# Opportunities to Use Natural Gas and Propane as a Transportation Fuel in Pennsylvania

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Prepared by

Gannett Fleming, Inc.

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Ben Franklin Technology Partners, Shale Gas Innovation & Commercialization Center

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## Summary

Natural gas and propane are increasingly gaining a foothold as alternative fuel sources for Pennsylvania's transportation sector. Across the state, transit agencies and other large fleets are converting from gasoline to natural gas or propane because of cost and environmental benefits. However, use of natural gas or propane is not limited to large fleets. Opportunities exist for small fleets or individual vehicles such as mid-size delivery vans and trucks, taxis, and high-mileage commercial vehicles. Opportunities also exist to become a station owner.

This paper was written as an educational tool for Pennsylvanians on the options for fuel conversions, refueling options, and a summary of what is available in the market. This paper covers a broad range of topics concerning natural gas and propane opportunities within the Commonwealth.

Some conclusions:

- **Market.** It is slowly growing relative to the choices for available alternative fuel vehicles being provided by the major automobile manufacturers. It is also growing slowly due to the current lower price of crude oil. The price differential of a $1.50/GGE from just over a year ago is now just about $0.86/GGE.
- **Best Niche.** CNG and propane are not just for the transit agencies. Other fleets, such as taxi cab companies, forklifts, concrete mix trucks, and school buses, can and should take advantage of the abundance of natural gas.
- **Vehicle Comparisons.** Potential owners should determine if a natural gas or propane engine is viable for the owner's specific application. Considerations include whether the vehicle will produce the torque and horsepower required for the need.
- **Conversions.** Converting a vehicle from gasoline or diesel to an alternative fuel may be a viable option. However, to ensure safety and compliance with regulatory requirements, a potential alternative fuel vehicle owner should ensure that the engine is EPA certified or compliant.
- **Fueling Station Opportunities.** CNG fueling stations can range in cost from several thousand to over a million dollars. Propane stations are generally less expensive to construct. There are a host of ownership options available to a potential station owner, but securing an anchor fleet is critical to the financial success of the station. For the homeowner, there are options for in-home refueling appliances that will allow an owner to time-fill their vehicle from the convenience of their own home.
- **Vehicle and Storage Facility Modifications.** Safety considerations will require modifications to facilities used to maintain CNG vehicles. A qualified consultant should perform a CNG Code Compliant assessment to include an Opinion of Probable Costs for the renovations. By Code, vehicle storage areas do not require any improvements.
- **Grants and Funding.** The Federal programs expired December 31, 2014. In the past, these programs have been retroactively reinstated. At the State level, DEP will not know if there will be any financial assistance available until after the FY 2015/16 budget is enacted.
- **Economics.** Extensive ROI calculators such as the AFDC CNG VICE 2.0 application are available. A potential alternative fuel vehicle owner

should consult a website like AFDC's to compare an alternative fuel vehicle to their existing fleets. Consulting engineer firms in the alternative fuels market also have their own versions of ROI calculators for fueling station construction.

- **Chicken and the Egg.** The number of CNG and propane stations is increasing monthly. The numbers need to continue to rise in order for potential alternative fuel vehicle owners to feel comfortable that they will be able to fill their vehicle without being stranded along the shoulder of the road.

In closing, it is a worthwhile exercise for any fleet owner regardless of the size of the fleet vehicles to investigate the opportunities available to convert all or a portion of their fleet to natural gas or propane. Most experts who are tracking the shale energy area believe we will see a long-term low cost availability of both natural gas and propane, especially in Pennsylvania. Of course, the price of gasoline or diesel may also remain lower than the recent high prices seen just a few years ago, as oil production also appears to benefit from the shale energy revolution. But, the spread between natural gas and propane versus gasoline and diesel still remains large enough to behoove any fleet operator, and also individuals who are high mileage drivers to study their fuel choice options.

# Opportunities to Use Natural Gas and Propane as a Transportation Fuel in Pennsylvania

# 1. Introduction

The Ben Franklin Technology Partners Central and Northern Pennsylvania (BFTP), through the Shale Gas Innovation & Commercialization Center (SGICC), contracted with Gannett Fleming to prepare a White Paper addressing the opportunity to use natural gas and propane as a transportation fuel in Pennsylvania. This study is funded by a grant from the PA Department of Community and Economic Development provided to the SGICC. This paper focuses on the opportunities other than the conversion of major fleet vehicles, such as large long haul trucking fleets and/or transit bus fleets. The intent of the white paper is to address niche opportunities such as mid-size delivery vans and trucks, taxis, car fleets, high mileage commercial vehicles such as pickup trucks, etc.

The goal of this paper is to educate Pennsylvania stakeholders and enable them to either purchase or sell services related to the use of natural gas or propane to power vehicles beyond a large fleet use. This paper includes discussions on the following topics and is supplemented by several documents prepared by the BFTP:

- Approved/available natural gas or propane-powered vehicles and engine systems and conversion kits/systems
- Estimated full conversion costs
- Available refueling systems with an emphasis on smaller scale systems
- Estimated cost of refueling systems
- Best niche conversion opportunities
- Vehicle storage and maintenance issues
- Bottlenecks regarding what has slowed the switch to natural gas or propane vehicles
- General economics regarding conversion costs and associated savings both a vehicle and refueling perspective
- Summary of state and federal grant funding opportunities and available tax incentives.

# 2. Market

## 2.1. Natural Gas

Natural gas is an increasingly popular vehicle fuel, currently powering about 150,000 vehicles in the United States (US) and roughly 15.2 million worldwide. According to the Pennsylvania Department of Transportation's (PennDOT) Vehicle Registrations report, the number of natural gas vehicles, excluding mass transit, increased from 289 in 2013 to 460 in 2015. Compressed natural gas (CNG) is typically used for high mileage, centrally fueled fleets that operate within a limited area, while liquefied natural gas (LNG) is a good choice for vehicles needing to travel long distances. A wide variety of new, heavy-duty natural gas vehicles are available from original equipment manufacturers (OEMs), such as Ford, GMC, Honda, and Dodge. Although the number of available light-duty natural gas vehicles from OEMs is limited, the choices are steadily growing. Fleet operators and individual consumers also have the option of reliably converting existing gasoline or diesel vehicles for natural gas operation using qualified systems retrofitters (www.afdc.energy.gov).

## 2.2. Propane

Propane, also known as liquefied petroleum gas (LPG) or propane auto gas, is the world's third most common transportation fuel (after gasoline and diesel), with almost 17 million vehicles in service (www.ok.gov). PennDOT reports 380 registered vehicles in Pennsylvania in 2014. Although propane has not enjoyed as much recent publicity as natural gas, it, too, is an increasingly popular fuel alternative in the United States, with the availability of new light- and medium-duty propane vehicles having surged in recent years. There are currently more than 143,000 on-road propane vehicles in the US, used in fleet applications such as school buses, shuttle vans and police vehicles (www.afdc.energy.gov). In addition, propane-fueled forklifts are common in indoor and outdoor applications throughout the US (www.diffen.com).

## 2.3. Natural Gas vs. Propane

The choice of natural gas over propane or vice versa is dependent on many factors, including the availability of local fueling stations. The fact sheets located in Appendices A and B provide additional information that may be considered when deciding between propane and CNG.

## 2.4. Best Niche Opportunities and Traditional Applications

Multiple applications of natural gas or propane fuel are available for small- to mid-sized fleet owners. Figure 1 presents the most popular applications as published by US Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), n.d.

### Heavy-Duty Vehicle Application Overview

The following list provides an overview of popular alternative fuel and advanced vehicle options for several common applications:

| | |
|---|---|
| **School Bus** | Compressed natural gas (CNG) and propane (also known as liquefied petroleum gas, or LPG) are popular alternatives to gasoline and diesel fuel for school buses. Hybrid electric buses and plug-in hybrid electric buses are also available. |
| **Shuttle Bus** | CNG, propane, hybrid electrics, and fuel cells are potential options for shuttle buses and large passenger vehicles that provide transportation on standard routes. |
| **Transit Bus** | Hybrid transit buses, along with those powered by CNG or liquefied natural gas (LNG), are available. Fuel cell demonstrations are also in progress. |
| **Refuse Truck** | Many fleets have refuse trucks with CNG engines, and they can even run on landfill gas where biomethane processing facilities are in operation. Regular routes and stop-and-go operation make refuse haulers a good application for hybrid operation as well. Hydraulic hybrid systems are well suited to refuse service. |
| **Tractor** | Diesel electric hybrids offer fuel-saving hybrid operation with the convenient availability of diesel. CNG and LNG systems are also attractive options. |
| **Van** | Step vans that service a set route, such as a package delivery service, may find all-electric battery operation an effective alternative to conventional vans. CNG and propane operation are also popular alternatives. |
| **Vocational Truck** | CNG, LNG, propane, all-electric, and hybrid vehicles operate in a variety of roles, from beverage delivery to utility boom trucks, paint striping trucks, and merchandise delivery. |

**Figure 1.**

# Opportunities to Use Natural Gas and Propane as a Transportation Fuel in Pennsylvania

Natural gas or propane use benefits can be seen across multiple industries. Schwan's Home Service operates 3,300 propane delivery trucks nationwide as part of its home-delivery service. A portion of the company's success is a result of eliminating price risk via fuel cost hedging, a practice that allows the company to lock in propane prices for months at a time. This has resulted in an estimated annual savings of $30 million (www.afdc.energy.gov). A more detailed economics discussion is presented later in this paper.


**Concrete mixer fills up at the public CNG fueling station at River Valley Transit, Williamsport, PA.**

**Street sweepers can consume 20-25 gal/day of CNG.**

**RVT is in the process of replacing its bus fleet with buses fueled by CNG.**


**Ford Transit Minivan replacing traditional taxicabs.**

**Figure 2.**

Some of the best niche opportunities include high fuel use vehicles that originate and conclude their daily activities from the same location. River Valley Transit (RVT) in Williamsport, PA is replacing buses as they reach the end of their service life and currently has four CNG buses out of a fleet of 35 total buses. The Centre Area Transportation Authority (CATA) in State College has been operating its entire bus fleet on CNG since 2005. Additional examples, with their corresponding estimated annual consumption rates, are as follows:

- Freight truck – 16-20K Gas Gallon Equivalent (GGE)
- Transit buses – 12.5-15K GGE
- Refuse trucks – 7.5-10K GGE
- Municipal sweeper – 5-6K GGE
- Airport shuttle service – 5.5-7.5K GGE
- Food and beverage, textile services, household goods – 3-5K GGE
- Taxi – 4.5-5.5K GGE
- School Bus – 2-3K GGE
- Concrete Mix Trucks
- Courier sedan, newspaper van, utility/telecom van, PW pick-ups, E&P LDVs – 1.2-1.5K GGE (www1.eere.energy.gov).

# 3. Vehicle Comparisons

## 3.1. Natural Gas or Propane vs. Gasoline or Diesel

Drivers should recognize that there are differences between traditional gasoline or diesel vehicles and an alternative fuel vehicle. Natural gas burns cleaner than gasoline or diesel, but it also burns hotter. An engine that is hardened at the factory can withstand these higher temperatures better than gasoline or diesel engines that are converted. In terms of fuel economy, natural gas is similar to diesel. As stated earlier, natural gas burns cleaner, which may result in fewer oil changes. One drawback to natural gas is that the energy value is not as good as diesel. A diesel engine may be able to produce more torque and horsepower than a CNG engine of similar size.

### Performance

*Natural gas.* The horsepower, acceleration, and cruise speed of natural gas vehicles (NGVs) are comparable with those of equivalent conventional vehicles. In heavy-duty vehicles, dual-fuel compression-ignited (diesel cycle) engines are slightly more fuel-efficient than spark-ignited dedicated natural gas engines. However, a dual-fuel engine increases the complexity of the fuel storage system by requiring storage of both types of fuel (www.afdc.energy.gov), so an analysis of fuel savings versus added cost for the conversion and tanks needs to be undertaken. Also, the performance of dual-fuel systems can vary significantly based on the terrain where the vehicles are being run, with significant variances in fuel savings noticed especially in hilly terrain.

*Propane.* A propane vehicle's power, acceleration, and cruising speed are similar to those of conventionally-fueled vehicles (www.afdc.energy.gov). Propane has a higher octane rating than gasoline (104 to 112 compared with 87 to 92 for gasoline) and potentially more horsepower, but its lower BTU rating results in lower fuel economy. However, the price per gallon can quickly offset the lower fuel economy. In addition, the higher octane prevents engine knock (www.diffen.com).

For reference, propane, vaporized and at atmospheric pressure, has a higher calorific value (94 MJ/$m^3$ or 26.1kWh/$m^3$) than natural gas (38 MJ/$m^3$ or 10.6 kWh/$m^3$) (www.diffen.com).

### Range

*Natural gas.* The driving range of NGVs is generally less than that of comparable gasoline and diesel vehicles because, with natural gas, less overall energy content can be stored in the same size tank. For instance, while Honda claimed a 220- to 250-mile range from their natural gas-powered Civic, when Consumer Reports tested a 2008 model, they were unable to get more than 130 miles before the low-fuel indicator came on (www.consumerreports.org). For larger vehicles, extra natural gas storage tanks (transit buses) or the use of LNG (over-the-road trucks) can increase the range (www.afdc.energy.gov). However, in sedans the installation of additional tanks can consume much of the available trunk space, and with pickup trucks, the tanks take up bed space.

The National Highway Traffic Safety Administration (NHTSA) FMVSS 304 requires all on-board CNG fuel systems and cylinders to be visually inspected after a motor vehicle accident or fire and at least every 36 months

or 36,000 miles, whichever comes first, for leaks, damage and deterioration. These tanks must be taken out of service at 20 years.

There are currently five types of onboard tanks. These tanks are designed for the current industry standard of 3,600 psi.

- Type I (all metal)
- Type II (metal liner, partial wrap)
- Type III (metal liner, full wrap)
- Type IV (plastic liner, full wrap)
- Type V (composite).

*Propane.* The driving range for propane vehicles is comparable to conventionally-fueled vehicles; extra tanks can increase the range, but the tank size and additional weight affect payload capacity (www.afdc.energy.gov). Propane has a lower energy density than gasoline or diesel, and hence the equivalent fuel consumption is more (www.diffen.com). In other words, since propane has a lower BTU rating than gasoline, it takes more fuel to the drive the same distance (www.afdc.energy.gov).

### Safety

*Natural gas*. Natural gas is lighter than air and disperses quickly, so risk of ignition of a leak is less than with gasoline (www.diffen.com). If fuel were to escape in a crash, it would evaporate rather than create a puddle under the vehicle. While the natural gas is escaping the storage tank, it is, however, highly volatile. Once the gas has dissipated, the fire danger is diminished. In contrast, a gasoline spill remains a danger until the pooled liquid is removed (www.consumerreports.org).

The Department of Energy states vehicles powered by natural gas are as safe as conventional gasoline or diesel vehicles, and their pressurized tanks have been designed to withstand severe impact, temperature, and environmental exposure (www.consumerreports.org).

*Propane.* Propane is stored as a liquid in a relatively low-pressure tank (about 150 psi) (www.afdc.energy.gov). Unlike gasoline and diesel fuel, if propane leaks, it does not puddle, but instead vaporizes and dissipates into the air (www.ok.gov). However, because propane is heavier than air, upon leakage, the vapors will settle to the ground and accumulate in low-lying areas (www.diffen.com). Propane has a narrow flammability range, comparable to that of gasoline and diesel fuel, and its tanks are 20 times more puncture-resistant than gasoline tanks. Propane requires a much higher temperature to ignite. For example, gasoline will catch fire at temperatures as low as $495^0$F, while propane requires a temperature of at least $920^0$F to ignite (www.ok.gov).

### Emissions

*Natural gas.* Due to increasingly stringent regulations, the gap has narrowed between natural gas vehicle tailpipe emissions benefits and conventional vehicles with modern emissions controls. Still, NGVs continue to provide emissions benefits – especially when replacing older conventional vehicles or when considering life cycle emissions (www.afdc.energy.gov). Based on the Argonne National Laboratory's model, natural gas emits approximately 6%

to 11% lower levels of greenhouse gases than gasoline throughout the fuel life-cycle. When comparing the life-cycle emissions of the two types of natural gas, CNG and LNG are nearly identical. Also, because CNG and LNG fuel systems are completely sealed, NGVs produce no evaporative emissions (www.afdc.energy.gov).

*Propane.* Compared to vehicles fueled with diesel or gasoline, propane vehicles can produce lower amounts of harmful tailpipe emissions, depending on vehicle type and drive cycle (www.afdc.energy.gov). Compared to gasoline-fueled vehicles, propane vehicles produce 12% fewer carbon dioxide emissions, 20% fewer nitrogen oxide emissions, and 60% fewer carbon monoxide emissions. Unlike gasoline-fueled vehicles, propane-fueled vehicles emit no evaporative vapors while running or parked, because propane fuel systems are tightly sealed. During refueling, very small amounts of propane may escape into the atmosphere. However, propane vapors are less reactive than gasoline vapors, so they do not generate nearly the amount of ozone that gasoline does (www.ok.gov).

#### Vehicle Maintenance

*Natural gas.* It is claimed that natural gas vehicles have lower maintenance costs when compared to other fossil fuel-powered vehicles. However, the complexities associated with the fueling system, as well as the need to compensate for the reduced lubricating properties of natural gas, may offset any other savings. On the other hand, CNG does not contaminate or dilute the crankcase oil, thus increasing the life of lubricating oil, and because neither lead nor benzene is used, lead fouling of spark plugs is eliminated. In addition, fuel systems are sealed, which prevents any spill or evaporation losses (www.diffen.com).

*Propane*. Potentially lower maintenance costs are one reason behind propane's popularity. Propane's high octane rating (104 to 112 compared with 87 to 92 for gasoline) combined with its low carbon and low oil contamination characteristics may result in longer engine life. Propane performs well in cold weather climates because the fuel's mixture (propane and air) is completely gaseous (www.afdc.energy.gov). However, propane provides less upper cylinder valve lubrication, so if a propane-fueled engine is not suitably modified, it will lead to valve wear (www.diffen.com).

### 3.2. Training

When considering use of either natural gas or propane, training is recommended for all users because of various safety concerns. Training is available for users from various industry experts.

#### *Natural Gas*

Safety is of critical importance in the operation of natural gas vehicles, due especially to the high storage tank pressures and the volatility of the fuel if trapped indoors due to an unplanned discharge. Consequently, operators of NGVs should ensure that their personnel are fully trained in the operation and maintenance of CNG fuel system components, as well as tank inspections. Because NVGs are not currently in wide use, technical training may not be readily available on a local basis. However, entities such as the Natural Gas Vehicle Institute (NGVi) provide a variety of training courses at locations nationwide (www.ngvi.com). Also, because CNG is delivered at

high pressure, a brief training session is recommended for individuals who will be fueling CNG vehicles.

*Propane*

Even though propane is not stored at the same high pressures as natural gas, the operation of propane vehicles demands the utmost attention to safety, and even experienced vehicle technicians need proper training before they can safely work on them. Although technician training may not be readily available locally, a number of organizations [ACME Alternate Fuel Systems (www.acmecarb.com), Roush CleanTech (www.roushcleantech.com), etc.] provide training nationwide. As for fueling, propane is delivered under pressure, which makes the process slightly more complicated than with gasoline. However, many individuals already have experience with propane appliances, so fueling training requirements are likely to be minimal.

## 3.3. OEM vs. Converted Vehicles

There are two primary options when considering the purchase of alternative fueled vehicles. The first option is to purchase the vehicle from an OEM. OEMs have US Environmental Protection Agency (EPA) certified clean alternative fuel conversion system manufacturers that work directly with them during production.

Figure 3 presents currently available new vehicles with their starting manufacturer's suggested retail prices (MSRPs).

**Figure 3.**

| Vehicle Make and Model | Starting MSRP for CNG Fuel | Starting MSRP for Propane Fuel* | Starting MSRP for Gasoline Fuel |
|---|---|---|---|
| Honda Civic | $26,640* (production to be halted) | | |
| Chevrolet Silverado 2500/3500HD | $42,130/ $44,425 (Bi-fuel) | -- | $32,630/ $34,925 |
| Chevrolet Express 2500/3500 | $40,380 | -- | $29,555 |
| Chevrolet Express Cutaway | $42,195 | -- | $31,370 |
| Chevrolet Impala | $38,210* (delayed until 2017) | -- | $27,060 |
| Ford Super Duty F-250 | $31,045* | $31,045 | $32,385 |
| Ford Super Duty F-350/450/550 | $31,400* | $31,400 | $33,280 |
| Ford Super Duty F-650 | $55,595* | $55,595 | $55,595 |
| Ford Transit Connect | $22,000* | $22,000 | $22,330 |
| Ford Transit 150/250/350 | $29,556* | $29,556 | $29,375 |

| Vehicle Make and Model | Starting MSRP for CNG Fuel | Starting MSRP for Propane Fuel* | Starting MSRP for Gasoline Fuel |
|---|---|---|---|
| Ford E-350/450 (producing only cutaways after 2014) | -- | -- | |
| Ram 2500 | $51,165 | -- | $30,685 |
| GMC Savana 2500/3500 | $41,375 | -- | $30,550 |
| GMC Savana Cutaway 3500/4500 | $39,575/ $41,870 | -- | $28,750/ $31,045 |
| GMC Sierra 2500/3500HD | -- | -- | $33,195/ $34,295 |

*From Clean Cities 2015 Vehicle Buyer's Guide (Appendix C).

Other currently available natural gas vehicles include:

- Ford F-150
- Ford Transit
- Chevrolet Equinox
- Chevrolet Trax
- Chevrolet Tahoe
- Chevrolet Cruz
- Ford Explorer
- Lincoln MKS, MKX, MKT
- Nissan NV1500
- Buick Regal
- Buick Verano.

The BFTP also prepared a comprehensive document regarding the current NGV purchasing opportunities with Pennsylvania vehicle dealerships. This document can be found in Appendix D.

The Clean Cities Guide to Alternative Fuel and Advanced Medium- and Heavy-Duty Vehicles is also an excellent guide and can be found in Appendix E.

The second option is to convert an existing conventional vehicle to natural gas or propane. Some of the major conversion manufacturers in the US include:

- IMPCO
- Landi Renzo USA
- Altech-Eco
- BAF Technologies
- NatGasCar
- Powerfuel CNG Conversion Systems
- Icom North America
- American Alternative Fuel
- Blossman Services
- Roush Industries.

The cost of conversion is going to vary greatly depending on how a vehicle is used. The cost of the largest, lightest tank available is going to be significantly higher than a smaller, full metal tank. Clean Energy, an NGV fueling station vendor, and BAF Technologies provided the following general conversion cost ranges.

- Sedans: $7,000-$10,000
- Small Vans (Transit Connect): $9,000-$11,000
- Pickups: F250/350 series: $13,000-$14,000
- Pickups: F450/550/650: $23,000-$25,000
- Dump Trucks: $30,000-$50,000.

The difference in pricing is mainly the type of CNG tanks (the lightest are the most expensive) and the number/volume of the tanks.

Typically sedans normally carry 8 to 10 GGE tanks, small vans can carry a 12 to 18 GGE tank, small pickups can carry a 18 to 21 GGE tank, and dump trucks can carry a 60-80 GGE tank.

### 3.4. EPA Certification/Compliance

Engines must meet EPA requirements. It is highly recommended that a licensed technician/conversion partner associated with that manufacturer perform the installation. Not all vehicles are candidates for conversion. There are age and mileage requirements, and a certified conversion system may not be available for a specific vehicle. It is not advisable to purchase a universal kit from the internet, as it is difficult to know where the kit originated from or if it is certified. The BFTP also prepared a document summarizing the EPA requirements. This document can be found in Appendix F. When searching the EPA website, there are links to Excel spreadsheets for the most current EPA certified and compliant engines for the three categories described below.

From the AFDC website concerning EPA categories of vehicles, all manufacturers must prove that a given vehicle or engine conversion complies with EPA regulations. Required demonstration and notification procedures differ according to the age of the converted vehicle or engine.

The BFTP also prepared a list of certified conversion providers that are available in Pennsylvania. This document can be found in Appendix G.

#### New and Relatively New Vehicles and Engines

This category includes conversions that take place within one calendar year following the original model year of the vehicle or engine. Vehicles and engines in this category need a certificate to qualify for an exemption from EPA's tampering prohibition. Manufacturers must submit applications to EPA, including test data, certification fees, and other information. EPA then issues a certificate to verify that the appropriate regulations and requirements have been met. Certificate documentation indicates the following:

- The original test group, as determined and provided by the manufacturer
- The evaporative emissions family
- The state(s) in which the test group is certified
- The "car line," which includes the model and engine size
- The model year of the vehicles included in the test group

- The emissions standards met.

A certificate is valid through December 31 of the specified certification year (referred to as the Model Year at the top of the certificate). Certificates can be renewed, and when they do expire, tampering exemptions remain in place as long as the conditions under which a certificate was issued do not change.

### Intermediate Age Vehicles and Engines

This category includes conversions of vehicles or engines that are no longer "new or relatively new" but still fall within EPA's definition of full useful life. Manufacturers of conversion systems designed for vehicles and engines within this category must demonstrate that the conversion meets emissions standards. EPA does not issue certificates for this category but will list the conversion systems online. Annual renewal is not required to maintain a tampering exemption, as long as the conditions under which the exemption was granted do not change.

### Vehicles and Engines Outside their Full Useful Life

This category includes conversions of vehicles or engines that are outside EPA's definition of useful life. Manufacturers must submit information showing the system is technically sound. As with the intermediate age category, EPA does not issue certificates but will publicly list the conversion systems as having satisfied the requirements. Annual renewal is not required to maintain a tampering exemption, as long as the conditions under which the exemption was granted do not change.

If certification or a tampering exemption has not been issued for a vehicle or engine, a manufacturer may consider completing the certification process for that vehicle or engine. Manufacturers will usually provide cost estimates for converting a vehicle or fleet. See the Federal and State Incentives and Laws section to find incentives and other programs that could help offset conversion costs. Select Conversion Companies in the related links search to identify companies that manufacture or perform conversions.

## 4. CNG Engines

There are three types of CNG engines.

- The **dedicated CNG conversion** runs strictly on natural gas.
- The **dual-fuel CNG conversion** burns CNG simultaneously with the primary engine fuel.
  - All diesel conversions are either dual-fuel or dedicated.
  - There are very few gasoline dual-fuel systems available.
- The **bi-fuel CNG conversion** burns 100% natural gas and has the ability to switch back to 100% gasoline.
  - There are zero bi-fuel CNG systems available for diesel engines.
  - Every bi-fuel CNG conversion system is designed for gasoline engines.

The availability of these engines is growing as OEMs are producing more NGVs that are available to the public.

Regarding available CNG engines, Cummins Westport produces the ISX12 G (11.9L) CNG or LNG engine, the ISL G (8.9L CNG or LNG) engine, and most recently announced the ISB6.7 G (6.7L dedicated CNG) engine.

Ford is offering a CNG/Propane prep package for their 2016 model F150. They estimate the upfit charge for this package is between $7,500 to $9,500.

With respect to maintenance of an NGV, Appendix H shows the current list of Certified NGV Maintenance Personnel in Pennsylvania. This spreadsheet was developed by the BFTP.

In an interview with James O'Donnell, Co-founder of Alternative Fuel Solutions of Pennsylvania, he does not recommend converting the following applications:

- Full size school/city buses
- Refuse trucks
- EMS vehicles.

He does recommend these vehicles should be bought new and be dedicated CNG engines.

## 5. Refueling

### 5.1. Propane

Thousands of liquefied petroleum gas (propone) fueling stations are available throughout the US. Because the infrastructure needed for propane is very similar to gasoline and diesel, fuel providers and fleets can place propane dispensers alongside gasoline, diesel, or other alternative fuels. Since propane is typically delivered by truck, no pipeline to the dispensing site is needed, although on-site storage, typically above ground, is required (www.afdc.energy.gov).

### 5.2. Natural Gas

The availability of natural gas (CNG or LNG) for vehicle use is limited at the present time. Although the US has an extensive natural gas distribution system in place, vehicle fueling infrastructure is quite limited, and of the existing refueling stations, many are operated by fleets and not open to the public (www.consumerreports.org). According to the AFDC, there are currently 1,565 CNG and 3,113 propane fueling stations in the US and 56 CNG and 80 propane fueling stations in Pennsylvania. Therefore, fleet owners considering converting to natural gas may find that they will need to install their own fueling facilities, which can be costly (www.afdc.energy.gov).

There are three types of commercial CNG fueling stations available with hybrids of each. When designing a fuel station, one must design for the end state. In other words, what is the long term plan for the fleet? Initially the fleet may be small, but in 10 years, the balance of the fleet may become NGVs, which suggests that it would be prudent to design the fueling strategy for that number 10 years in the future. However, one does not need to purchase/install everything now; just plan for it. For example, the future design may call for three compressors but the current design only calls for two. Install the piping and concrete pad for the third compressor but delay the compressor purchase. Appendix I is a document prepared by BFTP showing some of the engineering firms, vendors, and construction companies that can either design, build, operate, and/or maintain CNG fueling stations. It is not all inclusive.

The following is a discussion of each type of fueling station.

The most common type of CNG fueling station is a cascade fast-fill station. In this arrangement, vehicles are fueled in roughly the same amount of time as if they were fueling at a local gasoline station. Figure 4 represents a typical arrangement for the cascade CNG fueling station. These stations can range in cost from $500,000 to more than $2 million depending on natural gas availability, 3-phase power availability, backup power considerations, and natural gas usage. Siting a CNG fueling station near a natural gas line with relatively high pressure will help reduce the size and/or number of required compressor(s) and the amount of required storage vessels. Also directly tied to the size and number of compressors and storage vessels required is the client's required fill rate (GGE/min) for their fleet. Some clients want to fill their CNG vehicles in the same amount of time as it takes to fill their existing gasoline or diesel vehicles. Daily fuel consumption is measured in gasoline gallon equivalents (GGE) or diesel gallon equivalents (DGE) and is another important factor a designer must consider in properly sizing a station. There is no cookie cutter solution for a CNG fueling station.

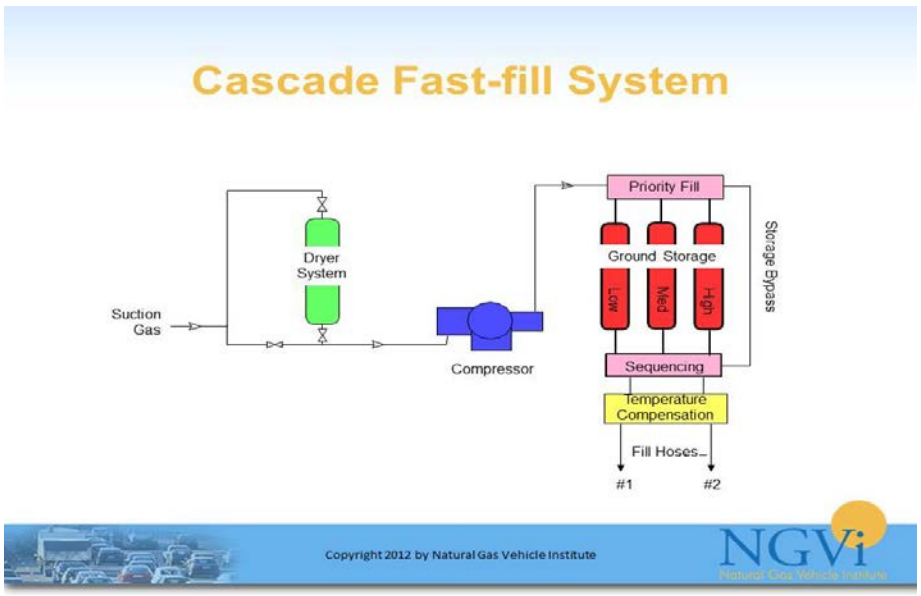



**Figure 4: Cascade Fast-Fill.**
*Source: NGVi CNG Fueling Station Design Training Manual with permission granted for use by Leo Thomason.*

The next type of station is a buffered fast-fill CNG fueling station. This type of station is ideal for a fleet owner that fills vehicles consecutively until they are all full. There is not as much CNG storage required as the compressors fill the vehicles directly. Figure 5 depicts this arrangement.

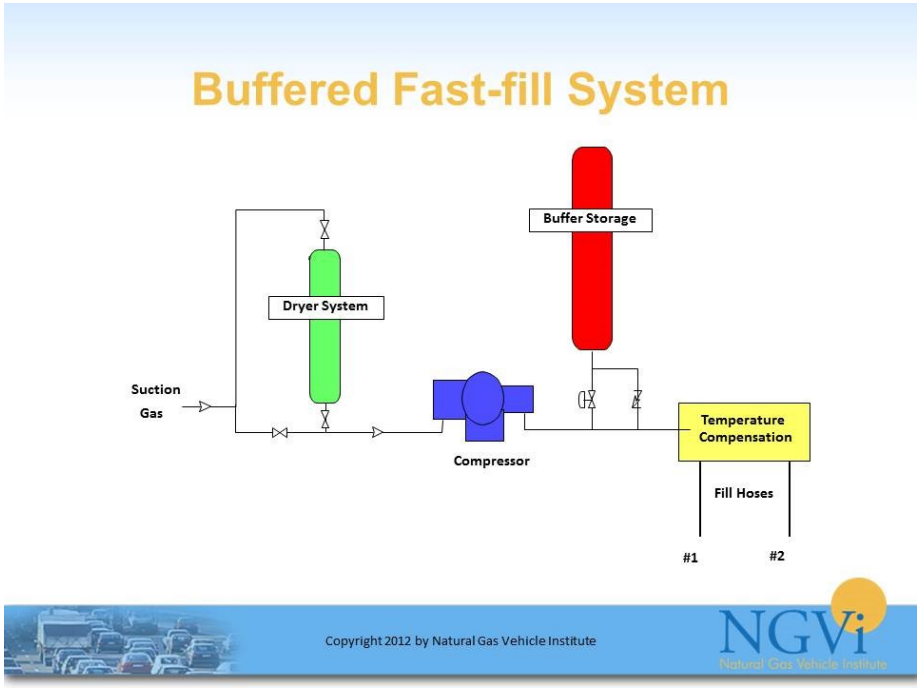



**Figure 5: Buffered Fast-Fill.**
*Source: NGVi CNG Fueling Station Design Training Manual with permission granted for use by Leo Thomason.*

The final type of CNG fueling station for this discussion is a time-fill station. This is the most economical type of station, as the compressors may be smaller and there is no storage requirement. This type of station is ideal for fleets that start and return to the same location every day. Vehicles are connected to a time fill post, and "x" amount of hours later, they are full and ready for the next day's activities. Figure 6 depicts a typical arrangement.

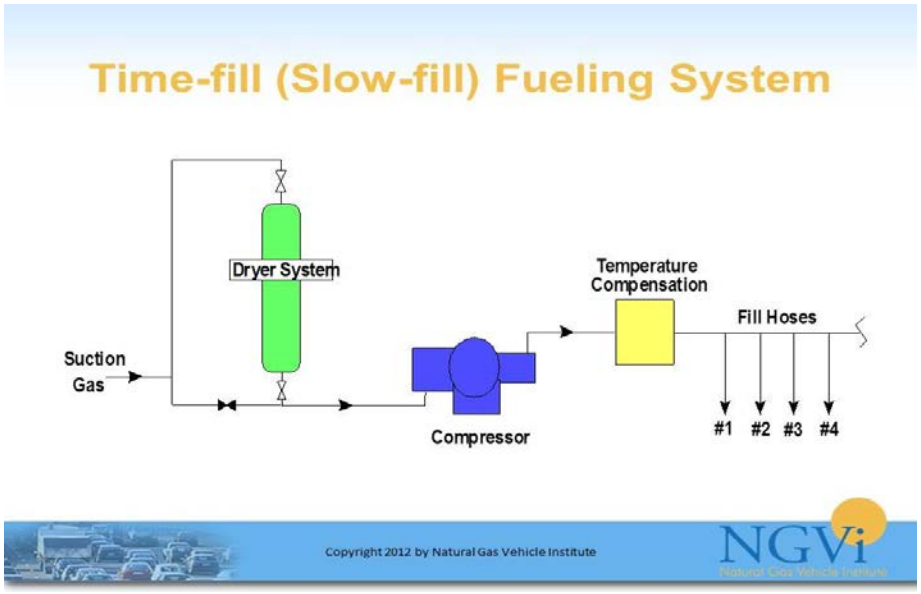



**Figure 6: Time-Fill.**
*Source: NGVi CNG Fueling Station Design Training Manual with permission granted for use by Leo Thomason.*

Figure 7 depicts the major pieces of equipment for a CNG fueling station. The first picture (starting from the left top) is the meter set provided by the utility company. The next picture is the dryer, which removes the moisture from the natural gas. The next picture shows the compressors used to compress the natural gas from the pipeline pressure to about 4,200 psi. On the bottom row, the first picture is the storage vessels. These can range in size and shape (tubes or spheres) and quantity depending on the client's needs. For a buffered fast-fill station, the quantity is smaller; for a time-fill station, there is no storage. The next picture is the card reader. This can be a standalone reader as shown or integrated into the dispenser. The last two pictures are that of a fast fill dispenser and a time-fill post arrangement.


**Figure 7: Typical CNG Fueling Station Major Pieces of Equipment.**

Hybrids of all of these types of stations are available. A potential owner may want time fill posts for their own fleet and a cascade dispenser available for the public to purchase CNG. Some station owners, such as transit agencies, are installing a cascade fast-fill station with dispenser(s) behind the fence for their bus fleet and a separate dispenser outside the fence for public use.

In some locales, the availability of natural gas may not exist. Vendors are now providing solutions to these situations by way of virtual pipelines/mother-daughter arrangements. The premise for these is the same; CNG is produced at an off-site location and trucked to the fueling station, where the trailer serves as the storage tank.

There are also stations available that are all encompassing – the major pieces of equipment are housed in one unit. These types of systems are designed to be either fast-fill or time-fill. This is not a station designed for general public use, but instead, is an option for small fleet operators. See Figures 8 and 9 for examples. Locally, Alternative Fuel Solutions of Mahaffey, PA offers the Cubo Gas Pocket and Fleet Energy of State College, PA distributes the Galileo systems. These types of stations can range from $150k to $1M installed.


**Figure 8.**

For homeowners, there are options available without the need to find a publically-operated CNG fueling station. These are referred to as home refueling appliances. These appliances are time-fill stations and connect


**Figure 9.**

directly to the natural gas line serving the home. Several vendors provide solutions for this type of arrangement with systems costing as little as $5,000. For those concerned with the safety of home refueling, BRC FuelMaker Corp. notes that their unit will not operate if it is not connected properly and that a built-in sensor shuts the system down if the system senses a methane leak or any other malfunction. The manufacturer also indicates that the device is considered a home appliance by municipalities, like a water heater or gas dryer. Still, it would be wise to check with local authorities before making the investment (www.afdc.energy.gov). It has also been reported that Eaton Corp. and General Electric Co. are working on competing projects to develop a $500 home natural gas fueling station.

### CNG Station Ownership

As previously discussed, a CNG fueling station can cost as much as several million dollars. Options include owning and operating the entire station or owning the station and contracting out the operations and maintenance. Key to building a CNG fueling station is to secure an anchor fleet. The anchor fleet will be the dedicated user and provide the steady income for investment recovery. A prospective owner should not solely rely on the anchor fleet; the owner also should secure other dedicated users/fleets and establish fuel purchase agreements for a minimum quantity of natural gas annually.

From a recent NGV America presentation, there are at least five different fueling station options. Those options are:

- Offsite (c-store)
- Onsite (inside the fence and outside the fence)
- Fleet owned and operated
- Outsourced station ownership, with operations entirely via independent fuel provider and contract gas price
- Fleet owned/leased station but contracted out operations for a fee on a GGE basis.

A convenience store owner is a typical example of offsite ownership. Qwik Trip in Wisconsin has added several CNG fueling stations to their convenience stores. American Natural Gas has a CNG fueling station at their convenience store in Pittsburgh.

A vendor is an entity that can design, build, operate, and/or maintain CNG fueling stations. Clean Energy, GAIN Clean Fuel, and Trillium CNG are a few examples of a vendor. A packager, by comparison, simply provides the CNG equipment. ANGI Energy is an example of a packager.

Vendors typically prefer a design/build/operate/maintain arrangement. This allows them maximum flexibility in station construction and innovative techniques and control of price per GGE.

A vendor may also approach an existing gasoline station owner to install a CNG fueling station at the existing site. An owner's profits are realized through land leases and/or profits from the quantities of CNG sold. GAIN Clean Fuel built a CNG fueling station on the property of an existing Pacific Pride. GAIN is responsible for finding the dedicated users of the station as well as maintaining it.

With the PennDOT CNG P3 initiative, some transit agencies will have a dispenser(s) outside the fence for general public sales and dispensers inside the fence for buses and/or other local government users on established fuel accounts. When River Valley Transit (RVT) in Williamsport first opened their public station in December 2013, they sold about 300 GGE to the public in the first month. In May 2015, they sold nearly 2,300 GGEs. This station accommodates sedans through Class VIII tractor-trailers.

## 5.3. Fueling Stations Available in Pennsylvania

The AFDC (www.afdc.energy.gov) reports there are currently 321 alternative fuel stations in Pennsylvania. This number does not include private/behind the fence stations. It does include CNG, LNG, propane, biodiesel, ethanol, hydrogen, and electric charging stations. Currently there are 56 CNG fueling stations and 80 propane stations. BFTP prepared a document titled "Natural Gas Vehicle (NGV) Fueling Stations and Current Projects: Pennsylvania." This document can be found in Appendix J and contains articles related to recently awarded grants and the AFDC Station locator.

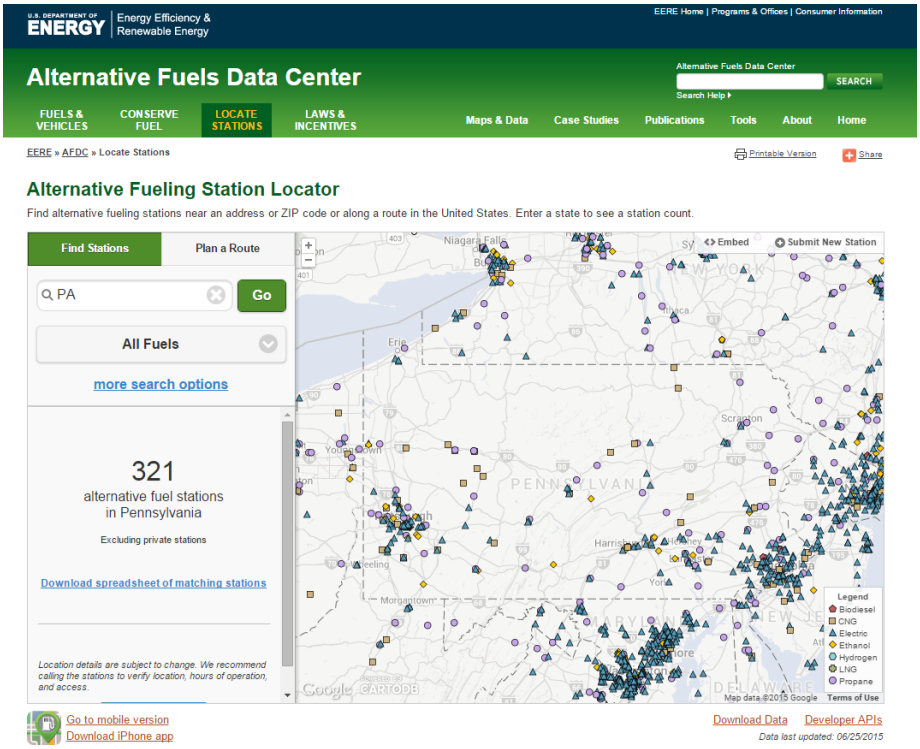
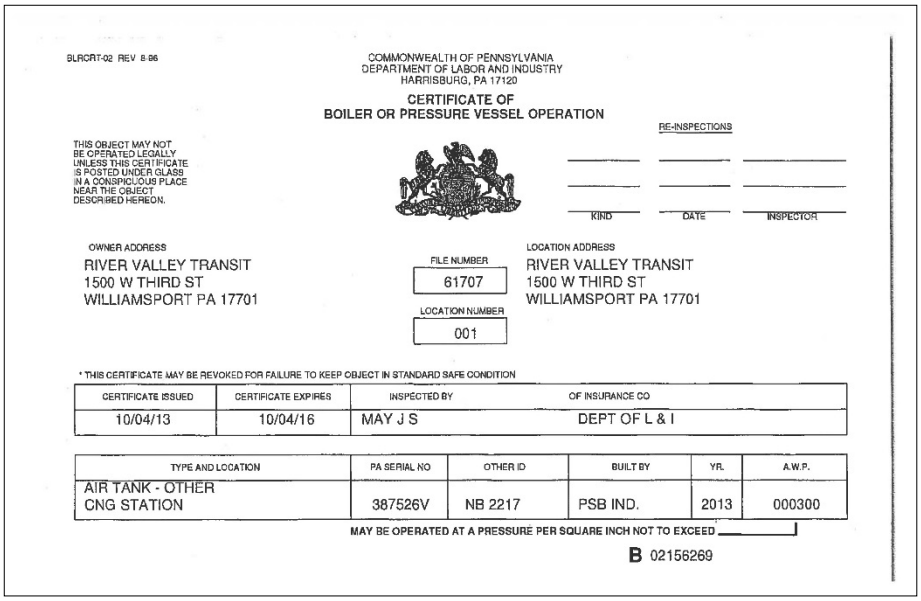



**Figure 10.**

Recently, PennDOT advertised and shortlisted four firms to provide CNG fueling stations at upwards of 36 transit agency locations across the state. PennDOT is in the process of developing the Request for Proposal for these vendors to respond to. The shortlisted firms are: Clean Energy, Trillium CNG, GP Strategies, and Spire, although Spire has recently withdrawn from this project. It is anticipated a single contract will be awarded in late 2015 with construction set to begin in 2016. It is expected that many of the selected sites will include a publically accessible dispenser(s).

## 5.4. Permitting and Inspections

To comply with PA Department of Labor and Industry (L&I) regulations, prospective station owners need to be sure to acquire the appropriate permits prior to construction. Additionally, all CNG storage vessels need to be ASME stamped and must be inspected every three years by L&I. This does not only include the large storage vessels in the rack, but also the blow down tank as part of the compressor package and the dryer vessels. There is a $15/vessel inspection fee and a $66/vessel certificate fee as well. Figure 11 shows an example of the vessel inspection form from L&I.



BLRCRT-02 REV 8-96

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF LABOR AND INDUSTRY
HARRISBURG, PA 17120

CERTIFICATE OF
BOILER OR PRESSURE VESSEL OPERATION

THIS OBJECT MAY NOT BE OPERATED LEGALLY UNLESS THIS CERTIFICATE IS POSTED UNDER GLASS IN A CONSPICUOUS PLACE NEAR THE OBJECT DESCRIBED HEREON.

RE-INSPECTIONS

KIND | DATE | INSPECTOR

OWNER ADDRESS
RIVER VALLEY TRANSIT
1500 W THIRD ST
WILLIAMSPORT PA 17701

FILE NUMBER
61707

LOCATION NUMBER
001

LOCATION ADDRESS
RIVER VALLEY TRANSIT
1500 W THIRD ST
WILLIAMSPORT PA 17701

* THIS CERTIFICATE MAY BE REVOKED FOR FAILURE TO KEEP OBJECT IN STANDARD SAFE CONDITION

| CERTIFICATE ISSUED | CERTIFICATE EXPIRES | INSPECTED BY | OF INSURANCE CO |
|---|---|---|---|
| 10/04/13 | 10/04/16 | MAY J S | DEPT OF L & I |

| TYPE AND LOCATION | PA SERIAL NO | OTHER ID | BUILT BY | YR. | A.W.P. |
|---|---|---|---|---|---|
| AIR TANK - OTHER CNG STATION | 387526V | NB 2217 | PSB IND. | 2013 | 000300 |

MAY BE OPERATED AT A PRESSURE PER SQUARE INCH NOT TO EXCEED

B 02156269

**Figure 11.**

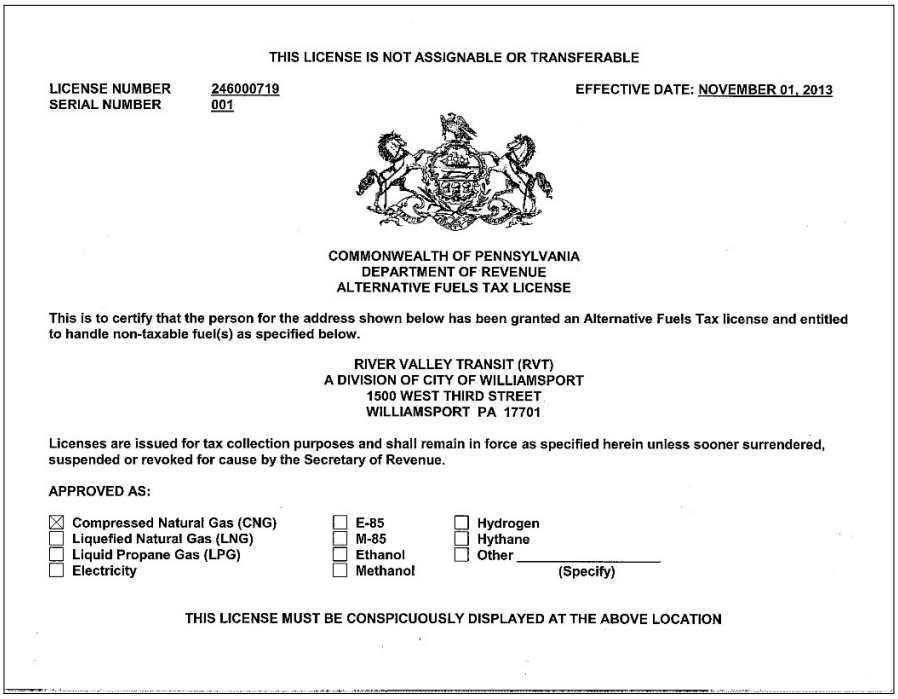
Regarding propane containers and cylinders, they are inspected per US Department of Transportation (DOT) requirements and NFPA 58 Chapter 5. For cylinders not under the DOT's jurisdiction, NFPA 58 states that they must be visually inspected within 12 years of manufacture and at least every 5 years thereafter.

A "CNG Vehicle Fuel Facility Application to Install" form (L&I Form CNGA1) must be submitted to L&I prior to commencing with construction of any station. This permit also requires the submission of detailed site plans, proof of ASME vessel certification, and notification to the gas utility. L&I will respond with their approval letter and a completed page 2 of the form allowing installation of the station if all documentation is in order. L&I will then periodically inspect the site at certain junctures during construction. For propane installations, NFPA 58 Chapter 4.3.1 and 4.3.2 mandate the Authority Having Jurisdiction (AHJ) receive the plans of the installation prior to construction.

The Weights and Measures Division is the arm of the Department of Agriculture responsible for regulating retail motor fuel dispensers. The Department inspects gasoline and diesel fuel dispensers annually. At this time, however, the Department does not inspect CNG dispensers.

An Alternative Fuels License (PA Department of Revenue), Form Rev-822 MF, is needed whenever alternative fuels (LNG, CNG, Methanol) are used;

i.e., placed into the supply tank of a motor vehicle intended for use on a public highway of the Commonwealth. Figure 12 is an example of the license from the Department of Revenue.



THIS LICENSE IS NOT ASSIGNABLE OR TRANSFERABLE

LICENSE NUMBER 246000719
SERIAL NUMBER 001

EFFECTIVE DATE: NOVEMBER 01, 2013

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF REVENUE
ALTERNATIVE FUELS TAX LICENSE

This is to certify that the person for the address shown below has been granted an Alternative Fuels Tax license and entitled to handle non-taxable fuel(s) as specified below.

RIVER VALLEY TRANSIT (RVT)
A DIVISION OF CITY OF WILLIAMSPORT
1500 WEST THIRD STREET
WILLIAMSPORT PA 17701

Licenses are issued for tax collection purposes and shall remain in force as specified herein unless sooner surrendered, suspended or revoked for cause by the Secretary of Revenue.

APPROVED AS:

- ☒ Compressed Natural Gas (CNG)
- ☐ Liquefied Natural Gas (LNG)
- ☐ Liquid Propane Gas (LPG)
- ☐ Electricity
- ☐ E-85
- ☐ M-85
- ☐ Ethanol
- ☐ Methanol
- ☐ Hydrogen
- ☐ Hythane
- ☐ Other _____ (Specify)

THIS LICENSE MUST BE CONSPICUOUSLY DISPLAYED AT THE ABOVE LOCATION

**Figure 12.**

## 6. Vehicle Storage and Maintenance

For an owner considering alternative fuels, hiring a consulting engineering firm to perform a CNG code compliance assessment with associated opinions of probable cost for a few options is well worth the investment. This allows an owner to make an informed decision on which fueling strategy makes the best economic sense. In hiring a consultant, the owner should check qualifications and experience in performing CNG and/or propane-related work. The range of these services can go from a few thousand dollars to more than $50,000 depending on the finalized scope of services with the consultant.

Regarding costs associated with bringing a maintenance facility on line, the costs will vary significantly from facility to facility, owner to owner, AHJ to AHJ, and insurance company to insurance company. The Authority Having Jurisdiction (AHJ) can be the local fire chief and/or the building code official. The cost of renovation is tied closely to the proposed use(s): whether it is a storage area, minor repair area, a major repair area, or a combination of all of these. The cost is also tied to the size and age of the building. In some cases, it may be more cost-effective to build a new facility. There are options to reduce these retrofit costs. For example, an owner may have 12 maintenance bays. An option would be to segregate a determined amount of bays and perform renovations to make only those bays major code compliant.

### 6.1. Storage

Regarding CNG compliance, there are no specific code requirements for vehicle storage areas. However, NFPA 88A – Parking Garages can be

referenced for general mechanical and electrical requirements for vehicle storage areas.

NFPA 58 Chapter 10 calls out structural, ventilation, and heating requirements for a building if propane vehicles are to be parked inside. The structural requirements include that the exterior walls, ceilings, and roofs are designed for explosion venting either with explosion venting windows or lightweight construction materials.

To have a facility assessed for CNG code compliance, the consultant should be using the applicable codes, standards, and regulations which include the following:

- PA Uniform Construction Codes (UCC), incorporating the following with amendments:
  - IBC–2009 International Building Code
  - IMC–2009 International Mechanical Code
  - IFGC–2009 International Fuel Gas Code
  - IFC–2009 International Fire Code
  - IPC–2009 International Plumbing Code
  - IEBC–2009 International Existing Building Code
  - IEEC-2009 International Energy Conservation Code
- Local Ordinances
- National Fire Protection Association (NFPA):
  - 10-2010, Portable Fire Extinguishers
  - 13-2012, Installation of Sprinkler Systems17-2010, Standard for Dry Chemical Extinguishing Systems
  - 30A-2012, Code for Motor Fuel Dispensing Facilities and Repair Garages
  - 51B-2009, Standard for Fire Prevention during Welding, Cutting, and other Hot Work
  - 52–2010, Compressed Natural Gas (CNG) Vehicular Fuel Systems
  - 58-2014, Liquefied Petroleum Gas Code
  - 70-2008, National Electrical Code
  - 88A-2011, Standard for Parking Structures
- American National Standards Institute / American Society of Mechanical Engineers (ANSI/ASME)
  - B31.3: Process Piping – 2004
- FM Global Loss Prevention Data Sheets
  - 7-15 Garages – 2013
  - 7-54 Natural Gas and Gas Piping – 2009
  - 7-95 Compressors – 2000.

In deciding how to interpret the codes, a facility owner/designer must coordinate with the AHJ. The AHJ's interpretation of the code is the final word. In some cases, the AHJ will not be fully knowledgeable regarding CNG. A consulting engineer firm may need to coach, teach, and mentor the AHJ in those situations. The codes should be used for guidance, however, the codes do have conflicts between them. It is very important to discuss with the AHJ the scope of the work and their needed involvement early and often during this process. There may also be local ordinances that have to be considered during the design of a new facility or renovation of an existing facility.

In support of this paper, BFTP developed an NGV Maintenance, Storage, and Infrastructure Development Guide, which can be found in Appendix K. Topics range from code compliance, to station ownership options, to passages from select NFPA Codes, to companies (list not all-inclusive) that design, build, operate, and/or maintain CNG fueling stations and/or facility modifications.

Currently, there exists some confusion and contradiction between the two relevant NFPA standards (70 for National Electrical Code, and 30A Code for Motor Fuel Dispensing Facilities and Repair Garages) regarding proper classification of garage spaces used for repair of CNG fueled vehicles. The essence of the contradiction is that the National Electrical Code Article 511 specifies that the area within 18 inches of the floor in major repair areas is to be considered a Hazardous (Classified) Location, while NFPA 30A properly recognizes this space as Unclassified. Based on conversations with NFPA, as well as the fact that natural gas is lighter than air and will naturally rise away from the floor, engineers believe that NFPA 30A should take precedence over the National Electrical Code with regard to this issue. However, it is noted that the National Electrical Code has the force of law, while NFPA 30A does not. Therefore, it is important to obtain agreement regarding use of the NFPA 30A classification rules over those of the National Electrical Code from the AHJ on a project-by-project basis.

Regarding equipment within 18 inches of the ceiling, NFPA 30A defines two ways for dealing with this situation. Options include either ventilating continuously at a rate of 1 CFM per square foot of area to declassify the space, or rating all electrical and mechanical components within the 18 inches for Class I, Division 2. The latter option (Class I Division 2 rated equipment) provides several major benefits to the facility owner:

- The installation will be intrinsically safe due to the selection of materials and equipment used in this upper 18-inch space. In other words, the safety of the installation will not be dependent upon the continued operation of a "moving parts" system (e.g., ventilation fans, etc.), which means that long-term maintenance is reduced.
- A ventilation system which is specifically intended to declassify a space would require a back-up generator system which meets National Electrical Code requirements for a Legally Required Standby system. Compliance with these requirements would likely necessitate redesign and replacement of the existing back-up generator system.
- Long-term energy costs will be lower, because heated air at the ceiling of the maintenance bay is not being "thrown away" during cold weather.

## 6.2. Maintenance Facilities

The following lists the types of activities associated with Minor Repair and Major Repair garages. This is applicable to CNG and propane applications.

Major Repair [NFPA 30A-2012, 3.3.12.1]:

- Engine overhauls
- Painting
- Body and fender work
- Repairs that require draining of the vehicle fuel tank
- Transmission changes.

Minor Repair [NFPA 30A-2012, 3.3.12.2]:

- Lubrication
- Inspection
- Engine tune-ups
- Replacement of parts
- Fluid changes (oil, antifreeze, transmission fluid, brake fluid, air conditioning refrigerant)
- Brake system repairs
- Tire rotation
- Similar routine maintenance work.

The following is a synopsis of the CNG and propane code requirements by area. Regardless of the area, the IMC 403.3 requires a minimum ventilation of 0.75 CFM/ft² exhaust airflow in repair garages.

For a Minor Repair Area, there are no specific CNG code requirements per NFPA 30A, or IFC. IMC 502.16 requires 5 air changes per hour (ACH) continuous **or** ventilation interlocked with gas detection system **or** ventilation interlocked with lights. NFPA 58, LP-Gas Code does not call out minor repair areas specifically.

For a Major Repair Area, a designer must consider ventilation requirements, as well as heating, adjacent spaces, architectural, and electrical requirements.

Ventilation:

- NFPA 30A /NFPA 52 - 5 ACH (continuous or ventilation interlocked with gas detection system).
- IMC 502.16 - 5 ACH (continuous or interlocked with gas detection system or interlocked with lights - CNG only).
- NFPA 58, 10.2.2, mechanically ventilate within 6 inches of floor at 1 CFM/Ft2 or naturally ventilate with a 50 $in^2$ opening every 20 feet of exterior wall totaling at least 1 $in^2/ft^2$ of floor area.

**Ducting in outside air for waste oil burner.**

**New exhaust fans to remove any natural gas in the event of a leak.**

**Ducting the skylights to remove any trapped natural gas in the event of a leak.**

**Figure 13.**

Heating:

- No open flames
- Surface temperatures less than 750° F.

Electrical (NFPA 30A and NFPA 70/NEC):

- Ceiling: Ventilate within 18 inches of ceiling at 1 CFM/Ft² or space is Class I, Div. 2.
- Floor: Ventilate within 18 inches of floor at 1 CFM/Ft² or space is classified.

Adjacent Spaces – Ventilation at 4 ACH or pressurize spaces or seal all openings.

Architectural:

- Seal doors, walls, and walls penetrations between major repair areas and adjacent spaces.
- Warning Signage.

**Sealing areas segregating major repair area from other areas of the building.**

**Infrared tube heaters that do not exceed 750 degrees.**

**Figure 14.**

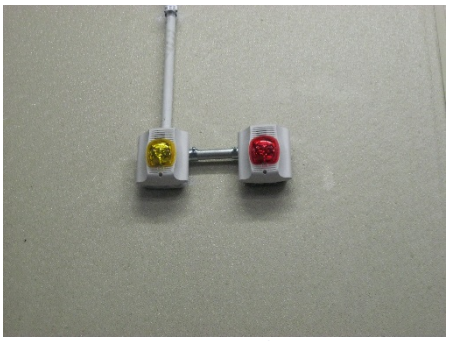
A gas detection system is required for the repair of vehicle engine fuel systems fueled by non-odorized gases such as LNG [NFPA 30A-2013, 7.4.7.] However, CNG and propane are generally odorized gases.

For propane, NFPA 58-2014, paragraphs 9.7.3.6, 9.7.3.7, and 9.7.3.8 specify what actions must be taken to a propane operated vehicle when parking or servicing the engine or chassis indoors (owner facility). These include:

- Maintain floor level ventilation
- Repair leaks before moving vehicle indoors
- Close all primary shutoff valves
- Do not park near a heat source or within the direct path of hot air
- Verify on-board tanks are not over-filled.

There are additional requirements for servicing propane vehicles at a non-owner facility as defined in NFPA-58, 2014, paragraph 9.7.3.8.

Gas detection sensors.



Strobes and alarms as part of the gas detection system.

Figure 15.

## 7. Bottlenecks

In order for natural gas and propane opportunities to expand in Pennsylvania as they have in other parts of the US and globally, there are several significant bottlenecks/hurdles that need to be overcome.

### 7.1. Bottleneck 1 – Education

There appears to be a general lack of knowledge about the use of natural gas as a vehicle fuel. More education of the public, AHJ, and insurance companies needs to happen. For example, in many ways, a CNG vehicle is safer than current gasoline or diesel vehicles since CNG is lighter than air and will dissipate if there is a leak. CNG has a very tight explosive limit so chances of an explosion are small. Technology has come a long way since the push for natural gas vehicles back in the 80's.

### 7.2. Bottleneck 2 – Infrastructure

There is not enough refueling infrastructure readily available for public use. A CNG fueling station is a major investment, and potential station owners want/require dedicated fleet usage in order to get their Return on Investment (ROI) in a timely manner. On the other hand, potential vehicle owners need fueling stations to fill at and either conversion kits or NGVs from the OEM. These are not inexpensive. Support through grants and/or loans from the state and federal government can help facilitate more rapid growth of both refueling stations and fleet conversions, and ultimately promote energy independence for the US. AFDC reports 840 public CNG fueling stations and 3,113 public propane stations across the United States as of June 24, 2015. This number pales in comparison to the number of publically accessible gasoline and diesel stations.

### 7.3. Bottleneck 3 – Price Differential

The current relatively low price of gasoline and diesel is great for those who drive conventional vehicles, but it is not so favorable for stimulating the switchover to CNG and propane. The savings touted of a $1.50/GGE are just not there today as they were just over a year ago. For example, today, RVT sells their CNG for $1.99/GGE, while a nearby gas station is selling gasoline for $2.85/gal. This is a savings of only $0.86/GGE. The price of natural gas continues to remain fairly constant without significant fluctuations. However, the price of crude oil has been in an extended dip, causing the

price differential to shrink and therefore public interest to wane at the present time. With the smaller price differential, a simple payback analysis would result in a longer payback timeframe.

### 7.4. Bottleneck 4 – NGV Availability

Another bottleneck is the availability of NGVs for the general public. Although these vehicles are not commonly found at local dealerships, fleets can take advantage of NGVs being available. The large automakers are starting to produce more NGVs. These newer vehicles are identified in the 2015 Clean Cities Buyer's Guide. This guide has been included in this white paper and can be found in Appendix C. PennDOT started reporting on the number of alternative fuel vehicle registrations beginning in 2013. There were only 289 natural gas and 241 propane vehicles registered out of a total registration of 11,616,715 vehicles. (It should be noted that there may be something amiss with this count as CATA in State College currently operates a fleet of 71 CNG buses and Schwan's entire fleet is propane.) In 2014, the numbers grew to 460 and 380 vehicles respectively of the 11,715,722 registered. The point here is the numbers are growing but alternate fueled vehicles still represent a very small percentage of registered vehicles in PA. Honda just announced they will no longer offer the CNG Honda Civic, an obvious setback to the push to offer more CNG passenger size vehicles.

## 8. Economics

### 8.1. Return on Investment

Discussions over the last three years with many oil and gas companies operating in PA have confirmed that they want to see a ROI of five years or less in terms of vehicle purchases. When it comes to footing the bill for a CNG fueling station, potential owners want a ROI of 10 years or less. The AFDC website has quite an extensive ROI calculator (CNG VICE 2.0) for determining whether converting to an alternative fueled vehicle is the best option for potential owners. It is a downloadable spreadsheet that is fairly user-friendly in terms of the inputs needed.

Consultants and vendors have also developed their own ROI calculators to help potential station owners determine if they want to make the investment. Inputs such as annual consumption (GGEs/year), commodity purchase price from utility, commodity selling price to users, expenses (electricity, maintenance, taxes, profit margin, overhead expenses, and fueling station costs), and equipment depreciation factors comprise a CNG fueling station ROI calculator.

On the vehicle side, a 2015 Chevrolet Impala starting MSRP is around $27,000, while upfitting from the factory will add $11,000 to the cost. The decision then becomes whether the owner drives enough miles annually to offset this cost, coupled with refueling issues – whether to install a home refueling system, if there are local refueling options, and whether out-of-the-area refueling options are workable.

The economics are also driven by whether or not incentives are available, the type of incentive, whether they are in the form of tax incentives or rebates from government programs, or whether they are outright grants from state or federal agencies. These financial aids have a direct impact on ROI.

NGVAmerica's presentation "The Compelling Case for NGVs in Public and Private Fleets" authored by Stephe Yborra contains a section titled "Dollars and Sense, NGV Economics." This material was presented at the Alternative Fuels Tri-State Expo in Monroeville, PA in February 2014. In general, Yborra presents a Simple Payback Analysis given the price of a barrel of crude oil at that time. It should be noted, however, that the savings identified do not include maintenance costs, depreciation, and other factors that would go into a sophisticated analysis of ROI. NGVAmerica has given permission to include this presentation in this report and it can be found in Appendix L.

In an interview with Yborra on June 18, 2015, he stressed that potential station owners should understand the intricacies of purchasing the natural gas commodity. One needs to do their homework whether they decide to purchase the natural gas from a utility company or purchase it on the open market and have the utility company just deliver it. In the latter case, there will be transportation fees associated with the delivery, and those fees can vary across the state depending on the utility company. On the other hand, utility companies may offer rate schedules based on different ranges of consumption if a station owner purchases everything from them. Other important elements of purchasing natural gas as a commodity are beyond the scope of this white paper.

Stephe also pointed out what has already been said before – do not expect these lower gasoline and diesel fuel prices to remain this low for much longer. Crude oil prices will eventually rebound while the price of natural gas is expected to remain fairly flat. As a result, we will once again see the $1.50/GGE savings at the pump.

## 9. Grants and Funding

There are programs at both the state and federal level for alternative fuels. The following discussion describes those programs and their current status. At the state level, the PA Department of Community and Economic Development's (DCED) Alternative Clean Fuels (ACE) program is still active for CNG infrastructure projects. This funding from DCED ACE is available in the form of a grant or loan. Specifics regarding this program can be found at the DCED ACE website: http://www.newpa.com/find-and-apply-for-funding/funding-and-program-finder/alternative-and-clean-energy-program-ace. Applicants can download the program guidelines at this website as well.

Appendix M shows the current list of DCED ACE Grantees. As of March 10, 2015, there are 58 CNG and LNG projects.

The Department of Environmental Protection (DEP) Alternative Fuels Incentive Grant (AFIG) Rebate Program for residents is also active. Residents can seek a $1,000 rebate for purchasing a natural gas or propane vehicle.

The DEP AFIG Program for fleets is currently closed. The DEP does not know what grant opportunities might be available next year until after the state budget passes. In the past, DEP has released separate RFPs for vehicles weighing less than 14,000 pounds and for vehicles weighing more than 14,000 pounds.

The Small Business Advantage Grant Program provides 50% matching grants up to $9,500 for PA small businesses to adopt or acquire energy efficient or pollution prevention equipment or processes. It is understood that this program will apply to natural gas and propane vehicles.

At the Federal level, there have been four programs/exemptions concerning alternative fuels. As of the writing of this paper, these credits and exemptions expired in 2014. However, for the past several years, they have been retroactively reinstated at the end of the calendar year.

The Alternative Fuel Excise Tax Credit of $0.50 per gallon is an incentive for alternative fuel that is sold for use or used as a fuel to operate a vehicle (www.afdc.energy.gov).

The Alternative Fuel Mixture Excise Tax credit is a tax credit of $0.50 per gallon of alternative fuel. An alternative fuel blender that is registered with the IRS may be eligible for a tax incentive on the sale or use of the alternative fuel blend (mixture) for use as a fuel in the blender's trade or business (www.afdc.energy.gov).

The Alternative Fuel Infrastructure Tax Credit provides up to 30% of cost not to exceed $30,000. This incentive is for fueling equipment for natural gas, propane, electricity, E85, and diesel fuel blends containing a minimum of 20% biodiesel. Consumers are eligible for up to $1,000 credit for the purchase of home refueling appliances (www.afdc.energy.gov).

Alternative fuels used in a manner that the IRS deems as nontaxable are exempt from federal fuel taxes. Common nontaxable uses in a motor vehicle are: for farming purposes, intercity and local buses, school bus, exclusive use by a nonprofit educational organization, and exclusive use by a state, political subdivision, of a state or the District of Columbia (www.afdc.energy.gov).

