliver the natural gas to the end user.

Both types of companies typically maintain large fleets of light and medium-duty service vehicles, including large populations of pickup trucks and commercial work vans. This vehicle population has been a primary focus of these companies for replacement with NGVs. Beyond these fleet vehicles, these companies have also been, more recently, looking at the opportunity to deploy heavy-duty natural gas trucks as part of their operations. While large scale deployments have taken place in the light and medium-duty fleets, and such growth is fully expected to continue, it is anticipated that these heavy-duty vehicle investigations will also soon result in actual deployments and thus further populate the Pennsylvania NGV market with new end-users, thus driving the development of additional fueling infrastructure in the market and providing a critical support base for the PCTC.

As the refueling infrastructure network continues to expand in Pennsylvania, particularly as it relates to the service of both E&P and LDC company vehicles, it will, in turn, provide for an opportunity for these companies to work with their employees to begin making personal investments in NGVs for their daily commuting needs. After all, the destination point for their daily commute – i.e., the office – will likely have a CNG refueling station available to them.

### **Exploration & Production (E&P) Companies**

E&P companies explore, extract and produce the natural gas that is often sold to large transportation pipelines. Such E&P companies use technology to locate natural gas reservoirs, with modern day technologies allowing for the production of natural gas from fewer wells and minimum impacts on the environment. In Pennsylvania alone, there are more than 20 E&P companies located at the Marcellus Shale. These companies are members of the Marcellus Shale Coalition, the organization working to develop and implement the PCTC roadmap outlined herein.

As “orders drive priorities” in the automotive sector, these E&P companies – together with a number of the nations’ LDCs – have been working to collectively pool their purchasing plans in order to demonstrate significant volume purchases and to encourage the “big three” automakers in Detroit to produce NGVs for the market. In the last 12-24 months, some of North America’s largest E&P companies have been instrumental in encouraging the development of new NGV product in the marketplace, including the pickup truck and work van products from GM and Ford (see Appendix B for a complete listing of these vehicles).

One of the MSC-member companies, Chesapeake Energy, provides a fantastic example of how these E&P companies are “walking the talk” and making significant investments in NGV product and thus, refueling infrastructure. Chesapeake Energy is

in the process of replacing 4,000 of its gasoline and diesel-powered work trucks with CNG versions, with likely another 1,000 NGVs to follow this first large replacement program. The company uses the extended cab GM 4x4 pickup trucks with 6-liter natural gas powered engines as its standard truck platform. With a commitment to buy more than 4,000 of these units, this technology is now readily available in the marketplace for other companies to purchase, thereby demonstrating leadership within the industry and using one’s own purchasing power to spur change within the market. As the company deploys these state-of-the-art NGVs in its gas drilling and field services operations, it is building new publicly accessible CNG refueling station to support not only its own operations, but to provide fueling access to other NGV users as well.



Figure 30: Chesapeake CNG Fuel Station and CNG Pickup Truck

***Chesapeake Energy, an industry leader, is replacing 4,000 of its gasoline and diesel-powered work trucks with new units that run on domestically produced and clean burning natural gas.***

There are numerous other E&P companies in Pennsylvania that have the potential to implement natural gas vehicles in their fleets. Operating one of the 10 largest fleets in Pennsylvania, with more than 1,100 vehicles in its corporate-wide fleet, EQT Corporation is one such example. The company has already demonstrated leadership on reducing petroleum fuel usage by equipping nearly 50% of its vehicles with monitoring systems aimed at increasing fleet efficiency<sup>43</sup>. As the natural gas refueling infrastructure continues to expand in Pennsylvania and throughout the Marcellus Shale play, EQT has the potential to reduce greenhouse gas emissions even further by switching to natural gas for its large-fleet-vehicle operations.

<sup>43</sup> <http://www.eqt.com/docs/pdf/EQTCSRBrochure.pdf>.

Range Resources Corporation is another example of an E&P company with the potential to implement natural gas vehicles. Range Resources is among the leading independent natural gas companies operating in the United States, with more than 1.2 acres in the Marcellus Shale. With such a large expanse of land dedicated to the extraction and production of natural gas, the company could be an ideal choice to contribute to the development of the PCTC and conversion to natural gas vehicles in its fleet.



**Figure 31: Chesapeake Energy CNG Pickup Truck**

In addition to their field services pickup trucks and work vans, there are a host of other opportunities by which E&P companies can further proliferate their use of natural gas in lieu of diesel fuel. Not only is most of the work at an E&P drilling site done via the use of very large and fuel-hungry natural gas engines, but these drill sites are served by dozens of over-the-road heavy-duty diesel-powered trucks. These trucks begin with the delivery and assembly of the rig equipment; then, as drilling proceeds, more diesel trucks arrive to supply hydraulic fracturing fluids, fuel supplies, and to extract waste. Additional heavy-duty diesel trucks then move dismantled equipment to the next drill site, while at the same time gasoline- and diesel-powered trucks transport the related workforce to and from rig sites. Beyond such a vast array of trucks serving each site, in almost every instance, electrical power generation, pressure pumps and other on-site supportive equipment is powered via diesel engines that operate 24 hours a day (production does not stop once it has begun).

These multiple stationary source applications, including the drill rig itself, as well as the dozens of trucks serving the drill site all make for ideal opportunities for replacement with natural gas powered alternatives. Given the high-fuel-use nature of all of these applications, they provide an opportunity for the development of refueling infrastructure, as well as for the potential demand required for the development of new natural gas vehicle fuel-production capacity (i.e., LNG) on a regional level.

### **Local Distribution Companies (LDCs)**

In addition to the E&P companies moving to CNG vehicles in large numbers, a number of natural gas LDCs have also been pursuing a similar strategy, especially due to the ideal fit that today's commercially available light- and medium-duty CNG vans and pickup trucks can play in these applications.

LDCs fulfill the last step in getting natural gas to end-users. Pipelines are typically the means of delivery for the distribution companies to provide the natural gas to households and businesses. There are about a dozen LDCs in Pennsylvania that provide natural gas as a utility to residents. Each LDC typically has a fleet to provide services to customers, as well as pipeline maintenance. Given the fixed nature of an LDCs infrastructure and service territory, the range of their fleet operations are very well known and these companies therefore make ideal opportunities for NGV deployments and associated refueling infrastructure development.

PECO, Pennsylvania's largest utility, provides a tremendous example of an LDC that has embraced fleet conversion to natural gas. A subsidiary of Exelon Corporation, PECO is headquartered in Philadelphia and has 491,000 natural gas customers in southern Pennsylvania. It is Pennsylvania's largest utility and is responsible for 2,500 jobs in Pennsylvania. Because of PECO's experience in the natural gas industry, it understands the

need for alternative fuel vehicles that allow for cleaner and more cost-effective business practices. During the last five years, PECO has invested more than \$1.2 billion in infrastructure. Fifty-seven percent of PECO's fleet already operates on alternative fuels. To fuel its large and growing fleet of CNG vehicles, PECO operates five publicly accessible CNG refueling stations and operates a number of private-access fueling stations to service its own fleet of CNG vehicles.

PECO's Plymouth Township publicly accessible CNG refueling station, in particular, is ideally located to play an important role in the PCTC. This station was recently upgraded to provide high-volume fueling for up to 100 light- and medium-duty CNG vehicles per day, and it is conveniently located off of the Pennsylvania Turnpike. It intersects with I-476 (which runs north to Allentown) and I-76 (the Schuylkill Expressway), an extremely important highway for commercial vehicle traffic serving downtown Philadelphia, the Philadelphia port complex, and connecting to I-95, one of the busiest interstates in America. This existing publicly accessible CNG refueling station will be incorporated into the overall framework of the PCTC roadmap.



**Figure 32: Equitable Gas CNG Honda Civic GX**

Equitable Gas Company is another example of an LDC that is becoming increasingly involved in NGV fueling. Equitable provides natural gas distribution services to over 275,000 residential, commercial and industrial customers located mainly in Pittsburgh and surrounding municipalities. Equitable also operates a private CNG station in Finleyville, Pennsylvania outside of Pittsburgh, and recently it received an AFIG grant from the Pennsylvania Department of Environmental Protection to assist in the construction of a regional CNG fueling station in Pittsburgh's Strip District<sup>44</sup>. The station is being constructed to provide cleaner burning natural gas to local government and private business fleet vehicles, including Equitable's service vehicles. The CNG refueling station will also be available to the public to refuel privately owned natural gas. Construction is expected to be completed by the summer 2011 and the station will create more than two dozen jobs locally, with additional job creation expected in the future as natural gas vehicles grow in use by local governments and authorities, private fleet carriers, and the general public. On a going forward basis, Equitable Gas Company is committed to converting at least 10% of its fleet to dedicated natural gas vehicles such as the Honda Civic GX and other NGV models as they become available.

People's Natural Gas Company also operates a number of fueling stations throughout Pennsylvania. Formerly Dominion Peoples, the company provides service to more than 359,000 residential, commercial, and industrial customers throughout 16 counties in Western Pennsylvania. The service ranges as far north as Grove City, to the east as Johnstown and

<sup>44</sup> <http://www.equitablegas.com/docs/pdf/EMJul2010PA.pdf>.

Altoona, to the south as Greene County, and west to the border of Pennsylvania and Ohio. People's Natural Gas operates nearly 250 NGVs and 10 fueling stations in Western Pennsylvania, further proving the market viability of employing natural gas vehicles in the natural gas industry. While most of these CNG fueling stations are not open for public access, it is recommended that as part of this PCTC roadmap implementation, Peoples Natural Gas Company work to assess the potential to open these stations to outside use.

### ***In Focus: Municipal and Utility Fleets***

Municipal and utility fleets share similarities in vehicle compositions and operating characteristics. These commonalities make the municipal and utility submarket a logical focal point for examining the operational and economic feasibility of utilizing NGVs in Pennsylvania.

Although specific fleet services vary by operator, municipal and utility fleets are designed to provide any combination of the following public services: water and sewage, power, road and traffic signal maintenance, transit, shuttle, refuse collection, parking enforcement, tree trimming, park and recreation, and fire and public safety services. The vehicles that support these operations and city administrative functions vary greatly in their frequency of use, size and duty-cycles, and range from basic gasoline passenger vehicles to Class-8 heavy-duty vehicles in multiple platforms. For purposes of this report, transit, refuse and school bus fleets are evaluated separately as opposed to being considered a small part of a widely varying public fleet.

Pennsylvania entails 67 counties and 2,566 municipalities<sup>45</sup> with fleet sizes from zero to 6,000 vehicles. Although their exact service requirements and population needs may vary widely, there are NGV options available to meet all of these variable applications. So long as there are enough vehicles using enough fuel in any given fleet, the municipal and utility market sector can be an excellent target for a transition to NGVs.

The largest segment of municipal and utility fleets are light-duty vehicles, particularly those between 6,000 and 14,000 lbs GVWR. The vehicles that are most prevalent among utilities in this class are pick-up trucks and vans which can easily be operated on CNG, as demonstrated by the natural gas E&P industry and LDCs. These vans and pickup trucks can justify an initial station to support the more service-specific and varied municipal and utility truck configurations detailed in Appendix B.

In the medium and heavy-duty utility truck sector, several of the major truck manufacturers such as Freightliner and Peterbilt offer base trucks that can easily be configured with a wide variety of specialty bodies. This includes some of the more popular utility configurations, such as aerial lift, material handling, welding, line, dump, and bucket trucks. Other manufacturers such as Elgin and Tympco also offer a full line of natural gas street sweepers.

