Guidebook – Natural Gas for **Delivery** Fleets in New York

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June 2012

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1 Purpose

The purpose of this guidebook is to help private delivery companies in New York State understand how compressed natural gas (CNG) vehicles can serve their fleet needs and save money. The use of CNG to displace gasoline or diesel fuel assists New York State in achieving its broad energy security and environmental air quality goals. This booklet describes an overall approach and process for converting a fleet to CNG. While every fleet and operation is different and has its own unique features, this material will provide overview information to assist a New York State delivery fleet in determining if CNG vehicles are a viable option and in locating the basic knowledge to start evaluating and implementing a CNG vehicle program. If more detailed information than provided in this guidebook is desired, the fleet should contact experts in the field to learn about all available options and obtain fleet-specific advice. The local Clean Cities Coalitions are well-connected to help fleets take advantage of all available resources, learn about opportunities to share infrastructure, explore vehicle bulk buying collaborations, and learn from other local organizations that have successfully implemented a CNG vehicle program.

A surge in interest in the use of CNG for commercial fleets, especially heavy-duty vehicles, has been driven by the fuel cost differential. Traditionally, the price of CNG for transportation applications has followed the price trend for conventional petroleum fuels in the transportation market, with modestly lower prices for CNG. Natural gas is primarily produced domestically and technological advancements have increased the potential domestic supply, while petroleum imports suffer from unstable world events. This has caused the price of CNG at the pump to stabilize while conventional petroleum fuel prices have risen; during some time periods producing wide cost differentials between CNG and diesel fuel, as shown in Figure 1. This price differential will fluctuate over time, but market and supply trends for natural gas and petroleum make it likely that it will continue to be less costly to operate a CNG vehicle than a diesel vehicle.

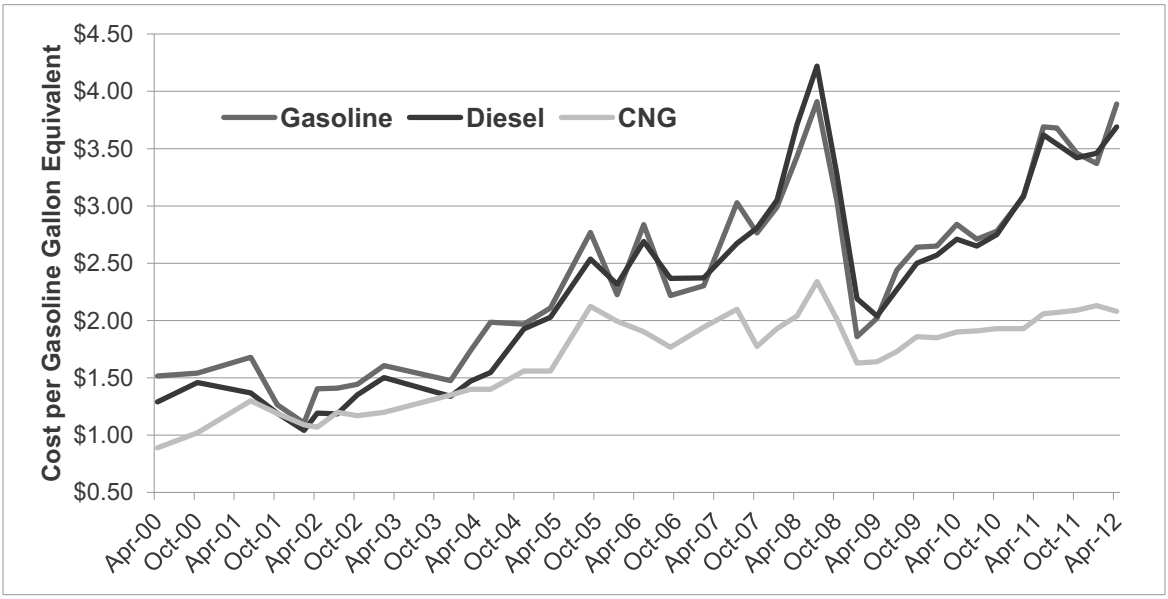

Figure 1. Average retail fuel prices in the United States (DOE, 2012)

2 Introduction

Delivery vehicles play a vital role in the economy by transporting products to consumers both in New York State and throughout the United States. They are necessary to deliver essential goods to every urban and rural community across the State: more than 80% of communities depend solely on these trucks for delivery of goods and commodities(American Trucking Associations, 2009). Delivery trucks are used to maintain a regular flow of inventory to stores, allowing them to minimize on-site storage for excess product and avoid stocking more than can be sold in a short time period. Many delivery companies also serve customers directly through business contracts or direct orders. Most medium- and heavy-duty delivery vehicles traditionally run on petroleum fuels, specifically diesel fuel. Petroleum fuels are New York State's largest energy source, and the transportation sector is the largest consumer of petroleum, accounting for 77% of the State's total petroleum consumption in 2009 (NYSERDA, 2011). The State must import virtually all of its petroleum. In 2009, $23.7 billion left the State's economy to purchase these fuels (NYSERDA, 2011). As the volatile price of oil continues to rise, dependence on petroleum will become an even greater drain on the State's economy. It also presents serious long-term energy security concerns both regionally and nationally.

Petroleum fuel combustion also contributes to poor air quality and the resulting negative health impacts. Transportation emission sources are especially significant contributors to the formation of ozone, particulate matter (PM), and toxic emissions. Metropolitan areas with high concentrations of vehicles (including delivery vehicles) such as Rochester, Buffalo, Poughkeepsie, the Capital District, and the greater New York City area have air pollution levels that persistently exceed the national ambient air quality standards (EPA, 2012). Petroleum fuel combustion by the transportation sector also contributed approximately 40% of the State's total greenhouse gas (GHG) emissions in 2009, making the transportation sector the single largest GHG emission contributor in the State for that year (NYSERDA, 2011).

The U.S. Environmental Protection Agency's (EPA's) heavy-duty engine emissions and fuel regulations have significantly reduced heavy truck emissions over the past decade. The EPA's 2007 standards required significant reductions in nitrogen oxides (NO_X) and PM emissions. Manufacturers met these standards using exhaust aftertreatment technologies, such as diesel oxidation catalysts (DOCs) and diesel particulate filters (DPFs). These devices can be complex, expensive, and maintenance intensive, while also having a detrimental effect on fuel economy. For the NO_X reductions required by the EPA 2010 standard, most manufacturers chose to use selective catalytic reduction (SCR) technology, which improves the fuel economy while increasing complexity and adding weight. SCR technology uses a Diesel Exhaust Fluid (DEF) that creates a chemical reaction to convert the NO_X to ammonia emissions. DEF must be stored in fleet yards to replenish its supply onboard the vehicle and continually injected by the SCR into the exhaust to reduce the NO_X emissions to meet the EPA standard. These systems have increased the costs of heavy-duty engines both in initial purchase price and in maintenance costs over the life of the vehicles. One heavy-duty vehicle manufacturer has chosen an alternative technology to meet the NO_X emission standard, but the engine has not yet been approved by the EPA.

Therefore, current engines sold by this manufacturer are subject to a fine until the technology has passed EPA certification. Manufacturers of heavy-duty diesel engines will continue to be challenged by the regulations, as new fuel efficiency and GHG standards have been adopted into law and will take effect by 2014.

Compressed natural gas (CNG), an alternative fuel for vehicles, can address the significant economic, environmental, and energy security concerns described above. Natural gas is extracted from underground reserves and can be found in many locations across the United States, including New York State. Domestic production of natural gas meets most of the current demand in electricity production, space and water heating, cooking, and transportation. Technical advancements have increased the amount of natural gas that can be extracted, as seen in the recent boom in supply from shale deposits. A renewable form of natural gas can be produced from decaying organic materials such as waste from landfills, wastewater, and livestock. It is estimated that North America has enough natural gas resources to last more than 100 years at current consumption levels (American Clean Skies Foundation, 2012). There are approximately 120,000 natural gas vehicles on roads today in the United States, accounting for only about 0.1% of the total natural gas consumption (DOE, 2012). Therefore, short-term increases in the number of natural gas vehicles will have minimal impact on the total consumption or available supply of this resource. The United States has a vast natural gas distribution system, with more than 300,000 miles of interstate transmission pipelines (more than 5,000 miles within New York State) and an additional 1.9 million miles of distribution lines within utility service areas (EIA, 2009). In New York State the distribution system includes thousands of delivery, receipt, and interconnection points that make it readily available to most commercial and residential locations.