## Glossary

| | |
|---|---|
| Alternative Fuel Vehicles (AFV) | A dedicated, flexible fuel, or dual-fuel vehicle designed to operate on at least one alternative fuel. |
| Alternative Fuels | The Energy Policy Act of 1992 defines an alternative fuel as:<br>• Biodiesel (B100)<br>• Natural gas and liquid fuels domestically produced from natural gas<br>• Propane (liquefied petroleum gas)<br>• Electricity<br>• Hydrogen<br>• Blends of 85% or more of methanol, denatured ethanol, and other alcohols with gasoline or other fuels<br>• Methanol, denatured ethanol, and other alcohols<br>• Coal-derived, domestically produced liquid fuels<br>• Fuels (other than alcohol) derived from biological materials<br>• P-Series fuels. |
| Bi-fuel | This term applies to both CNG and propane vehicles. The engines can run on either natural gas and gasoline or propane and gasoline. The vehicle will have two storage tanks and it will run on the alternate fuel until it is consumed and then the gasoline is consumed. Bi-fuel systems are also called “switchable” systems because you can switch between gasoline or CNG. Most conversions for light duty (new or used trucks) are bi-fuel because they give the customer the best of both worlds. |
| CARB | California's Air Resources Board |
| Compressed Natural Gas (CNG) | This is a natural gas that is highly compressed and stored in high-pressure surface containers. Compressed natural gas is used extensively as a transportation fuel for automobiles, truck and buses. |
| Dedicated | This term applies to both CNG and propane fueled vehicles. The engines in these vehicles can only run on CNG or propane. It can be either a new vehicle with a CNG engine or a repower. In either case, the old fuel tank is normally removed and replaced with CNG cylinders. This is a great choice for vehicles running predictable routes with access to company-owned fueling stations (for example, food and beverage delivery trucks and school buses). |
| Diesel Gallon Equivalent (DGE) | Diesel Gallon Equivalent is a way to rate CNG vehicle storage. Since diesel has a higher energy content than gasoline (129,500 BTUs standard), 1 DGE = 1.136 GGE and 1 GGE = 0.88 DGE. |
| Dual-fuel | This term applies mainly to heavy duty vehicles. Diesel fuel is used to ignition purposes and then the vehicle runs on CNG. You keep your existing diesel tanks and install additional CNG cylinders that extend the range. Depending on your load, a dual fuel system will use up to 50% CNG on average. This is a great choice for existing fleet customers that need range and fuel flexibility and do not want to go through the expense of replacing vehicles that have hundreds of thousands of miles remaining in their life. |

| | |
|---|---|
| Fast-Fill | The process of fueling a vehicle with natural gas in approximately the same time it would take to fuel the same vehicle with liquid fuels such as gasoline or diesel. |
| Gas Gallon Equivalent (GGE) | A unit for measuring compressed natural gas sold at public fueling stations and comparing fuel efficiencies. The amount of fuel it takes to equal the energy content of one liquid gallon of gasoline where one gasoline gallon equivalent (GGE) equals 120,167 British thermal units (BTUs). |
| Home Fueling Appliance | A natural gas fueling component that contains both compressor and fueling equipment which is sized for residential time fill use. |
| Mixed Fuel | The EPA calls any vehicle that blends CNG with diesel or other fuels a "mixed" fuel vehicle. In practice, there are some engines – like the Cummins/Westport ISX – that use a small amount of diesel but basically act as dedicated CNG Engines. That is to say, if you run out of CNG you are not going very far. We call these types of vehicles "mixed fuel" and, like dedicated systems, they are a great choice if you have predictable routes and you need the high torque of a heavy duty diesel engine. The main advantage of this system is that it can run 90% or more CNG while retaining many of the operating benefits of diesel. As of now, these are only available in new trucks. |
| Natural Gas Vehicle (NGV) | A vehicle powered by compressed natural gas. |
| OEM | Original Equipment Manufacturer. |
| Public Fueling Station | A fueling station that is accessible to the general public. |
| Time-Fill | A method of fueling a vehicle with natural gas over an extended period of time, usually six to eight hours. |
| Vehicle Conversion | Retrofitting a vehicle engine to run on natural gas or propane. |
| Vehicle Refueling Appliance | A natural gas fueling component that contains both compressor and fueling equipment. |
| Vehicle Weight Class | The size of vehicles. Includes light-duty, medium-duty, and heavy-duty vehicles based on their gross vehicle weight rating (the weight of a vehicle on its own plus the weight of cargo). |

# Appendix A

## Propane Fact Sheet

# TAKE YOUR INVESTMENT FURTHER

PROPANE
EXCEPTIONAL ENERGY®

## PROPANE AUTOGAS VS. COMPRESSED NATURAL GAS (CNG)

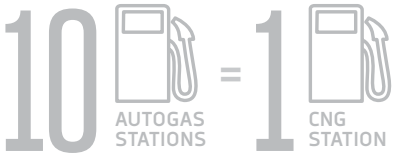
FLEET FACT SHEET

## SWITCH TO THE ALTERNATIVE FUEL THAT'S SAVING MONEY WHILE IT SAVES THE PLANET

*What can propane autogas offer that CNG cannot?*

### LESS EXPENSIVE FUELING STATIONS

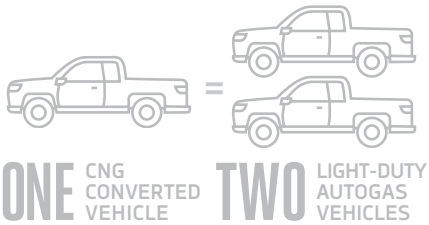
You can have up to 10 propane autogas refueling stations installed for the price of just one CNG fueling station. To further increase savings, propane retailers may cover installation costs when a fleet agrees to a fuel contract. And because propane autogas refueling stations use less electricity, they cost less to operate.




| PROPANE AUTOGAS STATION INSTALLATION |
|---|
| $45,000-$175,000 |
| **CNG STATION INSTALLATION** |
| $400,000-$1,700,000 |

### BEST VALUE FOR CONVERSIONS

Upgrading existing vehicles to alternative fuel doesn't need to damage your bottom line. For the approximate price of converting 1 light-duty vehicle to CNG, you could convert 2 light-duty vehicles to propane autogas.




| AVERAGE PROPANE AUTOGAS CONVERSION |
|---|
| $8,000 |
| **AVERAGE CNG VEHICLE CONVERSION** |
| $15,000 |

### NATIONWIDE AVAILABILITY

No other alternative fuel has refueling stations in every state, with more public refueling stations opening every day. Propane retailers are available nationwide and can help provide convenient central refueling stations for your fleet.

### YES, THEY'RE SIMILAR

More than 70 percent of propane autogas comes from clean, domestic natural gas. So they have a few shared characteristics:

#### THEY DRIVE GREEN

Propane-autogas- and CNG-fueled vehicles are both proven to substantially lower greenhouse gases and other harmful emissions compared to conventional fuels. Compared with gasoline, vehicles fueled by propane autogas cut carbon monoxide emissions by 60 percent, nitrogen oxide emissions by 20 percent, and carbon dioxide emissions by 12 percent.

#### THEY ARE EFFICIENT

CNG and propane autogas both deliver high performance for each dollar invested. And when you take advantage of potential government tax incentives, you have a real stimulus to the bottom line.

#### THEY ARE DOMESTICALLY ABUNDANT

In 2011, the United States became a net-exporter of propane — and domestic propane made from natural gas plant liquids exceeded consumer demand. Choosing abundant, American-made fuels like propane autogas and CNG boosts our nation's energy security by lessening dependence on foreign oil.

#### FOR MORE INFORMATION

Visit **autogasusa.org/fleets** to learn more about the advantages of propane autogas, including potential government incentives in your area.

# Appendix B

## CNG Fact Sheet

NGVAMERICA
Natural Gas Vehicles for America

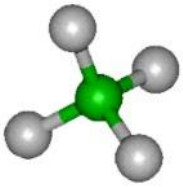
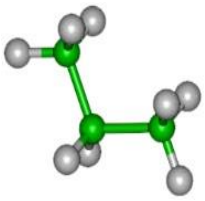
For more information visit ngvamerica.org
or email info@ngvamerica.org

FACT SHEET

Advocating the increasing use of NGVs where they benefit most.
For the economy. For the environment. For health. For security. For America.

# A Comparison of Compressed Natural Gas and Propane

**For General Background Purposes**

| Compressed Natural Gas (CNG) | Propane (LPG) |
|---|---|
| **The Basics** | |
|  Methane is the primary component of natural gas. It is the simplest hydrocarbon with a chemical formula of $CH_4$. |  Propane is the primary component of LPG and is derived from the processing of crude oil or natural gas. Propane is a three carbon alkane with a chemical formula of $C_3H_8$. |
| • Natural gas has the highest energy to carbon ratio (4:1) of any fossil fuel and thus produces less carbon dioxide per unit of energy than any other fossil fuel.<br>• Natural gas is compressed to 3,600 psi to become CNG, which is stored inside high pressure cylinders onboard natural gas vehicles (NGV).<br>• One gasoline gallon equivalent (GGE) is the amount of alternative fuel it takes to equal the energy content of one liquid gallon of gasoline.<br>• One GGE of CNG contains 114,898 Btu's.<br>• One GGE of CNG will power a vehicle the same number of miles as one gallon of gasoline. | • With only 3 carbon atoms per molecule, propane is a cleaner burning fossil fuel than gasoline or diesel.<br>• Propane is compressed to 120 psi and stored as a liquid inside steel tanks onboard LPG vehicles.<br>• One gallon of propane contains about 28% less energy than one gallon of gasoline or one GGE of CNG.<br>• One gallon of propane contains about 83,500 Btu's.<br>• One gallon of propane will power a vehicle about 28% fewer miles than one gallon of gasoline. |
| **Fuel Safety** | |
| • Natural gas is lighter than air with a specific gravity of 0.5537.<br>• When present in the environment, natural gas will dissipate into the atmosphere quickly, minimizing fire potential.<br>• Very narrow flammability range: 5% to 15%<br>• Auto-ignition temperature: 1,004° F | • Propane is heavier than air with a specific gravity of 1.5219.<br>• When present in the environment, propane does not puddle in liquid form but will pool near the ground similar to gasoline vapors.<br>• Very narrow flammability range: 2% to 9.5%<br>• Auto-ignition temperature: 850° F to 950° F |

| Economics | |
|---|---|
| **Station Construction**<br>• Stations require greater initial investment of $500K–$750K to build a standard fast-fill station.<br>• Investment partners are often willing to install private/public stations when fleet demand exists.<br>• CNG offers a second option, called time-fill. Time-fill stations provide concurrent fueling of multiple vehicles (up to 100's) at a slower rate per vehicle.<br>  ○ Example: A station can fill one truck at 8 GGE/minute on fast-fill or 100 trucks at 480 GGE/hour on time-fill.<br>  ○ If a fleet's vehicles sit in a parking lot overnight, every night, this is the most cost and time effective method of fueling.<br>Time-fill stations are considerably less expensive than fast-fill stations, which reduces costs and increases convenience where applicable. | **Station Construction**<br>• Fueling facilities are less expensive to install than CNG stations—about $45k–$175k to build an LPG filling station. A very simple dispensing system can be as low as $25K.<br>• Propane suppliers will often install private stations when fleet demand exists. |
| **Automobile Purchase/Conversion**<br>Light & Medium Duty Vehicles<br>• OEM options from<br>  ○ GM<br>  ○ Chrysler<br>  ○ Honda<br>  ○ (Ford offers a conversion/upfitting process)<br>• Conversions available across multiple platforms for the end user to find the best vehicle options. For a complete listing, click here.<br>• Incremental costs range from ~$7k–$15k per vehicle. The Drive Natural Gas Initiative "Add Natural Gas" project has created six bi-fuel NGVs at an additional cost of ~$2,600-$4,800 per vehicle to demonstrate lower incremental price feasibility. | **Automobile Purchase/Conversion**<br>Light & Medium Duty Vehicles<br>• No OEM options exist through GM (except noted immediately below) or Ford—only aftermarket options. Roush Clean Tech is a QVM of Ford product, not able to OEM. There are no Chrysler or Honda OEM products or certified conversion kits available.<br>• One Class 4 available (Collins Nex Bus – Express/school bus)<br>• Conversions available on several platforms. Less vehicle choices when compared to NGVs. A complete listing can be found here.<br>• Incremental costs range from ~$5k–$12k per vehicle. |

| | |
|---|---|
| Heavy Duty Vehicles<br>Multiple options exist across many platforms, including transit buses, waste management, and Class 8 over-the-road tractors. Examples of a variety of OEM heavy-duty vehicles is available here. | Heavy Duty Vehicles<br>• OEM: One class 7 vehicles available (Blue Bird Vision/school bus)<br>• OEM: Two class 8 vehicles available (Freightliner S2G chassis and Thomas Built Saf-T-Liner C2/school bus)<br>• Compared to NGVs, there are considerably fewer propane vehicles available when examining all light-, medium- and heavy-duty vehicles. |
| **Fuel Costs[1]**<br>• National average price: $2.09/GGE.<br>• National average retail price: $2.20/GGE.<br>• National average private price: $1.80/GGE<br>• Price fluctuations are rare.<br>• Seasonal price fluctuations are non-existent, due to gas utility buying patterns. Gas utility profits are regulated. | **Fuel Costs[1]**<br>• National average price: $4.31/GGE.<br>• National average retail price: $4.39/GGE<br>• National average private price: $3.35/GGE<br>• Prices fluctuate similar to gasoline and diesel, albeit improving as a result of propane being produced from U.S. natural gas reserves.<br>• Prices prone to seasonal fluctuation, due to large home heating demand in colder months (Compare propane prices above to last July's (2013) pricing as an example.) |
| **Tailpipe Emissions/Environmental** | |
| Natural gas is the cleanest burning fossil fuel and consequently has the emissions advantage over diesel and gasoline. It can be argued that because of this inherent environmental quality, the EPA has been able to set stricter emission mandates (particularly with NOx and PM reductions) that forced expensive diesel emission technology to be created to be as environmental as natural gas. Natural gas was compliant with 2010 EPA emission requirements in 2007.<br><br>Both natural gas and propane provide environmental advantages as these vehicles all must be certified to new demanding emission limits that require today's motor vehicles to be 90% cleaner for most pollutants than was the case just a few years ago. The biggest benefit in both cases—natural gas and propane—is to introduce them to replace older, dirtier diesel vehicles. For emission benefits of particular vehicles, potential purchasers should obtain copies of actual certification data and consider the emission certification levels (e.g., Tier 2, 4, or ULEV, SULEV). | |

[1] DOE Clean Cities Alternative Fuel Price Report, January 2014: http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_january_2014.pdf

| Infrastructure: Public vs. Private | |
|---|---|
| • Up to $3/4 billion currently being invested in creating U.S. natural gas fueling stations and fueling corridors:<br>  ○ Since 2009, the amount of CNG fueling infrastructure has grown by 73%.<br>  ○ Since mid-2010, the number of planned CNG fueling stations has grown 396%.<br>• There are more than 1,362 CNG stations nationwide, of which 50% are open to the public.<br>• Natural gas is a consistent fuel provided by local, regulated utilities nationwide. | • Investment in U.S. propane fueling infrastructure pales in comparison to natural gas.<br>• More than 2,986 fueling locations nationwide with an additional 28 planned to be built.<br>• HD5 propane is required for vehicular use; cannot use "barbecue grade" propane.<br>• HD10 propane could void engine warranty and damage fuel systems. |
| **Safety** | |
| National Fire Protection Agency (NFPA) guidelines for both CNG and propane conversions are strictly enforced. CNG and propane systems are tested to meet or exceed all safety requirements for gasoline and diesel equivalents. (Question: If gasoline and diesel transportation fuels were introduced today, would they hold up under the same scrutiny as CNG?) | |
| **Long-Term Price Stability** | |
| • Natural gas is currently estimated to have over 100 years of stable supply.<br>• Reserves of natural gas are estimated to keep prices stable through at least 2030, even assuming significant gains in power generation and vehicular use.<br>• The price at the pump is expected to remain significantly lower than gasoline and diesel, and the price differential is expected to widen as gasoline and diesel prices continue to increase.<br>• Over 98% of natural gas is produced within U.S. borders, providing long term, reliable resources. | • Propane is a by-product of natural gas and crude oil (foreign & domestic) production.<br>• Propane prices vary, similar to gasoline and diesel.<br>• Propane prices are expected to remain lower than gasoline and diesel, but fleet managers can still expect fluctuating prices, especially during the home heating months.<br>• More than 90% of propane is produced inside the U.S., which makes pricing more stable than before as a direct result to decreases in refining propane through foreign oil imports. |

**Pricing and Market Share Trends**

Any effort to compare the price of natural gas and propane with the price of gasoline should start by ensuring that the consumer is making an apples-to-apples comparison. CNG sold at retail is already converted to GGE units so consumers can figure out quickly if they are getting a good deal. For propane, it is generally sold in liquid gallons and must be converted to GGE units in order to put it on a level playing field for comparison sake (i.e., paying more or less for the same amount of energy). The formula to convert a gallon of propane to a GGE of propane:

$$\frac{Gasoline\ Btu}{Propane\ Btu}\ \frac{115{,}400}{83{,}500} = 1.38$$

The answer nets a conversion factor of 1.38 gallons of propane to 1 GGE. Therefore, the cost of a GGE of propane is 1.38 times greater than the cost of a gallon of propane.

Additional propane-to-gasoline analysis:

$$\frac{Propane\ Btu}{Gasoline\ Btu}\ \frac{83{,}500}{115{,}400} = .72$$

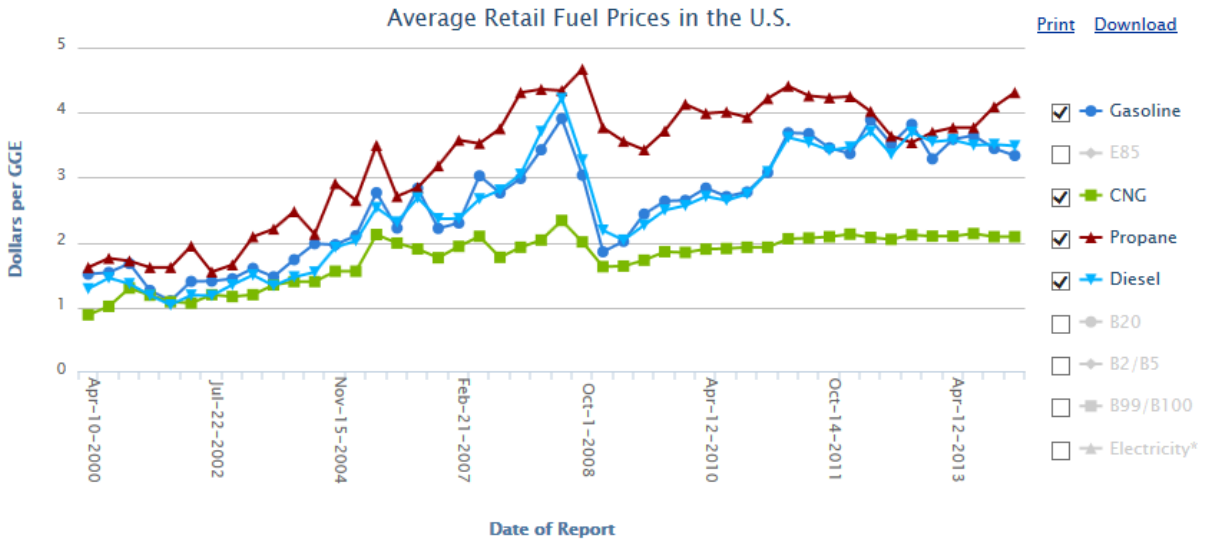
It is important to ensure that the GGE conversion is used when making comparisons because:

- A gallon of propane has 72% of the energy of a gallon of gasoline; or
- A gallon of propane contains 28% less energy than a gallon of gasoline

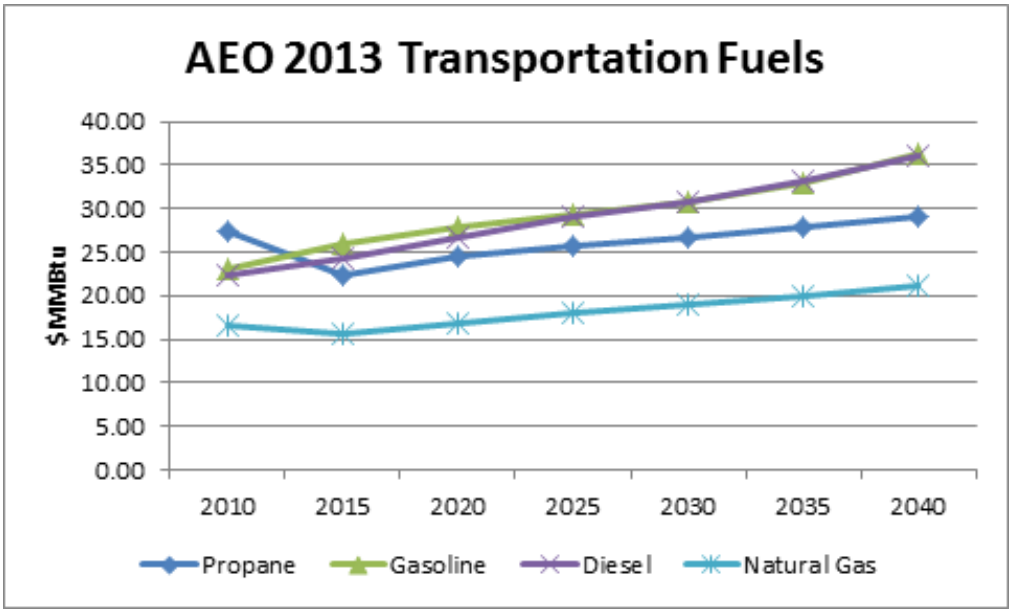
The aforementioned data is derived from the Transportation Energy Data Book (TEDB). The key point to this exercise is to calculate how much one is truly paying for the same amount of energy. That is why the Clean Cities Alternative Fuel Price Report (January 2014) provides exactly that type of analysis with charts that show the comparative price per GGE. Looking at the Clean Cities' report, the price of CNG offers a much better economic value than gasoline or propane. Btu values vary slightly from U.S. regions and it is important to check with local fuel suppliers to provide these numbers whenever possible.

Also note that all fuels, including CNG and propane, have two different Btu numbers: an HHV (Higher Heating Value = Gross) and an LHV (Lower Heating Value = Net), both calculated based on heat of combustion, a term that measures the energy released as heat when a compound undergoes complete combustion with oxygen under standard conditions. HHV can have a significantly higher Btu value when compared to LHV due to the additional heat (transferred to energy) gained through the vaporization of residual water during the combustion process. The HHV Btu measurement can be employed when evaluating products like natural gas or propane home heating furnaces or hot water tanks because these technologies leverage additional heat (energy) gained through water vaporization. The internal combustion engine, however, cannot capture these efficiencies and so the LHV value must be used due to its inability to recover and utilize the net benefits of water vapor during the combustion process.

The following graphs and charts are taken from various government entities responsible for tracking transportation fuels. They serve to visually show historical, current and forecasted industry trends.

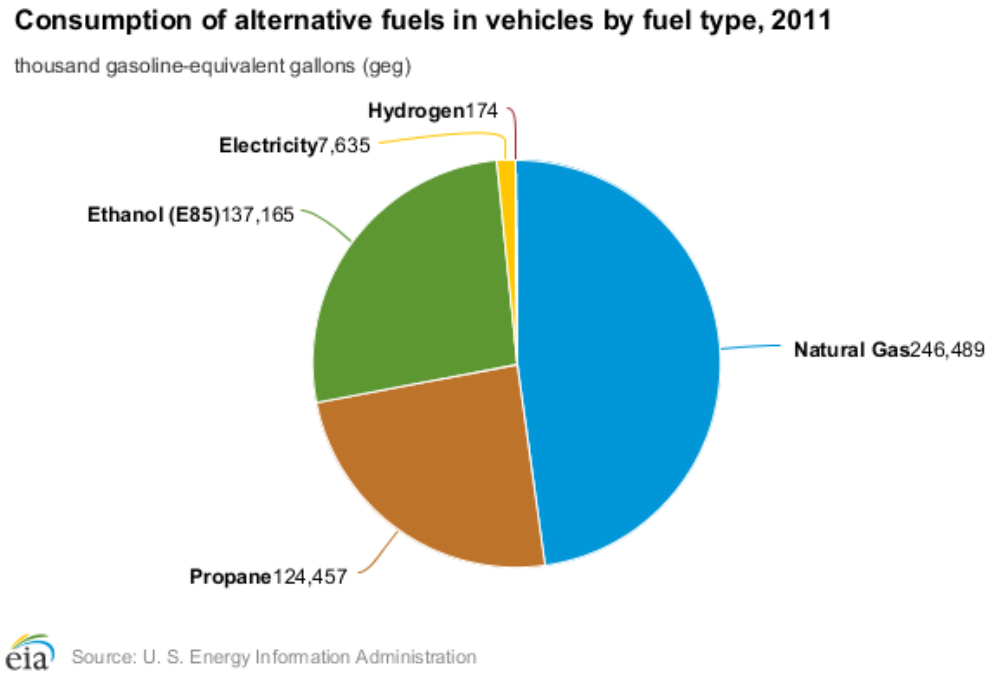



Source: US DOE AFDC Price Report (January 2014): http://www.afdc.energy.gov/fuels/prices.html

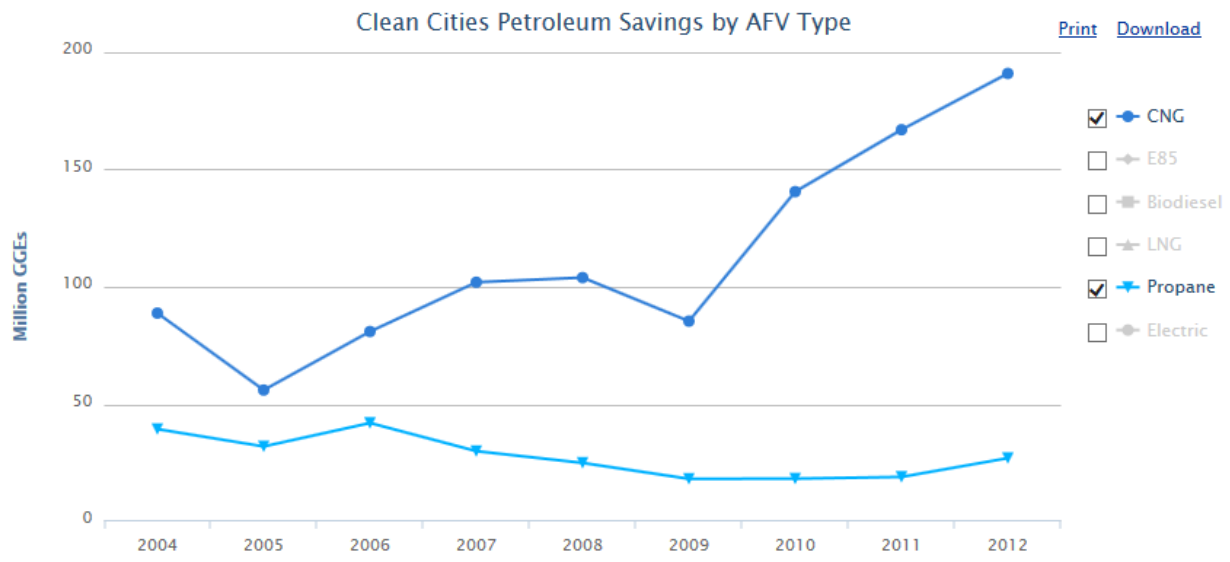



Source: US Energy Information Agency Annual Energy Outlook 2013: http://www.eia.gov/forecasts/aeo/index.cfm

The pie chart below shows that in 2011, natural gas accounted for 48% of the alternative fuels consumed; propane's contribution was 24%. The next release date for the report of this market share data is April 2014 where it is estimated that natural gas will capture close to 60% of the market.




US Energy Information Agency Alternative Fuel Vehicle Data (April 2013): http://www.eia.gov/renewable/afv/




Source: DOE AFDC Diesel Displacement Report (December 2013): http://www.afdc.energy.gov/data/10349

**Future: Scalability of Fuels and Infrastructure**

One of the important factors to consider when evaluating all transportation fuels, particularly for those responsible in fleet management, is scalability. A key question is whether natural gas and propane production and infrastructure can be scaled up to serve a large part of the U.S. transportation market. The U.S. transportation fuels market is roughly a 185 billion GGE market. The U.S. market for natural gas at 24 quadrillion Btu per year is equivalent to roughly 192 billion GGEs. Thus, the natural gas market today is actually larger than the on-road transportation fuels market by 3.8%. Propane at about 15 billion annual gallons represents the equivalent of about 10.9 billion GGE's and its total market size is less than 5.9% the size of the on-road transportation fuels market. The propane market is 5.7% of the size of the natural gas market.

To offset 5% to 10% of the total transportation fuel consumption (9.25 to 18.5 billion GGE), natural gas production would have to increase by about 4.8% to 9.6%, respectively. Propane production would have to increase by a staggering 84% to 169%, respectively. For propane, there is no reason to believe that domestic supply or infrastructure could possibly adjust to this level of demand without having a major impact on prices. Furthermore, there does not appear to be any effort in the propane industry to develop and expand the necessary infrastructure that would be required to service such an increase in demand. The natural gas industry on the other hand is investing hundreds of millions of dollars to expand its infrastructure to serve the transportation market. Thus, propane is most likely a niche market fuel at best that can help offset future transportation demand, but it will not have a substantial impact on the transportation fuels market or on petroleum imports.

Propane proponents' talking points critique the lack of and cost of infrastructure in the NGV market and choose to ignore the fact—that since 2009 there has been massive growth in the number of fueling locations in the U.S.: 64% and 125% increases in CNG and LNG infrastructure, respectively. Currently, natural gas infrastructure investments total up to $750 million ($3/4 billion), and multiple stakeholders are actively engaged in its development:

- Local gas distribution companies
- Natural gas retailers
- Natural gas exploration & production companies
- Leasing companies
- Customers (existing users of NGVs)
- "Traditional" fuel retailers (Truck Stops and "C-Stores")

Very simply put, both the capital and operating expenses of natural gas infrastructure, no matter how high or low, should be considered and weighed against revenue (or fuel savings) to determine investment worthiness (i.e., will the investor, whether it be a fleet or fuel provider, net a desirable return on their investment). Given the sheer volume of investments occurring in natural gas fueling infrastructure today, it appears that the answer is a resounding "yes" for a growing number of companies.

# Appendix C

## Clean Cities 2015 Vehicle Buyer's Guide

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Clean Cities

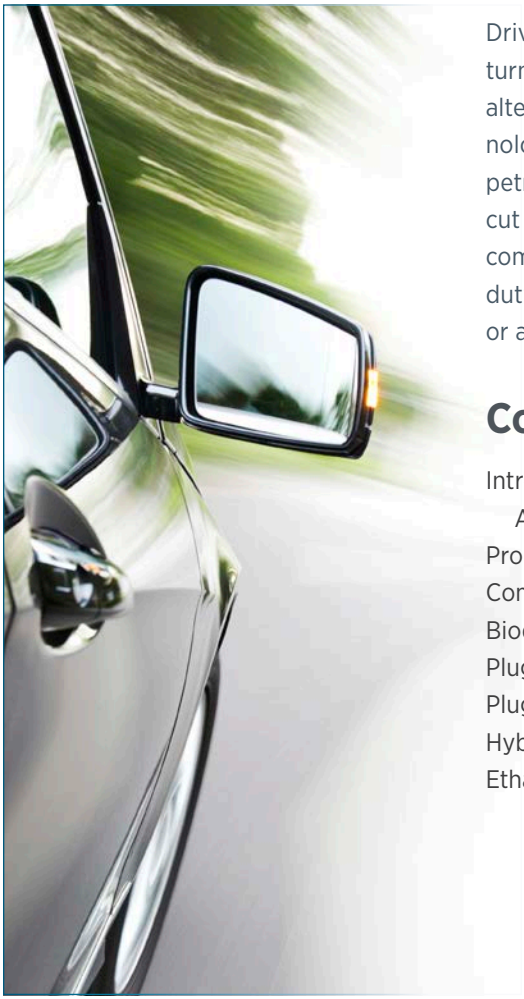
# 2015 Vehicle Buyer's Guide

- Propane
- Natural Gas
- Biodiesel
- Electric
- Hybrid
- Ethanol Flex-Fuel

Clean Cities
U.S. Department of Energy

Clean Cities

# 2015 Vehicle Buyer's Guide



Drivers and fleets are increasingly turning to the hundreds of light-duty, alternative fuel, and advanced technology vehicle models that reduce petroleum use, save on fuel costs, and cut emissions. This guide provides a comprehensive list of the 2015 light-duty models that use alternative fuels or advanced fuel-saving technologies.

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Clean Cities
U.S. Department of Energy

### Disclaimers



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# Introduction

Nissan Pathfinder HEV. *©, 2014 Nissan. Nissan, Nissan model names, the Nissan logo are registered trademarks of Nissan*

Society has a long history of using machines to move faster and go farther. Along the way, the innovation of manufacturers has both responded to and driven consumer priorities. Ingenuity has resulted in vehicles that incorporate new technologies and operate efficiently on alternative fuels, all while controlling emissions and lowering operating costs. In fact, there are approximately 20 million alternative fuel vehicles (AFVs) on U.S. roads today—more than a quarter million of which are plug-in electric vehicles.

Honda Civic CNG. *Photo from American Honda*

The number of AFVs continues to grow for several reasons, including the need to meet federal, state, and municipal requirements for reducing carbon emissions. The large number of available federal and state incentives, and fuel cost savings are driving consumer demand as well. Consumers and fleets are also finding more options to choose from, whether selecting biodiesel, electricity, ethanol, natural gas, or propane. In addition, the expanding network of fueling and charging infrastructure is opening up more possibilities. Across the United States, there are now close to 15,000 publicly accessible alternative fuel stations.

# About This Guide

This guide presents a comprehensive list of model year (MY) 2015 light-duty alternative fuel and advanced technology vehicles, grouped by fuel type and technology. It features model-specific information on vehicle specifications, manufacturer suggested retail price (MSRP), fuel economy, energy impact, and emissions. Consider this guide an unbiased resource when you are ready to evaluate options, compare vehicles, and find data to inform your buying decisions. This handy guide provides a snapshot of available vehicles. The information is also available through an online database hosted by the Alternative Fuels Data Center (AFDC). The database is regularly updated and may contain more vehicles and data than were available at the time this guide was printed. See the online data at *afdc.energy.gov/vehicles/search*.

## Fuel Economy

By choosing the most fuel-efficient vehicle in a particular class, it is possible to realize significant savings in fuel costs each year. This can amount to significant savings over a vehicle's lifetime.

For each fuel type listed in this guide, two fuel economy estimates are given. First is a "city" estimate that represents urban driving, in which a vehicle is started in the morning (after being parked all night) and driven in stop-and-go traffic. Second is a "highway" estimate that represents a mixture of rural and interstate highway driving in a warmed-up vehicle, typical of longer trips in free-flowing traffic.

Ram 1500 Diesel. *Photo from Chrysler Group LLC*

Estimates for all vehicles are based on manufacturers' laboratory tests using U.S. Environmental Protection Agency (EPA) standardized conditions to allow for fair comparisons. Plug-in hybrid electric vehicles (PHEVs) have estimates for (1) gasoline only or (2) charge-depleting operation, which may be electric-only or a combination of electric and gasoline use. Their fuel economy estimates are expressed in miles per gallon (MPG) and miles per gasoline gallon equivalent (MPGe), representing the number of miles a vehicle can travel using a quantity of fuel with the same energy content as a gallon of gasoline. Ethanol flex-fuel vehicles (FFVs), which can use gasoline and E85, have estimates for both fuels.

For some vehicle models, EPA data were not available at the time of this guide's publication. For answers to frequently asked questions about fuel economy estimates, visit *fueleconomy.gov*.

Kia Soul PEV. *Photo courtesy of Kia Motors America*

Your vehicle's actual fuel economy is likely to vary from the EPA estimates presented in this guide. Fuel economy varies significantly based on where the vehicle is driven, how it is driven, and other factors. No one set of estimates can predict fuel economy precisely for all drivers in all environments. However, the EPA estimates are useful for comparing the fuel economy of different vehicles, even though they may not accurately predict the average MPG you will achieve. Fueleconomy.gov's My MPG tool can help you calculate and track your fuel economy and compare it with EPA test ratings, and share your MPG with other users. To find out what you can do to improve the fuel economy of your vehicle, see the following pages on fueleconomy.gov:

- Driving More Efficiently
- Keeping Your Car in Shape
- Tips for Hybrids, Plug-in Hybrids, and Electric Vehicles
- Fuel Economy in Cold Weather
- Fuel Economy in Hot Weather.

## Energy Impact Scores

Energy Impact Scores allow buyers to compare vehicles' annual estimated petroleum consumption. These scores represent the number of barrels of petroleum a vehicle will likely consume each year. The scores are based on 45% highway driving, 55% city driving, and 15,000 annual miles. One barrel of petroleum equals 42 gallons.

## Smog Scores

Smog Scores, determined by EPA, reflect vehicle tailpipe emissions that contribute to local and regional air quality problems and related health issues. Scores are based on U.S. vehicle emission standards for criteria pollutants, including carbon monoxide, formaldehyde, nitrogen oxides, non-methane organic gas, and particulate matter. Scores range from 1 to 10, where 10 is best. In this guide, Smog Scores have been replaced for electric vehicles and PHEVs with estimated all-electric driving range to give consumers more meaningful information about the applicability of the vehicle to their needs.

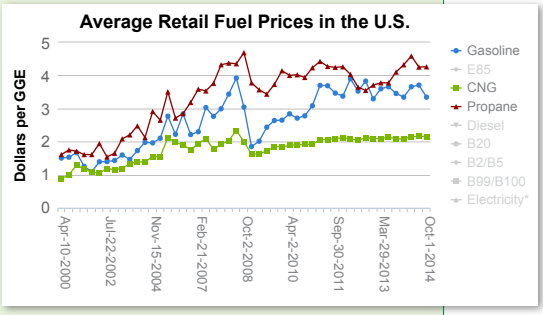
## Greenhouse Gas Emissions Scores

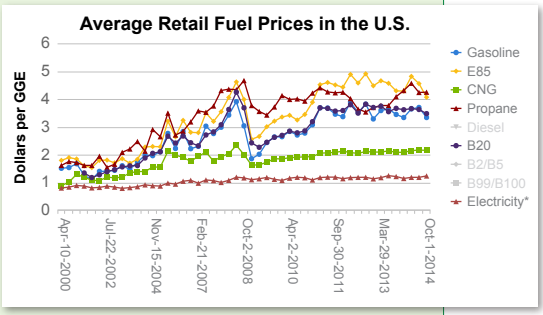
Greenhouse Gas (GHG) Scores reflect tailpipe emissions of carbon dioxide and other GHGs, which contribute to climate change. Scores range from 1 to 10, where 10 is best. The GHG Scores in this guide do not reflect emissions related to the production or distribution of fuels or vehicles.

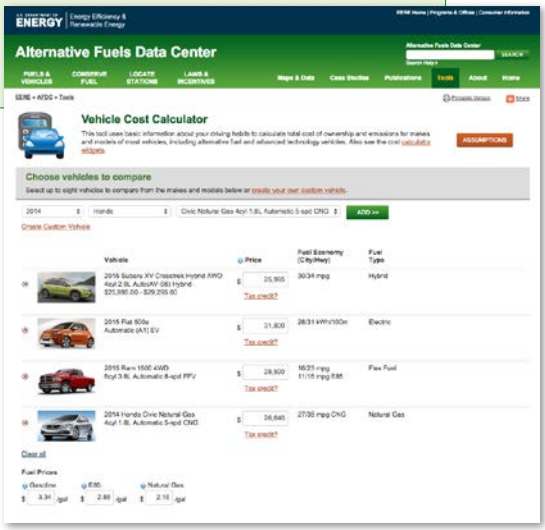
## Compare Vehicle Costs and Emissions Before You Purchase

The true cost of a vehicle is more than just the number on its price tag. It also includes lifetime ownership costs for fuel, maintenance, and other necessities. The AFDC's Vehicle Cost Calculator can help you easily assess the full cost of a vehicle. In addition, this online tool can perform a side-by-side comparison of multiple vehicles that includes the average current cost of conventional fuels, alternative fuels, and electricity. The Vehicle Cost Calculator also allows users to evaluate a vehicle's emissions benefits. The tool's capabilities help make vehicle purchase decisions easier and more thorough (see *afdc.energy.gov/calc*).

To find out how the price of alternative fuels compares to gasoline and diesel prices, see the Clean Cities Alternative Fuel Price Report, available online at *afdc.energy.gov/fuels/prices.html*.



Ford E-Series vans available with CNG/LPG prep package. *Photo from Ford Motor Company*

## Converting Vehicles to Run on Alternative Fuels

Several options are available to convert a vehicle from using only gasoline to using an alternative fuel. Many conventional vehicles can be converted to run on CNG, propane, electricity, or other alternative fuels, with little effect on horsepower, towing capacity, or factory warranty.

All conversions must meet emissions and safety standards instituted by EPA, the National Highway Traffic Safety Administration, and relevant state agencies. Conversions should be performed by an authorized technician associated with a manufacturer that holds all relevant emissions-related certifications and permissions.

Chevrolet Silverado HD 2500. *Photo from General Motors*

Many new and used conventional light-duty vehicles can be converted to run on propane or CNG for a cost of about $4,000 to $12,000 per vehicle.

The table on page 13 lists conversion companies that, as of September 2014, offer certified CNG or propane conversion systems for various 2014 and 2015 vehicles. Most conversion companies provide up-to-date information online about the vehicle models and powertrains with which their systems are compatible. The lists of systems certified by EPA and/or the California Air Resources Board (CARB) are updated regularly. Visit EPA's "Alternative Fuel Conversion" page (*epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm*) and CARB's page on Certification of Alternative Fuel Retrofit Systems (*arb.ca.gov/msprog/aftermkt/altfuel/altfuel.htm*) for the most current lists of certified systems for vehicles of all model years. Find out more about vehicle conversions at *afdc.energy.gov/vehicles/conversions.html*.

| 2014–2015 EPA-Certified Light-Duty Clean Alternative Fuel Conversions | | |
|---|---|---|
| **Conversion Fuel System** | **Original Equipment Manufacturer (OEM)** | **Conversion Fuel System Manufacturer** |
| ***Dedicated CNG*** | Ford Motor Company | Altech-Eco Corporation<br>BAF Technologies<br>IMPCO Automotive, Inc<br>Landi Renzo USA Corporation<br>World CNG |
| | General Motors | BAF Technologies<br>IMPCO Automotive, Inc<br>The CNG Store, LLC (dba Auto Gas America) |
| | Chrysler Group, LLC | NatGasCar, LLC |
| ***Bi-Fuel CNG/Gasoline*** | Ford Motor Company | AC Spółka Akcyjna (dba Stag Autogas Systems)<br>Altech-Eco Corporation<br>BAF Technologies<br>CNG Interstate of Oklahoma, LLC<br>Landi Renzo USA Corporation<br>M-Tech Solutions, Inc<br>NatGasCar, LLC<br>PowerFuel CNG Conversions, LLC<br>Westport Power, Inc |
| | General Motors | AGA Systems, LLC<br>IMPCO Automotive, Inc<br>NatGasCar, LLC<br>The CNG Store, LLC (dba Auto Gas America) |
| | Chrysler Group, LLC | NatGasCar, LLC |
| ***Dedicated Propane*** | Ford Motor Company | Icom North America, LLC<br>Roush Industries, Inc. |
| ***Bi-Fuel Propane/ Gasoline*** | Ford Motor Company | Blossman Services, Inc<br>Icom North America, LLC<br>IMPCO Automotive, Inc |
| | General Motors | Icom North America, LLC<br>IMPCO Technologies, Inc. |

*Source: EPA Certified Clean Alternative Fuel Conversion Systems (Excel)*
epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm#4

*CARB Alternative Fuel Retrofit Systems Certified By The Air Resources Board (Pdf)*
arb.ca.gov/msprog/aftermkt/altfuel/altfuel.htm

# Propane Vehicles

Ford Super Duty F-550 chassis cab available with LPG prep package. *Photo from Ford Motor Company*

## Propane is used worldwide

Chevrolet Express Cutaway. *Photo from General Motors*

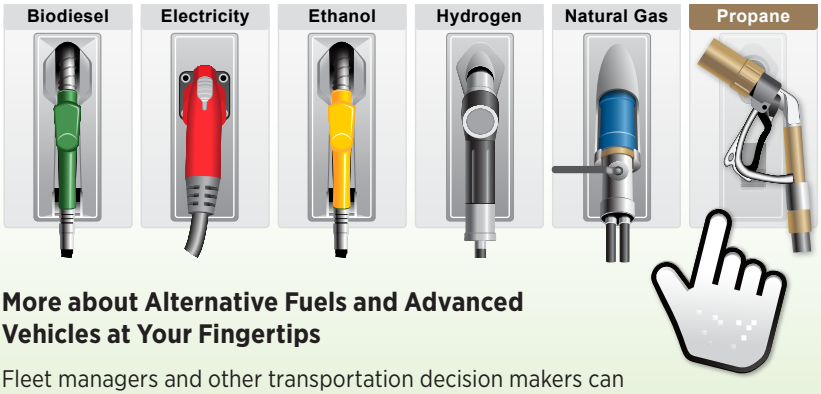
Also known as liquefied petroleum gas (LPG), propane is the most commonly used alternative motor fuel in the world, and its price is typically lower and more stable than gasoline. That means fuel cost savings can quickly offset any increased purchase price, and state incentives may further improve the return on investment. Propane-fueled vehicles produce about 10% fewer greenhouse gas emissions than equivalent conventional vehicles. Other advantages of propane as an alternative fuel include its domestic production, performance, and clean-burning qualities. It's important that you know where propane fueling is available before purchasing a propane vehicle. As of October 2014, propane is available at more than 2,600 stations throughout the country. See page 19 for information on finding propane fueling stations in your area.

See page 8 for more information about converting conventional vehicles to run on propane.

Ford Transit Connect Wagon available with LPG prep package. *Photo from Ford Motor Company*

| Propane Vehicle Model | Vehicle Type | Engine Size | Starting MSRP |
|---|---|---|---|
| Chevrolet Express Cutaway 3500/4500 | Van | 6.0L; V8 | - |
| GMC Savana Cutaway 3500/4500 | Van | 6.0L; V8 | - |
| Ford Super Duty F-350/450/550* | Chassis Cab | 6.2L; V8 | $31,400 |
| Ford Super Duty F-350/450/550* | Chassis Cab | 6.8L; V10 | $31,400 |
| Ford Super Duty F-250/350* | Pickup | 6.2L; V8 | $31,045 |
| Ford Super Duty F-650* | Chassis Cab | 6.8L; V10 | $55,595 |
| Ford Transit Connect* | Van/Wagon | 2.5L; I4 | $22,000 |
| Ford Transit 150/250/350* | Van/Wagon | 3.7L; V6 | $29,556 |
| Ford E-350/450* | Chassis Cab/ Cutaway | 5.4L; V8 | - |
| Ford E-350/450* | Chassis Cab/ Cutaway | 6.8L; V10 | - |

** Ford offers a "prep package" for this vehicle. An approved qualified vehicle modifier (QVM) can convert the vehicle to run on propane for delivery through select Ford dealerships, without impacting OEM warranties or service agreements.*




## More about Alternative Fuels and Advanced Vehicles at Your Fingertips

Fleet managers and other transportation decision makers can use a wide array of information, data, and tools on the AFDC website that will help reduce petroleum consumption. Up-to-date news on the latest manufacturer offerings, a selection of YouTube videos that share success stories from across the country, and the basics of converting vehicles to run on alternative fuels are a small sample of what's available from this helpful website. It's all online at *afdc.energy.gov*.

# Compressed Natural Gas Vehicles

Ram 2500. *Photo from Chrysler Group LLC*

## Compressed natural gas vehicles have low fuel costs and other benefits

Compressed natural gas (CNG) is readily available from domestic sources, and its use as a vehicle fuel is growing. On a gasoline gallon equivalent (GGE) basis, CNG vehicles get about the same fuel economy as comparable conventional vehicles—with lower fuel prices than those of gasoline and diesel. The resulting fuel cost savings can help offset the purchase price of a CNG vehicle, and state incentives may provide additional financial assistance (see page 29).

In the near future, renewable natural gas (or biogas) is expected to significantly reduce GHG emissions when used for transportation. Biogas is captured from landfills, sewage treatment facilities, or agricultural waste.

Chevrolet Impala. *Photo from General Motors*

## Fueling infrastructure is an important factor

If you are considering the purchase of a CNG vehicle or converting a conventional vehicle to run on CNG, it's important to determine whether CNG fueling infrastructure is available at locations that are convenient to you. As of October 2014, there were more than 750 publicly accessible CNG fueling stations across the country (see page 19 for information on fueling stations).

Ford Super Duty F-250. *Photo from Ford Motor Company*

| Natural Gas Vehicle Model | Vehicle Type | Engine Size | Starting MSRP |
|---|---|---|---|
| Chevrolet Silverado 2500/3500 HD | Pickup | 6.0L; V8 | - |
| Chevrolet Impala | Sedan | 3.6L; V6 | $38,210 |
| Chevrolet Express 2500/3500 | Van | 6.0L; V8 | - |
| Chevrolet Express Cutaway 3500/4500 | Van | 6.0L; V8 | - |
| Ford Super Duty F-350/450/550* | Chassis Cab | 6.2L; V8 | $31,400 |
| Ford Super Duty F-350/450/550* | Chassis Cab | 6.8L; V10 | $31,400 |
| Ford Super Duty F-250/350* | Pickup | 6.2L; V8 | $31,045 |
| Ford Super Duty F-650* | Chassis Cab | 6.8L; V10 | $55,595 |
| Ford Transit Connect* | Van/Wagon | 2.5L; I4 | $22,000 |
| Ford Transit 150/250/350* | Van/Wagon | 3.7L; V6 | $29,556 |
| Ford E-350/450* | Chassis Cab/ Cutaway | 5.4L; V8 | - |
| Ford E-350/450* | Chassis Cab/ Cutaway | 6.8L; V10 | - |
| GMC Savana 2500/3500 | Van | 6.0L; V8 | - |
| GMC Savana Cutaway 3500/4500 | Van | 6.0L; V8 | - |
| GMC Sierra 2500/3500 HD | Pickup | 6.0L; V8 | - |
| Honda Civic | Sedan | 1.8L; I4 | $26,640 |
| Ram 2500 | Pickup | 5.7L; V8 | - |

** Ford offers a "prep package" for this vehicle. An approved qualified vehicle modifier (QVM) can convert the vehicle to run on natural gas for delivery through select Ford dealerships, without impacting OEM warranties or service agreements.*


# Biodiesel Vehicles

Jeep Grand Cherokee. *Photo from Chrysler Group LLC*

## Biodiesel is a renewable option for diesel vehicles

Biodiesel is a renewable alternative fuel that is domestically produced from new and used vegetable oils, animal fats, and recycled restaurant grease. Compared to petroleum diesel, biodiesel is cleaner burning and can decrease life cycle emissions of carbon dioxide by more than half. Pure biodiesel (B100) must be produced to strict specifications (ASTM D6751) to ensure proper performance at any blend level. It can then be blended and used in different concentrations ranging from B2 (2% biodiesel, 98% diesel fuel) to B100. B20 (20% biodiesel, 80% diesel fuel) is a common biodiesel blend in the United States.

Ford Transit chassis cab. *Photo from Ford Motor Company*

Currently, every original equipment manufacturer (OEM) of diesel vehicles in the United States approves blends of up to B5 in their vehicles. Many OEMs already approve blends up to B20 in some or all of their diesel vehicles. B20 has been shown to perform well in cold weather conditions and in older engines. Close to 300 publicly accessible fueling stations across the country offer biodiesel blends of B20 or above. To find biodiesel stations with blends of B20 and higher in your area, see the Alternative Fueling Station Locator at *afdc.energy.gov/stations*.

**Note:** Pure vegetable oil is not biodiesel and is not a legal motor fuel in the United States. Using it can void your vehicle's warranty.

| Biodiesel Vehicle Model | Vehicle Type | Engine Size | Starting MSRP |
|---|---|---|---|
| Chevrolet Silverado 2500/3500 HD 2WD/4WD | Pickup | 6.6L; V8 | - |
| Chevrolet Silverado 3500 HD Chassis Cab | Pickup | 6.6L; V8 | - |
| Chevrolet Express 2500/3500 | Van | 6.6L; V8 | $41,500 |
| Chevrolet Express 3500/4500 Cutaway | Van | 6.6L; V8 | - |
| Chevrolet Cruze | Sedan | 2.0L; I4 | $17,170 |
| Ford Transit 150/250/350 | Van | 3.2L; I5 | $29,566 |
| Ford Transit 250/350 | Chassis Cab | 3.2L; I5 | $26,960 |
| Ford Super Duty F-250/350/450 | Pickup | 6.7L; V8 | $31,045 |
| Ford Super Duty F-450/550/650 | Chassis Cab | 6.7L; I6 | $55,595 |
| GMC Sierra HD 2500/3500 2WD/4WD | Pickup | 6.6L; V8 | - |
| GMC Sierra 3500 HD Chassis Cab | Pickup | 6.6L; V8 | - |
| GMC Savana 2500/3500 | Van | 6.6L; V8 | $41,500 |
| GMC Savana 3500/4500 Cutaway | Van | 6.6L; V8 | - |
| Jeep Grand Cherokee 2WD/FWD | SUV | 3.0L; V6 | $29,595 |
| Ram 1500 2WD/4WD | Pickup | 3.0L; V6 | $24,610 |
| Ram 2500/3500 HD | Pickup | 6.7L; I6 | - |
| Ram 3500 Chassis Cab | Pickup | 6.7L; I6 | - |

# Plug-In Electric Vehicles

Chevrolet Spark. *Photo from General Motors*

## All-electric vehicles can yield significant emissions benefits

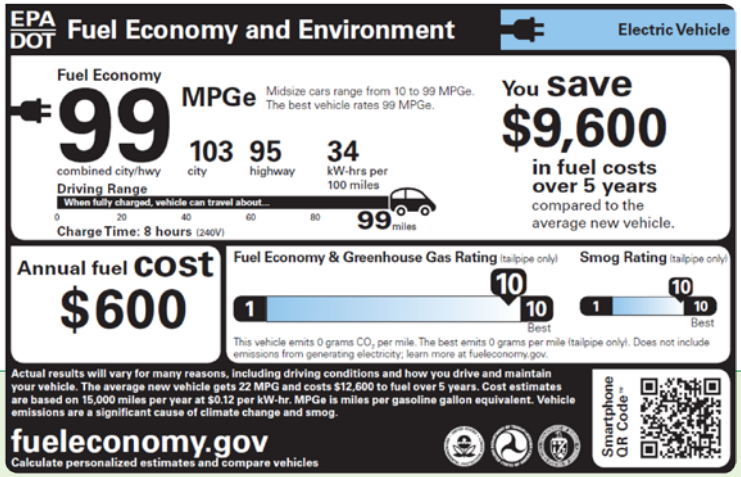
All-electric vehicles (EVs) run on electricity only. They are propelled by an electric motor (or motors) powered by rechargeable battery packs. EV batteries are charged by plugging them into an off-board electrical power source. They can also be charged in part through regenerative braking, which generates electricity from some of the energy normally lost when braking. EVs produce no tailpipe emissions, although the power plant producing the electricity may produce emissions. Electric motors provide quiet operation and require less maintenance than traditional internal combustion engines.

Nissan Leaf. *©, 2014 Nissan. Nissan, Nissan model names, the Nissan logo are registered trademarks of Nissan*

Battery charging times range from less than 20 minutes to 20 hours or more, depending on the type of charging equipment used, the type and capacity of the battery, and how depleted it is. Technology improvements are increasing battery capacity and lifetime, as well as lowering costs. The prices of EVs tend to be higher than those of similar conventional and hybrid electric vehicles, but some costs may be recovered through fuel savings, a federal tax credit, or state incentives. See page 19 to find out how to calculate EV fuel savings, and page 29 for information about finding incentives.

The popularity of EVs is expected to continue. All major OEMs now offer a fully electric vehicle for sale or lease, although the area of availability is limited for some. During 2014, the number of registered plug-in vehicles surpassed a quarter million.

Electric vehicles are being supported by a continuously growing network of publicly available charging stations that now exceeds 8,500. The number of "DC fast charge" stations is rising, allowing for shorter charging times and increasing vehicle utility. (See page 19 for information about finding stations in your area, and visit the AFDC website at *afdc.energy.gov/fuels/electricity_infrastructure.html* to learn more about EV charging.)




## Plug-In Vehicles and EPA Labels

EPA labels for EVs display fuel economy estimates in kilowatt-hours (kWh) per 100 miles and in MPGe. MPGe represents the number of miles a vehicle can travel using a quantity of fuel with the same energy content as a gallon of gasoline (33 kWh). For PHEVs, EPA labels display separate fuel economy estimates for the charge-depleting and gasoline-only modes. Estimates for the charge-depleting mode may be for electricity use only (MPGe and kWh/100 mi) or gasoline-plus-electricity use (MPGe and kWh/100 mi + gal/100 mi) depending on the type of PHEV system. Estimates for PHEVs in gasoline-only operation are expressed in MPG and gallons per 100 miles. All this information allows for efficiency comparisons across different types of vehicles and fuels. For more information, visit *fueleconomy.gov/label*.

EPA plug-in vehicle labels also contain information about GHG emissions and air pollution. EVs will show very good Smog Scores and GHG Scores. However, this information reflects tailpipe emissions only, and it does not account for well-to-wheels emissions, which are all emissions associated with the production, processing, and distribution of electricity, gasoline, or any other fuel that powers the vehicle. For information on comparing well-to-wheels emissions of conventional and plug-in vehicles, visit *afdc.energy.gov/vehicles/electric_emissions.php*.

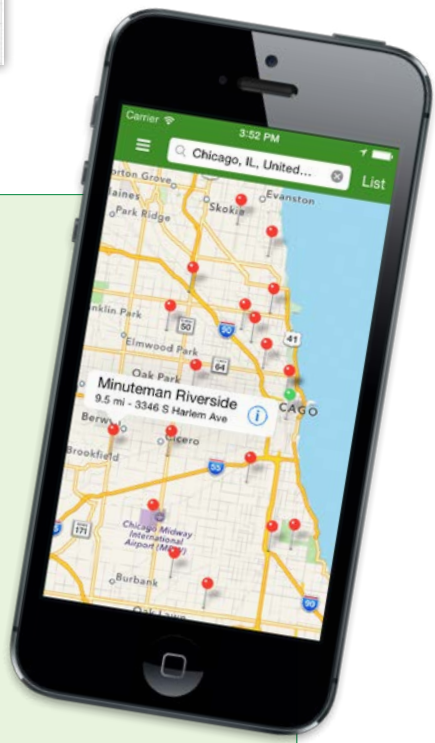
| Electric Vehicle Model | Electric Motor; Battery Size | Energy Impact Score* (Barrels Petroleum/Year) | Driving Range (Miles) | GHG Score** | Fuel Economy (MPGe) *City/Hwy* | Starting MSRP |
|---|---|---|---|---|---|---|
| BMW i3 | 125 kW/21 kWh | 0.2 | 81 | 10 | 137/114 | $41,350 |
| Chevrolet Spark | 104 kW/20 kWh | 0.2 | 82 | 10 | 128/109 | $27,495 |
| Fiat 500e | 83 kW/24 kWh | 0.2 | 87 | 10 | 122/108 | - |
| Ford Focus | 107 kW/23 kWh | 0.2 | 76 | 10 | 110/99 | $35,170 |
| Honda Fit | 92 kW/20 kWh | 0.2 | 82 | 10 | 132/105 | - |
| Kia Soul | 50 kW/16.4 kWh | 0.2 | 93 | 10 | 120/92 | - |
| Mercedes-Benz B-Class Electric | 132 kW/28 kWh | 0.2 | 87 | 10 | 85/83 | $41,450 |
| Mitsubishi i-MiEV | 49 kW/16 kWh | 0.2 | 62 | 10 | 126 / 99 | - |
| Nissan Leaf | 80 kW/24 kWh | 0.2 | 84 | 10 | 126/101 | $29,010 |
| smart fortwo | 55 kW/17.6 kWh | 0.2 | 68 | 10 | 122/93 | - |
| Tesla Model S | 300 kW/60 kWh | 0.2 | 208 | 10 | 94/97 | $69,900 |
| Toyota RAV 4 EV | 115 kW/41.8 kWh | 0.2 | 103 | 10 | 78/74 | $49,800 |
| Volkswagen e-Golf | 85 kW/24.2 kWh | 0.2 | 85 (est.) | 10 | 125/105 | $36,265 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*


Click "Personalize" to enter the fuel cost calculator

## Compare Fuel Costs Before You Buy

The Find and Compare Cars tool at *fueleconomy.gov* features an annual fuel cost calculator that allows you to insert your local gasoline prices and typical driving conditions (percentage of city and highway driving) to obtain the most accurate fuel cost information for your vehicle.




## Find an Alternative Fueling Station or Electric Charging Station

It is easy to locate alternative fueling sites across the country by using the tools offered by the AFDC. The Alternative Fueling Station Locator (*afdc.energy.gov/locator/stations*) is an online tool that helps drivers find stations that provide propane, biodiesel blends of 20% (B20) or greater, CNG, electric charging, E85, and hydrogen. Users can also download the data to determine the number of stations in a given geographic area, and plan a route with stations identified along the way.

The Station Locator is also available as a convenient iPhone app, which can be downloaded at no cost from iTunes. The app provides the same area- and fuel-specific information as the online tool. A mobile version of the tool is also available.

# Plug-In Hybrid Electric Vehicles


Audi A3 e-tron. *Photo Courtesy of Audi*

## Plug-in hybrid electric vehicles provide flexibility in fueling and charging

PHEVs use batteries to power an electric motor and use another fuel, such as gasoline or diesel, to power an internal combustion engine. The batteries can be charged from an off-board electrical power source, through regenerative braking, or by the internal combustion engine. Powering the vehicle with electricity some or all of the time significantly reduces operating costs, petroleum use, and tailpipe emissions.

PHEVs don't have to be plugged in before driving; they can be fueled solely with gasoline like a conventional hybrid. However, they will not achieve maximum fuel economy or take full advantage of their all-electric capabilities without plugging in. Like EVs, these vehicles are supported by the same continuously growing network of charging stations.

Ford Fusion Energi. *Photo from Ford Motor Company*

Mercedes-Benz S550. *Photo Mercedes-Benz USA*

| Plug-In Hybrid Electric Vehicle Model | Gasoline Engine/ Electric Motor | Energy Impact Score* (Barrels Petroleum/ Year) | All-Electric Range (Miles) | GHG Score** | Fuel Economy | | Starting MSRP |
|---|---|---|---|---|---|---|---|
| | | | | | Gasoline Only *(MPG) City/Hwy* | Electric + Gasoline *(MPGe) Combined City-Hwy* | |
| Audi A3 e-tron | 1.4L I4/75 kW | - | 31 | - | - | - | $40,000 (est.) |
| BMW i8 Plug-in Hybrid | 1.5L I3/96 kW | 7.4 | 14 | 10 | - | 76 | $135,700 |
| BMW i3 REX | 0.6L I2/125 kW | 1.6 | 72 | 10 | - | 117 | $45,200 |
| Cadillac ELR | 1.4L I4/111 kW | 3.6 | 37 | 10 | 31/35 | 82 | $75,995 |
| Chevrolet Volt | 1.4L I4/111 kW | 3.1 | 38 | 10 | 35/40 | 98 | $34,185 |
| Ford C-MAX Energi | 2.0L I4/68 kW | 4.9 | 20 | 10 | 40/36 | 88 | $31,635 |
| Ford Fusion Energi | 2.0L I4/68 kW | 4.9 | 20 | 10 | 40/36 | 88 | $34,700 |
| Honda Accord Plug-in Hybrid | 2.0L I4/124 kW | 4.8 | - | 10 | 47/46 | 115 | $39,780 |
| McLaren P1 | 3.8L V8/132 kW | 10.8 | 0 | 4 | 16/20 | 18 | - |
| Mercedes-Benz S550 Plug-in Hybrid | 3.0L V6/85 kW | - | 20 | - | - | - | - |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Plug-In Hybrid Electric Vehicle Model | Gasoline Engine/ Electric Motor | Energy Impact Score* (Barrels Petroleum/ Year) | All-Electric Range (Miles) | GHG Score** | Fuel Economy | | Starting MSRP |
|---|---|---|---|---|---|---|---|
| | | | | | Gasoline Only *(MPG) City/Hwy* | Electric + Gasoline *(MPGe) Combined City-Hwy* | |
| Porsche 918 Spyder | 4.6L V8/95 kW front/115 kW rear | 10.4 | 19 | 8 | 20/24 | 67 | $845,000 |
| Porsche Cayenne S E-Hybrid | 3.0L V6/70 kW | - | - | - | - | - | $76,400 |
| Porsche Panamera S E-Hybrid | 3.0L V6/70 kW | 8.1 | 12 | 9 | 23/29 | 50 | $96,100 |
| Toyota Prius Plug-in | 1.8L I4/38 kW | 4.7 | 11 | 10 | 51/49 | 95 | $29,900 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

## Hydrogen Fuel Cell Vehicles

A hydrogen fuel cell vehicle combines hydrogen gas with oxygen from the air to produce electricity, which drives an electric motor. Fuel cell vehicles produce no harmful tailpipe emissions.

Toyota, Hyundai, and Mercedes-Benz all offer limited numbers of vehicles for use in areas that have access to hydrogen fueling stations. Honda is set to release the next generation of their fuel cell vehicle in the near future.

Hyundai Tucson Fuel Cell.
*Photo courtesy of Hyundai Motor America*

# Hybrid Electric Vehicles

Infiniti Q70 Hybrid. *Photo courtesy of Infiniti USA*

## Hybrid technologies can boost fuel economy

Hybrid electric vehicles (HEVs) are powered by an internal combustion engine and an electric motor that uses energy stored in a battery. HEVs run on gasoline and the battery cannot be recharged by plugging it in. Instead, the battery is charged by the internal combustion engine and through regenerative braking. The extra power provided by the electric motor allows for a smaller engine, resulting in better fuel economy without sacrificing performance.

Toyota Highlander Hybrid.
*Photo from Toyota Motor Sales, U.S.A., Inc.*

Some HEVs achieve fuel economy ratings of 40–50 MPG. Compared to similar conventional vehicles, they generally produce lower levels of air pollutants and GHG emissions.

## Hybrid configurations vary among models

HEVs range from "full" to "mild" hybrids. Full hybrids are listed in this guide, and they can run on battery power alone during stops and at low speeds. When speeds increase, the electric motor works with the gasoline engine to provide power. Full hybrids are 25%–40% more fuel efficient than comparable conventional vehicles. Mild hybrids use a battery and electric motor to help power the vehicle, allowing the engine to shut off when the vehicle stops at traffic signals and in stop-and-go traffic, minimizing idling, and improving fuel economy. However, electricity alone cannot propel a mild hybrid. These vehicles usually cost less than full hybrids, but they provide more modest increases in fuel economy.

| Hybrid Electric Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) | Smog Score** | GHG Score** | Fuel Economy (MPG) *City/Hwy* | Starting MSRP |
|---|---|---|---|---|---|---|
| Audi Q5 Hybrid AWD | 2.0 I4 | 12.7 | 6 | 5 | 24/30 | $51,900 |
| BMW ActiveHybrid 3 | 3.0L I6 | 11.8 | 5 | 7 | 25/33 | $49,900 |
| BMW ActiveHybrid 5 | 3.0L I6 | 12.7 | 5 | 6 | 23/30 | $61,650 |
| BMW ActiveHybrid 7 | 3.0L I6 | 13.2 | 5 | 6 | 22/30 | $84,300 |
| Ford C-MAX Hybrid | 2.0L I4 | - | 7 | 9 | 42/37 | $27,170 |
| Ford Fusion Hybrid | 2.0L I4 | 7.8 | 7 | 9 | 44/41 | $26,475 |
| Honda Civic Hybrid | 1.5L I4 | 7.3 | - | 10 | 44/47 | $24,635 |
| Honda CRZ | 1.5L I4 | 8.9 | - | 9 | 36/39 | $19,995 |
| Honda Accord | 2.0L I4 | 7.0 | - | 10 | 50/45 | $35,055 |
| Hyundai Sonata | 2.4L I4 | 8.7 | 9 | 9 | 36/40 | - |
| Infiniti Q50 Hybrid FWD/AWD | 3.5L V6 | 10.6 | - | 8 | 29/36 | - |
| Infiniti Q50S Hybrid FWD/AWD | 3.5L V6 | 11.0 | - | 7 | 28/34 | - |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Hybrid Electric Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) | Smog Score** | GHG Score** | Fuel Economy (MPG) *City/Hwy* | Starting MSRP |
|---|---|---|---|---|---|---|
| Infiniti Q70 Hybrid | 3.5L V6 | 10.6 | 5 | 8 | 29/34 | $55,900 |
| Infiniti QX60 Hybrid | 2.5L I4 | 12.7 | - | 6 | 26/28 | - |
| Kia Optima | 2.4L I4 | 8.7 | 9 | 9 | 36/40 | - |
| Lexus CT 200h | 1.8L I4 | 7.8 | - | 9 | 43/40 | $32,050 |
| Lexus ES 300h | 2.5L I4 | 8.2 | 7 | 9 | 40/39 | $40,430 |
| Lexus LS 600h L | 5.0L V8 | - | - | - | - | $120,060 |
| Lexus GS 450h F Sport | 3.5L V6 | - | - | - | - | $69,130 |
| Lexus GS 450h | 3.5L V6 | 10.6 | - | 8 | 29/34 | $60,430 |
| Lexus RX 450h FWD/AWD | 3.5L V6 | 11.0 | 7 | 7 | 32/28 | $47,620 |
| Lexus NX 300h FWD/AWD | 2.5L I4 | 10.0 | - | 8 | 35/31 | - |
| Lincoln MKZ | 2.0L I4 | 8.2 | 7 | 9 | 41/39 | $35,190 |
| Mercedes-Benz E400 Hybrid | 3.5L V6 | 12.7 | 6 | 7 | 24/30 | - |
| Nissan Pathfinder Hybrid 2WD/AWD | 2.5L I4 | 12.7 | - | 6 | 25/28 | $36,300 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Hybrid Electric Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) | Smog Score** | GHG Score** | Fuel Economy (MPG) *City/Hwy* | Starting MSRP |
|---|---|---|---|---|---|---|
| Subaru XV Crosstrek Hybrid | 2.0L I4 | 10.6 | - | 8 | 30/34 | - |
| Toyota Avalon | 2.5L I4 | 8.2 | - | 9 | 40/39 | - |
| Toyota Camry | 2.5L I4 | 8.0 | 7 | 9 | 43/39 | $26,790 |
| Toyota Highlander | 3.5L V6 | 11.8 | 7 | 7 | 27/28 | $47,500 |
| Toyota Prius | 1.8L I4 | 6.6 | 7 | 10 | 51/48 | $24,200 |
| Toyota Prius c | 1.5L I4 | 6.6 | - | 10 | 53/46 | - |
| Toyota Prius v | 1.8L I4 | 7.8 | - | 9 | 44/40 | - |
| Volkswagen Jetta Hybrid | 1.4L I4 | 7.3 | - | 10 | 42/48 | $27,645 |
| Volkswagen Touareg Hybrid | 3.0L V6 | 15.7 | - | 5 | 20/24 | $64,745 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

## Selling an Older Vehicle?

If you plan to sell an older vehicle, use fueleconomy.gov's used car label tool to advertise your vehicle's fuel economy. The tool is easy to use—just enter some basic information and then print a label for the vehicle's window or download a graphic to use in your advertisement. The label content provides EPA estimates for the vehicle when it was new. Actual results will vary for many reasons, including driving conditions and how the car was driven and maintained. Aftermarket modifications to the vehicle can also affect fuel economy, especially those that change the vehicle's weight, aerodynamics, or wheel/tire size. Other factors can also affect fuel economy (see box below).


This information is provided as a sample only and should not be construed as an actual used car label. *Source: fueleconomy.gov/feg/UsedCarLabel.jsp*

## Easy Steps to Improve Fuel Economy

Driving behaviors significantly impact fuel economy. To get the most out of each gallon (or kilowatt-hour), follow these tips:

- **Don't drive aggressively:** Speeding and rapid acceleration and braking lowers gas mileage.
- **Observe the speed limit:** Fuel economy generally decreases at speeds above 50 mph.
- **Remove rooftop boxes and racks when not in use:** Increased drag lowers fuel economy.
- **Remove excess weight:** Don't keep unnecessary items in your vehicle.
- **Avoid excessive idling:** Turn off the engine when parked.
- **Use cruise control on the highway:** Keeping a constant speed saves gas, in most cases.
- **Warm up engines in cold weather.**
- **Keep engine tuned and tires properly inflated.**
- **Use overdrive gears:** When the car's engine speed goes down, so does the amount of gasoline used.

For more information, visit *fueleconomy.gov/feg/driveHabits.shtml.*

# Ethanol Flex-Fuel Vehicles

Dodge Dart. *Photo from Chrysler Group LLC*

GMC Terrain. *Photo from General Motors*

## Flex-fuel vehicles can operate on gasoline or E85

FFVs are able to run on gasoline, E85, or any combination of the two. E85 is a blend of gasoline and ethanol, with the ethanol content ranging between 51%–83% depending on geographical location and season.* According to EPA estimates, the fuel economy of today's FFVs is 25%–30% lower when running on E85 because ethanol contains less energy per gallon than gasoline. However, using ethanol in fuel helps the nation reduce petroleum consumption, thereby potentially reducing the amount of oil we import. An FFV is often distinguished by an emblem on the back of the vehicle, and many FFVs have yellow fuel caps.

### E15 and Intermediate Ethanol Blends

EPA has approved the use of ethanol-gasoline blends up to E15 in all MY 2001 and newer vehicles. Fuel containing more than 15% ethanol is only approved for use in FFVs. This includes various intermediate blends now available from stations with ethanol blender pumps. Using blends higher than E15 in non-FFVs may result in maintenance, safety, or performance problems.

Blends of E15 and above are also not approved for use in motorcycles; vehicles with heavy-duty engines; off-road vehicles, such as boats and snowmobiles; off-road equipment, such as lawnmowers and chainsaws; or any conventional vehicles MY 2000 or older. For more information, visit *afdc.energy.gov/fuels/ethanol_e15.html*.

E85 is available at a large number of publicly accessible stations. See page 19 for information about finding E85 stations near you.