Successful natural gas fleets in the municipal and utility sector are typically characterized by strong local leadership, partnerships with other local fleets and/or large fleets with higher fuel volumes. For a leadership example, the City of Los Angeles has long maintained a clean fuel purchasing policy, which expanded with the South Coast Air Quality Management District's requirement for local municipalities to utilize alternative fuel vehicles. The City of Los Angeles has pursued an aggressive NGV policy. Covering over 465 square miles and with approximately 3.8 million residents, the City of Los Angeles maintains a fleet population of over 6,500

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<sup>45</sup> <http://www.pamunicipalitiesinfo.com/>.

vehicles<sup>46</sup>, of which 2,005 are alternatively fueled. Of these, the city owns and operates 607 heavy-duty LNG and CNG vehicles, predominantly in its refuse collection and street services departments. In particular, the 132 CNG Street Services vehicles demonstrate the true range available to public CNG vehicles, with numerous dump trucks, sweepers, sewer cleaners, aerial lift, and street painting vehicles. Despite its large service area, the City has established infrastructure to support these municipal and refuse vehicles at strategic locations.



Figure 33: CNG powered AT&T Work Van

AT&T is one of the nation's leading utility companies for the use of CNG medium-duty trucks and vans. In 2009, the company committed itself to reducing its environmental impact by investing more than \$350 million to purchase 8,000 CNG vans<sup>47</sup>. This was a joint cost and environmental decision, with the environmental factors weighing heavily in AT&T's calculation. By December 2010, the company celebrated the deployment of its 2,000th CNG vehicle, less than two years after setting its goal. According to AT&T, the new vehicles will save 49 million gallons of traditional gasoline and reduce carbon emissions by 211,000 metric tons<sup>48</sup>. AT&T is a prime example of what fleets can rapidly achieve with strong leadership and a firm commitment to change.

***AT&T is investing more than \$350 million to purchase 8,000 CNG powered work vans for its fleet. The company already has 2,000 CNG vehicles in its operation, with more on the way every day.***

<sup>46</sup> Excluding emergency vehicles and vehicles operated by the City's transit department and Department of Water and Power, both of which are separately pursuing NGV programs.

<sup>47</sup> <http://www.att.com/gen/public-affairs?pid=12896>.

<sup>48</sup> <http://www.att.com/gen/press-room?pid=2644>.

The best municipal and utility candidates for economically viable NGV deployments include the major city and county fleets with locations that are convenient to the proposed PCTC infrastructure developments, or that can support their own refueling infrastructure. Aside from the obvious municipal targets of Philadelphia, Pittsburgh and Harrisburg, the following utility fleets are sufficiently large to potentially act as a baseline return-to-base fleet capable of supporting additional stations:

**Table 14: Large Utility Fleets in Pennsylvania**

<b>FLEET</b>	<b># OF VEHICLES</b>
<b>PPL</b>	1,094
<b>Verizon Pennsylvania, Inc.</b>	940
<b>UGI Corp.</b>	896
<b>Duquesne Light Co.</b>	786
<b>Trees, Inc.</b>	712
<b>Embarq Corp./CenturyLink</b>	700
<b>PECO Energy Co.</b>	580
<b>Buckeye Pipeline Co., LP</b>	470
<b>Pennsylvania Electric Co./Penelec</b>	368
<b>Sunoco, Inc. R&amp;M</b>	285
<b>Allegheny Power Co.</b>	284
<b>Metropolitan Edison Co./Met-Ed</b>	254

Another key PCTC target should be the Pennsylvania Turnpike Commission (PTC), which operates a fleet of personnel light-duty and heavy-duty vehicles. These vehicles are used daily within the toll road system and are replaced at approximately 125,000 miles (every six years). The PTC has a fleet of 310 heavy-duty vehicles, of which half are snow plows and half are dump trucks. The PTC network also has 23 existing gasoline and diesel refueling stations along the toll road system. Given that the PTC is located along a key PCTC stretch, it already utilizes a network of conventional fueling stations, and all its vehicle needs can be met by NGVs, this agency would be a candidate for using a PCTC network of public access natural gas fueling stations. The PTC could help increase utilization and cost effectiveness along the PCTC network, while also reducing its own investment in upfront NGV program costs.<sup>49</sup>

There are a number of viable municipal, county, public, and utility fleets that would be important PCTC targets. Both Philadelphia and Pittsburgh have several local natural gas users, but no significant NGV fleet presence of their own. Given the success of other municipalities and utilities with a variety of heavy-duty and light-duty fleet programs, and the wide availability of NGV product, Pennsylvania's two largest cities could create viable NGV fleet programs of their

<sup>49</sup> Information obtained from "Natural Gas Vehicle Conversion Plan For Pennsylvania Turnpike Authority," a research paper. Lehigh University, Matt Croshal, December 2010.

own that would in turn support PCTC infrastructure development and growth within their respective regions.

### ***In Focus: Airport and Regional Taxis and Shuttles***

Airports are an important transportation niche for the deployment of NGVs, particularly because they serve as a hub for so many potential NGV users, including: taxis, airport shuttles, transit shuttles, parking shuttles, hotel shuttles, and airport administrative vehicles. Airports also provide a central location for other regional NGV fueling, such as local transit operations and goods movement operators that deliver packages and cargo for air shipments. The concentration of high mileage / fueling consuming vehicles and transportation services that operate on a nearly 24/7 schedule at airports can provide the fuel volume necessary to develop a station that can support many fleets' transition to natural gas. More than 35 airports in the U.S. have natural gas vehicles in their own fleets or have policies encouraging NGV use by private fleets operating on premises, making this sector the third largest NGV sector in the United States, with about 9% of total vehicular natural gas use.<sup>50</sup>

Although airports require a variety of vehicular services, there are many NGVs available to meet these operational needs. For many years, taxis were generally Ford Crown Victorias, which had an easy CNG conversion. Since Ford discontinued the Crown Victoria model, taxi companies have found a variety of other vehicles, and NGV taxi needs are now met through the Ford Transit Connect. Paratransit shuttles and full transit bus shuttle configurations are also available from a variety of manufacturers in natural gas configurations (details included in Appendix B) to serve rental car shuttle needs, long term parking shuttle needs, hotel shuttle services, and public transit connection needs.



**Figure 34: CNG Powered Ford Transit Connect**

Dallas/Fort Worth International Airport (DFW) provides a valuable example of the ways in which access policies and the development of natural gas refueling infrastructure around the airport can spur adoption of alternative fuels. DFW is the world's third busiest airport, with nearly 1,750 flights per day and 57 million passengers a year. DFW commenced the development of an aggressive NGV program in the early 2000s. The airport's program has resulted in the successful development of multiple private and public access CNG fueling stations that support a range of airport-based fleets. The airport operates five (5) different types of shuttle services for

<sup>50</sup> [http://ngvc.org/about\\_ngv/index.html](http://ngvc.org/about_ngv/index.html)

customers and employees, including terminal link vans, shuttles to remote parking lots, shuttles to the consolidated rental car lot, express service, and employee shuttles to an employee parking lot. The airport has shifted all of these operations to CNG. About 95% of all the airport's vehicles run on CNG, including all of its shuttles, staff cars and airfield trucks, and other non-revenue vehicles.

DFW also recently give priority access to CNG taxis over conventionally fueled taxis. The new taxi policy was an important shift that will allow for even greater use of clean air CNG vehicles at the airport, even for vehicles outside DFW's direct control. Boston and San Jose have similar "front of the line" programs, demonstrating that incentives and fueling access can assist with a shift to CNG for taxi fleets.

In addition, the existence of a public fueling station at DFW allowed private operators such as The Parking Spot the opportunity to implement initial small-scale CNG operations. The Parking Spot is a private provider of airport parking services and runs shuttles from its lots to the airports in 18 locations, including Pittsburgh Airport. After experiencing a positive cost and public relations benefits with its initial CNG effort in DFW, the Parking Spot has drastically expanded its commitment to CNG operations, developing three CNG fueling stations on its own properties in DFW, Austin, and Houston. The fleet is also considering a national transition to CNG across all its airport operations, making it a key potential partner in the development of the PCTC roadmap.

Similarly, Super Shuttle, which provides airport shuttle ground transportation to more than eight million passengers per year around the U.S, has also been adding CNG units into its operations. Since its first CNG deployment in 1994, Super Shuttle has recognized the maintenance, fuel cost, and environmental benefits of CNG and now has hundreds of CNG vehicles in various locations including the District of Columbia, Arizona and California. One of the company's operations is located at Pittsburgh International Airport. The Pittsburgh fleet is composed of 30 vehicles, including 20 passenger vans and 10 town cars. These vehicles typically travel within a 50-mile radius from the airport and are thus all excellent candidates for the use of natural gas as a vehicle fuel and thus, a critical target for realizing the fuel throughput needed to justify the development of a refueling station in this location.

More than 14 million travelers utilize the Pittsburgh International Airport each year. Over 30 million passengers passed through the Philadelphia Airport in 2009 and the airport's facilities are stretched past capacity. To serve these two large airports, there are a tremendous number of taxis, shuttles, and private transportation providers that operate at these facilities. As the Dallas-Fort Worth airport example proves, this sector provides an ideal opportunity to support a transition to natural gas, both with a public access station and possible airport policies that incentivize natural gas

Any airport CNG plan should also coordinate with local taxi companies. Recently, one of the City's largest taxi cab fleets, Philadelphia Taxi Management LLC, received a \$900,000 AFIG grant to deploy 50 CNG taxis. The company has more than 200 taxi cabs, including a large contingent at the Philadelphia airport. The company plans to build a CNG fueling station in the city that will be publicly accessible. Even with its own station, airport located fueling could be important for its CNG vehicles operating around the airport and could support further expansion beyond the first 50 CNG vehicle deployments.

The Philadelphia Airport is a particularly strong PCTC target. Because its utilization has exceeded its capacity, the FAA just approved a \$5.2 billion expansion project to accommodate congestion and airport growth. Given the extent of the expansion and its unpopularity in neighboring communities, environmental mitigation measures like CNG fleet development and refueling might be viewed very favorably, making this an optimal time to push for CNG use at the airport.

### ***In Focus: School Districts***

School buses are the poster child for diesel emission reduction programs across the United States. The incomparably old and dirty fleet their tendency to idle and therefore produce more emissions, and their proximity to our children make it an ideal target for low emission technology projects with NGVs. As a result, in the last decade a number of schools have taken an active role in the deployment of natural gas buses and the development of necessary infrastructure. Unfortunately, due to low mileage and fuel use, most school bus projects are at a competitive disadvantage for public funding and their low fuel use makes a strictly economic case infeasible.

The average school bus drives between 10,000 and 15,000 miles a year and consumes approximately 1,500 to 2,000 gallons of diesel fuel. Compared to transit buses and refuse collection vehicles that consume an average of 8,000 to 12,000 diesel gallons per year, this relatively low activity level does not provide for the best opportunity by which to generate the fueling throughput needed to justify the cost-effective development of refueling infrastructure.

These low activity levels are important for several reasons. First, school bus replacement schedules often exceed 15 years due to the low utilization rates and the competition for limited resources and funding (i.e. “books vs buses”). At the same time, grants are typically awarded based on the cost per unit of emissions reduced and/or fuel displaced. In that the incremental cost of natural gas school buses is comparable to other heavy-duty vehicles (i.e. transit buses and refuse trucks), but provides well less than half the emission or petroleum reductions, it is difficult for school bus fleets to compete for these grant funds; they are simply not cost-effective compared to other competing projects. However, given the increased concern over the impact of diesel particulates on children and federal priorities, there are still opportunities and public commitment for natural gas school buses and there are several notable success stories, including one of the nation’s leading natural gas school bus operators in Pennsylvania.