CNG, which is primarily composed of methane, can offer notable reductions in criteria pollutant and GHG emissions as compared to diesel fuel. Tests have shown significant reductions in NO_X and PM by using CNG, even relative to current production diesel engines, but these results are very dependent on the vehicle type and duty cycle. In heavy-duty vehicles, CNG engines produce 20%–23% fewer GHG emissions (DOE, 2012). However, unlike diesel engines that now require extensive aftertreatment (DOC+DPF+SCR), CNG engines usually use a low-cost, maintenance-free, proven three-way catalyst to meet prevailing emission standards. This has reduced the incremental cost for new heavy-duty CNG engines compared to new diesel engines, improving the economic payback. CNG engines also operate much quieter than diesel engines, resulting in a better work environment for the operator and the surrounding community.

Environmental and economic benefits of CNG vehicles as well as their “green” image have convinced a number of large companies with national fleets to implement CNG vehicle programs. AT&T has committed to using CNG where fueling is available, and the company anticipates it will purchase up to 8,000 CNG vehicles by the end of 2013. After testing a pilot fleet of 18 CNG trucks, Frito-Lay announced plans to purchase CNG vehicles as its fleet is replaced, recognizing that it is a win-win solution both in terms of sustainability strategy and reducing costs. Waste Management is implementing a nationwide plan to convert all of its 18,342 trucks to CNG because of the economics for its application. Fleet operators must consider, however, whether the available CNG vehicles fit their needs and will use enough fuel to pay back the incremental vehicle costs. In addition, companies must determine if building a CNG fueling station is feasible

(either by the fleet itself or by an independent station operator) if publicly accessible fueling is not available. Because CNG may not be the right choice for every fleet, the New York State Energy Research and Development Authority sponsored the development of this document to inform private delivery fleet managers of the options for using CNG.

3 Fleet Assessment – Steps to Take

This section outlines the basic steps for initiating a compressed natural gas (CNG) vehicle program. The section covers all the aspects necessary for adopting CNG as a fuel for the fleet and summarizes the critical information that must be understood. Subsequent sections and appendices provide more in-depth details and are appropriately referenced in this Fleet Assessment when further information on a specific topic is desired. A condensed summary of the assessment steps is in **Appendix H: Natural Gas Vehicle Project Planning Checklist**. The basic steps for initiating a program are:

- Understand the basics of natural gas and CNG vehicles
- Assess fleet vehicle characteristics (Are route characteristics, vehicle age, etc. favorable for CNG use?)
- Review CNG vehicle options (Are there available CNG options for the fleet's preferred vehicles?)
- Evaluate existing and planned CNG infrastructure (Is a fueling station available close to fleet operations or is a new CNG station being planned nearby?)
- Assess facility property (Is the fleet willing to build its own station? Is there adequate gas supply? Is the site appropriate for building a CNG station? Would public access be viable?)
- Understand the corporate business strategy (If the fleet plans onsite fueling, will it be owned or provided by a third party? Who will take care of station maintenance? How will it be financed? What payback period is needed?)
- Examine infrastructure requirements (What will be needed to meet fleet infrastructure needs? Have you collected enough information to issue an accurate request for proposal to have a station built?)
- Assess the business case (How quickly will the fleet's investment in the CNG project be paid back with fuel cost savings? Does this fit with the fleet's typical business practices and preferences?)
- Develop an implementation plan and act on it

Understand the basics of natural gas and CNG vehicles – Most of the concerns and issues associated with CNG use stem from the fundamental difference in properties between natural gas and the liquid petroleum fuel that is currently being used. The section of this booklet titled **Compressed Natural Gas Basics** includes further details, but the key highlights are the following:

- Natural gas is primarily methane (CH_4), a colorless, tasteless, odorless, and nontoxic gas.
- Natural gas is lighter than air and will quickly disperse in an unconfined space, but confined space leaks can collect to form a flammable mixture that would become hazardous in the vicinity of an ignition source.
- Natural gas has a flammability range in air from 5% to 15% and an ignition temperature around 1,200 degrees Fahrenheit, both of which are higher than for gasoline or diesel.

- As a transportation fuel, natural gas is measured in gasoline gallon equivalents (GGEs), where 5.66 pounds of natural gas has an equal amount of energy as one gallon of gasoline. In volumetric terms, 125 cubic feet of natural gas contain the same energy in one GGE and 137 cubic feet are needed for a diesel gallon equivalent (DGE).
- To increase energy density for use in vehicles, natural gas is typically compressed to 3,600 pounds per square inch (psi), but a GGE of natural gas still occupies almost four times the volume of a single gallon of liquid fuel.

CNG terminology – CNG vehicles have some unique classifications, components, and operating characteristics that are explained in more detail in the section titled **CNG Vehicle System Components**. CNG has an octane rating of 130, which provides an opportunity for CNG vehicles to have better power, acceleration, and cruise speed if the engines are tuned to take advantage of the fuel. CNG engines can be cleaner and less noisy than diesel engines. Familiarity with CNG terminology is important when discussing your options with product manufacturers.

- Dedicated CNG vehicles: Work much like gasoline-powered vehicles with spark-ignited engines. Specialized CNG components include the natural gas fuel receptacle, high-pressure fuel storage cylinders, pressure relief devices on fuel storage cylinders, a master manual shut-off valve, high-pressure fuel lines, a gas regulator, and a natural gas fuel-injection system.
- Bi-fuel CNG vehicles: Have two separate fueling systems to run on either natural gas or gasoline (the fuels are not used simultaneously). This type is not common for the medium- and heavy-duty applications.
- Dual fuel CNG vehicles: Blends 40%–85% CNG with diesel after the engine is warmed up, but may operate entirely on diesel if necessary.
- CNG receptacle: Mounts to the vehicle to enable fueling.
- CNG nozzle (i.e., at the end of the hose on the fuel dispenser): Attaches to the fuel receptacle.
    - P36: Rated for 3,600 psi, usually yellow.
    - P30: Rated for 3,000 psi, usually blue.
    - Type 1: venting.
    - Type 2/Type 3: non-venting, various configurations.
    - CT1000: 1/4-inch tubing for fast-fill fueling of light- and medium-duty vehicles or time-fill fueling of heavy-duty vehicles.
    - CT5000: 3/8-inch tubing for extremely high-flow fueling of large trucks.
- CNG vehicle tanks: pressure vessels of 5–30 GGE in size, which can be placed within the chassis, behind the cab, or roof mounted. Might limit cargo space if identical diesel equivalent vehicle range is desired, depending on the available space on the chassis. Primary contributor to the additional weight and cost of a CNG vehicle. The four following types all meet safety requirements, but have trade-offs between weight and cost.
    - Type 1: All-metal, steel, or aluminum (heaviest, but least expensive).
    - Type 2: Steel or aluminum lined and hoop wrapped with fiber composite.
    - Type 3: Aluminum lined and fully wrapped with fiber composite.

- Type 4: Thermoplastic lined and fully wrapped in fiber composite (lightest, but most expensive).

Unless weight is a concern or a limiting factor, Type 1 tanks are used to maximize the economic benefits. Types 2 and 3 provide some weight savings without paying the premium cost for Type 4 tanks. However, tank type is often specified through the system installer because these companies bulk purchase CNG tanks and will typically always use the same type on all their installations.