Toyota Tundra. *Photo from Toyota Motor Sales, U.S.A., Inc*

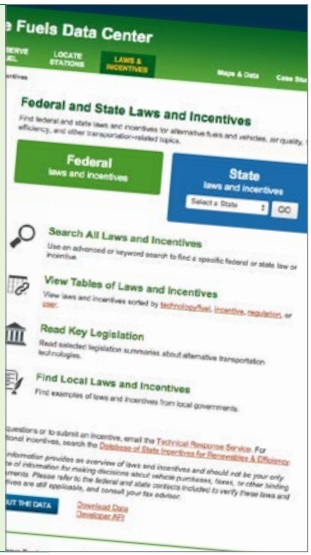
* *The E85 fuel economy estimates presented in this section are based on tests with blends containing 79%–85% ethanol.*

## A Focus on Fuel Economy

Ensure that your efforts to improve fuel economy are well-informed with information and tools available at fueleconomy.gov. Compare conventional and alternative fuel vehicles using the Find a Car tool. Explore the collection of information (on vehicles of current and past model years) on fuel economy ratings, emissions, energy impacts, annual fuel costs, and more. To find out what you can do to improve the fuel economy of your car, visit "Keeping Your Vehicle in Shape" (*fueleconomy.gov/feg/maintain.shtml*) and "Driving More Efficiently" (*fueleconomy.gov/feg/driveHabits.shtml*).

## Find Incentives for Alternative Fuels and Advanced Vehicles

Purchasing an alternative fuel vehicle involves upfront costs that can, in many cases, be offset by federal, state, and local tax exemptions, rebates, grants, or other incentives, as well as lower operating costs. A comprehensive database of state and federal laws and incentives related to alternative fuels and vehicles, air quality, fuel efficiency, and other transportation topics is available at *afdc.energy.gov/laws*. Your local Clean Cities coalition will also have information resources and technical assistance. Find the closest Clean Cities coalition at *cleancities.energy.gov*. Be sure to consult with your tax advisor to determine your eligibility for any tax incentive.



| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) On Gasoline / On E85 | Smog Score** | GHG Score** Gasoline/ E85 | Fuel Economy (MPG) Gasoline City/Hwy | Fuel Economy (MPG) E85 City/Hwy | Starting MSRP |
|---|---|---|---|---|---|---|---|
| Audi A4 Quatro | 2.0 I4 | 13.2 / 4.2 | 5 | 6/6 | 22/31 | 15/22 | $36,400 |
| Audi A5 Quatro | 2.0 I4 | 13.2 / 4.2 | 5 | 6/6 | 22/31 | 15/22 | $40,000 |
| Audi A5 Cabriolet Quatro | 2.0 I4 | 14.3 / 4.7 | 5 | 5/5 | 20/28 | 15/21 | $47,600 |
| Audi Allroad Quatro | 2.0 I4 | 13.7 / 4.4 | 5 | 6/6 | 21/28 | 15/21 | $42,400 |
| Audi Q5 AWD | 2.0 I4 | 14.3 / 4.7 | 5 | 5/5 | 20/28 | 14/19 | $38,900 |
| Bentley Continental Flying Spur | 6.0L V12 | 22.0 / 6.8 | 5 | 3/3 | 12/20 | 9/15 | $195,100 |
| Bentley Continental GT | 6.0L V12 | 22.0 / 6.8 | 5 | 3/3 | 12/21 | 9/15 | $187,900 |
| Bentley Continental GTC | 6.0L V12 | 22.0 / 6.8 | 5 | 3/3 | 12/20 | 9/15 | $206,300 |
| Buick Regal FWD/AWD | 2.4L I4 | - | - | - | - | - | $29,990 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) *On Gasoline* / *On E85* | Smog Score** | GHG Score** *Gasoline/ E85* | Fuel Economy (MPG) Gasoline *City/Hwy* | Fuel Economy (MPG) E85 *City/Hwy* | Starting MSRP |
|---|---|---|---|---|---|---|---|
| Buick Verano | 2.4L I4 | - | - | - | - | - | $23,380 |
| Buick LaCrosse FWD/AWD | 3.6L V6 | 15.7 / 4.7 | 6 | 5/5 | 18/28 | 14/20 | $33,635 |
| Cadillac ATS RWD/AWD | 3.6L V6 | - | - | - | - | - | $33,215 |
| Chevrolet Silverado 1500 2WD/4WD | 5.3L V8 | 17.3 / 5.3 | 6 | 4/4 | 16/23 | 12/17 | $25,575 |
| Chevrolet Silverado 1500 2WD/4WD | 4.3L V6 | 16.5 / 5.3 | - | 5/5 | 18/24 | 12/17 | $25,575 |
| Chevrolet Silverado 1500 Special Services 2WD/4WD | 5.3L V8 | - | - | - | - | - | - |
| Chevrolet Silverado 1500 Chassis Cab 2WD/4WD | 5.3L V8 | 19.4 / 6.2 | - | 4/4 | 15/20 | 11/15 | - |
| Chevrolet Silverado 1500 Chassis Cab 2WD/4WD | 4.3L V6 | 18.3 / 6.2 | - | 4/4 | 16/21 | 11/15 | - |
| Chevrolet Silverado 2500 2WD/4WD | 6.0L V8 | - | 1 | - | - | - | $32,165 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) On Gasoline / On E85 | Smog Score** | GHG Score** Gasoline/ E85 | Fuel Economy (MPG) Gasoline City/Hwy | Fuel Economy (MPG) E85 City/Hwy | Starting MSRP |
|---|---|---|---|---|---|---|---|
| Chevrolet Silverado 3500 2WD/4WD | 6.0L V8 | - | 1 | - | - | - | $33,265 |
| Chevrolet Suburban 2WD/4WD | 5.3L V8 | 18.3 / 5.3 | 6 | 4/4 | 16/23 | 12/17 | $47,300 |
| Chevrolet Tahoe Police 2WD/4WD | 5.3L V8 | - | - | - | - | - | - |
| Chevrolet Tahoe 2WD/4WD | 5.3L V8 | 18.3 / 5.3 | 6 | 4/4 | 16/23 | 12/17 | $44,600 |
| Chevrolet Express 2500/3500 | 6.0L V8 | 25.3 / 8.3 | - | 1/1 | 11/16 | 8/11 | $41,500 |
| Chevrolet Captiva FWD/AWD | 2.4L I4 | 14.3 / 4.2 | 6 | 5/6 | 20/28 | 15/22 | - |
| Chevrolet Equinox FWD/AWD | 2.4L I4 | 12.7 / 4.2 | 6 | 6/6 | 22/32 | 15/22 | - |
| Chevrolet Equinox FWD/AWD | 3.6L V6 | - | - | - | - | - | $24,520 |
| Chevrolet Impala | 3.6L V6 | 15.0 / 4.7 | 6 | 5/5 | 19/29 | 14/20 | $27,060 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) On Gasoline / On E85 | Smog Score** | GHG Score** Gasoline/ E85 | Fuel Economy (MPG) Gasoline City/Hwy | Fuel Economy (MPG) E85 City/Hwy | Starting MSRP |
|---|---|---|---|---|---|---|---|
| Chevrolet Impala Limited Police | 3.6L V6 | - | - | - | - | - | - |
| Chevrolet Caprice Police Patrol Vehicle | 6.0L V8 | - | - | - | - | - | - |
| Chrysler 200 FWD/AWD | 3.6L V6 | 14.3 / 4.4 | 6 | 5/6 | 19/32 | 14/23 | $25,995 |
| Chrysler 200 | 2.4L I4 | 11.8 / 3.6 | 6 | 7/7 | 23/26 | 17/28 | $21,700 |
| Chrysler Dart | 2.0L I4 | 12.2 / 3.7 | 6 | 7/7 | 24/34 | 18/25 | $16,495 |
| Chrysler Town & Country | 3.6L V6 | 16.5 / 5.3 | 6 | 5/5 | 17/25 | 12/18 | - |
| Dodge Grand Caravan | 3.6L V6 | 16.5 / 5.3 | 6 | 5/5 | 17/25 | 12/18 | $20,895 |
| Dodge Durango AWD | 3.6L V6 | 17.3 / 5.0 | 6 | 4/5 | 17/24 | 13/17 | $29,995 |
| Dodge Journey FWD | 3.6L V6 | 17.3 / 5.3 | 6 | 4/5 | 17/25 | 12/18 | $19,995 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) *On Gasoline* / *On E85* | Smog Score** | GHG Score** *Gasoline/ E85* | Fuel Economy (MPG) Gasoline *City/Hwy* | Fuel Economy (MPG) E85 *City/Hwy* | Starting MSRP |
|---|---|---|---|---|---|---|---|
| Dodge Charger Police Pursuit | 3.6L V6 | - | - | - | - | - | - |
| Dodge Durango Police Special Service Vehicle | 3.6L V6 | - | - | - | - | - | - |
| Ford Police Interceptor | 3.5L V6 | - | - | - | - | - | - |
| Ford Police Interceptor | 3.7L V6 | - | - | - | - | - | - |
| Ford Police Interceptor Utility | 3.7L V6 | - | - | - | - | - | - |
| Ford Focus | 2.0L I4 | - | - | - | - | - | - |
| Ford Taurus FWD/AWD | 3.5L V6 | 14.3 / 4.7 | 5 | 5/5 | 19/29 | 13/21 | $26,790 |
| Ford Explorer 2WD/AWD | 3.5L V6 | 16.5 / 5.0 | 5 | 5/5 | 17/24 | 13/18 | $30,600 |
| Ford Expedition 2WD/AWD | 5.4L V8 | - | - | - | - | - | $43,390 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) *On Gasoline* / *On E85* | Smog Score** | GHG Score** *Gasoline/ E85* | Fuel Economy (MPG) Gasoline *City/Hwy* | Fuel Economy (MPG) E85 *City/Hwy* | Starting MSRP |
|---|---|---|---|---|---|---|---|
| Ford F-150 | 3.5L V6 | - | - | - | - | - | $25,720 |
| Ford F-150 | 5.0L V8 | - | - | - | - | - | $25,720 |
| Ford Transit 150/250/350 | 3.7L V6 | 20.6 / 6.2 | 2 | 3/4 | 14/19 | 11/14 | $32,100 |
| Ford Transit 250/350 | 3.7L V6 | - | - | - | - | - | $26,960 |
| Ford Super Duty F-250/350 | 6.2L V8 | - | 2 | - | - | - | $31,045 |
| Ford Super Duty F-350 | 6.2L V8 | - | 2 | | - | - | $31,400 |
| GMC Sierra 1500 2WD/4WD | 4.3L V6 | 16.5 / 5.3 | - | 5/5 | 18/24 | 12/17 | $26,995 |
| GMC Sierra 1500 2WD/4WD | 5.3L V8 | 17.3 / 5.3 | 6 | 4/4 | 16/23 | 12/17 | $26,995 |
| GMC Sierra 1500 Cab-chassis 2WD/4WD | 4.3L V6 | 18.3 / 6.2 | - | 4/4 | 16/21 | 11/15 | - |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) On Gasoline / On E85 | Smog Score** | GHG Score** Gasoline/ E85 | Fuel Economy (MPG) Gasoline City/Hwy | Fuel Economy (MPG) E85 City/Hwy | Starting MSRP |
|---|---|---|---|---|---|---|---|
| GMC Sierra 1500 Cab-chassis 2WD/4WD | 5.3L V8 | 19.4 / 6.2 | - | 4/4 | 15/20 | 11/15 | - |
| GMC Sierra 2500 2WD/4WD | 6.0L V8 | - | 1 | - | - | - | $32,420 |
| GMC Sierra 3500 2WD/4WD | 6.0L V8 | - | 1 | - | - | - | $33,520 |
| GMC Yukon 1500 2WD/4WD | 5.3L V8 | 18.3 / 5.3 | 6 | 4/4 | 16/23 | 12/17 | $46,355 |
| GMC Yukon XL 1500 2WD/4WD | 5.3L V8 | 18.3 / 5.3 | 6 | 4/4 | 16/23 | 12/17 | $49,035 |
| GMC Savana 2500/3500 | 6.0L V8 | 25.3 / 8.3 | - | 1/1 | 11/16 | 8/11 | - |
| GMC Terrain FWD/AWD | 2.4L I4 | 12.7 / 4.2 | 6 | 6/6 | 22/32 | 15/22 | $26,560 |
| GMC Terrain FWD/AWD | 3.6L V6 | - | - | - | - | - | $26,560 |
| Jaguar XJ FFV | 3.0L V6 | 15.7 / 5.3 | 5 | 5/5 | 18/27 | 12/19 | - |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) On Gasoline / On E85 | Smog Score** | GHG Score** Gasoline/ E85 | Fuel Economy (MPG) Gasoline City/Hwy | Fuel Economy (MPG) E85 City/Hwy | Starting MSRP |
|---|---|---|---|---|---|---|---|
| Jaguar XJ FFV | 5.0L V8 | 18.3 / 5.8 | 5 | 4/4 | 15/23 | 11/17 | - |
| Jaguar XJL FFV | 3.0L V6 | 16.5 / 5.3 | 5 | 5/5 | 17/27 | 11/19 | - |
| Jaguar XJL FFV | 5.0L V8 | 18.3 / 5.8 | 5 | 4/4 | 15/23 | 11/17 | - |
| Jaguar XF FFV | 5.0L V8 | 18.3 / 5.8 | 5 | 4/4 | 15/23 | 11/17 | - |
| Jeep Cherokee 2WD/FWD | 2.4L I4 | 13.2 / 4.2 | 6 | 6/6 | 22/31 | 15/23 | $22,995 |
| Jeep Grand Cherokee 2WD/FWD | 3.6L V6 | 16.5 / 4.7 | 6 | 5/5 | 17/25 | 14/19 | $29,595 |
| Land Rover Range Rover | 5.0L V8 | 20.6 / 6.8 | 5 | 3/3 | 14/19 | 9/14 | $83,495 |
| Land Rover Range Rover L | 5.0L V8 | 20.6 / 6.8 | 5 | 3/3 | 14/19 | 9/14 | $106,995 |
| Land Rover Range Rover Sport | 5.0L V8 | 20.6 / 6.8 | 5 | 3/3 | 14/19 | 10/14 | $63,350 |

** Assuming 15,000 miles driven per year. ** 10 = Best.*

*Table continued on next page*

| Flex-Fuel Vehicle Model | Engine Size | Energy Impact Score* (Barrels Petroleum/Year) *On Gasoline* / *On E85* | Smog Score** | GHG Score** *Gasoline/ E85* | Fuel Economy (MPG) Gasoline *City/Hwy* | Fuel Economy (MPG) E85 *City/Hwy* | Starting MSRP |
|---|---|---|---|---|---|---|---|
| Mercedes-Benz GLA 250 4Matic | 2.0L I4 | 12.2 / 3.7 | | 7/7 | 24/32 | 17/24 | - |
| Mercedes-Benz ML350 4Matic | 3.5L V6 | 17.3 / 5.0 | | 4/5 | 17/22 | 13/17 | $50,800 |
| Nissan Armada 2WD/4WD | 5.6L V8 | 22.0 / 6.8 | 5 | 3/3 | 12/19 | 9/13 | - |
| Nissan Titan 2WD/4WD | 5.6L V8 | - | - | - | - | - | - |
| Ram 1500 2WD/4WD | 3.6L V6 | 16.5 / 5.3 | - | 5/5 | 17/25 | 12/17 | $24,610 |
| Ram CV | 3.6L V6 | 15.7 / 5.0 | 6 | 5/5 | 18/26 | 13/18 | - |
| Toyota Sequoia 4WD | 5.7L V8 | 23.0 / 7.5 | 5 | 2/3 | 13/17 | 9/13 | $44,395 |
| Toyota Tundra 4WD | 5.7L V8 | 22.0 / 7.5 | 5 | 3/3 | 13/17 | 9/12 | $29,020 |

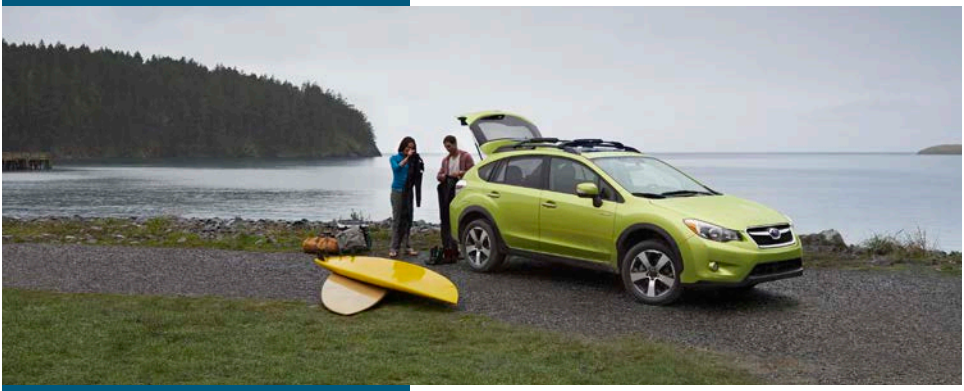
** Assuming 15,000 miles driven per year. ** 10 = Best.*

U.S. Department of Energy

Clean Cities advances the nation's economic, environmental, and energy security by supporting local actions to cut petroleum use in transportation. A national network of nearly 100 Clean Cities coalitions brings together stakeholders in the public and private sectors to deploy alternative and renewable fuels, idle-reduction measures, fuel economy improvements, and emerging transportation technologies.

For more information, visit:

- *cleancities.energy.gov*
- *fueleconomy.gov*
- *afdc.energy.gov*



Subaru XV Crosstrek Hybrid. *Photo from Subaru*

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800-254-6735
*technicalresponse@icfi.com*

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Clean Cities
U.S. Department of Energy

# Appendix D

## PA Companies that Provide Natural Gas Vehicles

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**About Ben Franklin Technology Partners**
Ben Franklin Technology Partners/CNP, an initiative of the Pennsylvania Department of Community and Economic Development and funded by the Ben Franklin Technology Development Authority, provides investment capital, operational assistance, and entrepreneurial support to emerging tech-based companies and small, existing manufacturers for the purpose of creating and retaining jobs in Pennsylvania.

# PA Companies that Provide Natural Gas Vehicles 12/23/14



## Preface

Some automotive and truck manufacturers provide an option to supply a natural gas vehicle as an option to one of their standard lines. In some cases, each vehicle is considered a custom and so a standard vehicle does not exist. Even though customers have had the ability to choose a natural gas vehicle for several years, this niche market remains a very small portion of vehicle sales for many of these manufacturers. Therefore, the process of specifying and ordering a vehicle with the option to run on natural gas, is not always obvious.

The number of natural gas filling stations continues to grow, however, because of the limited number of stations, the markets for natural gas vehicles often remains regional. This is why some dealers outside of these regional areas, may not even know that a particular vehicle can be ordered to run on natural gas. In some cases, corporate sales may not be familiar with the right process in identifying the correct path to ordering this type of vehicle. Most of the information in this report was based on many conversations with the corporations, and so may appear to conflict with the information found on various websites.

Even though some vehicle manufacturers supply their natural gas versions through a third party, the process is not very consistent and sometimes the vehicle is shipped directly to the customer point of order and sometimes it is shipped from the third party. So to simplify things, this report list the dealer locations in Pennsylvania where the vehicle can be ordered, since this is really the intent of the manufacturers. They want to help the customer learn of their product and have control over the process. Because of this, third party conversion facilities that may be located in Pennsylvania will not be listed independently.

## Providers

This is a list of vehicle manufacturers and their dealer locations where a natural gas vehicle can be ordered.

**Autocar**
http://www.autocartruck.com/Page/GoingGreen
They don't call us the Green Leader for nothing! Take a look around and you'll see an Autocar® running on an alternative fuel system. "Green" is the way of the future and we're already there.

River's Truck Center, Inc.
2975 Cape Horn Road, Red Lion, PA 17356
717 244 4903

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**Chrysler Ram**
**http://www.ramtrucks.com/en/**

| | | | | | |
|---|---|---|---|---|---|
| Kuntz Motor Company | 4732 COLONEL DRAKE HIGHWAY | MAHAFFEY | 15757 | PA | 814-2776682 |
| Tri-Star Chrysler Motors Inc | 404 N 4TH ST | INDIANA | 157011207 | PA | 724-4599300 |
| Ferrario Auto Center Inc | 212 GOLDEN MILE RD | TOWANDA | 188489227 | PA | 570-2656111 |
| Jeff D'Ambrosio Chrysler Jeep Dodge | 1221 E LANCASTER AVE | DOWNINGTOWN | 193355369 | PA | 610-2699500 |
| C Classic Dodge Chrysler Jeep | 1238 SOUTH SECOND STREET | CLEARFIELD | 168302596 | PA | 814-7652500 |
| Diehl Chrysler Jeep Dodge | 258 PITTSBURGH RD | BUTLER | 160023952 | PA | 724-2828898 |
| Diehl Chrysler Dodge Jeep Ram | 6181 STEUBENVILLE PIKE | MC KEES ROCKS | 151361338 | PA | 412-3313636 |
| Waynesburg Chrysler Jeep Dodge, LLC | 1625 E HIGH ST | WAYNESBURG | 153709563 | PA | 724-6277111 |
| Jim Shorkey Chrysler Dodge Jeep Ram | 13230 ROUTE 30 | NORTH HUNTINGDON | 156421327 | PA | 412-8722400 |
| Humes Chrysler Jeep Dodge | 1010 ROUTE 19 NORTH | WATERFORD | 16441 | PA | 814-7962666 |

**Crane Carrier**
http://www.cranecarrier.com/Products/cng.htm
Crane Carrier is a leading producer of Class 6, 7 & 8 alternate fueled vehicles equipped with CNG or LNG systems. CNG chassis are factory equipped with Agility Systems Fuel Control Modules, (FCM) regulating CNG fuel system pressure, filtration and delivery to engine manufacturer's design recommendations ensuring proper operation and factory support. Crane offers Agility Systems behind the cab, (BTC) and Saddle Mount systems in various combinations, configurations and capacities to meet your specific installation and operating requirements.
http://cranecarrier.com/Products/cng.htm
Since 1953, CRANE has evolved as a leader in the production of custom-engineered heavy-duty Class 8, diesel and alternate fueled truck chassis. CRANE is one of the world's foremost manufacturers of custom vehicles for Heavy Truck, Refuse Collection, Mobile Drill Rig, Terminal Tractors, OEM and various other demanding On & Off highway vocational applications.

Dealer
**Trans Edge Truck Center**
1501 Beaver Ave Pittsburgh, PA 15233
http://www.cranecarrier.com/dealer.asp?ST=PA&R=NE

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
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**Ford**
http://www.ford.com/resources/ford/general/promotions/Alt_Fuel_Guide_Final_km.pdf
Engine and Vehicle Modifiers
Ford is working with seven gaseous fuel qualified modifiers. Together they provide QVM-qualified packages for the vehicles and engines shown below. These companies provide finished, ready-to-use vehicles through Ford dealerships. Modifiers may also provide and install other equipment, bodies and accessories necessary for your business.

| | | GASEOUS FUEL MODIFIERS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| VEHICLE | Engine | ALTECH-ECO | BAF | IMPCO | LANDI RENZO | ROUSH CLEANTECH | VENCHURS | WESTPORT |
| Transit Connect | 2.0L | CNG | CNG | CNG | | | | |
| E-Series Cargo Vans | 5.4L/6.8L | CNG | CNG | CNG | CNG (2) | LPG | | |
| E-Series Wagons | 5.4L/6.8L | CNG | CNG | CNG | CNG (2) | LPG | | |
| E-Series Cutaway & Stripped Chassis | 5.4L/6.8L | | CNG | CNG | CNG (2) | LPG (1) | | |
| F-Series Super Duty Pickup & F-350 Chassis Cab | 6.2L | CNG | CNG | CNG | CNG | LPG | CNG | CNG |
| F-Series Super Duty Chassis Cabs F-450/550/650 | 6.8L | | CNG | CNG | CNG | LPG | | CNG (3) |
| F53 & F59 Stripped Chassis | 6.8L | | CNG | CNG | CNG | LPG | | |

(1) E-450 6.8L School Bus Package available through ROUSH CleanTech and Micro Bird.
(2) 5.4L engine only.
(3) F-450/F-550 only.

## Gaseous Fuel Modifier Contact Information*

| COMPANY | WEBSITE |
|---|---|
| Altech-Eco | http://altecheco.com/pages/CNG_Conversions.htm |
| BAF® | www.baftechnologies.com |
| IMPCO® | www.impcoautomotive.com |
| LandiRenzo® | www.landiusa.com |
| ROUSH® CleanTech | www.roushcleantech.com |
| Venchurs | www.venchurs.com/venchurs-vehicle-systems |
| Westport | www.wingpowersystem.com/ |

* For additional Gaseous Fuel Modifier contact information, go to **www.fleet.ford.com/truckbbas** and click on the "Other" tab. From the drop-down menu, select "QVM Participants" then click on "Alternative Fuel."

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mjc33@psu.edu
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http://corporate.ford.com/microsites/sustainability-report-2013-14/environment-products-plan-migration-cnglpg.html
Interest in CNG and LPG vehicles is growing globally. In the U.S., for example, sales of Ford's commercial vehicles with CNG/LPG prepped engine packages increased by more than 350 percent from 2009 to early 2013. Today, CNG/LPG prep packages are purchased 3 to 5 percent of Ford vehicles that offer this option. In the U.S., we provide gaseous prepped engine packages as a factory installed option on select commercial vehicles. We work with qualified vehicle modifiers (QVM) to convert vehicles with gaseous prepped engines to CNG and LPG fuel systems. Ford has established a rigorous qualification program for QVMs that provides guidance, modification recommendations, and engine operating specifications required to ensure customer satisfaction and reliability in line with Ford Motor Company standards. We perform on-site assessments at each QVM location to ensure conformance to a high standard of manufacturing, assembly, workmanship and customer service. We currently work with five QVM suppliers for CNG conversions (Altech-Eco, IMPCO, Landi Renzo, Venchurs and Westport) and one QVM for LPG conversions (ROUSH CleanTech).

**Locate a Ford dealer**
http://corporate.ford.com/microsites/sustainability-report-2013-14/environment-products-plan-migration-cnglpg.html
According to the marketing department at Ford, any dealer can help a customer specify a vehicle to run on natural gas. The dealers use their own "call center" to obtain help in specifying the product/vehicle for this option.
The list of dealers in PA is quite extensive, so the link directly above can be used to identify the dealers in PA.

**GM (Chevrolet & GMC)**
http://www.gmfleet.com/overview/alternative-fuel-vehicles.html

**Chevrolet**
When it comes to managing budgets and keeping an eye on the environment, business owners and fleet managers alike face many challenges. That's where GM's Bi-Fuel CNG Silverado and Sierra come in. They're designed to help businesses reduce their fuel costs – and their environmental impact.

GM has several vehicle models that have CNG-powered versions. Chevrolet Express and GMC Savana use a proven, 6.0L Vortec V-8 engine with factory-installed hardened exhaust valves and intake/exhaust valve seats. These components are engineered to GM durability standards for gaseous fuel use.

The CNG fuel system is available on Cargo and Passenger full-size vans, in both regular and long wheelbases.

The Bi-Fuel Impala joins Chevrolet's growing range of manufacturer-engineered and validated CNG vehicles, which includes the Bi-Fuel Silverado HD full-size pickups and dedicated CNG Express full-size Cargo and Passenger vans.

**LAWRENCE CHEVROLET**
6445 CARLISLE PIKE
MECHANICSBURG, PA 17050-5233
Sales Phone: (717) 766-0284
Fax: (717) 766-8398
Dealer Website

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**SUTLIFF CHEVROLET CO**
1251 PAXTON ST
HARRISBURG, PA 17104-3703
Sales Phone: (717) 234-4444
Fax: (717) 234-6501
Dealer Website

**APPLE CHEVROLET APPLE CADILLAC**
1200 LOUCKS RD
YORK, PA 17404-2219
Sales Phone: (717) 848-1300
Fax: (717) 845-9660
Dealer Website

**FREDERICK CHEVROLET-CADILLAC**
1505 QUENTIN RD
LEBANON, PA 17042-7431
Sales Phone: (717) 274-1461
Fax: (717) 454-0501
Dealer Website

**WHITMOYER BUICK-CHEVROLET,INC.**
1001 E MAIN ST
MOUNT JOY, PA 17552-9333
Sales Phone: (717) 653-8183
Fax: (717) 653-9277
Dealer Website

**HONDRU CHEVROLET OF MANHEIM, LLC**
350 S MAIN ST
MANHEIM, PA 17545-2213
Sales Phone: (717) 665-2466
Fax: (717) 665-2525
Dealer Website

**FAIRWAY MOTORS, INC.**
ROUTE 309N PO BOX K
HAZLETON, PA 18201-8201
Sales Phone: (570) 455-7701
Fax: (570) 455-2881
Dealer Website

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
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## GMC

**SUTLIFF BUICK GMC CADILLAC**
169 W AARON DR
STATE COLLEGE, PA 16803-3008
Sales Phone: (814) 867-4444
Fax: (814) 867-9920
Dealer Website

**CALKINS BUICK GMC SUBARU**
12951 FERGUSON VALLEY RD
BURNHAM, PA 17009-1841
Sales Phone: (717) 248-3901
Fax: (717) 248-6350
Dealer Website

**TEAM CHEVROLET BUICK GMC**
RTE 22
HUNTINGDON, PA 16652-0000
Sales Phone: (814) 643-1111
Fax: (814) 643-3750
Dealer Website

**FIORE BUICK GMC**
808 LOGAN BLVD
ALTOONA, PA 16602-4189
Sales Phone: (814) 943-6181
Fax: (814) 943-8745
Dealer Website

**TROUTMAN'S CHEVROLET BUICK GMC**
640 STATE ST
MILLERSBURG, PA 17061-1462
Sales Phone: (717) 692-2137
Fax: (717) 692-3081
Dealer Website

**OSBURN BUICK GMC, INC.**
501 LIBERTY BLVD
DU BOIS, PA 15801-2409
Sales Phone: (814) 371-4600
Fax: (814) 371-3806
Dealer Website

**RON DAVIDSON CHEVROLET BUICK GMC**
3885 ADMIRAL PEARY HWY
EBENSBURG, PA 15931-3917
Sales Phone: (814) 472-7580
Fax: (814) 472-4273
Dealer Website

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
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**GRAHAM MOTOR COMPANY, INC.**
1402 HOLLY PIKE
CARLISLE, PA 17015-7632
Sales Phone: (717) 243-3066
Fax: (717) 249-7998
Dealer Website

**ALEXANDER CADILLAC BUICK GMC TRUCK**
800 MARKET ST
SUNBURY, PA 17801-2324
Sales Phone: (570) 286-4541
Fax: (570) 286-5156
Dealer Website

**COTTER GMC**
435 HALL AVENUE
SAINT MARYS, PA 15857-1422
Sales Phone: (814) 834-2063
Fax: (814) 781-3945
Dealer Website

**FREYSINGER BUICK GMC, INC.**
6251 CARLISLE PIKE
MECHANICSBURG, PA 17050-5234
Sales Phone: (717) 766-8422
Fax: (717) 795-7807
Dealer Website

**JENNINGS CHEVROLET, BUICK, GMC**
916 NORLAND AVE
CHAMBERSBURG, PA 17201-4203
Sales Phone: (717) 264-4161
Fax: (717) 264-8679
Dealer Website

**FAULKNER BUICK GMC, LLC**
2650 PAXTON ST
HARRISBURG, PA 17111-1033
Sales Phone: (717) 238-7324
Fax: (717) 346-5636
Dealer Website

**THOMAS BUICK - GMC TRUCK**
750 EISENHOWER BLVD
JOHNSTOWN, PA 15904-3520
Sales Phone: (814) 266-5844
Fax: (814) 269-4331
Dealer Website

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**KIGHTLINGER MOTORS, INC.**
358 ROUTE 6 WEST
COUDERSPORT, PA 16915-8450
Sales Phone: (814) 274-9660
Fax: (814) 274-8293
Dealer Website

**COLONIAL MOTOR MART**
349 N FOURTH ST
INDIANA, PA 15701-2061
Sales Phone: (724) 349-5600
Fax: (724) 349-0660
Dealer Website

**BUCHANAN CHEVROLET BUICK PONTIAC GMC CADILLAC**
1035 E MAIN ST
WAYNESBORO, PA 17268-2345
Sales Phone: (717) 762-3141
Fax: (717) 762-0651
Dealer Website

**ALEXANDER FAMILY BUICK GMC TRUCK**
399 CENTRAL RD
BLOOMSBURG, PA 17815-3126
Sales Phone: (570) 784-0794
Fax: (570) 784-3799
Dealer Website

**COLE & BURD AUTOMOTIVE**
2558 S MAIN ST
MANSFIELD, PA 16933-9366
Sales Phone: (570) 662-7120
Fax: (570) 659-5476
Dealer Website

**EBERSOLE BUICK GMC**
1900 CUMBERLAND ST
LEBANON, PA 17042-4495
Sales Phone: (717) 273-7611
Fax: (717) 272-7455
Dealer Website

**WOY BROTHERS, INC.**
10674 SOMERSET PIKE
SOMERSET, PA 15501-7353
Sales Phone: (814) 445-9474
Fax: (814) 445-8677
Dealer Website

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**JACK GIAMBALVO MOTOR CO., INC.**
1390 EDEN ROAD
YORK, PA 17402-1938
Sales Phone: (717) 846-1821
Fax: (717) 854-5509
Dealer Website

**SEIDLE CHEVROLET-BUICK-GMC**
1141 E MAIN ST
CLARION, PA 16214-1299
Sales Phone: (814) 226-8300
Fax: (814) 226-6207
Dealer Website

**BOB WEAVER CHEVROLET BUICK GMC**
2174 W MARKET ST
POTTSVILLE, PA 17901-1928
Sales Phone: (570) 622-7191
Fax: (570) 628-3610
Dealer Website

**Elgin Sweepers**
http://elginsweeper.com/Products/AlternateFuelStreetSweepers/tabid/151/Default.aspx
*Alternative Fuel Street Sweepers*
Most Elgin Sweepers are available with as alternative fuel sweepers, including systems such as Liquid Natural Gas (LNG), Compressed Natural Gas (CNG) and Liquid Propane Gas (LPG).

**A & H Equipment Company**
1124 McLaughlin Run Road
Bridgeville, PA 15017
USA
1.412.257.1160 (Phone)
sales@ahequipment.com
www.ahequipment.com

**A & H Equipment Company**
1405B Hagy Way
Harrisburg, PA 17110
USA
1.717.724.0310 (Phone)
www.ahequipment.com

**Granturk Equipment Company, Inc.**
One Schuylkill Parkway Building B
Bridgeport, PA 19405
USA
1.610.239.9800 (Phone)
gteco@cs.com
www.granturk.com

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**International Truck**
http://www.internationaltrucks.com/trucks/
In business, you can't afford to sit around and wait for the promise of tomorrow. That's why International is actively working to create new technologies and develop the infrastructure needed to propel the trucking industry into the 21ST century. Fortunately, the wait is over, because with the advent of natural gas, the promise of tomorrow starts today.

International understands the North American trucking market better than anyone. And we see this as an incredible opportunity for your business to not only do your part to help the environment and strengthen our economy, but to save money in the long run doing it.
http://www.internationaltrucks.com/trucks/naturalgas

**NOERR'S INTERNATIONAL**
700 US Highway 22 | Lewistown, PA 17044
**Sales** (855) 313-1966 **Service** (855) 313-1967 **Parts** (717) 248-5429

**Five Star International**
2751 Mccoy Street | Williamsport, PA 17701
**Sales** (855) 287-8481 **Service** (855) 287-8483 **Parts** (570) 494-1400

**Allegheny Trucks, Inc.**
49A Greenwood Road | Altoona, PA 16602
**Sales** (855) 297-7451 **Service** (855) 297-7452 **Parts** (814) 944-3505

**Five Star International LLC**
1810 S. 19Th Street | Harrisburg, PA 17104
**Sales** (855) 314-8967 **Service** (855) 314-8969 **Parts** (717) 986-1500

**Zacherl Motor Truck Sales, Inc.**
795 Greenville Pike | Clarion, PA 16214
**Sales** (855) 332-1017 **Service** (855) 332-1294 **Parts** (800) 832-8580

**Tri-County Motor Sales**
1575 Ferndale Ave | Johnstown, PA 15905
**Sales** (855) 297-6460 **Service** (855) 297-6461 **Parts** (814) 288-1551

**FIVE STAR INTL., L.L.C.**
1294 Strickler Rd. | Mount Joy, PA 17552-8889
**Sales** (855) 314-8966 **Service** (855) 314-8968 **Parts** (717) 986-1500

**Five Star International, L.L.C.**
1294 Stricker Road | Mt Joy, PA 17552
**Sales** (855) 313-2690 **Service** (855) 313-2700 **Parts** (717) 492-0046

**Five Star International LLC**
2818 W. Market Street | York, PA 17404
**Sales** (855) 313-7780 **Service** (855) 313-9099 **Parts** (717) 792-2277

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**Hunter Truck Sales & Service, Inc.**
101 East Main Street | Eau Claire, PA 16030
**Sales** (855) 320-7571 **Service** (855) 320-7572 **Parts** (724) 791-2525

**Kovatch Mobile Equipment**
44 Mountain Avenue | Nesquehoning, PA 18240
**Sales** (855) 287-9443 **Service** (855) 287-9444 **Parts** (570) 669-9461

**Stadium International Sales and Service, LLC**
1006 Underwood Road | Scranton (Olyphant), PA 18447
**Sales** (855) 288-3455 **Service** (855) 288-3649 **Parts** (570) 941-3600

**Lowe & Moyer Garage**
731 CHURCH ST | FOGELSVILLE, PA 18051
**Sales** (855) 294-3782 **Service** (855) 294-3865 **Parts** (610) 395-2072

**Five Star International LLC**
1846 North 5Th Street | Reading, PA 19612
**Sales** (855) 293-7081 **Service** (855) 294-3702 **Parts** (610) 374-4914

**Hunter Truck Sales & Service, Inc.**
519 Pittsburgh Rd | Butler, PA 16002
**Sales** (855) 317-9266 **Service** (855) 320-7569 **Parts** (724) 586-7744

**Hunter Truck Sales, Inc.**
4637 Campbell's Run Road | Pittsburgh, PA 15205
**Sales** (855) 276-1502 **Service** (855) 276-1503 **Parts** (412) 787-0600

**Five Star International, L.L.C.**
2131 Hanover Ave. | Allentown, PA 18109
**Sales** (855) 294-4051 **Service** (855) 294-4052 **Parts** (610) 433-5167

**Hill International Trucks N.A., LLC**
300 Alton Hill Drive | Eighty Four, PA 15330
**Sales** (855) 317-7881 **Service** (855) 317-8337 **Parts** (724) 222-8680

**Hunter Truck Sales, Inc.**
100 Hunters Way | Smithfield, PA 15478
**Sales** (855) 317-9245 **Service** (855) 317-9264 **Parts** (724) 564-4292

**Five Star International, L.L.C.**
6100 Wattsburg Road | Erie, PA 16509
**Sales** (855) 297-7436 **Service** (855) 297-7438 **Parts** (814) 825-6150

**G.L. Sayre, Inc.**
1231 W. Ridge Pike | Conshohocken, PA 19428
**Sales** (855) 293-7077 **Service** (855) 293-7080 **Parts** (610) 277-2000

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**Del-Val International Trucks**
1034 Bethlehem Pike (Rte. 309) | Montgomeryville, PA 18936
**Sales** (855) 242-0010 **Service** (855) 242-0012 **Parts** (215) 641-5800

**Bucks County International, Inc.**
134 Old Oxford Valley Road | Langhorne, PA 19047
**Sales** (855) 252-8944 **Service** (855) 252-8945 **Parts** (267) 397-4000

**Johnston Trucks**
http://www.johnstonnorthamerica.com/products/truck-mounted/vs651-cng/
CNG – A Greener Bottom Line
Lower alternative fuel costs and lower incremental maintenance costs can save valuable dollars. Maintenance-free exhaust systems and lower life-cycle costs help green-up your bottom line. Government incentives and Infrastructure Tax Credits may be available to green fleets that can help reduce acquisition costs significantly.

U.S. Municipal Supply
1519 Evans City Rd
Evans City, PA 16033
Website

U.S. Municpal Supply
10583 Raystown Road
Huntingdon, PA 16652
Website
U.S. Municpal Supply
461 Glennie Circle
King of Prussia, PA 19406
Website

**Kenworth Truck**
The spirit of innovation that drove our earliest designs continues to guide the evolution of today's Kenworth. Integrating the latest in component technology with advanced aerodynamics allows Kenworth to remain the hands-down favorite when operations demand a critical competitive edge.

**Kenworth of Pennsylvania - Clintonville**
4054 State Road 308
Clintonville, PA 16372
Phone: 814-385-1040

**Kenworth of Pennsylvania - New Stanton**
530 North Center Avenue
New Stanton, PA 15672
Phone: 724-925-5000

**Kenworth of Pennsylvania - Carlisle**
198 Kost Road
Carlisle, PA 17013
Phone: 717-766-8000

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**Kenworth of Pennsylvania - Shartlesville**
16 Motel Drive
Shartlesville, PA 19554
Phone: 6104881660

**Kenworth of Pennsylvania - Dunmore**
109 Keystone Industrial Park
Dunmore, PA 18512
Phone: 5703475671

**Coopersburg Kenworth**
1930 Route 309
Coopersburg, PA 18036
Phone: 6102824500

**Mack Truck**
http://www.macktrucks.com/powertrain-and-suspensions/engines/natural-gas/
At Mack®, we're embracing the energy revolution by expanding the availability of natural gas engines. For years we've produced an energy-efficient Mack TerraPro® model running on natural gas, and now we're bringing those same savings to our vocational and regional-haul applications.

We've partnered with the leading natural gas engine manufacturer—Cummins Westport—to bring you one of the cleanest heavy-duty natural gas engines on the market today.

TRANSEDGE TRUCK CENTER
1501 BEAVER AVE
PITTSBURGH, PA 15233-3220
Phone : +1(412)237-6000

TRI-COUNTY TRUCK CENTER
1098 STATE ROUTE 28 & 66
KITTANNING, PA 16201
Phone : +1(724)548-1548

W. W. ENGINE AND SUPPLY, INC. - SOMERSET DIV
178 LEWIS DR
SOMERSET, PA 15501-1107
Phone : +1(814)445-9617

W W ENGINE & SUPPLY INC - ALTOONA DIV
649 BRUSH MOUNTAIN RD
ALTOONA, PA 16601-1897
Phone : +1(814)742-8055

SUSQUEHANNA MOTOR CO INC
370 OLD ROUTE 15
WEST MILTON, PA 17886-6005
Phone : +1(570)568-6941

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

W. W. ENGINE AND SUPPLY, INC. - HARRISBURG DIVISION
4230 INDUSTRIAL RD
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Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

Hunter Keystone Peterbilt
9981 Old Route 22
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Phone: (610) 285-2244

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| I-80 EXIT 21 OLD | KYLERTOWN | PA | 16847 | http://www.volvo-truck.com/wwkyltertown |
| 8059 STATE ROUTE 22 | NEW ALEXANDRIA | PA | 156703103 | |
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Washington, PA 15301
(724)222-2213

**Conicelli Honda**
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(215)305-5000

**Author** Mike Chmela (Project Director, Market Research)

# Appendix E

## Clean Cities Guide to Alternative Fuel and Advanced Medium and Heavy Duty Vehicles

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

# Clean Cities Guide to

# Alternative Fuel and Advanced Medium- and Heavy-Duty Vehicles

Clean Cities
U.S. Department of Energy

School Bus • Shuttle Bus • Transit Bus • Refuse Truck • Tractor • Van • Vocational Truck

# Table of Contents



*Photos, from top: North American Bus Industries, Kenworth, Turtle Top*

*Front cover photos, clockwise from top: Kenworth, Thomas Built Buses, Boulder Electric Vehicle, Peterbilt*

# About the Guide

Today's fleets are increasingly interested in medium- and heavy-duty vehicles that use alternative fuels or advanced technologies that can help reduce operating costs, meet emissions requirements, improve fleet sustainability, and support U.S. energy independence. Vehicle and engine manufacturers are responding to this interest with a wide range of options across a steadily growing number of vehicle applications.

This guide provides an overview of alternative fuel power systems—including engines, microturbines, and fuel cells—and hybrid propulsion systems. The guide also offers a brief overview of individual medium- and heavy-duty vehicles, listed by application. Notably, a transition to any alternative fuel or advanced technology is a long-term commitment that merits thoughtful research and planning, with attention to technical, economic, and geographical considerations. Clean Cities' Alternative Fuels Data Center (AFDC) offers a suite of tools that can aid a fleet in its analysis (*afdc.energy.gov/tools*).

Clean Cities collects the vehicle information presented in this guide from multiple sources, including original equipment manufacturers (OEMs), conversion companies, and product literature. Diligent effort was made to contact all manufacturers that offer commercially available vehicles with alternative fuel or advanced technology options. Manufacturers are also invited to send comments, additions, or corrections related to any information contained in the guide by contacting the AFDC webmaster at *afdc.energy.gov/progs/webmaster.php*. The AFDC's online heavy-duty vehicle database (afdc.energy.gov/vehicles/search/heavy) reflects product changes made or identified after publication.

# Heavy-Duty Vehicle Application Overview

The following list provides an overview of popular alternative fuel and advanced vehicle options for several common applications:

**School Bus** — Compressed natural gas (CNG) and propane (also known as liquefied petroleum gas, or LPG) are popular alternatives to gasoline and diesel fuel for school buses. Hybrid electric buses and plug-in hybrid electric buses are also available.

**Shuttle Bus** — CNG, propane, hybrid electrics, and fuel cells are potential options for shuttle buses and large passenger vehicles that provide transportation on standard routes.

**Transit Bus** — Hybrid transit buses, along with those powered by CNG or liquefied natural gas (LNG), are available. Fuel cell demonstrations are also in progress.

**Refuse Truck** — Many fleets have refuse trucks with CNG engines, and they can even run on landfill gas where biomethane processing facilities are in operation. Regular routes and stop-and-go operation make refuse haulers a good application for hybrid operation as well. Hydraulic hybrid systems are well suited to refuse service.

**Tractor** — Diesel electric hybrids offer fuel-saving hybrid operation with the convenient availability of diesel. CNG and LNG systems are also attractive options.

**Van** — Step vans that service a set route, such as a package delivery service, may find all-electric battery operation an effective alternative to conventional vans. CNG and propane operation are also popular alternatives.

**Vocational Truck** — CNG, LNG, propane, all-electric, and hybrid vehicles operate in a variety of roles, from beverage delivery to utility boom trucks, paint striping trucks, and merchandise delivery.

# Heavy-Duty Emission Standards

Engine on a dynamometer at the National Renewable Energy Laboratory's ReFUEL facility. *Photo by Dennis Schroeder, NREL 22781*

The U.S. Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) regulate vehicle emissions to reduce impacts to public health and the environment. These regulations apply to all vehicles, regardless of the fuels they operate on.

Emission standards are set based upon vehicle weight class. However, the emission certifications for heavy-duty vehicles apply to the engine rather than to the complete vehicle. A single engine can have multiple certifications if it can be used in vehicles of multiple weight classes. Notably, vehicle weight classifications vary from one regulatory agency to the next. For more information on emission standards, visit *epa.gov/otaq/hd-hwy.htm* and *arb.ca.gov/msprog/msprog.htm*.

Vehicle emissions fall into two categories:

- Air pollutants are smog-forming compounds and other emissions known to or suspected to cause serious health and environmental effects. These include particulate matter (PM), non-methane hydrocarbons (NMHC), sulfur oxides (SOx), and nitrogen oxides (NOx).
- Greenhouse gas (GHG) emissions, primarily carbon dioxide ($CO_2$), contribute to climate change. EPA and the National Highway Traffic Safety Administration recently adopted GHG emissions regulations for heavy-duty engines and vehicles.

EPA established the following emission limits for heavy-duty engines made after 2009:

- PM—0.01 grams per brake horsepower-hour (g/bhp-hr)
- NMHC—0.14 g/bhp-hr
- NOx—0.20 g/bhp-hr.

EPA also regulates the sulfur content in on-highway diesel fuel. Ultra-low sulfur diesel fuel was considered a "technology enabler," paving the way for advanced, sulfur-intolerant exhaust emission control technologies, such as catalytic diesel particulate filters and NOx catalysts.

PM and NMHC are well controlled by these catalytic filtering systems. NOx may be reduced by the use of exhaust gas recirculation (EGR) and selective catalytic reduction (SCR).

EGR is a NOx emissions reduction process that recirculates a portion of an engine's exhaust gas back to the engine combustion chambers. This recirculated gas dilutes the mixture of gases and helps reduce the combustion temperature. Because NOx form primarily at high temperature, the lower combustion temperature results in reduced NOx output.

SCR involves injecting a urea-based solution known as diesel exhaust fluid (DEF) into a stream of exhaust gas. The urea is combined with engine exhaust in the presence of a catalyst to convert smog-forming NOx into nitrogen and water vapor.

Conversion emission standards for heavy-duty vehicles manufactured before 2010 remain the same as the standards applicable in the year of engine manufacture. Conversion companies must obtain a certificate of compliance for each model year engine family being converted.

# Multiple-Stage Construction of Medium- and Heavy-Duty Vehicles

Vocational heavy-duty trucks are typically manufactured in multiple stages: An incomplete vehicle or chassis cab is progressively upfitted with equipment according to the specific tasks the vehicle will perform and is then certified as a complete vehicle by a final-stage manufacturer before delivery to the end user. The incomplete vehicle may be modified, or "manufactured," by multiple intermediate-stage manufacturers before going to the final-stage manufacturer or may only require a single manufacturing operation by the final-stage manufacturer. The "manufacturing" process performed on the incomplete vehicle by intermediate- or final-stage manufacturers depends on the end-use application and the associated specialized equipment requirements, which may include installing equipment, such as refuse packing bodies, paint-striping systems, snow plows, or aerial platform boom truck bodies, or modifying the chassis (e.g., moving or adding axles or modifying the length of the frame).

Because of the vast array of possible final vehicle configurations, and to increase overall flexibility of the manufacturing process, alternative-fuel storage systems (e.g., for CNG, LNG, or propane) may be installed by intermediate- or final-stage manufacturers rather than by the incomplete chassis manufacturer. This may add steps to the manufacturing process but also allows greater design flexibility. This installation is typically transparent to the vehicle purchaser and is consistent with the multistage manufacturing approach utilized within the market segment. The intermediate- and final-stage manufacturers are typically coordinated by the vehicle dealer, final-stage manufacturer, or equipment manufacturer, depending on the established purchasing arrangements, which may be unique for each type of vehicle purchased or for each fleet.

## Step-by-Step Manufacturing Process

Four major systems must be integrated into each heavy-duty vocational truck:

- Chassis
- Engine
- Fuel system
- Specialty equipment.

### *Chassis*

For alternative fuel applications, chassis configurations are selected based on end-use requirements in the same way that conventionally fueled chassis cabs are, except in cases where additional frame length or increased gross vehicle weight rating (GVWR) is required to accommodate a larger and/or heavier fuel storage system. Chassis are available in conventional and cab-over-axle configurations based on manufacturers' decisions about the best design that will accommodate alternative fuel engines. Cab configurations and frame length are important considerations in chassis selection.

### *Engine*

Chassis are available with OEM alternative-fuel engines, or with gasoline or diesel engines converted to operate on an alternative fuel by installing an emissions-certified conversion system. Alternative fuel engines that run on CNG, LNG, or propane can be dedicated to operate full time on the alternative fuel; bi-fuel to run on either the alternative fuel or gasoline; or dual-fuel to run on the alternative fuel and use diesel for ignition assist. Advanced hybrid vehicles combine gasoline or diesel engine operation with battery power that reduces petroleum consumption.

### *Fuel System*

CNG, LNG, and propane are stored in cylinders onboard a vehicle. Cylinders are heavier than gasoline or diesel tanks and less flexible in shape—making them more challenging to package on the vehicle. This can result in less volume or weight capacity for these vehicles when compared to a vehicle with a conventional fuel system. Thoughtful design considerations can compensate for these drawbacks.

Specialty equipment manufacturers have recognized the challenges associated with packaging alternative fuel storage systems with sufficient storage capacity and have developed products that seamlessly integrate the alternative fuel system into their product or body structure. In other cases, utility body manufacturers have integrated the fuel system into the body equipment to minimize any reductions in fuel storage capacity.

### *Specialty Equipment Upfitting*

The final step is upfitting the chassis with the equipment necessary for the desired application, e.g., refuse packer, paint-striping rig, shuttle bus, or beverage delivery hauler.

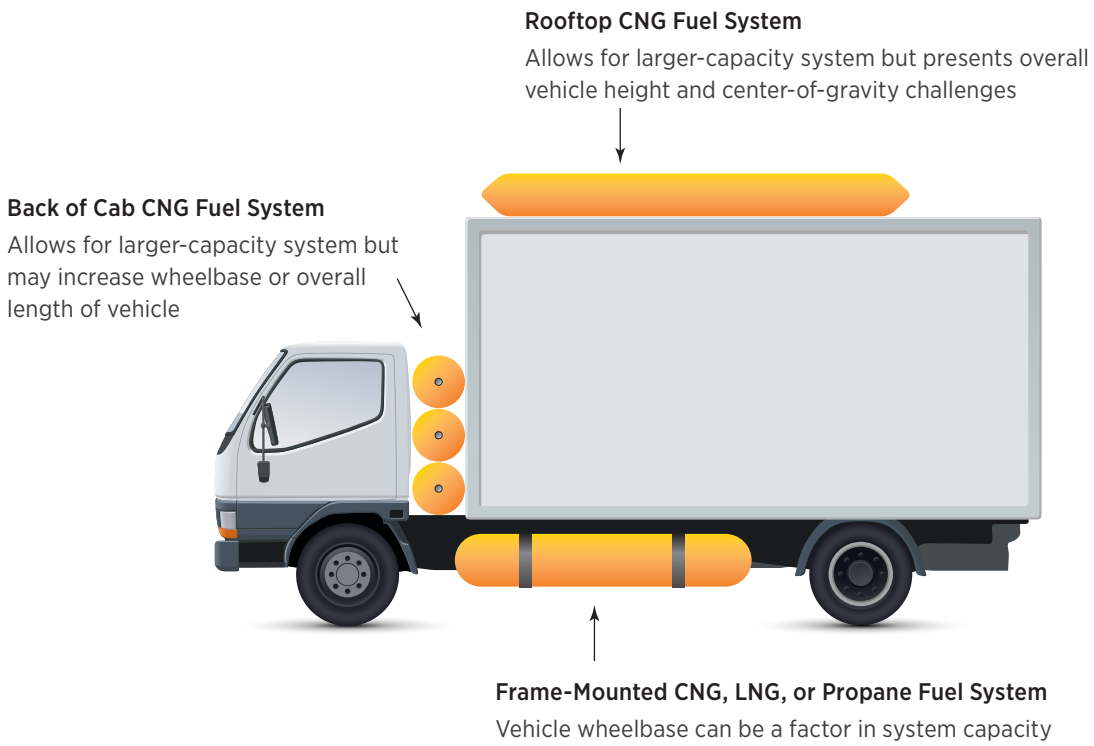



*Illustration from iStock 9723056, NREL*

# Chassis Selection

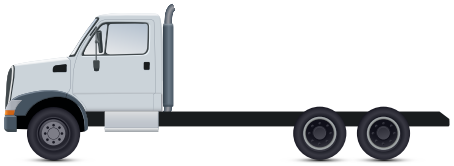
A cab chassis is a body style and type of vehicle construction often found in medium-duty commercial vehicles. Instead of a pre-assembled flatbed, cargo container, or other equipment, the customer buys the vehicle with just chassis rails and a cab. This allows the upfitter to assemble any desired aftermarket equipment, such as fire apparatus, an ambulance, beverage truck, or other application-specific equipment.

Chassis selection for use with alternative fuels must account for the weight of required fuel tanks or battery packs. The additional weight may reduce cargo space or cargo capacity. In the case of a truck plus a trailer or trailers, the gross vehicle weight as well as the overall length of the vehicle must be within the limits specified by state regulations where the truck or tractor-trailer is to be operated.

## Cab Chassis Types

### Conventional Cab

The long hood design allows for the power plant to be located ahead or mostly ahead of the cowl. It may be used on a two- or three-axle chassis. It is best suited to long-distance highway operation.



### Conventional Cab with Set-Back Axle

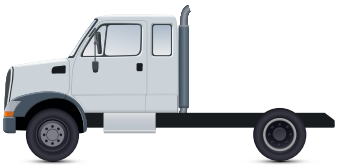
This is similar to a conventional cab but features a set-back front axle for better maneuverability in traffic and better weight transfer to the front axle. It may be used on a two- or three-axle chassis.

### Tilt Cab or Cab Over Engine

This chassis features an extremely short front-bumper-to-back-of-cab dimension. The engine is positioned beneath the cab with a provision for tilting the cab forward on a pivot to provide access to the engine. It permits better weight transfer to the front axle and better maneuverability compared to conventional cab-forward designs. It is usually used on a three-axle chassis; it can also be used on a two-axle chassis.

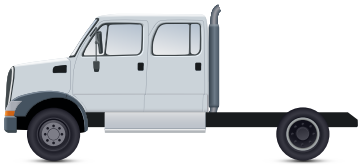
### Extended Cab

An extended cab has additional storage space behind the front seat for cargo and/or passengers and is longer than a conventional cab. It is usually used with a two-axle chassis.



### Crew Cab

A crew cab features four doors and six-passenger seating. It is used with a two-axle chassis.



*Source: NTEA*

*Illustrations from iStock 9723056, NREL*

## Chassis Manufacturers

| Manufacturer | Models | Applications | Website |
|---|---|---|---|
| **Autocar LLC** | Xpeditor ACX, Xpeditor E3, Xpert | Heavy-duty refuse hauler or vocational truck, medium-duty truck | *www.autocartruck.com* |
| **Blue Bird Corp.** | All-American Rear Engine, Vision | School bus | *www.blue-bird.com* |
| **Crane Carrier** | LDT2, LET2, COE2 | Medium-duty vocational truck, heavy-duty refuse hauler | *www.cranecarrier.com* |
| **Ford Motor Co.** | E-150/250/350/450, F-250/350/450/550/650/750, F-53/59 | Shuttle bus, vocational truck | *www.fleet.ford.com/showroom/environmental_vehicles* |
| **Freightliner Custom Chassis** | MT-45, MT-55 | Heavy-duty truck, vocational truck | *http://freightlinerchassis.com* |
| **Freightliner Trucks** | Business Class M2 106, Plug-In Walk-In Van | Hybrid vocational truck, bus, walk-in van | *www.freightlinertrucks.com* |
| **General Motors** | Chevrolet/GMC 4500 Cutaway | Van, vocational truck | *www.gmfleet.com* |
| **International** | Durastar, Terrastar, WorkStar | Medium-duty and heavy-duty vocational truck, refuse hauler, over-road tractor | *www.internationaltrucks.com* |
| **Kenworth** | T270, T370, T440, T470H, T660, T800, W900 | Medium-duty vocational truck, heavy-duty hauling, concrete mixer | *www.kenworth.com/2100_vir.asp* |
| **Mack Trucks** | TerraPro Cabover, TerraPro Low Entry | Heavy-duty refuse hauler, vocational truck | *www.macktrucks.com/#/home* |
| **Peterbilt** | 320, 330 HE, 337 HE, 348 HE, 365, 367, 382, 384, 386, 388 | Medium-duty vocational truck, heavy-duty refuse hauler, concrete mixer | *www.peterbilt.com/index.aspx* |
| **Smith Electric Vehicles** | Newton Cab Chassis | Medium-duty vocational applications, shuttle bus, school bus | *www.smithelectric.com* |

# Alternative Fuel Engines, Motors, Fuel Cells, and Microturbines

## Natural Gas Engines

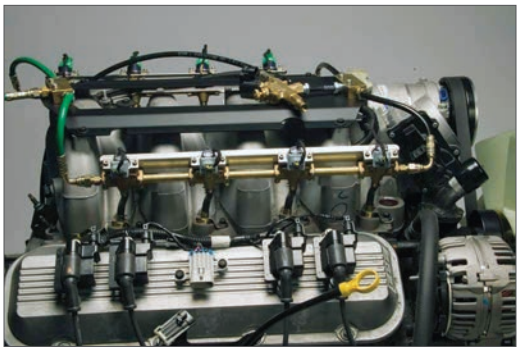
Current-production natural gas engines are designed to operate solely on natural gas (dedicated), on either natural gas or gasoline (bi-fuel), or on a combination of natural gas and diesel fuel (dual-fuel). Dedicated and bi-fuel natural gas engines are spark-ignited, and dual-fuel engines utilize a minimal amount of diesel for pilot ignition in compression-ignition combustion. Natural gas is stored onboard the vehicle as either CNG or LNG. CNG is more common and has a longer history of use in vehicles, but LNG is popular in heavy-duty applications for which maximum fuel capacity and extended driving range are required. CNG is stored at pressures of 3,000–3,600 pounds per square inch (psi) in specially designed and constructed cylinders onboard the vehicle. LNG is cooled to a cryogenic temperature of approximately -260°F and stored as a liquid onboard the vehicle in double-wall, vacuum-insulated storage tanks.

Cummins Westport ISL G natural gas engine.
*Photo from Cummins Westoport*

Natural gas is a clean-burning alternative fuel and offers a number of advantages to users. It is colorless, non-corrosive, and odorless, though an odorant is commonly added to aid in leak detection. A switch from conventional diesel vehicles to natural gas vehicles (NGVs) has the potential to result in lower levels of emissions, including NOx and PM. Additionally, natural gas is generally less expensive than diesel or gasoline.

## Propane Engines

Propane—also known as liquefied petroleum gas, LPG, or autogas—is a byproduct of crude oil refining and natural gas processing. Propane is a gas at room temperature and is stored onboard a vehicle as a liquid in a tank pressurized to about 150 psi.



CleanFUEL USA liquid propane injection system.
*Photo from CleanFUEL USA*

Propane vehicles operate much like gasoline vehicles with spark-ignited engines. There are two types of propane fuel-injection systems available: vapor and liquid injection. In a vapor-injection system, liquid propane is controlled by a regulator or vaporizer, which converts the liquid to vapor, which is then drawn into the combustion chamber. In a liquid-injection system, fuel is delivered to the combustion chamber in liquid form.

Because propane is a low-carbon, clean-burning fuel, a switch to propane has the potential to result in reductions of hydrocarbon, carbon monoxide (CO), NOx, and GHG emissions. In addition, propane is nontoxic, so it isn't harmful to soil or water when spilled or leaked.

## All-Electric

An all-electric vehicle, sometimes called a battery-electric vehicle, is one that uses a battery pack to power an electric motor as its sole source of propulsion. The battery pack is charged by being plugged in. Batteries may be, but are not limited to, lead acid, nickel metal hydride, or lithium ion. Electric vehicles powered by rechargeable batteries offer a number of benefits, including reduced noise from the lack of an internal combustion engine (ICE), no gear changes, and fewer moving parts. The vehicles themselves generate no NOx, SOx, PM, $CO_2$, or CO emissions, though emissions are associated with the majority of electricity production in the United States.

## Fuel Cells

Fuel cells produce electricity through a chemical reaction—typically between hydrogen and oxygen—with water and heat as byproducts. In a fuel cell vehicle, the electricity is used to power an electric motor that drives the vehicle's wheels. In addition to producing zero tailpipe emissions, hydrogen fuel cells are attractive for transportation applications for two main reasons: First, hydrogen can be produced from various sustainable and domestic resources; second, fuel cells are more efficient than conventional ICEs in utilizing the chemical energy contained in the fuel. Fuel cells convert roughly 50% of the hydrogen's energy into electricity.


Ballard FCvelocity fuel cell.
*Photo from Ballard Power Systems*

Hydrogen storage is one of the major barriers to fuel cell use in vehicles. Hydrogen has a low energy density. To give fuel cell vehicles an adequate driving range, hydrogen must be stored onboard the vehicles in a gaseous state under very high pressure (e.g., 700 bar), as a cryogenic liquid, or in another medium (e.g., methanol, ethanol, or natural gas) from which hydrogen is extracted through an onboard reformer. Another option is materials-based storage, including chemical hydrides or adsorbents. Several manufacturers are testing hydrogen vehicles and have demonstrated models with the driving ranges required for the consumer market.

## Microturbines

A microturbine acts as an auxiliary power unit (APU) in series hybrid vehicles, in applications such as transit buses or trucks. The microturbine charges the batteries, which in turn power the electric motor that drives the wheels of the vehicle. The microturbine can be fueled with natural gas, waste methane, biodiesel, diesel, or propane. A microturbine expands a vehicle's range while providing added power for auxiliary loads (e.g., air conditioning and heat), thus reducing engine wear, fuel use, and emissions.

Microturbine. *Photo from Capstone Turbine Corp.*

## Engines Certified for Biodiesel

Biodiesel or biodiesel blends are used by heavy-duty vehicle operators to reduce petroleum consumption and pollutant emissions. Biodiesel is a domestic, renewable fuel for diesel engines, which must meet the specifications of ASTM D6751. Biodiesel is produced from vegetable oils, animal fats, or biomass conversion, but it is not the same as raw vegetable oil.

B5 (5% biodiesel, 95% petroleum diesel) can be used in any diesel vehicle. Engine manufacturers may certify their engines for use with B20 (20% biodiesel, 80% petroleum diesel). Significant reductions of PM, CO, and hydrocarbon emissions can be achieved with B20 blends. Minor impacts in peak torque and fuel economy are related to the lower energy density of biodiesel fuels, but thermal efficiency is unchanged. The National Renewable Energy Laboratory's Biodiesel Handling and Use Guide is a source of more information about biodiesel as a transportation fuel. Find it using the AFDC publications search (*afdc.energy.gov/afdc/progs/pubs.php*).

## Conversions

Some fleets may decide to convert their existing conventional vehicles to operate on an alternative fuel. Conversions of heavy-duty vehicles involve replacing or rebuilding the engine and adding appropriate fuel storage systems.

Alternative fuel engines and powertrains are now being packaged by their manufacturers to be a direct replacement for their diesel counterparts. A Cummins Westport CNG engine, for example, is configured to mount in a chassis just like a diesel engine does, and an Allison parallel hybrid transmission can mount in the same space as a standard automatic transmission.

Companies that perform alternative fuel conversions must possess EPA or CARB certification that is specific to the make, model, and model year of the engine in question. The lists of systems certified by EPA and/or CARB are updated regularly. Visit *epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm* and *arb.ca.gov/msprog/aftermkt/altfuel/altfuel.htm* for the most current lists of certified systems for vehicles of all model years.

**Engine, Motor, Fuel Cell, and Microturbine Manufacturers**

| Manufacturer | Model | Fuel/Technology | Website |
|---|---|---|---|
| **Ballard Power Systems** | FCvelocity HD6 Fuel Cell Module, FCvelocity-9SSL Fuel Cell Stack | Hydrogen | *www.ballard.com* |
| **Capstone Turbine Corp.** | C30, C65, C200, C600, C800, C1000 MicroTurbine | Natural gas, propane | *www.microturbine.com* |
| **Clean Air Power** | MaxxForce 13 dual-fuel engine | Natural gas | *www.cleanairpower.com* |
| **Cummins Westport** | ISL G 8.9L, ISX12 G | Natural gas | *www.cumminswestport.com* |
| **DesignLine International** | ECOSaver IV | Microturbine | *www.designlinecorporation.com* |
| **Doosan Infracore America Corp.** | GL11K | Natural gas | *http://usa.doosaninfracore.co.kr/Product/CE_engine.aspx* |
| **Enova Systems** | Zero Emissions Drive System (120kW) | Electricity | *www.enovasystems.com* |
| **Ford Motor Co.** | 4.6L FFV, 5.4L FFV, 6.8L EFI FFV engines | E85 | *www.fleet.ford.com* |
| **General Motors** | 6.0L Vortec | Natural gas, propane | *www.gmfleet.com* |
| **Greenkraft** | Greenkraft 8.8L | Natural gas | *http://greenkraftinc.com/index.html* |
| **Hydrogenics** | HyPM HD; HD 30; HD 90; HD 180 Fuel Cell Power Modules | Hydrogen | *www.hydrogenics.com* |
| **UTC Power** | PureMotion Model 120 Fuel Cell | Hydrogen | *www.utcpower.com* |
| **Westport Innovations** | GX 15L Engine, HD 400, HD 450, HD 475 | Natural gas | *www.westport.com* |

## Medium- and Heavy-Duty Vehicle Conversion Companies

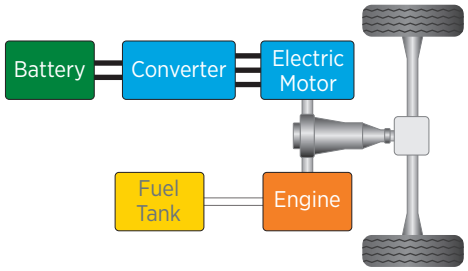
| Conversion System Manufacturer | Fuel/Technology | Vehicle OEMs | Website |
|---|---|---|---|
| **A-1 Alternative Fuel Systems** | Natural gas, propane | Ford | *www.a1autoelectric.com* |
| **American Alternative Fuel** | Propane | Ford, General Motors | *www.aafuel.com* |
| **American Power Group** | Natural gas | Caterpillar, Detroit Diesel | *www.americanpower groupinc.com* |
| **BAF Technologies** | Natural gas | Ford | *www.baftechnologies.com* |
| **Bi-Phase Technologies** | Propane | Ford, General Motors | *www.bi-phase.com* |
| **CleanFUEL USA** | Propane | General Motors | *www.cleanfuelusa.com* |
| **Go Natural** | Natural gas | Ford | *www.gonaturalcng.com/ index.php* |
| **Greenkraft** | Natural gas | General Motors | *http://greenkraftinc.com/ alternativeFuelKits.html* |
| **IMPCO Technologies** | Natural gas, propane | Ford, General Motors | *www.impcoautomotive.com* |
| **Landi Renzo** | Natural gas, propane | Ford, General Motors, Isuzu | *www.landiusa.com* |
| **Lightning Hybrids** | Hybrid electric | Most existing vehicles, model year 2008 and newer | *http://lightninghybrids.com* |
| **NatGasCar** | Natural gas | Chrysler | *www.natgascar.com* |
| **Odyne/DUECO** | Electricity | Medium- and heavy-duty vocational vehicles | *www.odyne.com* |
| **Quantum Technologies** | Electricity, hybrid electric, hydrogen, natural gas, propane | Various, including Ford and General Motors, as well as custom military vehicles | *www.qtww.com* |
| **Roush CleanTech** | Propane | Ford | *www.ROUSHcleantech.com* |
| **TransEco Energy** | Natural gas | Ford | *www.transecoenergy.com/ index.htm* |
| **Venchurs** | Natural gas | Ford | *www.venchurscng.com* |
| **World CNG** | Natural gas | Chrysler, Ford, General Motors, Isuzu | *www.worldcng.com* |

# Hybrid Propulsion Systems by Design

Hybrid vehicles rely on two or more sources to produce and deliver power, combined with an onboard rechargeable energy storage system. In hybrid electric vehicles, these two power sources are (1) a conventional ICE and (2) an electric motor combined with a battery pack. Hydraulic hybrids employ (1) a conventional ICE and (2) a hydraulic pump/motor combined with a hydraulic energy storage system or accumulator. The efficiency of hybrids can be further increased through use of advanced technologies such as regenerative braking, which captures and stores energy that would otherwise be lost during braking.

Hybrid configurations are very attractive for numerous medium- and heavy-duty applications, including stop-and-start delivery vans and trucks, refuse collection, transit buses, utility bucket trucks, and warehouse tractors. Each of these applications involves frequent engine stops and starts, extended idling, and frequent braking.

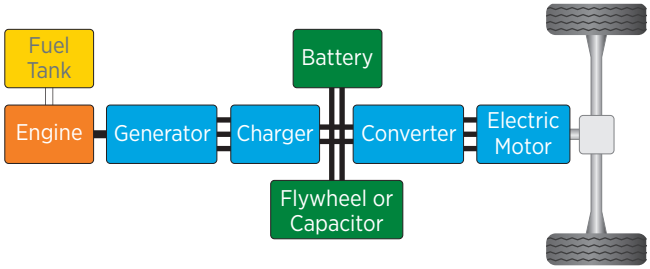
## Parallel Hybrid System




Parallel hybrid systems have both an ICE and an electric motor connected directly to the transmission. Most designs combine a large electrical generator and a motor into one unit, replacing both the conventional starter motor and the alternator. To store energy, a hybrid uses a large battery pack with a higher voltage than the traditional automotive 12-volt battery.

Parallel hybrids can be further categorized depending on how balanced the two systems are in providing motive power. In some cases, the ICE is the dominant system (the electric motor turns on only when a boost or supplemental power for acceleration is needed). Other parallel hybrids can run with just the electric system operating.