- ***The average school bus drives 10,000 to 15,000 miles a year and consumes 1,500 to 2,000 gallons of diesel fuel.***
- ***The average transit bus or refuse truck consumes 8,000 to 12,000 gallons of diesel fuel per year.***

In general the school bus market includes standard school buses that can carry 16 passengers or more, and paratransit vehicles designed to carry 16 passengers or less and are 10,000 GVWR or less. The two primary natural gas school bus manufacturers, Blue Bird and Thomas Built, both provide full size school buses powered by the Cummins Westport ISL-G. The paratransit vehicles are essentially the same as the medium-duty shuttle buses used by transit agencies and airport shuttle services and there are several natural gas configurations that are detailed in Appendix B.

With public funding, school bus projects can succeed and can have very positive healthy impacts on children over diesel buses. Several Pennsylvania districts used public funding to achieve these successes.

The Lower Merion School District located in Ardmore has been firmly dedicated to the replacement of its bus fleet with natural gas units and is arguably the nation's "poster child" for the successful use of natural gas in a school bus application. Lower Merion's natural gas bus program began in 1992, in response to local community concerns about noise and pollution from the district's diesel school buses. Since then, the district's natural gas fleet has logged more than eight million miles, displacing approximately one million gallons of diesel fuel. Of the district's 112 buses, 72 are powered by natural gas. These natural gas school buses are fueled by two (2) refueling stations located in Ardmore and Rosemont respectively. Many of these programs were supported by AFIG grants, with two of the most recent including \$315,000 for nine (9) CNG buses in 2009 and \$121,641 for nine (9) buses in 2010.



Figure 35: Lower Merion CNG School Bus Fleet

Local residents have noted the improved quality of life due to the lower noise levels of the natural gas buses, in addition to the reduced emissions. In addition to its environmental and economic benefits, the Lower Merion School District reports that its natural gas school buses have promoted driver retention and have improved student behavior due to noise reduction and increased comfort. The school district is now in the process of replacing its first generation of school buses with new natural gas models and has committed to purchasing only natural gas units for all new school bus purchases in the future.

***The Lower Merion School District in Ardmore, Pennsylvania is the nation's "poster child" for the successful use of CNG in a school bus application. The district operates 72 CNG buses in its fleet.***

Other districts in Pennsylvania have expressed a strong interest in CNG buses, including Bensalem Township School District and Central Bucks School District. Bensalem Township School district is composed of six (6) elementary schools, two (2) middle schools and one (1) high school. Central Bucks contains a larger number of schools with 15 elementary schools, five (5) middle schools and a combination of four (4) technology institute and high schools. Both school districts operate more than 100 school buses, creating the potential for a very significant switch to natural gas. Each district bus transports about 70 students daily and consumes around 1,700 gallons of diesel fuel annually. While these fleets are unlikely to be the impetus for the development of new natural gas refueling infrastructure as part of the PCTC, the development of infrastructure within the PCTC will allow for these school bus fleets to consider a shift to natural gas buses when they are located near public access fueling stations along the corridor. The fact that the infrastructure development costs will be paid by others will make the deployment of natural gas schools buses by these districts more economically viable, especially if grant funds can be used to support the purchase of the bus, while also providing students and drivers a healthier environment.

## PCTC Project Cost and Investment in Pennsylvania

The Total Project Investment required for the full implementation of the PCTC Project is projected to be approximately \$98 million and \$208 million under the Foundation and Developed Case scenarios respectively. The Total Project Investment is assumed to include:

- A \$100,000 base cost of each heavy-duty vehicle purchased as part of the project<sup>51</sup>.
- A \$65,000 incremental cost for a natural gas version of each heavy-duty vehicle purchased as part of the project.
- A \$2.6 million cost for each publicly accessible natural gas refueling station built as part of the project.
- A \$400,000 cost for each garage facility that is modified as part of the project for the proper maintenance and repair of natural gas vehicle.
- A 5% budget line item for personnel training and project management.
- A 10% cost contingency.

If the \$100,000 base cost of each vehicle is removed, the remaining Total Project Cost is the cost over and above baseline diesel operations, or, the incremental cost of the PCTC project to the status quo. The Total Incremental Investment Cost for the PCTC is therefore estimated to be \$58 million to \$123 million respectively under the two scenarios. Based upon the historical development of the heavy-duty natural gas vehicle market, it is assumed that these Total Project Costs must be offset via some kind of incentive, subsidy or other third-party investment.

Although fuel cost savings are almost always realized by natural gas fleet operators due to the lower cost of natural gas compared to diesel fuel, such savings are generally insufficient to overcome the reluctance of fleet operators to accept the longer payback period posed by the additional incremental costs of the vehicle, refueling infrastructure, maintenance facility modification, training and project management expenses. With few exceptions, nearly every heavy-duty NGV deployment and fuel station infrastructure development project in the last ten (10) years in the United States has received some form of incentive or subsidy.

## Financing Options

A combination of incentives is generally considered essential by the natural gas industry to help fleets absorb the incremental costs of NGVs, associated fueling stations and maintenance facilities, and training costs. Fleet operators have not been able to justify investment in the incremental capital purely to leverage “green” PR, or to gain marketing advantages; hence the necessary assistance of funding incentives. The economic payback of fuel-cost savings, with few exceptions, is insufficient to justify the high up-front investment in NGV technologies; however, this is changing as petroleum prices remain high and natural gas prices remain low.

Pennsylvania is, of course, no stranger to incentive programs. The Commonwealth's AFIG program has had one of the more successful alternative-fuel vehicle incentive programs in the nation. While the AFIG has been successful in helping to develop the alternative-fuel and low-emission vehicle market in Pennsylvania, there are various other incentive models that have been used throughout the U.S. that Pennsylvania.

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<sup>51</sup> The actual base cost of the vehicles varies from \$65,000 to \$400,000 per unit depending on the vehicle type. \$100,000 is conservative average per unit based on the predominance of goods movement and natural gas industry deployments.

### Utah Model

The Utah Public Service Commission (PSC) has allowed the local distribution companies and utilities in the state to develop natural gas fueling stations and infrastructure from revenues generated from all residential and commercial users of natural gas (not just vehicle natural gas) through the standard rate mechanism. Because of this, Questar Gas has developed and operates over 20 CNG fueling stations in Utah with extremely competitive fuel costs to the public.

Recently, the Utah PSC has decided to implement a specific tariff for natural gas purchased for vehicle fuel use. Under this new tariff structure, there were fewer ratepayers to share the base cost structure, and thus the price of natural gas fuel increased. Even with this rate increase, however, CNG at the utility-owned stations remains considerably cheaper than anywhere else in the United States. Average pricing at the CNG pump, as of January 2011, was \$1.27 per GGE, and continued investment in new fueling stations remains strong. With 20 CNG fueling stations already operating, the state's largest natural gas utility, Questar, recently announced a plan to invest millions of dollars into upgrading and enhancing existing CNG fueling stations and building new CNG fueling stations. The takeaway here is that even under this new rate structure, the economics remain favorable and infrastructure development continues at an aggressive pace.



Figure 36: State of Utah Natural Gas Fuel Station Map

**The average price of CNG at the pump in Utah in January 2011 was \$1.27 per gasoline equivalent gallon.**

In addition to the favorable utility structure, Utah has experienced success in expanding its natural gas market via the Utah Clean Cities Coalition (UCCC), which is extremely active in recruiting fleets and seeking grant funding. The UCCC reports that the Coalition and its members have received funding to help offset the cost for 16 new CNG and three LNG/LCNG

public access fueling stations. These stations will be in addition to the 24 existing stations and service more than 1,500 NGVs in varying applications. In total, the state has successfully incentivized the deployment of approximately 5,000 NGVs that fuel at 85 public and private CNG stations. The excellent station redundancy increases consumer confidence, which is a cornerstone of Utah's overarching plan to massively expand the NGV market. These combined utility and coalition efforts have had tremendous success thus far, and their momentum is a strong indication that this market will help trigger critical economies of scale that will help drive down the incremental cost of NGVs.

### ***Southern California Model***

Southern California has some of the worst air pollution in the nation. The large population and some of the country's busiest water ports, the associated vehicle traffic, goods movement, and energy production for commercial and residential use produce very high quantities of smog-forming pollution, as well as greenhouse gases. With the topography of Southern California, much of that pollution gets trapped in the region, causing it to be one of the most polluted regions in the U.S. Because of this, the South Coast Air Quality Management District (SCAQMD) has enacted some of the toughest pollution control and prevention measures in the nation.

SCAQMD has enacted regulations that apply to most public and private fleets that support public services. The fleets affected by these regulations are street sweepers, transit buses, refuse-collection vehicles, school buses, airport ground access vehicles (including taxis and shuttle buses), and other public fleet vehicles. SCAQMD has seven fleet rules (the 1190 Series Rules) that regulate each of these types of fleets. The rules vary in content, with most requiring the purchase of only alternative-fueled versions of affected vehicles; NGVs are thus far the most popular alternative fuel compliance strategy under these rules due to the wide range of commercially available natural gas powered equipment in the marketplace.

While the SCAQMD may have regulations requiring the purchase of alternatively-fueled vehicles, the Air District has also offered substantial monetary incentives in the form of competitive grants to purchase alternative-fueled vehicles, alternative-fueled stations, upgrades to existing stations, upgrades to maintenance facilities to maintain alternative-fueled vehicles, personnel training, etc. These grants are funded through a variety of creative programs including fees, emission reduction credits (ERCs), penalties, alternatives to ridesharing requirements, bonds and federal assistance. One example is the successful Mobile Source Reduction Review Committee (MSRC), which is funded by a portion of Department of Motor Vehicle (DMV) fees imposed when purchasing a new car or renewing vehicle registrations on cars in Southern California. The fees collected by the DMV and distributed to the SCAQMD are then used to fund various emissions-reduction programs, including those that apply to natural gas trucks, natural gas fueling stations, maintenance facility upgrades to accommodate NGVs, NGV training, and even outreach and education.