Assess fleet vehicle characteristics – Characteristics of an ideal CNG fleet vehicle would include the following:

- Regular, consistent routes that return to a common base location
- High annual miles, but no more than available vehicle range options based on fuel tank configurations (typically around 300 miles per tank, but larger ranges are possible on larger trucks that have long chassis or available cargo space)
- No potential need to be used for a long haul or route in an emergency

An analysis of the most up-to-date fleet inventory and operations should help determine if a CNG vehicle program is a good fit. Key characteristics that are important to record on a per-vehicle basis for CNG compatibility are the following:

- Make, model, engine, and chassis (to identify possible CNG vehicle options for replacement)
- Average fuel economy (to estimate payback)
- Average annual mileage (to estimate payback)
- Average mileage or fuel use per day
- Maximum mileage per day (to exclude vehicles that push/exceed CNG range limitation)
- Expected replacement time or vehicle lifecycle

As the use of CNG in delivery fleets is growing, so are the number of best practice examples that can be used to help determine if a CNG vehicle program is right for your fleet. Most of the fleets currently using CNG are not only great models for natural gas programs, but they are very willing to share their experiences with others. While it is typically uncommon for competing businesses to be so open about their operations, many of the key personnel that pushed their own company to adopt CNG realize that it is in their best interest to promote CNG usage. This will encourage more product manufacturers to offer CNG alternatives, more contractors to offer CNG services, and more fueling infrastructure to be developed that could be shared. The section on **Best Practices – Successful CNG Fleet Deployments** shares a number of best practices from delivery fleets, some in New York, that provide successful examples that may be good models to follow.

Review CNG vehicle options – There are many CNG vehicle options currently available for medium- and heavy-duty delivery truck applications, but the selection does not include every size and type that a fleet may want to use. Natural gas engines are a limiting factor in which vehicles may be offered with CNG options. At present, there are five engine options as listed in the **CNG Engines for Delivery Application** section, although two additional options should be

available soon. The General Motors and Ford engines are factory-prepared for CNG, but the CNG upfit is performed by a Small Volume Manufacturer (SVM). Some SVMs also offer the option to retrofit vehicles with these engines to use CNG. The Cummins Westport Inc. (CWI) and Emissions Solutions Inc. (ESI) engines are options available from various chassis manufacturers that integrate the CNG fueling system into their product offerings. Current CNG engine and chassis options are detailed in **Appendix A: CNG Vehicles for Fleet Applications** and include the following:

- General Motors Vortec 6.0-liter V8
  - 322-360 horsepower (hp) with 382-373 pound-foot (lb-ft) of torque
  - Chevy Express/GMC Savana Cutaway 4500, Isuzu NPR, JAC Commercial Trucks, and Workhorse W42, and Workhorse W62
  - CNG upfit through Greenkraft Inc, IMPCO Automotive, and Landi Renzo USA
- Ford 6.8L Triton V10 3-valve
  - 355 hp with 455 lb-ft of torque
  - F-450, F-550, F-650, and F-59 Commercial Stripped Chassis
  - CNG upfit through BAF Technologies, Greenkraft Inc, and IMPCO Automotive
- Ford 6.8L Triton V10 2-valve
  - 305 hp with 455 lb-ft of torque
  - E-450 Cutaway and E-450 Stripped Chassis
  - CNG upfit through BAF Technologies, Greenkraft Inc, and IMPCO Automotive
- Cummins Westport Inc. 8.9-liter V6 ISL-G
  - 250-320 hp with 660-1,000 lb-ft of torque
  - Freightliner M2 112, Freightliner 114 SD, International TranStar, International LoadStar, Kenworth T440, Kenworth T470, Peterbilt 320, Peterbilt 365, Peterbilt 384, Kenworth W900S, Kenworth T800SH, and Volvo Daycab Tractor
- Emissions Solutions Inc. Phoenix NG 7.6-liter
  - 210-300 hp with 520-860 lb-ft of torque
  - International DuraStar 4300/4400 and International WorkStar 7300/7400
  - Available as a retrofit/repower on vehicles with the Navistar DT466E engine
- Emissions Solutions Inc. Phoenix NG 7.3-liter
  - Up to 255 hp with 650 lb-ft of torque
  - Available as a retrofit/repower on vehicles with the Navistar T444E engine
- Cummins Westport Inc. ISX12 G (expected to be available for MY2013)
  - 330-400 hp with 1,150-1,450 lb-ft of torque
  - Freightliner Cascadia 113 & 114SD, Kenworth T660, Kenworth T800SH, Kenworth W900S, Mack Granite, Mack Pinnacle, Peterbilt 320, Peterbilt 365, Peterbilt 384, and Volvo VNL

Based on this listing and the fleet inventory analysis, the fleet will need to make a decision on whether there are available CNG vehicles that meet the fleet needs. The fleet must also review normal replacement schedules to identify how many new CNG vehicles could be acquired and on what timeframe. The fleet should investigate how many new CNG vehicles could be acquired on an accelerated replacement schedule, or if it is possible to retrofit CNG engines in recent vehicle

purchases. There is a limited range where retrofitting compatible CNG engines makes sense, so discuss this fully with an SVM that has an active certification for the specific models you are interested in converting. Note that CNG vehicle availability can sometimes be limited. Some manufacturers do not begin production of CNG vehicles until a sufficient number of orders have been received, or they might schedule a single production run at an established time of the year, so having flexibility on the delivery times of these vehicles is necessary.

Another aspect to consider is the operation and maintenance of CNG vehicles. If the fleet outsources its maintenance, it is critical to verify that a CNG vehicle maintenance provider is available if the fleet purchases CNG vehicles. If CNG vehicle maintenance is performed on-site, the fleet should investigate the facility upgrades necessary to meet fire codes with the local fire marshal. Further information on this topic is included in the section **CNG Vehicle Operation and Maintenance**.

Fleets with existing CNG vehicle programs can offer best practices for performing these upgrades cost-effectively. While this is usually not a major investment, the cost burden for the upgrades will be distributed among the CNG vehicles, so there may need to be a sufficient number of vehicles to make the business case to justify this expense.

Decision – Is the fleet a good candidate for a CNG vehicle program?

Evaluate existing and planned CNG Fueling Infrastructure – There are more than 100 CNG stations in service in New York State; those stations are described in the section **Public Fueling Options.** Thirty-four stations are publicly accessible, and all except 3 of these are open 24 hours a day. Further station details in **Appendix F: CNG Stations in New York State** may provide additional guidance for initiating an investigation into whether one of these is suitable for the fleet. If one of these stations is close to the existing fleet operations, then the fleet could likely implement a CNG vehicle program incrementally by starting with a few vehicles to become comfortable with the technology. As additional CNG vehicles are added to the fleet, other fueling options may be explored. However, before committing to a CNG program that relies on a public fueling station, investigate the following features to ensure that it will suit the needs of the fleet:

- Accessibility – In terms of both hours of operation and ease of use for the fleet vehicles, consider the traffic flow and turn lanes from the main road as well as the ingress and egress within the station itself.
- Location – A location closer to the fleet base would be better to reduce additional time and effort associated with fueling. Route planning can also be used to coordinate fueling at public stations.
- Dispensing capability – To ensure complete fill-ups, 3,600 pounds per square inch (psi) of pressure is necessary (3,000 psi would only fill tanks to about 80% capacity). Larger compressors provide adequate flow rates to reduce fueling times and can sometimes be used with large CT5000 diameter nozzles. Ample on-site CNG storage can also better support faster filling times, but their ability to contribute fuel will depend on the station usage.

- Pricing – The advertised price will provide a starting price point, but significant regular fueling at one station may allow the company to negotiate a strategic pricing contract.
- Reliability – Find out if there is any redundancy in equipment in the event a failure or maintenance. Talk to other users of the station and find out how often the station has been down or out of service and how long it typically takes to get back up.

Always involve the station owner in the evaluation of the CNG fueling capabilities to find out about the current usage of the station, which may affect the accessibility and dispensing capability. With the opportunity to support your additional fleet fuel requirements, the owner may be able to upgrade the station to suit your fleet's need at a much lower investment than building an entirely new station.