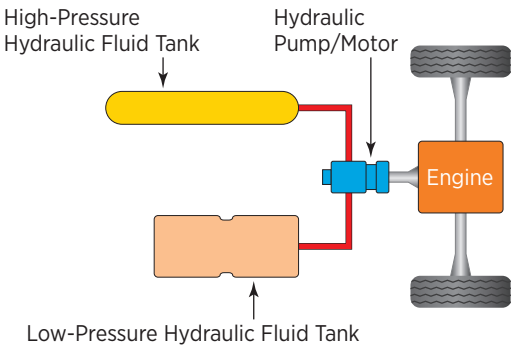
## Series Hybrid System




In series or serial hybrids, the ICE drives an electric generator instead of directly driving the wheels. The generator can either charge the batteries or power an electric motor that propels the vehicle. When large amounts of power are required, the motor draws electricity from both the batteries and the generator. Series hybrids can also be fitted with an ultracapacitor or a flywheel to store regenerative braking energy, which can improve efficiency by minimizing charge depletion of the battery.

Because a series hybrid lacks a mechanical link between the ICE and the wheels, the engine can run at a constant and efficient rate, even as the vehicle changes speed.

## Parallel Hydraulic Hybrid System (Launch Assist)

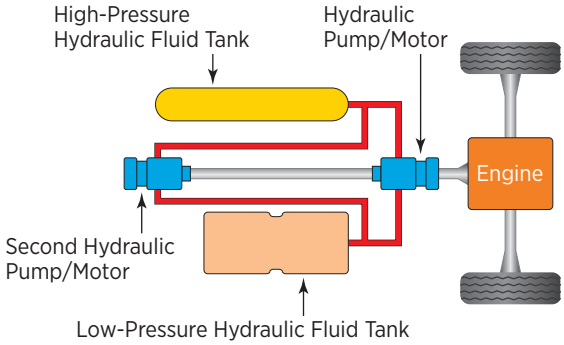



A hydraulic launch assist (HLA) system uses a hydraulic pump and motor and hydraulic storage tanks to supplement the conventional vehicle powertrain. During braking, the vehicle's kinetic energy drives the pump/motor as a pump, transferring hydraulic fluid from the low-pressure reservoir to a high-pressure accumulator. The fluid compresses nitrogen gas in the accumulator and pressurizes the system. Regenerative braking captures about 70% of the kinetic energy produced during braking. During acceleration, fluid in the high-pressure accumulator is metered out to drive the pump/motor as a motor. The system propels the vehicle by transmitting torque to the driveshaft.

### Series Hydraulic Hybrid System

In a series hydraulic hybrid system, the conventional transmission and driveline are replaced by the hydraulic hybrid powertrain, and energy is transferred from the engine to the drive wheels through fluid power. The vehicle uses hydraulic pump/motors and hydraulic storage tanks to recover and store energy, similar to the way in which hybrid electric vehicles employ electric motors and batteries. The system is suited to vehicles that operate in stop-and-go duty cycles, including heavy-duty refuse hauling.

The engine operates at its "sweet spot" of fuel efficiency, facilitated by the continuously variable transmission functionality of the series hydraulic hybrid system and by regenerative braking.




## Hybrid Propulsion Systems by Fuel

### Diesel Hybrids

Diesel electric hybrids are powered by both a diesel ICE and an electric motor. The diesel engine powers the vehicle and generates electricity for the electric motor. The electric motor derives its power from an alternator or generator that is coupled with an energy storage device, such as a set of batteries or ultracapacitors.

Medium- and heavy-duty vehicles that stop and start often are well suited for this technology, which captures regenerative braking energy to power the electric motor. The efficient operation of hybrid vehicles results in lower tailpipe emissions by running on electricity part of the time and thereby reducing fuel use.

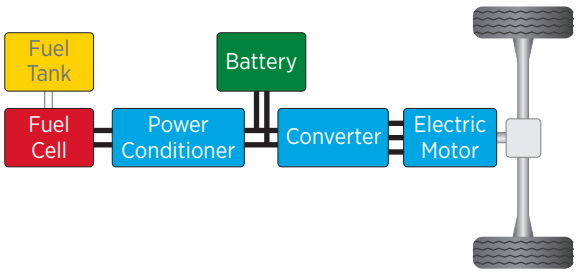
### CNG Hybrids

A CNG hybrid electric system features a CNG-powered ICE, an electric motor/generator, inverters, and a battery pack. The electric motor draws energy from the battery pack or other energy storage device, such as ultracapacitors.

Because natural gas is mostly methane, NGVs have much lower NMHC emissions than gasoline vehicles do. And because the vehicle's fuel system is closed, there are no evaporative emissions, and refueling emissions are negligible. Cold-start emissions from NGVs are also low, because cold-start enrichment is not required; this reduces both volatile organic compound and CO emissions.

### Fuel Cell Hybrids

Fuel cell hybrids operate much like other hybrid electric vehicles but with fuel cells producing electricity that charges the batteries, and a motor that converts electricity from the batteries into mechanical energy that drives the wheels.




*System illustrations by NREL*

| Hybrid Propulsion System Manufacturers | | | |
|---|---|---|---|
| **Manufacturer** | **Model** | **Type** | **Website** |
| **Allison Transmission** | Allison H 40 EP | 2-mode split parallel | *www.allisontransmission.com* |
| **Allison Transmission** | Allison H 50 EP | 2-mode split parallel | *www.allisontransmission.com* |
| **BAE Systems** | HybriDrive Propulsion System | Series, parallel | *www.baesystems.com/ ProductsServices/bae_ prod_eis_hybridrive.html* |
| **DesignLine International** | ECOSaver IV | Series | *www.designlinecorporation.com* |
| **Eaton** | Eaton Hybrid Drive System | Parallel | *www.eaton.com* |
| **Eaton** | Eaton Hybrid HLA | Parallel | *www.eaton.com* |
| **Eaton** | Eaton Parallel Hybrid with Power Take-Off | Parallel | *www.eaton.com* |
| **Enova Systems** | Post Transmission Parallel Hybrid Electric Drive (90kW, 120kW, 170kW, 240kW Drive Systems) | Parallel | *www.enovasystems.com* |
| **Lightning Hybrids** | Hydraulic Hybrid | Parallel | *http://lightninghybrids.com* |
| **Odyne** | Odyne Plug-in hybrid with electric PTO | Parallel | *www.odyne.com* |
| **Parker Hannifin Corp.** | RunWise Advanced Hydraulic Hybrid | Series | *www.parker.com* |
| **Quantum Technologies** | F-Drive | Gasoline plug-in hybrid (150kW parallel system) | *www.qtww.com* |
| **Quantum Technologies** | M-Drive | Diesel (JP8) series hybrid system with 8-mile EV range | *www.qtww.com* |
| **Quantum Technologies** | Q-Drive | Gasoline plug-in hybrid (300kW series system) | *www.qtww.com* |
| **Quantum Technologies** | Quiet-Drive | 50kW EV drive system | *www.qtww.com* |
| **Voith** | DIWAhybrid | Parallel | *www.usa.voithturbo.com* |

# Medium- and Heavy-Duty Vehicles by Application

## School Bus

*Photo from Blue Bird Corp.*

**Manufacturer: Blue Bird Corp.**

- Manufacturer Website: *www.blue-bird.com*
- Model: All American Rear Engine
- Application: School bus
- Fuel Type(s): CNG
- Maximum Seating: 84
- Power Source(s): Cummins Westport ISL G 8.9L

No Photo Available

**Manufacturer: Blue Bird Corp.**

- Manufacturer Website: *www.blue-bird.com*
- Model: Micro Bird G5
- Application: School bus
- Fuel Type(s): Propane
- Maximum Seating: 30
- Power Source(s): Ford 6.8L V-10
  - Roush CleanTech liquid propane fuel system

*Photo from Blue Bird Corp.*

**Manufacturer: Blue Bird Corp.**

- Manufacturer Website: *www.blue-bird.com*
- Model: Vision
- Application: School bus
- Fuel Type(s): Propane
- Maximum Seating: 77
- Power Source(s): Ford 6.8L V-10
  - Roush CleanTech liquid propane fuel system

*Photo from Collins Bus Corp.*

**Manufacturer: Collins Bus Corp.**

- Manufacturer Website: *www.collinsbuscorp.com*
- Model: NexBus Propane
- Application: School bus
- Fuel Type(s): Propane
- Maximum Seating: 30
- Power Source(s): GM 6.0L V-8
  - CleanFUEL USA liquid propane injection (LPI) system

*Photo from Thomas Built Buses*

**Manufacturer: Thomas Built Buses**

- Manufacturer Website: *www.thomasbus.com*
- Model: Minotour Propane
- Application: School bus
- Fuel Type(s): Propane
- Maximum Seating: 30
- Power Source(s): GM 6.0L V-8
  - CleanFUEL USA liquid propane injection (LPI) system


*Photo from Thomas Built Buses*

**Manufacturer: Thomas Built Buses**

- Manufacturer Website: *www.thomasbus.com*
- Model: Saf-T-Liner C2e Hybrid
- Application: School bus
- Fuel Type(s): Diesel electric hybrid
- Maximum Seating: 81
- Power Source(s): Cummins ISB 6.7L
- Hybrid System(s): Eaton parallel hybrid-drive system

No Photo Available

**Manufacturer: Thomas Built Buses**

- Manufacturer Website: *www.thomasbus.com*
- Model: Saf-T-Liner C2 Propane
- Application: School bus
- Fuel Type(s): Propane
- Maximum Seating: 81
- Power Source(s): GM 8.0L V-8
  - CleanFUEL USA liquid propane injection (LPI) system

*Photo from Thomas Built Buses*

**Manufacturer: Thomas Built Buses**

- Manufacturer Website: *www.thomasbus.com*
- Model: Saf-T-Liner HDX CNG
- Application: School bus
- Fuel Type(s): CNG
- Maximum Seating: 90
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Trans Tech*

**Manufacturer: Trans Tech**

- Manufacturer Website: *www.transtechbus.com*
- Model: ETrans
- Application: School bus
- Fuel Type(s): Electricity
- Maximum Seating: 52
- Power Source(s): 120kW induction motor with lithium-ion batteries

# Shuttle Bus

No Photo Available

**Manufacturer: Champion Bus Inc.**

- Manufacturer Website: *www.championbus.com*
- Model: CTS – Front Engine
- Application: Shuttle bus
- Fuel Type(s): CNG
- Maximum Seating: 32
- Power Source(s): Cummins Westport ISL G 8.9L

No Photo Available

**Manufacturer: Champion Bus Inc.**

- Manufacturer Website: *www.championbus.com*
- Model: Defender
- Application: Shuttle bus
- Fuel Type(s): Gasoline electric hybrid
- Maximum Seating: 32
- Additional Description: Available with an optional hybrid chassis

No Photo Available

**Manufacturer: Ebus**

- Manufacturer Website: *www.ebus.com*
- Model: EBUS22FC
- Application: Shuttle bus
- Fuel Type(s): Hydrogen fuel cell hybrid, gasoline electric hybrid
- Maximum Seating: 22
- Power Source(s): Ballard Power Systems FCvelocity-HD6 fuel cell
  Ballard Power Systems PEM Mark 9 SSL fuel cell
  Capstone Turbine C30 (30kW) MicroTurbine
- Additional Description: Ebus fuel cell buses are plug-in electric buses with the fuel cell and batteries configured electrically in series. The bus can operate on battery-only power for part of the day. The Ebus hybrid electric bus uses an ultra-low emission micro-turbine as an onboard hybrid generator.

*Photo from Goshen Coach*

**Manufacturer: Goshen Coach**

- Manufacturer Website: *www.goshencoach.com*
- Model: GCII/G-Force
- Application: Shuttle bus
- Fuel Type(s): CNG, propane
- Maximum Seating: 33
- Power Source(s): Ford 6.8L V-10
  GM 6.0L V-8
- Additional Description: May be converted to use CNG or propane

*Photo from IC Bus*

**Manufacturer: IC Bus**

- Manufacturer Website: *www.icbus.com*
- Model: HC Series Hybrid
- Application: Shuttle bus
- Fuel Type(s): Diesel electric hybrid
- Maximum Seating: 45
- Power Source(s): Navistar MaxxForce DT
- Hybrid System(s): Eaton Fuller hybrid drive

No Photo Available

**Manufacturer: StarTrans Bus**

- Manufacturer Website: *www.startransbus.com*
- Model: President
- Application: Shuttle bus
- Fuel Type(s): CNG, propane
- Maximum Seating: 35
- Additional Description: May be converted to use CNG or propane

No Photo Available

**Manufacturer: StarTrans Bus**

- Manufacturer Website: *www.startransbus.com*
- Model: Senator
- Application: Shuttle bus
- Fuel Type(s): CNG
- Maximum Seating: 17
- Power Source(s): Ford 5.4L V-8
  Ford 6.8L V-10
- Additional Description: May be converted to use CNG

*Photo from Turtle Top*

**Manufacturer: Turtle Top**

- Manufacturer Website: *www.turtletop.com*
- Model: Odyssey
- Application: Shuttle bus
- Fuel Type(s): CNG, propane
- Maximum Seating: 24
- Power Source(s): GM 6.0L V-8
  Ford 6.8L V-10
- Additional Description: Available as a Chevrolet G4500 or Ford E-450 chassis; may be converted to use CNG or propane

*Photo from Turtle Top*

**Manufacturer: Turtle Top**

- Manufacturer Website: *www.turtletop.com*
- Model: Odyssey XL
- Application: Shuttle bus
- Fuel Type(s): CNG, propane
- Maximum Seating: 41
- Power Source(s): Ford 6.8L V-10
- Additional Description: Available as a Ford F-550 chassis; may be converted to use CNG or propane

*Photo from Turtle Top*

**Manufacturer: Turtle Top**

- Manufacturer Website: *www.turtletop.com*
- Model: Odyssey XLT
- Application: Shuttle bus
- Fuel Type(s): CNG, diesel electric hybrid
- Maximum Seating: 50
- Hybrid System(s): FM2 Eaton hybrid system
- Additional Description: Available as a Freightliner M2 106 chassis; may be converted to use CNG

*Photo from Turtle Top*

**Manufacturer: Turtle Top**

- Manufacturer Website: *www.turtletop.com*
- Model: Terra Transport
- Application: Shuttle bus
- Fuel Type(s): CNG, propane
- Maximum Seating: 15
- Power Source(s): GM 6.0L V-8
- Additional Description: Available as a Chevrolet Express or GMC Savana 3500 chassis; may be converted to use CNG or propane

*Photo from Turtle Top*

**Manufacturer: Turtle Top**

- Manufacturer Website: *www.turtletop.com*
- Model: Van Terra
- Application: Shuttle bus
- Fuel Type(s): CNG, propane
- Maximum Seating: 15
- Power Source(s): Ford 6.8L V-8
- Additional Description: Available as a Ford E-350 chassis; may be converted to use CNG or propane

# Transit Bus

*Photo from DesignLine Corp.*

**Manufacturer: DesignLine Corp.**

- Manufacturer Website: *www.designlinecorporation.com*
- Model: EcoSaver IV
- Application: Transit bus
- Fuel Type(s): CNG electric hybrid, diesel electric hybrid
- Maximum Seating: 40
- Power Source(s): Capstone C30 MicroTurbine (30kW)
  Capstone C65 MicroTurbine (65kW)
- Hybrid System(s): DesignLine EcoSaver IV
- Additional Description: Uses a small APU and can operate on battery-only power, with regenerative braking

*Photo from DesignLine Corp.*

**Manufacturer: DesignLine Corp.**

- Manufacturer Website: *www.designlinecorporation.com*
- Model: Eco-Smart 1
- Application: Transit bus
- Fuel Type(s): Electricity
- Maximum Seating: 28
- Power Source(s): Two 120kW Bosch Rexroth induction motors
- Additional Description: Operates up to 120 miles on a single charge under high-density, stop-and-go, urban transit

*Photo from ElDorado National*

**Manufacturer: ElDorado National**

- Manufacturer Website: *www.econline.com*
- Model: Axess
- Application: Transit bus
- Fuel Type(s): CNG, LNG, diesel electric hybrid, hydrogen fuel cell
- Maximum Seating: 41
- Power Source(s): Cummins ISL 8.9L
  Cummins Westport ISL G 8.9L
  Ballard Power Systems FCvelocity-HD6 fuel cell
- Hybrid System(s): Allison H 40 EP
  BAE Systems HybriDrive

*Photo from ElDorado National*

**Manufacturer: ElDorado National**

- Manufacturer Website: *www.econline.com*
- Model: EZ Rider II BRT
- Application: Transit bus
- Fuel Type(s): CNG, LNG, diesel electric hybrid
- Maximum Seating: 33
- Power Source(s): Cummins ISB 6.7L
  Cummins Westport ISL G 8.9L
- Hybrid System(s): Allison H 40 EP

*Photo from ElDorado National*

**Manufacturer: ElDorado National**

- Manufacturer Website: *www.econline.com*
- Model: XHF
- Application: Transit bus
- Fuel Type(s): CNG, LNG
- Maximum Seating: 39
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Gillig*

**Manufacturer: Gillig**

- Manufacturer Website: *www.gillig.com*
- Model: Diesel Electric Hybrid Bus and CNG Bus
- Application: Transit bus
- Fuel Type(s): CNG, diesel electric hybrid
- Maximum Seating: 40
- Power Source(s): Cummins ISL 8.9L
  Cummins Westport ISL G 8.9L
- Hybrid System(s): Allison H 40 EP

*Photo from Motor Coach Industries*

**Manufacturer: Motor Coach Industries**

- Manufacturer Website: *www.mcicoach.com*
- Model: D4500 CT Hybrid Commuter Coach
- Application: Transit bus
- Fuel Type(s): CNG, diesel electric hybrid
- Maximum Seating: 57
- Power Source(s): Cummins ISL 8.9L
  Cummins Westport ISL G 8.9L
- Hybrid System(s): Allison H 50 EP

*Photo from New Flyer*

**Manufacturer: New Flyer**

- Manufacturer Website: *www.newflyer.com*
- Model: Xcelsior
- Application: Transit bus, trolley
- Fuel Type(s): CNG, LNG, diesel electric hybrid, hydrogen fuel cell hybrid, electricity
- Maximum Seating: Varies
- Power Source(s): Ballard Power Systems FCvelocity-HD6 fuel cell
  Cummins ISL 8.9L
  Cummins Westport ISL G 8.9L
- Hybrid System(s): Allison H 40 EP
  BAE Systems HybriDrive

*Photo from North American Bus Industries*

**Manufacturer: North American Bus Industries**

- Manufacturer Website: *www.nabusind.com*
- Model: 31LFW/35LFW/40LFW
- Application: Transit bus
- Fuel Type(s): CNG, diesel electric hybrid
- Maximum Seating: 40
- Power Source(s): Cummins ISL 8.9L
  Cummins Westport ISL G 8.9L
- Hybrid System(s): Allison H 40 EP
  Allison H 50 EP
- Additional Description: Available in 31-, 35-, and 40-foot models with a low-floor body

*Photo from North American Bus Industries*

**Manufacturer: North American Bus Industries**

- Manufacturer Website: *www.nabusind.com*
- Model: 42BRT
- Application: Transit bus
- Fuel Type(s): CNG, LNG, diesel electric hybrid
- Maximum Seating: 43
- Power Source(s): Cummins ISL 8.9L
  Cummins Westport ISL G 8.9L
- Hybrid System(s): Allison H 40 EP
  Allison H 50 EP

*Photo from North American Bus Industries*

**Manufacturer: North American Bus Industries**

- Manufacturer Website: *www.nabusind.com*
- Model: 60BRT
- Application: Transit bus
- Fuel Type(s): CNG, LNG, diesel electric hybrid
- Maximum Seating: 43
- Power Source(s): Cummins ISL 8.9L
  Cummins Westport ISL G 8.9L
- Hybrid System(s): Allison H 40 EP

*Photo from North American Bus Industries*

**Manufacturer: North American Bus Industries**

- Manufacturer Website: *www.nabusind.com*
- Model: CompoBus
- Application: Transit bus
- Fuel Type(s): CNG, diesel electric hybrid
- Maximum Seating: 47
- Power Source(s): Cummins ISL 8.9L
  Cummins Westport ISL G 8.9L
- Hybrid System(s): Allison H 40 EP

*Photo from Nova Bus*

**Manufacturer: Nova Bus**

- Manufacturer Website: *www.novabus.com*
- Model: LFS Artic HEV
- Application: Transit bus
- Fuel Type(s): Diesel electric hybrid
- Maximum Seating: 62
- Power Source(s): Cummins ISB 6.7L
- Hybrid System(s): Allison H 40 EP

*Photo from Nova Bus*

**Manufacturer: Nova Bus**

- Manufacturer Website: *www.novabus.com*
- Model: LFS HEV
- Application: Transit bus
- Fuel Type(s): Diesel electric hybrid
- Maximum Seating: 41
- Power Source(s): Cummins ISB 6.7L
- Hybrid System(s): Allison H 40 EP

*Photo from Nova Bus*

**Manufacturer: Nova Bus**

- Manufacturer Website: *www.novabus.com*
- Model: LFX
- Application: Transit bus
- Fuel Type(s): Diesel electric hybrid
- Maximum Seating: Varies
- Power Source(s): Cummins ISB 6.7L
  Cummins ISL 8.9L
- Hybrid System(s): Allison H 40 EP
  Allison H 50 EP
- Additional Description: Engine-drive combination depends on length


*Photo from Proterra*

**Manufacturer: Proterra**

- Manufacturer Website: *www.proterra.com*
- Model: EcoRide BE35
- Application: Heavy-duty transit bus
- Fuel Type(s): Electricity
- Maximum Seating: 35
- Power Source(s): UQM PowerPhase 150kW permanent magnet motor


*Photo from Van Hool*

**Manufacturer: Van Hool**

- Manufacturer Website: *www.vanhool.be*
- Model: A300L Fuel Cell
- Application: Transit bus
- Fuel Type(s): Hydrogen fuel cell
- Maximum Seating: 28
- Power Source(s): Ballard Power Systems hydrogen fuel cell
  UTC fuel cell

# Refuse Truck

No Photo Available

**Manufacturer: Autocar**

- Manufacturer Website: *www.autocartruck.com*
- Model: E3 Hybrid
- Application: Refuse truck
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Cummins ISL 8.9L
- Hybrid System(s): Parker RunWise

*Photo from Heil Environmental*

**Manufacturer: Heil Environmental**

- Manufacturer Website: *www.heil.com*
- Model: DuraPack Python
- Application: Refuse truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Heil Environmental*

**Manufacturer: Heil Environmental**

- Manufacturer Website: *www.heil.com*
- Model: Front Loader
- Application: Refuse truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Heil Environmental*

**Manufacturer: Heil Environmental**

- Manufacturer Website: *www.heil.com*
- Model: Rapid Rail
- Application: Refuse truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Heil Environmental*

**Manufacturer: Heil Environmental**

- Manufacturer Website: *www.heil.com*
- Model: Rear Loader
- Application: Refuse truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L

No Photo Available

**Manufacturer: Heil Environmental**

- Manufacturer Website: *www.heil.com*
- Model: Roll-Off Hoist
- Application: Refuse truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Mack Trucks*

**Manufacturer: Mack Trucks**

- Manufacturer Website: *www.macktrucks.com*
- Model: LEU TerraPro Low Entry
- Application: Refuse truck
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Mack Trucks*

**Manufacturer: Mack Trucks**

- Manufacturer Website: *www.macktrucks.com*
- Model: MRU TerraPro Cabover
- Application: Refuse truck
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L


*Photo from McNeilus*

**Manufacturer: McNeilus**

- Manufacturer Website: *www.mcneiluscompanies.com*
- Model: Front Loader (Contender, Atlantic, Low-Profile)
- Application: Refuse truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L


*Photo from McNeilus*

**Manufacturer: McNeilus**

- Manufacturer Website: *www.mcneiluscompanies.com*
- Model: Rear Loader (Std, HD, XC, Tag, MS, Metro-Pak)
- Application: Refuse truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L


*Photo from McNeilus*

**Manufacturer: McNeilus**

- Manufacturer Website: *www.mcneiluscompanies.com*
- Model: Side Loader (ZR, AutoReach)
- Application: Refuse truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L

No Photo Available

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: Model 320 G
- Application: Refuse truck
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: Model 320 HLA
- Application: Refuse truck
- Fuel Type(s): Diesel hydraulic hybrid
- Power Source(s): Cummins ISL 8.9L
- Hybrid System(s): Eaton hydraulic launch assist (HLA)

# Tractor

No Photo Available

**Manufacturer: Balqon**

- Manufacturer Website: *www.balqon.com*
- Model: Nautilus XE-20
- Application: Terminal tractor
- Fuel Type(s): Electricity
- Power Source(s): 200-hp, 230V AC induction motor with 215kWh, 312V lithium-ion batteries

*Photo from Balqon*

**Manufacturer: Balqon**

- Manufacturer Website: *www.balqon.com*
- Model: Nautilus XE-30
- Application: Terminal tractor
- Fuel Type(s): Electricity
- Power Source(s): 200-hp, 230V AC induction motor with 215kWh, 600V lithium-ion batteries

No Photo Available

**Manufacturer: Capacity Trucks**

- Manufacturer Website: *www.capacitytrucks.com*
- Model: HETT
- Application: Terminal tractor
- Fuel Type(s): Electricity

*Photo from Capacity Trucks*

**Manufacturer: Capacity Trucks**

- Manufacturer Website: *www.capacitytrucks.com*
- Model: TJ5000/TJ7000
- Application: Terminal tractor
- Fuel Type(s): Propane
- Power Source(s): Ford 6.8L V-10
  GM 8.0L V-8

*Photo from Capacity Trucks*

**Manufacturer: Capacity Trucks**

- Manufacturer Website: *www.capacitytrucks.com*
- Model: TJ9000
- Application: Terminal tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Cargotec*

**Manufacturer: Cargotec**

- Manufacturer Website: *www.cargotec.com*
- Model: Ottawa 4x2
- Application: Terminal tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Freightliner*

**Manufacturer: Freightliner**

- Manufacturer Website: *www.freightlinertrucks.com*
- Model: Business Class M2 112
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Freightliner*

**Manufacturer: Freightliner**

- Manufacturer Website: *www.freightlinertrucks.com*
- Model: Cascadia 113 NG
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISX12 G

No Photo Available

**Manufacturer: Freightliner**

- Manufacturer Website: *www.freightlinertrucks.com*
- Model: M2 106 Hybrid
- Application: Tractor
- Fuel Type(s): Diesel Electric Hybrid
- Power Source(s): Cummins ISB 6.7L
- Hybrid System(s): Eaton parallel electric hybrid

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: T270/T370 Diesel Electric Tractor
- Application: Tractor
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Paccar PX-6 6.7L
- Hybrid System(s): Eaton parallel electric hybrid

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: T440 Tractor
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L
- Additional Description: Can be a Class 7 or a Class 8 truck

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: T470 Tractor
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L
- Additional Description: Can be a Class 7 or a Class 8 truck

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: T660 Tractor
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISX12 G
- Additional Description: A Class 8 heavy-duty truck designed for on-highway purposes, such as general freight and regional haul

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: T800 Short Hood
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISX12 G
- Additional Description: Can be configured to accomplish a variety of heavy-duty vocational applications

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: T800 Tractor
- Application: Tractor
- Fuel Type(s): LNG
- Power Source(s): Westport GX
- Additional Description: Designed for heavy-duty port, freight, and vocational applications with an operating range of 300 to 500 miles

No Photo Available

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 337
- Application: Tractor
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Paccar PX-6 6.7L
- Hybrid System(s): Eaton parallel electric hybrid

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 365
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 367/386/388
- Application: Tractor
- Fuel Type(s): LNG
- Power Source(s): Westport GX
- Additional Description: Designed for regional- and long-haul applications

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 382
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L
- Additional Description: A heavy-duty truck designed for regional-haul applications

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 384
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 386HE
- Application: Tractor
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Paccar MX-13
- Hybrid System(s): Eaton diesel electric hybrid


*Photo from Vision Motor Corp.*

**Manufacturer: Vision Motor Corp.**

- Manufacturer Website: *www.visionmotorcorp.com*
- Model: Tyrano
- Application: Tractor
- Fuel Type(s): Hydrogen fuel cell hybrid
- Power Source(s): 65kW hydrogen fuel cell
- Hybrid System(s): Eaton hybrid
- Additional Description: A Class 8, zero-emission tractor that combines the acceleration of a battery-powered electric vehicle with the extended range of a hydrogen fuel cell vehicle

No Photo Available

**Manufacturer: Vision Motor Corp.**

- Manufacturer Website: *www.visionmotorcorp.com*
- Model: ZETT Zero-Emission Terminal Tractor
- Application: Terminal tractor
- Fuel Type(s): Hydrogen fuel cell hybrid
- Power Source(s): 16.5kW hydrogen fuel cell
- Hybrid System(s): Vision electric hydrogen hybrid
- Additional Description: Developed in conjunction with Capacity Trucks

*Photo from Volvo*

**Manufacturer: Volvo**

- Manufacturer Website: *www.volvotrucks.com*
- Model: VNL Daycab
- Application: Tractor
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISX12 G
  Volvo D12-LNG

*Photo from Volvo*

**Manufacturer: Volvo**

- Manufacturer Website: *www.volvotrucks.com*
- Model: VNM Daycab
- Application: Tractor
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L

# Van

*Photo from Boulder Electric Vehicle*

**Manufacturer: Boulder Electric Vehicle**

- Manufacturer Website: *www.boulderev.com*
- Model: DV-500 Delivery Truck
- Application: Step van
- Fuel Type(s): Electricity
- Power Source(s): AC brushless induction motor with lithium-ion batteries
- Additional Description: Has an estimated range of up to 120 miles per eight-hour charge


*Photo from Electric Vehicles International*

**Manufacturer: Electric Vehicles International**

- Manufacturer Website: *www.evi-usa.com*
- Model: WI EVI
- Application: Step van
- Fuel Type(s): Electricity
- Power Source(s): 120kW, AC permanent magnet electric motor with 99kWh lithium-ion batteries manufactured by Valence Technologies


*Photo from Enova*

**Manufacturer: Enova Systems**

- Manufacturer Website: *www.enovasystems.com*
- Model: Ze Step Van
- Application: Step van
- Fuel Type(s): Electricity
- Additional Description: Built on a custom Freightliner MT-45 chassis

*Photo from Ford Motor Co.*

**Manufacturer: Ford Motor Co.**

- Manufacturer Website: *www.ford.com/commercial-trucks*
- Model: E-Series Cargo Van/Wagon
- Application: Cargo van
- Fuel Type(s): CNG, propane
- Power Source(s): Ford 5.4L V-8
  Ford 6.8L V-10
- Additional Description: CNG and propane models are available from contract converters for models equipped with Ford's gaseous fuel engine prep package.

*Photo from Ford Motor Co.*

**Manufacturer: Ford Motor Co.**

- Manufacturer Website: *www.ford.com/commercial-trucks*
- Model: Transit Connect
- Application: Cargo van
- Fuel Type(s): CNG, propane
- Power Source(s): Ford 2.0L I-4
- Additional Description: CNG and propane models are available from contract converters for models equipped with Ford's gaseous fuel engine prep package.


*Photo from General Motors*

**Manufacturer: General Motors**

- Manufacturer Website: *www.gmfleet.com*
- Model: Express/Savana CNG Cargo Van
- Application: Cargo van
- Fuel Type(s): CNG
- Power Source(s): GM 6.0L V-8
- Additional Description: Available with a three-tank (200-mile range) or four-tank (300-mile range) system


*Photo from General Motors*

**Manufacturer: General Motors**

- Manufacturer Website: *www.gmfleet.com*
- Model: Express/Savana Cutaway Van
- Application: Cutaway van
- Fuel Type(s): Propane
- Power Source(s): GM 6.0L V-8
- Additional Description: Available with a three-tank (200-mile range) or four-tank (400-mile range) system


*Photo from Smith Electric Vehicles*

**Manufacturer: Smith Electric Vehicles**

- Manufacturer Website: *www.smithelectric.com*
- Model: Newton Step Van
- Application: Step van
- Fuel Type(s): Electricity
- Power Source(s): 134kW brushless permanent magnet electric motor with lithium-ion batteries
- Additional Description: Batteries available in 40kWh, 60kWh, 80kWh, 100kWh, and 120kWh capacities

# Vocational Truck

*Photo from Balqon*

**Manufacturer: Balqon**

- Manufacturer Website: *www.balqon.com*
- Model: Mule M150
- Application: Vocational truck
- Fuel Type(s): Electricity
- Power Source(s): 200-hp AC induction motor with lithium-ion batteries


*Photo from Electric Vehicles International*

**Manufacturer: Electric Vehicles International**

- Manufacturer Website: *www.evi-usa.com*
- Model: EVI-MD
- Application: Vocational truck
- Fuel Type(s): Electricity
- Power Source(s): 260-hp AC permanent magnet motor with lithium-ion batteries


*Photo from Elgin*

**Manufacturer: Elgin**

- Manufacturer Website: *www.elginsweeper.com*
- Model: Broom Bear/Crosswind/Eagle/Pelican
- Application: Street sweeper
- Fuel Type(s): CNG, LNG, propane
- Power Source(s): Cummins Westport ISL G 8.9L
  Ford 2.5L propane
  GM 3.0L CNG

*Photo from Ford Motor Co.*

**Manufacturer: Ford Motor Co.**

- Manufacturer Website: *www.ford.com/commercial-trucks*
- Model: E-Series Cutaway and Stripped Chassis
- Application: Vocational truck
- Fuel Type(s): CNG, E85 flex fuel, propane
- Power Source(s): Ford 5.4L V-8
  Ford 6.8L V-10

No Photo Available

**Manufacturer: Freightliner**

- Manufacturer Website: *www.freightlinertrucks.com*
- Model: Business Class M2 106 Hybrid
- Application: Vocational truck
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Cummins ISB 6.7L
- Hybrid System(s): Eaton parallel electric hybrid

*Photo from Freightliner*

**Manufacturer: Freightliner**

- Manufacturer Website: *www.freightlinertrucks.com*
- Model: Business Class M2 112, 114SD, Cascadia
- Application: Vocational truck
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISX12 G
  Cummins Westport ISL G 8.9L


*Photo from Greenkraft*

**Manufacturer: Greenkraft**

- Manufacturer Website: *www.greenkraftinc.com*
- Model: 1061
- Application: Vocational truck
- Fuel Type(s): CNG, LNG, propane
- Power Source(s): GM 6.0L


*Photo from Hino*

**Manufacturer: Hino**

- Manufacturer Website: *www.hino.com*
- Model: 195n
- Application: Vocational truck
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Hino 5L
- Hybrid System(s): Hino hybrid drive

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: T270
- Application: Vocational truck
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Paccar PX-6 6.7L
- Hybrid System(s): Eaton hybrid drive

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: T370
- Application: Vocational truck
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Paccar PX-6 6.7L
- Hybrid System(s): Eaton hybrid drive

*Photo from Kenworth*

**Manufacturer: Kenworth**

- Manufacturer Website: *www.kenworth.com*
- Model: W900S
- Application: Vocational truck
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISX12 G


*Photo from McNeilus*

**Manufacturer: McNeilus**

- Manufacturer Website: *www.mcneilusconcrete.com*
- Model: CNG Cement Mixer
- Application: Vocational truck
- Fuel Type(s): CNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 330 Hybrid
- Application: Vocational truck
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Paccar PX-6 6.7L
- Hybrid System(s): Eaton hybrid drive

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 337/338 Hybrid
- Application: Vocational truck
- Fuel Type(s): Diesel electric hybrid
- Power Source(s): Paccar PX-6 6.7L
- Hybrid System(s): Eaton hybrid drive

*Photo from Peterbilt*

**Manufacturer: Peterbilt**

- Manufacturer Website: *www.peterbilt.com*
- Model: 365
- Application: Vocational truck
- Fuel Type(s): CNG, LNG
- Power Source(s): Cummins Westport ISL G 8.9L

*Photo from Smith Electric Vehicles*

**Manufacturer: Smith Electric Vehicles**

- Manufacturer Website: *www.smithelectric.com*
- Model: Newton
- Application: Vocational truck
- Fuel Type(s): Electricity
- Power Source(s): 134kW brushless permanent magnet electric motor with lithium-ion batteries

No Photo Available

**Manufacturer: TYMCO**

- Manufacturer Website: *www.tymco.com*
- Model: 600
- Application: Street sweeper
- Fuel Type(s): CNG, propane
- Power Source(s): KEM 5.7L

*Photo from ZeroTruck*

**Manufacturer: ZeroTruck**

- Manufacturer Website: *www.zerotruck.com*
- Model: ZeroTruck
- Application: Vocational truck
- Fuel Type(s): Electricity
- Power Source(s): UQM PowerPhase 100 electric motor

# Glossary

**AFDC** . . . . . Alternative Fuels Data Center
**APU** . . . . . Auxiliary power unit
**B20** . . . . . A blend containing 20% biodiesel and 80% petroleum diesel fuel
**BRT** . . . . . Bus rapid transit
**CARB** . . . . . California Air Resources Board
**CNG** . . . . . Compressed natural gas
**CO** . . . . . Carbon monoxide
**$CO_2$** . . . . . Carbon dioxide
**EGR** . . . . . Exhaust gas recirculation
**EPA** . . . . . U.S. Environmental Protection Agency
**FFV** . . . . . Flexible fuel vehicle
**GCWR** . . . . . Gross combined weight rating
**GHG** . . . . . Greenhouse gas
**G/BHP-HR** . . . . . Grams per brake horsepower-hour
**GVWR** . . . . . Gross vehicle weight rating
**HLA** . . . . . Hydraulic launch assist
**ICE** . . . . . Internal combustion engine
**LF** . . . . . Low floor
**LNG** . . . . . Liquefied natural gas
**LPG** . . . . . Liquefied petroleum gas (propane)
**LPI** . . . . . Liquid propane injection
**NGV** . . . . . Natural gas vehicle
**NMHC** . . . . . Non-methane hydrocarbons
**NOx** . . . . . Oxides of nitrogen
**OEM** . . . . . Original equipment manufacturer
**PM** . . . . . Particulate matter
**SCR** . . . . . Selective catalytic reduction
**SOx** . . . . . Sulfur oxides

*Photo from Nova Bus*

U.S. Department of Energy

The U.S. Department of Energy's Clean Cities program advances the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum use in transportation. A national network of nearly 100 Clean Cities coalitions brings together stakeholders in the public and private sectors to deploy alternative and renewable fuels, idle-reduction measures, fuel economy improvements, and emerging transportation technologies. To find your local coalition, visit *cleancities.energy.gov*.


U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

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*Photo from Mack Trucks*

# Appendix F

## Natural Gas Conversion in the Transportation Industry

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**About Ben Franklin Technology Partners**
Ben Franklin Technology Partners/CNP, an initiative of the Pennsylvania Department of Community and Economic Development and funded by the Ben Franklin Technology Development Authority, provides investment capital, operational assistance, and entrepreneurial support to emerging tech-based companies and small, existing manufacturers for the purpose of creating and retaining jobs in Pennsylvania.

# Natural Gas Conversion in the Transportation Industry 12/23/14



## EPA Certifications & Approvals

http://www.usealtfuels.com/?page_id=16 (see additional details)

List of EPA Certification & Approval

In April 2011, the U.S. Environmental Protection Agency (EPA) adopted changes to the regulations found in 40 CFR part 85 subpart F for clean alternative fuel conversion manufacturers. This action affects regulations applicable to manufacturers of light-duty vehicle and heavy-duty highway vehicle and engine clean alternative fuel conversion systems. The revisions will streamline the compliance process while maintaining environmentally protective controls.

**Overview**

With the vast majority of vehicles in the United States designed to operate on gasoline or diesel fuel, there has been a long and growing interest by the public in clean alternative fuel conversion systems. These systems allow gasoline or diesel vehicles to operate on alternative fuels such as natural gas, propane, alcohol, or electricity. Use of alternative fuels opens new fuel supply choices and can help consumers address concerns about fuel costs, energy security, and emissions. EPA supports such innovation and encourages the development of clean aftermarket technologies that enable broader transportation fuel choices. At the same time EPA is responsible for ensuring that all vehicles and engines sold in the United States, including clean alternative fuel conversions, meet emission standards. EPA has adopted a new approach that simplifies and streamlines the process by which manufacturers of clean alternative fuel conversion systems may demonstrate compliance with these vehicle and engine emissions requirements. The new options will reduce some economic and procedural impediments to clean alternative fuel conversions while maintaining environmental safeguards to ensure that acceptable emission levels from converted vehicles and engines are sustained. The final rule covers alternative fuel conversion of light-duty vehicles and heavy-duty highway vehicles and engines.

Previous EPA regulations required vehicle and engine conversion systems to be covered by a certificate of conformity to gain a regulatory exemption from potential tampering charges. EPA evaluated the requirement and determined that it is appropriate to introduce new flexibilities for all clean alternative fuel converters and to expand the compliance options for certain categories of conversions. EPA has amended the regulatory procedures in 40 CFR part 85 subpart F and part 86 to establish these new compliance options. The new approach builds upon the concept that it is appropriate to treat conversions differently based on the age of the vehicle or engine being converted. Under the new regulations, testing and compliance procedures differ based on the age category of the vehicle or engine that is converted: new and relatively new, intermediate age, or outside useful life. All conversion manufacturers seeking an exemption must demonstrate compliance, but the requirements differ among age categories. EPA expects the streamlined approach to result in a cost savings for many converters.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**Key Elements of the Rulemaking**

The Clean Air Act prohibits altering a vehicle or engine from its certified configuration. Alternative fuel conversion systems alter one or more elements of a vehicle's or engine's original configuration to enable operation on a new fuel. The revised regulations provide compliance options that allow conversion manufacturers to make the necessary changes without violating the law. This rule provides clear and comprehensive compliance pathways for alternative fuel converters to gain exemption from the prohibition against tampering.

The new compliance program enables conversion manufacturers to qualify for an exemption from tampering by demonstrating that the converted vehicle or engine satisfies EPA emissions requirements. The specific demonstration and notification requirements differ based on the age of the vehicle or engine being converted. The demonstration and notification requirements for new and relatively new vehicles and engines will continue to involve a certification process that is very similar to previous practice. Once certified, however, annual recertification will no longer be required to maintain the tampering exemption. The notification and demonstration requirements for intermediate age vehicles and engines include testing and submission of data to show that the converted vehicle or engine continues to meet applicable standards. The notification and demonstration process for outside useful life vehicles and engines involves submission of a description of the conversion system that provides sufficient technical detail to determine that the conversion will not increase emissions.

| **Overview of Program Elements** | | | | | |
|---|---|---|---|---|---|
| **Vehicle/Engine Age** | | | **Conversion Manufacturer Requirement** | | **Certificate Issued?** |
| **Category** | **Applicability** | **Example for 20111** | **Demonstration** | **Notification** | |
| New | MY >= current calendar year – 1 | MY 2010, 2011, 2012 and < useful life mileage | Exhaust, Evap, and OBD testing2 | Certification application | YES |
| Intermediate age | MY <= current calendar year – 2 and < useful life | MY 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009 and < useful life mileage | Exhaust and Evap testing2 + OBD scan tool test and attestation | Compliance submission3 | NO |
| Outside useful life | Exceeds useful life | MY2001 and older or > full useful life in mileage | Technical justification4 and OBD scan tool test and attestation | Compliance submission3 | NO |

**Note:**

1. This example is for light-duty Tier 2 vehicles operating in the 2011 calendar year which have a useful life of 10 years or 120,000 miles.
2. Exhaust and evap refers to all exhaust emission testing and all evaporative emission and refueling emission testing required for OEM vehicle/engine certification, unless otherwise excepted. OBD testing refers to all OBD demonstration testing as required for OEM vehicle/engine certification.
3. The compliance notification process for intermediate age and outside useful life conversions will be electronic submission of data and supporting documents.
4. The technical justification may include data from exhaust and evaporative emissions testing.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

## Age-Based Demonstration and Notification Requirements

All conversion manufacturers are required to demonstrate to EPA that the conversion satisfies technical criteria, but the demonstration and notification process will differ depending on vehicle or engine age. The demonstration and notification apply to a group of vehicles or engines that share similar technology, known as a test group or engine family and evaporative/refueling family. The test group/engine family criteria also differ somewhat based on age of the vehicles or engines being converted.

### New vehicles and engines

- The new and relatively new category includes vehicles and engines less than about two years old: those of a model year that is greater than or equal to the current calendar year minus one.
- The compliance demonstration requirement remains very similar to the previous certification requirement. Manufacturers must conduct certification tests to demonstrate that the converted vehicle or engine complies with exhaust and evaporative emission standards and with on-board diagnostics (OBD) requirements.
- The notification requirement also remains the same as the previous certification application process.
- Converted vehicles and engines that satisfy the demonstration and notification requirements will be issued a certificate of conformity.
- The new regulations introduce some important flexibilities that will be available to most manufacturers of new vehicle/engine conversion systems:
  Manufacturers may apply a single set of test data to a broader set of candidate vehicles and engines.
  A certified conversion system retains its tampering exemption even after the certificate expires such that annual re-certification is no longer required.

### Intermediate age vehicles and engines

- The intermediate age category covers vehicles and engines at least two years old (those of a model year less than or equal to the current calendar year minus two) but still within their regulatory useful life.
- The compliance demonstration involves conducting exhaust and evaporative emissions tests to show that the converted vehicle or engine meets applicable standards. The notification requirement includes submitting a full description of the conversion system as well as the test data to EPA.
- In addition, manufacturers must submit an OBD scan tool report to show that the OBD system on the converted vehicle or engine continues to function properly, plus applicable statements of attestation.
- Converters are permitted further flexibilities for expanded test groups.
- No certificate is issued, and annual re-certification is not required.

### Outside useful life vehicles and engines

- The outside useful life age category covers vehicles and engines that have exceeded their regulatory useful life.
- Conversion manufacturers must submit a sufficiently detailed description to show that the conversion technology is technically sound and is applied according to principles of good engineering judgment.
- The notification requirement, as for the intermediate age program, involves submitting the required information, data, and/or attestations to EPA.
- In addition, manufacturers must submit an OBD scan tool report to show that the OBD system on the converted vehicle or engine continues to function properly, plus applicable statements of attestation.
- The outside useful life program permits the same expanded test group flexibilities as the intermediate age program.
- No certificate is issued, and annual re-certification is not required.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**EPA Alternative Fuel Conversion**
Dec lists
http://epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm

## EPA-Compliant Conversion Systems

http://www.epa.gov/oms/consumer/fuels/altfuels/altfuels.htm

**Certified Clean Alternative Fuel Conversion Systems**

The conversion systems on this list have been certified by EPA as meeting applicable emission standards and are exempt from the Clean Air Act tampering prohibition. Certified conversion systems may be applied to new, intermediate age, or outside useful life vehicles/engines covered by the conversion certificate. Please note that this is not a comprehensive list of certified systems. Certified conversions that do not appear on this list may also be exempt from the tampering prohibition. EPA will add conversion systems to this list upon request of the conversion manufacturer. Please check back periodically for updates.

You can use the Document Index System to search for certified clean alternative fuel conversion systems appropriate for use on light duty vehicles and chassis-certified heavy duty vehicles. From the Document Index System home screen, select "Certificates of Conformity" as the Compliance Document Type and select "Alternative Fuel Conversions" as the Industry. Detailed search instructions are provided in EPA's October, 2010 guidance letter for fuel converters. See the response to Question #12.
(http://iaspub.epa.gov/otaqpub/display_file.jsp?docid=23319&flag=1 )

To find certified clean alternative fuel conversion systems for heavy-duty highway engines, you may search the lists of certificates that are available in the on-highway engine certification data section at http://www.epa.gov/otaq/certdata.htm. Please note that the certificate lists do not distinguish original manufacturer and clean alternative fuel conversion certificates. To find the conversion certificates, you must either look for the conversion fuel you are interested in or for the name of a specific conversion manufacturer. Please contact Fakhri Hamady for assistance.

**Intermediate Age Clean Alternative Fuel Conversion Systems**

Conversion systems that are compliant under the intermediate age program may be applied to intermediate age or to outside useful life vehicles/engines covered by the converter's compliance demonstration and notification package. Please check back periodically for updates.

**Outside Useful Life Clean Alternative Fuel Conversion Systems**

Conversion systems that are compliant under the outside useful life program may only be applied to vehicles/engines that have exceeded their regulatory useful life and that are covered by the converter's compliance demonstration and notification package. Please check back periodically for updates.

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

## Certified and Approved Conversion Systems

https://www.ngvamerica.org/vehicles/vehicle-availability/

The documents below cover aftermarket conversion systems that consumers and businesses may purchase in order to modify new or used vehicles so that they can operate on natural gas. Some of these systems may be ordered directly through automotive dealerships when placing an order for a new vehicle. However, all of the systems listed here are aftermarket from the standpoint that they are offered as modifications to OEM gasoline or diesel fueled vehicles.

The information is organized by certified or approved light-duty and heavy-duty chassis vehicles, as well as by certified or approved heavy-duty engines. The individual sheets are further organized by OEM (e.g., Chrysler, Ford, or GM), model year, and engine size, so that persons interested in a conversion system for a particular vehicle may quickly locate it. All of the systems listed have been either certified or approved by the EPA or CARB.

Please review the listings of available systems and also the websites of the companies who offer them. All of these companies are dealing with a large number of inquiries and a significant demand for NGVs, so please review all available materials before making inquiries about particular vehicles, systems, or engines.

Last update: October 15, 2014

- Light-Duty and Heavy-Duty Chassis Vehicles
- Heavy-Duty Engines

**Author** Mike Chmela (Project Director, Market Research)

# Appendix G

## CNG Conversion Providers in PA

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

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Ben Franklin Technology Partners/CNP, an initiative of the Pennsylvania Department of Community and Economic Development and funded by the Ben Franklin Technology Development Authority, provides investment capital, operational assistance, and entrepreneurial support to emerging tech-based companies and small, existing manufacturers for the purpose of creating and retaining jobs in Pennsylvania.

# CNG Conversion Providers in PA 12/23/14



## Preface

The list in this report includes Pennsylvania companies that provide aftermarket conversion systems that consumers and businesses may purchase in order to modify new or used vehicles so that they can operate on natural gas. Some of these systems may be ordered directly through dealerships when placing an order for a new vehicle. However, in most cases the systems are aftermarket from the standpoint that they are offered as modifications to OEM gasoline or diesel fueled vehicles.

Some of these facilities are dedicated to only one OEM. However, were a facility will provide the conversion service to multiple products, an example of the conversion kit manufacturer/provider is listed.

## Certified and Approved Conversion System Facilities in PA

### AR Natural Gas Fueling Systems

http://www.arngfuelsys.com/conversionsystems.html
6015 Maryland Ave. #2
Altoona, PA 16602
AR Natural Gas Fueling Systems has multiple conversion systems to suit a wide variety of needs.
These systems are for CNG and LPG.
We are able to convert most major automobile manufactures including:

- Cars
- Light Duty Trucks
- Heavy duty trucks.

These conversions can be dedicated, bi fuel or duel fuel systems and are CARB and or EPA certified.

Installs products from:

**Greenkraft**
http://www.greenkraftinc.com/alternative-fuel-systems/
Greenkraft has obtained EPA certifications on different systems and is currently working on additional EPA and CARB certifications.

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University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

## Alternative Fuel Solutions

**http://www.DriveOnNaturalGas.com/**
Support@DriveOnNaturalGas.com
P 814-277-4456
F 814-746-4694

Mahaffey Conversion/Service Center
6162 Colonel Drake Highway
Mahaffey, PA 15757

McKeesport Service Center
3716 Liberty Way
McKeesport, PA 15133

At **Alternative Fuel Solutions**, we provide a clear and complete path to achieving domestic fuel freedom utilizing alternative fuels. Alternative Fuel Solutions of Pennsylvania is a woman-owned business enterprise. For years we have been catering to clients in the Marcellus and Utica Shale region with our expert service. We have completed hundreds of conversions and retrofits for on and off-road engines. We are fully licensed, insured, and qualified to meet all of your alternative fuel project needs. Our CSA certified technicians convert new vehicles to run seamlessly on CNG (Compressed Natural Gas) and LP (Liquid Propane) without voiding the factory warranty. We only utilize **EPA Certified** CNG and LP systems for new gasoline engines.

**AFS supports/offers the following EPA system providers;**

**Altech Eco - Ford QVM**
**Auto Gas America - GM**
**IMPCO Automotive - Ford QVM/GM**
**Landi Renzo - Ford QVM**
**STAG USA**
**Zebulon Innovations**
**M-Tech - Ford**
**NatGasCar**
**Crazy Diamond Performance**
**ICOM North America**
**Clean Air Power**

## Cleveland Brothers

www.ClevelandBrothers.com
Cleveland Brothers is an authorized installation center for Omnitek's diesel-to-natural gas engine conversion systems.
Contact: Brandon Fritz : 866 – 627 – 2737

Manada Hill
336 Fairville Ave
Harrisburg, PA 17112
Phone: (717) 526-2121

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

Milesburg
1025 North Eagle Valley Road
Howard, PA 16841
Phone: (814) 355-3500

New Stanton
190 Earnhardt Drive
Hunker, PA 15639
Phone: (724) 861-6080

Installs products from:

**Omnitek Engineering**
http://www.omnitekcorp.com/main.htm
Omnitek Engineering, Corp. (OMTK) develops and sells proprietary diesel-to-natural gas engine conversion systems (DNG) and complementary products, including new natural gas engines that utilize the company's technology -- providing global customers with innovative alternative energy and emissions control solutions that are sustainable and affordable.

The DNG system has established Omnitek as a leader in the industry. Omnitek offers a total-system approach and is dedicated to supplying alternative energy and emissions control solutions that are sustainable and affordable.

## CNG One Source Conversions

http://cngonesource.com/
CNG One Source installs conversions for gasoline to CNG and diesel to CNG. Currently, CNG One Source installs conversions systems for ***Buick, Chevrolet, Chrysler, Dodge, Ford, Freightliner, GMC, Isuzu, Jeep, Lincoln, Mazda, Mercedes, Mercury, Mitsubishi, Navistar, Oldsmobile, Pontiac, Volkswagen and Workhorse.*** Prices vary according to the make and model or the vehicle and the size and type of the fuel tank.

CNG One Source, Inc.
1620 Harper Drive
Erie, PA 16505
info@cngonesource.com
Tel: 814-835-0200

## CNG Conversions NEPA

http://www.cngconversionsnepa.com/
312 E. Jefferson St.
Olyphant, PA
CNGCofNEPA@yahoo.com
570-677-3200

Installs products from:

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

**IMPCO Technologies**
http://www.impcoautomotive.com/
IMPCO Technologies is a business unit of Fuel System Solutions, Inc., and designs, manufactures and supplies alternative fuel components and systems. For a full line of products and services available, visit IMPCO Automotive.

**Altech-Eco**
http://www.transecoenergy.com/
Here at Altech-Eco Corporation (AEC) we are dedicated to the development and growth of alternative energy for the transportation sector. We promote a cleaner and healthier environment by utilizing only our own EPA and CARB certified CNG conversion systems for vehicles.

## Fyda Energy Solutions

http://fydaenergy.com/products
20 Fyda Drive
Canonsburg, PA 15317
Toll Free: (800) 393-2556
info@fydaenergy.com

Fyda Energy Solutions has expanded its alternative fuel service offerings, and has joined the Alliance AutoGas network as the newest certified conversion center. This allows us to handle both CNG (compressed natural gas) and propane autogas conversions, including pick-up trucks, passenger vans, police cars, taxi cabs of all makes and models. We can offer conversions on Dodge, Ford, GM and may other vehicle makes. We currently have over 175 different vehicle combinations for which we are EPA certified. Fyda Energy Solutions has contracted the rights to handle conversions and retrofits for all of Ohio, and parts of Pennsylvania and New York.

Dual Fuel Powered Gliders are a market that Fyda Energy Solutions pioneered. Fyda Freightliner has been a leader in offering Glider Kits to their customers and now Fyda Energy Solutions is offering turnkey Dual Fuel Powered Gliders. Many companies choose glider kits to increase fuel economy, simplify maintenance and meet emissions requirements. Fyda Energy Solutions Dual Fuel Powered Gliders offer the fuel cost savings of a dedicated CNG truck, the power and range of a diesel only truck and all the benefits of brand new equipment. Don't tax your company by running new trucks with SCR, DOC's, and DPF's which add cost and provide no financial benefits.

We can retrofit your vehicle for alternative fuels and can diagnose and repair your alternative fuel vehicle. As an authorized dealer for Freightliner, Condor, and WesternStar, as well as most other vehicle makes and models, we are highly skilled and experienced to handle all of your trucking service needs.

## J&J Truck Equipment

Somerset, PA
contact: Dave Spear; Sales Director; dns@jjtruckequipment.com ; 814-444-7006

Installs products from:

**Landi Renzo USA**
http://www.landiusa.com/

115 Technology Center
University Park PA 16802-7000
Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

Offers a dedicated CNG kit for GM 6.0L and 8.1L engines, as well as the Ford 5.4L engine. The company installs, calibrates, and provides extended service for its EPA and CARB certified systems.

## Mardinly Enterprises

http://www.mardinly.com/machineshop.html
701 Park Way
Broomall, PA 19008
Phone : (610) 544-9103

Installs products from:

**MGV Motori equipment**
http://ngvmotori.com/
http://www.ngvus.com/
ISO 9001 certified OEM supplying aftermarket Natural Gas re-powered engines and Kits.

## MC Auto Repair

Attn: Mark or Bruce
992 Stony Lonesome Road
Clarion, PA 16214
Tel: 814-745-3254

Installs products from:

**Energy and Water Solutions**
http://ewsews.com/cng.php
Offers two types of conversion kits for gasoline engines and a low-cost kit for diesel engines. Find out more at Energy and Water Solutions.

## SMF Truck

Palmerton, PA
contact: Galen Edris, VP of Sales; gedris@smftruck.com ; 610-824-7000.

Installs products from:

**Landi Renzo USA**
http://www.landiusa.com/
Offers a dedicated CNG kit for GM 6.0L and 8.1L engines, as well as the Ford 5.4L engine. The company installs, calibrates, and provides extended service for its EPA and CARB certified systems.

## WheelTime Dealers

(see map http://www.wheeltime.com/locations.html )
http://www.americanpowergroupinc.com/vehicular-dealers.html

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Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

The WheelTime® Network is comprised of 18 member-companies with over 180 service centers, 30 training centers and 3,500 certified technicians providing quality, affordable service and repair.

In addition to being authorized dealers and certified installers of APG Dual Fuel Technology, the WheelTime® member companies routinely package and install CNG and LNG tank fueling systems, giving fleet owners a single point of contact for all their natural gas fuel system needs.

**PENN Commercial Vehicle Solutions**
21260 Route 19 Cranberry Township, PA
Phone: **(724) 631-1234**
http://www.penncvs.com/

**PENN Commercial Vehicle Solutions**
499 Weber Lane Bedford, PA
Phone: **(814) 623-6171**
http://www.penncvs.com/

**PENN Power Group**
285 John Brady Drive Muncy, PA
Phone: **(570) 546-0656**
http://www.pennpowergroup.com/

**PENN Commercial Vehicle Solutions**
355 Sipe Road York Haven, PA
Phone: **(717) 938-5141**
http://www.penncvs.com

**PENN Commercial Vehicle Solutions**
1080 Hanover Street Wilkes Barre, PA
Phone: **(570) 208-1192**
http://www.penncvs.com

**PENN Commercial Vehicle Solutions**
13974 Kutztown Road
(Route 222 - Between Reading & Allentown Fleetwood, PA
Phone: **(610) 944-0451**
http://www.penncvs.com

**PENN Commercial Vehicle Solutions**
8330 State Road Philadelphia, PA
Phone: **(215) 335-0500**
http://www.penncvs.com

Installs products from:
**American Power Group**
http://www.americanpowergroupinc.com/class-8-truck-conversions.html

APG says that its "V5000 Turbocharged Natural Gas" dual fuel offering is based on "a cost-effective and non-invasive patented turbocharged natural gas dual fuel conversion technology.

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Tel: (814) 865-6878
Fax: (814) 865-0960
mjc33@psu.edu
www.cnp.benfranklin.org

"The system displaces a large percent of diesel with either CNG or LNG, uses normal diesel oil, allows a vehicle to retain existing diesel maintenance cycles, and offers a 300- to 800-mile dual fuel range with no loss of power and torque, depending on the route profile and tank configuration. No high-temperature parts or custom high-pressure fuel injectors are required."

## Zoresco Equipment Company (Inc)

http://www.zoresco.com/
412-829-2120
1241 Lower Rodi Road
Turtle Creek, PA 15145
contact: Sal Davelli, Inside sales; sdavelli@zoresco.com

http://www.zoresco.com/products.asp?navtype=cat&cat=71&mfg=4 1
Zoresco® is a nationally recognized designer of transportation and storage solutions. We satisfy each customer's truck body, equipment, chassis and trailer needs.

Installs products from:

**IMPCO Technologies** is a business unit of Fuel System Solutions, Inc., and designs, manufactures and supplies alternative fuel components and systems. For a full line of products and services available, visit IMPCO Automotive.

**Landi Renzo USA**
http://www.landiusa.com/
Offers a dedicated CNG kit for GM 6.0L and 8.1L engines, as well as the Ford 5.4L engine. The company installs, calibrates, and provides extended service for its EPA and CARB certified systems.

**BAF (Now Westport)**
http://www.zoresco.com/proddetail.asp?prodid=470&retpage=products.asp%3Fnavtype%3Dcat%26cat%3D71
BAF serves fleet managers and dealers in providing the dedicated CNG Ford E-250/350 Van. This SULEV vehicle utilizes the BAF CalComp System™ to exceed the most stringent emissions standards of CARB and EPA.

SYSTEM OVERVIEW: BAF CalComp System™; CARB and EPA certified; *OBD-II compliant; SULEV; CNG Fuel Capable Engine; "Ford Approved" System; OEM warranty not voided; FMVSS-303 compliant (Crash Tested); Dedicated CNG operation; HOV lane eligible in many states; Tax credits may be available, check with your tax advisor; Order from your Ford dealer with the CNG option

| **Turtle Creek - Corporate Office** | **Altoona** | **Cranberry Township** |
|---|---|---|
| 1241 Lower Rodi Road | 404 Kettle Street | 1655 Route 228 |
| Turtle Creek, PA 15145 | Altoona, PA 16602 | Cranberry Township, PA 16066 |
| Ph: 412-829-2120 | Ph: 814-941-9922 | Ph: 724-935-6700 |
| Fax: 412-829-7286 | Fax: 814-941-6639 | Fax: 724-935-6944 |

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Email This Location
Turtle Creek - Corporate Office Map

Email This Location
Altoona Map

Email This Location
Cranberry Township Map

http://www.zoresco.com/contact.asp

LIST of vehicles and locations
http://www.ngvamerica.org/pdfs/Certified_Approved_Conversions_LD-HD_14.10.15.pdf
This mid Oct 2014 document provides further details of the manufacturer (OEM), product models, conversion manufacturer, and the status of compliance.

**Author** Mike Chmela (Project Director, Market Research)

# Appendix H

## Natural Gas Vehicle (NGV)
## Certified Maintenance Personnel: Pennsylvania

Ben Franklin Technology PArtners
Central and Northern Pennsylvania

pennsylvania DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

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# Natural Gas Vehicle (NGV)

# Certified Maintenance Personnel:

# Pennsylvania

**Certified CNG Cylinder and Fuel System Inspectors: Pennsylvania (next 2 pages)**
http://www.csagroup.org/us/en/services/education-and-training/personnel-certification/people-search

| Name | Company | City | Certification # | Phone # | Email |
|---|---|---|---|---|---|
| O'Donnell, Dennis | AFS of PA | Mahaffey | U6523A | 814-277-4456 | |
| Chandler, Brian | Allegheny Ford Isuzu Truck Sales | Pittsburgh | U6347A | 412-481-9615 | |
| Dainty, Richard | American Natural | West Mifflin | U6973A | 412-505-7977 | |
| Greco, Charles | ANC Automotive | Pittsburgh | U6129A | 412-489-9981 | |
| Helms, Richard | Cleveland Brothers Equipment | Millersburg | U6634A | 814-355-3500 | |
| Chase, Nathan | Cleveland Brothers Equipment Co. | Turbotville | U6582A | 570-538-2551 | |
| Kinger, Roger | Community College of Allegheny County/ Pittsburgh Region Clean Cities | Oakdale | U6885A | 412-788-7373 | rkinger@ccac.edu |
| Kennedy, Travis | Fyda Energy Solutions | Canonsburg | U6379A | 724514-2055 | |
| Lickert, Mike | Giant Eagle/Pittsburgh Region Clean Cities | Pittsburgh | U7137A | 412-735-4114 | mike.lickert@gianteagle.com |
| Chatary, Jim | Giant Eagle/Talon Logistics | Pittsburgh | U5397A | | |
| Angerett, Greg | Hunter Truck Sales | Pittsburgh | U5395A | 724-791-2525 | gangerett@huntertrucksales.com |
| Corcetti, Jeffrey | Jeff's Performance Plus, Inc. | Shippenville | U5431A | 814-226-6900 | jeffsperformance@aol.com |
| Shaffer, Dustin | Jeff's Performance Plus, Inc. | Franklin | U6055A | 814-229-7300 | drshaff730@gmail.com |
| Blackham, Richard | Kenworth of PA | New Stanton | U7050A | 724-925-5000 | |
| Kosakowski, Stephen | Lower Merion School Dist. | Ardmore | U6152A | 610-645-1942 | |
| Bachurski, Kipp | Lower Merion School District | Conshohocken | U7099A | 610-645-1942 | |
| Bohn, Bryan | Lower Merion School District | Conshohocken | U5429A | 610-645-1942 | bohnb@lmsd.org |

Ben Franklin Technology PArtners
Central and Northern Pennsylvania

pennsylvania DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

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115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

| Name | Company | City | Certification # | Phone # | Email |
|---|---|---|---|---|---|
| Ebersole, Jay | Metzler Bros. Tank Truck & Trailer, Inc. | Duncansville | U6159A | 814-695-9239 | |
| Pearson, Jr., William | Metzler Bros. Tank, Truck & Trailer, Inc. | Duncansville | U5950A | 814-695-9239 | jpyzowski@metzlercompanies.com |
| Rodriguez, Brian | Metzler Bros. Tank, Truck & Trailer, Inc. | Duncansville | U6020A | 814-695-9239 | |
| Kowalchik, Anthony | Mid Valley CNG Tank Inspections | Olyphant | U6630A | 570-468-0243 | |
| Dambrowski, Thomas | Mid-Atlantic Waste | Chester | U6137A | 800-338-7274 | |
| Kasinec, Robert | Mid-Atlantic Waste System | Cheswick | U6203A | 724-274-6100 | |
| Graziano, Mario | Oshkosh-McNeilus | Morgantown | U6421A | 610-286-0400 | |
| Palermo, Thomas | Preferred Automotive | Jenkintown | U5687A | 215-379-1300 | |
| Burkert, Thomas | Rohrer | Duncannon | U7008A | | |
| Quinzi, Phillip | Rose Tree Media School District | Media | U6808A | 610-627-6474 | |
| Boyer, Timothy | Transedge Truck Centers | Schuylkill Haven | U7121A | 570-385-2540 | |
| Nichols, Marshall | Waste Management | Washington | U6093A | 724-225-1589 | |
| Barrett, Christopher | White Oak Farms, Inc. | Dayton | U6312A | 814-757-9832 | |
| Camp, Chad | Zoresco Equipment Company | Turtle Creek | U6353A | 412-829-2120 | info@zoresco.com |
| Flowers, Neal | | Pittsburgh | U5561A | | |
| Gallant, Douglas | | Cambridge Springs | U6656A | | |
| Hummel, Michael | | Harrisburg | U6581A | | |
| Long, Wayne | | Gilbertsville | U5796A | | |
| Lupton, Craig | | Howard | U6633A | | |
| Raudensky Jr., John | | Harrisburg | U6580A | | |
| Smith, Matthew | | W. Conshohocken | U7010A | | |

# Appendix I

## Natural Gas Vehicle (NGV) Fueling Stations: Infrastructure Solutions Companies – Pennsylvania

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

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# Natural Gas Vehicle (NGV) Fueling Stations:

# Infrastructure Solutions Companies—Pennsylvania

## Contents

Ben Franklin Technology PArtners
Central and Northern Pennsylvania

pennsylvania DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

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www.cnp.benfranklin.org

## CNG Infrastructure Options

*The current CNG infrastructure developer base is composed of* ***four primary types of companies****. While each has a specific role, all four may provide services in sizing and designing stations, which can cause increased station costs for the customer.*

### Major Types of Developers

While there are numerous manufacturers and distributors that play some role in CNG infrastructure development, there are four main categories of companies that have the most involvement: compressor manufacturers/suppliers/packagers, engineering companies, construction companies, and retailers. Their roles are shown in the table below**.**

**1. Compressor Manufacturers/Suppliers/Packagers**
These infrastructure developers either manufacture compressors and then assemble them with other components into complete fueling systems, or they purchase compressors from a manufacturer, assemble them with other required components, and then distribute the CNG fueling systems. For many companies, compression manufacturing is a segment of a larger industrial gas compression business. These companies are usually privately held and provide fueling equipment through a construction company either to an onsite fueling customer or the retailer. They have in-house engineering expertise, size fueling stations based on input data from the client, and do not involve an outside engineering firm.

**2. Engineering Companies**
Regularly, CNG fueling infrastructure customers rely on an outside engineering or technical services firm to size, design, and develop specifications for their stations. There are a small number of engineers in the U.S. and Canada who have been working in the CNG fueling field for a significant number of years and who have developed expertise in this area. Several began their careers in the natural gas utility industry and attribute their experience to that work. They understand the unique aspects of high pressure gas, the principles under which the CNG fueling process operates, and the special equipment that may be required for gaseous fuels (such as gas dryers) and are familiar with the codes to which CNG stations must be designed.

**3. Construction Companies**
There are a limited number of construction companies (sometimes combined with engineering services) that currently provide CNG station construction services on a regular basis either locally or nationally. Construction companies must be educated and experienced in dealing with high pressure gas and familiar with the permitting requirements; national, state, and local codes to which CNG stations must be built; and the safety aspects of building fueling stations that operate on high pressure fuels as opposed to liquid fuels.

**4. CNG Retailers**
These are companies that provide retail and/or third party CNG fueling to a single fleet customer under contract or public CNG fueling to any and all customers. Generally, they fall into three categories of businesses: LDCs, existing gasoline and diesel retailers, and independent retailers. Regardless of the category, CNG retailers provide retail fueling for customers for a profit.

Different types of CNG infrastructure developers have specific but sometimes overlapping roles in the station procurement process.

| Type of Infrastructure Developer | Size, Design, Develop Specifications for CNG Station | Manufacture of Package CNG Equipment | Permit and Build CNG Station | Operate/Retail CNG Station |
|---|---|---|---|---|
| Manufacturer | X | X | | |
| Engineering Company | X | | | |
| Construction Company | X | | X | |
| CNG Retailer | X | | | X |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**ACE Solutions Inc.**
http://goacesinc.com/index.htm

There are several ways we can help you switch to CNG as a vehicle fuel. We can help prepare documentation for available grants, manage infrastructure installations, and provide clients with financial and ROI analysis on the utilization of CNG as a vehicle fuel.

Contact Name: Rick Bunn
1505 Generals Way
West Chester, PA 19380
Ph: (484) 244-4848
Email: Rbunn@GoACESInc.com

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**AECOM**
http://www.aecom.com/What+We+Do/Environment/Market+Sectors/Oil+&+Gas

For a wide range of oil and gas facilities (natural gas compressor stations, marine terminals, air fields at remote cold-climate facilities, and operations and support facilities, such as control rooms and process control labs) AECOM provides engineering, design, and construction management.