Figure 37: State of California Natural Gas Fuel Station Map

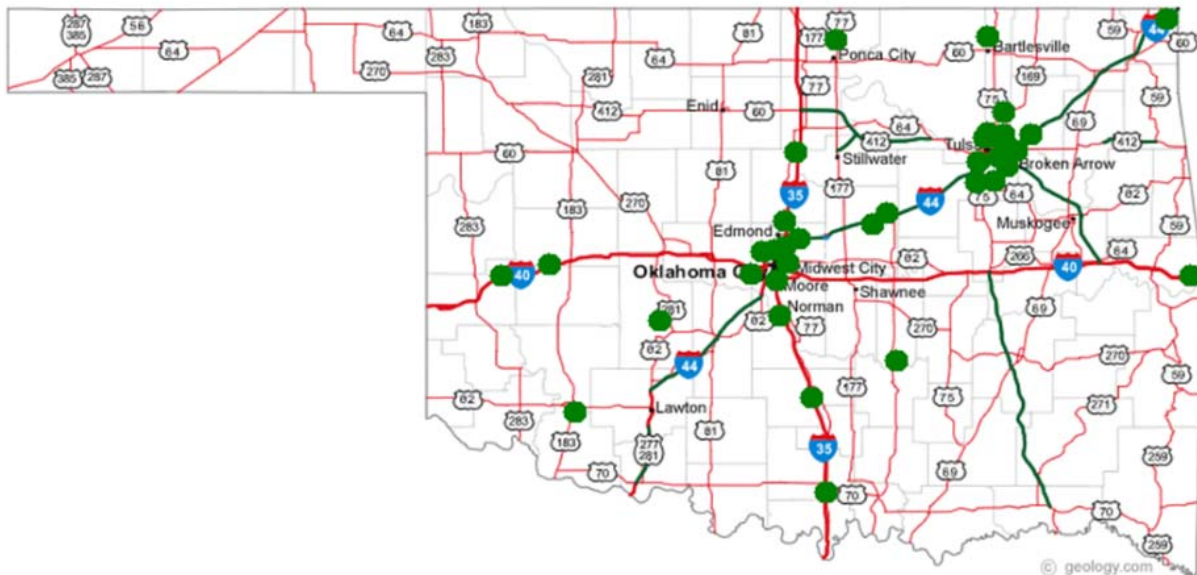
The dedication and investment extended by SCAQMD has resulted in a world-renowned local proliferation of natural gas stations and vehicles. The prevalence of NGVs in SCAQMD's jurisdiction is so great that in January 2011, 7% of the cargo hauled to and from the Port of Long

Beach was pulled by natural gas powered trucks<sup>52</sup>. Also in January 2011, the Los Angeles County Metropolitan Transit Agency replaced its all of its 2,221<sup>st</sup> diesel buses with CNG transit buses. There are thousands of natural gas powered refuse trucks operating in Southern California, in addition to hundreds of others delivery trucks, street sweepers, shuttle buses, taxi cabs, and a variety of other NGVs. In total, SCAQMD reports 210 public and private stations fueling 38,000 NGVs with 0.1 BCF per year. This incredible success story allows SCAQMD to enjoy significantly reduced emissions from the one of the most prolific and congested regions in the nation.

### ***Oklahoma Model***

While Utah and Southern California have developed programs around the gas utilities and grant programs for fleets, the state of Oklahoma has chosen to incentivize fleets and fuel station owners through state tax credits.

Current legislation in Oklahoma authorized through 2014 provides a one-time income tax credit covering 50% of the incremental cost of purchasing new, original equipment for AFV or converting a vehicle to operate on an alternative fuel. Oklahoma also provides a tax credit for up to 75% of the cost of installing alternative-fuel infrastructure. A tax credit up to \$2,500 is also available for up to 50% of the cost of installing a residential CNG fueling system.. Furthermore, all of these tax credits may be carried forward for up to five years.



**Figure 38: State of Oklahoma Natural Gas Fuel Station Map**

Oklahoma is becoming a national leader in alternative energy by focusing on making the transition to lower-cost, locally produced alternative fuels feasible for its residents and businesses. Oklahoma's CNG laws have been so successful they are even attracting national attention. For example, Oklahoma House Speaker Chris Benge was asked to testify about the State's alternative energy credits before the Congressional Natural Gas Caucus in Washington D.C. in 2010.

<sup>52</sup> Page 2, Port of Long Beach Truck Activity Report (Tars), Clean Trucks, Feb. 16, 2011

The state's income tax credits and focus on take-or-pay fuel contracts has led to the construction of 50 CNG stations that refuel 4,000 NGVs statewide. Some examples of successful projects funded under the Oklahoma Model include:

***Oklahoma's recent natural gas vehicle program state tax-credit program has helped to build 50 CNG refueling stations and deploy more than 4,000 NGVs statewide.***

- Tulsa Public Schools is converting its fleet of 177 diesel-powered buses to compressed natural gas. The change is expected to save the district up to \$1 million a year.
- The city of Norman will purchase its third natural gas refuse hauler in early 2011. All three vehicles operate exclusively on CNG, reducing dependence on petroleum, reducing tailpipe emissions, reducing noise pollution and saving fuel costs.
- Oklahoma City owns, operates and maintains a fleet of 80 light-duty, CNG vehicles, many of which were dedicated CNG, as well as two heavy-duty CNG refuse haulers.
- Chesapeake Energy has successfully leveraged this program to support its aggressive CNG vehicle and refueling infrastructure development program.

### ***New York Model***

The state of New York has a combination of incentives for alternative-fuel vehicles, including state tax incentives (like Oklahoma) and a state-funded grant program (like Southern California). New York provides a state tax credit covering 50% of the cost of the installation of infrastructure used to store or dispense an alternative fuel into the fuel tank of alternative-fuel vehicles.

In addition to the state tax credit, the state provides various alternative-fuel vehicle grants through the New York State Energy Research and Development Authority (NYSERDA). NYSERDA currently has specific programs providing funds to state and local transit agencies and schools for up to 100% of the incremental cost of new, alternative-fuel buses and associated infrastructure. This program has been very successful in helping to deploy large volumes of NGVs. For example, the Metropolitan Transportation Authority utilized this program to secure \$10.2 million in funding for the purchase of 192 full-size CNG buses.

***There are more than 100 public and private access CNG refueling stations in New York State fueling approximately 10,000 NGVs.***

New York City also runs a Private Fleet Program to help provide funding to private firms for up to 50% of the incremental cost of light-duty natural gas and electric vehicles, and up to 80% of the incremental cost for new and converted medium- and heavy-duty natural gas vehicles. These combined efforts have resulted in nearly 100 public and private access CNG stations that fuel approximately 10,000 NGVs.

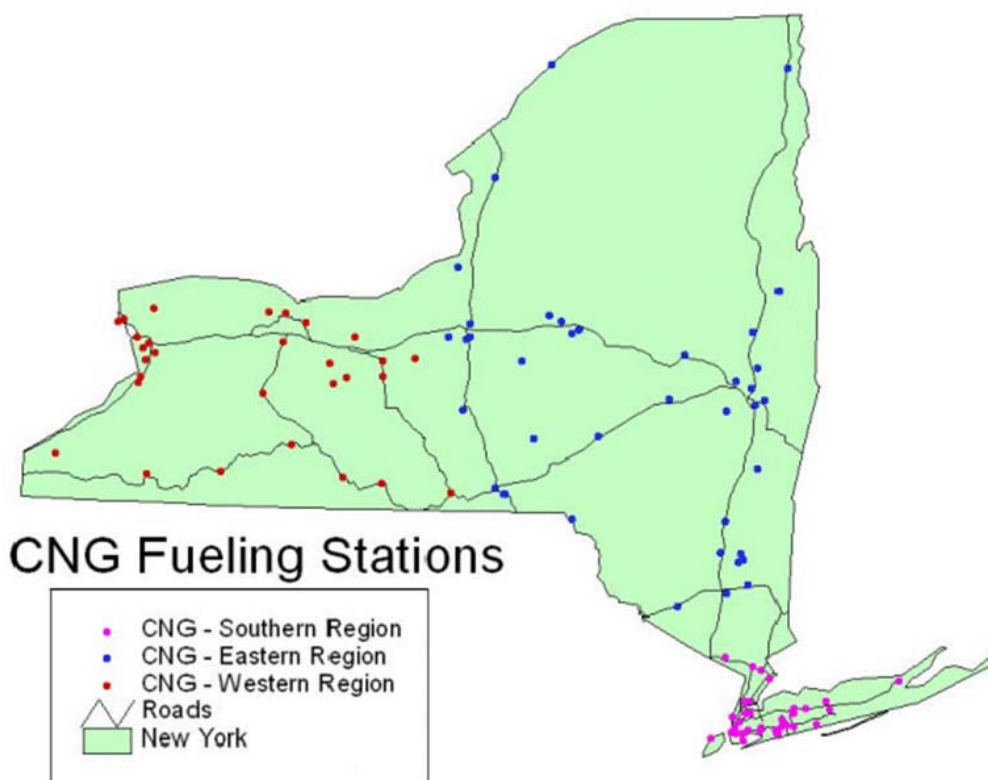


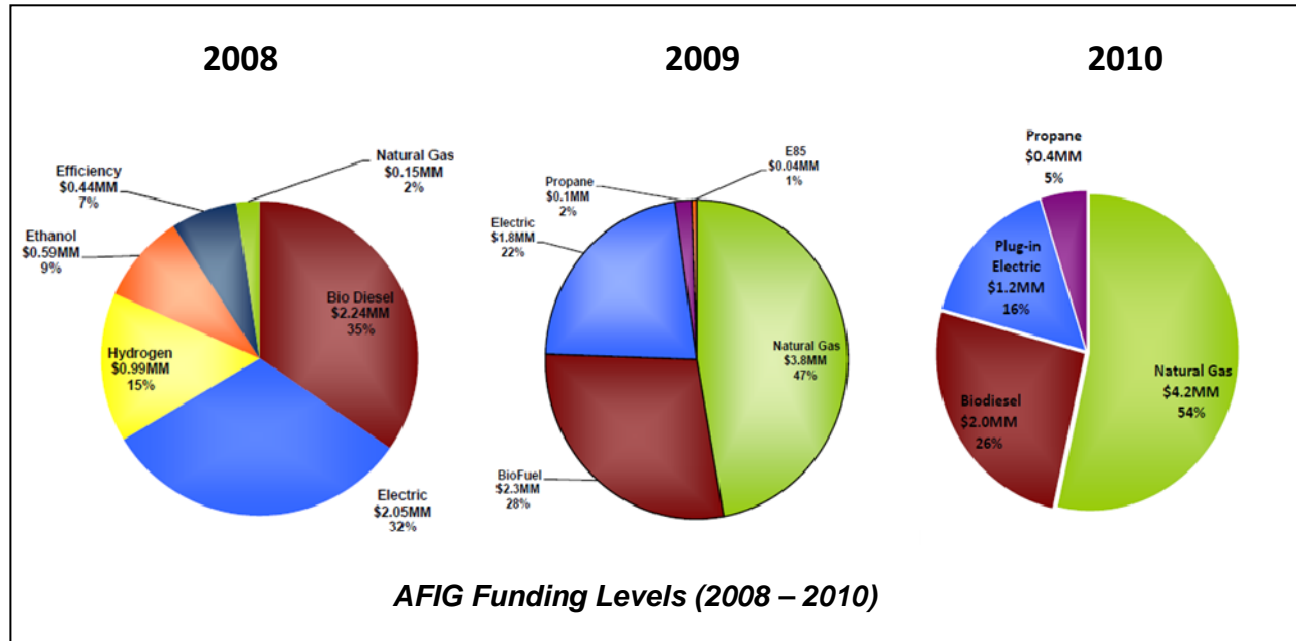
Figure 39: State of New York Natural Gas Fuel Station Map

### ***Pennsylvania Model***

Pennsylvania already has its own AFIG program that has been operating for nearly two decades. The AFIG program was originally established in 1992, and it was further expanded in 2004. The program is designed to reduce Pennsylvania's dependence on imported oil, improve air quality, and foster economic development through new energy technologies and the use of fuels indigenous to Pennsylvania (e.g., shale gas).

The AFIG program is administrated by the Pennsylvania DEP. The AFIG program is funded by the General Fund through a gross receipts tax on utilities. The amount of funding for the program varies by year due to economic conditions, but it has had as much as \$10 million to spend annually in recent years.

The AFIG program funds can be used to convert existing vehicles to operate on alternative fuels; to purchase new bi-fuel, dual-fuel, hybrid, and dedicated alternative fuel vehicles; to install the necessary fueling infrastructure for alternative fuels; to perform research and development (R&D) on new alternative fuel technologies; and to help defer the incremental costs of purchasing biofuels.