Existing New York State owned CNG stations that are currently not publically accessible could also be considered as potential fueling locations since New York State Office of General Services and Clean Energy could potentially expand their contract which allows Clean Energy to retail CNG fuel at certain New York State Department of Transportation locations. Some private fast-fill CNG stations may consider allowing another company to use its facility through a negotiated agreement and could implement a Fleet Fuel Card system to handle the accounting. Other CNG stations may be willing to add the equipment necessary to enable public fueling at their site if they are aware of a large fleet that would fuel there. New CNG stations are being planned and built throughout New York State as more fleets turn to CNG and these may offer additional opportunities for collaboration. Expressing interest in CNG to the local Clean Cities coordinator could facilitate a public/private partnership opportunity for municipal and private fleets to combine their projected CNG usage and encourage a fuel provider to invest in a new CNG station.

Recommendation – If public CNG fueling is acceptable, incrementally pursue a CNG vehicle program until it is large enough to justify on-site fueling.

Decision – If public fueling is not possible, will the company consider on-site fueling (i.e., is the business/personnel capable of operating a fueling station and/or will the CNG fleet be large enough to justify the investment)?

Assess facility property – On-site CNG fueling infrastructure can be a profitable business venture. As an example, Indiana Geothermal, a private company that provides geothermal products, custom system designs, and system installations, built a CNG station to support its light- and medium-duty truck fleet and is now profiting from CNG sales to other fleets that are fueling at its location. However, a few critical factors must be investigated to determine if the location makes sense as a fueling station. Most importantly, CNG supply from the utility should be readily available and have a sufficient capacity to support vehicle fueling. The local utilities, listed in **Appendix C: Local Utilities in New York State**, should be contacted for this assessment, which is commonly referred to as a Gas Capacity Request. The gas utility will need to know the size of the compression equipment for the proposed fueling station. The utility will

then evaluate the additional gas demand and evaluate the gas supply and determine the gas system requirements necessary to meet your new gas demand. The utility may also help identify a larger supply line separate from where the current natural gas is being requested that could be more suitable for CNG vehicle fueling. Increased distance from the adequate natural gas supply to the fueling infrastructure adds costs, so this might dictate where the station should be located. It is also important to assure the required electrical power is available in close proximity to where the compression equipment is to be located.

The business must have adequate space available on-site to build the CNG fueling infrastructure. The section on **CNG Station Basics** outlines the types of fueling systems, components, and applicable code requirements for CNG infrastructure. Time-fill fueling nozzles are strategically placed between dedicated CNG parking spaces for the system to deliver fuel to vehicles that are parked for an extended period of time. This avoids the need for the operator to drive to a dispenser and fuel the vehicle. Fast-fill stations require one or more fueling islands with ample space for the vehicles to flow through. These stations will also typically utilize large tanks (usually vessels or spheres) for the onsite storage of CNG that must be properly secured and protected. Another important siting consideration is the potential to open up the station for public access or pre-arranged contract access. This public/private partnership is often a requirement if grant funding is being provided or an independent operator is building the station based on a long term fuel agreement with the fleet as its base demand. However, security concerns must be addressed (compression and station equipment is typically located "inside the fence" while dispensers are located "outside the fence" for user access) and station costs could increase (payment system, certified dispensers, more fueling locations, increased safety precautions, etc.) with public accessible stations. Consider and investigate if the company's management and insurance company will allow for public access (or pre-arranged contract access), since the fuel provider role may not be something the company is interested in pursuing. Also consider whether the location is suitable for public access and will draw enough business to make it worth the investment. A good public accessible station will be near other fleets (municipalities, refuse, other private delivery companies, phone carriers, etc.) and also near major highways for personal CNG vehicles or out-of-town CNG fleet vehicles to utilize.

Decision – Is the facility a good candidate for installing a CNG station? Would publicly accessible fueling work and would the company consider it?

Understand the corporate business strategy – The approach to building and operating a CNG station is often dictated by the capabilities and strategic business plan of the company. Different portions of the CNG vehicle program can be outsourced to experts, with various levels of risk and reward. It is important to have a good understanding of the level of risk the company is willing to take for a natural gas program and the existing capabilities of the staff to oversee various operation and maintenance responsibilities. Ownership can have significant financial benefits, but it carries with it additional risk.

- Ownership of the CNG station – Requires a significant initial investment by the company and depending on other available CNG fueling in the region, could require system

redundancy (backup provisions) to assure for fuel availability. May be a good choice for fleets that only require time-fill fueling, which would not require as much equipment, such as storage tanks and metered dispensers. Might be the only choice for small and medium fleets that do not have the required fuel usage for an independent operator to commit to building a station.

- Outsourcing of the CNG station – If the fleet has enough CNG demand to serve as the base load, an independent operator may be willing to build the station at its costs and expect to recoup that investment through a long-term fuel agreement. The fleet may likely receive a favorable CNG price that is lower than public fueling costs, but it may need to provide land for the station and maintain negotiated fuel throughput. It may also be an opportunity to receive a monthly lease or a "royalty fee" for the fuel sold by the operator to other third party users. The longer the initial contract, the more favorable the fuel prices because the initial station costs is spread out over more years.
- Ownership of CNG station service and maintenance – An option for companies that own the station, but this option requires significant expertise and knowledge from company personnel to regularly service the equipment, diagnose problems, maintain an inventory of parts, and have the capability to replace broken parts quickly to minimize downtime. This is not typically done, but it is an option if this competency exists internally.
- Outsourcing of CNG station service and maintenance – Included when outsourcing the station itself, but also an option for CNG station owners that wish to delegate this responsibility to a third party. This can be written into the contract awarded to the firm that builds the station, but it can also be issued as an independent bid. Companies that outsource service and maintenance often still train one or more of their staff to be familiar with the CNG infrastructure to diagnose simple issues and respond to minor service needs to keep the system operating until the service provider arrives. While many companies hate to "leave money on the table" by outsourcing this, there are numerous advantages to placing the responsibility of maintaining parts inventories, training technicians, and ensuring regular service to the equipment on others.

Common advice from existing CNG fleets is to only take on the aspects that the company and employees can handle. Large fleets typically have more capabilities and options in developing CNG infrastructure, but the cost differential between CNG and conventional liquid fuels permits companies to pay a little extra for decreased risk and responsibility while still maintaining an economic advantage with CNG vehicles.

Decision – Is owning or outsourcing the CNG station build and maintenance the best option for the company? If outsourcing is preferred, would ownership be considered if no agreement can be reached with an independent operator?

Examine infrastructure requirements – Both ownership and outsourcing approaches can use a bid process to acquire the services of a CNG infrastructure specialist. Most of the existing CNG programs are willing to share the framework and even the language used in their bid documents to assist in drafting these for a new CNG station. Accurately quantifying the fleet's current and future expected CNG utilization is critical for bidders to appropriately size the

CNG infrastructure. The contract's scope of services and duration will also significantly affect the proposed solution and costs. Identify and reach out to potential qualified bidders to gauge interest and gather insight into the special requirements that might be needed at this site. However, avoid over-specification in the bid to allow for flexibility to meet the needs of the fleet, which may reduce costs. With the ownership approach, it is possible to separately bid out the station design and construction, but many CNG infrastructure suppliers combine these services. An independent consultant could be used to help develop, review, and oversee the procurement process if there is not enough in-house expertise to intelligently review the responses from the bidders. Based on the quantity and quality of the bids received, it may be necessary to re-assess or adjust the approach.

Decision – Was an acceptable CNG station proposal received that meets the fleet's requirements for a CNG vehicle program?