URS Corp / AECOM
625 West Ridge Pike
Suite E-100
Conshohocken, PA 19428
Ph: (610) 832-3500
Fax: (610) 832-3501

URS Corp / AECOM
4507 North Front Street
Suite 200
Harrisburg, PA 17110-1787
Ph: (717) 635-7901
Fax: (717) 635-7902

125 Rock Road
Horsham, PA 19044-2310
Ph: (215) 315-4150
Fax: (215) 315-4151

100 Sterling Parkway
Suite 205
Mechanicsburg, PA 17050
Ph: (717) 795-8001
Fax: (717) 795-8280

1700 Market Street
Suite 1600
Philadelphia, PA 19103
Ph: (215) 735-0832
Fax: (215) 735-0883

Tishman Construction / AECOM
1700 Market Street
17th Floor
Philadelphia, PA 19103
Ph: (215) 636-0909
Fax: (215) 636-0930

URS Corp / AECOM
8 Penn Center, 21st Floor
1628 John F. Kennedy Boulevard
Philadelphia, PA 19103
Ph: (215) 587-9000
Fax: (215) 587-0668

Gulf Tower
707 Grant Street
Pittsburgh, PA 15219
Ph: (412) 395-8888
Fax: (412) 395-8897

URS Corp / AECOM
626 Cochrans Mills Road
Pittsburgh, PA 15236-3611
Ph: (412) 386-7595
Fax: (412) 386-4542

URS Corp / AECOM
Foster Plaza 6
681 Andersen Drive
Suite 400
Pittsburgh, PA 15220
Ph: (412) 503-4700
Fax: (412) 503-4701

315 South Allen Street
Suite 126
State College, PA 16801
Ph: (814) 235-1379 ext. 4152
Fax: (814) 235-1495

URS Corp / AECOM
11 Hap Arnold Boulevard
Tobyhanna, PA 18466-5113
Ph: (570) 856-3697
Fax: (570) 894-7995

URS Corp / AECOM
715 Washington Boulevard
Williamsport, PA 17701
Ph: (570) 505-1674
Fax: (570) 505-1682

URS Corp / AECOM
1050 Broad Street
Williamsport, PA 17754
Ph: (570) 368-4580
Fax: (570) 369-7153

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Alternative Fuel Solutions of Pennsylvania LLC (AFS)**
http://driveonnaturalgas.com/

At Alternative Fuel Solutions, we provide a clear and complete path to achieving domestic fuel freedom utilizing alternative fuels. AFS is a woman-owned business enterprise. For years we have been catering to clients in the Marcellus and Utica Shale region with our expert service. We have completed hundreds of conversions and retrofits for on and off-road engines. We are fully licensed, insured, and qualified to meet all of your alternative fuel project needs. Our CSA certified technicians convert new vehicles to run seamlessly on CNG (Compressed Natural Gas) and LP (Liquid Propane) without voiding the factory warranty. We only utilize EPA Certified CNG and LP systems for new gasoline vehicles. Cubogas Pocket is a compact, integrated, plug and fill CNG refueling station designed to meet different needs of refueling Alternative fuel on-site service and fleet assessments are available upon request.

AFS - Mahaffey location
6162 Colonel Drake Highway
Mahaffey, PA 15757
Ph: (814) 277-4456
Fax: (814) 277-7042
Email: Support@DriveOnNaturalGas.com

AFS - McKeesport location
3716 Liberty Way
McKeesport, PA 15133

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**American Natural Operations LLC**
https://americannatural.com/

As American Natural's wholesale CNG, LNG and traditional gasoline/diesel fuel distribution arm, ANS tailors customized fueling solutions for commercial and industrial customers. Our CNG experts work with companies to design and construct CNG solutions that are optimized for specific fleet needs. ANS's LNG team works with industrial, transportation, marine and other heavy duty users to analyze and develop small scale LNG fueling applications. Our fuel tanker hauling fleet delivers gasoline and diesel across Western Pennsylvania, Eastern Ohio and West Virginia, with a team of drivers who have decades of experience and commitment to service.

Headquarters
333 Baldwin Rd., Fl 2
Pittsburgh, PA 15205
Ph: (412) 489-9971

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**AR Natural Gas Fueling Systems**
http://www.arngfuelsys.com/

AR Natural Gas Fueling Systems is a development company focused on the use of natural gas as a transportation fuel. We provide the following services:

- Design, build, and maintain compressed natural gas fueling systems with time-fill and/or fast-fill fueling options which will meet specific customer needs.
- Evaluate fleet operations and provide proper vehicle applications.
- Assist in the acquisition of bi-fuel, dual fuel, or dedicated vehicles.
- Assist with vehicle purchases, conversions, and financing.
- Optimize the use of Federal and State incentives, as well as private grant opportunities.

Contact: Ron Yoder
6015 Maryland Ave. #2
Altoona, PA 16602
Ph: (814) 932-8265
Email: ryoder@atlanticbb.net

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Clean Energy Fuels Corp.**
http://www.cleanenergyfuels.com/viewstations.html
https://www.cleanenergyfuels.com/

We build both private and public, time-fill (aka slow) and fast-fill fueling stations, serving all types of Clean Energy Natural Gas: CNG (Compressed Natural Gas), LNG (Liquefied Natural Gas) and LNG / CNG (combined Liquefied & Compressed Natural Gas).

Headquarters
4675 MacArthur Court, Suite 800
Newport Beach, CA 92660
Ph: (949) 437-1000
Fax: (949) 724-1397
Email: customerservice@cleanenergyfuels.com

Branch
1501 Harrisburg Pike
Carlisle, PA 17015
Ph: (562) 493-2804

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**CNGo Co, LLC**
http://www.cngoco.com/

We understand and will guide you on the best path to gaining all the advantages of using natural gas to power your vehicles. Our staff at CNGo has accumulated decades of experience in designing, installing, operating, and maintaining complex systems. We have experience in all the areas required to complete CNG conversion projects from one vehicle to CNG station projects for commercial, public, and private use.

Headquarters
103 Harkle Rd
Indiana, PA 15701
Ph: (724) 463-3333
Email: info@cngoco.com

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**CNG One Source, Inc.**
http://www.cngonesource.com/

CNG One Source provides feasibility studies, conversions, refueling stations, service, maintenance, and training.

In April 2013, CNG One Source, Inc. purchased certain assets of Emissions Solutions, Inc. including ESI's patented technology converting diesel engines to CNG and all existing equipment and inventory. CNG One Source, Inc. has moved all equipment and inventory to Erie, PA.

Headquarters
1620 Harper Drive
Erie, PA 16505
Ph: (814) 835-0200
Email: info@cngonesource.com

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**CNG Services International, Inc.**
http://www.cng-lng.com/

Design and construction of CNG fueling stations for gas utilities and fleet operators throughout the U.S. Experienced in the conversion of vehicles to LNG and CNG fueling systems

Roosevelt Building, Suite 613
609 Penn Ave
Pittsburgh, PA 15222
Ph: (412) 552-0141
Fax: (412) 434-0161
Email: BobPetsinger@CNG-LNG.com

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**Commonwealth Energy Group, LLC (CEG)**
http://cwenergygroup.com/services/cng/

Our turnkey consultative and facility improvement services can significantly reduce energy consumption and generate bottom-line operational savings.We offer financing solutions for all your CNG services, including CNG fuel station design and construction.

Headquarters
1128 Meade Street
Dunmore, PA 18512
Ph: (570) 489-5700
Fax: (570) 489-5001
Email: info@cwenergygroup.com

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Cryostar USA LLC (Linde)**
http://www.cryostar.com/web/lng-lcng-natural-gas.php

Our refueling solution is dedicated to fuel different types of vehicles running either on compressed natural gas (CNG) or liquefied natural gas (LNG). Cryostar refueling stations are available for the following filling applications:

- Cars
- Forklift trucks
- Buses
- Trucks
- Special vehicles: ferry boat, train, etc.

Cryostar USA East site is a sales office and a service workshop servicing customers on the East Coast as well as Canada.

Engineering and East Coast Sales & Service Center
5897 Colony Drive
Bethlehem, PA 18017
Ph: (484) 281-3401
Fax: (484) 281-3402
Email: usa@Cryostar.com

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**EQT Corporation**
https://www.eqt.com/our-business/commercial-operations/natural-gas-vehicles

In July 2011, we opened a public–access compressed natural gas (CNG) fueling station in Pittsburgh, PA, and began using the conversion of our corporate fleet as a demonstration project to help other fleet owners learn more about the benefits of natural gas. Using that knowledge, we were able to provide technical assistance to several companies in the vicinity of our CNG station, and through the EQT Foundation, we also helped several Pittsburgh-based nonprofits replace existing service vehicles with NGVs. The Company is promoting the use of natural gas fleet vehicles, including its own. As our own transition continues, we are also working with other organizations to encourage infrastructure expansion so more new CNG fueling stations become available to fleets and the general public.

Headquarters
EQT Plaza
625 Liberty Ave, Ste 1700
Pittsburgh, PA 15222
Ph: (412) 553-5700
Fax: (412) 553-5757

474 Jeffers Street
DuBois, PA 15801

2A, Main Street
Mansfield, PA 16933

455 Racetrack Road
Washington, PA 15301

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Evergreen CNG Systems (Gas & Air Systems, Inc.)**
http://www.evergreen-cng-systems.com/
http://www.gasair.net/

Evergreen CNG Systems is a division of Gas & Air Systems (GAS), a leading compressor supplier and packager to the North American market. We will help you determine the best design and technology for the job, engineer the system and design modifications as required, and construct your CNG station or compressor package to the most exacting specifications. Upon delivery, we will work with you on commissioning and instruction, assuring a smooth product installation. Evergreen CNG Systems will be continually available for any operational questions, genuine replacement parts,and expert service.

Headquarters
1304 Whitaker Street
Hellertown, PA 18055
Ph: (610) 838-9625
Ph: (888) 842-7247
Fax: (610) 838-9650
Email: info@gasair.net

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**Fleet Energy America, Inc.**
http://fleetenergy.com/

From assessment to financing, Fleet Energy can take care of your CNG & LNG fueling needs.

Fleet Fueling Assessment, Projections & Planning
- How much fuel will be needed?
- By whom? When? Public or Private?

System Design
- What system configuration and capacity is needed
- For the short term? For the future?

Equipment
- Compression, Storage, Dispensing
- Payment/Accounting

Financing & Incentives
- Leasing Programs
- National & State
- Infrastructure Incentives

U.S. Headquarters
1224 N. Atherton St., Suite 2
State College, PA 16803
Ph: (814) 867-3590
Fax: (814) 234-2216
Email: info@fleetenergy.com

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Gannett Fleming, Inc.**
http://www.gannettfleming.com/markets/oil-gas/overview

With more than 40 years of proven insight into the toughest oil and gas projects, we can tackle full-scale upstream and midstream operation units to developmental feasibility studies to CNG fueling station design and construction. We're highly responsive engineering and environmental problem-solvers who can navigate the tough terrain both in the field and in regulatory offices. Plus, our unwavering focus on safety enables us to maintain an outstanding record of environmental compliance and strong relationships with state and federal agencies.

Downstream Solutions
- Compressed Natural Gas (CNG) fueling stations
- Maintenance and storage facilities
- Vehicle fleet assessments.

Corporate Headquarters-Harrisburg
207 Senate Avenue
Camp Hill, Pennsylvania 17011
Ph: (717) 763-7211
Ph: (800) 233-1055
Fax: (717) 763-8150
Email: headquarters@gfnet.com
Email: administration@gfnet.com

500 Rugh Street, Suite 100
Greensburg, PA 15601
Contact Cy Whitson, CWD, CPWD
Ph: (724) 836-1972
Email: cwhitson@gfnet.com

101 Millersville Road
Lancaster, PA 17603
Contact Steve Rowley, CHMM
Ph: (717) 299-9840
Fax: (717) 299-9870
Email: (srowley@gfnet.com

Environmental Acoustics and PAVL Systems
1400 Hummel Avenue, Unit A
Lemoyne, PA 17043
Contact Ahmed El-Aassar, PhD, PE, INCE, ASA
Ph: (717) 730-4680
Fax: (717) 730-4685
Email: aelaassar@envact.com
Contact Joe Bower, PE
Ph: (717) 737-4751
Email: jbower@gfnet.com

554 South Erie Street
Mercer, PA 16137
Contact Daniel Goncz, PE
Ph: (724) 662-2402
Fax: (724) 662-2459
Email: dgoncz@gfnet.com

Ten Penn Center
1801 Market Street, Suite 2600
Philadelphia, PA 19103-1628
Contact Esther McGinnis
Ph: (215) 557-0106
Fax: (215) 557-0337
Email: emcginnis@gfnet.com

29 Richard Lee Lane
Phoenixville, PA 19460
Contact Richard Lee, PG, RGP
Ph: (610) 917-9100
Fax: (610) 917-9108
Email: rlee@gfnet.com

Foster Plaza 8
730 Holiday Drive, Suite 400
Pittsburgh, PA 15220
Contact John Kovacs, PE, PMP, DGE
Ph: (412) 922-5575
Ph: (888) 700-5575
Fax: (412) 922-3717
Email: jkovacs@gfnet.com

2601 Gateway Drive, Suite 300
State College, PA 16801
Contact Mark Garlicki, PE
Ph: (814) 234-8625
Fax: (814) 234-8086
Email: mgarlicki@gfnet.com

Valley Forge Corporate Center
1010 Adams Avenue
Audubon, PA 19403
Contact Esther McGinnis
Ph: (610) 650-8101
Fax: (610) 650-8190
Email: emcginnis@gfnet.com

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu



## G.M. McCrossin, Inc.

http://mccrossin.com/

McCrossin continues to expand its services throughout the Mid-Atlantic, from New York State to Virginia. McCrossin is one of four teams PennDOT invited to submit proposals for a program to develop clean-burning compressed natural gas (CNG) fueling stations at public transit agencies around the state.

Corporate Headquarters
2780 Benner Pike
Bellefonte, PA 16823
Ph: (814) 355-4848
Fax: (814) 355-7363
Email: info@gmmccrossin.com

Pittsburgh Foundations Office
2607 Nicholson Road
Sewickley, PA 15143
Ph: (724) 933-9222
Fax: (724) 933-9223

Hershey Foundations Office
1016 Old W. Chocolate Avenue
Hershey, PA 17033
Ph: (717) 298-1873
Fax: (717) 298-1874

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## GP Strategies Corporation

http://altfuels.gpstrategies.com/stations.aspx

GP Strategies has been designing, constructing, and maintaining alternative fuel stations for over 15 years. GP Strategies can support your alternative fuels needs:

- Station and dispenser design—Our experienced and professional team designs, engineers, and constructs unique and efficient fueling stations and fuel dispensers with consumer convenience in mind.
- Construction services —Whether it's a new build or a station upgrade, GP Strategies offers various construction services. If you have an existing station that could use improvements, GP Strategies can perform an assessment and engineer ways to improve its performance.
- Maintenance—GP Strategies can perform monthly and quarterly maintenance based on your specific needs to ensure your station is performing efficiently and according to design.
- Training—GP Strategies can train your operators and maintenance technicians to operate efficiently and safely.

Branch
500 Creekside Drive, Suite 513
Pottstown, PA 19464
Ph: (888) 458-0900
Fax: (610) 323-9223
Toll Free Fax: (855) 641-2935
Email: info@gpstrategies.com

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## Jerome H. Rhoads, Inc. (Rhoads Energy Corp)

http://www.jhrhoads.com/rhoads-installs-natural-gas-fuel-pumps/

Today, the company offers heating oil, natural gas and propane delivery; complete HVAC installation and service; and fleet fueling services. For the pump installation, Rhoads Energy partners with U.S. Gain, which builds and operates CNG stations across the country.

Headquarters
624 South Prince Street
Lancaster, PA 17603
Ph: (717) 397-5277
Ph: (800) 673-2423
Fax: (717) 295-3140
Email: info@rhoadsenergy.com

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**J-W Power Company**
http://www.jwenergy.com/compressed-natural-gas2/

J-W Power Company has been involved in natural gas compression since 1966 and currently operates the largest privately-owned compression leasing fleet in the U.S. Building over 4,000 compressor packages over a forty year span naturally led J-W Power to be an authority in highly-engineered compressor package design, such as the equipment used in CNG applications. J-W Power CNG packages are available for sale, with or without maintenance. We can provide our customers with station equipment installation assistance and contract maintenance services.

District Office
2200 Georgetowne Drive, Suite 301
Sewickley, PA 15143
Ph: (724) 749-4745
Ph: (513) 702-8962
Email: sales@jwenergy.com
Email: cng@jwenergy.com

Sales Office
1000 Commerce Park Drive, Suite 404
Williamsport, PA 17701
Ph: (570) 666-7110
Email: compression@jwenergy.com

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**K.C. Larson, Inc. / Penn CNG Solutions, Inc.**
http://www.kclarson.com/Compressed-Natural-Gas.php

K.C. Larson is Central Pennsylvania's regional dealer for the BRC FuelMaker brand of CNG Vehicle Refueling Appliances (VRA). Our office staff and field mechanics have been trained and certified by BRC Fuelmaker's representatives to provide consultation, design, and complete installation of a CNG refueling station at your home or business. Our CNG market focus is residential, businesses and small to mid-sized commercial refueling stations for fleet vehicles and forklifts.

K.C. Larson
97 Eck Cir
Williamsport, PA 17701
Ph: (570) 329-1441
Toll Free: (877) 371-1441
Fax: (570) 321-5439
Email: contact.us@kclarson.com

Penn CNG Solutions
Ph: (570) 329-0910

**Larson Design Group, Inc.**
http://www.larsondesigngroup.com/markets/cngngv/

We provide full-service project solutions from fleet feasibility studies and site evaluation to gas detection systems and equipment specifications. We help clients assess their fleets and understand the regulatory requirements established by the National Fire Protection Association (NFPA) and International Code Council (ICC). Our process allows us to determine the most efficient solution for each client and our equipment vendor partners offer ongoing operations and maintenance support as desired. Each CNG project team includes the right mix of Mechanical, Electrical, Structural, and Site Engineers; Architects; Surveyors; and Construction Inspectors.

Headquarters
1000 Commerce Park Drive, Suite 201

Transportation Engineering Dept. Address
1020 Commerce Park Drive Entrance B, 2nd floor
Williamsport, PA 17701
Ph: (570) 323-6603
Toll Free: (877) 323-6603
Fax: (570) 323-9902

Main Office
300 South Walnut Lane, Suite 202
Beaver, PA 15009
Ph: (724) 495-7020
Fax: (724) 495-2594

Bethel Business Center
9533 Old 22
Bethel, PA 19507
Ph: (717) 933-5530
Fax: (717) 933-9130

Lititz LDG Office
201 East Oregon Road, Suite 110
Lititz, PA 17543
Ph: (717) 824-4618
Fax: (717) 945-7574

LDG Pittsburgh
220 Grant St 7th Floor
Pittsburgh, PA 15219

LDG Cranberry
8050 Rowan Road, Suite 504
Cranberry Twp, PA 16066
Ph: (724) 591-8562
Fax: (724) 779-5044

Selinsgrove LDG Office
1780 Route 522
Selinsgrove, PA 17870
Ph: (570) 374-5700
Fax: (570) 374-5703

Main Office
213 State Street, Suite 250
Harrisburg, PA 17101
Ph: (717) 461-2671

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**"O" Ring CNG Fuel Systems, L.P.**
http://www.oringcng.com/

Our services range from feasibility studies to assess your needs all the way through concept, design, and implementation. We primarily focus on the design and installation of CNG fueling stations, with a secondary focus on vehicle and fleet conversion to NGVs.

Headquarters
5349 Route 36
Coolspring, PA 15730
Ph: (814) 590-4498
Fax: (814) 938-1093
Email: rhbeatty@oringcng.com

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**P.C. McKenzie Company**
http://www.mckenziecorp.com/natural-gas-compressor-station.htm

Since 1946, P.C. McKenzie has been actively involved in the natural gas industry. Today, P.C. McKenzie is a leading supplier of compressed natural gas (CNG) equipment for vehicle fueling. P.C. McKenzie is the Master Distributor and Packager for Ingersoll Rand's entire CNG product line. These packages, engineered and manufactured by Ingersoll Rand, are ideal for fleets with 10 to 100 vehicles.

Headquarters
1365 McLaughlin Run Road
Pittsburgh, PA 15241
Ph: (412) 257-8866
Toll Free: (877) 244-4883
Fax: (412) 257-8890
Email: slk@mckenziecorp.com

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**Pine Run Construction Corporation**
http://www.pinerunconstruction.com/

As an experienced, certified CNG system installer, Pine Run Construction is able to provide the following services to our clients:

- Fueling Station Site Survey/Facility Design/Site Selection/Site Evaluation
- Cost Estimating
- Equipment Specification
- Permitting Services

The certification includes the following types of CNG fueling stations:

- Fast-Fill Stations (Cascade) for retail applications
- Buffered Fast-Fill Stations for large fleet applications
- Time-Fill (Slow-Fill) Stations for smaller fleet applications

Headquarters
4125 Landisville Road,
Doylestown, PA 18902
Ph: (215) 348-4500
Fax: (215) 348-8650
Email: info@pinerunconstruction.com

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**REV LNG, LLC**
http://revlng.com/

REV LNG is a pioneer in the LNG industry and one of the first companies to convert their own fleet to LNG from diesel. They are experts in logistics and LNG supply chain management for both on and off road applications. REV LNG will design and implement a dependable and safe LNG fueling system for your company's needs. REV LNG can create L/CNG fueling stations to service both LNG and CNG or only CNG. The system has the ability to fuel both CNG and LNG vehicles from the same source tank.

Headquarters
1002 Empson Rd
Ulysses PA 16948
Contact: David Kailbourne
Ph: (585) 797-8441
Email: edk@REVH2O.COM

Contact: Jake Digel
Ph: (570) 877-3132

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**UGI Corporation / UGI Utilities, Inc.**
http://www.ugicorp.com/Alternative-Fuel/default.aspx
http://www.ugi.com/portal/page/portal/UGI/Business_Gas/NGV
http://ugiperformance.com/solutions/cng-energy/

UGI Performance Solutions provides compressed natural gas (CNG) fueling solutions as a clean and affordable alternative. UGI Performance Solutions is a full service energy provider. We can integrate CNG solutions to help you reduce energy costs and decrease carbon emissions. In addition, several natural gas vehicle fueling stations are open or currently under construction in the UGI service territory. Contact us to learn how we can help put a natural gas vehicle program solution together for your fleet.

UGI Corporation
460 North Gulph Road, Ste 100
King of Prussia, PA 19406
Ph: (610) 337-1000
Fax: (610) 992-3259
Email: investors@ugicorp.com

UGI Performance Solutions
271 Bethlehem Pike, Suite 201&203
Colmar, PA 18915
Ph: (215) 690-0396
Fax: (267) 308-1687

# Appendix J

## Natural Gas Vehicle (NGV) Fueling Stations and Current Projects: Pennsylvania

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**About Ben Franklin Technology Partners**
Ben Franklin Technology Partners/CNP, an initiative of the Pennsylvania Department of Community and Economic Development and funded by the Ben Franklin Technology Development Authority, provides investment capital, operational assistance, and entrepreneurial support to emerging tech-based companies and small, existing manufacturers for the purpose of creating and retaining jobs in Pennsylvania.
www.cnp.benfranklin.org

# Natural Gas Vehicle (NGV) Fueling Stations and Current Projects: Pennsylvania

## Contents

Ben Franklin Technology PArtners
Central and Northern Pennsylvania

pennsylvania
DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu





## AWARDED FY 2013-2014 NGEDP PROJECTS

**Penske Truck Leasing Co., L.P. $499,997**
Penske Truck Leasing (PTL) will purchase and deploy 23 heavy-duty CNG vehicles in Schuylkill County. PTL will lease the vehicles to its customers (National Freight Inc., Wegman's and Penske Logistics) operating from the **Highridge Business Park in Schuylkill** and throughout the state. In conjunction with this project, **Trillium CNG will construct a brand new CNG station along I-81 in Schuylkill County.**

**Greater Philadelphia Clean Cities $500,000**
The **Keystone State LNG Conversion Initiative** seeks to help fleets convert to LNG for long haul applications. The project will utilize a centralized location near the convergence of three interstate highways to help **construct a public LNG refueling site** anchored by a fleet of 20 Class 8 tractors. This project will help stimulate the use of LNG as an alternative to gasoline and diesel for long haul applications. **See http://www.ep-act.org/Keystone-State-LNG-Conversion-Initiative**

**Clinton County Solid Waste Authority $291,974**
The Clinton County Solid Waste Authority (CCSWA), owner and operator of the Wayne Township Landfill, recently **completed construction of a publicly available CNG fuel station**, and have committed to utilize natural gas fuel in their daily operations. CCSWA has partnered with three other local entities to purchase a total of 14 heavy-duty CNG trucks.

**"O" Ring CNG Fuel Systems, Inc. $498,229**
"O" Ring CNG Fuel Systems has teamed up with **HighStar Capital, Advanced Disposal and the Paris Companies** for a CNG development project that will include the construction of a new, publicly available CNG fuel station along the I-80 corridor near **DuBois, PA**. The Act 13 grant will provide for a portion of the incremental purchase price of 20 new dedicated CNG refuse trucks, and the conversion of five trucks to dual fuel (CNG and diesel) technology.

**Beemac Trucking, LLC $500,000**
Beemac will purchase 20 dedicated CNG powered class 8 tractors for local flatbed trucking transportation of freight for their local Pennsylvania customers. The vehicles will be fueled at a **new CNG fueling station being constructed by Beemac**. The station will be open to the public and will be available in Fall of 2014.

**Waste Management of PA $300,000**
Waste Management seeks to deploy 20 new heavy duty CNG solid waste collection vehicles to their Erie (seven vehicles) and Washington (13 vehicles) locations **and install limited third party access CNG fueling to their Erie location.** The **Washington vehicles will fuel at Waste Management's existing public station**. The project will use about 190,000 GGEs of natural gas in the first year of the project. The total incremental cost of the vehicle purchases is $849,338.

**Lancaster County Solid Waste Management Authority $125,000**
LCSWMA, in partnership with the City of Lancaster and Goods Disposal Service, will expand the use of clean, domestic CNG in south-central Pennsylvania through the collective purchase/retrofit of 10 new heavy-duty CNG vehicles. The vehicles funded under this project will utilize a **newly constructed CNG fuel station owned and operated by LCSWMA**. The vehicles will consume an estimated 125,000 GGE of natural gas fuel annually.

**Schneider Resources, Inc. $150,000**
Schneider Resources, Inc. will use Act 13 grant funds to offset 33 percent of the incremental cost of six CNG heavy-duty trucks. The six CNG trucks will use approximately 73,000 GGE of CNG per year, and will fuel at the **future Clean Energy CNG station in Pittston.**

**Greater Philadelphia Clean Cities $418,650**
The **Northeast Extension CNG Vehicle Conversion Initiative** seeks to spur the acceptance of using CNG as a vehicle fuel by deploying 23 new dedicated CNG trucks that will utilize a **new fuel station built by Lehigh Gas**. The two project partners, Pennsylvania American Water Co. and the PA Turnpike Commission, will collectively displace petroleum fuel by using an estimated 100,000 GGE of natural gas annually. **See http://www.ep-act.org/Northeast-Extension-CNG-Conversion-Initiative**

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Constructural Dynamics, Inc. $500,000**
Constructural Dynamics, Inc. (Silvi Concrete) received Act 13 funding in the amount of $500,000 to offset 50 percent of the incremental cost of 20 dedicated CNG concrete mixer trucks. The 20 CNG trucks will use 160,000 GGE of CNG per year (8,000 GGE/truck), and will fuel at the **new Silvi Concrete CNG station at their fleet base in Fairless Hills.**

**Rose Tree Media School District $300,000**
Rose Tree Media School District will use Act 13 grant funds to offset the incremental purchase of 12 new dedicated CNG buses. This is the second phase of the District's CNG conversion project. The first phase included the purchase or conversion of 23 buses and the **installation of an onsite fueling station** with both time-fill and fast-fill capabilities. Rose Tree Media plans to eventually run its entire 74 bus fleet on natural gas. The 12 buses purchased under this grant award are expected to displace diesel fuel with approximately 22,000 GGE of natural gas.

## AWARDED FY 2012-2013 NGEDP PROJECTS

**W.C. McQuaide, Inc. $500,000**
W.C. McQuaide, Inc. is a trucking company with **two terminals in Bethel and Johnstown, PA** that is ready to execute a plan to fully utilize CNG in their daily trucking operations. The fullscale plan includes **constructions of two new CNG stations at each of their terminals,** the purchase of 65 new dedicated CNG trucks to replace their current fleet, the acquisition of another 25 new trucks, and conversion of all35 maintenance and company vehicles, all of which is to be in place and operational by 2015.

**Birkmire Trailer Company $500,000**
The company plans to build a **filling station at its facility in Fairview, PA** capable of filling 30 trucks on slow fill and to install a 200 gallon tank for fast fill. The plan also includes conversion of 15 trucks to dual fuel to run on CNG and diesel. The trucks will have 100 gallon CNG tanks to go within the 1,000 mile range with Pennsylvania sourced CNG. The company will also purchase six new trucks over the next year with two 120 gallon tanks to run only on CNG.

**Hoopes Turf Farm, Inc. $250,000**
Hoopes Turf Farm, Inc., is a female- and family-owned sod production and contract truck transportation company located in **Ulysses, Potter County.** This alternative fuel infrastructure and vehicle project will include the **installation of a new, onsite 16,000 gallon, public access LNG fueling mechanism** and the deployment of ten liquefied natural gas fueled heavy duty trucks.

**Giant Eagle, Inc. $500,000**
The proposed project entails the purchase of 19 Freightliner Volvo CNG fleet vehicles and one Freightliner Mll2 CNG Powered Day Cab. The vehicles will utilize **existing station infrastructure at the Pittsburgh Distribution Facility**. In addition, the fleet will have expanded refueling opportunities via a **new planned CNG station along the 179 corridor in Cranberry, PA.** Upon completion, 60 percent of Giant Eagle's Pittsburgh based fleet will be operating on CNG.

**Penske Truck Leasing, Co. LP $500,000**
Penske is a trucking company based in Wilkes-Barre, PA that will purchase and deploy 20 heavy-duty Freightliner CNG trucks (seven M2 112 and 13 Cascadia units). The vehicles will fuel at a **new limited access CNG station that will be constructed by Penske's leasing customer Core-Mark in Wilkes-Barre.** The 20 CNG vehicles will use approximately 292,537 GGE per year.

**Waste Management of Pennsylvania $491,444**
Waste Management (WM) will deploy 25 heavy-duty CNG solid waste collection vehicles in Northampton County., displacing an estimated 222,300 gasoline gallon equivalents (GGE) per year. The vehicles will fuel at **WM's brand new station at its property at 910 Pennsylvania Avenue in Pen Argyl. The new fueling facility will be accessible to the public.**

**McKissick Trucking, Inc. $100,000**
McKissick Trucking, Inc., is a company that transports brine from wells in north central Pennsylvania to licensed injection wells in Ohio. This project is the first step in a plan to transition to fuller use of NGV beginning with a five vehicle pilot series of LNG fueled tankers as well as **install a LNG fueling station for additional fleet fueling**. The initial move will effectively transfer more than two million diesel fueled miles/year to LNG.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu



**Lancaster County Solid Waste Management Authority $350,000**
LCSWMA will convert its 14-truck tractor waste transfer fleet to compressed natural gas (CNG). As a part of this project, LCSWMA will displace 156,800 GGEs per year. **LCSWMA will develop new CNG fueling infrastructure** (fast & time-fill).

**Park's Garbage Service, Inc. $335,840**
This project involves the purchase of 15 CNG refuse trucks to be used at two locations: five vehicles at **Shirley Twp. near Mount Union, Huntingdon County**, and 10 **at Greene Township, Franklin County**. The 15 CNG trucks will replace 56 percent of the present total fleet of 27 diesel-powered refuse trucks. The **CNG refuse trucks will be fueled by two new fast fill CNG fueling stations that will be constructed, one at each location.** Both CNG fueling stations will have public access for other fleets and the general public.

**Borough of Chambersburg $472,500**
The Borough of Chambersburg, , with IESI and the Borough of Shippensburg, project partners, will purchase or retrofit 19 vehicles to operate on compressed natural gas. The vehicles include refuse and recycling trucks, a utility bucket truck, and an ambulance. The Borough of Chambersburg will also develop a **new CNG station adjacent to the Interstate 81 Exit 14 off ramps.**

**Rose Tree Media School District $499,994**
Rose Tree Media School District will begin upgrading its school bus fleet to natural gas vehicles by converting 14 existing diesel buses to compressed natural gas, and purchasing eight new CNG 2013 Thomas Built Buses. The fuel capacity will be supported by a **new hybrid fueling station (time-fill and fast-fill) owned/operated by the district, to be built as an extension to the transportation center located in Media, PA.**

**Shipley Fuels Marketing, LLC $224,178**
Shipley Energy is a heating and cooling company headquartered in York, PA. Working with the City of York, **Shipley Energy** will retrofit three diesel powered tractors to CNG hi-fuel, replace five tractors with brand new dedicated CNG vehicles, and replace one diesel powered street sweeper with a brand new dedicated CNG powered street sweeper. The project will have a fuel displacement of 115,600 GGE annually, and result in the construction of a **new, fast-fill fueling facility in York**.

**Greater Philadelphia Clean Cities $492,216**
The **Montgomery County Natural Gas Vehicle Conversion Initiative** seeks to help the project partners with the foray into utilizing CNG as a fuel for their fleets. This project partners ARAMARK, Delaware Valley Concrete, King Limousine, Sustainable Waste Solutions, Lower Merion Scholl District, Lower Providence Township, and TransNet, The project will convert 35 vehicles to CNG, for a fuel displacement of 114,413 GGE annually, and includes **construction of a fueling station in King of Prussia, PA.**
**See http://www.ep-act.org/Montgomery-County-NGV-Conversion-Initiative**

**Centre County Commissioners $140,359**
Centre County, along with its partners the Centre County Recycling and Refuse Authority and Centre Area Transportation Authority (CATA), will purchase or convert ten CNG vehicles; nine to serve as paratransit buses and one as a refuse truck. A **new fueling station will be constructed by a private partner by the fourth quarter of 2014**, and in the meantime, the partners will use the existing CATA station. The station will be located within two miles of an interstate and accessible by the public and the participating entities.

**McAneny Brothers, Inc. $173,307**
McAneny Brothers, Inc. is a Pennsylvania-based family-owned regional wholesale food distributor. For the project they will purchase eight CNG vehicles to replace eight diesel vehicles currently in use in its truck fleet. These vehicles will operate throughout western Pennsylvania, eastern Ohio and northern Maryland and West Virginia at a fuel displacement of 100,510 GGE per year. McAneny will **install a CNG fueling station at its company site in Cambria County** to fuel these vehicles, and will utilize existing fueling stations in the area until its fueling station is completed.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**UPS to build 8 natural gas fuel stations in New Stanton, Pa**
http://usgasvehicles.com/news_detalle.php?id=2632

2/13/2015—UPS Inc. wants to build eight stations dispensing CNG to fuel company vehicles at its facility in New Stanton, Pennsylvania. Marie Bolechowski of TruStar Energy of Fontana, California, reviewed plans with the borough planning commission this week. The facility would be the first in the community dispensing compressed natural gas, borough officials said. “They're for the package trucks and the trailer trucks,” Bolechowski said.

**TruStar** is involved in constructing 16 fueling sites for UPS. Natural gas stations in Oklahoma City and New Orleans are scheduled to open later this month. UPS has nearly 1,000 package trucks on the road that use natural gas. UPS began extensively using CNG in 1989 to assess its benefits and viability as an alternative fuel, company officials said. “The results include: particulate emissions are 95 percent lower than with diesel engines; carbon monoxide emissions are 75 percent lower; and emissions of nitrogen oxides are 49 percent lower,” according to the UPS website.

The dispensing islands are proposed to be situated on about 3,500 square feet near the front of the New Stanton complex, Bolechowski said. Columbia Gas of Pennsylvania will supply the fuel, and fueling of vehicles takes less than five minutes, Bolechowski said. UPS wants to start construction in New Stanton in May and begin using the fueling islands in July, Bolechowski said.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Congressional Research Service: Natural Gas for Cars and Trucks: Options and Challenges, 2014**
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&ved=0CEcQFjAH&url=http%3A%2F%2Fwww.fas.org%2Fsgp%2Fcrs%2Fmisc%2FR43791.pdf&ei=Z1LeVPTHJpGbyQSNsoDQBQ&usg=AFQjCNEi7SW86TND_IVNr3bilPDodcC-qQ&sig2=1x9XwGR4j4mcnNe6yvnPoQ&bvm=bv.85970519,d.aWw

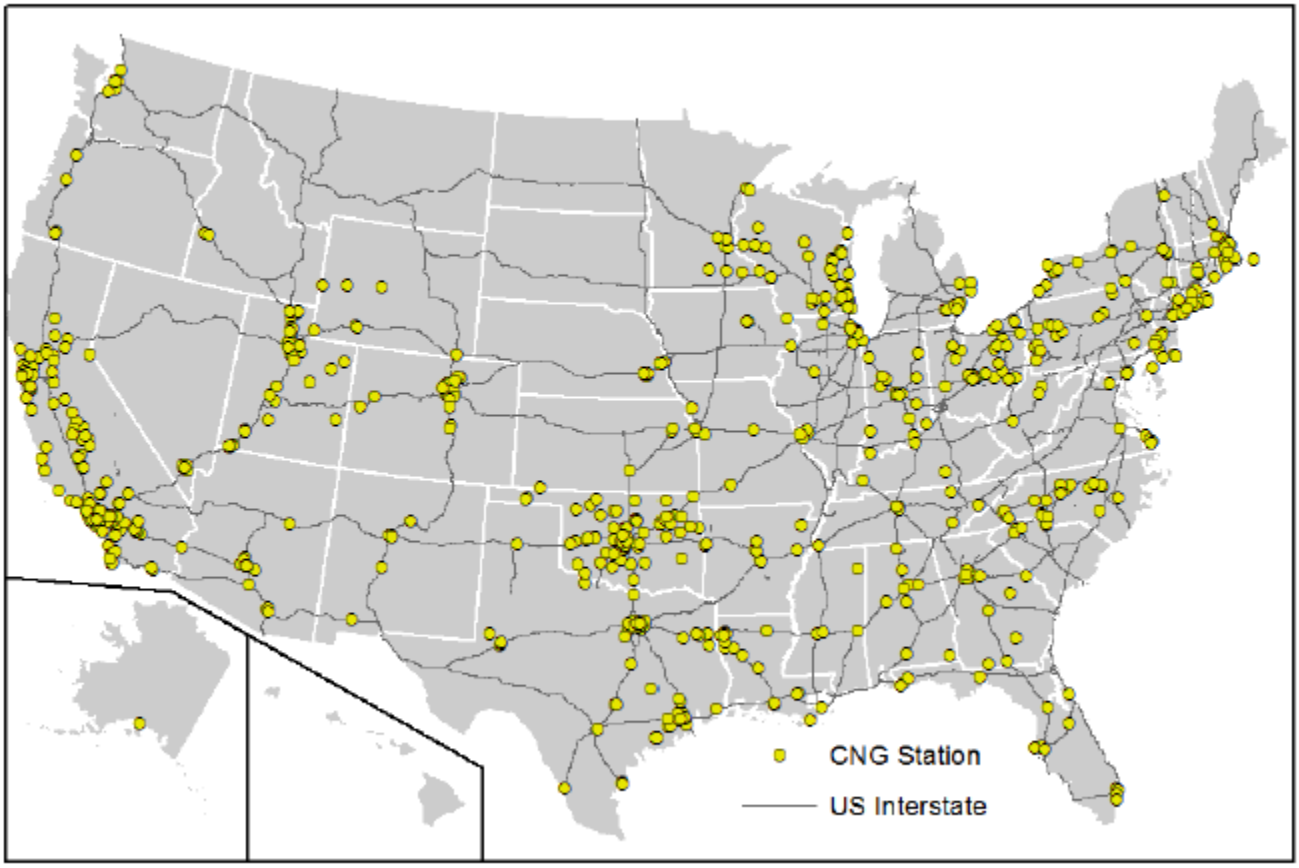
## Cars and CNG

Natural gas fueling is less expensive than gasoline. For example, in mid-October 2014, a gallon of gasoline was $3.20, and CNG on a GGE basis was $2.69. An extensive network of natural gas pipelines throughout the United States provides a ready source of gas in most communities. The most difficult step is finding an economical way to transfer that gas to facilities where it can be pressurized as CNG and distributed commercially.

Stations can offer three ways to fill up a vehicle tank: fast-fill, time-fill, and combination fill (using both fast- and time-fill). Fast-fill draws gas from the gas utility line, filters it with a dryer to remove water and humidity, compresses it, and then stores it in a tank from which it is dispensed. Most retail and some fleet operations use this process, which requires only a few minutes to fill a 20-gallon-equivalent tank. With time-fill, the CNG is provided straight from utility gas line to the compressor. Since there is no storage tank to draw from, time-fill's speed depends on the size of the compressor; it could take a few minutes or many hours. An advantage to a slower fill is that the tank is filled more thoroughly than with fast-fill. Time-fill is usually a slower refueling option and is often used by delivery trucks and buses refueling overnight at a central garage or by car owners at home.

There are 772 public CNG service stations throughout the country (**Figure 4**), and another 127are planned. Car owners also have the option of refueling vehicles at home. A home refueling unit, including installation, can cost about $5,000.

**Figure 4. CNG Refueling Stations**
Open in 2014




**Source:** CRS map developed using DOE data, http://www.afdc.energy.gov/fuels/natural_gas_locations.html.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

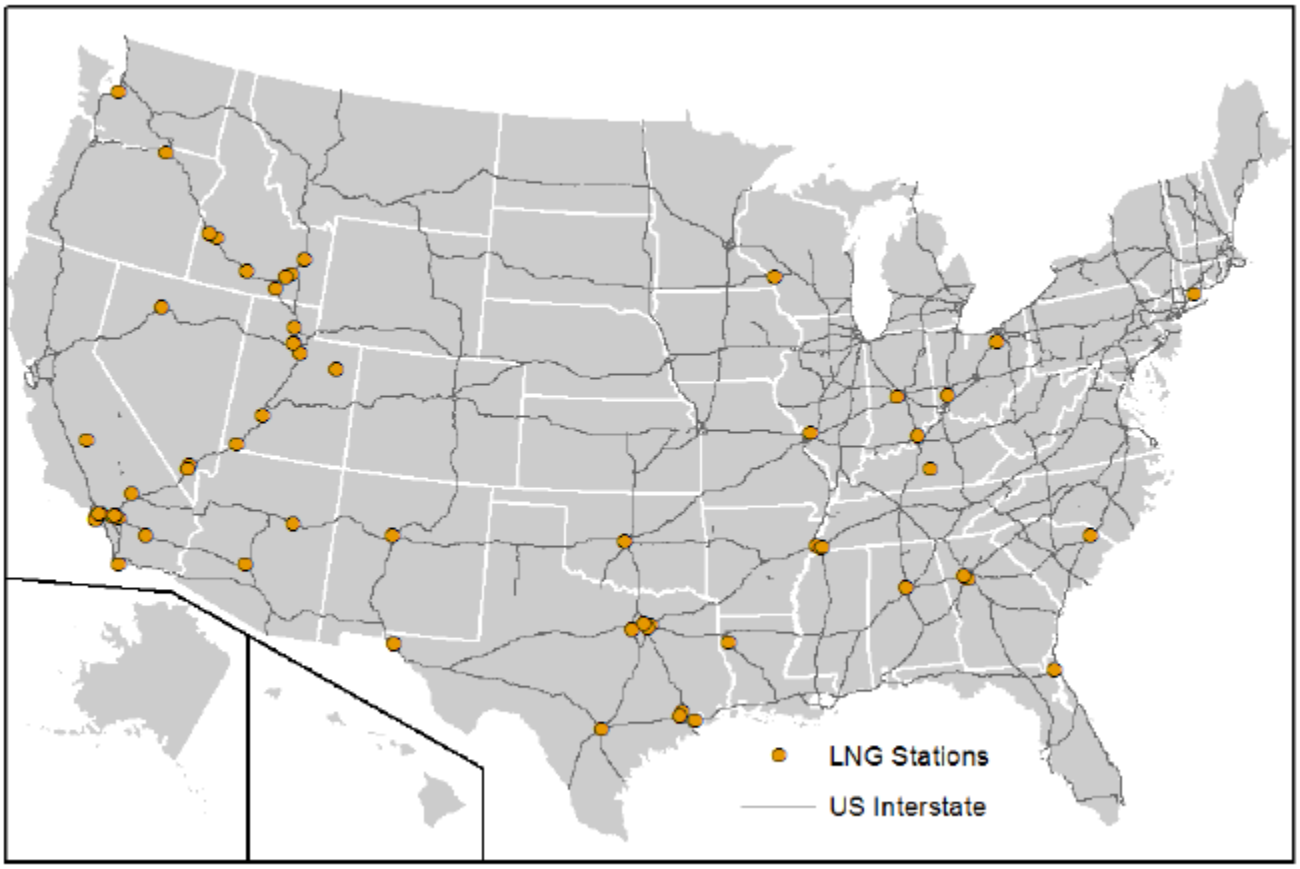
## Trucks and LNG

LNG refueling infrastructure is not yet as developed as the CNG network. Stations use LNG produced off-site at liquefaction facilities. The fuel is then trucked to the refueling station for use. LNG refueling is similar to diesel refueling and takes about the same amount of time: fuel is dispensed at pressures of 30-120 psi. However, the cryogenic nature of LNG requires the person filling the tank to use safety equipment, such as gloves and eye protection. In addition to filling stations, LNG is available from mobile tanker trucks with onboard metering and dispensing capacity.

Refueling stations are being built primarily on major interstate highways used by long-haul trucks and at wide intervals, since the trucks can usually travel about 500 miles without refueling. According to DOE, 64 public LNG stations are open (**Figure 5**), and another 82 are planned. The public network is being built by three investor groups**. Clean Energy Fuels and Pilot Flying J**, a truck stop operator, are building an LNG infrastructure known as "America's Natural Gas Highway," which will have over 200 stations in 33 states when completed. **Shell Oil Company** has announced plans to build 200 LNG stations across the country in conjunction with truck stop operators **TravelCenters of America and Petro Stopping Centers**. These truck stops will also have LNG truck repair and servicing capability. **Blu.LNG**, a Utah-based company, is building an infrastructure in that state and adjoining western states as well as in a few Midwestern states.

**Figure 5. LNG Refueling Stations**

Open in 2014




**Source:** CRS map developed using DOE data, http://www.afdc.energy.gov/fuels/natural_gas_locations.html.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
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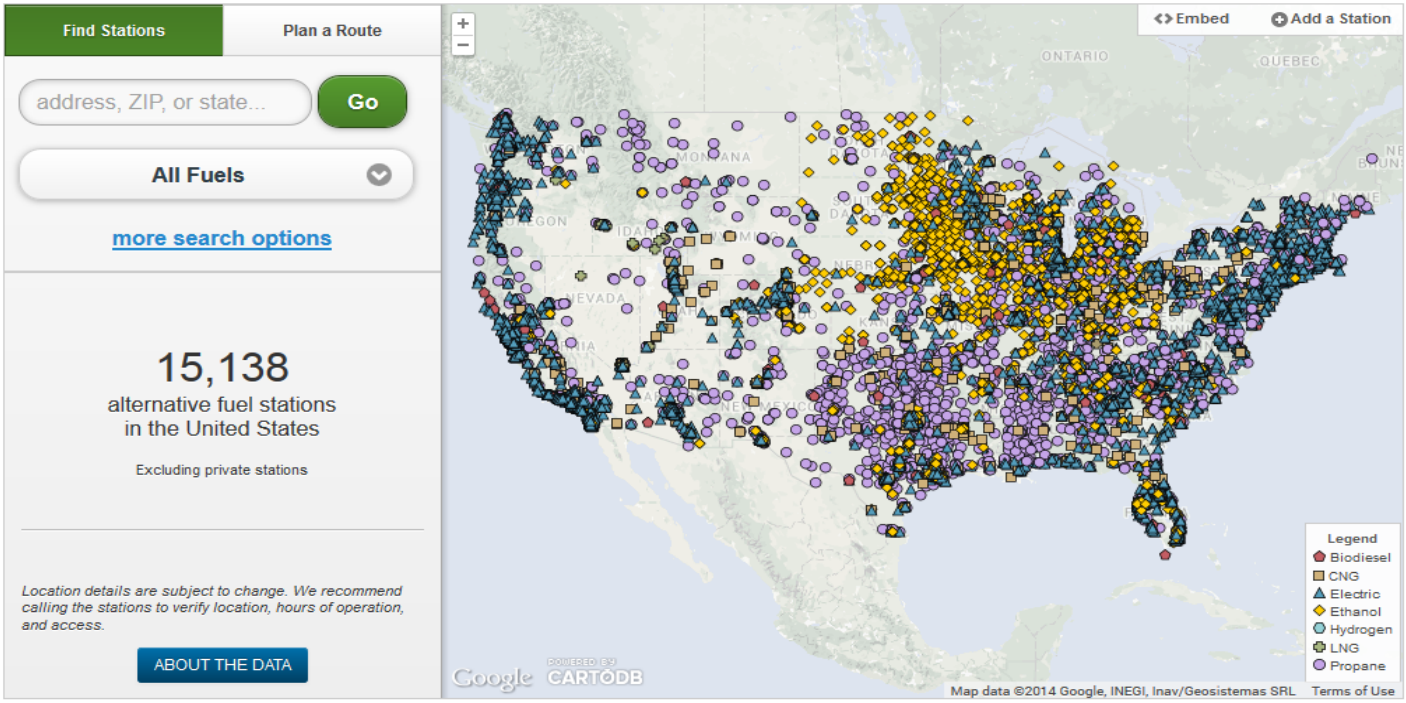
Name: Nate Porter
Email: nwp105@psu.edu



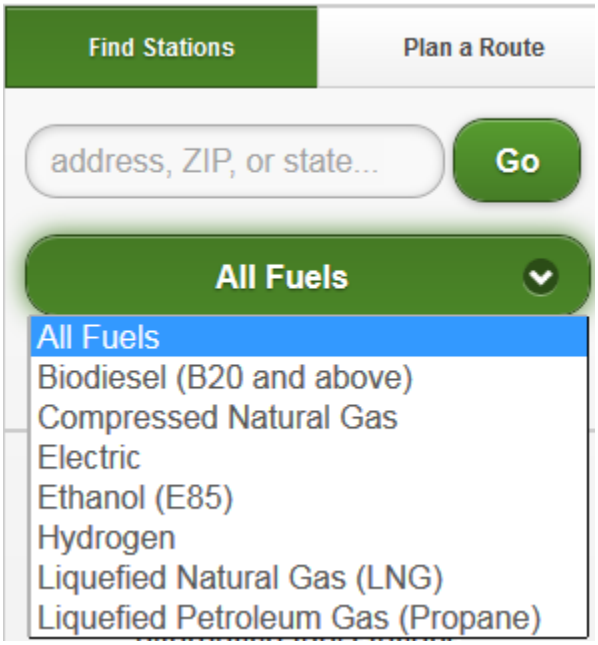
## Alternative Fueling Station Locator

http://www.afdc.energy.gov/locator/stations/

Users can find Alternative Fueling Stations near an address or ZIP code or along a route in the United States.



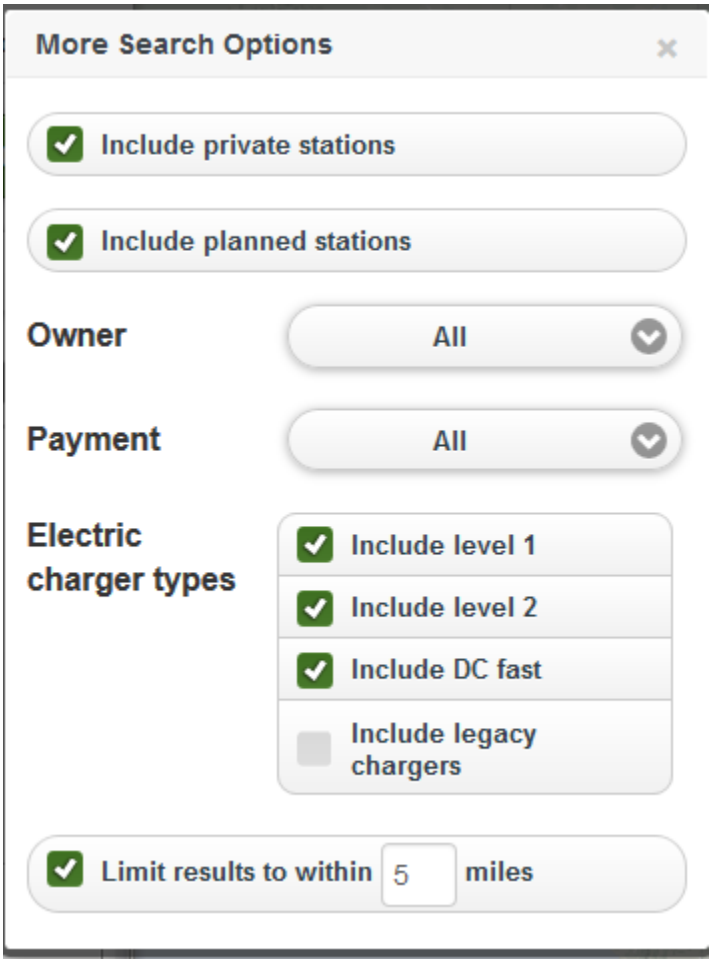

Users can see all Alternative Fueling Stations or limit the results by the type of alternative fuel (i.e. CNG, LNG, etc.)



115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

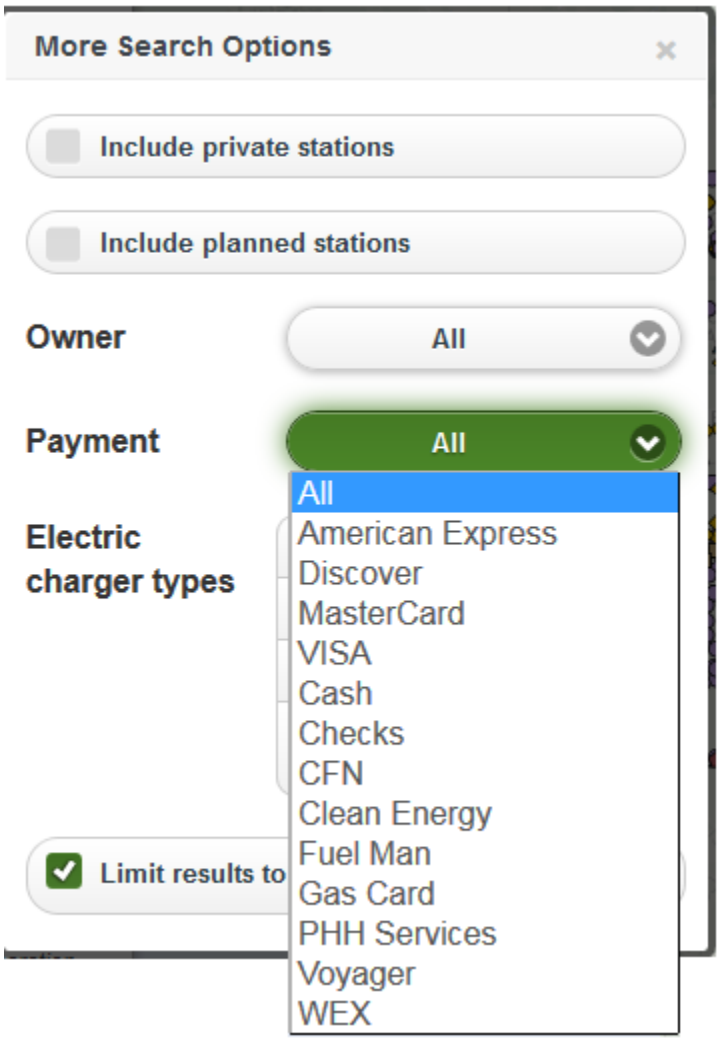
Under **"More Search Options"** a user can choose to add additional features to the map and filter data:

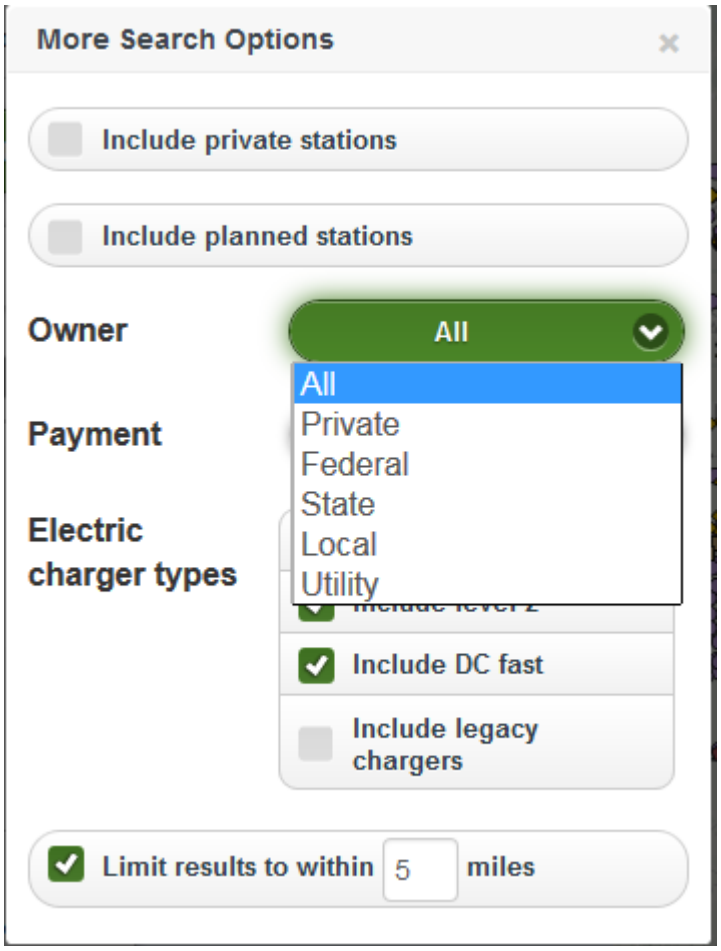
- private station locations
- planned (but not operating yet) station locations
- filter by ownership type
- filter by payment type
- filter by electric charger types for EVs
- limit results based on distance from a location



115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

Additional screenshots.



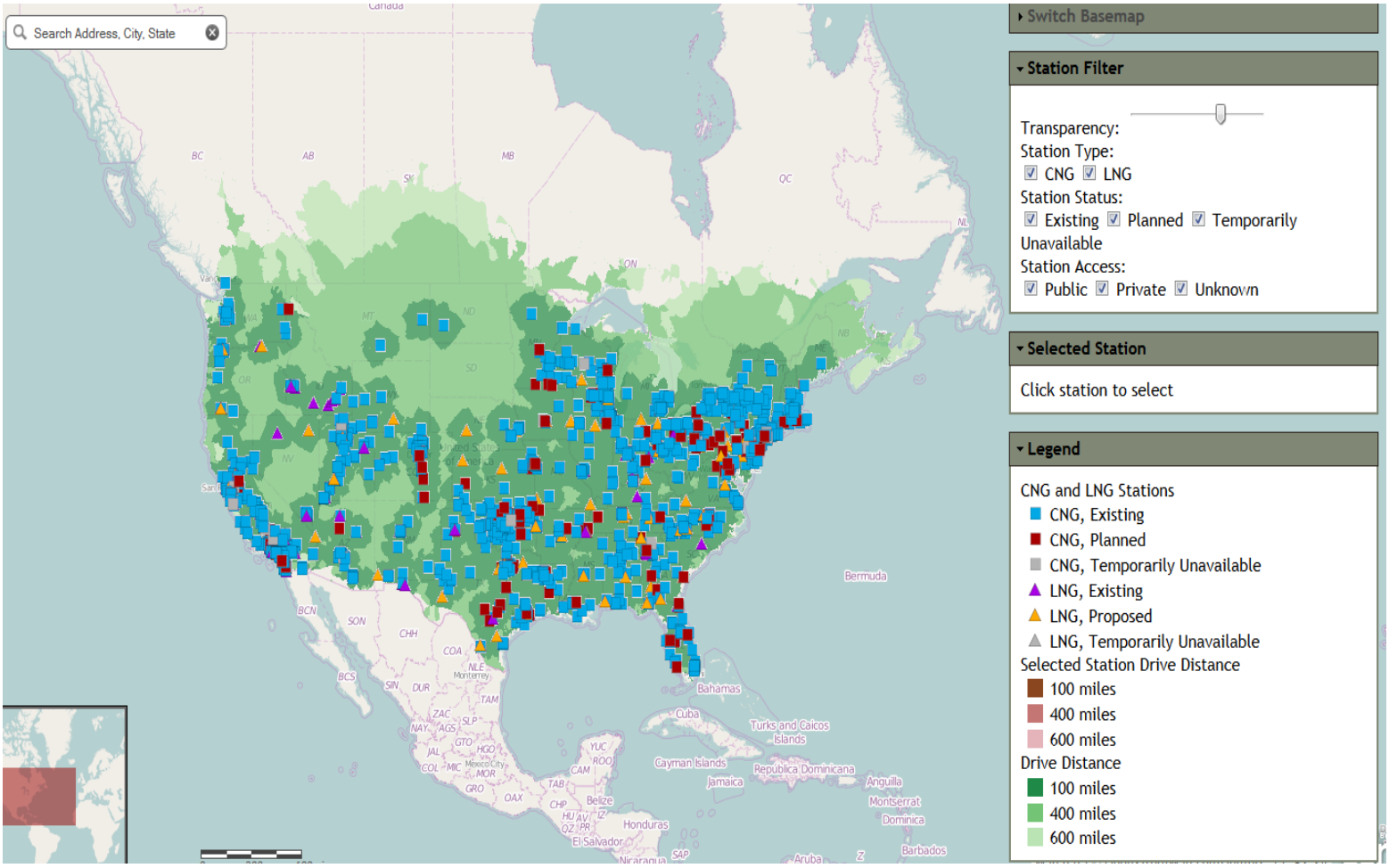
115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu



## Natural Gas Vehicles (NGV) for America Station Analysis Map

http://www.ngvamerica.org/stations/
http://ngvamerica.stone-env.net/

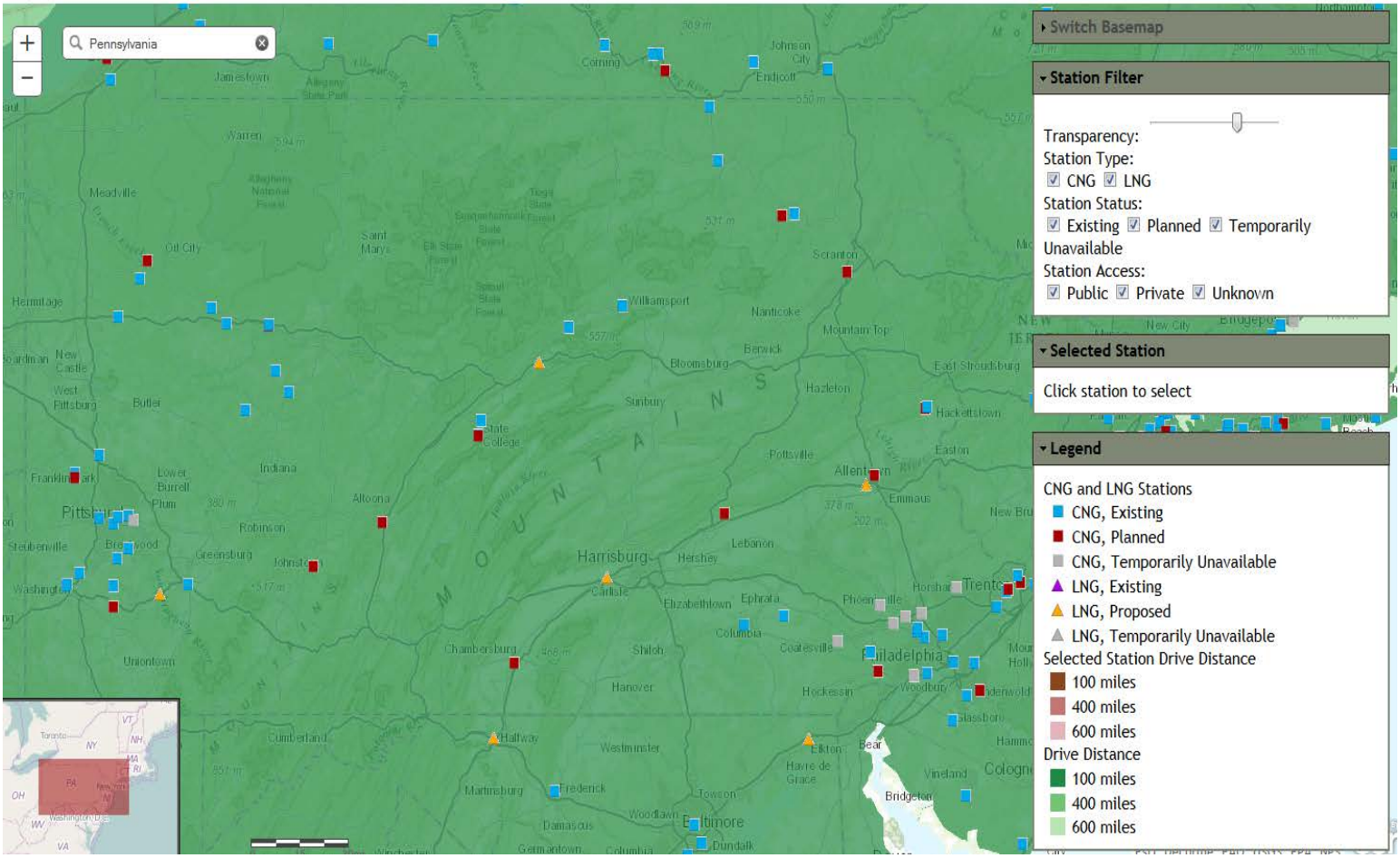
The NGVAmerica Station Analysis Map is an interactive tool that features the most comprehensive and up-to-date information on natural gas stations in the U.S. This information includes station locations, accessibility, and contact information. NGVAmerica's unique tool also includes the incremental driving range that each station supports. The highlighted 100, 400, and 600 mile supported ranges makes charting routes and planning trips easy.



**About Ben Franklin Technology Partners**
Ben Franklin Technology Partners/CNP, an initiative of the Pennsylvania Department of Community and Economic Development and funded by the Ben Franklin Technology Development Authority, provides investment capital, operational assistance, and entrepreneurial support to emerging tech-based companies and small, existing manufacturers for the purpose of creating and retaining jobs in Pennsylvania.
www.cnp.benfranklin.org

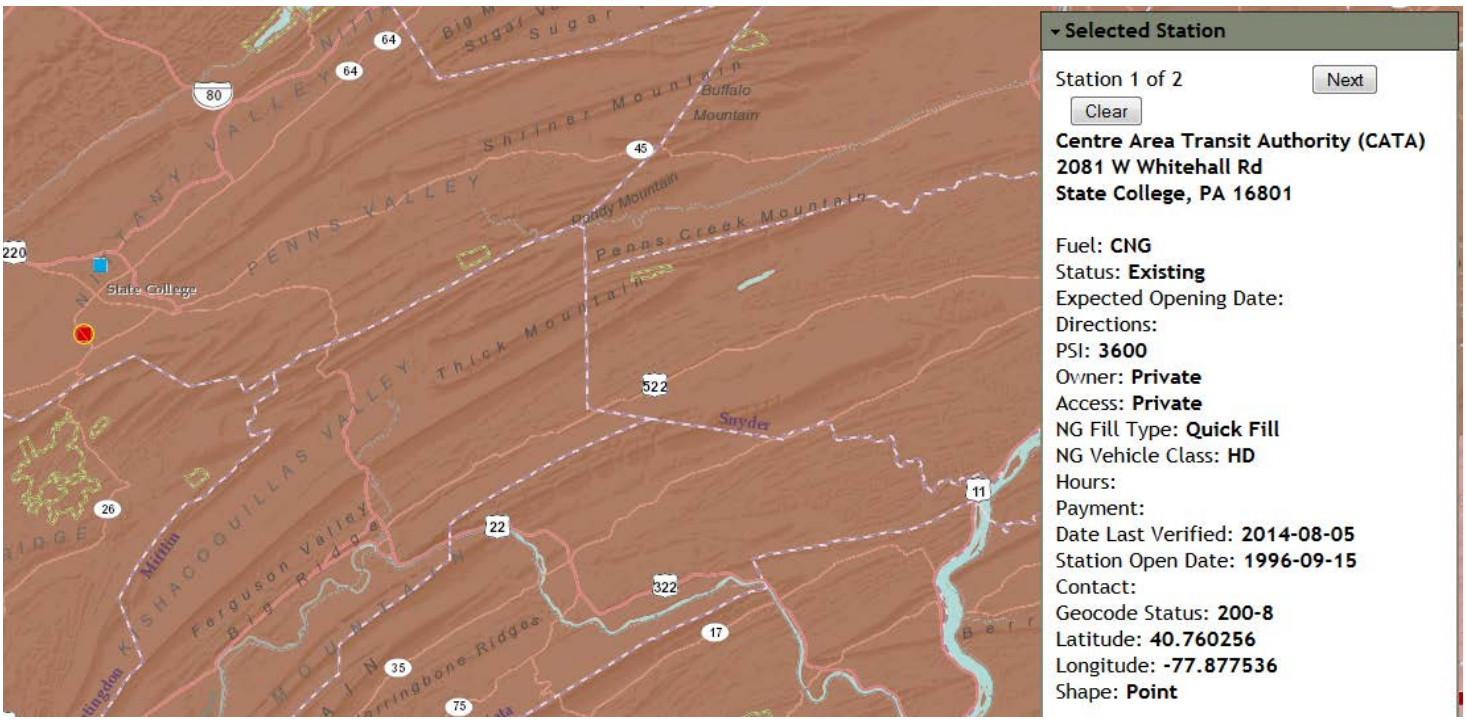
115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

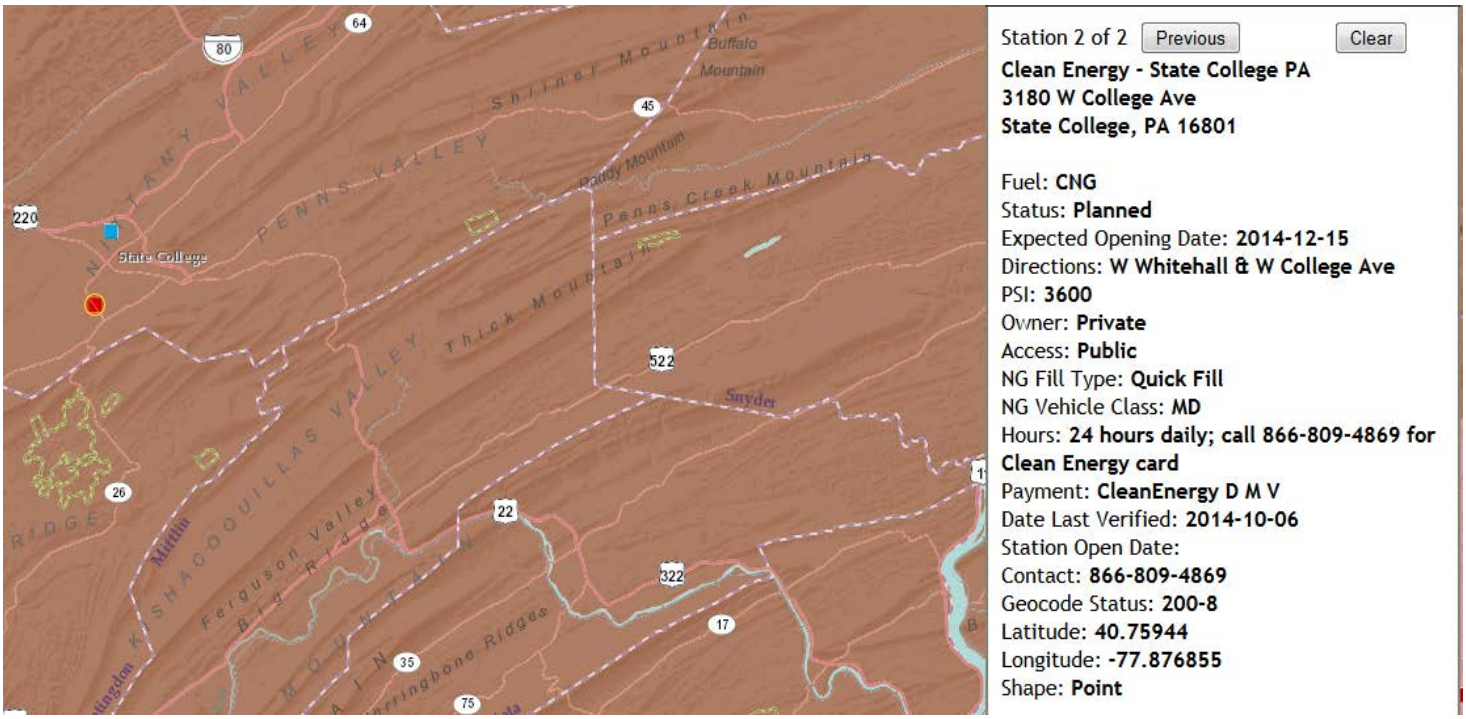
Users can search for information on natural gas stations using a street address, city, or state.