**Figure 40: Summary of AFIG Funding Awards (2008 - 2010)**

In recent years, NGV deployment programs have gained an increasing share of the AFIG program funds. Whereas only 2% of the program funds were allocated to NGV projects in 2008, the percentage of the overall AFIG awards for NGV projects dramatically increased to 47% in 2009 and to 54% in 2010, thereby demonstrating a year-over-year increased demand for NGVs in the Pennsylvania transportation sector.

### **Federal Tax Credits**

In addition to the various grant and state tax incentives described above, federal tax credits for alternative fuel vehicles and infrastructure have been very important financial drivers over the past several years.

The three primary credits that have been available include:

- A \$0.50 excise tax credit for each gallon of LNG or gasoline gallon equivalent of CNG;
- A vehicle-purchase tax credit of up to \$32,000 for the largest and cleanest of natural gas engines;
- A refueling-equipment tax credit of up to \$30,000 for large equipment and \$1,000 for home refueling equipment. The American Recovery and Reinvestment Act of 2009 increased the value of this credit to \$50,000 for large stations and \$2,000 for home refueling devices.

Coupled with private, third-party funds or other grant funds, these federal tax credits have dramatically improved the economic competitiveness of natural gas vehicles, particularly those in high-mileage operations. In addition, unlike grant funding, the value of a federal tax credit is not considered taxable income to a private entity. It is therefore equivalent to a cash rebate, or grant funding at 100% of the value.

Although the \$32,000 vehicle tax credit expired at the end of 2010, the \$0.50 fuel-excise tax credit and refueling-equipment tax credit have recently been extended through 2011, and several members of the 112<sup>th</sup> Congress have repeatedly signaled their interest in extending all three of these NGV program tax incentives well into the future.

Without a doubt, the \$0.50 fuel-excise tax credit has been one of the most successful programs in terms of driving large deployments of natural gas trucks. In high-fuel-use application such as transit, refuse and over-the-road trucking, the \$0.50-per-LNG gallon has a significant positive impact on the aggressive deployment of heavy-duty natural gas trucks given the tremendous fuel-cost savings realized by the end user. A heavy-duty fleet operator burning 50 gallons of LNG per day will reduce his or her per-truck fuel bill by nearly \$12,000 *annually* via the application of this federal tax credit, savings that are *in addition to* the already \$1.00-plus-per-diesel-gallon price difference between natural gas and diesel fuel. When combined, expedited payback periods of less than two years can be realized on the incremental investment required for a natural gas truck. After this payback period, the fuel-cost savings go directly to the bottom line of the fleet operator. Given that a typical refuse truck will be in operation for over 10 years, this fuel-cost savings becomes a very significant benefit to a fleet operator.

### ***Private Investment Model***

Another method for financing a new natural gas fueling station is via a private investment, where the investment is paid back through the sale of CNG or LNG to vehicles. In this scenario, a natural gas fueling station provider may design and build a new CNG or LNG fueling station. The end users would then buy the dispensed LNG or CNG at some price per gallon that allows the station provider to recover their investment into the initial build within a reasonable amount of time, typically 10 years.

While the business model for each project is different, the minimum conversion that is generally required for this business model is to replace sufficient vehicles to displace approximately 20,000 gallons of diesel fuel per month. This use level will obviously depend upon the size of the fueling station and the specific terms that are negotiated, as well as the applicability of any grant funds, tax credits and/or other incentives.

Natural gas fuel suppliers such as Clean Energy Fuels, Trillium, Pinnacle and others have been very successful in the application of this business model. It has been one that allows these companies to invest their capital to build and operate a fueling station to support a heavy-duty fleet conversion to natural gas.

Because fuel-cost savings for NGV fleet programs have been so significant in recent years, especially when the added benefit of \$0.50-per-gallon federal tax credits and other possible incentives are also applied, many heavy-duty fleet operators have begun to recognize the tremendous value to the bottom line that an aggressive NGV program can bring. This realization, often gained through experience, has often resulted in the fleet making its own private investment in its NGV project so it can recognize such cost savings and not have to pay a premium for such investments.

## Conclusions and Summary of Key PCTC Messages

The natural gas resources in the Marcellus Shale represent one of the largest energy reserves in the world, and the PCTC offers a unique opportunity for Pennsylvania to drive growth in both the natural gas and transportation sectors. NGVs offer the single best opportunity to achieve immediate gains in energy security in the transportation sector, and the PCTC provides an effective pathway to achieve a multitude of benefits that extend beyond energy security into jobs, the economy, and major environmental improvements for both Pennsylvania and the nation.

Under the Developed Case, the PCTC will result in a total investment in Pennsylvania's economy of up to \$208 million that will yield tremendous benefits, including:

- A direct impact on nearly 1,360 jobs in Pennsylvania;
- The replacement of 9.2 million gallons of diesel fuel each year with 1.4 billion cubic feet (BCF) of Pennsylvania-produced, lower-carbon, and lower-cost natural gas;
- An astounding reduction in annual fuel costs for Pennsylvania fleet operators of \$9.2 million; savings that can then be reinvested in their business, personnel hiring, and the overall Pennsylvania economy;
- A reduction of NOx emissions by 720 tons, PM emissions by 14.5 tons, and greenhouse gas emissions by 21,000 metric tonnes each year.

To commence development of this NGV roadmap for Pennsylvania, it is recommended that some critical early successes be realized in order to further advertise the concept of the PCTC. Together with these early wins, Pennsylvania needs to pursue and adopt aggressive policy positions in a number of areas, and begin to develop strategic partnerships within and beyond Pennsylvania's borders to further encourage the implementation of the roadmap vision. Through these efforts, it is likely that several obstacles that would otherwise slow the progress of the successful implementation of the PCTC can be overcome.

The PCTC is a viable plan that provides an economically sustainable pathway for long-term NGV market development in the northeastern United States and with linkages to developing Canadian NGV freight corridors. Effective implementation of the roadmap will require local leadership in developing key policies, partnerships, incentive programs and messages to support the proposed PCTC program. Policies should include:

- Clear policy direction on NGVs as an opportunity for economic stimulus in Pennsylvania;
- Allowance of U.S. EPA certified bi-fuel NGVs in the Pennsylvania market;
- Long-term state and federal incentives focused on expansion of the NGV market;
- Clear push for regional planning and partnership development to support effective long-term growth of the regional NGV market.

The development of the PCTC will rightly put Pennsylvania at the leading edge of the nation's effort to address critical issues, including energy security, fuel cost, economic recovery, job creation, air pollution and climate change. It will also make Pennsylvania the hub of clean-corridor development in the eastern part of North America. Framing the PCTC in the broader context of a national domestic and international fueling infrastructure will be critical in showcasing the big-picture objectives of this initial but highly focused effort.

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**NGV ROADMAP FOR PENNSYLVANIA JOBS,  
ENERGY INDEPENDENCE, AND CLEAN AIR**

# **Appendix A**

## **Natural Gas Infrastructure and Facility Modification Technical Specifications**



## Appendix A

### Natural Gas Infrastructure and Facility Modification Technical Specifications

#### Station Design

When planning to develop an LNG fueling station, one must consider building up a “critical mass” of LNG fleet vehicles in order to achieve the minimum 1,200 gallon per day throughput needed in order to eliminate the threat of losing fuel to boil off and venting. While this minimum fuel throughput is purely an operational requirement, as described elsewhere in this document, it also provides for a close parallel to the fuel throughput required in order to justify the economic investment.

It is important to note that CNG fuel stations do not have fuel boil off and venting issues to contend with. Once CNG is compressed, it is stored in the station’s high-pressure gas storage bottles until such time as it is used. CNG stations can therefore be constructed to serve very small fleets of CNG vehicles that are anticipated to grow over time, without having to worry about losing any fuel to venting.

The design and sizing of both CNG and LNG refueling stations is very dependent upon site specific conditions, the size of the site, fuel demands and fueling windows of the fleet to be served, and the required energy inputs and operational preferences for each facility. It is important that stations not be undersized, as inefficiencies will result within the fleet operation due to extended fueling times and truck queuing at the fuel dispensers – a surefire recipe pushing fleet operators back to diesel. At the same time, it is important not to oversize a fueling station, as boil-off and venting of fuel will occur with LNG stations, and inefficient operations will result with CNG stations (i.e. constant stopping and starting of compressors, high energy bills and high maintenance costs). While there are some common CNG and LNG station equipment sizes and configurations for fleet operations, a “one size fits all” approach is difficult to use as each station design must consider the individual site and fleet application at each facility.

Although, GNA recommends the use of LNG/LCNG stations throughout the PCTC for the various reasons mentioned throughout the report, most likely the project will proceed with at least a few of the total proposed stations being CNG only sites.

#### CNG Stations

For CNG stations, a rule of thumb is to design the facility in order to provide fuel at a rate of approximately four to eight (4 to 8) gasoline equivalent gallons (GGE) per minute through each fueling nozzle. At the heart of a CNG fueling station is the gas compressor. Compressor sizing is typically based upon the cubic feet of gas that the unit can provide at the outlet (i.e. to the downstream fueling system and, ultimately, the dispenser nozzle). With approximately 125 standard cubic feet (SCF) of natural gas per GGE, minimum compressor sizing for any station within the PCTC project should be at least 500 standard cubic feet per minute (SCFM). In order to provide for redundancy within each system, dual 250 SCFM or 300 SCFM units are recommended as the minimum compressor size for each site. Ideally, dual 500 SCFM can be provided; however, such sizing will largely depend upon the ultimate fueling demand at each site location.

It is also important to remember that the measurement of the compressor outlet in SCFM must also consider the number of dispensing nozzles that the compressor must serve, and thus, could be required to supply gas to on a simultaneous basis. For example, if a CNG station has

four (4) CNG fueling nozzles and all are activated at the same time, a 1000 SCFM compressor will only be able to supply 250 SCFM of compressed gas to each dispensing nozzle (i.e. 2 GGE per minute). Such a fueling rate is likely too small to efficiently refuel a heavy-duty truck requiring 40 to 50 gallons of fuel. In such an example, the driver will require a minimum of 30 minutes of time to refuel the vehicle. Most fleet operators will find this unacceptable, and will require fueling to be accomplished in approximately 15 minutes. Therefore, publicly accessible CNG refueling stations considered for the PCTC should be designed with this goal in mind.

To augment the fueling capabilities of a fast-fill CNG refueling station, CNG ground storage provides a buffer of pre-compressed gas. Most CNG refueling stations are equipped with a “three pack” of CNG storage cylinders (either tubes or spheres), each having a capacity of approximately 12,000 SCF. Therefore, total ground storage capacity is, 36,000 SCF, or about 300 GGE. As CNG fueling from ground storage is possible via simple pressure equalization, the complete volume of ground storage is not useable for fueling. As a rule of thumb, one-third of the ground storage is available for fast-fueling to vehicles; in this case, approximately 100 GGE of CNG.

For CNG refueling stations serving medium and heavy-duty fleet operations, two (2) “three-packs” of ground storage are often provided in order to provide 200 GGE of buffer storage (i.e. six cylinders having a total capacity of 75,000 SCF). With an anticipated per truck fueling requirement of approximately 50 GGE, this provides enough fuel to allow four heavy-duty trucks to refuel without having to rely on the capacity of the CNG compressor. Depending upon the vehicle fueling demand, fueling windows, and other specific requirements of a CNG station, a large ground storage system can sometimes allow for the downsizing of the CNG compressor requirements, thus reducing capital and operating cost requirements for a station.