Assess the business case – While CNG vehicles are typically less expensive to operate because of lower fuel costs, a CNG vehicle may not always be the most cost-effective solution. CNG vehicles cost more than diesel or gasoline vehicles, referred to as the vehicle's incremental cost. Vehicle utilization is the primary factor in determining how long it takes for operational savings to payback the incremental system cost. A simple calculation of payback using delivery vehicle example factors of diesel fuel economy at 6 miles per gallon, yearly mileage of 30,000, an incremental CNG new vehicle cost of $28,000, and fuel savings of $1.44 per DGE work out as follows:

30,000/6 = 5,000 DGE/yr * $1.44 = $7,200/yr | $28,000/$7,200 = 3.9 years

After the incremental cost of the CNG system is paid back, the company collects the operational savings as a return for its investment. Greater annual mileage reduces the payback time and increases the lifetime cost savings for the vehicle, but it can also require additional range. CNG vehicles can be range limited by the amount of fuel they hold and the availability of fueling. Additional CNG storage tanks can be added to increase range, but they add cost and can decrease load capacity.

The business case for a CNG vehicle program depends on a number of factors, many of which have already been mentioned above (e.g., number of CNG capable vehicles to be acquired; incremental cost per vehicle; average fuel use, which is dependent on annual mileage; cost of natural gas; cost for maintenance facility upgrades; cost for the fueling infrastructure). A simplified approach to calculating overall CNG program payback would incorporate the initial expenses for the maintenance facility and fueling infrastructure into the overall CNG fuel cost by amortizing these over the expected gallons of fuel used for the duration of these investments. Ongoing costs such as the electricity for the station operation and service and maintenance of the CNG station can also be integrated into a fully loaded CNG fuel cost. Public CNG fueling prices already reflect these cost components plus an operator's profit margin. Comparing this to the anticipated cost of conventional fuels will result in the potential cost savings per gallon of fuel used, which will estimate the economic benefits of CNG for the fleet. In addition, some companies consider intangible benefits (e.g., corporate image, environmental benefits, energy

security), and may monetize them as part of their business case analysis; others may consider only the tangible costs and benefits. These factors, described in more detail in section **Business Case Analysis for a Natural Gas Program** will all feed the calculation of an expected payback period for the CNG vehicle program, which will need to conform to the fleet's expectations for a successful project. In some cases, financial assistance in the form of grants, low-interest loans, public/private partnerships, or other novel financing arrangements may be available to improve the business case by lowering the costs of the program. CNG applicable financial assistance options are listed and summarized in section **Funding Options for Vehicles and Infrastructure**.

Decision – Does a CNG vehicle program make economic sense for the fleet?

Develop an implementation plan and act on it – As with any other large initiative, the fleet should develop a plan for the proposed CNG program. Items to be identified in the plan include the following:

- CNG vehicles – Proposed number to be purchased and the time period in which they will be acquired.
- Financing to cover the incremental vehicle costs – or other financial assistance options.
- Procurement of fuel – Using public stations at market cost, using long-term fuel purchase agreements, or developing on-site fueling.

Careful planning at the start of the project will allow the fleet to realize the maximum benefits of a successful project.

The CNG industry has grown significantly over the past decade, and many companies can support the development of a CNG vehicle program. Even with significant in-house expertise and capabilities, if CNG is something new for the fleet, then further consulting or training may be needed to increase knowledge about the regulations and safety requirements. This guidebook is a starting point to implement a CNG vehicle program. See **Appendix D: Vendors for Natural Gas Equipment and Services** and **Appendix E: Resources for Additional Information** for a listing of resources and organizations that provide CNG-specific information and knowledge. Clean Cities can be available to assist with funding or other technical questions through its network of coordinators across the country. While many CNG equipment and product manufacturers offer an abundance of advice and support, there are also third-party consultants whose services can be used to guide decisions and help address the requirements necessary for using CNG in your fleet.

Once the plan has been developed, the fleet should start taking action. Fleets should track success wherever possible: verifying fuel savings as compared to current practices will ensure management buy-in to maintain the program and possibly expand it. Fleets should also share successes with other fleets in New York to help build momentum for wider markets.

Decision flowchart – Figure 2 is a summary of the key factors a delivery company should consider when investigating CNG for their fleet. It may be necessary to use the remaining sections of this guidebook to understand the reasoning behind these questions and to reach an appropriate answer for the company and its fleet. However, this high-level flow chart should help decision makers determine if CNG is an option for their fleet.

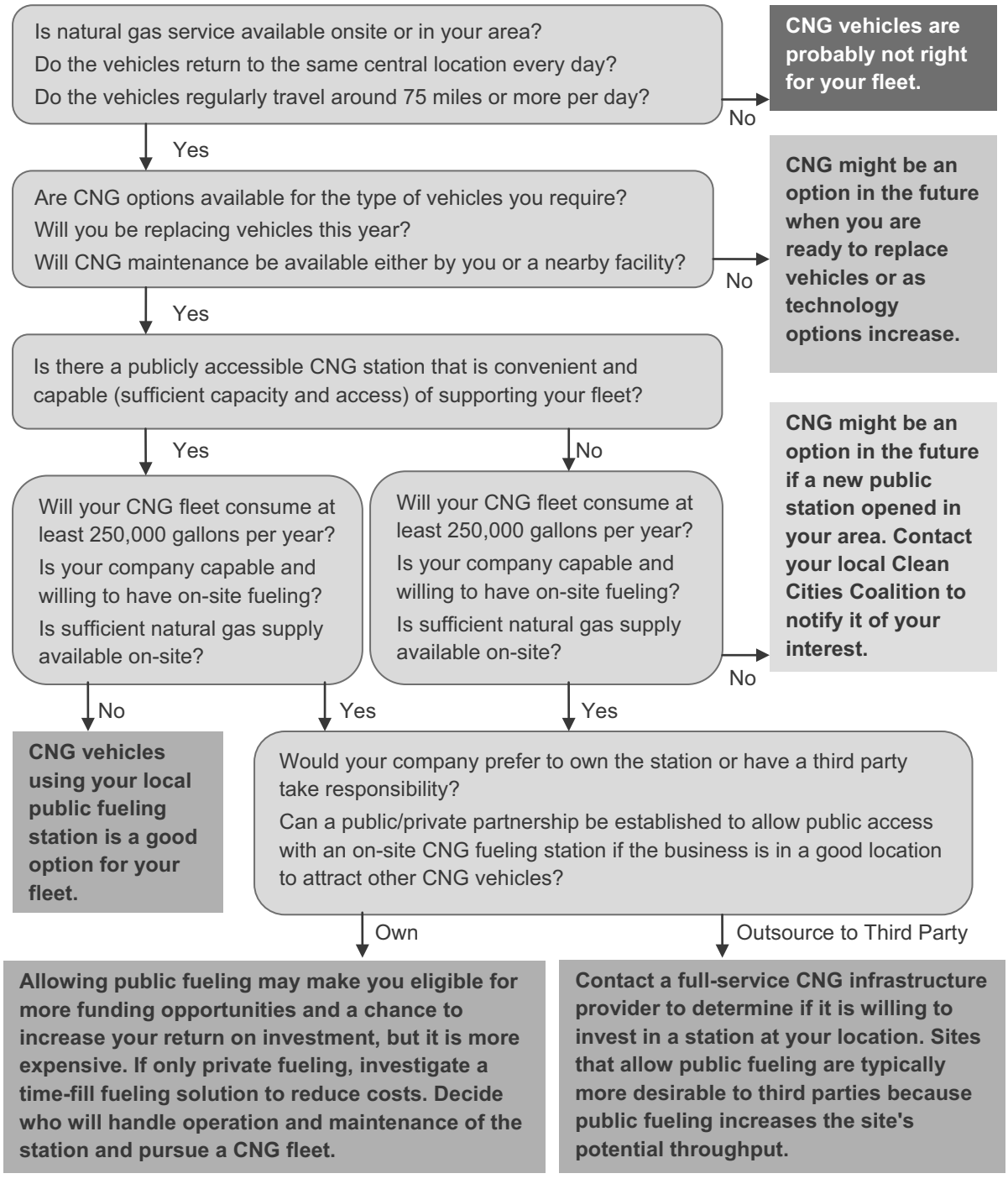

Figure 2. Decision flowchart to determine if compressed natural gas is right for your fleet

4 Compressed Natural Gas Basics

Natural gas, in its pure form, is colorless, tasteless, odorless, and nontoxic. The distinctive “rotten egg” smell often associated with natural gas is actually an odorant called mercaptan that is added to the gas before it is delivered to the end-user. This aids in detecting any leaks. As produced from gas wells, natural gas is a mixture of gaseous hydrocarbons consisting primarily of methane, but may also include ethane, propane, butane and pentane. Additional impurities that are removed in the refining process include carbon dioxide, hydrogen sulfide, nitrogen, and water vapor (NaturalGas.org, 2011). Natural gas is considered 'dry' when it is almost pure methane, having had most of the other commonly associated hydrocarbons removed. Dry natural gas is what is typically delivered through the network of pipelines. When other hydrocarbons are present, the natural gas is referred to as 'wet'. Regardless of the source, it is commonly recommended to filter natural gas with a dryer to remove any water vapor prior to compressing for use in vehicles.