115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

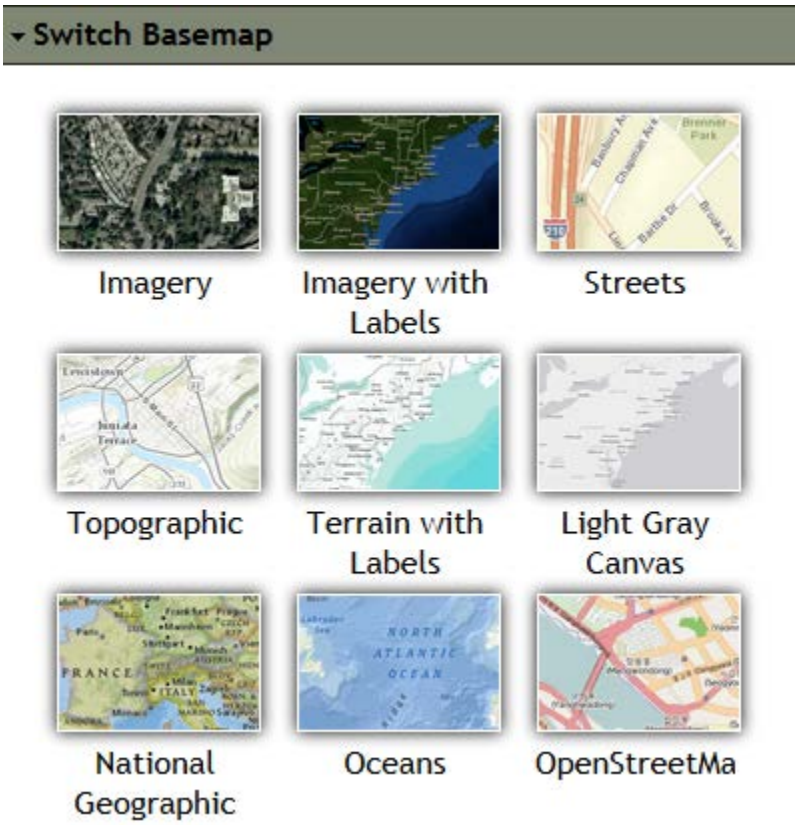
Users can click on a specific station to see additional details. For example, there are two stations in State College, PA—one that is already operating, and one that is planned to open soon:



115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

Users also have the option to switch the basemap view.



# Appendix K

## Natural Gas Vehicle (NGV) Maintenance, Storage, & Infrastructure Development Guide

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
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# Natural Gas Vehicle (NGV)

# Maintenance, Storage, & Infrastructure Development Guide

## Contents

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**How to make maintenance facilities CNG compliant**
http://www.vehicleservicepros.com/article/11210836/how-to-make-fleet-maintenance-facilities-cng-compliant-for-compressed-natural-gas

12/12/2013—Making the switch to compressed natural gas (CNG) as a fueling source can be an easy decision once you crunch the numbers and see the possible savings. You may have already decided to take advantage of those savings by converting your fleet to CNG.

You conducted a feasibility study, calculated your ROI and even applied for federal and state funding to help with the conversion. Now you just have to commission the design for the station and build, right? Wrong. There's more to it than you think.

In your cost-benefit analysis you probably included the cost of the fueling station and applicable components, and even the cost of the vehicle conversions or new CNG vehicles, depending on what makes sense for your fleet. But what about storing and/or maintaining your new or retrofitted CNG vehicles? **Did you know that because of the gaseous state of CNG and its tendency to rise that your maintenance and storage facilities need to be compliant with the applicable codes and regulations?**

If you get too far into your CNG conversion before considering and accommodating these issues, your project could be delayed, come to a complete halt or even crash and burn. Enlisting a trusted advisor, most likely a design or consulting firm with CNG conversion experience who is familiar with the requirements, codes and regulations surrounding CNG, can help you to achieve a seamless conversion.

## WHY CNG?

CNG as an alternative fuel to diesel or gasoline makes economic sense. Making the switch to CNG improves your bottom line, a benefit that a variety of fleets can enjoy. Whether you are a private or public fleet, regional delivery fleet, municipality, school district, taxi fleet or airport, the savings are universal.

You can save an average of 30 to 50 percent on fueling and associated vehicle and maintenance costs. CNG is clean, green, affordable, abundant and most importantly, American. Major regional and even national fleets that have already made the decision to switch include Frito-Lay, Pepsi, UPS, Smith's Dairy, Dr. Pepper/Snapple and Waste Management, to name a few.

## THE WRONG PERCEPTIONS

Most individuals involved in CNG conversions for their fleets tend to think it's all about the vehicles and station. While those are two major components, **there is a third, more "incognito" factor that tends to get overlooked: the maintenance/storage facility. This is one of the major operational components for fleets that need to be upgraded in order to store and perform even light maintenance on CNG vehicles.**

There are a lot of players involved in CNG conversions and some of them just want to make money. It is easy to get caught up with manufacturers and salesmen directing you "to do this" and "buy that." Some of them play on the ignorance and fear of people involved in their fleet's conversion in order to sell products.

Moreover, there are a lot of over compliance rumors out there, and companies are capitalizing on the misinformation.

Jeff Gicewicz, vice president of corporate holdings for Try-it Distributing, a beverage distributor in Western New York, openly admitted that he didn't have all of the answers when he pitched the conversion project to his boss. "Plain and simple, there is more to it than I anticipated," Gicewicz said. "But you don't know what you don't know, right?"

Conversions to bring maintenance facilities up to code can be costly and complicated. This is not something most fleets are equipped to handle themselves. Choosing the right trusted advisor can help you through it while minimizing the cost of mistakes or rework, and ensuring a safe working atmosphere.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

## THINGS YOU NEED TO CONSIDER

**Facilities where CNG vehicles are stored or maintained follow a different set of rules because of the chemistry of CNG.** Because CNG is a gas, it rises and collects in pockets in the ceiling. Therefore, any items that fall within 18" of the ceiling (for example lighting fixtures or fans) must be Class 1 Division 2.

Class 1 Division 2 references an area where ignitable concentrations of flammable gases, vapors or liquids are present within the atmosphere under abnormal operating conditions. As a result, any equipment that resides in that area must be classified in order to operate under such conditions.

On the other side of that, diesel and gasoline is heavier than air and, therefore, pools on the ground and fumes/liquid seep into the floor and pits. In facilities where maintenance or storage occurs on diesel- or gasoline-powered vehicles, all equipment that falls within 18" of the floor must be Class 1 Division 2.

This is important to consider because if you are building a new facility and considering switching to CNG in the future, making your new garage CNG compliant from the start is much cheaper than retrofitting it down the road.

In most cases, if the building being retrofitted already meets today's codes, the cost to get it compliant with CNG codes is incremental. The problem lies in the fact that there are a lot of facilities being used regularly that do not even meet today's standards for ventilation. These facilities cost more when being retrofitted due to the need to make them current with today's requirements before considering CNG code compliance.

## THE MANY PATHS TO COMPLIANCE

**There are several different ways to become CNG compliant. There is not one correct way, or a one-size-fits-all solution**.

For example, when retrofitting your garage you have the option of increasing the number of air changes, operating the ventilation system continuously or installing a bunch of methane detectors in order to detect a leak. You can also make alterations to your facility to eliminate pockets in the ceiling where gas collects, or designate a confined area where maintenance and/or storage of CNG vehicles occur to limit the amount of modifications needed.

In some cases, it may be more cost effective to build a brand new facility altogether.

If you prefer not to upgrade your facility, you can outsource the maintenance and storage of your CNG vehicles. That was the decision Try-it Distributing made when it realized that funding for facility upgrades was non-existent.

"The third part beyond the trucks and the filling station would be the building modifications to support the trucks when inside the building for maintenance," explained Try-it's Gicewicz. "Because we are not doing it on-site, that really took that third component off the table for us.

"I fully expected us to have to drop $500,000 to $600,000 into our facility to come up to code. It was nice that that price tag went away."

Try-it entered into a design-build, own and operate contract with Kenworth Truck Company to service Try-it's CNG vehicles at the OEM's facility in Buffalo, NY. Kenworth is making the necessary upgrades to its maintenance facility there in order to service Try-it's fleet, taking a sizable chunk of change out of Try-it's project cost altogether.

Try-it will still be making minor upgrades to a limited part of its facility to accommodate the CNG vehicles that are indoors briefly when being loaded with product.

The type of modifications needed depends on what the maintenance facility is being used for. For example:

- **Storage/Light Maintenance**: Requires continuous ventilation or methane detection using methane detectors and then implementation of an approved response, such as increasing ventilation, shutting down electric devices and/or opening doors.
- **Heavy Maintenance**: Requires continuous ventilation or methane detection using methane detectors and then implementation of an approved response, such as increasing ventilation to exceed normal ventilation rates, shutting down electric devices and/or opening doors.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

## WHAT CODES AFFECT CNG?

Your trusted advisor can help to make sense of international, national, state and local codes and their contradictions, and navigate you through the facility retrofit. The major codes that affect maintenance facilities come from the National Fire Protection Association (NFPA). They include:

- **NFPA 30A**
  - Relevance: Motor Fuel Dispensing Facilities and Repair Garages.
  - In short: Defines major and minor repair garages, which determines the type of codes that are required to store and/or maintain a CNG vehicle.
- **NFPA 52**
  - Relevance: Vehicular Gaseous Fuel Systems.
  - In short: Pertains to the design, construction, installation and operation of containers, pressure vessels, compression equipment, buildings and structures, and associated equipment used for storage and dispensing of CNG as an engine fuel.
- **NFPA 70**
  - Relevance: National Electrical Code.
  - In short: Addresses the installation of electrical/communications conductors and equipment, and optical fiber cables in commercial, residential and industrial occupancies.
- **NFPA 88A**
  - Relevance: Standard for Parking Structures.
  - In short: Pertains to the parking and storage of CNG vehicles in open and closed parking structures. It also concerns the storage, handling and dispensing of fuels.
- **Other important codes include:**
  - International Fire Code.
  - International Building Code.
  - Federal Regulations, such as the *Alternative Fuel Vehicle Acquisition* and *Fuel Use Requirements*. (For more information on federal regulations visit the Department of Energy (DOE) website at www.afdc.energy.gov/fuels/laws.)
  - Mechanical Codes.
  - Energy Codes.
  - Local Codes. (For example, the *New York City Fire Code* is a major factor in Wendel's CNG facilities upgrade project with the New York City Transit Authority.)

## WHAT'S THE DEAL WITH THE AHJ?

The Authority Having Jurisdiction (AHJ) enforces the codes in their respective state, county or city/town, depending on who it is. The AHJ can be the local fire department, state fire marshal, insurance company or the like.

Although CNG-powered vehicles have been around since the 1930s, they have just recently begun to take off due to the decoupling of crude oil and natural gas. As a result, **a large number of AHJ's have little experience concerning codes that affect CNG vehicles and facilities where they are stored and maintained.**

This process is just as new to them as it is to you and your fleet. Finding a trusted advisor who knows the codes and how they affect the design of your facility will truly help to expedite the process and save you money.

One issue that has come up when Wendel was serving its clients is the conflicts that exist between codes. For example, the international and national codes do not always agree. The AHJ tends to lean toward the more restrictive end of things, or over-compliance.

The most restrictive code is not always the correct answer and having someone there to debate intelligently on your behalf could save you money.

It is also very important to get the AHJ involved in your project as early on as possible. It is much easier to explain what you are doing and why to the AHJ during the design process, rather than presenting them with a finished design and trying to get them on board. That way all comments and concerns can be addressed early on, keeping your project on track.

One way Wendel proactively tackles potential conflict is by employing a process where all team members, including stakeholders and the AHJ, fully immerse themselves into the design by way of several regimented Charrettes and meetings over a two- to three-day period.

One of our recent CNG fueling station/building modification projects in St. Cloud, Minn., got off to a great start as a result of this process, with all stakeholders bought in on the design and the AJH in agreement concerning applicable codes and regulations.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

## THINGS YOU CAN DO

If you are on the cusp, knee-deep in it or just toying with the idea of upgrading your maintenance facility, there are a few things you can - and should - do:

1. Do your research. Attend seminars and seek out advice from fleets that have already converted or are in the process. Educate yourself on who the key players are in your region.
2. "Align yourself with quality people within the industry," cautioned Gicewicz of Try-it. "I did a lot of research on my own, but we aligned ourselves with the team that seemed to have the most knowledge about this, and that was Wendel's team."
3. Seek out a trusted advisor who will work with you and on your behalf. Choose a firm that is experienced, understands the codes and regulations, and has completed projects of similar scope.

Code review and design approach to the storage and maintenance facility may be the determining factor if CNG is economically feasible for your fleet. This is why an experienced trusted advisor is critically important when deciding on converting.

As someone who is leading the charge and at the heart of Try-it's conversion, Gicewicz wanted to stress that their decision to switch involved more than the savings on fuel costs.

"We really like to push the fact that it [converting to CNG] lessens our dependence on foreign oil and all of the troubles and heartaches that come with that," he said. "Not all those companies have our best interests in mind, or our troops' best interests in mind. That's definitely a priority for us to get that word out."

If you are not sure if CNG is a possibility for you, we can conduct a quick, free analysis that estimates possible savings and even a payback period. See Wendel's website, www.wendelcompanies.com, for contact information.

**CNG Infrastructure Guide**
https://www.aga.org/sites/default/files/sites/default/files/media/cng_infrastructure_guide.pdf

## Fleet or End-User Ownership

Several variants exist for a Fleet or End-User Ownership model. These models typically apply to entities that have vehicles that require fueling and desire to own the station that provides that fuel.

The "Own and Operate" model applies to entities that will own and operate the CNG station. In some cases, the ownership could be shared among multiple entities using the same station or with a utility in a hybrid arrangement.

Variations include the following:

**1) Ownership Differences:**

- a) The ownership entity uses its own personnel for operation and maintenance of the facility
- b) The ownership entity contracts with a third-party for operation and maintenance of the facility

**2) Fueling Sources:**

- a) The ownership entity contracts with a utility for the regulated transportation and sale of natural gas to the station
- b) The ownership entity contracts with a third party for the natural gas commodity and the utility entity provides regulated transportation service to the delivery point

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

## Local Distribution Company (LDC) Ownership

LDC Ownership occurs when the natural gas utility or LDC owns the CNG station and operates it for the benefit of others. LDC models follow a rate-based or non-rate based model. The "rate base" refers to how much money utilities have invested in facilities and equipment to ensure service to the utility's customers.

Most LDC ownership relies on a rate-based model in which the capital investment is made by the LDC and is reimbursed through a regulated rate (typically set by a public utility commission) charged to the customer. It is possible in some cases for the LDC to capture a rate of return where a profit is realized. These models are seldom used.

Unregulated affiliates of LDCs also pursue natural gas vehicle infrastructure where the rate of return is based on the project risk and potential profits are not limited.

| LDC | Number of Retail Stations Reported | Estimated Market Share |
|---|---|---|
| Questar Gas | 29 | 6% |
| Pacific Gas & Electric | 24 | 5% |
| Oklahoma Natural Gas | 23 | 5% |
| National Grid | 15 | 3% |
| Southern California Gas | 13 | 3% |
| Other LDCs | 40 | 9% |
| Total | 156 | 35% |

**In 2010, the American Gas Association surveyed its membership to determine how many natural gas utilities offered natural gas for sale under a special natural gas vehicle (NGV) tariff or pursuant to a compressed natural gas (CNG) tariff. Of the 32 utilities that responded to AGA's 2010 survey, 53% of the utilities had a special NGV or CNG rate.**

**Further, of the nearly 450 public CNG stations in the U.S. currently, approximately 35% are owned by LDCs.** LDC ownership in a facility can be full or partial and this will often affect the access type

- public access, private access, or limited access.

A full versus partial ownership model is a hybrid where a regulated natural gas utility owns a portion of the CNG facilities (generally the compressor, storage and auxiliaries) under a rate-based model and a third party commercial retailer owns the dispensing means (along with the land, card-reader, and retail transaction functions) using an unregulated model. The LDC recovers its investment in facilities and associated operations and maintenance costs through a "compression services" fee that is charged to the retailer. The retailer charges its customers for the delivered CNG under an unregulated price per fuel unit. Examples of this model include the Atlanta Gas Light Company (AGL), the regulated LDC serving a portion of the Georgia market.

LDCs also own public access stations, and provide CNG service at stations that are part of their facilities, or a nearby public location. The user pays for the fuel consumed based on a dispensed published rate per unit (typically a thermal unit or Gasoline Gallon Equivalent (GGE), as established by the regulatory authority. The utility may also fuel its own company vehicles at the same location. Examples of this model include **Questar Gas, PSNC Energy, and Piedmont Natural Gas.**

LDCs also own limited access stations, often located at a customer location, and provide CNG service to a limited number of vehicles. The vehicles are typically owned by one or more fleets, and generally do not include vehicles used by the general public. They may be filled using a time-fill approach if appropriate. The user pays for the fuel consumed based on a per unit basis, and may be subject to a take-or-pay contract to assure a return on the utility investment.

## Third Party or Commercial Ownership

Third-Party Ownership, also known as a Commercial Operator, is an unregulated commercial business entity which owns the CNG station on a for profit model. These models are typically found in non-rate based, economically viable areas. The entity is not subject to utility regulation and is separate from the owner/ operator of the vehicle. Commercial business models have the most flexibility in terms of the type of ownership interests, the means of financing, and the range of associated activities needed to operate a CNG station. There are two mechanisms for this type of model: "Own and Operate" and "Operate Only".

"Own and Operate" models are just that – a commercial operator owns and operates the CNG station. That operator may or may not own the land on which the facilities are located. The operations functions may include the commodity purchasing, maintenance, retail transaction management or these may be outsourced to other entities under some type of contractual arrangement (fee for service, lease, etc.)

In an "Operate Only" model, the ownership of the facilities is separate from the responsibility of operation.

Ben Franklin Technology PArtners
Central and Northern Pennsylvania

pennsylvania
DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**About Ben Franklin Technology Partners**
Ben Franklin Technology Partners/CNP, an initiative of the Pennsylvania Department of Community and Economic Development and funded by the Ben Franklin Technology Development Authority, provides investment capital, operational assistance, and entrepreneurial support to emerging tech-based companies and small, existing manufacturers for the purpose of creating and retaining jobs in Pennsylvania.
www.cnp.benfranklin.org

## CNG Maintenance Facilities

Maintenance facilities are typically designed with liquid fuels in mind, and constructed to meet basic safety requirements related to the physical properties of gasoline and diesel. Facilities constructed to service CNG vehicles must consider the differences between gaseous and liquid fuels, while ensuring the same level of safety. For example, natural gas is lighter than air and in the event of a leakage will rise, instead of pooling on the ground and must be considered in facility design.

**NGV maintenance facilities are governed by the National Fire Prevention Association (NFPA) and required to consider the following in facility modification/ construction:**

### Heating System

Maintenance facilities that service gasoline and/or diesel vehicles typically mount overhead heaters near the ceiling. Since natural gas is lighter than air and auto ignites at a temperature of 1080 degrees Fahrenheit, open flame heaters are prohibited from use in NGV maintenance facilities. As an alternative, the code requires the usage of infrared, sealed combustion or catalytic heaters with a skin temperature below 800 degrees Fahrenheit. Although industry best practices suggest that NGVs should never be parked below an open flame, NFPA states that an open flame heater may only be located in a general purpose area and mounted below 18 inches from the ceiling.

### Potential Ignition Sources, Including Lighting and General Electrical Equipment

In NGV maintenance facilities, potential ignition sources (i.e., anything that could create an arc or spark that would ignite natural gas in either the on or off position) should not be located 18 inches from the ceiling. Traditional lighting should be pendant mounted below the 18-inch cavity or sealed lighting systems should be utilized in NGV maintenance facilities. It is also stated that general electrical equipment should not be located within the 18-inch space below the ceiling. Class 1 Division 2 Group D rated motors are approved for usage or electrical door(s) located within the 18-inch space should be relocated.

The table below compares the recommendations for modifying an existing facility with specifications for a new facility.

| Requirement/ Recommended Practice | Existing Facility Modification | New Facility Design |
|---|---|---|
| **Ventilation** | | |
| Methane detection | Add methane detection | Specify methane detection for new facility |
| HVAC systems | Replace existing system or add supplementary exhaust system | Specify to function counter flow to HVAC conventional system to include no open flame heaters |
| Supplementary exhaust | Add supplementary exhaust fans that are Class 1 Div 2 Group D rated | N/A |
| Class 1 Div 2 Group D fans | See above | Specify for new facility |
| **Heating Systems** | | |
| Space heaters | Replaced with sealed combustion, infrared or catalytic heaters with skin temperature less than 800°F | N/A |
| **Potential Sources of Ignition** | | |
| Pendant mount lighting | Pendant mount below 18 inches from ceiling | N/A |
| Class 1 Div 2 Group D lighting | Install Class 1 Div 2 Group D lighting | Specify Class 1 Div 2 Group D lighting |
| Other Ignition Sources within Class 1 Div 2 Group D area (motors, switches, etc.) | Move below 18 inches from ceiling or replace with Class 1 Div 2 D rated equipment | Specify Class 1 Div 2 Group D rated equipment |

Note. From "Natural Gas Vehicle Market Analysis," by TIAX, 2012 CNG Infrastructure, Table 3.4.2-1.

### Ventilation

NFPA defines the area extending from the ceiling down 18 inches as the Class 1 Division 2 Group D hazardous area in NGV maintenance facilities. Ventilation air is introduced at higher levels and exhausted in the lower 18 inches of the facility to prevent electrical sparks from igniting fuels. This compares to facilities for diesel and/or gasoline that have the defined Class 1 Division 2 Group D defined from the floor to 18 inches above the floor. The difference between designations is based on the characteristics of the varying fuels and where they will gather or pool during a leak.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu



**U.S. and Canadian Natural Gas Vehicle Market Analysis: Compressed Natural Gas Infrastructure, 2012**
https://www.aga.org/sites/default/files/legacy-assets/our-issues/natural-gas-vehicles/Documents/TIAX%20CNG%20Full%20Report.pdf

*The current CNG infrastructure developer base is composed of **four primary types of companies**. While each has a specific role, all four may provide services in sizing and designing stations, which can cause increased station costs for the customer.*

## Major Types of Developers

While there are numerous manufacturers and distributors that play some role in CNG infrastructure development, there are four main categories of companies that have the most involvement: compressor manufacturers/suppliers/packagers, engineering companies, construction companies, and retailers. Their roles are shown in **Table 4.3-1.**

**1. Compressor Manufacturers/Suppliers/Packagers**
These infrastructure developers either manufacture compressors and then assemble them with other components into complete fueling systems, or they purchase compressors from a manufacturer, assemble them with other required components, and then distribute the CNG fueling systems. For many companies, compression manufacturing is a segment of a larger industrial gas compression business. These companies are usually privately held and provide fueling equipment through a construction company either to an onsite fueling customer or the retailer. They have in-house engineering expertise, size fueling stations based on input data from the client, and do not involve an outside engineering firm.

**2. Engineering Companies**
Regularly, CNG fueling infrastructure customers rely on an outside engineering or technical services firm to size, design, and develop specifications for their stations. There are a small number of engineers in the U.S. and Canada who have been working in the CNG fueling field for a significant number of years and who have developed expertise in this area. Several began their careers in the natural gas utility industry and attribute their experience to that work. They understand the unique aspects of high pressure gas, the principles under which the CNG fueling process operates, and the special equipment that may be required for gaseous fuels (such as gas dryers) and are familiar with the codes to which CNG stations must be designed.

**3. Construction Companies**
There are a limited number of construction companies (sometimes combined with engineering services) that currently provide CNG station construction services on a regular basis either locally or nationally. Construction companies must be educated and experienced in dealing with high pressure gas and familiar with the permitting requirements; national, state, and local codes to which CNG stations must be built; and the safety aspects of building fueling stations that operate on high pressure fuels as opposed to liquid fuels.

**4. CNG Retailers**
These are companies that provide retail and/or third party CNG fueling to a single fleet customer under contract or public CNG fueling to any and all customers. Generally, they fall into three categories of businesses: LDCs, existing gasoline and diesel retailers, and independent retailers. Regardless of the category, CNG retailers provide retail fueling for customers for a profit.

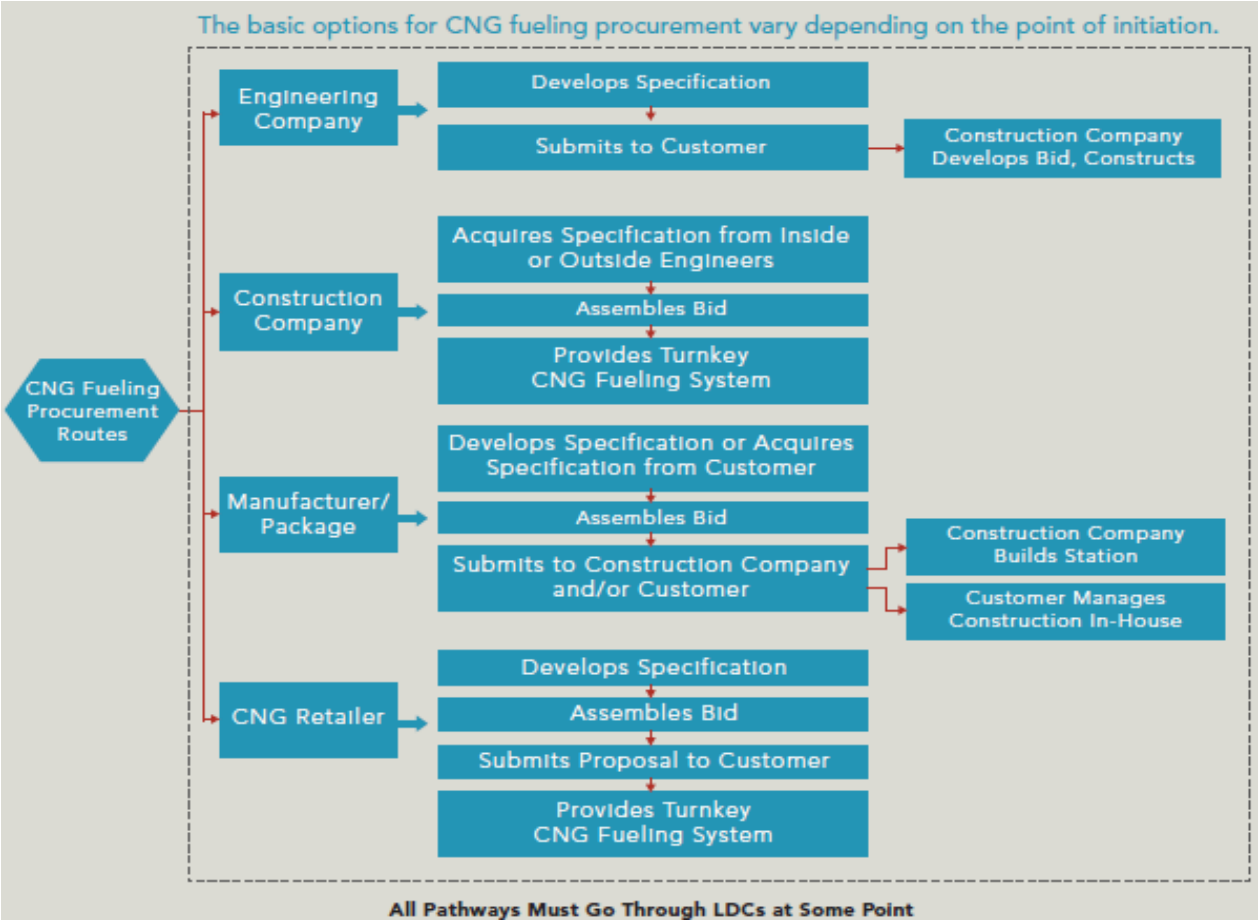
Table 4.3-1

Different types of CNG infrastructure developers have specific but sometimes overlapping roles in the station procurement process.

| Type of Infrastructure Developer | Size, Design, Develop Specifications for CNG Station | Manufacture of Package CNG Equipment | Permit and Build CNG Station | Operate/Retail CNG Station |
|---|---|---|---|---|
| Manufacturer | X | X | | |
| Engineering Company | X | | | |
| Construction Company | X | | X | |
| CNG Retailer | X | | | X |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

## Station Procurement Process




## Compressor Manufacturers/Suppliers/Packagers

**Table 4.5.1-1** summarizes basic information about the major companies involved in manufacturing and/or packaging CNG fueling station equipment.

Table 4.5.1-1

Current low demand for compressor packages is met by a small number of CNG fueling station manufacturers/packagers.

| Company (Location) | Manufacturer or Packager | Compressor Brand | Power Range (HP) | Specialty/Size Limitations (scfm) | Estimated Market Position | Years in Business | Current Units per Year |
|---|---|---|---|---|---|---|---|
| ANGI (WI) | Both | ANGI, Ariel | 40 to 600 | 50 to 3,000 | 1 | 40 | Proprietary |
| Bauer (VA) | Both | Bauer | 5 to 125 | 5 to 161 | | 15+ | 10 |
| GESI (CA) | Package | Gardner Denver | | 47 to 700 | | 12+ | No Response |
| Greenfield Compression (TX) | Both | Greenfield | | Up to 1000 | 2 | 52 | No Response |
| IMW (BC) | Both | IMW | 40 to 300 | | 3 | 26 | Confidential |
| JW Operating (TX) | Package | Ariel | 18 to 1,775 | | | 40+ | 6 |
| Knox Western (PA) | Both | Knox | 10 to 1,600 | 75 to 4,000 | | 30 | Re-entering Market |
| Kraus Global (Canada) | Package | Ariel | 18 to 1,775 | | | | No Response |
| Phoenix Energy (AL) | Package | Ingersoll Rand | | | | < 1 Year | 9 |
| Pinnacle (TX) | Both | Pinnacle | 200 to 450 | 300 to 1,200 | | 19 | 4 |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

There is a **small number of engineering and construction companies** that have been working over the past years to size, design, and build CNG stations in the U.S. and Canada. These companies have developed expertise required to provide the services necessary to meet CNG fueling customer needs, and their reported information is summarized in **Table 4.5.2-1.**

Derived from the reported data, **T. Mitchell Engineers** captures the most significant market share of the engineering business at approximately 25 projects in 2010. The next closest reported number of projects was nine for **Allsup Corporation**. It should be noted that several firms did not respond to the survey, which affects the market shares estimated in **Table 4.5.2-1**.

**Station Engineering and Construction Companies**

Table 4.5.2-1

Current low demand for CNG stations is met by a small number of CNG station engineering and construction companies.

| Company | Engineering or Construction | Estimated Market Share | Units per Year | Units per Year for Stable Business Case | Units per Year to Exceed Capacity |
|---|---|---|---|---|---|
| AE COM | Engineering | 3% | 2 | 6 | 8 |
| Zeit Energy | Both | 3% | 2 | 12 | 16 |
| Amtek | Both | 6% | 4 | N/A | N/A |
| Fuel Solutions | Engineering | 7% | 5 | 10 | 14 |
| Weaver Inc | Both | 9% | 6 | 10 | 14 |
| ET Environmental | Both | 10% | 7 | 10 | 14 |
| Marathon Technical Services | Engineering | 12% | 8 | 12 | 16 |
| Allsup Corporation | Both | 13% | 9 | 9 | 12 |
| T Mitchell Engineers Inc | Engineering | 37% | 25 | 40 | 54 |
| AVSG LP | No Response | | | | |
| EFS West | No Response | | | | |
| Engineered Energy Solutions | No Response | | | | |
| Raymundo Engineering | No Response | | | | |
| Burnett & Burnette | No Response | | | | |
| **Total Reported** | | | **68** | **109** | **147** |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

*The current base of major CNG retailers is dominated by LDCs as a group and a single company, Clean Energy.*

There are an estimated 450 public access retail CNG stations in the U.S. As shown in **Table 4.5.3-1**, LDCs operate approximately 36% of these stations, while Clean Energy operates 26%. The LDC with the largest number of stations is **Questar Gas** with 29 stations, followed by **Pacific Gas & Electric Company** with 24 stations, **Oklahoma Natural Gas** with 23 stations, **National Grid** with 14 stations, **Southern California Gas** with eleven stations, and **WE Energies** with eight stations. The remaining CNG retailers in the U.S. offering more than one station include **AVSG** (eight stations), **Trillium** (estimated three public stations), and **Pinnacle CNG** (two public stations.)

It can be hypothesized that the reason the market is dominated by LDCs is due to their ability in some cases to provide CNG fueling infrastructure and include the capital cost in the rate base. Some LDCs (such as California companies) are prohibited from including CNG infrastructure costs in their rate base unless the infrastructure primarily serves their own fleets.

**Public utilities commissions or other similar regulatory bodies in several other states allow rate-basing of CNG stations. These include regulatory authorities in North Carolina, Georgia, Oklahoma, Indiana, New York, New Jersey, Wyoming and Pennsylvania**. LDCs also have expertise in dealing with natural gas, and vested interest in finding markets for natural gas that will help offset demand reductions that have occurred over the past two decades due to demand side management and/or conservation.

**Clean Energy** is the nation's largest independent retailer. The company is publicly owned, operating CNG stations in the U.S. and Canada. Clean Energy's approach to developing the market for natural gas as a transportation fuel is comprehensive and includes aggressive marketing, a finance subsidiary (**Clean Energy Finance**) that provides capital for fleet operators to lease/purchase vehicles, ownership of a vehicle conversion company (**BAF Technologies**), and ownership of a CNG equipment distributor **(IMW**). Much of Clean Energy's success can be attributed to their entrepreneurship, their access to large amounts of capital (latest reported stockholder equity is $277 million), their success at leveraging their capital with federal, state, and local grants, and their level of political influence.

**CNG Retailers**

Table 4.5.3-1

Public retail CNG stations are dominated by LDCs as a group and a single company, Clean Energy.

| Company | Number of Retail Stations Reported | Estimated Market Share | Geographic Focus or Concentration of Stations | Company Ownership |
|---|---|---|---|---|
| Clean Energy | 118 | 26% | National | Public |
| LDCs Total | 156 | 35% | Local/Regional Service Areas | Public |
| Questar Gas | 29 | 6% | | |
| Pacific Gas & Electric | 24 | 5% | | |
| Oklahoma Natural Gas | 23 | 5% | | |
| National Grid | 15 | 3% | | |
| Southern California Gas | 13 | 3% | | |
| DTE | 12 | 3% | | |
| Other LDCs | 40 | 9% | | |
| AVSG | 10 | 2% | Massachusetts | Private |
| Trillium | 2 | 0.4% | Regional | Private |
| Pinnacle CNG | 2 | 0.4% | National (Concentration in CA and TX) | Private |
| Other Retailers | 162 | 36% | | |
| Total Public Retail CNG Stations | 450 | | | |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu



**U.S. and Canadian Natural Gas Vehicle Market Analysis: Liquefied Natural Gas Infrastructure, 2012**
https://www.aga.org/sites/default/files/legacy-assets/our-issues/natural-gas-vehicles/Documents/TIAX%20LNG%20Full%20Report.pdf

*The majority of current fueling infrastructure to support LNG vehicles is concentrated in California. This station network largely supports LNG vehicle operation within limited ranges and will enable wider operating areas as it expands.*

Currently, there are 48 LNG stations operating in the U.S., 24 of which dispense CNG as liquefied-to-compressed natural gas (LCNG) stations (discussed in Section 3). Of the total LNG stations, 41% are private access and 28% are public access. **All active stations are located in nine states (Alabama, Arizona, California, Connecticut, Louisiana, Nevada, Ohio, Texas and Utah), with 35 of the 48 stations located in California (Table 2.2-1**). 100 additional stations are planned to come online in the near future.

The LNG infrastructure that has developed to date is largely clustered in specific hubs (e.g., Los Angeles and Phoenix). As such, LNG vehicles currently in operation are in effect limited in range by the distribution of stations. Unlike diesel vehicles, LNG vehicles are not yet able to traverse the entire country using a system of public truck stops. However, as the infrastructure develops, broader opportunities for LNG vehicle markets will emerge. Regional deployments of LNG vehicles have been accompanied by development of infrastructure, such as at the Ports of Los Angeles and Long Beach, and the expansion of this infrastructure enable regions to be connected. Already, the establishment of corridors to connect various hubs is in progress, including the joint UPS-Clean Energy effort to connect Southern California to Las Vegas.

**Stations**

Table 2.2-1

This map depicts the stations noted in Table 2.2-1


| | |
|---|---|
| **Alabama**<br>North American Bus Industries | **Connecticut**<br>Enviro Express Natural Gas |
| **Texas**<br>Clean Energy - Baytown TX LNG - Pilot/TRIMAC<br>Clean Energy - DART Northwest Division<br>Clean Energy - DART South Oak Cliff Division<br>Clean Energy - HEB Grocery<br>Sun Metro | **Arizona**<br>East Valley Bus Maintenance and Operation Facility<br>Tempe Transit<br>Grand Canyon National Park<br>Phoenix Public Transit Department - North Facility<br>Phoenix Public Transit Department - South Facility<br>Phoenix Public Transit Department - West Facility<br>Valley Metro RPTA- Mesa |
| **Nevada**<br>Clean Energy - United Parcel Service | **Utah**<br>Flying J Travel Plaza - CH4 Energy |
| **Louisiana**<br>DeSoto LNG Station - Encana | **Ohio**<br>Clean Energy - Pilot Travel Center |

**California**

City of Barstow
City of Redlands
Burrtec Waste
Clean Energy - Carson
City of Long Beach
Clean Energy - City of Tulare
City of Los Angeles - East Valley Station
City of Los Angeles - North Central Station
City of Los Angeles - South LA Station
Clean Energy - Downs Truckstop
City of Los Angeles - West Valley Station
City of Sacramento
City of San Bernardino
Clean Energy - Port of Long Beach
Clean Energy - Apple Valley Walmart
Clean Energy - Riverside County Waste Management
Clean Energy - City of Commerce
Clean Energy - Consolidated Disposal
Clean Energy - Los Angeles World Airports (LAX)
Clean Energy - Norcal Waste Systems
Clean Energy - Republic Waste Services of Southern California
Clean Energy - Solano Garbage
Clean Energy - Waste Management
County of Sacramento
LA County Sanitation District
Southwest Education Support Service Center
Speedy Fuel
Norcal Waste - Recology San Francisco
United Parcel Service
Waste Management
Waste Management
Santa Monica - Big Blue Bus
Waste Management - USA Waste of California
Waste Management - USA Waste of California
Waste Management - USA Waste of California

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

*LNG infrastructure requires unique modifications that have been well-established by a variety of national codes and standards and implemented by developers.*

## Facility Modification Requirements

The temperature and insulation requirements of LNG necessitate modifications to conventional fuel infrastructure. In the U.S., LNG fueling stations are designed and constructed to meet specific national codes and standards:

- **Code of Federal Regulations**
  - CFR Title 49, Part 193 LNG Facilities Federal Safety Standards

- **Codes and Standards**
  - API 620 Recommended Rules for Welded Low-Pressure Storage ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 CGA 341 Insulated Cargo tank Specifications for Cryogenic Liquids

- **National Fire Protection Agency**
  - NFPA 59A Production, Storage, and Handling of LNG
  - NFPA 30 Flammable and Combustible Liquids Code
  - NFPA 385 Tank Vehicles for Flammable and Combustible Liquids
  - NFPA 88A Parking Structures
  - NFPA 88B Repair Garages

The temperature and insulation requirements of LNG necessitate modifications to conventional fuel infrastructure. In the U.S., LNG fueling stations are designed and constructed to meet specific national codes and standards:
In Canada, the single primary regulatory agency responsible for LNG design and safety is the Canadian Standards Association, which provides codes and standards for all natural gas fueling stations and related equipment.

To ensure safety, secondary containment structures must be built around the areas where the tanks, pumps, and vaporizers are located (Figure 3.4-1). The purpose of these structures is to contain the entire volume of liquid stored at the stations that may leak in case of an incident. However, unlike conventional liquid fuels, if a tank is punctured, LNG will evaporate away instead of pooling on the ground. In working with this cryogenic fuel, handlers must wear a face shield, insulated gloves, apron, and boots. Because of the need to maintain low temperatures, LNG storage and dispensing systems must be insulated.

**Other unique requirements for LNG fueling stations include:**
- Methane detection system
- Fire detection system
- Temperature detection system • Emergency shut-down device
- Fire suppression system
- Eye wash/splash station

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Table 5.1-1** shows some of the major current players in the LNG production and fueling station business. The dearth of companies, particularly in station design/ engineering/construction and operation, suggests that the LNG market may benefit greatly from a larger number of participants.

## LNG Business Opportunities

**Table 5.1-1**

This list of the major companies currently involved in the engineering, construction, and contract management of liquefaction facilities and the design and management of LNG fueling stations suggests that the LNG market may benefit from a greater number of participants.[44]

| Companies | LNG Liquefaction Engineering/ Construction | Fueling Station Design/ Engineering/Construction | Fueling Station Owner/Operator |
|---|---|---|---|
| ABB Group | X | | |
| Air Products | X | | |
| Aker Kvaerner | X | | |
| AMEC | X | | |
| Bechtel | X | | |
| CB&I John Brown | X | | |
| Chart | X | X | |
| Clean Energy | | X | X |
| Cryostar | X | X | |
| Fluor | X | | |
| Foster Wheeler | | | |
| General Physics | | X | |
| Linde | X | X | |
| M W Kellogg | X | | |
| Northstar | | X | |
| Prometheus | X | | |
| Worley Parsons | X | | |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Pennsylvania Laws and Incentives for Natural Gas**
http://www.afdc.energy.gov/fuels/laws/NG/PA

The list below contains summaries of all Pennsylvania laws and incentives related to Natural Gas.

## Laws and Regulations

**Alternative Fuels Tax**
Alternative fuels used to propel vehicles of any kind on public highways are taxed at a rate determined on a gasoline gallon equivalent basis. For more information, including applicable tax rates, see the Pennsylvania Department of Revenue website. Certain exemptions apply. (Reference Title 75 Pennsylvania Statutes, Chapter 90, Section 9004)

**Natural Gas Vehicle (NGV) Production Support and Procurement**
In 2011, Pennsylvania joined Arkansas, Colorado, Kentucky, Louisiana, Maine, Mississippi, New Mexico, Ohio, Oklahoma, Tennessee, Texas, Utah, Virginia, West Virginia, and Wyoming in signing a memorandum of understanding (MOU) to stimulate the production and demand for original equipment manufacturer (OEM) NGVs. The MOU aims to encourage OEMs to offer functional and affordable light- and medium-duty NGVs, aggregate state vehicle procurement through a joint request for proposals (RFP), boost private investment in natural gas fueling infrastructure, and encourage greater coordination between state and local agencies. In 2012, the National Association of State Procurement Officials coordinated the solicitation of a joint RFP, which the Oklahoma Department of Central Services (DCS) issued on behalf of the MOU signatories and additional states. As a result, state fleets have access to more affordable NGVs through dealerships now included in state vehicle purchasing bids. For more information, including awarded vehicles by state and vehicle purchase information for state fleets, see the DCS Statewide Contract for NGVs solicitation page.

## State Incentives

**Alternative Fuel Development and Deployment Grants**
The Pennsylvania Energy Development Authority (PEDA) provides grants of up to $1,000,000 for alternative energy projects and research related to deployment projects or manufacturing. PEDA funding is available for projects involving biomass, fuel cells, and clean and alternative fuels for transportation, and may be used for equipment purchases, construction, contractor expenses, and engineering design necessary for construction or installation. Pure research is not eligible for funding. The PEDA grant program is currently closed and no longer accepting applications, but interested applicants may sign up for notifications about the program status via the PEDA website (verified October 2014). For more information, refer to the PEDA website.

**Natural Gas Vehicle (NGV) Grants**
The Pennsylvania Department of Environmental Protection administers the Natural Gas Vehicle Grant Program, which provides funding to eligible municipal and commercial fleets for the purchase or conversion of dedicated or bi-fuel NGVs. Eligible vehicles must have gross vehicle weight ratings of at least 14,000 pounds. Competitive grants are capped at 50% of the incremental or conversion cost, up to $25,000 per vehicle. Grants may not be used for project development, fueling stations, or other fueling infrastructure. Eligible applicants include Commonwealth or municipal authorities, the Pennsylvania Turnpike Commission, non-profit entities, for-profit companies, local transportation organizations, and state-owned or state-related universities. Funding for grants has been allocated to the through fiscal year 2015 with portions set aside specifically for local transportation agencies through 2014 (verified October 2014). For more information, refer to the Natural Gas Vehicle Program website. (Reference Title 58 Pennsylvania Statutes, Chapter 27, Sections 2701-2704)

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115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**About Ben Franklin Technology Partners**
Ben Franklin Technology Partners/CNP, an initiative of the Pennsylvania Department of Community and Economic Development and funded by the Ben Franklin Technology Development Authority, provides investment capital, operational assistance, and entrepreneurial support to emerging tech-based companies and small, existing manufacturers for the purpose of creating and retaining jobs in Pennsylvania.
www.cnp.benfranklin.org

**Pennsylvania Permitting Guide to Building and Operating Compressed Natural Gas (CNG) Fueling Stations**
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0CDMQFjAD&url=http%3A%2F%2Fwww.elibrary.dep.state.pa.us%2Fdsweb%2FGet%2FDocument-95403%2F0340-FS-DEP4412.pdf&ei=lmHjVOTVLuPHsQSyloGADQ&usg=AFQjCNGJTPWxAja7LGelBvx1sqfPME-F1g&sig2=dj8iTLhfuCz1tV1aEAOysg&bvm=bv.85970519,d.cWc&cad=rja

The construction and operation of a compressed natural gas (CNG) fueling station in Pennsylvania will require some permits, approvals and inspections from state and local agencies. The number and type can vary depending on site-specific plans, conditions and location.

Following is a list of permits, approvals, inspections or other requirements that are applicable to commercial and public entities planning to install CNG fueling equipment. Some items on the list will be required for all installations, some only in certain circumstances. Contact the identified agency for questions on a particular requirement.

This list does not include information on local building permits, local fire inspections or pipeline rights-of-way approvals that might be required by a municipality. Please contact the local municipality and the local natural gas distribution company to determine if they have particular requirements that apply.

This list is not intended to identify installation requirements for individual residents for home fuel systems. Homeowners considering a CNG fueling appliance at home should contact their local code official to determine applicable requirements.

## REQUIREMENTS FOR ALL COMMERCIAL CNG FUELING STATIONS

**1. CNG Vehicle Fuel Facility Application to Install.**
Issued by the **Pennsylvania Department of Labor & Industry (L&I). This permit is required for all non-residential CNG installations in Pennsylvania regardless if the fuel station will be for public or private use. The facility owner completes an application and, upon approval by L&I, obtains permission to install. A post-installation inspection by L&I is required prior to operation. The inspection verifies that the installation complies with the requirements under the Combustible and Flammable Liquids Act** (Act 15 of 1988, www.portal.state.pa.us/portal/server.pt?open=514&objID=552949&mode=2), the **Boiler and Unfired Pressure Vessel Law** (Act 85 of 1998, www.portal.state.pa.us/portal/server.pt?open=514&objID=552935&mode=2), and the **National Fire Prevention Association Code 52 on Vehicular Gaseous Fuel Systems Code** (NFPA 52, www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=52&cookie%5Ftest=1). (Note: Installers should also be aware of NFPA 30A, www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=30A&cookie%5Ftest=1, Code for Motor Fuel Dispensing Facilities and Repair Garages.)

The permit application is currently not available online, but can be obtained by sending an email to Larry Kline at L&I, lakline@pa.gov or calling 717-772-2443. Note: Do not use this permit process for installations in Allegheny County or the City of Philadelphia, each of which has its own permit and approval process. In Allegheny County, contact the Fire Marshal's office at 412-473-2631. In Philadelphia, contact the Philadelphia Fire Department, Fire Code Unit, at 215-686-1356.

**2. CNG Dispenser Registration and Inspection**
Administered by the Pennsylvania Department of Agriculture's (PDA) Bureau of Ride and Measurement Standards under authority of Pa. Code Chapter 7, www.pacode.com/secure/data/070/chapter7/chap7toc.html, Registration and Report of Inspection of Commercial Weighing and Measuring Devices. CNG dispensers used for commercial purposes must be registered and inspected by the Bureau or its designee based on the current published schedule of inspections. More information, including a request form for inspection, can be found at PDA's Weights and Measures website, http://www.agriculture.state.pa.us/portal/server.pt/gateway/PTARGS_0_2_24476_10297_0_43/AgWebsite/OrganizationDetail.aspx?name=Bureau-of-Ride-&-Measurement-Standards&navid=34&parentnavid=0&orgid=23&, or by calling 717-787-9089.

**3. Alternative Fuel Tax License**
Administered by the Pennsylvania Department of Revenue. Title 75 of the Vehicle Code requires that all alternative fuel dealer-users must be licensed in Pennsylvania. Further, CNG used to propel vehicles on public highways is subject to the alternative fuels tax. The tax rate applied to the gasoline gallon equivalent equals the current liquid fuels tax, www.portal.state.pa.us/portal/server.pt/community/liquid_fuels___fuels_tax/14434 and oil company franchise tax, www.portal.state.pa.us/portal/server.pt/community/oil_company_franchise_tax/14437 applicable to one gallon of gasoline. For more information, including application form for Alt Fuel Tax license and reporting forms, go to the Department of Revenue Alt Fuel Tax website, http://www.portal.state.pa.us/portal/server.pt/community/alternative_fuels_tax/14435, or call 717-787-1064.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

## POTENTIAL PROJECT-SPECIFIC REQUIREMENTS
## (will only be required if certain circumstances exist)

**1 .Highway Occupancy Permit (HOP).**
Issued by the Pennsylvania Department of Transportation (PennDOT). An HOP may be needed for the installation or alteration of a driveway that provides access to the CNG fueling station from a highway. For further information, guidelines and forms, go to the PennDOT HOP website, www.dot.state.pa.us/Internet/Bureaus/pdBHSTE.nsf/BHSTEHomepage?openframeset&frame=main&src=infoOccupancyPermits?OpenForm or contact the appropriate district HOP staff.

**2. Underground Storage Tanks (UST) Registration, Inspection and Remediation.**
Administered by the Pennsylvania Department of Environmental Protection (DEP). While a CNG fueling system does not utilize USTs, some CNG fuel station builders may also plan to sell conventional liquid fuels, or they may plan to convert existing or abandoned liquid fuel stations into CNG fuel stations. In these cases, the project developer should be aware of the need to properly manage USTs and address possible contamination from leaking USTs. Visit DEP's UST website, www.portal.state.pa.us/portal/server.pt/community/underground_storage_tanks/20604 or contact the appropriate regional DEP office, www.portal.state.pa.us/portal/server.pt/community /regional_resources/13769.

**3. Construction Stormwater (Chapter 102) and Water Obstruction and Encroachment (Chapter 105) permits.**
Issued by DEP in conjunction with the county conservation district for earth disturbance projects greater than one acre and for encroachment on wetlands and waterways. Projects that simply place a new CNG fueling system within the footprint of an existing fuel station or other facility will likely not require either of these permits. New or expanded driveways, access roads and gas pipelines should be considered when determining the need for these permits. Contact the local county conservation district, www.pacd.org/your-district/find-your-district representative to verify if these permits are applicable to the project.

**4. Air Quality Plan Approval.**
Issued by DEP. CNG fueling stations are currently proposed to be exempted, www.pabulletin.com/secure/data/vol43/43-5/188.html from the need for air quality plan approval. If that exemption is approved, CNG fuel stations that operate within identified parameters and perform annual leak detection would not be required to go through the plan approval process. Until such time that the exemption is approved, contact the Air Quality Program at the local regional DEP office, www.portal.state.pa.us/portal/server.pt/community/regional_resources/13769 to determine if the project will require any approvals or determinations before installation.

For projects in Allegheny County, contact the Allegheny County Health Department, Office of Air Pollution Control, at 412-578-8111; and in Philadelphia, contact the Philadelphia Department of Public Health Air Management Services at 215-823-7584.

For more information, visit www.dep.state.pa.us, keyword: CNG.

**§ 175.242. Inspection of fuel system and controls.**
http://www.pacode.com/secure/data/067/chapter175/s175.242.html

**§ 175.241. Compressed and liquefied gas fuel systems.**
http://www.pacode.com/secure/data/067/chapter175/s175.241.html

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Central and Northern Pennsylvania

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115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu



# Pennsylvania Flammable and Combustible Liquids: Installation and Other Requirements

http://www.portal.state.pa.us/portal/server.pt?open=514&objID=553490&mode=2



## A. Scope of Requirements

Under the Combustible and Flammable Liquids Act, the Department of Labor & Industry is responsible for approving the installation or relocation of tanks, pumps and dispensing devices associated with flammable and combustible liquids.

The covered liquids include ethanol, gasoline, naphtha, kerosene, fuel oil, or any other flammable or combustible liquid that is stored, sold or kept in any location, in an amount exceeding 30 gallons.

A "combustible liquid" is defined as a liquid having a flash point at or above 100ºF and below 200ºF.

A "flammable liquid" is defined as a liquid having a flash point below 100ºF and having a vapor pressure not exceeding 40 pounds per square inch absolute at 100ºF (Class I liquids).

The requirements of the Combustible and Flammable Liquids Act and its regulations do not apply to:

- Refineries.
- The storage, use and the like of flammable or combustible liquids in fuel tanks, containers or reservoirs that are integral components of motor vehicles.
- The farm use or storage of motor fuels or any substance that facilitates the production of crops, livestock and livestock products. (This includes any tank in which these liquids may be stored in on a farm.)

Please note that there are other State requirements pertaining to the installation, maintenance and removal of aboveground and underground storage tanks. The Pennsylvania Department of Environmental Protection (DEP) enforces these requirements.
Click here to access the DEP web page dealing with these requirements.

## B. Installation and Inspection Requirements

Owners (or their agents) must submit an application to the Department of Labor & Industry for approval before installing, replacing or relocating any tank, pump or drawing-off device (dispenser) that must comply with the requirements of the Combustible and Flammable Liquids Act.

All of the following must be filled out and submitted to the Department:

1. One (1) copy of the Department's F & C LIQUIDS INTENT TO INSTALL form (LIBI-703).

   If installing only an **aboveground tank** (and related pumps or drawing-off devices), you must also submit one (1) copy of the Department's ABOVEGROUND TANKS/PUMPS/DISPENSERS form (LIBI-702).

   If installing only an **underground tank** (and related pumps or drawing-off devices), you must also submit one (1) copy of the Department's UNDERGROUND TANKS/PUMPS/DISPENSERS form (LIBI-701).

   If installing an **attended, self-service fueling station**, you must also submit:
   - One (1) copy of the Department's ATTENDED SELF-SERVICE STATION form (LIBI-700).
   - Two (2) site plans, if installing a new service station or tearing down and replacing an existing service station. and
   - One (1) copy of the Department's UNDERGROUND TANKS, PUMPS & DISPENSERS form (LIBI-701).

   **IMPORTANT NOTES:**
   If the installation will involve Ethanol-85% tanks and related equipment, you must submit (in addition to the forms listed above) a copy of the Department's E-85 INSTALLATION form (LIBI-706). If the only work being done is replacement of dispensers, the only forms that need to be submitted are the Department's F & C LIQUIDS INTENT TO INSTALL form (LIBI-703) and either the ABOVEGROUND TANKS/PUMPS/DISPENSERS form (LIBI-702) or the UNDERGROUND TANKS/PUMPS/ DISPENSERS form (LIBI-701).

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

2. A check or money order (payable to "Commonwealth of Pennsylvania") in the amount of $75.00.

   If the installation involves a facility owned by the Commonwealth of Pennsylvania, no fee is charged.

Mail the required information and payment (if required) to the following address:
PA DEPARTMENT OF LABOR & INDUSTRY
F&C SECTION
651 BOAS STREET, ROOM 1606
HARRISBURG, PA 17121

After the submission has been processed by the Central Collections Office, staff will review the submission for completeness and compliance with regulatory requirements. If the submission is incomplete or non-compliant (and the deficiencies cannot be corrected over the telephone), the application package will be returned for additional information.

If the application is complete and in compliance with all regulatory requirements, a copy of all application forms (with their permit numbers) will be mailed to the applicant. If the installation involves Ethanol-85, the applicant will also receive a copy of the Department's E-85 INSTALLATION CERTIFICATION form (LIBI-707), a copy of which must be presented to the Department's inspector and also kept on site.

The installation may then proceed. The work must be completed within one year of the application approval date.

When the work is completed, the applicant is required to call the L&I inspector whose name and phone number appears on the INTENT TO INSTALL form, to arrange for a safety inspection. This call should be made **at least three days** before the desired inspection date.

If the inspection is passed, the applicant will be issued a permit for the storage and handling of flammable and combustible liquids. This permit must be displayed at the site and made available for examination upon request.

Should the installation not match up with the installation described on the approved application or otherwise fail to comply with the regulations, the applicant will be issued a repair letter indicating all of the deficiencies that must be corrected. When all the deficiencies have been corrected, the applicant should indicate this on the letter and mail or fax it to the Department at:
PA DEPARTMENT OF LABOR & INDUSTRY
F&C SECTION
651 BOAS STREET, ROOM 1614
HARRISBURG, PA 17121
FAX: 717-705-7262

If the Department deems a re-inspection to be unnecessary, the applicant will then be issued a permit for the storage and handling of flammable and combustible liquids. This permit must be displayed at the site and made available for examination upon request. If a re-inspection is required, the required permit for the storage and handling of flammable and combustible liquids will not be issued, until the inspector has confirmed that all deficiencies have been corrected.

## C. Variance Requests

If needed in the case of an initial installation or after a correction order has been issued by the Department, the owner (or his agent) may seek a variance from requirements found in the Flammable and Combustible Liquids (37 Pa Code, Chapters 11, 13, or 14).

If seeking a variance, an owner (or his agent) must submit the following to the Department:
1. One (1) copy of the Department's VARIANCE REQUEST: FLAMMABLE & COMBUSTIBLE LIQUIDS (LIIB-121).
2. Two (2) copies of a site plan clearly showing the location of all tanks, pumps, and dispensers and the distances from any buildings and property lines. Additionally, if the variance pertains to the "line of sight" of the attendant, the applicant must include two (2) copies of a "line of sight" plan, showing the location of the attendant and distances to all dispensers.
3. If an application package for an installation has not yet been submitted, include this information with the variance request (see section B above).

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

Mail these items to:
PA DEPARTMENT OF LABOR & INDUSTRY
F&C SECTION
651 BOAS STREET, ROOM 1606
HARRISBURG, PA 17121

Staff will review the variance request and submit it to the Pennsylvania Industrial Board, with a recommended action. The Industrial Board will communicate its decision to the applicant, shortly after the meeting at which the variance is considered.

## D. Complaints

All **written** complaints about any installation subject to the requirements of the Combustible and Flammable Liquids Act will be investigated by the Department. These can be directed to the Department by fax or mail, using the following address or fax number:
PA DEPARTMENT OF LABOR & INDUSTRY
F&C SECTION
651 BOAS STREET, ROOM 1614
HARRISBURG, PA 17121
FAX: 717-705-7262

When a complaint alleging a violation is received (or should we discover violations in the course of performing other Department enforcement work), the alleged violation will be investigated. If hazardous conditions are discovered or non-compliance exists at an approved (or unapproved) installation, an L&I inspector is authorized to issue a written order (under Section 9 of Act 15), placing the tank, pump or dispensers "out-of"-service." This order will state the corrective action needed. Before the owner can place the tank, pump or dispenser back into service, the L&I inspector must rescind the order previously issued. Should an owner fail to comply, the Department will enforce the order by prosecution before a district magistrate.

## E. Questions

If you have questions about the Department of Labor & Industry's requirements that are not answered on these web pages, write, call or fax:
PA DEPARTMENT OF LABOR & INDUSTRY
F&C SECTION
651 BOAS STREET, ROOM 1614
HARRISBURG, PA 17121
PHONE: 717-705-2787
FAX: 717-705-7262

## F. Forms (All F & C Liquids Forms)

ATTENDED SELF-SERVICE STATION (LIBI-700)
UNDERGROUND TANKS/PUMPS/DISPENSERS (LIBI-701)
ABOVEGROUND TANKS/PUMPS/DISPENSERS (LIBI-702)
F & C LIQUIDS INTENT TO INSTALL (LIBI-703)
ETHANOL-85 INSTALLATION (LIBI-706)
ETHANOL-85 INSTALLATION CERTIFICATION (LIBI-707)
VARIANCE REQUEST: FLAMMABLE & COMBUSTIBLE LIQUIDS (LIIB-121)

## G. Combustible and Flammable Liquids Act and Regulations

Click on one of the links below to access a copy of the Combustible and Flammable Liquids Act and the regulations implementing this law.
Combustible and Flammable Liquids Act (Act 15 of 1998)
Flammable and Combustible Liquids Regulations

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Pennsylvania Uniform Construction Code (UCC)**
http://www.dli.state.pa.us/portal/server.pt/community/uniform_construction_code/10524
http://www.portal.state.pa.us/portal/server.pt?open=514&objID=553835&mode=2
http://www.portal.state.pa.us/portal/server.pt/community/uniform_construction_code/10524/certified_code_officials/553799

These pages provide information regarding Pennsylvania's statewide building code, generally known as the Uniform Construction Code (UCC). Enforcement of the UCC began in April 2004.

## Status of 2012 I-Codes Adoption

The UCC Review and Advisory Council (RAC) is charged with the review of new and amended provisions contained in triennial revisions of the ICC codes, except for the accessibility provisions, and must inform the Department of any code provisions that should be excluded from the UCC. On April, 19, 2012, the UCC RAC informed the Department that no ICC 2012 triennial code revisions shall be adopted. Therefore, the 2009 edition of the ICC codes will remain in effect.

Effective December 31, 2012, Chapter 11 and Appendix E of the 2012 International Building Code is adopted as required by Act 1 of 2011.

See "Codes and Standards Enforced Under the UCC" below for information about which version of the triennial codes applies to your construction project.

## Administration and Enforcement of the UCC

**Over 90% of Pennsylvania's 2,562 municipalities have elected to administer and enforce the UCC locally, using their own employees or via certified third party agencies (private code enforcement agencies) that they have retained**. In these municipalities, the Department has no code enforcement authority, except where the municipality lacks the services of a person certified as an "**Accessibility Inspector/Plans Examiner**."

**If a municipality has "opted out," the Department is responsible for all commercial code enforcement in that municipality.** The Department also has sole jurisdiction for all elevators and all state-owned buildings, no matter where they are located.

Certified third party agencies hired by property owners (or their contractors) enforce the residential requirements of the UCC in all opt-out municipalities. Detailed information about these agencies can be accessed by clicking on the link below entitled "Certified Third Party Agencies: Buildings" (found under "Code Official and Third Party Agency Info").

A listing of all of Pennsylvania's municipalities and their decisions regarding local enforcement of the UCC can be accessed below by clicking on the link entitled "Municipal Elections and Contact Information" (under the "Local Enforcement" header).

## Codes and Standards Enforced Under the UCC

As noted above, the codes applicable to work for which a construction permit is sought on or after January 1, 2013, are the 2009 International Codes issued by the International Code Council (ICC) and Chapter 11 and Appendix E of the 2012 International Building Code. Only these codes as first published and their errata are applicable in Pennsylvania. For further information about the codes and standards adopted, click on the UCC Codes button.

Please note the following exceptions to the statement made above about the applicability of the 2009 and 2012 ICC Codes:

- If a design or construction contract for the proposed work was signed between April 9, 2004, and December 30, 2006, the **2003 International Codes** must be complied with.
- If a design or construction contract for proposed work was signed between December 31, 2006, and December 30, 2009, the **2006 International Codes** must be complied with.
- If a design or construction contract for proposed work was signed between December 31, 2009, and December 30, 2012, the **2009 International Codes** must be complied with.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Revised UCC Regulations**
Click on the UCC Regulations & Statutes button to access a copy of the revised UCC Regulations that took effect on Dec. 31, 2012.
http://www.dli.state.pa.us/portal/server.pt/community/uniform_construction_code/10524/ucc_regulations_and_statutes/553804

## Local Enforcement: Municipal Elections and Contact Information

**The link below will open a table that lists all of Pennsylvania's 2,562 municipalities, by county, and their status under the Uniform Construction Code (UCC). Municipal Elections and Contact Information**

**Opt-ins** are those municipalities that have elected to enforce the UCC. **Opt-outs** are those that have relinquished all UCC enforcement authority to either the Department of Labor & Industry (for non-residential buildings and structures) or certified third-party agencies (hired by the property owner for residential code enforcement).

If an opt-in municipality carried over changes to the UCC (these must equal or exceed the requirements found in the UCC and must have been in a locally enacted building code ordinance as of July 1, 1999), the word **Amendments** will appear in the column headed **PRE July 1, 1999 Amendments**. Since the Department of Labor & Industry had no review and approval authority over this matter, we have no record as to what these changes may be. Customers will have to contact the municipal that has amendments, to determine what these changes may be.

To facilitate customer contacts with local code enforcement programs, this table includes the name and phone number for the person serving as the "**Building Code Official**." Local enforcing jurisdictions are required to provide this name and contact information in a timely manner. Some fail to do so, even though the Department may make repeated attempts to secure this information. Thus, from time to time there may be municipalities on this list that lack this contact information.

## Certified Code Officials

As of Apr. 10, 2009, the only persons who may legally engage in any aspect of UCC enforcement are those who hold UCC certification in each category of work that they perform.

Clicking on "**Certification List**" below will direct you to a list of persons that the Department has approved as certified code officials. This list is updated daily.

**CERTIFIED CODE OFFICIALS:** Your certification card expires three years after the date it was issued. Please check the expiration date on the front of your card and submit your renewal application before your card expires. Note: if you fail to renew your certification within one year of the expiration date, you will have to re-test in order to be re-certified. Click here to access a copy of the Department's Certification Renewal Booklet.

Users should note the following regarding these listings.
**Certification List:**
The numbers listed under the "Code" headers represent all the categories of work that an individual is certified to perform.

- Numbers 15 and higher are for commercial categories.
- The **key to these numbers is shown on the right**:
- A person who holds a **commercial inspection certification** may perform the **corresponding residential inspection** without holding a certification for that residential category.

**As of Apr. 10, 2009, persons who hold Department–issued Registration cards** (i.e., were "grandfathered" and temporarily relieved of certification requirements) **may no longer engage in any aspect of UCC enforcement.**

| NUMBER | CERTIFICATION CATEGORY |
|---|---|
| 10 | Residential Building Inspector |
| 11 | Residential Electrical Inspector |
| 12 | Residential Mechanical Inspector |
| 13 | Residential Plumbing Inspector |
| 14 | Residential Energy Inspector |
| | |
| 15 | Building Inspector |
| 18 | Fire Inspector |
| 19 | Electrical Inspector |
| 20 | Mechanical Inspector |
| 21 | Plumbing Inspector |
| 22 | Energy Inspector |
| 23 | Accessibility Inspector/Plans Examiner |
| 24 | Building Plans Examiner |
| 25 | Electrical Plans Examiner |
| 26 | Mechanical Plans Examiner |
| 27 | Plumbing Plans Examiner |
| 28 | Energy Plans Examiner |
| 29 | Building Code Official |
| 30 | Elevator Inspector |
| 31 | Passenger Ropeway Inspector |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**Natural Gas Fuel Safety**
http://www.afdc.energy.gov/vehicles/natural_gas_safety.html

## Natural Gas Fuel Safety

Like any fuel, natural gas is flammable, so the fuel storage and delivery systems for natural gas vehicles (NGVs) are governed by the National Fire Protection Association (NFPA). **NFPA 52, the Vehicular Gaseous Fuel Systems Code, spells out specific safety requirements for NGVs and their fueling facilities. In addition NFPA 30A applies to facilities that perform maintenance and repair of NGVs; NFPA 88A applies to parking garages.**

## Compressed Natural Gas (CNG)

Natural gas is odorless and invisible in its natural state, but when put into the local distribution network of pipelines, chemicals (odorants) are intentionally added to give it a distinctive, pungent smell, similar to rotten eggs. Owners that notice this kind of lingering odor coming from their vehicle should close the vehicle's manual shut-off valve, if it has one. They should then contact a qualified repair facility and request guidance on how to proceed. Note that a slight odor may be detected when the fueling nozzle is being connected or disconnected during the refueling process. This is normal and should quickly dissipate when fueling has been completed.

Natural gas is lighter than air, so leaking natural gas from vehicles parked outside will generally rise and disperse safely; however, natural gas leaks in an enclosed garage could pose a danger. Owners noticing a rotten egg odor coming from their garage should keep clear of the area and contact their fleet manager and fire-safety officials.
Compressed natural gas (CNG) is also stored at very high pressures, presenting different safety issues than gasoline or diesel fuel tanks. When vehicles and fueling stations are operating well and are properly maintained, the high pressure gas is unlikely to present any danger to the driver of the vehicle. Repair facilities need to take precautions to secure CNG cylinders while they are being serviced, and follow standard safety procedures while working.

## Liquefied Natural Gas (LNG)

Liquefied natural gas (LNG) is a cryogenic liquid stored at about -260°F. LNG is too cold to contain odor-causing chemicals, so an LNG leak is hard to detect, which is why LNG vehicles and garages include electronic methane sensors to detect leaks. The cold natural gas vapors are also heavier than air when they initially leak from a vehicle, so they may cling to the ground, causing a potential fire hazard, as well as an asphyxiation hazard in enclosed spaces. For these reasons, gas detectors should be installed near the ground in areas where LNG or LNG vehicles are stored. LNG or LNG vehicle maintenance facilities should be equipped with both floor- and ceiling-level ventilation to exhaust any potential leaks.

LNG is also different than CNG because LNG tanks may occasionally vent off natural gas if stored unused for a long period of time. LNG tanks are typically designed to hold a full tank of LNG for a week or more without venting, but once the tank warms sufficiently that the LNG begins to vaporize, pressure will rise in the tank until the relief valve opens to vent some natural gas. For this reason, LNG vehicles need to be either parked outside or in a facility equipped with proper ventilation to safely remove any vented LNG. They should also be used in applications where the vehicles are used regularly.

Another safety concern related to LNG is due to the very cold temperatures at which it is stored. Cryogenic or freeze burns can be caused by coming in contact with LNG liquid, LNG vapor, or cold surfaces of pipes or tanks containing LNG. While LNG refueling hoses are well-insulated and designed to avoid accidental leaks, anyone working with LNG should be aware of the hazards and, if necessary, wear protective gear. LNG fueling systems and tanks require minimal maintenance, but should be regularly inspected for leaks and to assure proper functioning of the tank's pressure gauge and LNG level indicator.

**For more information, see:**

- NFPA 52, the Vehicular Gaseous Fuel Systems Code
- NFPA 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages
- NFPA 88A, Standard for Parking Structures
- NFPA 59A, Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)

**National Fire Protection Association: NFPA 52—Vehicular Gaseous Fuel Systems Code, 2010 Edition**
http://files.dep.state.pa.us/oilgas/bogm/bogmportalfiles/act13/ngvprogram/nfpa_52_2010_vehicular_gaseous_fuel_systems.pdf

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**About Ben Franklin Technology Partners**
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www.cnp.benfranklin.org

**NGVAmerica: The Compelling Case For NGVs in Public and Private Fleets, 2014**
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&ved=0CDkQFjAE&url=http%3A%2F%2Fwww.centerpointenergy.com%2Fstaticfiles%2FCNP%2FCommon%2FDocuments%2FNGVFleetWebinarQ22014.pdf&ei=WAziVJPqKPbdsATx-YGYCQ&usg=AFQjCNHHqbK5kB9uIcYWh7NJphiBqxKSBw&sig2=qNyxw49Cue1RR4g72RDQpw&bvm=bv.85970519,d.cWc&cad=rja

## Growing Selection of NGVs from OEMs, SVMs

### HD Truck OEMs
- Freightliner Truck
- Volvo
- International
- Kenworth
- Peterbilt
- Mack

### HD Vocational OEMs
- Mack
- Peterbilt
- Crane Carrier
- Autocar Truck
- ALF Condor
- Elgin
- Johnston
- Schwarze
- Tymco
- Capacity

### HD Bus OEMs
- Thomas Built Bus
- Blue Bird Bus
- Optima/NABI
- El Dorado
- New Flyer
- Motor Coach Ind.
- Gillig
- DesignLine

### HD Retrofit/Repowers
- American Power Group
- Clean Air Power
- Fyda Energy Solutions
- NGV Motori
- Omnitek Engineering

Dual fuel retrofits and SING repowers of Cummins, Daimler, Navistar, Detroit Diesel, Mack, Volvo, Caterpillar

### LD OEMs
- American Honda
- General Motors
- Chrysler Ram Trucks

### LD/MD Retrofits*
- Altech-Eco
- Landi Renzo/Baytech
- IMPCO Automotive
- Westport/BAF Technologies
- NGV Motori USA
- NatGasCar
- Auto Gas America
- Greenkraft
- PowerFuel Conversions
- World CNG

Retrofits of GM, Ford, Dodge, VW, Mazda, Mitsubishi, Workhorse, Isuzu, JAC, UtiliMaster, Freightliner Custom Chassis

**Multiple Stakeholders** Are Engaging NGV Fueling Infrastructure Development
- Local Gas Dist Cos.
- NG Retailers
- NG Exploration & Production Cos.
- Leasing Companies
- Customers
- "Traditional" Fuel Retailers

**Truck Stops** Are Embracing Public-Access Fueling Infrastructure
- Pilot/Flying J is working with Clean Energy to develop LNG (and potentially L/CNG) stations at locations all across the country.
- Love's is co-developing CNG locations in the Midwest and South Central regions.
- TravelCenters of America has partnered with Shell to install LNG capability at 100 locations

**C-Stores** Are Embracing Public-Access Fueling Infrastructure
- Kwik Trip has installed LNG and CNG dispensing capability at its central warehouse/HQ in LaCrosse, WI and adding CNG and/or L/CNG at additional 35+ retail locations throughout their 3-state trading area (KT's fleet is serving as its own anchor)
- OnCue Express has built multiple locations in OK and AR…. focus is on light-duty commercial and retail consumer sales.