For the PCTC project, as a rule of thumb, GNA recommends a minimum of 500 SCFM of CNG compressor capacity and two (2) three-packs of CNG ground storage. For larger stations, or for ones where CNG fuel demand growth is anticipated, additional CNG compressors can be added to augment the fueling facility and to provide for operational redundancy (i.e. if one compressor is off line, for whatever reason, the other compressor can still provide fueling service to vehicles).

A larger CNG station that has planned use for many heavy-duty vehicles, the station should be equipped with three (3) 500 SCFM compressors, two (2) three-packs of CNG ground storage and one or two dual-hose CNG fuel dispensers. The station will also be equipped with a universal card reader payment system and appropriate safety systems. While site specific considerations and site civil work requirements will always impact the final station costs, for the purpose of this report, GNA estimates that a larger CNG fueling station with these specifications will cost about the same as an LNG/LCNG station capable of fueling with the same flow rate; \$2.6 million.

## **LNG Stations**

For LNG refueling stations, the rule of thumb is to design the facility with a minimum of three days of on-site LNG fuel storage capacity, but no more than seven days of storage capacity. This requires careful consideration and planning based upon the anticipated daily fueling demand, and to a certain extent, access to and reliability of the LNG fuel supply. Under or over sizing an LNG fuel storage system will result in inefficiencies, fuel venting and/or potential reliability issues. An LNG/LCNG system is included in this report in order to provide for both LNG and CNG fueling to heavy-duty trucks.

The smallest bulk LNG storage tank that is used for a fueling station has a capacity of 6,000 gallons. For typical “full size” installations, 15,000 gallon storage tanks are used. While some very large installations that require the daily fueling of several hundred vehicles have used 30,000 gallon bulk storage tanks, this is not anticipated for the PCTC, at least at the point of start-up. Therefore, GNA has assumed a standard station size based upon a 15,000 gallon LNG storage tank.

For this project, GNA has assumed that each truck will consume approximately 50 LNG gallons of fuel per day. As such, using the three and seven day storage capacity rule of thumb, an LNG/LCNG fuel station installation with a 15,000 gallon LNG storage tank will support approximately 50 heavy-duty trucks consuming 50 LNG gallons a day (or the equivalent amount in CNG). These assumptions and numbers, therefore, become the basis for the air quality and petroleum reduction numbers stated elsewhere in this report. Additionally, these numbers will also help guide the implementation phase of this project in terms of making decisions between small and large LNG/LCNG station installations.

### **Garage Modification Design for Natural Gas Vehicle Maintenance and Storage**

Ventilation When CNG or vaporized LNG is released into the atmosphere of a closed building, it will generally rise to the ceiling of that building because methane is lighter than air when at ambient temperatures. LNG presents a particular problem because at temperatures just above the vaporizing temperature it is heavier than air. As LNG warms, however, it will become lighter than air and rise. If allowed to accumulate at the high point of the ceiling and an ignition source is present, the accumulated methane may be ignited. Methane has a narrow range of concentration within the explosive limits (about 5 percent to 15 percent in air) so if the release is heavily diluted with air, the lower flammability limit (LFL) is not reached.

Ventilation either with mechanical fans or by gravity flow is generally suitable for reducing the concentrations of methane below the LFL and evacuating the release out of the building, thus eliminating the potential danger. Thus ventilation is considered an essential part of the garage modifications. Systems are generally required to have a certain number of air exchanges per hour, with the number of exchanges doubled during periods of alarm.

Elimination of Ignition Sources For a release of gaseous methane to be ignited, an ignition source in the form of a flame, electrical spark or a hot surface is required. Elimination of all possible ignition sources is another goal of garage modifications. This may include installing explosion-proof electrical appliances, including lighting fixtures and electric door motors, or retrofitting unsealed conduits that may exist in areas where methane can accumulate. Elimination of space heaters that have either open flames or hot elements is also a means for eliminating sources of ignition, as is the restriction of either electric arc or gas welding within the facility. Prohibiting smoking within the building is also a means for eliminating ignition sources.

Combustible Gas Monitoring and Alarm Systems In addition to the actual modifications required to the building structure or appurtenances, regulations require that combustible gas detectors be installed at strategic locations within the building – generally near the high points of the ceiling – so that methane releases can be detected at very low levels (generally 25 percent of the LFL). If these devices detect methane at or above this concentration (they are programmable over a range of detection limits), the detectors will sound alarms through pre-programmed control circuitry, switch on (or off) certain electrical equipment, and summon the

fire department. The most common action at the 25 percent LFL detection point is to sound an alarm and activate the mechanical ventilation fans (or increase their flow). If a higher level is encountered, the controllers will do the above, but also shunt trip off all but critical electrical appliances (generally only the fans and the detection/alarm system itself), and contact the fire department and others by means of a modem. Some designs may require that power for the critical electrical appliances be via a backup emergency generator.

Implementation of these requirements varies significantly based upon the specific considerations of each garage facility. In some cases, very few modifications are required. In other cases, the existing ventilation system must be completely replaced, all space heaters removed, lighting fixtures either replaced or relocated, and the entire electrical infrastructure of the building revamped. The development of a suitable ventilation system will also be dependent upon the existing ceiling configuration – level, peaked, or sloped. If maintenance bay doors are equipped with electric door motors, these may need to be replaced with explosion proof units.

If the maintenance building has an integral office, parts store, break room or other associated function, those areas may need to be fitted with overpressure ventilation to prevent the possible migration of methane into unprotected areas. If the facility is required to have emergency power if the mains are tripped, then an emergency generator may be needed.

Similarly, depending upon the size and complexity of the existing facility, the installation requirements for a suitable detection and alarm system will vary considerably. The requirements of the detection control system may be complex: is it required to open doors, as well as activate the fans or the emergency generator, for example. Even the geographic location of the facility is important. In cold climates, for example, continuous ventilation with outside air may not be acceptable.

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**NGV ROADMAP FOR PENNSYLVANIA JOBS,  
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# **Appendix B**

**Natural Gas Vehicle Technical Specifications**



## Appendix B

### Summary of Natural Gas Vehicle Options

#### Light-Duty and Medium-Duty Natural Gas Vehicle Options

Light-duty vehicles have a gross vehicle weight rating (GVWR) of less than 14,000 pounds. Currently, there is only one production light-duty natural gas vehicle available in the market, the Honda Civic GX sedan. The Honda Civic GX continues to be voted as the cleanest car in America by the EPA and several other “green” organizations. Although the Honda Civic GX is the only straight-from-the-manufacturer light-duty vehicle option, there are a number of certified “upfit” options that convert gasoline vehicles to natural gas. Some of these upfitters have relationships with the original equipment manufacturers for a more seamless purchasing and warranty process. For example, Ford and BAF work together and GMC/Chevrolet work with Natural Drive. This section provides an “at a glance” look at the different light-duty NGV options available for Pennsylvania.

#### SEDANS

##### **Honda Civic GX Sedan**

Manufacturer: Honda

Model: Civic GX

Application: 4 Door - Passenger Vehicle



##### **Buick Lucerne**

Manufacturer: Buick

Model: Lucerne

Application: Sedan

Upfitter: Natural Drive



**Chevrolet Malibu**

Manufacturer: Chevrolet

Model: Malibu

Application: Sedan

Upfitter: Natural Drive

**Chevrolet Impala**

Manufacturer: Chevrolet

Model: Impala

Application: Sedan, Police

Upfitter: Natural Drive

**Pontiac G6**

Manufacturer: Pontiac

Model: G6

Application: Sedan

Upfitter: Natural Drive



**Ford Transit Connect**

Manufacturer: Ford

Model: Transit Connect

Application: Taxi/Utility Van/Delivery

Upfitter: BAF



**PICKUP TRUCKS**

**Ford F150**

Manufacturer: Ford

Model: F150

Application: Pick Up Truck

Upfitter: BAF



**Ford F250**

Manufacturer: Ford

Model: F250

Application: Pick Up Truck

Upfitter: BAF



**Ford F350**

Manufacturer: Ford

Model: F350

Application: Pick Up Truck

Upfitter: BAF

**Chevrolet Colorado**

Manufacturer: Chevrolet

Model: Colorado

Application: Pick Up Truck

Upfitter: Natural Drive

**Chevrolet Silverado 2500**

Manufacturer: Chevrolet

Model: Silverado

Application: Pick Up Truck

Upfitter: Baytech Corporation, Natural Drive



**Chevrolet Silverado 3500**

Manufacturer: Chevrolet

Model: Silverado

Application: Pick Up Truck

Upfitter: Baytech Corporation, Natural Drive

**GMC Canyon**

Manufacturer: GMC

Model: Canyon

Application: Pick Up Truck

Upfitter: Natural Drive

**GMC Sierra 2500**

Manufacturer: GMC

Model: Sierra 2500

Application: Pick Up Truck

Upfitter: Baytech Corporation, Natural Drive



**GMC Sierra 3500**

Manufacturer: GMC

Model: Sierra 3500

Application: Pick Up Truck, Utility Truck

Upfitter: Baytech Corporation, Natural Drive

**Ford F450**

Manufacturer: Ford

Model: F450

Application: Pick Up Truck/Utility

Upfitter: BAF

**Ford F550**

Manufacturer: Ford

Model: F550

Application: Pick Up Truck/Utility

Upfitter: BAF

**VANS (CARGO AND PASSENGER)**

**Ford E150**

Manufacturer: Ford

Model: E150

Application: Van

Upfitter: BAF



**Ford E250**

Manufacturer: Ford

Model: E250

Application: Van

Upfitter: BAF



**Ford E350**

Manufacturer: Ford

Model: E350

Application: Van

Upfitter: BAF



**Chevrolet Express 1500**

Manufacturer: Chevrolet

Model: Express 1500

Application: Cargo Van

Upfitter: Baytech Corporation, Natural Drive



**Chevrolet Express 2500**

Manufacturer: Chevrolet

Model: Express 2500

Application: Cargo Van, Passenger Transport

Upfitter: Baytech Corporation, Natural Drive



**Chevrolet Express 3500**

Manufacturer: Chevrolet

Model: Express 3500

Application: Cargo Van, Passenger Transport

Upfitter: Baytech Corporation, Natural Drive



**GMC Sierra 1500**

Manufacturer: GMC

Model: Sierra 1500

Application: Cargo Van

Upfitter: Natural Drive



**GMC Sierra 2500**

Manufacturer: GMC

Model: Sierra 2500

Application: Cargo Van, Passenger Transport

Upfitter: Baytech Corporation, Natural Drive



**GMC Sierra 3500**

Manufacturer: GMC

Model: Sierra 3500

Application: Cargo Van, Passenger Transport

Upfitter: Baytech Corporation, Natural Drive



**CUTAWAY**

**Ford E-450**

Manufacturer: Ford

Model: E-450 Cutaway Van

Application: Shuttle Bus, Cargo

Upfitter: BAF

**Chevrolet G4500**

Manufacturer: Chevrolet

Model: G4500 Cutaway Van

Application: Shuttle Bus, Cargo

Upfitter: Baytech

**TRANSIT AND SHUTTLE****Freightliner MB 55**

Manufacturer: Freightliner

Model: MB 55

Application: 27- 32 Passenger Shuttle Bus



**StarTrans “President” Shuttle Bus**

Manufacturer: StarTrans

Model: President RE

Application: 33 Passenger Shuttle Bus



**Chevy StarTrans “Senator” Shuttle Bus**

Manufacturer: Chevy

Model: Senator

Application: 17 Passenger Shuttle Bus



**Ford E450**

Manufacturer: Ford

Model: Odyssey

Application: 25 Passenger Shuttle bus



**Ford “Van Terra” Shuttle Bus**

Manufacturer: Ford

Model: E350 Van Terra

Application: Shuttle Bus



**Heavy-Duty Natural Gas Vehicle Options**

Heavy-duty vehicles have a gross vehicle weight rating (GVWR) of 26,000 pounds or more. Natural gas has been the fuel of choice for heavy-duty alternative fuel vehicle operators including school and transit buses as well as drayage trucks. These natural gas-fueled vehicles provide similar power, torque and fuel range as conventionally fueled vehicles, while providing significantly improved emissions benefits and opportunities for long term operational cost reductions. Below is a list of heavy-duty natural gas vehicles currently available in the market.