The methane molecule, shown in Figure 3, is comprised of one carbon atom and four hydrogen atoms (CH_4), making it the simplest hydrocarbon gas. This ratio of carbon to hydrogen is significantly lower than diesel ($C_{14}H_{30}$) or gasoline (C_8H_{18}), making it a low carbon fuel that emits fewer greenhouse gas emissions when combusted. Methane itself is a greenhouse gas, and care should be taken to avoid leaks wherever possible. Natural gas is lighter than air, so it will not pool on or near the ground as gasoline, diesel, or propane vapors do. It is nontoxic and poses no threat to land or water if accidentally released into the atmosphere where it will quickly disperse in an unconfined space. However, indoor or confined space leaks can collect near the top of confined spaces and form a flammable mixture, which could be an issue if the gas is in the vicinity of an ignition source. Methane is also slightly soluble in water and under certain anaerobic conditions does not biodegrade.

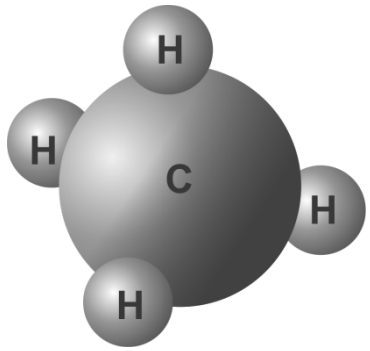

Figure 3. Methane molecule consisting of one carbon atom and four hydrogen atoms

Natural gas is deregulated in New York State, which allows residents to choose their supplier. While the utilities, including Consolidated Edison, National Grid, New York State Electric & Gas, Rochester Gas & Electric, Central Hudson, Orange and Rockland, National Fuel Gas, Corning Natural Gas, and St. Lawrence Gas, deliver the gas and respond to service interruptions and outages, gas can be purchased from alternate suppliers know as Energy Service Companies or ESCOs. If no alternative gas supplier is chosen, the utility is the “default service” and serves as a benchmark for pricing in the market, with rates typically changing every month. ESCOs often offer a locked-in gas supply rate, which can provide additional price stability.

Much as with conventional fuels, natural gas is safe to use in vehicle applications when proper safety procedures are followed. In fossil fuels, energy is stored as chemical potential energy, which is converted to gaseous expansion energy in the course of combustion. Natural gas has a low expansion-energy potential and therefore, like other fuels, does not pose a significant risk of

tank explosion. However, the risk of explosion is high when natural gas (or any other fuel) comes into contact with air after leakage or tank rupture, especially in confined spaces. Natural gas has a flammability range (the concentration of gas in an air-fuel mixture that will ignite or explode) from 5%–15%, whereas diesel is 0.6%–5.5%, gasoline is 1.4%–7.6%, and propane is 3.4%–13.8%. It also has a very high ignition temperature (more than 1000 degrees Fahrenheit), which is double that of diesel or gasoline, making accidental ignition or combustion less likely (Gordon, Burdelski, & Cannon, 2003). In order for natural gas vehicles to effectively provide satisfactory and safe operations for users, standards were established to address specific issues relative to the use of natural gas as a vehicle fuel. The Society of Automotive Engineers (SAE) Recommended Practice for Compressed Natural Gas Vehicle Fuel, J1616, presents the more important physical and chemical characteristics of natural gas vehicle fuel and describes pertinent test methods for defining or evaluating these properties. Approved by the American National Standards Institute (ANSI), the intent of SAE J1616 is to protect the interior surface of fuel containers (storage cylinders) and fuel system components (injectors, exhaust catalyst elements, engine, etc.) from the onset of corrosion, poisoning, the deposition of liquids or large dust particles, and the formation of water, ice particles, frost or hydrates (SAE, 1994).

By weight, natural gas has an energy content of approximately 21,000 British thermal Units(Btu)/pounds (lbs), which is greater than gasoline at around 18,400 Btu/lb. A standard of 5.66 pounds of natural gas was set by the National Institute of Standards and Technology (NIST) as equal to one gallon of gasoline (6 lbs) and defined as the gasoline gallon equivalent (GGE) for which natural gas is measured and priced for use as a transportation fuel. Since diesel fuel has 13% more energy content per gallon than diesel, a greater mass of natural gas is needed to provide expected energy equivalents for heavy-duty vehicles. By volume however, it takes 125 cubic feet of natural gas to contain the same energy in one gallon of gasoline and 137 cubic feet for the equivalent of one gallon of diesel fuel (DOE, 2012). It is not practical to store this volume of uncompressed gas on a vehicle, so the fuel is compressed for use in the transportation sector. Modern compressed natural gas (CNG) storage systems in the United States pressurize to 3,600 pounds per square inch (psi). In the past, natural gas systems were limited to 3,000 psi, which still is the case in other countries (public CNG fueling in Canada is limited to 3,000 psi). Pressures were raised in the United States to allow greater fuel capacities onboard a vehicle. At 3,600 psi, a GGE of natural gas still takes up 0.51 cubic feet, which is almost four times larger than a single gallon of liquid fuel. Therefore, CNG vehicles must either have larger tanks to provide equivalent ranges or compromise the distance for which it can travel between fueling.

Strict safety standards set forth by the National Fire Protection Association (NFPA) through Standard 52 make CNG vehicles as safe as gasoline-powered vehicles. CNG cylinders undergo extreme testing for both heat tolerance (if involved in a fire) or impact tolerance (if involved in an accident), before they receive standards approval. Despite this, proper safety precautions must still be observed. Any system under pressure has the potential to be harmful if the gas is uncontrollably released in a short period. Caution must be taken when fueling and repairs or maintenance should only be performed by qualified personnel. Various training programs and safety workshops are offered through nationally recognized programs that should be attended by anyone working with CNG.

5 CNG Vehicle System Components

There are three types of compressed natural gas (CNG) vehicles: dedicated, bi-fuel, and dual fuel. Dedicated CNG vehicles are designed to run only on compressed natural gas, while bi-fuel CNG vehicles can operate either on CNG or on a conventional fuel (but not both simultaneously). Both use spark-ignited internal combustion engines. In general, dedicated CNG vehicles can demonstrate better performance and have lower emissions than bi-fuel CNG vehicles because their engines are usually specifically tuned to run on a gaseous fuel to take advantage of the favorable properties of natural gas. They are also not as heavy as bi-fuel vehicles that must have two separate fueling systems to run on either natural gas or conventional fuels. Bi-fuel CNG systems are only found in light- and medium-duty vehicles. These systems are also not available in New York State because they are not certified by the California Air Resources Board. CNG has an octane rating of 130, which can be used to great advantage in dedicated vehicles with spark-ignited internal combustion engines. If the engine is optimized for natural gas, a CNG vehicle's power, acceleration, and cruise speed can be greater than that of a gasoline-powered vehicle, which makes it an acceptable alternative to diesel in larger vehicles. Due to the characteristics of the fuel, natural gas engines are less noisy than diesel engines (EPA, 2002). The use of CNG eliminates the cold weather start issues associated with diesel.