**Customers** Are Embracing Public-Access Fueling Infrastructure
- Waste Management has been co-developing retail locations under the Clean-N-Green brand. WM fleet serves as anchor load inside the fence (primarily time fill) while promoting to public outside the fence (and extending their "green" messaging)
- Transit agencies, municipalities, F&B companies, other small businesses are collaborating with other fleets to aggregate load to meet critical throughput thresholds

Ben Franklin Technology PArtners
Central and Northern Pennsylvania

pennsylvania
DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

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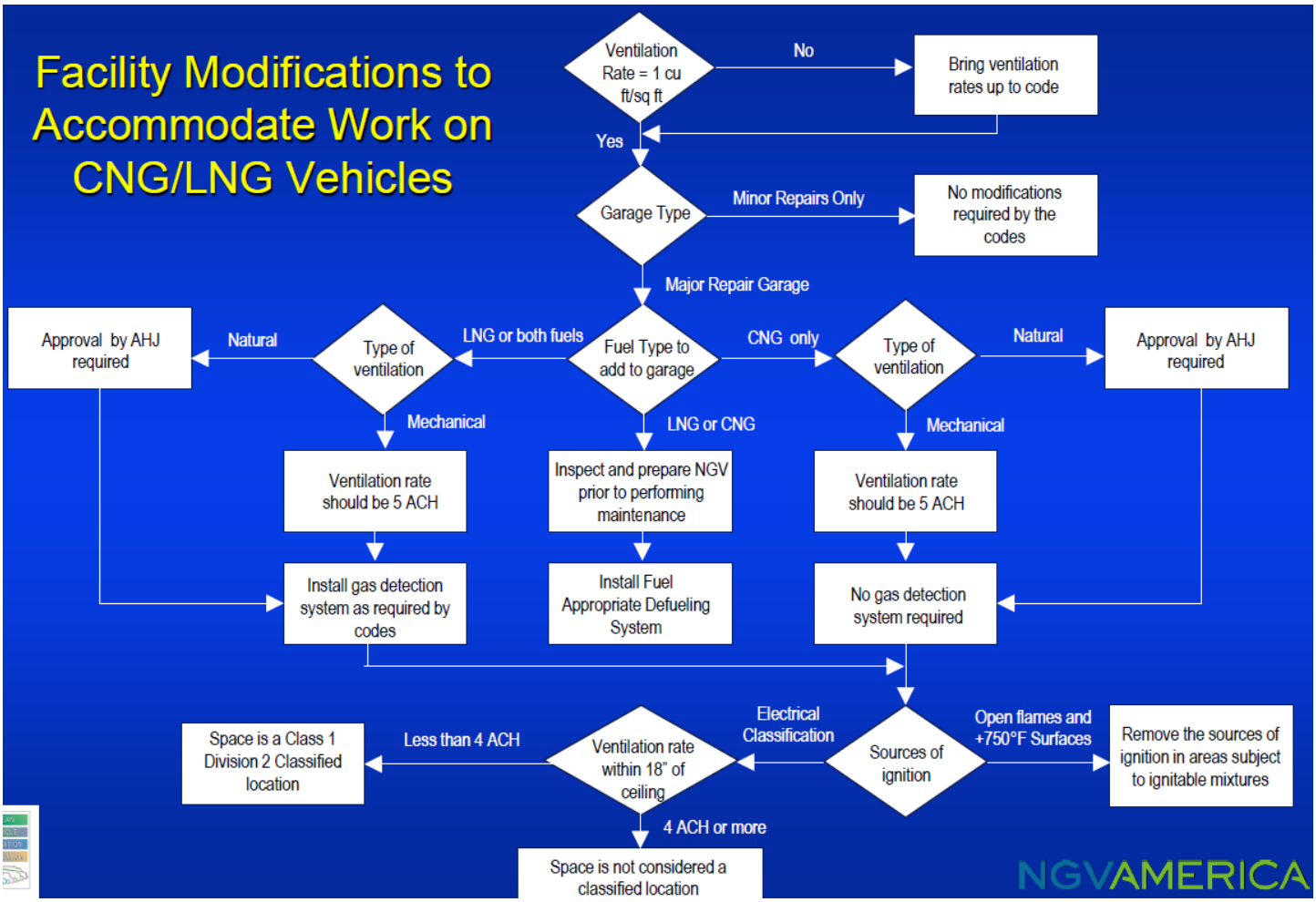
## Snapshot of US NGV Market Today

- Existing NGV inventory: ~142K
  - ~33-35,000 HDVs
    - 11,000 buses
    - 5,300 school bus
    - 7,500+ refuse
    - 5,000 ports/regional haul
    - 4,500-5,000 muni/F&B/Misc
  - ~83,000 LDVs (fleet and consumer vehicles)
    - Cars/SUVs, trucks/vans
  - ~22-24,000 MDVs
    - 9,000 gov't
    - 1,700 package delivery
    - 3,000 airport/university/ community shuttle
    - 9,000 utilities, F&B, comm. services, household goods, construction, misc
- 2012: ~17,450 NGVs added to US roads (net gain of ~10K vehicles)
- 2013: ~19,600 NGVs added (net gain of ~ 12K vehicles)

## Facility Modifications to Accommodate Work on CNG/LNG Vehicles



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115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**NGV Maintenance Bulletin: Advice for Preparing NGVs for Repair in Existing Liquid Fuel Maintenance Facilities, 2013**
www.cleanvehicle.org/technology/CVEFNGVMaintenanceBulletin1013.pdf

**What Is The Purpose of This Bulletin?** Fleets that are purchasing natural gas vehicles for the first time, often in low numbers, have expressed concern about the cost of modifying their maintenance facilities for gaseous fuels. At some point as their fleet of NGVs grows in number, facility modifications based on NFPA and ICC Code requirements will be needed. **In the interim there is an option that allows NGVs to be repaired in existing liquid fuel maintenance facilities.**

**What is the Option?** The NFPA and ICC Code requirements are based on the perceived hazard of a release of natural gas from a NGV inside the maintenance facility. **The hazard can be eliminated and the associated code requirements satisfied by simply removing ("defueling") the natural gas from the vehicle prior to entering the facility.** A best practice would be to use as much of the fuel as possible in normal operations before bringing it in for maintenance so that only a small amount of residual CNG or LNG will need to be removed. This option holds true for both dedicated and dual fuel NGVs. The dual fuel vehicle may continue to be operated on the liquid fuel and driven into the maintenance facility as long as the natural gas system has been properly defueled. More information on the defueling process can be found in NFPA 52-2013 Section 6.14 and on the CVEF website at:
http://www.cleanvehicle.org/committee/technical/PDFs/CVEFDefuelDecomDisposeFinal.pdf

**Guideline for Determining the Modifications Required for Adding CNG & LNG Vehicles To Existing Maintenance Facilities, 2012**
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCAQFjAA&url=http%3A%2F%2Fwww.cleanvehicle.org%2Fcommittee%2Ftechnical%2FPDFs%2FGuidelinesDocumentFinal.pdf&ei=QAjiVPGlKbfCsASmhIGwDg&usg=AFQjCNFSeZldOWGBAhvJyj7hM-5rGmeCQA&sig2=xKVYQgY09uotL0u47oWKIA&bvm=bv.85970519,d.cWc

## Existing Code Requirements by Facility Activity

The codes discussed below *only apply* to major repair facilities. Both NFPA 30A and the IFC exempt minor repair facilities from all of the code requirements specific to CNG and LNG.

- IFC 2211.7 exempts garages that do not work on the vehicle fuel system or do not use open flames or welding from all additional requirements.
- By definition NFPA 30A exempts garages that do not perform engine overhauls, painting, body and fender work and any repairs requiring draining vehicle fuel tanks from all additional requirements. The maintenance work that can be done without any modifications to the facility include lubrication, inspection, engine tune-ups, replacement of parts, fluid changes, brake system repairs, tire rotation and similar routine maintenance work

When a maintenance facility is considering adding CNG and /or LNG vehicles to their operations, an analysis of maintenance tasks by type as a percentage of the overall activities should be done. The analysis can help determine if the **facility could be divided into 'major repair' and 'minor repair' areas. With proper physical separation, the codes require only that those areas of the facility designated as 'major repair' areas to be subject to the additional requirements for CNG and LNG.**

## Existing Code Requirements by Category

The sections below discuss the existing national code requirements for liquid and gaseous fuels (CNG and LNG) repair garages or maintenance facilities. There are seven main areas to consider when reviewing the existing codes: ventilation, pits or basement ventilation, gas detection, heating equipment (sources of ignition), electrical classification, vehicle preparation for entering repair garage and maintenance, and decommissioning of fuel containers. In each area, the requirement for each fuel will be shown side by side for comparison.

**Table 1 – Code References by Category**

| Modification Category | Code References |
|---|---|
| Ventilation | IMC (2012) Table 403.3;<br>NFPA 88A (2007) 5.3.2;<br>IFC (2009) 2211.7.1, 2211.1.1, 2211.7.1.2;<br>NFPA 30A (2012) 7.5.1, 7.5.2,7.5.3, 7.5.4, 7.4.7.2,7.4.7.3 |
| Ventilation in Pits | IFC (2009) 2211.3;<br>NFPA 30A 7.4.5.4 |
| Gas Detection | IFC (2009) 2211.7.2,2211.7.2.1, 2211.7.2.2, 2211.7.2.3;<br>NFPA 30A (2012) 7.4.7,7.4.7.1, 7.4.7.2, 7.4.7.3, 7.4.7.4 |
| Sources of Ignition | NFPA 30A (2012) 7.6.6 |
| Electrical Classification | NFPA 30A (2012) 8.2.1 |
| Preparation of vehicles for Maintenance | IFC (2009) 2211.5 |
| Maintenance and decommissioning of containers | NFPA 52 (2010) 6.13, 6.14 |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

## Analysis of Existing Maintenance Facility

When modifications are anticipated for existing maintenance facilities, a review of the facilities compliance with the existing codes may be necessary. Since the existing maintenance facilities may have been built under older editions of the codes, and codes are generally not retroactive, any new modifications may require bringing the facility up to the codes now enforced for liquid fuels.

**Code Compliance of Maintenance Facility for Class I and Class II Fuels**

The primary concerns for code compliance for existing facilities are:

- Ventilation rate in general garage area should be between 0.75 (IMC) and 1.0 (NFPA) cfm/sqft with inlet at least 18" above the floor.
- Ventilation rate for below grade areas (pits or basement) should be between 1.0 (NFPA) and 1.5 (IFC) cfm/sqft with exhaust air taken within 12" of the floor.
- Review the IFC and NFPA documents for requirements for sources of ignition including heating appliances since their design and placement may have a significant influence on the modifications for the CNG/LNG garage.
- When the AHJ tours the facility in the initial review process, they may determine that some remedial modifications are needed to the existing facility to come into compliance with the code editions now in place.

## Minor vs. Major Repair Garages

The codes discussed in the sections above *only apply* to major repair facilities. Both NFPA 30A and the IFC exempt minor repair facilities from all of the code requirements specific to CNG and LNG. There may be significant savings in the cost of modifications if the maintenance facility can be divided into separate designated areas for minor and major repair activities. This can be accomplished by either having separate buildings or separated areas within one facility. The codes are not specific in how to separate major from minor repair areas but using some of the same requirements for separating indoor fueling rooms from the repair areas may be appropriate. The codes provide some guidance for separating the minor and major repair areas within a facility, such as:

- Interior walls or partitions shall have a 2-hour fire rating and be continuous from floor to ceiling.
- For the major repair area at least one wall shall be an exterior wall and primary access shall be from the outside through the exterior wall.
- Interior access between the major and minor repair areas shall be through self-closing fire doors with the appropriate rating for the location installed as approved by the AHJ.
- The major and minor repair areas shall have separate ventilation systems as required by the codes.

**If the major and minor repair areas cannot be separated, the entire maintenance garage should be modified as required to perform major repairs on CNG and/or LNG as needed.**

**Analysis of Maintenance Activities**

An analysis of existing and anticipated maintenance activities by type and quantity may be helpful to determine if the facility can be configured into separate major and minor repair areas. Table 10 below provides guidance on classifying repairs by type. Consideration should also be given to defining additional areas that may be required for inspection and preparation of vehicles prior to entering the repair facility. Also a designated location for defueling vehicle fuel cylinders for maintenance or decommissioning should be identified.

**Table 10 – Major vs. Minor Garage Activities**

| Code | Major Repair Activities | Minor Repair Activities |
|---|---|---|
| IFC 2211.7 | Work on the vehicle fuel system or use of open flames or welding | All other repairs |
| NFPA 30A 3.3.12 | Work including engine overhauls, painting, body and fender work and any repairs requiring draining vehicle fuel tanks | All work including lubrication, inspection, engine tune-ups, replacement of parts, fluid changes, brake system repairs, tire rotation and similar routine maintenance work. |

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**2009 International Codes: Section 2208 Compressed Natural Gas Motor Fuel-Dispensing Facilities**
http://publicecodes.cyberregs.com/icod/ifc/2009/icod_ifc_2009_22_sec008.htm

**2208.1 General.** Motor fuel-dispensing facilities for compressed natural gas (CNG) fuel shall be in accordance with this section and Chapter 30.

**2208.2 Approvals.** Storage vessels and equipment used for the storage, compression or dispensing of CNG shall be *approved* or *listed* in accordance with Sections 2208.2.1 and 2208.2.2.

- **2208.2.1 Approved equipment.** Containers, compressors, pressure relief devices (including pressure relief valves), and pressure regulators and piping used for CNG shall be *approved*.
- **2208.2.2 Listed equipment.** Hoses, hose connections, dispensers, gas detection systems and electrical equipment used for CNG shall be *listed*. Vehicle-fueling connections shall be *listed* and *labeled*.

**2208.3 Location of dispensing operations and equipment.** Compression, storage and dispensing equipment shall be located above ground, outside.

**Exceptions:**
1. Compression, storage or dispensing equipment shall be allowed in buildings of noncombustible construction, as set forth in the *International Building Code*, which are unenclosed for three-quarters or more of the perimeter.
2. Compression, storage and dispensing equipment shall be allowed indoors or in vaults in accordance with Chapter 30.

- **2208.3.1 Location on property.** In addition to the requirements of Section 2203.1, compression, storage and dispensing equipment not located in vaults complying with Chapter 30 shall be installed as follows:
  1. Not beneath power lines.
  2. Ten feet (3048 mm) or more from the nearest building or *lot line* that could be built on, public street, sidewalk or source of ignition.
  **Exception:** Dispensing equipment need not be separated from canopies that are constructed in accordance with the *International Building Code* and that provide weather protection for the dispensing equipment.
  3. Twenty-five feet (7620 mm) or more from the nearest rail of any railroad track and 50 feet (15 240 mm) or more from the nearest rail of any railroad main track or any railroad or transit line where power for train propulsion is provided by an outside electrical source, such as third rail or overhead catenary.
  4. Fifty feet (15 240 mm) or more from the vertical plane below the nearest overhead wire of a trolley bus line.

**2208.4 Private fueling of motor vehicles.** Self-service CNG-dispensing systems, including key, code and card lock dispensing systems, shall be limited to the filling of permanently mounted fuel containers on CNG-powered vehicles.

In addition to the requirements in Section 2205, the *owner* of a self-service CNG motor fuel-dispensing facility shall ensure the safe operation of the system and the training of users.

**2208.5 Pressure regulators.** Pressure regulators shall be designed and installed or protected so that their operation will not be affected by the elements (freezing rain, sleet, snow or ice), mud or debris. The protection is allowed to be an integral part of the regulator.

**2208.6 Valves.** Gas piping to equipment shall be provided with a remote, readily accessible manual shutoff valve.

**2208.7 Emergency shutdown control.** An emergency shutdown control shall be located within 75 feet (22 860 mm) of, but not less than 25 feet (7620 mm) from, dispensers and shall also be provided in the compressor area. Upon activation, the emergency shutdown system shall automatically shut off the power supply to the compressor and close valves between the main gas supply and the compressor and between the storage containers and dispensers.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**2208.8 Discharge of CNG from motor vehicle fuel storage containers.** The discharge of CNG from motor vehicle fuel cylinders for the purposes of maintenance, cylinder certification, calibration of dispensers or other activities shall be in accordance with Sections 2208.8.1 through 2208.8.1.2.6.

- **2208.8.1 Methods of discharge.** The discharge of CNG from motor vehicle fuel cylinders shall be accomplished through a closed transfer system in accordance with Section 2208.8.1.1 or an *approved* method of atmospheric venting in accordance with Section 2208.8.1.2.
  - **2208.8.1.1 Closed transfer system.** A documented procedure that explains the logical sequence for discharging the cylinder shall be provided to the *fire code official* for review and approval. The procedure shall include what actions the operator will take in the event of a low-pressure or high-pressure natural gas release during the discharging activity. A drawing illustrating the arrangement of piping, regulators and equipment settings shall be provided to the *fire code official* for review and approval. The drawing shall illustrate the piping and regulator arrangement and shall be shown in spatial relation to the location of the compressor, storage vessels and emergency shutdown devices.
  - **2208.8.1.2 Atmospheric venting.** Atmospheric venting of CNG shall comply with Sections 2208.8.1.2.1 through 2208.8.1.2.6.
    - **2208.8.1.2.1 Plans and specifications.** A drawing illustrating the location of the vessel support, piping, the method of grounding and bonding, and other requirements specified herein shall be provided to the *fire code official* for review and approval.
    - **2208.8.1.2.2 Cylinder stability.** A method of rigidly supporting the vessel during the venting of CNG shall be provided. The selected method shall provide not less than two points of support and shall prevent the horizontal and lateral movement of the vessel. The system shall be designed to prevent the movement of the vessel based on the highest gas-release velocity through valve orifices at the vessel's rated pressure and volume. The structure or appurtenance shall be constructed of noncombustible materials.
    - **2208.8.1.2.3 Separation.** The structure or appurtenance used for stabilizing the cylinder shall be separated from the site equipment, features and exposures and shall be located in accordance with Table 2208.8.1.2.3.

**TABLE 2208.8.1.2.3 SEPARATION DISTANCE FOR ATMOSPHERIC VENTING OF CNG**

| EQUIPMENT OR FEATURE | MINIMUM SEPARATION (feet) |
|---|---|
| Buildings | 25 |
| Building openings | 25 |
| CNG compressor and storage vessels | 25 |
| CNG dispensers | 25 |
| Lot lines | 15 |
| Public ways | 15 |
| Vehicles | 25 |

*For SI: 1 foot = 304.8 mm*

    - **2208.8.1.2.4 Grounding and bonding.** The structure or appurtenance used for supporting the cylinder shall be grounded in accordance with NFPA 70. The cylinder valve shall be bonded prior to the commencement of venting operations.
    - **2208.8.1.2.5 Vent tube.** A vent tube that will divert the gas flow to atmosphere shall be installed on the cylinder prior to commencement of the venting and purging operation. The vent tube shall be constructed of pipe or tubing materials *approved* for use with CNG in accordance with Chapter 30.

      The vent tube shall be capable of dispersing the gas a minimum of 10 feet (3048 mm) above grade level. The vent tube shall not be provided with a rain cap or other feature which would limit or obstruct the gas flow.

      At the connection fitting of the vent tube and the CNG cylinder, a *listed* bidirectional *detonation* flame arrester shall be provided.
    - **2208.8.1.2.6 Signage.** *Approved* "No Smoking" signs complying with Section 310 shall be posted within 10 feet (3048 mm) of the cylinder support structure or appurtenance. *Approved* CYLINDER SHALL BE BONDED signs shall be posted on the cylinder support structure or appurtenance.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

## 2009 International Codes: Section 2211 Repair Garages

http://publicecodes.cyberregs.com/icod/ifc/2009/icod_ifc_2009_22_sec011.htm

**2211.1 General.** Repair garages shall comply with this section and the *International Building Code*. Repair garages for vehicles that use more than one type of fuel shall comply with the applicable provisions of this section for each type of fuel used.

Where a repair garage also includes a motor fuel-dispensing facility, the fuel-dispensing operation shall comply with the requirements of this chapter for motor fuel-dispensing facilities.

**2211.2 Storage and use of flammable and combustible liquids.** The storage and use of flammable and *combustible liquids* in repair garages shall comply with Chapter 34 and Sections 2211.2.1 through 2211.2.4.

- **2211.2.1 Cleaning of parts.** Cleaning of parts shall be conducted in *listed* and *approved* parts-cleaning machines in accordance with Chapter 34.
- **2211.2.2 Waste oil, motor oil and other Class IIIB liquids.** Waste oil, motor oil and other Class IIIB liquids shall be stored in *approved* tanks or containers, which are allowed to be stored and dispensed from inside repair garages.
  - **2211.2.2.1 Tank location.** Tanks storing Class IIIB liquids in repair garages are allowed to be located at, below or above grade, provided that adequate drainage or containment is provided.
  - **2211.2.2.2 Liquid classification.** Crankcase drainings shall be classified as Class IIIB liquids unless otherwise determined by testing.
- **2211.2.3 Drainage and disposal of liquids and oil-soaked waste.** Garage floor drains, where provided, shall drain to *approved* oil separators or traps discharging to a sewer in accordance with the *International Plumbing Code*. Contents of oil separators, traps and floor drainage systems shall be collected at sufficiently frequent intervals and removed from the premises to prevent oil from being carried into the sewers.
  - **2211.2.3.1 Disposal of liquids.** Crankcase drainings and liquids shall not be dumped into sewers, streams or on the ground, but shall be stored in *approved* tanks or containers in accordance with Chapter 34 until removed from the premises.
  - **2211.2.3.2 Disposal of oily waste.** Self-closing metal cans shall be used for oily waste.
- **2211.2.4 Spray finishing.** Spray finishing with flammable or *combustible liquids* shall comply with Chapter 15.

**2211.3 Sources of ignition.** Sources of ignition shall not be located within 18 inches (457 mm) of the floor and shall comply with Chapters 3 and 26.

- **2211.3.1 Equipment.** Appliances and equipment installed in a repair garage shall comply with the provisions of the *International Building Code*, the *International Mechanical Code* and NFPA 70.
- **2211.3.2 Smoking.** Smoking shall not be allowed in repair garages except in *approved* locations.

**2211.4 Below-grade areas.** Pits and below-grade work areas in repair garages shall comply with Sections 2211.4.1 through 2211.4.3.

- **2211.4.1 Construction.** Pits and below-grade work areas shall be constructed in accordance with the *International Building Code*.
- **2211.4.2 Means of egress.** Pits and below-grade work areas shall be provided with *means of egress* in accordance with Chapter 10.
- **2211.4.3 Ventilation.** Where Class I liquids or LP-gas are stored or used within a building having a *basement* or pit wherein flammable vapors could accumulate, the *basement* or pit shall be provided with mechanical ventilation in accordance with the *International Mechanical Code*, at a minimum rate of $1^1/_2$ cubic feet per minute per square foot (cfm/ft$^2$) [0.008 m$^3$/(s · m$^2$)] to prevent the accumulation of flammable vapors.

**2211.5 Preparation of vehicles for repair.** For vehicles powered by gaseous fuels, the fuel shutoff valves shall be closed prior to repairing any portion of the vehicle fuel system.

Vehicles powered by gaseous fuels in which the fuel system has been damaged shall be inspected and evaluated for fuel system integrity prior to being brought into the repair garage. The inspection shall include testing of the entire fuel delivery system for leakage.

**2211.6 Fire extinguishers.** Fire extinguishers shall be provided in accordance with Section 906.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**2211.7 Repair garages for vehicles fueled by lighter-than-air fuels.** Repair garages for the conversion and repair of vehicles which use CNG, liquefied natural gas (LNG), hydrogen or other lighter-than-air motor fuels shall be in accordance with Sections 2211.7 through 2211.7.2.3 in addition to the other requirements of Section 2211.

**Exception:** Repair garages where work is not performed on the fuel system and is limited to exchange of parts and maintenance requiring no open flame or welding.

- **2211.7.1 Ventilation.** Repair garages used for the repair of natural gas- or hydrogen-fueled vehicles shall be provided with an *approved* mechanical ventilation system. The mechanical ventilation system shall be in accordance with the *International Mechanical Code* and Sections 2211.7.1.1 and 2211.7.1.2.
  **Exception:** Repair garages with natural ventilation when *approved*.
  - **2211.7.1.1 Design.** Indoor locations shall be ventilated utilizing air supply inlets and exhaust outlets arranged to provide uniform air movement to the extent practical. Inlets shall be uniformly arranged on exterior walls near floor level. Outlets shall be located at the high point of the room in exterior walls or the roof.

    Ventilation shall be by a continuous mechanical ventilation system or by a mechanical ventilation system activated by a continuously monitoring natural gas detection system or, for hydrogen, a continuously monitoring flammable gas detection system, each activating at a gas concentration of not more than 25 percent of the lower flammable limit (LFL). In all cases, the system shall shut down the fueling system in the event of failure of the ventilation system.

    The ventilation rate shall be at least 1 cubic foot per minute per 12 cubic feet [$0.00139\ m^3 \times (s \cdot m^3)$] of room volume.
  - **2211.7.1.2 Operation.** The mechanical ventilation system shall operate continuously.

  **Exceptions:**
  1. Mechanical ventilation systems that are interlocked with a gas detection system designed in accordance with Sections 2211.7.2 through 2211.7.2.3.
  2. Mechanical ventilation systems in repair garages that are used only for repair of vehicles fueled by liquid fuels or odorized gases, such as CNG, where the ventilation system is electrically interlocked with the lighting circuit.
- **2211.7.2 Gas detection system.** Repair garages used for repair of vehicles fueled by nonodorized gases, such as hydrogen and nonodorized LNG, shall be provided with a flammable gas detection system.
  - **2211.7.2.1 System design.** The flammable gas detection system shall be *listed* or *approved* and shall be calibrated to the types of fuels or gases used by vehicles to be repaired. Gas detectors or sensors shall be *listed* in accordance with UL 2075 and shall indicate the gases they are intended to detect. The gas detection system shall be designed to activate when the level of flammable gas exceeds 25 percent of the lower flammable limit (LFL). Gas detection shall also be provided in lubrication or chassis service pits of repair garages used for repairing nonodorized LNG-fueled vehicles.
  - **2211.7.2.2 Operation.** Activation of the gas detection system shall result in all the following:
    1. Initiation of distinct audible and visual alarm signals in the repair garage.
    2. Deactivation of all heating systems located in the repair garage.
    3. Activation of the mechanical ventilation system, when the system is interlocked with gas detection.
  - **2211.7.2.3 Failure of the gas detection system.** Failure of the gas detection system shall result in the deactivation of the heating system, activation of the mechanical ventilation system and where the system is interlocked with gas detection and causes a trouble signal to sound in an *approved* location.

115 Technology Center
University Park PA 16802-7000
Tel: (814) 863-1488
Fax: (814) 865-0960
Name: Nate Porter
Email: nwp105@psu.edu

**2211.8 Defueling of hydrogen from motor vehicle fuel storage containers.** The discharge or defueling of hydrogen from motor vehicle fuel storage tanks for the purpose of maintenance, cylinder certification, calibration of dispensers or other activities shall be in accordance with Sections 2211.8.1 through 2211.8.1.2.4.

- **2211.8.1 Methods of discharge.** The discharge of hydrogen from motor vehicle fuel storage tanks shall be accomplished through a closed transfer system in accordance with Section 2211.8.1.1 or an *approved* method of atmospheric venting in accordance with Section 2211.8.1.2.
  - **2211.8.1.1 Closed transfer system.** A documented procedure that explains the logic sequence for discharging the storage tank shall be provided to the code official for review and approval. The procedure shall include what actions the operator is required to take in the event of a low-pressure or high-pressure hydrogen release during discharging activity. Schematic design documents shall be provided illustrating the arrangement of piping, regulators and equipment settings. The *construction documents* shall illustrate the piping and regulator arrangement and shall be shown in spatial relation to the location of the compressor, storage vessels and emergency shutdown devices.
  - **2211.8.1.2 Atmospheric venting of hydrogen from motor vehicle fuel storage containers.** When atmospheric venting is used for the discharge of hydrogen from motor vehicle fuel storage tanks , such venting shall be in accordance with Sections 2211.8.1.2.1 through 2211.8.1.2.4.
    - **2211.8.1.2.1 Defueling equipment required at vehicle maintenance and repair facilities.** All facilities for repairing hydrogen systems on hydrogen-fueled vehicles shall have equipment to defuel vehicle storage tanks. Equipment used for defueling shall be *listed* and *labeled* for the intended use.
    - **2211.8.1.2.1.1 Manufacturer's equipment required.** Equipment supplied by the vehicle manufacturer shall be used to connect the vehicle storage tanks to be defueled to the vent pipe system.
    - **2211.8.1.2.1.2 Vent pipe maximum diameter.** Defueling vent pipes shall have a maximum inside diameter of 1 inch (25 mm) and be installed in accordance with Section 2209.5.4.
    - **2211.8.1.2.1.3 Maximum flow rate.** The maximum rate of hydrogen flow through the vent pipe system shall not exceed 1,000 cfm at NTP (0.47 $m^3/s$) and shall be controlled by means of the manufacturer's equipment, at low pressure and without adjustment.
    - **2211.8.1.2.1.4 Isolated use.** The vent pipe used for defueling shall not be connected to another venting system used for any other purpose.
  - **2211.8.1.2.2 Construction documents.** *Construction documents* shall be provided illustrating the defueling system to be utilized. Plan details shall be of sufficient detail and clarity to allow for evaluation of the piping and control systems to be utilized and include the method of support for cylinders, containers or tanks to be used as part of a closed transfer system, the method of grounding and bonding, and other requirements specified herein.
  - **2211.8.1.2.3 Stability of cylinders, containers and tanks.** A method of rigidly supporting cylinders, containers or tanks used during the closed transfer system discharge or defueling of hydrogen shall be provided. The method shall provide not less than two points of support and shall be designed to resist lateral movement of the receiving cylinder, container or tank. The system shall be designed to resist movement of the receiver based on the highest gas-release velocity through valve orifices at the receiver's rated service pressure and volume. Supporting structure or appurtenance used to support receivers shall be constructed of noncombustible materials in accordance with the *International Building Code.*
  - **2211.8.1.2.4 Grounding and bonding.** Cylinders, containers or tanks and piping systems used for defueling shall be bonded and grounded. Structures or appurtenances used for supporting the cylinders, containers or tanks shall be grounded in accordance with NFPA 70. The valve of the vehicle storage tank shall be bonded with the defueling system prior to the commencement of discharge or defueling operations.
- **2211.8.2 Repair of hydrogen piping.** Piping systems containing hydrogen shall not be opened to the atmosphere for repair without first purging the piping with an inert gas to achieve 1 percent hydrogen or less by volume. Defueling operations and exiting purge flow shall be vented in accordance with Section 2211.8.1.2.
- **2211.8.3 Purging.** Each individual manufactured component of a hydrogen generating, compression, storage or dispensing system shall have a label affixed as well as a description in the installation and owner's manuals describing the procedure for purging air from the system during startup, regular maintenance and for purging hydrogen from the system prior to disassembly (to admit air).

  For the interconnecting piping between the individual manufactured components, the pressure rating must be at least 20 times the absolute pressure present in the piping when any hydrogen meets any air.
- **2211.8.3.1 System purge required.** After installation, repair or maintenance, the hydrogen piping system shall be purged of air in accordance with the manufacturer's procedure for purging air from the system.

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Central and Northern Pennsylvania

# Appendix L

## The Compelling Case for NGVs in Public and Private Fleets
by Stephe Yborra

# The Compelling Case For NGVs in Public and Private Fleets

## (and the potential for consumer market adoption)


Stephe Yborra
Director of Market Analysis, Education & Communications
Clean Vehicle Education Foundation

Director of Market Development
NGVAmerica


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# What is the Compelling Case?

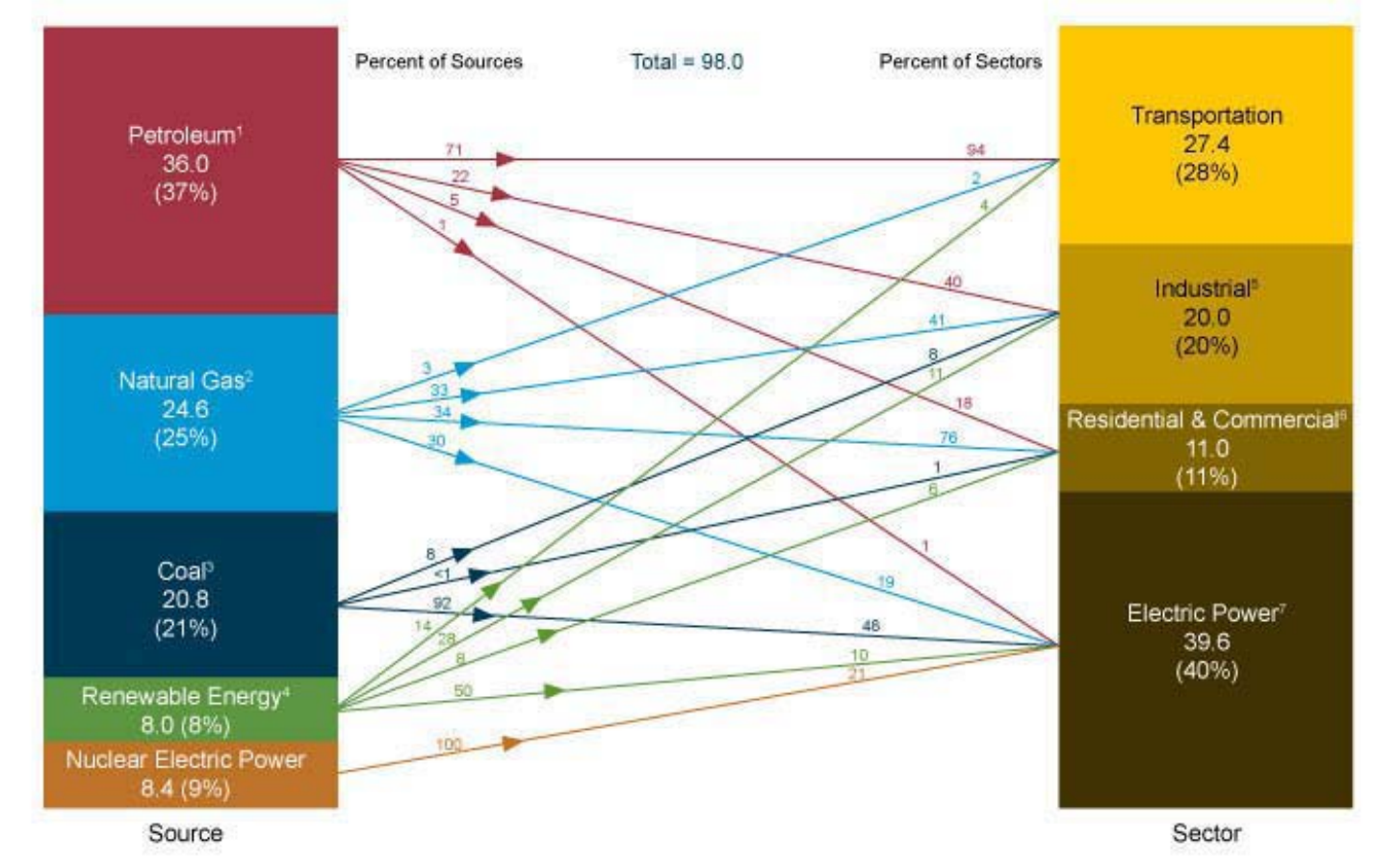
- Environmental, energy security and – now, more than ever due to domestic natural gas abundance - ***economic*** market drivers are behind the trend toward greater use of NGVs. While fleet fuel use has been the primary focus, potential consumer market is now spurring additional investment in infrastructure.

- A growing selection of light-, medium- and heavy-duty NGVs are available from OEMs and SVMs, delivering performance and reliability that are on par with gasoline and diesel counterparts.

- A variety of fueling options are available – LDCs, E&Ps, leasing companies, other customers and independent fuel retailers – both NGV-focused and, now, more traditional fuel retailers - are engaging to develop fueling infrastructure.

- Natural gas is America's fuel: America's resource, America's jobs. Reduced reliance on volatile foreign oil supplies = Energy Security

# Snapshot of Energy Supply and End Use




- Transportation (on-road, off-road, rail, marine and aviation) = ~28% of all energy use
- ~71% of all oil is for transportation
- On-road vehicles account for ~60% of all petroleum use

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# LNG / CNG

**Liquefied Natural gas (LNG)**

- Cryogenically cooled natural gas @ ~(260)F,
  stored in liquid form onboard vehicle and vaporized before it enters engine cylinder
- Preferred by many heavy-duty fleets due to its energy density, space requirements
- Option for locations without pipeline gas.


**Compressed Natural gas (CNG)**

- Typically delivered via the local gas utility's distribution system at low pressure, then compressed and stored on site for fast filling of vehicles …or compressed and distributed directly to vehicles' onboard storage cylinders (time-fill applications)

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# Snapshot of US NGV Market Today

- Existing NGV inventory: ~140K (revised up from 2013)
  - 2012: ~17,550 "new" NGVs hit the road; 10.7K LDVs, 1.3K MDVs, 5.5K HDVs
  - 2013: ~19,250 (data compilation is still incomplete)
  - Pace of attrition of older LDVs is gradually declining; total LDV count again increasing; beginning to see attrition of HDVs placed in service 12-15 yrs ago
  - Steady growth in MDV/HDV inventory due to expanded truck OEM options
    - ~33-35,000 HDVs
      - 11,000 buses
      - 5,300 school bus
      - 7,500+ refuse
      - 5,000 ports/regional haul
      - 4,500-5,000 municipal/F&B/Misc
    - ~83,000 LDVs (fleet and consumer use vehicles)
      - Cars/SUVs, trucks/vans
    - ~22-24,000 MDVs
      - 9,000 gov't
      - 1,700 package delivery
      - 3,000 airport/university/ community shuttle
      - 9,000 utilities, F&B, commercial services, household goods, construction, misc

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# Independent Forecasts

- Frost & Sullivan:
  - By 2017: 8% of ~370,000 Class 6-8 truck market (30,000 trucks)
    - Doesn't account for Class 3-5 market (step vans, small box trucks, c/c utility work trucks, shuttles)
- National Petroleum Council (NPC) study:
  - Under "aggressive" (high oil price case), NPC's scenario shows, by 2050, NGV capturing:
    - 50 percent of LD market
    - Upwards of 35 percent of the class 3-6 truck market
    - Almost 50 percent of the class 7-8 truck market by 2050

# Snapshot of US NGV Market Today

- Vehicular natural gas consumption :~10-12% AGR past 6 years
  - 2005: ~200MM GGE
  - 2011: ~325MM GGE
  - 2012: ~350MM GGE
  - 2013: ~400MM GGE
  - Medium- and Heavy-duty vehicle fuel use is growing dramatically
  - Growth rate will accelerate with new niche market successes, new platform availability for MD/HD truck sector…and consumer market?
  - Factors affecting timeframe include pace of worldwide economic recovery, petroleum-natural gas differential, vehicle choices…

    ….vehicle and station tax credits, grants that accelerate adoption

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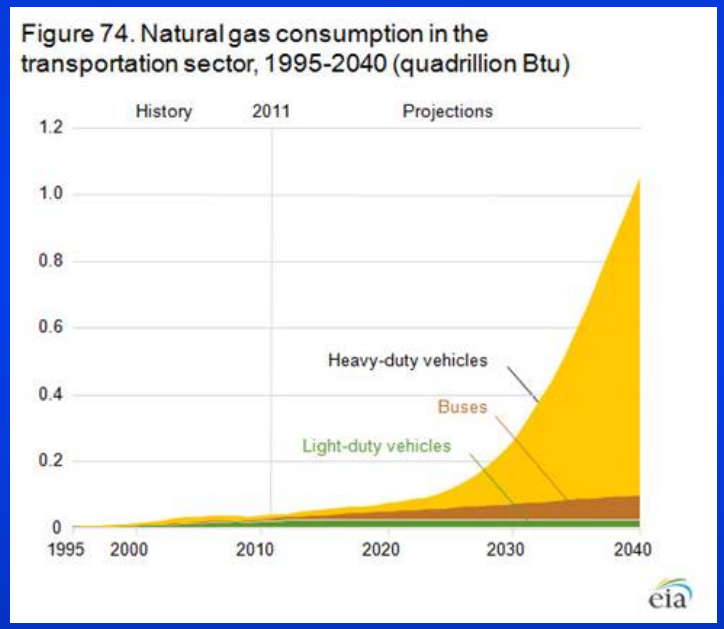
# Energy Use in On-Road Transportation

- Total on-road transportation energy usage: 21.97 Tcf (2010):
  - Light-duty: 16.7
  - Heavy-duty freight: 4.41
  - Commercial light trucks: 25% 0.59
  - Buses: 0.27

- US DOE EIA forecast →




- Independent Forecasts (PIRA Consulting):
  - By 2030:
    5.1 Tcf gas used in vehicles per year
  - Equal to 24% of today's on-road energy use

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# Snapshot of US NGV Market Today


- Station count is ~1325. Just now achieving same number as late1990s. Count has grown steadily in past 30 months and installed capacity is up significantly
  - Attrition of older stations built in 1990s is finished;
  - New investment/upgrades to older stations
  - New stations are based on better economics, either higher throughput with anchor accounts or aggregated loads and better sizing of equipment to loads
- While less than half of all stations are “public access” and most do not meet public expectations, emphasis today is on upgrading that experience
- CNG able to handle local and some regional trucking
- Increased LNG infrastructure for OTR trucking
- Potential for 250-300 new stations in 2014!

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## Multiple Stakeholders Are Engaging NGV Fueling Infrastructure

- Local Gas Dist Cos.
- NG Retailers
- NG Exploration &Production Cos.
- Leasing Companies
- Customers
- “Traditional” Fuel Retailers


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# Truck Stops Are Embracing Public-Access Fueling Infrastructure

- Pilot/Flying J is working with Clean Energy to develop LNG (and potentially L/CNG) stations at locations all across the country.

- Love's is co-developing CNG locations in the Midwest. Love's continues to develop backyard and front-of-store retail options.

- TravelCenters of America has partnered with Shell to install LNG capability at 100 locations



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# C-Stores Are Embracing Public-Access Fueling Infrastructure

- Kwik Trip has installed LNG and CNG dispensing capability at its central warehouse/HQ in LaCrosse, WI and adding CNG and/or L/CNG at additional 35+ retail locations throughout their 3-state trading area (KT's fleet is serving as its own anchor)

- OnCue Express has built multiple locations in OK and AR…. focus is on light-duty commercial and retail consumer sales.

- Additional C-store chains are in process of evaluating similar options


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# Customers Are Embracing Public-Access Fueling Infrastructure

- Waste Management has been co-developing retail locations with PetroCard under the Clean-N-Green brand. WM fleet serves as anchor load inside the fence (primarily time fill) while promoting to public outside the fence (and extending their “green” messaging)

- Transit agencies, municipalities, F&B companies, small businesses are collaborating with other fleets to aggregate load to meet critical throughput thresholds.



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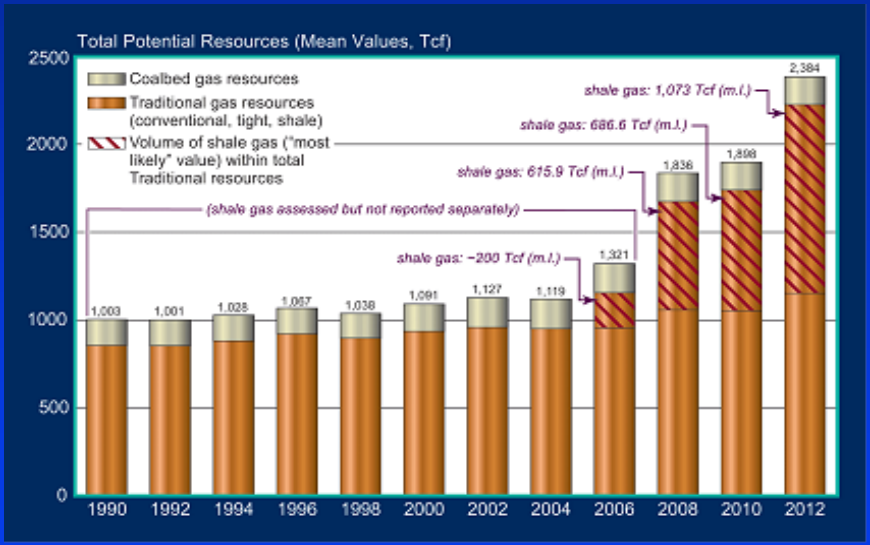
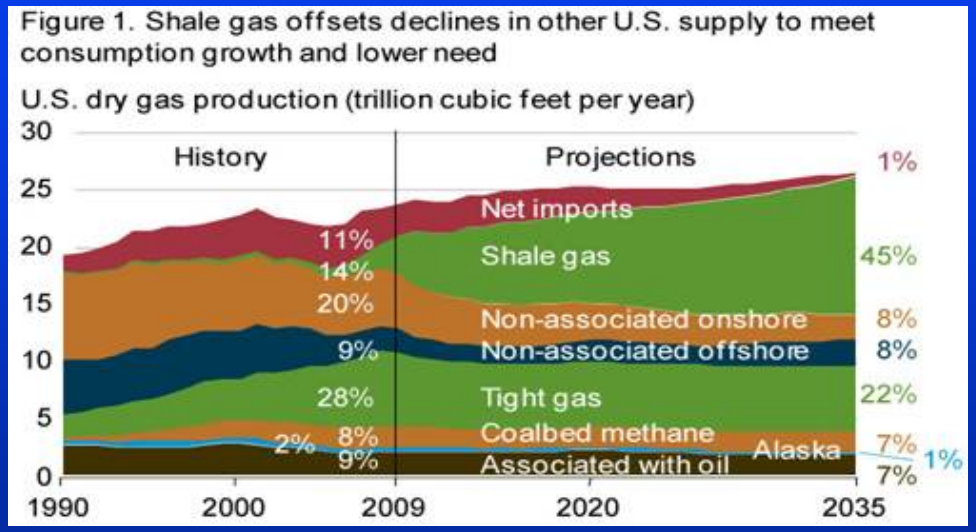
# Natural Gas is an Abundant Domestic Fuel




PGC Resource Assessments, 1990-2012

- 98+% of US gas consumption comes from North America (~90% from US)
- Well-developed distribution infrastructure;
- Technology improvements are expanding our economically recoverable base so much so that the estimated supply is now @ 115+ yrs!
- **Natural gas E&P activity is generating tens of thousands of quality jobs which gives direct and indirect economic boost to communities across America**


Shale Basins and the U.S. Pipeline Grid
Source: American Clean Skies Foundation.

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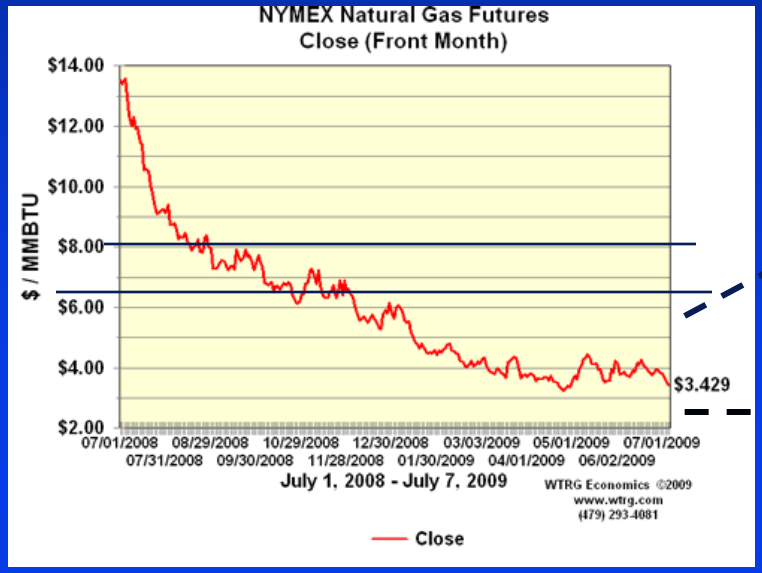
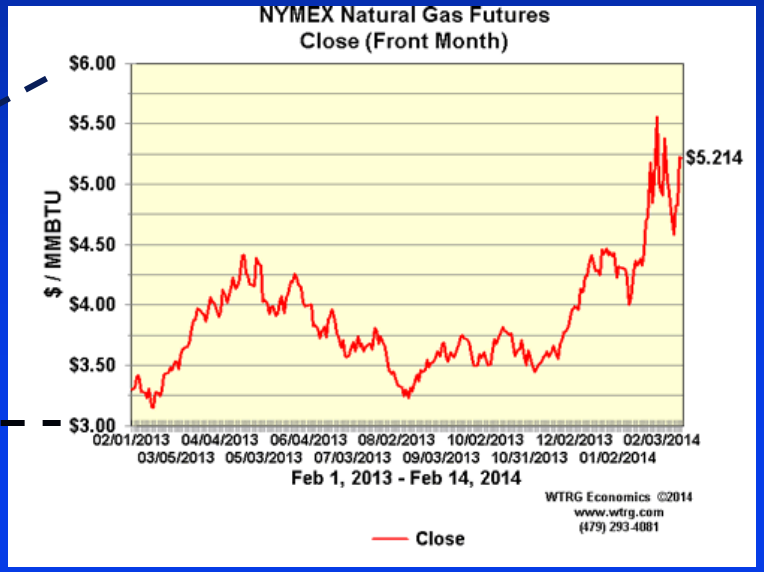
# Translating Abundance into Savings




**One MMBtu is ~8.0 GGE of (uncompressed) natural gas**
**One MMBtu is ~7.2 DGE of (uncompressed) natural gas**.

If average MMBtu is ~$4.75; commodity % is $.59/GGE ($.66/DGE) . Add LDC delivery, compression, maintenance, equipment amortization: ~$1.45-1.65/GGE ($1.63 -1.85/DGE) + fed and state taxes. LNG pricing derived differently but base stock gas cost is same

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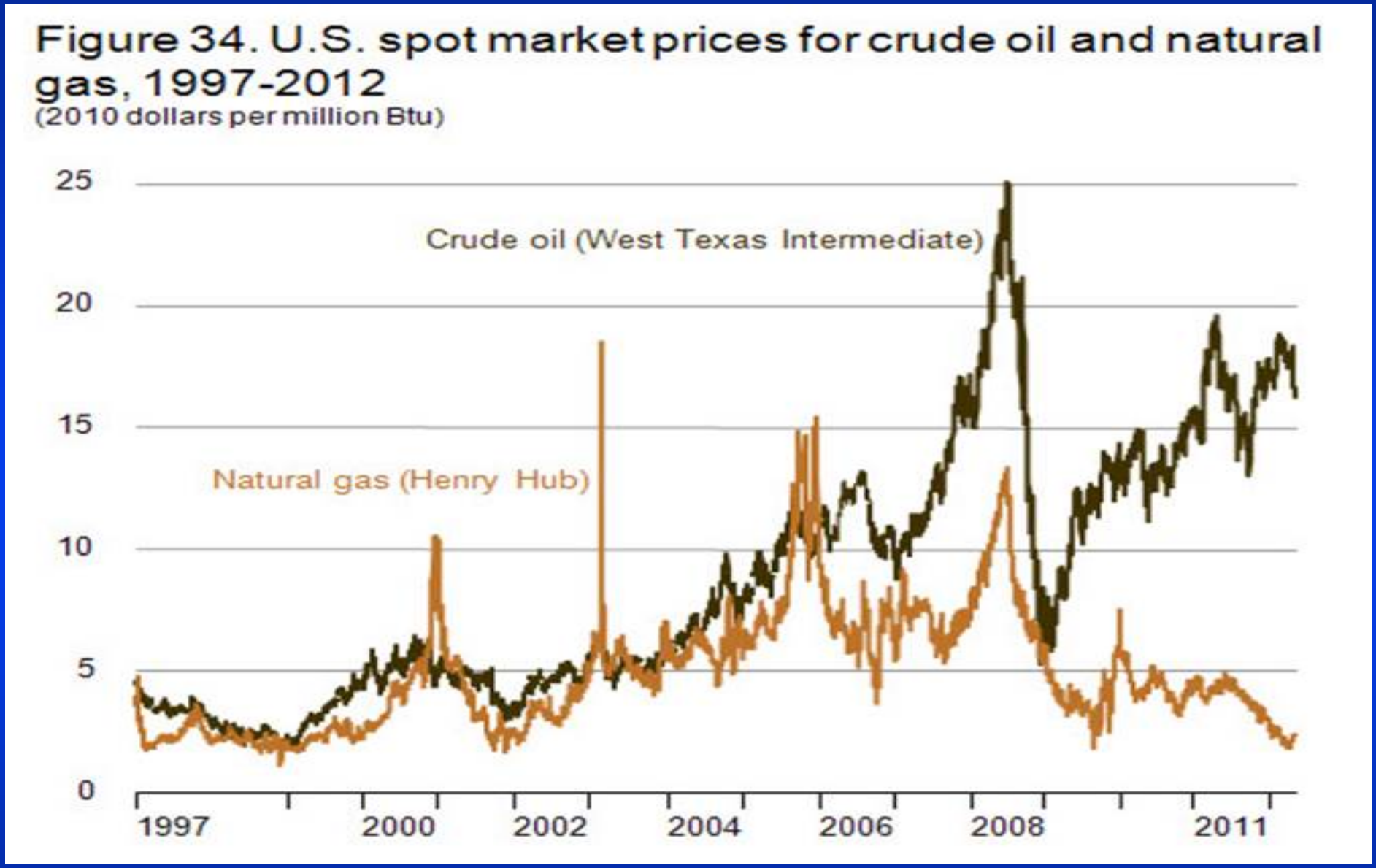


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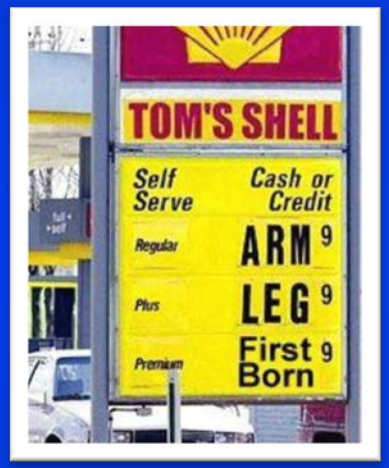
# Snapshot of US NGV Market Today

- On a Btu basis, natural gas and oil prices are now decoupled.
  - BBL:MCF ratio was 40:1 for much of 2012; upper 30s:1 for 2013
  - Even when gas is at more sustainable $4.50/MCF, ratio tends to hover at ~20:1;
  - This “new norm” is up from long-time 7:1 ratio




- **Currently, CNG saves $1.25-1.75 versus gasoline and $1.50-2.00+ versus diesel.**

- Favorable fuel cost differential between natural gas and petroleum is expected to improve further as economy recovers because fundamentals of oil supply-demand have not changed

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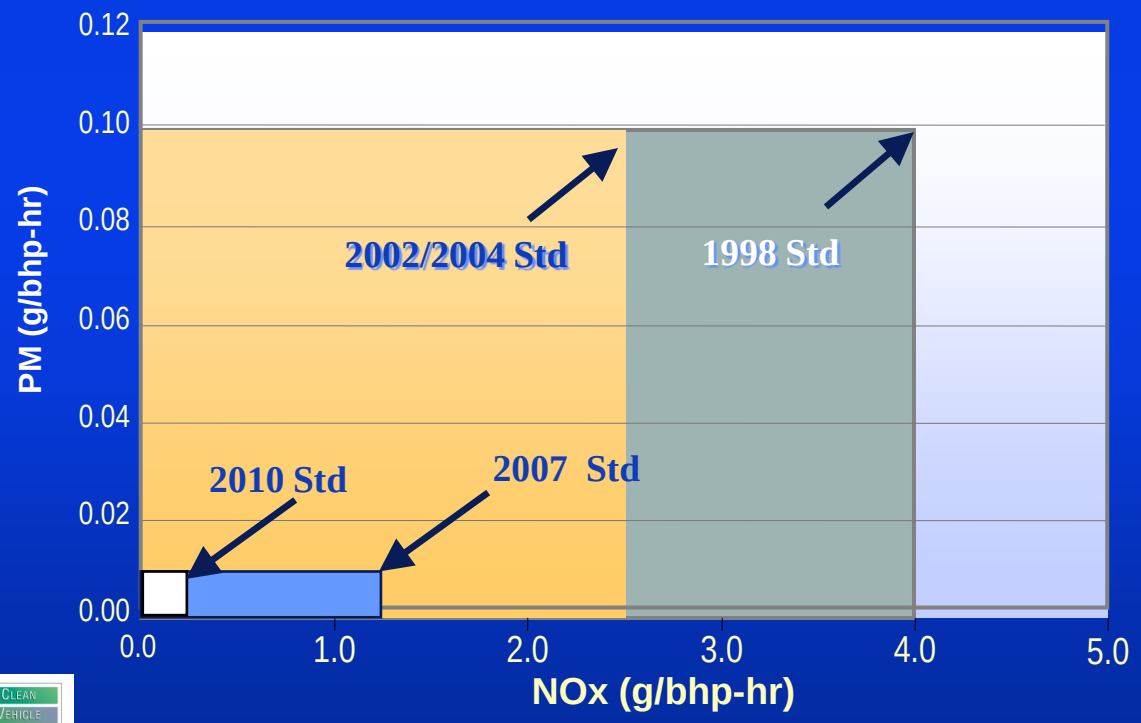
# Market Driver of Change

## Emissions/Improvement in AQ

- AQ Goals, NAAQS and EPA Vehicle Emissions Requirements
  - CAAA drives local/regional govts to reduce criteria emissions (NOx, PM)
  - EPA and CARB vehicle/engine emissions requirements impact OEMs' product offerings, vehicle performance and fuel economy




- 2004 and 2007 diesel emissions strategies increased purchase price and O&M cost ; added complexity.
- 2010 NOx reduction using SCR technology further increased cost, complexity and O&M costs. "DEF" systems and usage
- 2014 phase-in of GHG and fuel efficiency requirements

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# The Price of Progress: OUCH!

## Complexity, Confusion and Cost

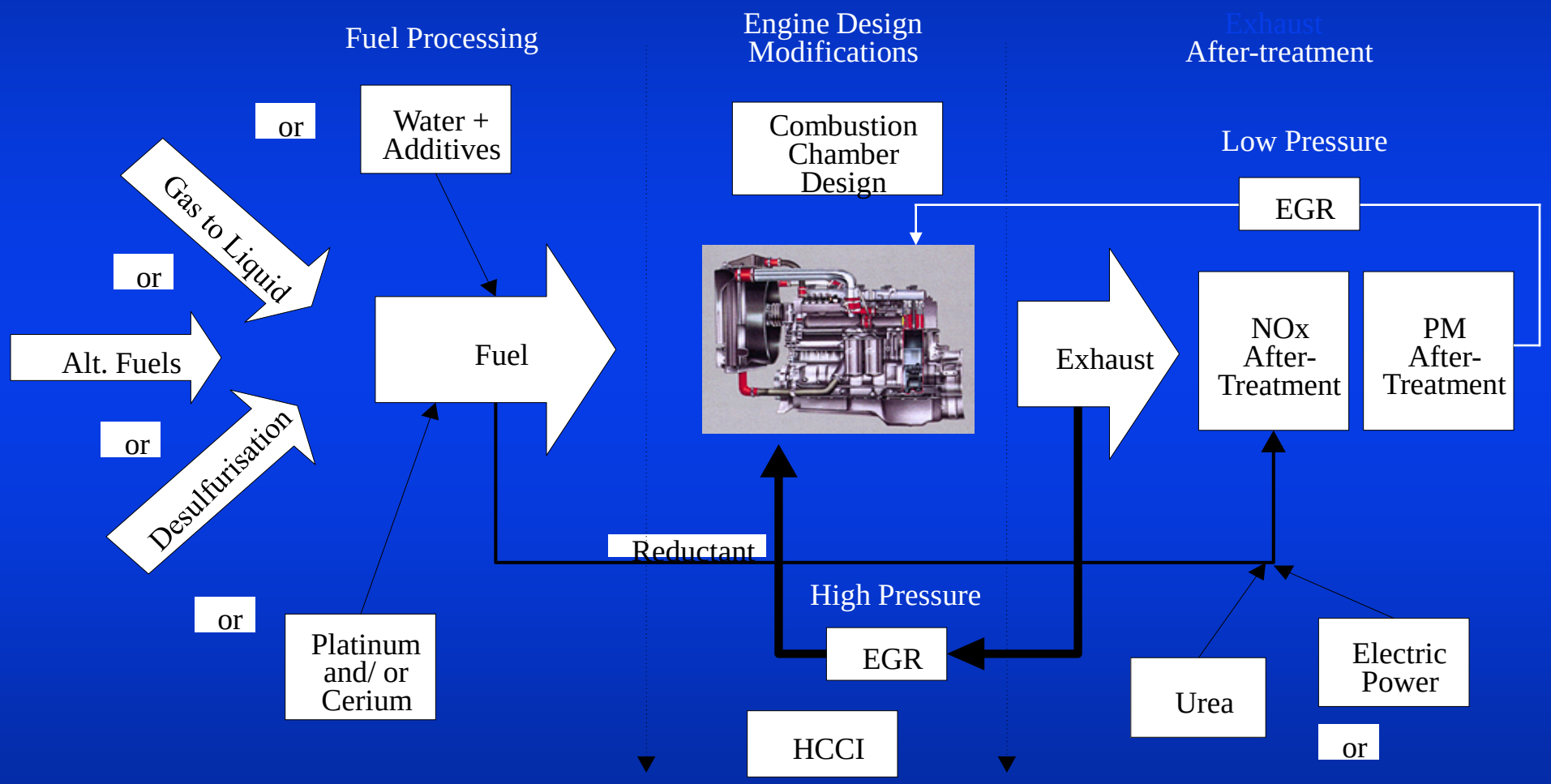


Diagram Courtesy of TIAX LLC

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# Market Driver for NGVs

## Lower Greenhouse Gases (GHG)

- The Environmental, Economic and Political Realities of Global Warming and Greenhouse Gases
  - Issue is gaining traction internationally and here in US
  - New LDV GHG requirements are already phasing in and EPA and NHTSA are phasing in HDV GHG/fuel economy requirements (2014-2018)
- **Natural gas vehicles reduce GHGs significantly**
  - According to CEC study, between 20-29%
    - For HDVs, about 20-23%; for LDVs, 26-29%
    - Depends on comparative vehicles and duty cycles
  - Revised EPA GREET model (2012) based on new data
    - GHG savings are still significant: 15-20+%

# Market Driver For NGVs

## Energy Security and Impact at Fuel Pump

- Global oil supply-demand imbalance getting worse, pushing fuel prices up
  - US = <5% of world pop but 25% of oil use
  - Oil price is based on world market so even new oil discoveries here are driven by world demand, which is outpacing supply;
  - Political instability in key producer regions further exacerbates price volatility
  - Existing refinery capacity is at/or near peak – new capacity is lengthy process
  - Barrel of oil topped $145 in late spring 2008! WTI currently ranges between $85-100

**West Texas Intermediate 2/17/2014**


**Are you prepared for the next spike?**

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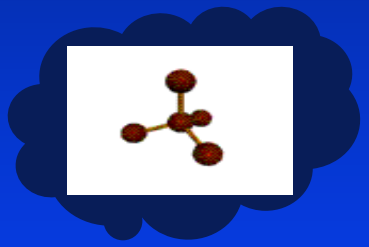
# Market Driver For NGVs

## Energy Security and Diversity

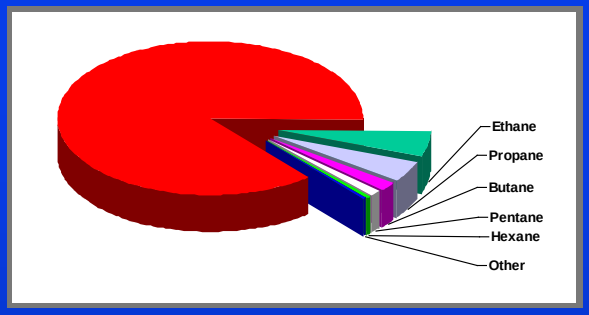
- Diversifying America's Transportation Fuel Portfolio
  - Electricity
    - All-electric
    - Hybrids, PHEVs
  - Bio-diesel (B100) and blends
  - Ethanol
    - E85 (limited production/distribution – majority is in Midwest market)
    - Oxidant additive to gasoline (e.g. E10 gasoline – perhaps to be increased)
  - Propane
  - Natural Gas
    - CNG for light and medium duty and LNG for heavy duty vehicles
  - Hydrogen
    - Internal combustion engines (H/CNG blends like Hythane)
    - Fuel cells (eventually)

# Natural Gas and the Hydrogen Future

- Natural gas and NGVs are the logical energy pathway and technology bridge to the hydrogen transportation energy future
  - Natural gas is 87-95% Methane
  - Methane is CH4 - 80% Hydrogen
  - Reform at station or on-board
  - H/CNG blending in internal combustion engines is likely precursor to wider use of H2
  - Market acceptance of gaseous fuel compression, storage vessels, engine maintenance
  - NGV industry is spearheading Codes & Standards development



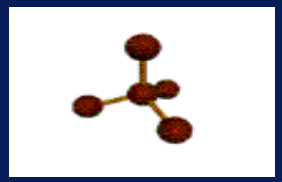
Methane Molecule



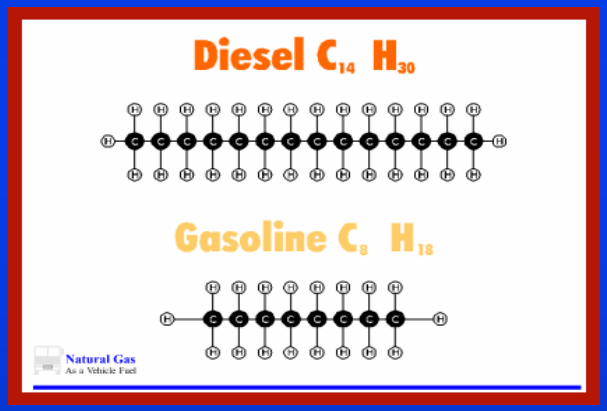

- Still a LONG way to go before H2 vehicles are commercially viable and represent significant impact

# Benefits of Natural Gas/NGVs

- Natural gas is an inherently clean fuel
  - Natural gas is low-carbon fuel (CH4)
  - Less NOx, PM  and GHGs
- Natural gas is very safe
  - Lighter than air; Limited combustion ratio (5-15%)
  - High ignition temperature: 1000+F
  - Colorless, odorless, non-toxic substance
  - Doesn't leak into groundwater
- NGVs are proven and reliable
  - 16+ million worldwide;
- NGVs are quiet
  - HDVs are 80-90% lower db than comparable diesel
- NGV life-cycle costs are significantly lower
  - Fuel costs are far lower!
  - Maintenance costs are =/< than gas or diesel



**Methane  Molecule**

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# Key Attributes and Best Prospects




- High fuel use vehicles with return-to-base operations or repetitive route or pre-set geographic operating areas

  -**Regional / long haul freight truck – 18-22K DGE**
  -Transit buses – 11-13K DGE
  -Refuse/Concrete trucks – 7.5-10K DGE
  -Municipal sweeper – 5-6K DGE
  -Airport shuttle service – 5.5-7.5K GGE
  **-Local goods/svcs: F&B, Textiles etc – 7K DGE**
  -Taxi - 4.5-5.5K GGE
  -School Bus – 2.5-3K GGE
  -E&P pick-up 2-2.5K GGE
  -Courier sedan, newspaper van, utility/ telecom van, public works pick-ups – 1.2-1.5K GGE

- Consumers have already shown that they will adopt given sufficient infrastructure

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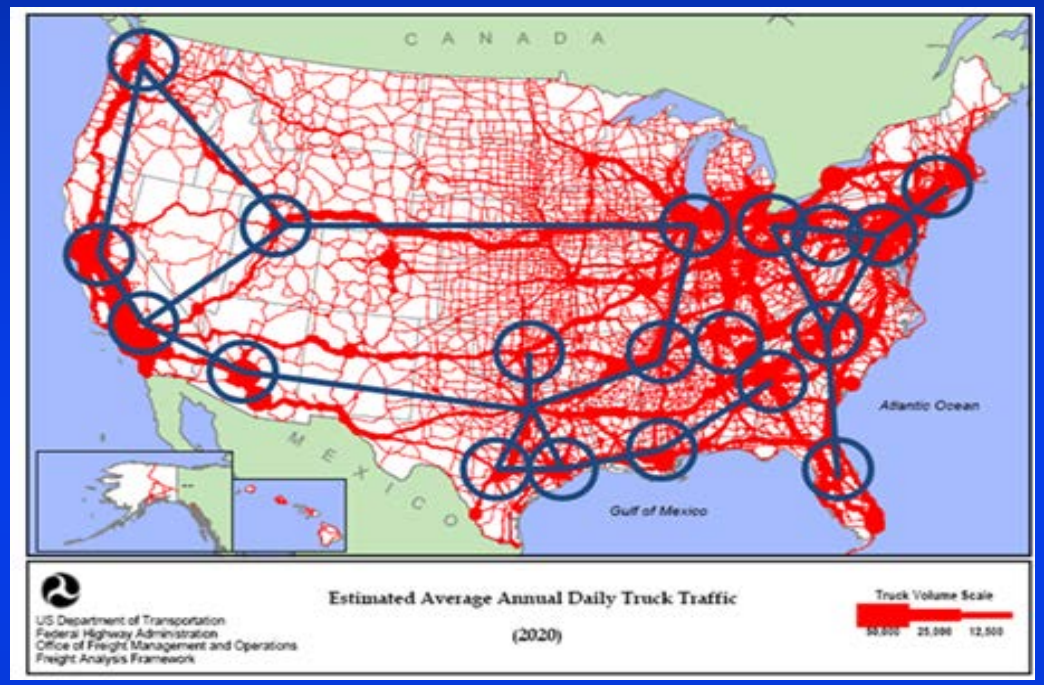
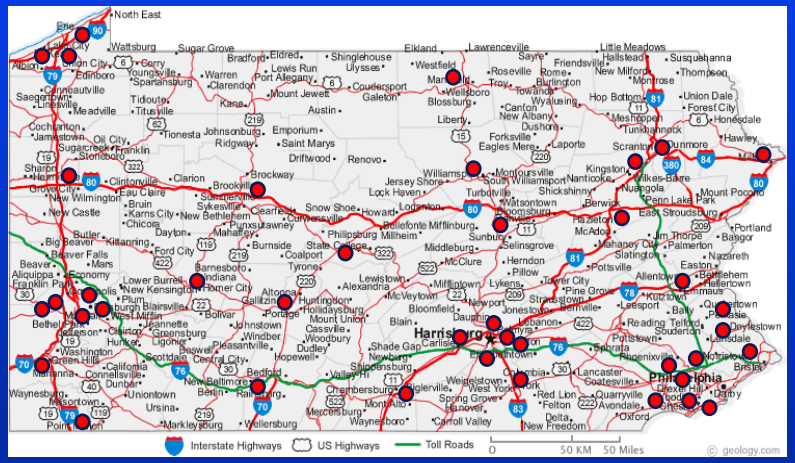
# Expanding Infrastructure: “Hub and Spoke” and Corridor Development




**Hub and spoke:**
Local fleets with predictable “limited” range needs (CNG or L/CNG).

**Corridor:**
Lanes that connect the hubs (CNG or LNG, depending on range)

**Hypothetical example based on key population centers, travel patterns:**

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# Growing Selection of NGVs from OEMs, SVMs

## HD Truck OEMs

- Freightliner Truck
- Volvo
- International
- Kenworth
- Peterbilt
- Mack

## HD Vocational OEMs

- Mack
- Peterbilt
- Crane Carrier
- Autocar Truck
- ALF Condor
- Elgin
- Johnston
- Schwarze
- Tymco
- Capacity

## HD Bus OEMs

- Thomas Built Bus
- Blue Bird Bus
- Optima/NABI
- El Dorado
- New Flyer
- Motor Coach Ind.
- Gillig
- DesignLine

## HD Retrofit/Repowers

- American Power Group
- Clean Air Power
- Eco Dual Inc
- Fyda Energy Solutions
- NGV Motori
- Omnitek Engineering

Dual fuel retrofits and SING repowers of Cummins, Daimler, Navistar, Detroit Diesel, Mack, Volvo, Caterpillar