**School Buses****All American FE & RE**

Manufacturer: Blue Bird Corp.

Model: D3

Application: School Bus

**Thomas Built Saf-T-Liner HDX CNG**

Manufacturer: Thomas Built Buses

Model: Saf-T-Liner HDX CNG

Application: School Bus

**Transit Bus****Orion VII CNG**

Manufacturer: Orion International

Model: Orion VII Next Generation

Application: Transit Bus



**EIDorado National Axess**

Manufacturer: EIDorado National

Model: Axess CNG

Application: Transit Bus



**EIDorado National E-Z Rider II**

Manufacturer: EIDorado National

Model: BRT

Application: Transit Bus



**EIDorado National XHF**

Manufacturer: EIDorado National

Model: XHF

Application: Transit Bus



**Foton America FCB**

Manufacturer: Foton America

Model: L40

Application: Transit Bus

**NABI BRT**

Manufacturer: NABI-North American Bus Industries

Model: 60 BRT

Application: Transit Bus

**NABI LFW**

Manufacturer: NABI-North American Bus Industries

Model: LFW

Application: Transit Bus



**NABI LF**

Manufacturer: NABI-North American Bus Industries  
Model: Blue Bird Ultra LF  
Application: Transit Bus



**NABI Metro 45C**

Manufacturer: NABI-North American Bus Industries  
Model: Metro 45 C  
Application: Transit Bus



**Gillig BRT and Low Floor**

Manufacturer: Gillig  
Model: BRT and Low Floor  
Application: Transit Bus



**New Flyer Advanced Style BRT**

Manufacturer: New Flyer of America

Model: DE60LFA

Application: Transit Bus



**New Flyer Restyled**

Manufacturer: New Flyer of America

Model: Restyled D35LFR

Application: Transit Bus



**New Flyer Xcelsior Bus**

Manufacturer: New Flyer of America

Model: Xcelsior

Application: Transit Bus



**Street Sweeper**

**Elgin Pelican**

Manufacturer: Elgin

Model: Pelican CNG/ LNG

Application: Sweeper



**Elgin Eagle**

Manufacturer: Elgin

Model: Eagle CNG

Application: Sweeper



**Elgin Alternative Fuel Broom Bear**

Manufacturer: Elgin

Model: Broom Bear

Application: Sweeper



**Elgin Alternative Fuel Crosswind**

Manufacturer: Elgin

Model: Crosswind J

Application: Sweeper



**TYMCO Alternative Fuel Sweeper**

Manufacturer: TYMCO

Model: 600 CNG

Application: Sweeper



**Schwarze Mechanical Street Sweepers**

Manufacturer: Schwarze

Model: M6000SE CNG

Application: Sweeper



**Allianz-Johnston Street Sweepers**

Manufacturer: Allianz-Johnston

Model: 4000 Heavy Duty CNG Sweeper

Application: Sweeper



**Refuse Trucks**

**American LaFrance**

Manufacturer: American LaFrance

Model: Condor

Application: Refuse truck



**Peterbilt**

Manufacturer: Peterbilt CNG

Model: 320

Application: Refuse truck



**Crane Carrier**

Manufacturer: Crane Carrier- LNG or CNG

Model: LET

Application: Refuse Truck

**MACK Terra Pro Cabover**

Manufacturer: MACK - LNG or CNG

Model: Terra Pro Cabover

Application: Refuse Truck

**Autocar Xpeditor**

Manufacturer: Autocar

Model: Xpeditor

Application: Refuse truck

**Miscellaneous Trucks**

**Capacity TJ9000**

Manufacturer: Capacity

Model: TJ9000

Application: Terminal Tractor, Yard Tractor



**Autocar**

Manufacturer: Autocar

Model: Xspotter

Application: Terminal Tractor, Yard Tractor



**Isuzu**

Manufacturer: Isuzu

Model: NPR

Application: Utility Truck

Upfitter: Baytech Corporation



**Freightliner Custom Chassis**

Manufacturer: Freightliner

Model: Custom Chassis

Application: Step Van, Delivery



**Peterbilt 365**

Manufacturer: Peterbilt LNG

Model: 365 NG

Application: Cement Truck

**Peterbilt 384**

Manufacturer: Peterbilt LNG

Model: 384

Application: Tractor, Heavy-Duty Trucking

**Peterbilt 384**

Manufacturer: Peterbilt LNG or CNG

Model: 384

Application: Heavy Duty Truck

**Freightliner Business Class M2 112**

Manufacturer: Freightliner LNG

Model: M2 112

Application: Construction Truck



**NGV ROADMAP FOR PENNSYLVANIA JOBS,  
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# **Appendix C**

**Pennsylvania Natural Gas E&P Companies**



### Appendix C Pennsylvania Natural Gas E&P Companies

Pennsylvania Gas Companies	Description	Notes	Website
Anadarko Petroleum Company	Exploration and Production	Anadarko has been working to safely produce natural gas from tight sands since the early 1980s, and in recent years, the company has become a leading producer in shale plays in Pennsylvania, Texas and Louisiana. To produce natural gas from tight sands and shales requires the application of fracture-stimulation technology. Anadarko continuously strives to enhance and improve its drilling and completion techniques to increase well productivity, reduce cost and protect the environment.	<a href="http://www.anadarko.com/Home/Pages/Home.aspx">http://www.anadarko.com/Home/Pages/Home.aspx</a>
Antero Resources Appalachian	Exploration and Production	Antero Resources is an independent exploration and production (E&P) company engaged in the acquisition, development, and production of unconventional natural gas resources in the United States.	<a href="http://www.anteroresources.com/wp-content/uploads/2009/10/Antero-Brochure.pdf">http://www.anteroresources.com/wp-content/uploads/2009/10/Antero-Brochure.pdf</a>
Ardent Resources, Inc.	Exploration and Production, Development and Sale	Ardent Resources is a privately held, independent oil and gas company headquartered in Pittsburgh, Pennsylvania. Ardent was incorporated in 1988 and for the past 20 years has been engaged in the exploration, development, production and sale of oil and gas, primarily in the Appalachian Basin. Core areas of operation include Pennsylvania, New York, West Virginia and Ohio.	<a href="http://www.ardentresources.com">www.ardentresources.com</a>
Atlas Energy Resources, LLC	Drilling, Operating wells	Atlas Resources, LLC, the managing general partner of the natural gas drilling partnership programs, and its affiliates, operate more than 10,000 natural gas wells located in Ohio, Pennsylvania, New York, Michigan, Indiana, Tennessee and Colorado.	<a href="http://www.atlasenergyresources.com/ngdp/overview.aspx">http://www.atlasenergyresources.com/ngdp/overview.aspx</a>
Cabot Oil & Gas	Drilling	Cabot Oil & Gas Corporation is focused on developing low risk, repeatable drilling opportunities across North America. As of December 31, 2009 the Company had approximately 2,060 Bcfe of total proved reserves, including substantial shale holdings and conventional horizons. Cabot's activity focuses on the Marcellus shale in northeast Pennsylvania and on multiple plays including the Haynesville and Eagle Ford shales in Texas.	<a href="http://www.cabotog.com/ops_north.html">http://www.cabotog.com/ops_north.html</a>
Chesapeake Appalachia, LLC	Exploration and Production	Headquartered in Oklahoma City, the company's operations are focused on discovering and developing unconventional natural gas and oil fields onshore in the U.S. Chesapeake owns leading positions in the Barnett, Fayetteville, Haynesville, Marcellus and Bossier natural gas shale plays and in the Eagle Ford, Granite Wash, Niobrara and various other unconventional liquids-rich plays. The company has also vertically integrated its operations and owns substantial midstream, compression, drilling and oilfield service assets.	<a href="http://www.chk.com/About/Pages/Default.aspx">http://www.chk.com/About/Pages/Default.aspx</a>
Chief Oil & Gas	Exploration and Production	Chief Oil & Gas is a privately held, independent oil & gas company that has been drilling and producing clean natural gas for more than a decade. Chief is proud of our environmental record as well as the way in which we have efficiently and responsibly protected water and natural resources. Founded in 1994, Chief is engaged in the exploration, development and production of oil and natural gas reserves in several fields in the Appalachian Basin, northern Texas, and Central Utah.	<a href="http://www.chiefog.com/">http://www.chiefog.com/</a>