Dedicated CNG vehicles work much like gasoline-powered vehicles with spark-ignited engines. During fueling, CNG enters the vehicle through a natural gas fill valve and flows into high-pressure cylinders. When the engine requires natural gas, the gas leaves the cylinders and passes through a master manual shut-off valve. The gas travels through a high-pressure fuel line and enters the engine compartment where it enters a regulator, which reduces the gas pressure used for storage (up to 3,600 pounds per square inch [psi]) to the required vehicle fuel injection system pressure. A natural gas solenoid valve allows natural gas to pass through a fuel filter and into the gas mixer or fuel injectors. Natural gas mixed with air flows down through the fuel-injection system and enters the engine combustion chambers where it is burned to produce power. Some CNG vehicles have a safety interlock on the fill port cover that prevent the ignition from turning on if it is open. The American National Standards Institute (ANSI) natural gas vehicle (NGV) 3.1 establishes requirements for newly produced compressed natural gas fuel system components, intended for use on natural gas powered vehicles (ANSI, 2012). This includes the check valve, manual valve, manual container valve, automatic valve, gas injector, pressure indicator, pressure regulator, gas flow adjuster, gas/air mixer, pressure relief valve, pressure relief device, excess flow valve, gas tight housing and ventilation, hoses, rigid fuel line, flexible fuel line, filter, fittings, and relief line closures.

Dual fuel CNG systems burn natural gas in a compression ignition (diesel) cycle. Under the pressures found in the combustion chamber of a normal diesel engine, natural gas requires a higher ignition temperature than diesel. During initial startup, the engine operates on 100% diesel fuel. After certain permissive criteria are satisfied the automatic control system commences dual fuel operation. In dual fuel operation, low pressure natural gas mixes with the intake air much like a spark ignition engine, such that an air and natural gas fuel mixture enters the cylinder. As it is

compressed, the diesel fuel system injects a small quantity of diesel fuel, which auto-ignites and burns the air and natural gas fuel mixture. In dual fuel mode, natural gas can displace 40% - 65% of the diesel fuel. Because there are no changes in the engine compression ratio, cylinder heads, or basic operation, the engine can operate entirely on diesel if CNG is not available. When idling, the engine operates on 100% diesel. Dual fuel engine designs can be retrofitted on existing engines to allow the combustion of natural gas. Two companies that offer dual fuel systems are EcoDual and American Power Group. The systems are currently approved by the EPA on engines that are classified as "outside of useful life" (OUL) because they are old or have been used enough that the EPA is not concerned about emission testing the system as long as the manufacturer meets certain requirements. Dual fuel CNG conversions may provide a cost-effective upgrade for some applications.

Dual fuel systems are different from high-pressure direct injection (HPDI) or high-pressure fuel injection (HPFI) systems that enable an engine to retain the efficiency advantage of compression-ignition while consuming natural gas, in the form of liquefied natural gas (LNG), as its primary fuel. To assist with ignition in this system, diesel fuel is injected into the engine cylinder followed by the main LNG fuel injection. The diesel acts as a pilot, rapidly igniting in the hot compressed air in the cylinder (as with conventional diesels) and serving as the catalyst to begin natural gas combustion. Fuel injection timing has a large influence on the engine performance, combustion, and emissions. Technologically advanced injection systems are key to providing precise control over the amount of fuel injected to provide an optimally mixed air to fuel ratio that produces combustion performance and emissions characteristics equivalent to well-designed, state-of-the-art internal combustion engines. HPDI engines are factory-built and designed to maximize natural gas use by burning only 5%–10% diesel to ignite it. These engines cannot operate without natural gas, which is used in liquid form for storage and in the fuel delivery system. These engines are often used in Class 8 delivery trucks with longer routes. The engines are often larger and more powerful than currently-available, spark-ignited natural gas engines although the latest CNG engine offering from Cummins will offer more power capability than has historically been available with CNG.

Figure 4. P36 CT1000 compressed natural gas push-pull actuating nozzle

The NGV1 standard is the most common system used in North America for CNG fueling connection devices (ANSI, 2006). The part that attaches to the fueling device at the end of the hose is called the nozzle, shown in Figure 4. The part that mounts to the vehicle is called the receptacle, shown in Figure 5. There are two different pressure ratings for both these components; the P30 is for 3,000 psi service and is usually blue, while the P36 is for 3,600 psi service and is usually yellow (as shown in Figure 4). In order to prevent a P36 nozzle from connecting to a P30

receptacle, the P30 receptacle is 1 millimeter (mm) larger in diameter at the rear. A P30 nozzle can connect to a P36 receptacle, but will only be able to fill up the tank to 80% capacity. There are venting (Type-1) and non-venting (Type-2 and Type-3) nozzles. Type-1 nozzles release pressure built up in the fuel hose at the nozzle end and capture this gas at disconnect by operating a manual "fill/vent" valve on the device after fueling is complete. The relieved gas pressure is then diverted to a separate hose leading back to the fueling apparatus to be vented into the atmosphere or fed back into the compressor. A Type-1 nozzle can also vent directly into the atmosphere at the nozzle end, thus precluding the requirement for a separate relief hose. A Type-3 nozzle relies on the fueling apparatus to vent the pressure at the supply end. A Type-2 nozzle is basically a Type-3 nozzle with a separate relief valve fitted to it at the nozzle end, so it operates much like a Type-1 nozzle. The Type-1 nozzles are usually found in fast-fill applications, while the Type-2 and Type-3 nozzles are usually found in slow-fill fueling applications.

Figure 5. P36 CT1000 compressed natural gas receptacle

Figure 6. P36 CT5000 Type-1 compressed natural gas ball valve nozzle

CNG nozzles and receptacles also come in various sizes to allow more rapid fueling rates for larger vehicles. The CT1000 has a ¼-inch stainless-steel vent tube that is used for quick-fill, self-service fueling of light and medium duty vehicles or time-fill fueling of heavy duty vehicles. The CT5000 has 3/8-inch stainless steel tubing for extremely high-flow fueling of large trucks, shown in Figure 6. There are also CNG defueling receptacles and nozzles that do not have a check valve. These are designed to safely depressurize vehicles if maintenance is required on the high-pressure system. CNG defueling receptacles can be used to transfer fuel from one vehicle to another, which is an important backup option if a vehicle runs out of fuel away from the base.

CNG tanks sizes range from 5 to 30 gasoline gallon equivalents (GGE) which are typically custom configured in the chassis or body of the vehicle to minimize impedance on normal vehicle operations. However, if a driving range equivalent to a similar diesel fueled vehicle is desired, then the extra tanks will likely require a reduction in cargo space or payload. CNG cylinders must be installed on a vehicle in compliance with the National Fire Protection Association (NFPA)

Standard 52 which provides guidance on proper and secure mounting, along with protection from damage caused by road hazards, loading and unloading, sunlight, heat, accidental cargo leakage, and collision damage. The most vulnerable element of the CNG cylinder is the cylinder valve. Shown in Figure 8, tanks are commonly placed within the chassis, behind the cab, or on the roof. Most include an enclosure that provides multiple mounting points and protection from the above mentioned hazards. The CNG tanks, enclosures, and fuel delivery system add weight to the vehicle when compared to a similar diesel or gasoline vehicle. These components and their installation usually represent the majority of the additional costs of a CNG vehicle(commonly referred to as incremental cost), since the increased cost of the CNG engine is offset by the cost savings from the simpler emissions control system. For medium and heavy duty delivery vehicles, the additional incremental cost for a CNG platform can range between $25,000 and $35,000, primarily depending on the amount of CNG storage that is desired. The increased fuel storage system weight may have some fuel economy penalty and could cause a slight increase in braking distance or slower acceleration. However, because the fuel system is a small fraction of the vehicle's total weight, this is a relatively small concern.