## LD OEMs

- American Honda
- General Motors
- Chrysler Ram Trucks

## LD/MD Retrofits*

- Altech-Eco
- Landi Renzo/Baytech
- IMPCO Automotive
- Westport/BAF Technologies
- NGV Motori USA
- NatGasCar
- Auto Gas America
- Greenkraft
- PowerFuel Conversions

Retrofits of GM, Ford, Dodge, VW, Mazda, Mitsubishi, Workhorse, Isuzu, JAC, UtiliMaster, Freightliner Custom Chassis

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# LDVs Available from OEMs

**Honda Natural Gas Civic Sedan (dedicated)**

**GM Silverado/Sierra pick-up (bi-fuel)**

**GM Express/Savana Cargo <u>& Passenger</u> Vans (dedicated)**

**Ram 2500 dual-cab pick-up (bi-fuel)**

**NEW! MY 2015 Bi-fuel GM Impala (late summer 2014)**

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# LDVs Available Through SVMs

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# Additional Vehicles Available Through SVMs

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# MDVs Available Through SVMs



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# OEM HD Natural Gas Powertrains

| CWI 8.9L ISL-G | CWI 11.9L ISX-G | (2014) Volvo 13L D13 | (2015) CWI 6.7L ISB-G | (2016?) CWI 15L ISX-G |
|---|---|---|---|---|
|  |  | ? | ? | ? |
| • Spark Ignition | • Spark Ignition | • Dual Fuel (LNG+Diesel) | • Spark Ignition | • Spark Ignition |
| • CNG or LNG | • CNG or LNG | • LNG Only | • CNG or LNG | • CNG or LNG |
| • Peak Rating: | • Peak Rating: | • Peak Rating: | • Peak Rating: | • Peak Rating: |
| – 320 hp / 1,000 ft-lbs | – 400 hp / 1,450 ft-lbs | – hp /torque TBD | – ~260 hp / ~660 ft-lbs | – hp /torque TBD |

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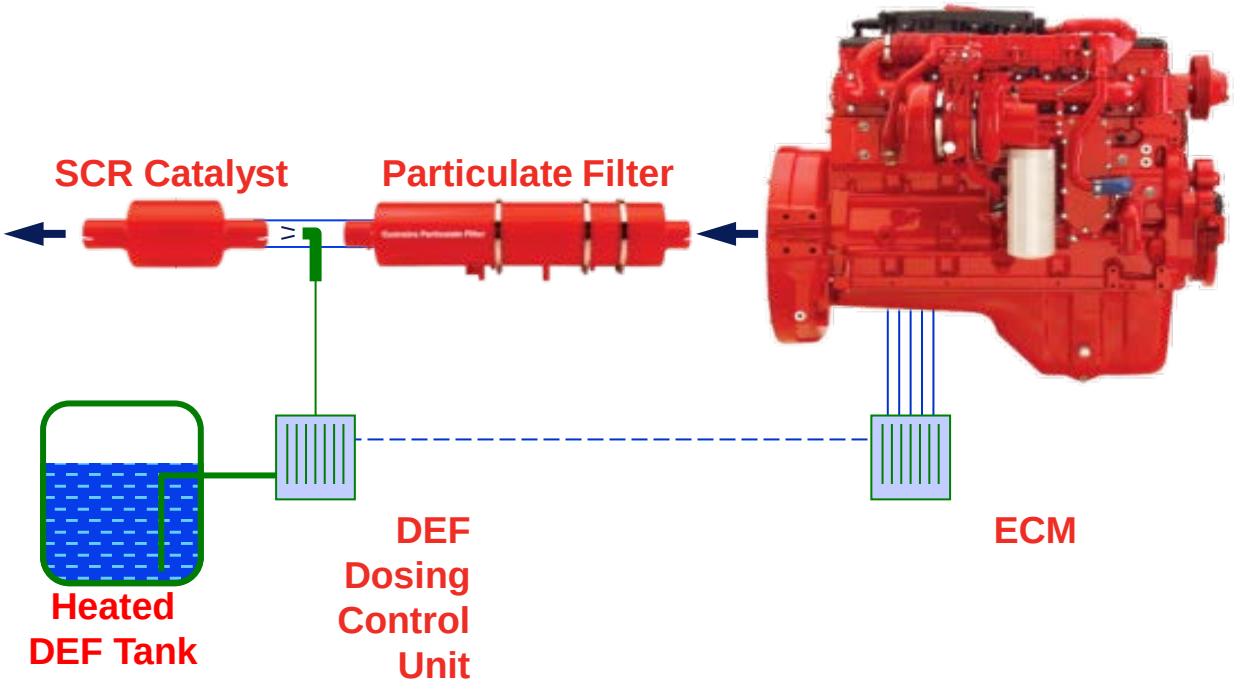
# Aftertreatment Comparison

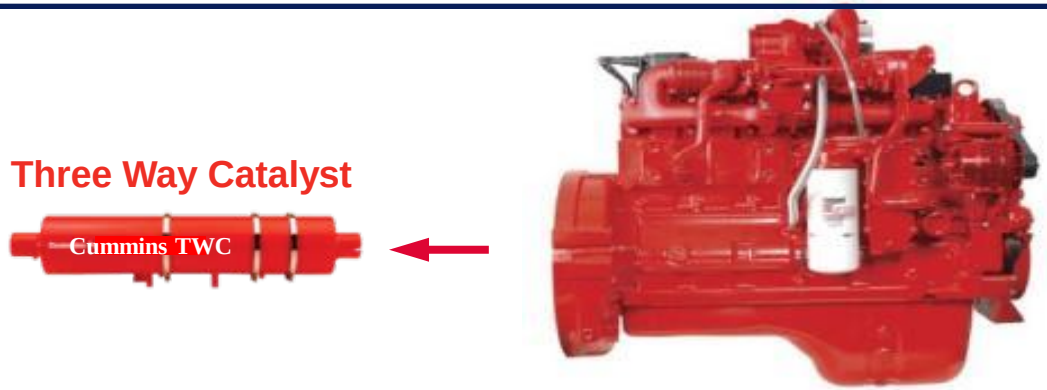
**ISL9**

(diesel)




**ISL G**

(natural gas)



# Transit and School Bus Platforms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# Vocational/Specialty/Work Truck















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# Local-Regional Haul/Line Haul





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| OEM | Model | Segment | ISL G | ISX12 G |
|---|---|---|---|---|
| Freightliner Truck | Business Class M2 112 (Class 7/8) | MD/HD Truck | X | |
| | Cascadia | HD Truck | | X |
| Kenworth | W900S | MD/HD Truck | X | X |
| | T440 / T470 | MD/HD Truck | X | |
| | T660 | HD Truck | | X |
| Peterbilt | Model 384 | MD/HD Truck | X | X |
| | Model 365 | MD/HD Truck | X | X |
| Volvo | VNM | MD/HD Truck | X | |
| | VNL | HD Truck | | X |
| Mack | Pinnacle | HD Truck | | X |
| | Granite | HD Truck | | X |
| International | TranStar | MD/HD Truck | X | |
| | | | | |
| American LaFrance | Condor | Refuse | X | |
| AutoCar | ACX | Refuse | X | X |
| Crane Carrier | LCF | Refuse | X | |
| Peterbilt | 320 | Refuse | X | X |
| Mack | TerraPro Low Entry | Refuse | X | |
| Mack | TerraPro Cab Over | Refuse | X | |
| | | | | |
| NABI | 35 LFW/40 LFW/60 BRT | Urban Bus | X | |
| New Flyer | 30 LF/35 LF/40 LF | Urban Bus | X | |
| Orion | Orion V HF/Orion VII LF | Urban Bus | X | |
| Foton | City - L40 CNG | Urban Bus | X | |
| Gillig | LF | Urban Bus | X | |
| MCI | Commuter Coach 40/45 | Motor Coach | X | |
| DesignLine | Commuter Coach 40/45 | Motor Coach | X | |
| El Dorado National | Axess/E-Z Rider II/Transmark RE/XHF | Shuttle | X | |
| | | | | |
| Blue Bird | All American | School Bus | X | |
| Thomas Bus | Saf-T Liner | School Bus | X | |
| Capacity | TJ9000 , TJ5000 | Yard Spotter | X | |
| AutoCar | Xspotter | Yard Spotter | X | |

# Dual Fuel Technologies: Re-emerging Opportunity

- Dual fuel technology is making a comeback, primarily applied to "Intermediate Use (IUL)" and "Out of Useful Life (OUL)" HD engine applications either for legacy fleets or for use of older engine in new glider
  - Varying amounts of diesel is displaced by natural gas during duty cycle
- 3/11 - EPA established a lower cost "approval" process that reduced cost and data burden

- "Approval" process requires technical supporting documentation, field data
- Presently, 500+ engine families have been approved and more are added each month
  - EcoDual, APG, CAP, NGV Motori, Fyda, Landi Renzo, Diesel 2 Gas

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# Dollars and Sense

NGV Economics:
Components of CNG Cost,
Calculating Simple Payback
and
Life-Cycle Cost Savings

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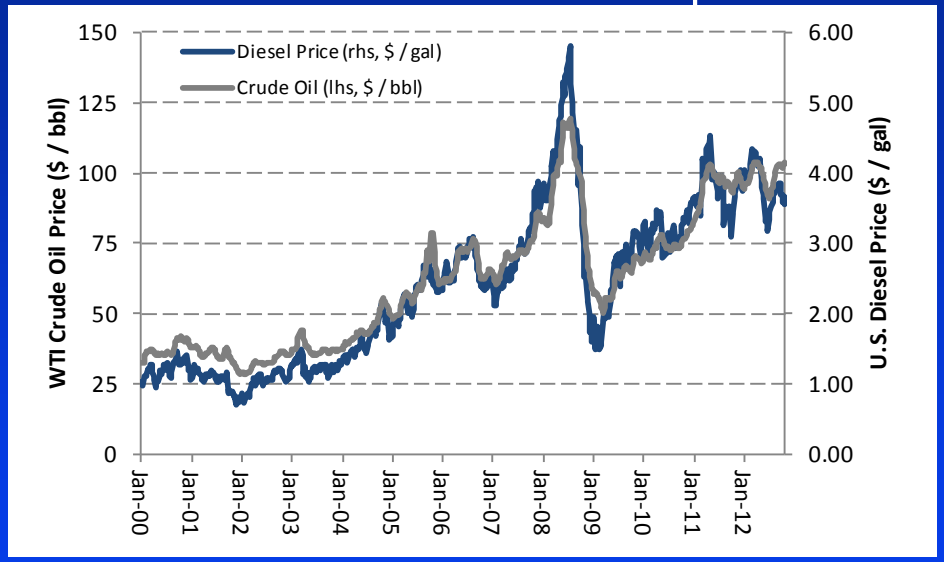
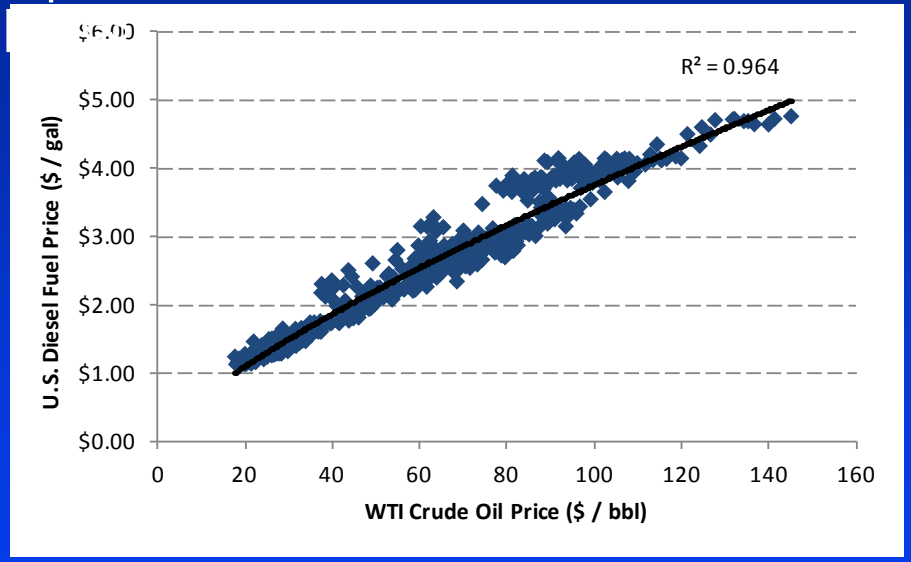
# Components of CNG Cost

- Gas Bill:
  - Unregulated portion associated with purchasing gas
  - Regulated local gas utility distribution company (LDC) services
- Compression
  - Electric motor  KWH and KW …OR engine driven unit's  natural gas use
- Station Maintenance
  - Normal PM, scheduled replacement of parts, compressor rebuilds
- Capital /equipment amortization
  - Amortized cost of equipment or cost of capital factored into GGE price
- Federal, state and local excise fuel taxes (if applicable)
  - Tax is paid by the fuel seller; tax status of buyer determines
- Margin

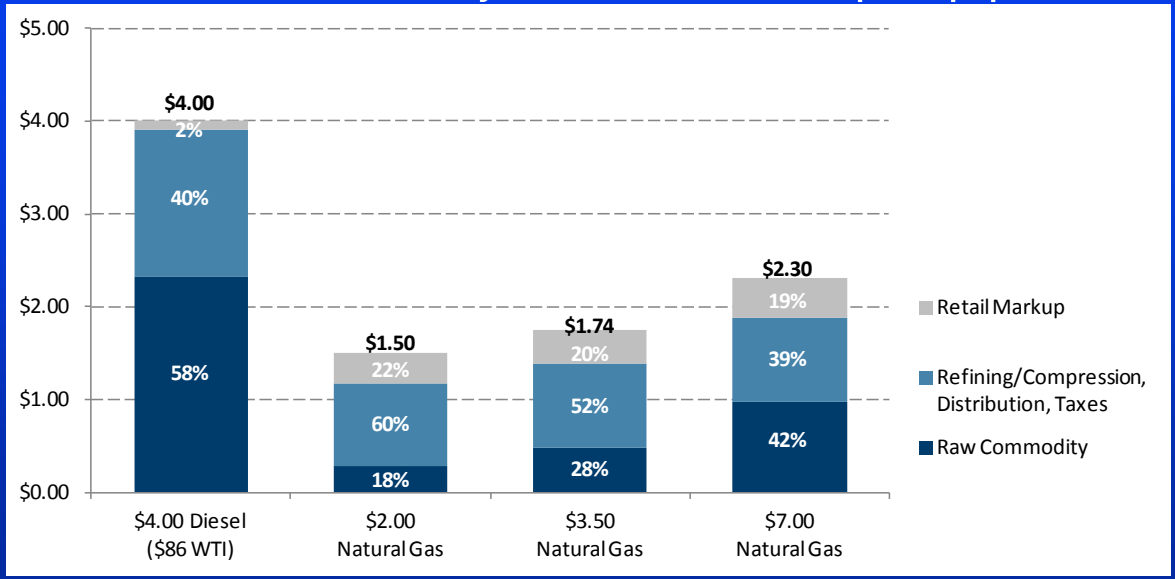
## Historical crude and U.S. diesel prices




## Relationship between crude and diesel




## Ratio of raw commodity contributions to pump prices

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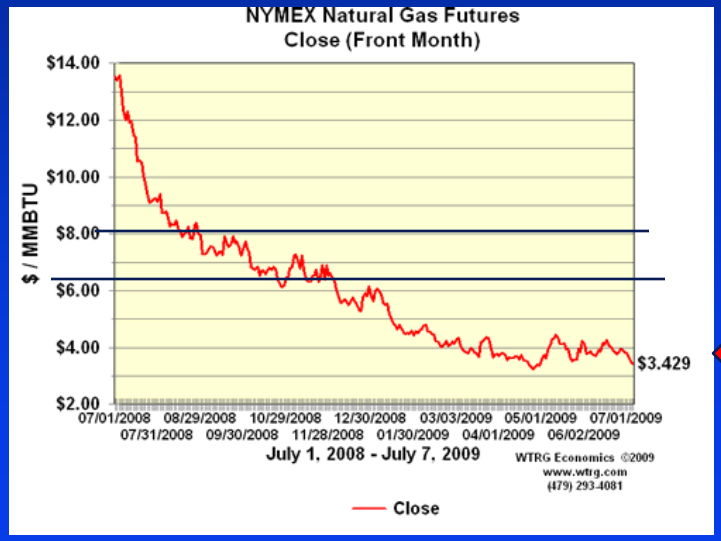
# Components of CNG Cost

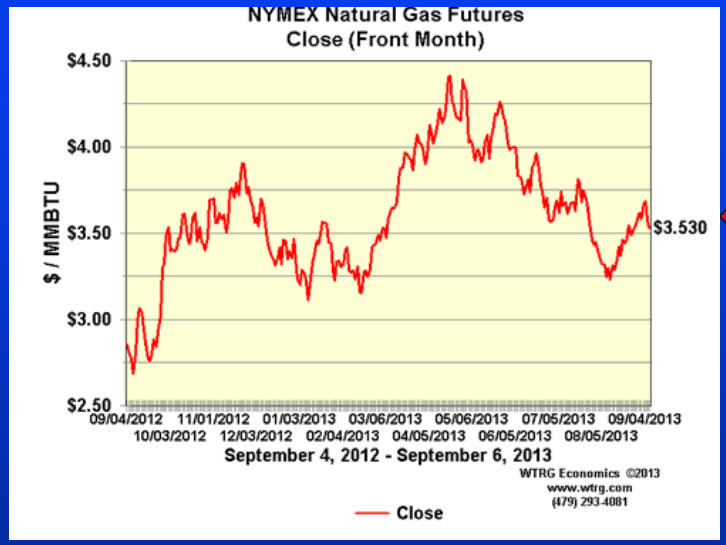
- Gas company bill (unregulated portion)
  - Commodity:

    Gas is drawn from wells, gathered/ pooled, stripped of impurities and “heavy” gases, then transported to “hubs” where it is available on the commodities market. Henry Hub (Louisiana) is used for NYMEX pricing.

    US DOE and industry long term price forecasts (prior to the economic collapse) pegged NYMEX natural gas at $6.50-8.00/MCF. Impact of shale gas is being reflected in more recent forecasts.

    Future market projections for gas are still up in the air now that shale gas has changed the equation

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# Components of CNG Cost

Gas company bill (unregulated portion):

Gas Commodity:

- One cubic foot = ~1000 BTUs (Note: cf = volume, BTU = energy)
- One Mcf = 1000 cubic feet
- One Mcf = 1000x1000 = ~1,000,000 Btus (MMBtu or decatherm)
- US Gov't says 124,800Btu/GGE and 138,700Btu/DGE…therefore….
- **One MMBtu = roughly 8.0 GGE of (uncompressed) natural gas**
- **One MMBtu = roughly 7.2 DGE of (uncompressed) natural gas**.

- Although up sharply in last 30-45 days due to severe cold throughout much of the nation, 2013 NYMEX MMBtu averaged about $3.70; thus the commodity portion of CNG was $.46/GGE ($.52/DGE)
- Your local gas company buys gas at various prices and uses weighted formula to pass along commodity at cost….commodity cost is PART OF the purchased gas adjustment (PGA).

# Components of CNG Cost

- Gas company bill (unregulated portion):
  - In addition to commodity costs, Purchased Gas Cost Adjustment (PGC/PGA) includes costs associated with getting gas to LDC's gate.
    - Gas acquisition
    - Pipeline capacity and transmission; "balancing" charges
    - Storage to supplement pipeline flows during heaviest demand periods
  - These costs vary across the country but may range from $.75-$2/MMBtu
    - Storage is often about half that fee
  - Commercial and industrial customers with steady gas loads often elect to buy their own gas through a broker/marketer and "transport" via the LDC, thus eliminating/reducing fees associated with storage.
    - Commercial/industrial customers with process loads (e.g., bakeries, bottlers, dairies, laundries, manufacturing plants)
    - Fleets (regardless of their facility load)

# Components of CNG Cost

- Gas company bill (regulated portion):
  - Local utility distribution system charges a regulated tariff for delivery of gas from their city gate to your meter. This is a per-unit cost, not tied to the PGA. Rate typically includes:
    - Recovery of distribution system investment/depreciation
    - System operations and maintenance
    - Meter set / customer services
    - Administrative G&A
    - Other mandated fees / assessments
  - These tariffs are often stepped (i.e. larger volumes often earn lower rates)
  - Customers that do not meet minimum load requirements to qualify for ‘transportation” rates buy “bundled” gas service from their LDC. Those with sufficient load can opt to buy their own gas and pay LDC to transport.
    - Minimum amount required to qualify for transportation rate varies widely from one utility area to the next… as little as 10,000 DGE/year to as much as 150,000 DGE/year

# Components of CNG Cost

Sample case: commercial baking company with 20 step vans

- Gas Bill: $.85/GGE
  - Gas costs: ~$.59/GGE
    (based on estimated wellhead price of $4.00/MMBtu + $.75/MMBtu associated fees for transportation and services up to LDC city gate)
  - LDC's regulated city-gate-to-meter services: $.21/therm (~$0.26/GGE) (transportation rate)

# Components of CNG Cost

- Gas Bill: $.85/GGE
- Electric compression costs
  - Gas delivered to the customer has to be compressed.
  - Most stations use electric motors although many larger stations use natural gas engine-drive compressors (depends on local regs).
  - Be sure to factor in both KWH consumption and KW demand
  - Estimated @ 1 fully-loaded KWh/GGE – a bit less for larger stations and more for small stations
  - Varies significantly from one utility area to the next
  - Nat'l range:$.04 -.30/KWH – **: ~$.12/GGE**

# Components of CNG Cost

- Gas Bill: $.85/GGE
- Electric compression costs:$.12/GGE

- CNG stations require regular preventative maintenance/ service and occasional rebuilds of compressors and replacement of other parts.

- Cost per GGE will vary based on total throughput (generally, larger throughput = less cost/GGE due to economies of scale)

- Maintenance/Repair/Service: $.20-.50/GGE.: **$.30/GGE***

# Components of CNG Cost

- Gas Bill: $.85/GGE
- Electric compression costs: $.12/GGE
- Maintenance/Repair/Service: Assume average of $.30/GGE
- **Capital amortization of equipment: $.25-.60/GGE**
  - Station cost divided by total GGE over life of equipment
  - Depreciation (5 yrs,7 yrs,10 yrs?), Cost of capital, Utilization factor

Example 1:

- 20 veh. x 15 GGE/day x 5 days/wk = 1500 GGE/wk =~80,000 GGE/yr
- 80,000 GGE/year x 10 yrs = 800,000 GGE
- If 100 scfm 10-post/20-hose time-fill station cost is $400K, then **$.50/GGE**

Example 2:

- Ex 2: 20 veh. x 20 GGE/day x 6 days/wk = 2400 GGE/wk = ~125,000 GGE/yr
- Same 100 scfm station, then **$.32/GGE**

Example 2 using 7 year depreciation:

- 125,000 GGE/year x 7 yrs = 875,000 GGEs = $.46/GGE

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# Components of CNG Cost

- Gas Bill: $.85/GGE
- Electric compression costs: $.12/GGE
- Maintenance/Repair/Service: $.30/GGE
- Capital amortization of equipment: $.40/GGE

**SUB-TOTAL:**

- **$1.67 (use by or sales to tax exempt entities)**
- **$2.17 (use by or sales to taxable entities)**
  - Federal motor fuels excise tax: $0.183/GGE;
  - Pennsylvania Fuels Taxes: $.312/GGE (same as gasoline)

# Components of CNG Cost

- **What if NYMEX MMBtu cost rose to $8.00/MMBtu?**

- **Gas Bill: $1.35/GGE**
  - **Gas acquisition cost: $1.09/GGE ($8.00+.75 = $8.75/8)**
  - LDC transportation tariff remains: $.26/GGE
- Electric compression costs: $.12/GGE
- Maintenance/Repair/Service: $.30/GGE
- Capital amortization of equipment: $.40/GGE

- **Tax exempt fuel sales: $2.17/GGE**
- **Taxable fuel sales in PA: $2.67/GGE**

- **At $8.00/MMBtu, oil is very likely to be well over $200+/barrel… easily equates to $5+ for diesel!**

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# Medical Lab Courier Service

- Honda Civic Natural Gas sedan
- MPG: 31 (combined); 30K miles/year
- Fuel Use: 4GGE/day; 1000GGE/yr
- CNG Premium*: $6500
- Without grant, simple payback = 5yrs (based on $1.30/GGE savings)
- Without grant, LCC = $1300 (based on 6 year life)
- Grant: $3000
- Remaining premium: $3500
- Simple Payback: 2.7 yrs
- Life-cycle cost advantage: $4290

# Passenger van for Limo

- Ford E-350 passenger van, Chevy/GMC 3500 passenger van
- MPG: 15/16 (combined), 90K miles/year
- Fuel Use: 17GGE/day; 5500GGE/yr
- CNG Premium: $13,500
- Without grant, simple payback = 1.9 years and LCC savings = $29,315 (6yr life; $ 1.30/GGE savings)

- With Grant: $ 6000
- Remaining premium: $7500
- Simple Payback: 1 year and LCC savings = $35K+

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# Step Van

- Sample Applications (e.g., textile rental service, comm. bakery)
- MPG:  6.0, 95mpd x6 dys/wk, 30K/yr
- Fuel Use: 16GGE/day;  5000GGE/yr
- CNG Premium: $25,000
- Without grant, simple payback = 3.3 years;
  LCC savings = $50,250
  (based on 10 yr life and 1.50 savings/GGE)
- Grant: $15,000
- Remaining premium: $10,000
- Simple Payback: 1.3 yrs; LCC savings: $65K !!!

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# Refuse Truck
## (LCF model)

- Crane Carrier LET, Autocar Xpeditor, Peterbilt LCF 320, Condor , Mack TerraPro
- MPG: 2.5 – 3.0 (lots of idle and PTO time)
- Fuel Use: 35-40gge/day; 10,500DGE/yr
- CNG/LNG Premium: $30,000
- If no grant, payback is 1.9 years and Life-Cycle Cost savings = $96+K
  (based on $1.50 savings/DGE and 8 year life )
- Grant $15,000
- Remaining Premium: $15K
- Simple Payback: 0.95 years; LCC savings: $110K

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# Grocery Truck

- Volvo VNM/VNL, Freightliner M2/Cascadia
- MPG: 5.6 miles/DGE; 100K miles /year
- 17,850 DGE/yr
- CNG Premium (w 84 DGE capacity): $60,000
- If no grant, payback is 2.25 yrs
- Life-cycle cost savings: $127K
  (based on $1.50/DGE savings, 7-year /700K life before resale)

- Grant $25K; Remaining Premium: $35K
- Simple Payback: $26,775 yr savings = 1.3 yrs
  (based on 1.50 savings /DGE )
- Life-cycle cost savings: $152+K

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# Fill'er Up

Natural Gas Fuel Station Types

Development, Ownership and Operations Options

Sizing/Design Considerations

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# CNG Fuel Station Types

- **Time-fill capability**
  CNG is dispensed slowly directly to vehicles' onboard storage tanks. Lower cost station investment. Best for fleets that return to central lot and sit idle overnight or for extended periods and do not need fast fill capability.
  Home fueling devices are time-fill applications.


- **Fast-fill capability**
  Similar to liquid fueling station, same fill rates and times. A MUST for public access. Also good for larger fleets where fueling turn-around time is short.

- **Combo-fill capability**
  Comprises both time-fill and fast-fill. Often good for fleets that can fuel on time-fill but need occasional "top off" or want/need ability to provide public access

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# Q: How Do We Solve The "Chicken & Egg" Conundrum?

## (A: Make a chicken-egg omelet*)

- Throughput (sales volume) is key to generating economies of scale for the public access station owner, thus allowing pump price differentials that drive reasonable payback and life-cycle savings for customers

- Minimum load thresholds vary based on a variety of factors including: station type, station size, fuel price differential, ability to amortize maintenance costs, equipment depreciation, grants …..ROI expectations

- Achieve minimum load thresholds by:
  - Identifying an anchor fleet that justifies the investment…or
  - Aggregate several semi-anchor fleets' loads  if their depots or operating areas are geographically acceptable…or
  - Create retail public access for small fleets and consumers….or
  - All of the above

# Station Options


- Station Location Options:
  - Offsite – use existing public access station if available, convenient and of sufficient capacity. Anchor fleets or ‘pooled loads’ create economies of scale.
  - Onsite - private access only or with public access “outside the fence”

- Different ownership & operations options available depending on throughput, funding:
  - Fleet owned & operated station
  - Outsource station O&O entirely via independent fuel provider and contract gas price
  - Fleet owned/leased station but contracted out operations for a fee (usually on a GGE basis)

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# CNG Station Design Considerations

- How Much Fuel in How Much Time?
  - Vehicles/day, fuel/vehicle, fueling patterns
  - Maximum *daily* flow, maximum *hourly* flow, targeted fueling time per hose
  - Back-up fueling availability? Redundancy

- Real estate concerns
  - Proximity to major travel routes
  - Vehicle needs (entry/egress patterns)
  - Equipment footprint
  - Site development issues


- Equipment needs/performance/cost
  - Balance of compression and storage
  - Gas service (volumes/pressures, moisture)
  - Electric service (kVa, etc)
  - Dispensers and fuel management needs

# Implementation: How do we transition?

- Communicate benefits to your staff to get their “buy in” and to create feedback mechanisms that keep your program on track. Tell your customers; show environmental stewardship.

- Identify your internal champion, assemble stakeholders and resources; learn from others’ successes, don’t repeat mistakes… Use the resources of your Clean Cities Coalition

- Maximize use of OPM while it is available. Investigate other creative financing/leasing and station operation options. Learn how to purchase gas to lower fuel costs.

- Connect with your Clean Cities Coalition and fed/state agencies. Prepare fleet inventory replacement schedule and fuel use projections. Contact LDC, vehicle, fuel station development and/or equipment providers. Get started!

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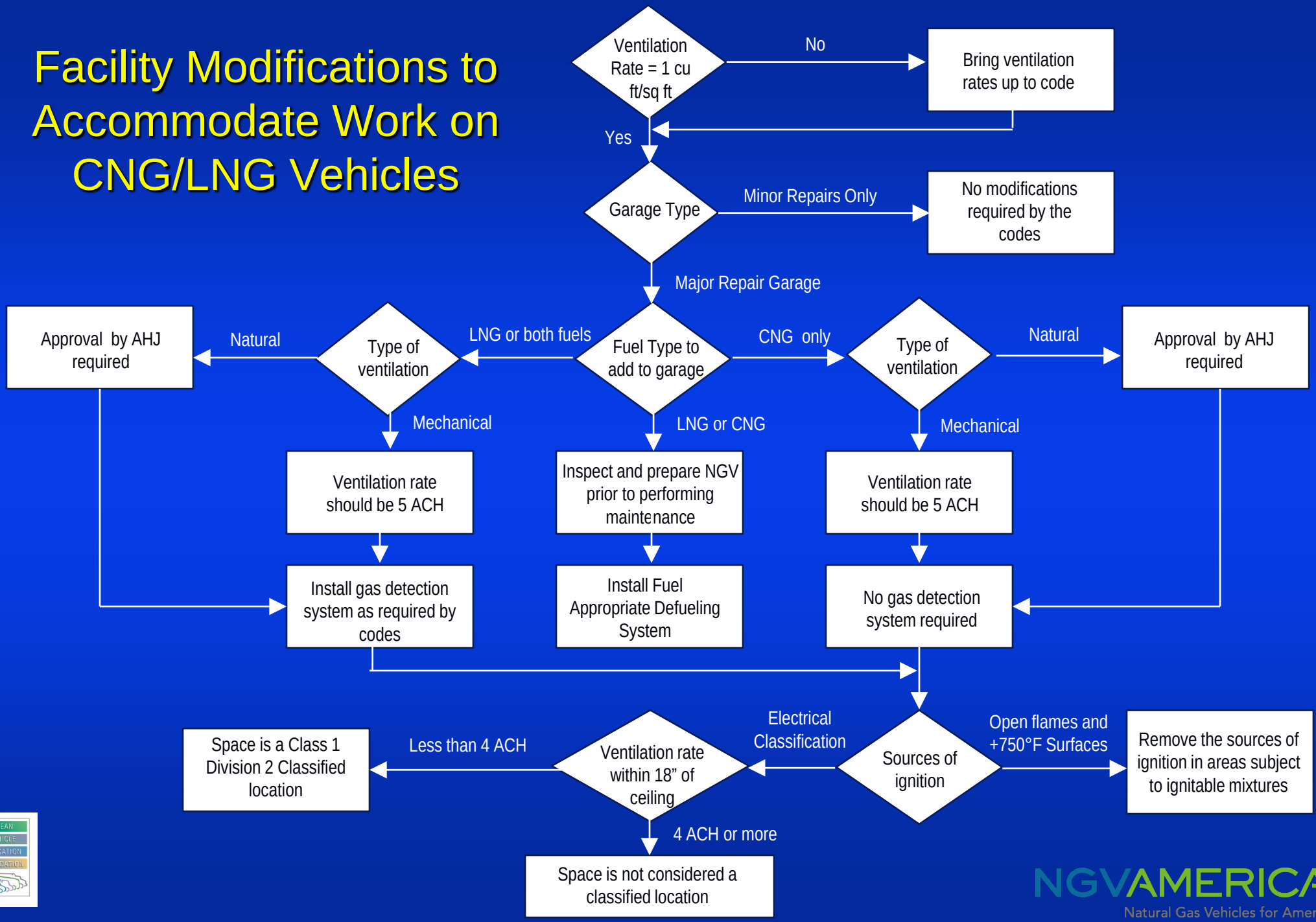
# Legislative/Regulatory Issues

- Federal Legislative Priorities
  - Reinstate tax credits for fueling infrastructure (30%/$100K sought)
  - Reinstate $.50/GGE fuel tax incentive
  - Fix LNG motor fuels excise tax penalty
  - Allow 2000lb weight exemption for HDVs for added fuel system weight
  - Eliminate 12% federal excise tax on natural gas trucks or, at least, on the incremental cost of natural gas trucks
  - CAFÉ standards and NGVs
- Working at state level to get some of these passed
- Hundreds of state bills/actions to incentivize NGVs
  - Grants, tax credits, motor fuels excise tax provisions, other incentives,
- NCWM: Adopt DGE standard; protect GGE standard

# Facility Modifications to Accommodate Work on CNG/LNG Vehicles

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For more information please contact:

Stephe Yborra

Director of Market Development

NGVAmerica

400 N. Capitol Street, NW - Suite 450
Washington, DC 20001

Director of Market Analysis, Education and Communications

Clean Vehicle Education Foundation

6011 Fords Lake Court

Acworth, GA 30101

syborra@ngvamerica.org / syborra@cleanvehicle.org

(301) 829-2520

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# 5 Tips that Make Some Grant Applications More Successful Than Others

- Speak to the area of interest/evaluation criteria of the funding agency
- Clearly spell out the proposed benefits, the criteria by which you plan to measure those benefits, the action plan and the proposed processes in place to manage resources/take corrective action mid-stream to achieve the goal(s).
- Leverage funding of multiple stakeholders.
- Communicate succinctly and effectively
- Meet the administrative requirements

# ADDENDUM
# Components of CNG Cost

Sample case: commercial baking company with 20 tractors, each traveling ~375-400 miles/day, utilizing ~75DGE

- Gas Bill: **$.95/DGE**
  - Gas costs: ~$.66/DGE
    (based on estimated wellhead price of $4.00/MMBtu + $.75/MMBtu associated fees for transportation and services up to LDC city gate)
  - LDC's regulated city-gate-to-meter services (transportation rate): $.0.21/therm which is $.29/DGE ($.26/GGE)

# Components of CNG Cost

- Gas Bill: $.95/DGE
- Electric compression costs
  - Gas delivered to the customer has to be compressed.
  - Most stations use electric motors although many larger stations use natural gas engine-drive compressors (depends on local regs).
  - Be sure to factor in both KWH consumption and KW demand
  - Estimated @ 1.1 fully-loaded KWh/DGE – a bit less for larger stations and more for smaller stations
  - Varies significantly from one utility area to the next
  - Nat'l range:$.04 -.30/KWH – **: ~$.13/DGE**

# Components of CNG Cost

- Gas Bill: $.95/DGE
- Electric compression costs:$.13/DGE

- CNG stations require regular preventative maintenance/ service and occasional rebuilds of compressors and replacement of other parts.

- Cost per DGE will vary based on total throughput (generally, larger throughput = less cost/DGE due to economies of scale)

- Maintenance/Repair/Service: $.25-.55/DGE.: **$.35/DGE***

# Components of CNG Cost

- Gas Bill: $.95/**DGE**
- Electric compression costs: $.13/**DGE**
- Maintenance/Repair/Service: Assume average of $.35/**DGE**
- **Capital amortization of equipment: $.30-.65/DGE**
  - Station cost divided by total DGE over life of equipment
  - Depreciation term will affect this cost (5 yrs,7 yrs,10 yrs, 10+?)
  - Cost of capital
  - Utilization factor (what % of capacity is actually utilized)

  - **Ex 1**: 20 veh. x 75 DGE/day x 6 days/wk = 9000 DGE/wk =~465,000 DGE/yr
  - 465,000 DGE/year x 7 yrs = 3,255,000 DGE
  - If fast-fill station cost is $1.5M, then **$.46/DGE**

  - **Ex 2**: 25 veh. x 75 DGE/day x 6 days/wk = 11,250 DGE/wk = ~585,000 DGE/yr x 7 years = 4,095,000 DGE
  - Same station, then **$.37/DGE**

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# Components of CNG Cost

- Gas Bill: $.95/DGE
- Electric compression costs: $.13/DGD
- Maintenance/Repair/Service: $.35/DGE
- Capital amortization of equipment: $.45/DGE

**SUB-TOTAL:**

- **$1.88/DGE (use by or sales to tax exempt entities)**
- **$2.44/DGE (use by or sales to taxable entities)**
  - Federal motor fuels excise tax: $0.183/GGE = ~$.205/DGE
  - Pennsylvania Motor Fuels Excise Taxes on CNG: $.312/GGE = ~$.35/DGE

# Appendix M

## Commonwealth Financing Authority
## Approved Projects – Energy Programs

*Projects approved at the March 10, 2015 meeting are highlighted in yellow*

# COMMONWEALTH FINANCING AUTHORITY
# APPROVED PROJECTS - ENERGY PROGRAMS

## SOLAR ENERGY

| | Applicant | Project | County | Loan | Grant |
|---|---|---|---|---|---|
| 1 | Merck & Co., Inc. | Merck Facility | Montgomery | | $937,650 |
| 2 | PA Solar Park, LLC | PA Solar Park Nesquehoning | Carbon | | $5,500,000 |
| 3 | Brown's Super Store, Inc. | ShopRite Cheltenham | Philadelphia | | $553,856 |
| 4 | Meck Energy Partners, LLC | FesslerUSA - Deer Lake Facility | Schuylkill | $815,360 | |
| 5 | City of Pittsburgh | City of Pittsburgh Firehouses | Allegheny | | $36,633 |
| 6 | Solar Roofing Systems, Inc., dba SRS Energy | SRS Energy | Montgomery | | $342,887 |
| 7 | Solar Power Industries | Manufacturing | Westmoreland | $1,005,017 | $937,500 |
| 8 | McNeil PPC, Inc. | Lancaster County Facility | Lancaster | | $876,000 |
| 9 | Dauphin County Industrial Development Authority | Facility-Middle Paxton Twp. | Dauphin | | $1,600,000 |
| 10 | Lehigh Valley Hospital | Two Hospital Buildings | Northampton | | $96,120 |
| 11 | Dallastown Area School District | High School/Middle School | York | | $1,000,000 |
| 12 | Carlisle Area School District | School Campus | Cumberland | | $950,000 |
| 13 | Artman Lutheran Home | Solar Hot Water | Montgomery | | $48,925 |
| 14 | Chatham University | Solar Hot Water | Allegheny | | $113,037 |
| 15 | Illuminex Corporation | R&D - Equipment | Lancaster | | $185,910 |
| 16 | Harleysville Mutual Insurance Co. | Solar PV-Montgomery County Facility | Montgomery | | $355,000 |
| 17 | Romark Logistics of PA | Solar PV-Warehouse Facility | Luzerne | | $2,160,346 |
| 18 | SKF USA, Inc. | Solar PV-Montgomery County Facility | Montgomery | | $344,839 |
| 19 | Knouse Foods Cooperative, Inc. | Solar PV-Operating Facility | Cumberland | | $3,500,000 |
| 20 | Adams Electric Cooperative, Inc. | Solar PV-Ground Mount Farm | Adams | | $84,240 |
| 21 | Tredyffrin Township | Solar PV-Turnpike Soundwall | Chester | | $31,500 |
| 22 | West Chester Borough | Solar PV - Mosteller Parking Garage | Chester | | $123,941 |
| 23 | UGI Development Company | Solar PV - Propane Storage Facility | Dauphin | | $125,000 |
| 24 | Masser Farms Realty, LTD | Solar PV - Facility | Schuylkill | | $1,000,000 |
| 25 | SEC BESD Solar One, LLC | Solar PV - High School/Middle School/Elementary School | Centre | | $1,440,720 |
| 26 | Positive Energy PA 1, LLC | Solar PV - Williams Township | Northampton | | $58,590 |
| 27 | Terradime-5637 Forbes, LLC | Solar PV - Apartment Complex | Allegheny | | $44,000 |
| 28 | Axion Power Manufacturing, Inc. | Solar R&D - Equipment | Lawrence | | $298,605 |
| 29 | Elizabethtown Solar Electric Partners, LLC | Solar PV - Masonic Village | Lancaster | | $1,000,000 |
| 30 | Plumbers Local Union No. 27 | Solar PV - Allegheny County Facility | Allegheny | | $25,300 |
| 31 | East Lycoming School District | Solar PV - Hughesville Campus | Lycoming | | $1,000,000 |
| 32 | Positive Energy Pennsylvania 3, LLC | Solar PV - Nazareth Middle School | Northampton | | $966,000 |
| 33 | GlaxoSmithKline LLC | Solar PV - Montgomerty County Facility | Montgomery | | $500,000 |
| 34 | WJB Entities, LLC | Solar PV - Allegheny County Facility | Allegheny | | $347,200 |
| 35 | SEC Bellefonte SD Solar One, LLC | Solar PV - Bellefonte High School | Centre | | $1,298,420 |
| 36 | Plumbers Local Union No. 27 | Solar Hot Water | Allegheny | | $5,000 |

| | | | | | |
|---|---|---|---|---|---|
| 37 | East Norwegian Solar 1, LLC | Solar PV - Schuylkill County (Flexera) | Schuylkill | | $1,500,000 |
| 38 | Blythe Solar 1, LLC | Solar PV - Schuylkill County (Flexera) | Schuylkill | | $1,500,000 |
| 39 | Ryan Solar 1, LLC | Solar PV - Schuylkill County (Flexera) | Schuylkill | | $1,500,000 |
| 40 | Blythe Water Authority Solar 1, LLC | Solar PV - Schuylkill County (Flexera) | Schuylkill | | $1,500,000 |
| 41 | Positive Energy Pennsylvania 2, LLC | Solar PV - Nazareth Middle School | Northampton | | $924,140 |
| 42 | Refreshing Mountain Camp, Inc. | Solar PV - Lancaster County Facility | Lancaster | | $106,314 |
| 43 | Air Products and Chemicals, Inc. | Solar PV - Headquarters Facility | Lehigh | | $1,000,000 |
| 44 | Colonial Solar, LLC | Solar PV - Colonial School District | Montgomery | | $689,635 |
| 45 | GlaxoSmithKline | Solar PV - Distribution Center | York | | $1,000,000 |
| 46 | Blue Renewable Energy, LLC (Church Farm) | Solar PV - Church Farm | Chester | | $1,191,154 |
| 47 | 500 Virginia Solar, LP | Solar PV - Office Building | Montgomery | | $759,360 |
| 48 | CIT Solar, LLC | Solar PV - Career Institute of Technology | Northampton | | $496,255 |
| 49 | Aqua Pennsylvania | Solar PV - Water Treatment Plant | Chester | | $1,500,000 |
| 50 | Blue Renewable Energy, LLC | Solar PV - Moravian Academy | Northampton | | $1,356,201 |
| 51 | BASD Farmersville Solar, LLC | Solar PV - Farmersville Elementary | Northampton | | $391,510 |
| 52 | BASD East Hills Solar, LLC | Solar PV - East Hills Middle School | Northampton | | $354,000 |
| 53 | Morningstar Marketplace, Inc. | Solar PV - Farmer's Market | York | | $733,200 |
| 54 | NewAge Industries | Solar PV - Manufacturing Facility | Bucks | | $1,000,000 |
| 55 | Mt. Joy Solar Power, LLC | Solar PV - Water Treatment Plant | Lancaster | | $485,000 |
| 56 | BASD Buchanan Solar, LLC | Solar PV - Buchanan Elementary | Northampton | | $331,632 |
| 57 | Laureldale Solar, LLC | Solar PV - Yuasa Battery Headquarters | Berks | | $300,212 |
| 58 | BASD Spring Garden Solar, LLC | Solar PV - Spring Garden Elementary | Northampton | | $297,000 |
| 59 | Beaver Solar, LLC | Solar PV - Eaton Corp. Facilities | Beaver/Allegeny | | $1,675,000 |
| 60 | Quarryville Power Partners, LLC | Solar PV - Retirement Community | Lancaster | | $575,000 |
| 61 | JLTwin Land Co LP | Solar PV - Headquarters Facility | Allegheny | | $110,050 |
| 62 | Lower Moreland Township School District | Solar PV - Lower Moreland SD | Montgomery | | $851,000 |
| 63 | Blue Renewable Energy, LLC | Solar PV - Anncillae-Asumpta Academy | Montgomery | | $121,500 |
| 64 | Blue Renewable Energy, LLC | Solar PV - Gettysburg College | Adams | | $446,738 |
| 65 | Blue Renewable Energy, LLC | Solar PV - Springside School | Philadelphia | | $201,894 |
| 66 | SSA Solar of PA, LLC | Solar PV - Water Treatment Plant | Franklin | | $1,437,696 |
| 67 | BASD Freedom Solar, LLC | Solar PV - Freedom High School | Northampton | | $453,870 |
| 68 | Urban Redevelopment Authority of Pittsburgh | Solar PV - EECO Center | Allegheny | | $14,000 |
| 69 | UGI Development Company | Solar PV - Crayola Facility | Northampton | | $508,000 |
| 70 | Cumberland Valley School District | Solar PV - Cumberland Valley SD | Cumberland | | $160,000 |
| 71 | Blue Renewable Energy, LLC | Solar PV - Delaware Valley Friends | Chester | | $124,740 |
| 72 | Blue Renewable Energy, LLC | Solar PV - Flat Iron Building/Sycamore | Northampton | | $55,440 |
| 73 | Urban Redevelopment Authority of Pittsburgh | Solar Hot Water | Allegheny | | $3,000 |
| 74 | Converteam Naval Systems, Inc. | Outdoor Solar Inverter Research & Development | Allegheny | | $18,135 |
| 75 | Young Men's Christian Association of Chambersburg | Solar Thermal for Chambersburg YMCA | Franklin | | $9,375 |
| | | | **Total:** | **$1,820,377** | **$53,568,270** |

**RENEWABLE ENERGY - GEOTHERMAL AND WIND PROJECTS**

| Applicant | Project | County | Loan | Grant |
|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | EZNERGY, LLC | Installation of a Geothermal System | Montgomery | $7,635 | | |
| 2 | Curwensville Area School District | Curwensville Elementary-Jr /Sr High School | Clearfield | $644,280 | | |
| 3 | Mennonite Historians of Eastern Pennsylvania | Mennonite Heritage Center | Montgomery | $34,500 | | |
| 4 | Pittsburgh Gateways Corporation | Green Innovators Flagship Campus | Allegheny | $493,810 | | |
| 5 | Armstrong County Industrial Development Authority | Northpointe Multi-tenant Building | Armstrong | $90,000 | | |
| 6 | St. Jacobs Lutheran Church | Geothermal Unit for Church | York | $31,200 | | |
| 7 | Jeffrey Fanok and Susan Fuertsch-Fanok | Residence Geothermal System Purchase and Installation | Montgomery | $12,110 | | |
| 8 | Kevin Hiestand and Jennifer Hiestand | Purchase and installation of residential geothermal system | Lehigh | $11,134 | | |
| 9 | G. Blaine Hetrick III and Elizabeth Hetrick | Purchase and installation of residential geothermal system | Lancaster | $19,150 | | |
| 10 | Harold and Maria Ciampoli | Purchase and installation of residential geothermal system | Montgomery | $14,749 | | |
| 11 | Gary and Carmella Deck | Purchase and installation of residential geothermal system | Berks | $9,118 | | |
| 12 | Omni Wind Energy Systems, LLC | New Equipment Purchase | Bucks | $300,000 | | |
| 13 | Randy and Marilyn Moses | Geothermal System Installation | Berks | $8,000 | | |
| 14 | Chestnut Flats Wind, LLC | Chestnut Flats Wind Farm | Blair | | $1,000,000 | |
| 15 | Hillandale Farms East, Inc. | Hillandale Farms East Wind Turbine Project | York | | $100,000 | |
| 16 | Joseph and Marilyn Ging | Home Georthermal Project | Berks | $10,478 | | |
| 17 | Kenneth L. and Jennifer E. Eshleman | Tim Drive Geothermal Unit | Lancaster | $9,427 | | |
| 18 | David and Amanda Bokash | Geothermal Installation | Butler | $14,802 | | |
| 19 | Michael DeLeo and Kimberly DeLeo | Geothermal low interest loan | Chester | $13,492 | | |
| 20 | Ambar Falcon Property LP | Geothermal System Installation | Allegheny | $234,000 | | |
| 21 | Jody and James Rule | Geothermal System Purchase and Installation | Lebanon | $11,539 | | |
| 22 | John and Christa Zitko | Residential Geothermal Heat Pump Installation | Dauphin | $8,223 | | |
| 23 | Miroslaw & Margaret Baranowski | Home Geothermal | Monroe | $15,625 | | |
| 24 | Gregory P. Bokoch & Diana L. Bokoch | Geothermal Installation | Fayette | $11,725 | | |
| 25 | Mark Foley | Residential Geothermal Project | Bucks | $24,956 | | |
| 26 | The Service Team, Inc. | Wind Turbine Project | Carbon | | $150,000 | |
| 27 | Patton Wind Farm, LLC | Patton Wind Farm Project | Cambria | | $3,200,000 | |
| 28 | Donna & John Powell | Geothermal for 1332 Monk Road | Montgomery | $27,970 | | |
| 29 | Eric S. Poe | Poe PA House | Bucks | $56,425 | | |
| 30 | Lawrence Street Partners, LP | Lawrence Street Partners Geothermal | Dauphin | $292,320 | | |
| 31 | Big Savage LLC | Twin Ridges Wind Farm | Somerset | | $12,651,000 | |
| 32 | David B. Rodgers | Purchase and installation of residential geothermal system | Venango | $11,735 | | |
| 33 | Trevor S. and Hannah R. Martin | Residential Geothermal Project | Berks | $16,856 | | |
| | | | **Total:** | **$2,435,259** | **$17,101,000** | |

## ALTERNATIVE AND CLEAN ENERGY

| | Applicant | Project | County | Loan | Grant | Guarantee |
|---|---|---|---|---|---|---|
| 1 | Lake Erie Biofuels, LLC | Lake Erie Biofuels Production & Distribution | Erie | | $1,640,240 | |
| 2 | Tri State Biofuels LLC | Tri State Biofuels | Fayette | | $360,000 | |
| 3 | Keystone Pellet, Inc. | Wood Pellet Manufacturing Plant | Carbon | $770,000 | $220,000 | |
| 4 | Pittsburgh Gateways Corporation | Green Innovators Flagship Campus | Allegheny | | $2,000,000 | |
| 5 | Northeast Bradford School District | Northeast Bradford Energy Conservation Project | Bradford | $905,000 | | |
| 6 | Ernst Biomass, LLC | Ernst Switchgrass Densification Project | Crawford | $902,707 | | |

| | | | | | |
|---|---|---|---|---|---|
| 7 | American Refining Group, LLC | Biofuels Mandate Compliance Project | McKean | | $497,042 |
| 8 | Ben Franklin Technology Partners of NEP | Ben Franklin TechVentures Expansion | Northampton | | $750,000 |
| 9 | Phipps Conservatory & Botanical Gardens | Center for Sustainable Landscapes Building | Allegheny | $2,000,000 | |
| 10 | Dinwiddie Housing Limited Partnership | Lower Hill Geothermal District | Allegheny | $273,872 | |
| 11 | Energex American, Inc. | Wood Pellet Fuel Expansion | Juniata | | $129,978 |
| 12 | KBI Industries, Inc. | KBI, Inc. - Advanced Bio-refinery Upgrade Project | Cumberland | | $2,000,000 |
| 13 | CeeLite Technologies, LLC | CeeLite Manufacturing Project | Montgomery | | $260,738 |
| 14 | The Pennsylvania State University | Development of Central PA Laboratory for Biofuels | Dauphin | | $817,000 |
| 15 | ACTION-Housing, Inc. | Pittsburgh Net Zero Project | Allegheny | | $111,062 |
| 16 | Beaver County | Beaver County Energy Conservation Lighting Upgrades | Beaver | $58,403 | |
| 17 | Lower Saucon Township | Lower Saucon Township Energy Efficiency Upgrade | Northampton | $87,748 | |
| 18 | Granger Energy of Morgantown, LLC | Conestoga Landfill Gas Project | Berks | | $2,000,000 |
| 19 | Crawford Central School District | Biomass District Heating System | Crawford | | $240,498 |
| 20 | Accelergy Corporation | PA Integrated Coal - Biomass to Liquids Feasibility Study | N/A | | $175,000 |
| 21 | Quanta Technologies Inc. | Quanta Panel TM/IGS Manufacturing Operation | Lancaster | $585,298 | |
| 22 | Penns Valley Area School District | Penns Valley Area SD Biomass Boiler Project | Centre | | $858,483 |
| 23 | Minersville Area School District | Energy Improvement Project | Schuylkill | $496,368 | |
| 24 | County of Blair | Blair County (Blair County Airport Project) | Blair | $86,681 | |
| 25 | Alcoil, Inc. | High Efficiency, Microchannel Heat Exchanger Production | York | | $516,205 |
| 26 | Y-Carbon, Inc. | Development of Y-Carbon's Alternative Energy Manufacturing | Bucks | | $41,911 |
| 27 | ILLUMINEX Corporation | Development of NanoStructured Lithium Ion Battery Anodes | Lancaster | | $5,862 |
| 28 | City of York | Micro-turbine Co-generation System Project | York | $1,500,000 | |
| 29 | Evangelical Community Hospital | Evangelical Community Hospital Biomass Boiler | Union | $800,000 | |
| 30 | Sullivan County School District | Sullivan County School District Biomass Project | Sullivan | $686,556 | $250,000 |
| 31 | Providence Township | Wood Gasification Boiler | Lancaster | | $43,687 |
| 32 | Jay C and Andrea Sensenig | Small Co-op Digester at Sensenig Family Farm | Lancaster | | $575,000 |
| 33 | Zoological Society of Pittsburgh | ICC Biomass Burner | Somerset | | $267,000 |
| 34 | City of Allentown | Waste to Energy Project | Lehigh | | $2,000,000 |
| 35 | Furman Foods Inc. dba Furmano Foods | Furmano's Waste to Energy | Northumberland | | $1,750,000 |
| 36 | Albright College | Albright Sustainability Project | Berks | $295,000 | |
| 37 | Highland North LLC | Highland North Wind Project | Cambria | | $6,000,000 |
| 38 | Roaring Spring Blank Book Company | Roaring Spring Blank Book Biofuel | Blair | | $70,000 |
| 39 | Monongahela Valley Hospital | MVH Energy Efficiency Project | Washington | $1,948,000 | |
| 40 | EnergyWorks BioPower, LLC | Gettysburg Energy and Nutrient Recovery Facility | Adams | $5,000,000 | |
| 41 | Tamaqua Area School District | Energy Efficiency and Geothermal Project | Schuylkill | $754,980 | |
| 42 | Clarion Hospital | Clarion Hospital Chiller | Clarion | $179,000 | |
| 43 | Advanced-Tech Materials LLC | Advanced-Tech Materials Manufacturing Project | Luzerne | | $13,764 |
| 44 | The Pennsylvania State University | Grid STAR: Smart Grid Training & Application Resource Center | Philadelphia | | $1,022,500 |
| 45 | Power Source LLC | Sodium Sulfer Energy Storage | Wayne | | $2,000,000 |
| 46 | Accelergy Corporation | Pennsylvania ICBTL Demonstration Project | Allegheny | | $1,300,648 |
| 47 | Reinford-Freymoyer LLC | Reinford-Freymoyer Farm Waste to Power Project | Juniata | | $388,113 |
| 48 | Hard Earned Acres Inc. | Biogas Project at Hard Earned Acres Inc. | Cumberland | | $300,114 |
| 49 | Yippee Farms | Biogas Project at Yippee Farms | Lancaster | | $838,690 |
| 50 | Twin Springs Fruit Farm, Inc. | On farm fuel stich to wood biomass from coal | Adams | | $248,500 |
| 51 | UO Real Estate, LLC | UO Fuel Cell Installation | Philadelphia | | $1,274,843 |
| 52 | Vynecrest LLC | Renewable Energy - Geothermal Project | Lehigh | $30,000 | |

| | | | | | |
|---|---|---|---|---|---|
| 53 | The Cooperage Project | The Cooperage Alternative Energy Project | Wayne | | $35,430 |
| 54 | Northern Bedford County School District | Northern Bedford County School District Campus Biomass Plant | Bedford | | $746,192 |
| 55 | Omnova Solutions, Inc. | Omnova Auburn CHP | Schuylkill | | $1,115,464 |
| 56 | Borough of Chambersburg | Express Generator Feeder & Substation Expansion | Franklin | | $900,000 |
| 57 | Green Resource Energy, LLC | Biofuel Project | Bucks | $258,153 | |
| 58 | Aquion Energy, Inc. | Aquion Manufacturing Facility | Westmoreland | $3,000,000 | $2,000,000 |
| 59 | The Borough of Mount Oliver | Mt. Oliver Borough Energy Efficiency Street Lighting | Allegheny | $39,523 | |
| 60 | Clemens Food Group, LLC | Combined Heat and Power | Montgomery | | $2,000,000 |
| 61 | Phoenix Contact Services Inc. | Combined Heating and Power Unit | Dauphin | | $975,000 |
| 62 | PMF Industries, Inc. | US CNG Products | Lycoming | | $250,000 |
| 63 | Beemac Trucking LLC | Beemac Trucking CNG | Beaver | | $469,292 |
| 64 | Birkmire Trailer Company | CNG Filling Station | Erie | | $207,969 |
| 65 | Clean Energy | Carlisle Flying-J Liquefied Natural Gas Fueling Station | Cumberland | | $539,014 |
| 66 | Desdemona Holdings LP | American Natural Station Square CNG Development | Allegheny | $248,200 | $372,300 |
| 67 | LT Verrastro, Inc. | L.T. Verrastro Filling Station | Lackawanna | | $217,399 |
| 68 | Bensalem Township School District | Bensalem High School | Bucks | | $2,000,000 |
| 69 | Tri-Valley School District | Hegins-Hubley Elementary | Schuylkill | | $565,000 |
| 70 | Tri-Valley School District | Mahantongo Elementary | Schuylkill | | $320,000 |
| 71 | Mahoning Creek Hydroelectric Company, LLC | Mahoning Creek Hydroelectric Project | Armstrong | | $3,800,000 |
| 72 | Bloomsburg University | Steam Plant Biomass Cogen Upgrade | Columbia | | $2,000,000 |
| 73 | Green Harvest Augsburger Corporation | Distributed Energy Resource Facility - Phase 2 | Lancaster | $2,000,000 | |
| 74 | Hickory Hollow Farms | On-Farm anaerobic digester | Chester | | $365,690 |
| 75 | UO Real Estate, LLC | URB200 kW Fuel Cell | Philadelphia | | $432,000 |
| 76 | "O" Ring CNG Fuel Systems, Inc. | Borough of Chambersburg CNG Project | Franklin | | $645,000 |
| 77 | Sunoco | CNG Refueling - PA Turnpike King of Prussia Service Plaza | Montgomery | | $504,348 |
| 78 | VNG.CO LLC dba V NG.CO | 2901 Abbottsford | Philadelphia | $169,150 | $253,725 |
| 79 | Clean Energy dba Clean Energy Inc. | New Oxford CNG Station | Adams | | $436,267 |
| 80 | Clean Energy dba Clean Energy Inc. | King of Prussia CNG Station | Montgomery | | $196,543 |
| 81 | Halifax Area School District | High Performance Building project | Dauphin | | $1,500,000 |
| 82 | Hatboro-Horsham School District | Construction of HPB project | Montgomery | | $2,000,000 |
| 83 | Manheim Central School District | High Performance Building project | Lancaster | | $2,000,000 |
| 84 | Newport Area School District | High Performance Building project | Perry | | $1,000,000 |
| 85 | Lancaster Resort Limited Partnership | Eden CHP | Lancaster | | $338,511 |
| 86 | Indian Springs Sawmill | Wood Biomass Boiler | Luzerne | $49,861 | $74,791 |
| 87 | Aqua Pennsylvania, Inc. | West Chester ACE Grant | Chester | | $34,100 |
| 88 | Aqua Pennsylvania, Inc. | Willow Grove ACE Grant | Montgomery | | $35,295 |
| 89 | Clean Energy dba Clean Energy Inc. | Allentown LNG Public-Access Fueling | Lehigh | | $502,297 |
| 90 | REV LNG, LLC | REV LNG Small Scale Liquefaction Project | Bradford | $2,300,000 | |
| 91 | Bethlehem Area School District | LEED-Certified Middle School | Northampton | | $2,000,000 |
| 92 | The Lehigh Valley Charter High School for the Arts | High Performance Building project at Senior High School | Berks | $2,000,000 | |
| 93 | ENER-G Rudox, Inc. | Cathedral Village Clean Energy Infrastructure Project | Philadelphia | | $500,000 |
| 94 | Love's Travel Stops & Country Stores | Love's Mifflin CNG Station Project | Columbia | | $885,910 |
| 95 | Love's Travel Stops & Country Stores | Love's Jonestown CNG Station Project | Lebanon | | $924,809 |
| 96 | Love's Travel Stops & Country Stores | Love's Carlisle CNG Station Project | Cumberland | | $924,809 |
| 97 | Silvi Concrete of Chester County, LLC | Downingtown Natural Gas Station | Chester | | $244,222 |
| 98 | Constructional Dynamics, Inc. | Limerick Natural Gas Station | Montgomery | | $244,222 |

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| 99 | Waste Management of Pennsylvania, Inc. | WM Pen Argyl Grand Central Station CNG Station Project | Northampton | | $806,248 |
| 100 | Clean Energy dba Clean Energy Inc. | Pittston Public-Access LCNG Fueling Station | Luzerne | | $1,172,080 |
| 101 | Clean Energy dba Clean Energy Inc. | Pottsville Public-Access LCNG Fueling Station | Schuylkill | | $1,172,080 |
| 102 | Clean Energy Trache A LNG Plant, LLC | PA LNG Facility | Eastern PA | | $2,000,000 |
| 103 | Pottsgrove School District | Pottsgrove High School Modernization Project | Montgomery | | $2,000,000 |
| 104 | Ariel Holdings LP | American Natural Harmar CNG Project | Allegheny | | $720,000 |
| 105 | Hypatia Holdings LP | American Natural Wexford CNG Project | Allegheny | | $600,000 |
| 106 | Biomaxx, Inc. | Biomaxx Process Optimization & Product Expansion Project | Potter | | $90,000 |
| 107 | Lehighton Area School District | HPB Lehighton Primary/Elementary Center | Carbon | | $2,000,000 |
| 108 | Downs Racing, L.P. | Mohegan Sun at Pocono Downs CHP | Luzerne | | $950,000 |
| 109 | Doylestown Hospital | Doylestown Hospital Cogeneration Systen | Bucks | $857,727 | $442,273 |
| 110 | Empower Energies, Inc. | LeBus Bakery CHP Project | Montgomery | | $457,473 |
| 111 | Global Tungsten & Powders Corp | GTP Cogeneration | Bradford | | $2,000,000 |
| 112 | Lock+ Hydro Friends Fund XLII | Braddock Hydropower Project | Allegheny | | $4,000,000 |
| 113 | MBC Development, LP | Franklin & Marshall CHP | Lancaster | $939,000 | $614,000 |
| 114 | PH Glatfelter Company | Spring Grove BMACT Natural Gas Project | York | | $3,000,000 |
| 115 | Robert Packer Hospital | Robert Packer Hospital Combined Heat and Power | Bradford | $1,589,139 | |
| 116 | SFG CHP LLC | Rittenhouse Claridge CHP | Philadelphia | | $150,000 |
| 117 | Clean Energy dba Clean Energy Inc. | Warminster PECO Public-Access CNG Station | Bucks | | $257,109 |
| 118 | Clean Energy dba Clean Energy Inc. | Berwyn PECO Public-Access CNG Station | Chester | | $217,268 |
| 119 | Clean Energy dba Clean Energy Inc. | Coatesville PECO Public-Access CNG Station | Chester | | $215,060 |
| 120 | Clean Energy dba Clean Energy Inc. | Phoenixville PECO Public-Access CNG Station | Chester | | $215,060 |
| 121 | Clean Energy dba Clean Energy Inc. | Mill Hall Public-Access CNG Station | Clinton | | $400,257 |
| 122 | Clean Energy dba Clean Energy Inc. | Carlisle | Cumberland | | $400,257 |
| 123 | Clean Energy dba Clean Energy Inc. | Alternative and Natural Gas | Delaware | | $215,060 |
| 124 | Clean Energy dba Clean Energy Inc. | Concordville-Glen Mills Lehigh Gas Public-Access CNG Station | Delaware | | $417,786 |
| 125 | Clean Energy dba Clean Energy Inc. | Lehigh Gas Public-Access CNG Station | Lehigh | | $430,991 |
| 126 | Clean Energy dba Clean Energy Inc. | Plymouth Meeting PECO Public-Access CNG Station | Montgomery | | $215,060 |
| 127 | Clean Energy dba Clean Energy Inc. | Smithon Public-Access CNG Station | Westmoreland | | $400,257 |
| 128 | CNG Motor Fuels of Clearfield County, Inc. | New CNG Station in Dubois, PA | Clearfield | | $681,680 |
| 129 | CNG Motor Fuels of Jefferson County, LP | Brookville CNG Station Expansion Project | Jefferson | | $287,600 |
| 130 | CNG Motor Fuels of Jefferson County, LP | Punxsutawney CNG Station Expansion Project | Jefferson | | $353,600 |
| 131 | CNG Motor Fuels of Somerset County LLC | New CNG Station in Somerset, PA | Somerset | | $1,024,800 |
| 132 | Export Fuel Company, Inc. | New CNG Station in Greensburg, PA | Westmoreland | | $681,680 |
| 133 | Integrys Transportation Fuels dba Trillium CNG | Schuylkill County CNG Station Project | Schuylkill | | $824,000 |
| 134 | Sunoco, Inc. | Sunoco CNG Refueling - Pittsburgh Airport | Allegheny | | $830,961 |
| 135 | Sunoco, Inc. | Sunoco CNG Refueling - PA Turnpike New Staton Plaza | Westmoreland | | $733,556 |
| 136 | VNG.CO LLC | 400 W. Street Road | Bucks | $96,903 | $387,610 |
| 137 | VNG.CO LLC | 3001 W. Germantown Pike | Montgomery | $96,803 | $387,210 |
| 138 | Clean Energy dba Clean Energy Inc. | Allentown LCNG | Lehigh | | $400,257 |
| 139 | United Parcel Service | The Commonwealth's LNG Conversion Inititive | Cumberland | | $767,740 |
| 140 | Pittsburgh Parks Conservancy | Frick Environmental Center | Allegheny | | $1,590,000 |
| 141 | Southern Lehigh School District | Southern Lehigh School District - New Elementary School | Lehigh | | $2,000,000 |
| 142 | WATT Fuel Cell | Fuel Cell Manufacturing Line | Westmoreland | | $330,000 |
| 143 | Lehighton Area School District | HPB Lehighton Area Middle School, LASD in Carbon Co. | Carbon | | $1,450,000 |
| 144 | Lehighton Area School District | HPB Lehighton Area High School, LASD in Carbon Co. | Carbon | | $1,065,000 |

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|---|---|---|---|---|---|---|
| 145 | South Middleton School District | Iron Forge Elementary School Modernization Project | Cumberland | | $2,000,000 | |
| 146 | State College Area School District | State College Area High School Modernization Project | Centre | | $2,000,000 | |
| 147 | Clean Energy dba Clean Energy Inc. | Clean Energy South Philadelphia Public-Access CNG Station | Philadelphia | | $921,217 | |
| 148 | Constellation New Energy, Inc. | Commonwealth Energy Group CNG Station Initiative | Lackawanna | | $1,250,589 | |
| 149 | Integrys Transportation Fuels dba Trillium CNG | HIA Public Access CNG Fueling Station | Dauphin | | $712,063 | |
| 150 | Snyder Brothers, Inc. | Snyder Brothers Inc. CNG Fueling Station | Armstrong | | $308,172 | |
| 151 | Sunoco, Inc. | Sunoco CNG Refueling - Canonsburg | Washington | | $772,310 | |
| 152 | Sunoco, Inc. | Sunoco CNG Refueling - Chambersburg | Franklin | | $591,502 | |
| 153 | U.S. Venture, Inc. | Fairless Hills Public CNG Filing Station | Bucks | | $547,074 | |
| 154 | U.S. Venture, Inc. | Fredericksburg Pacific Pride Station | Lebanon | | $643,389 | |
| 155 | Ar Joy Farms LLC | Ar Joy Farms - Digester | Chester | | $564,301 | |
| 156 | Brubaker Farms LLC | Brubaker Farms - Anaerobic Digester | Lancaster | | $725,013 | |
| 157 | Drew Remley Farm | Remley Farm | Tioga | | $546,382 | |
| 158 | Knouse Foods Corp., Inc. | Wastewater Treatment with Biogas Fuel Cell Project | Adams | | $780,000 | |
| 159 | NBC Philadelphia Merchants, Inc. | TJX Philadelphia Distribution Central Fuel Cell Project | Philadelphia | | $2,000,000 | |
| 160 | Oak Spring Farms | Oak Spring Farms - Anaerobic Digester | Centre | | $625,082 | |
| 161 | The Tuthill Corporation | Blue Mountain Combined Heat & Power | Carbon | $1,506,400 | | |
| 162 | ENER-G Rudox, Inc. | Simpson Senior Services Clean Energy Infrastructure Project | Philadelphia | | $400,000 | |
| 163 | M. Simon Zook Company | Conversion of LFG Generation to Combined Heat & Power | Lancaster | $211,296 | | |
| 164 | Lancaster General Hospital | Combined Heat and Power | Lancaster | | $1,300,000 | |
| 165 | Robert Packer Hospital | Combined Heat and Power | Bradford | | $1,589,139 | |
| 166 | Lackawanna County Commissioners | Lackawanna County CHP | | | $302,816 | |
| 167 | Borough of Columbia | Columbia Avenue Anaerobic Digester Project | Lancaster | $853,135 | | |
| 168 | Clean Energy dba Clean Energy Inc. | Clean - Centre County Public Access CNG Station | Centre | | $642,894 | |
| 169 | Great River Energy, LLC | The Easton PA Public CNG Station Initiative | Northampton | | $736,350 | |
| 170 | United Parcel Service | UPS New Stanton CNG Conversion Initiative | Westmoreland | | $896,286 | |
| 171 | Sycamore Hill Farm Development, LP | Creating a LEED Gold Neighborhood in Bethlehem, PA | Northampton | $834,338 | | |
| 172 | Lewisburg Area School District | New Lewisburg Area High School | Union | | $2,000,000 | |
| 173 | Council Rock School District | Council Rock - Newtown | Bucks | | $2,000,000 | |
| 174 | Council Rock School District | Council Rock - Holland | Bucks | | $2,000,000 | |
| 175 | Manheim Central School District | HPB Doe Run Elementary School | Lancaster | | $2,000,000 | |
| | | | **Total:** | **$34,409,241** | **$133,731,069** | **$0** |

## HIGH PERFORMANCE BUILDING

| | Applicant | Project | County | Loan | Grant |
|---|---|---|---|---|---|
| 1 | Dr. Ahmed Gomaa | High Performance Building Renovation | Lackawanna | | $29,000 |
| 2 | Lucyna de Barbaro and Ayres Freitas | Squirrel Hill Passive House Duplex | Allegheny | | $69,676 |
| | | | **Total:** | | **$98,676** |

| | Loan | Grant | Guarantee |
|---|---|---|---|
| **Subtotal Approved:** | **$38,664,877** | **$204,499,015** | **$0** |
| **(284) Total Projects** | | | |