Citrus Energy Corporation	Exploration and Production	Pennsylvania. Citrus Energy Corporation is conducting a leasing program in the Marcellus Shale in Pennsylvania. As of July 2009 Citrus Energy has leased over 40,000 acres in Pennsylvania. Citrus Energy's primary positions are located in Armstrong, Clarion, Northern Columbia, and Wyoming counties. The acreage blocks are strategically located on or near pipeline infrastructure and have been high graded with seismic data. Based on current data, over 90% of the acreage is geologically drillable. Additionally, Citrus Energy has secured water permits for drilling wells, completing wells, and water disposal sites. Citrus Energy has plans to drill 5 wells in 2009.	<a href="http://www.citrusenergy.com/">http://www.citrusenergy.com/</a>
CNX Gas Corporation, LLC	Exploration and Production	In 2005, CONSOL established CNX Gas Corporation, a business that has expanded to become one of the largest independent natural gas exploration, development, production and gathering companies in the country.	<a href="http://www.consolenergy.com/Business/CNXGas.aspx">http://www.consolenergy.com/Business/CNXGas.aspx</a>
Columbia Gas of Pennsylvania, Inc.	Distribution	Columbia Gas of Pennsylvania, with local headquarters in Canonsburg, Pa., is one of the 10 energy distribution companies of NiSource Inc. (NYSE: NI). NiSource distribution companies serve 3.8 million natural gas and electric customers primarily in nine states.	<a href="http://www.columbiagaspa.com/en/home.aspx">http://www.columbiagaspa.com/en/home.aspx</a>
Dominion Exploration & Production Inc.	Distribution	Dominion is one of the nation's largest producers and transporters of energy, with a portfolio of more than 27,600 megawatts of generation, 12,000 miles of natural gas transmission, gathering and storage pipeline and 6,000 miles of electric transmission lines. Dominion operates the nation's largest natural gas storage system with 942 billion cubic feet of storage capacity and serves retail energy customers in 13 states. Corporate headquarters are in Richmond, Va.	<a href="http://www.dom.com/about/index.jsp">http://www.dom.com/about/index.jsp</a>
EOG Resources	Exploration and Production	EOG Resources, Inc. is one of the largest independent (non-integrated) oil and natural gas companies in the United States with proved reserves in the United States, Canada, Trinidad, the United Kingdom and China.	<a href="http://www.eogresources.com/operations/division_operations.html">http://www.eogresources.com/operations/division_operations.html</a>
Equitable Production, LLC	Distribution	Equitable Gas Company provides natural gas distribution services to over 252,000 homes in 10 counties in southwestern Pennsylvania and 14 counties in northern West Virginia.	<a href="http://www.equitablegas.com/">http://www.equitablegas.com/</a>
EXCO Resources Inc.	Exploration and Production	A natural gas and oil company engaged in the exploration, exploitation, development and production of onshore natural gas and oil properties.	<a href="http://www.excoresources.com/">http://www.excoresources.com/</a>
Exelon Corporation (PECO Gas)	Distribution	PECO, an energy delivery subsidiary of Exelon Corporation, is headquartered in Philadelphia. PECO is the largest electric and natural gas utility in Pennsylvania, serving approximately 1.6 million electric customers and 490,000 natural gas customers in southeastern Pennsylvania.	<a href="http://www.exeloncorp.com/energy/delivery/peco.aspx">http://www.exeloncorp.com/energy/delivery/peco.aspx</a>
GFI Oil and Gas, Inc.	Exploration and Production	GFI Oil & Gas is a Pennsylvania based company, whose focus is the development and exploration of natural gas.	<a href="http://www.gfiog.com/about.php">http://www.gfiog.com/about.php</a>
J-W Operating Company	Exploration and Production	J-W Energy Company is an Energy Development and Energy Services company that specializes in natural gas compression, gathering, exploration and production, well servicing and gas measurement.	<a href="http://www.jwenergy.com/home/">http://www.jwenergy.com/home/</a>
National Fuel Gas Distribution Corporation	Distribution & Exploration and Production	National Fuel Gas Distribution Corporation sells or transports natural gas to over 732,000 customers through a local distribution system located in western New York and northwestern Pennsylvania. National Fuel Gas Supply Corporation provides interstate natural gas transmission and storage for affiliated and nonaffiliated companies through an integrated gas pipeline system that extends 2,972 miles from southwestern Pennsylvania to the New York-Canadian border at the Niagara River.	<a href="http://www.natfuel.com/AboutUs.aspx">http://www.natfuel.com/AboutUs.aspx</a>
Pennsylvania General Energy Company, LLC	Exploration and Production	PGE is a Warren, Pennsylvania-based company that has been quietly and successfully producing oil and natural gas for over 30 years. PGE currently operates more than 1,100 oil and natural gas wells. Our company has become a leading energy production company in the Appalachian Basin.	<a href="http://www.penngeneralenergy.com/">http://www.penngeneralenergy.com/</a>

Penn Virginia Oil & Gas Corp.	Exploration and Production	Penn Virginia Corporation ("Penn Virginia," the "Company," "we," "us" or "our") is an independent oil and gas company engaged primarily in the development, exploration and production of natural gas and oil in various domestic onshore regions including Oklahoma, Texas, the Appalachian Basin and Mississippi.	<a href="http://www.penngeneralenergy.com/">http://www.penngeneralenergy.com/</a>
Peoples Natural Gas Company LLC	Distribution	Peoples Natural Gas — formerly Dominion Peoples — provides service to more than 359,000 residential, commercial and industrial customers throughout 16 counties in Western Pennsylvania. Our service territory ranges from as far north as Grove City, to the east as Johnstown and Altoona, to the south as Greene County, and west to the border of Pennsylvania and Ohio.	<a href="http://peoples-gas.com/Home.aspx">http://peoples-gas.com/Home.aspx</a>
Philadelphia Gas Works	Distribution	The PGW is owned by the City of Philadelphia and is the largest municipally owned gas utility in the country. It manages a distribution system of approximately 6,000 miles of gas mains and service pipes supplying approximately 500,000 customers.	<a href="https://www.pgworks.com/index.aspx">https://www.pgworks.com/index.aspx</a>
Phillips Production Company	Exploration and Production	Phillips Resources, Inc. (Phillips) is an independent natural gas exploration and production company with approximately 250,000 net acres of land holdings. Phillips owns or operates more than 4,000 producing natural gas wells in Pennsylvania and is actively exploring drilling opportunities in both shallow conventional formations as well as the more prolific Marcellus Shale formation in Pennsylvania. To date, Phillips has operated or participated in the drilling of more than 50 Marcellus Shale wells (both vertical & horizontal).	<a href="http://www.phillipsres.com/">http://www.phillipsres.com/</a>
Range Resources Appalachia LLC	Exploration and Production	Range Resources Corporation is among the leading independent natural gas companies operating in the United States through subsidiaries in both the Southwestern and Appalachian regions of the country.	<a href="http://www.rangeresources.com/Our-Company.aspx">http://www.rangeresources.com/Our-Company.aspx</a>
Rex Energy Corporation	Exploration and Production	Rex Energy Corporation is an independent energy company engaged in the acquisition, production, exploration and development of oil and gas, with properties concentrated in the Appalachian Region, Illinois Region and Rockies Region.	<a href="http://www.rexenergy.com/">http://www.rexenergy.com/</a>
Rice Energy, LLC	Exploration and Production	Today, Rice Energy is actively involved in the unconventional resource plays of the Marcellus Shale in Pennsylvania and Spraberry Trend in West Texas.	<a href="http://www.riceenergyllc.com/company.html">http://www.riceenergyllc.com/company.html</a>
Snyder Brothers Inc.	Exploration and Production	Snyder Brothers Inc. is one of the largest, privately-funded, independent producers of natural gas in Pennsylvania. We have been drilling natural gas and oil wells since the mid 1970's and currently drill more than 150 wells per year. Snyder Brothers produces in excess of 30,000 mcf per day in Armstrong, Indiana, Clarion, Warren, Jefferson, Fayette, Westmoreland, McKean, and Clearfield Counties.	<a href="http://www.snyderbrothersinc.com/">http://www.snyderbrothersinc.com/</a>
Stone Energy	Exploration and Production	Stone Energy Corporation is an independent oil and natural gas exploration and production company headquartered in Lafayette, Louisiana, with additional offices in New Orleans, Louisiana, Houston, Texas and Morgantown, West Virginia.	<a href="http://www.stoneenergy.com/links/corporateProfile.aspx?hid=1">http://www.stoneenergy.com/links/corporateProfile.aspx?hid=1</a>
T.W. Gas & Oil Company	Distribution	T.W. Phillips Gas and Oil Co. ("T.W. Phillips") sells natural gas to over 60,000 customers in western Pennsylvania and has been in business since 1896.	<a href="http://www.twphillips.com/">http://www.twphillips.com/</a>
UGI Utilities Inc.	Distribution	UGI Utilities, Inc. is a natural gas and electric utility headquartered in Reading, Pennsylvania.	<a href="http://www.ugi.com/portal/page/portal/UGI/About%20Us">http://www.ugi.com/portal/page/portal/UGI/About Us</a>
Valley Energy	Distribution	Valley Energy is a natural gas distribution company located in Sayre, Pennsylvania.	<a href="http://www.valley-energy.com/">http://www.valley-energy.com/</a>

[http://www.puc.state.pa.us/naturalgas/naturalgas\\_companies.aspx](http://www.puc.state.pa.us/naturalgas/naturalgas_companies.aspx)  
<http://extension.psu.edu/naturalgas/service-directory/energy-companies>

**NGV ROADMAP FOR PENNSYLVANIA JOBS,  
ENERGY INDEPENDENCE, AND CLEAN AIR**

# **Appendix D**

## **Emissions Benefit Calculation**

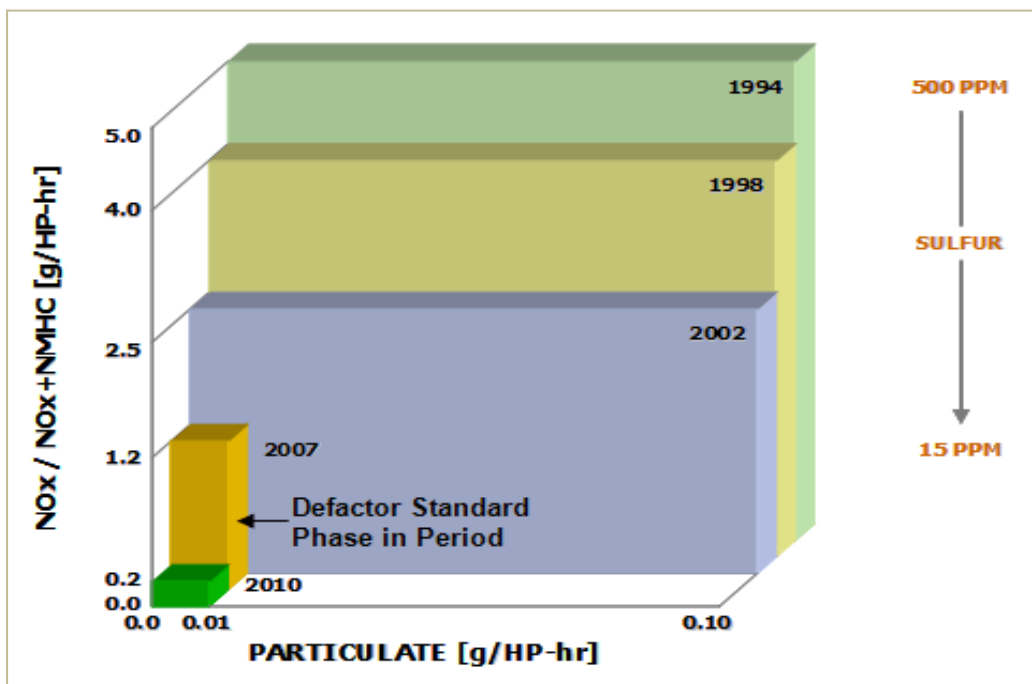


## Appendix D

### Emissions Benefit Calculation

The figures for emissions benefits were calculated by assuming that a new natural gas truck with an engine certified to the U.S. EPA 2010 heavy duty engine emission standards will replace a 5- to 7-year old diesel truck powered by a Model Year 2003 or 2005 engine meeting the U.S. EPA emission standards in place at that time. As the EPA's emission standards in place at that time were much higher than they are today, the above NOx and PM emission benefits can be claimed. However, it is important to point out that today's diesel engines are certified to the same EPA 2010 emission standards as available natural gas engines (0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM). As most diesel engines on the market today are still using emission credits under EPA's Averaging, Banking and Trading (ABT) Program, the actual engine-out emissions from diesel engines are slightly higher than the actual 2010 emission standard. Natural gas engines, on the other hand, are not only meeting the actual 2010 standards; they average 20 percent below the standard, with the most popular natural gas heavy-duty engines calculating to be as much as 50 percent below the 2010 NOx standard. While the incremental emissions from diesel engines using ABT credits are slight, they are worth noting.

The following graphic provides a summary of the U.S. EPA on-road heavy-duty emission standards for heavy-duty engines over the last several years. As is clear from this graph, the EPA's 2010 emissions are extremely low. While some of the natural gas engine manufacturers are working to develop heavy-duty natural gas engine products with "zero regulated emissions" (i.e. the emissions are too low to be measured by conventional testing equipment), the NOx emission difference between a zero emission natural gas engine and a fully compliant 2010 diesel engine is relatively small. The fact that diesel exhaust is considered a TAC / carcinogen will always allow the argument to be made that natural gas exhaust is "better" from a PM perspective. And natural gas engines will still have a 20 to 30 percent benefit in terms of greenhouse gases compared to even today's clean diesel technologies.



U.S. EPA On-Road Heavy-Duty Emission Standards by Engine Model Year

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