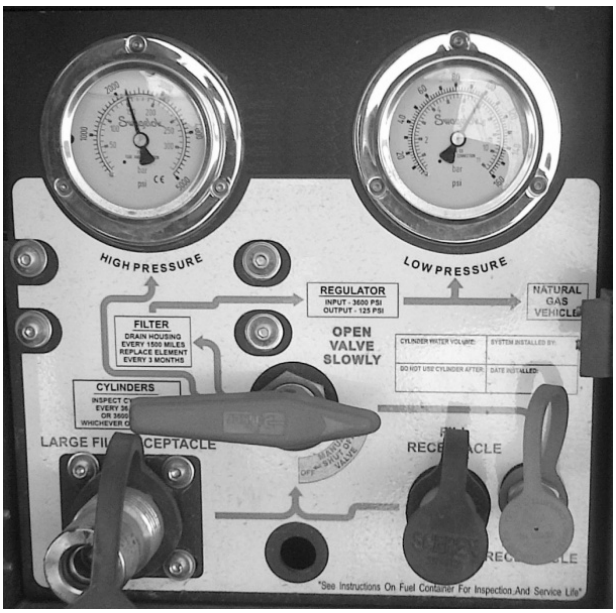

Figure 7. Multiple compressed natural gas receptacles (CT5000, CT1000, and defueling) for a large truck application

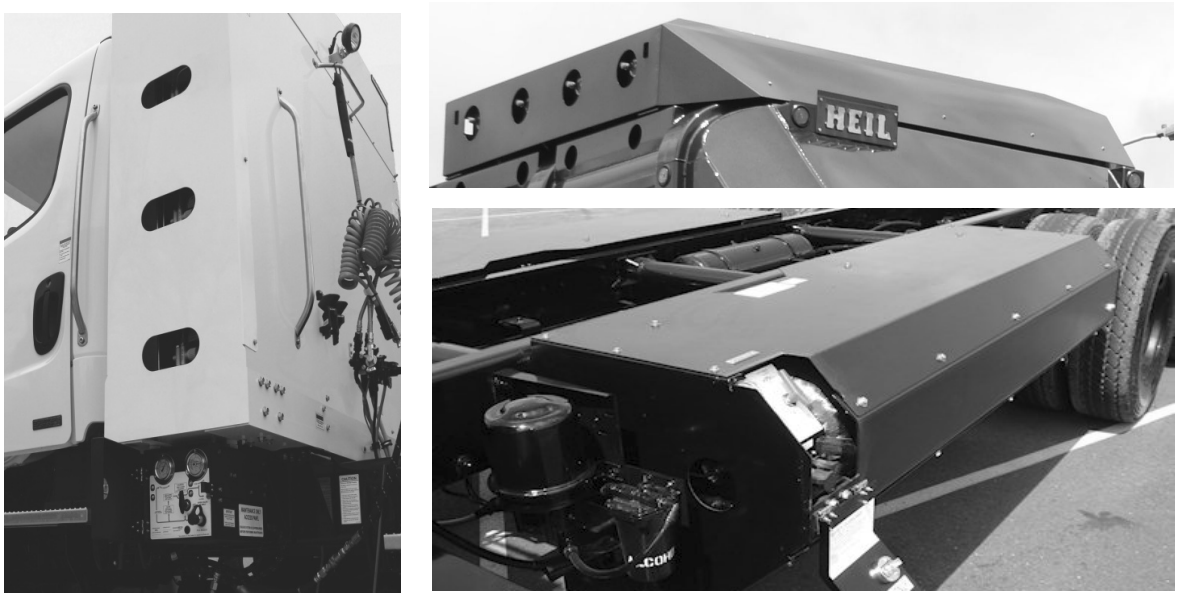

Figure 8. Compressed natural gas vehicle storage tank configurations: behind the cab, on the roof, or within the chassis

The American National Standard for Natural Gas Vehicle Containers, NGV2, establishes a standard for safe operation, substantial and durable construction, and performance testing of containers for the onboard storage of compressed natural gas for vehicle operation (ANSI, 2007). Each must be designed, manufactured, and tested to pass a bonfire test, pressure test for 18,000 cycles of pressurization and depressurization, gunfire test, and drop test. There are four different CNG tank types used by the industry. Each type must meet the stringent safety requirements and are generally equivalent in storage performance. Type 1 tanks are all-metal using steel or aluminum: these are the least expensive, but heaviest. Type 1 cylinders typically pass inspections easily because they are allowed to show some wear, whereas the other three cylinder types are held to a higher standard of visual damage. Type 2 tanks use a mix of metal and composite materials, often steel or aluminum lined and hoop wrapped (covering the sides, not the ends) with fiber composite. Type 3 tanks also employ a mix of metal and composite materials, but these tanks are aluminum lined and fully wrapped with fiber composite. The lightest and most expensive tanks are type 4, which are entirely composite materials using a thermoplastic lining and fully wrapped in fiber composite. A 10 GGE Type 1 cylinder could weigh more than 350 lbs, but only cost around $1,000. On the other hand, a 10 GGE Type 4 cylinder may weigh less than 100 lbs, but cost more than $7,000 (SkyCNG, 2012). The life of any CNG cylinder can be 15, 20, or 25 years, which should be matched to the vehicle life cycle or replacement period. The burst pressure of the tanks is 2.25 times its operating pressure rating, with pressure release devices (PRDs) set to release the fuel in a controlled manner well below this threshold in the event of a fire. The basic requirements for PRDs are set by the standard PRD1 and subsequent addenda 1a and 1b (ANSI, 2007). In colder climates like New York State, moisture trapped in PRDs and their vent lines can freeze and damage these safety components. Routine inspection of the PRD vent system to verify the integrity of the vent lines and assure that all vent caps are in place is recommended.

6 CNG Engines for Delivery Application

There are many medium-duty and heavy-duty vehicle options available in compressed natural gas (CNG) for the delivery fleet market in New York State. Additionally, many major engine manufacturers are currently engineering and designing additional heavy duty CNG engines that will be commercially available in the near future. Currently there are six dedicated CNG engines suited for the demands of class 4–8 commercial vehicles, with a few additional offerings projected to enter the market in the near future. Three of the currently available CNG engines suitable for medium-duty applications originate from the vehicle manufacturers Ford and General Motors (GM) with special CNG-prep configurations and engineering adjustments to accommodate the use of CNG, which will burn hotter than gasoline. If the CNG-prep package for the engine was selected when ordering the vehicle, then the upfit or retrofit to CNG can be performed in accordance with the manufacturer's engineering requirements by certified upfitters at their location. However, most CNG vehicles will be ordered new. The Ford and GM fuel-prepped engines with a customer-specified chassis are sent to a small volume manufacturer (SVM) or qualified vehicle modifier (QVM) who will install the CNG components on the engine, as well as the fuel tanks and delivery system. Depending on the SVM, these vehicles could be sent to the customer directly from the SVM, or be "shipped through" an upfitter by the Original Equipment Manufacturers (OEMs) and sold to the customer through their network of dealers.

The U.S. Environmental Protection Agency (EPA) has adopted emission standards for almost every kind of engine, including OEM engines that run on CNG. To show compliance with these emission standards, engine manufacturers must follow test procedures specified in the Code of Federal Regulations. The EPA also regulates conversion systems that modify vehicles and engines so that they can run on different fuels than the ones for which they were originally designed. Any change to the original configuration of a certified vehicle or engine, including alternative fuel conversion, is a potential violation of the Clean Air Act, which has a tampering to prevent poorly designed modifications that could actually increase emissions. However, the EPA has established protocols through which conversion manufacturers may seek exemption from the tampering prohibition by demonstrating that emission controls in the converted vehicle or engine will continue to function properly and that pollution will not increase as a result of conversion. New York State has chosen to adopt even more stringent emission rules and guidelines established by California's Air Resource Board (CARB) which apply to vehicles under 14,000 pounds.

SVMs offering CNG engine and chassis packages suitable for medium-duty delivery vehicles include BAF Technologies, Greenkraft Inc, IMPCO Automotive, and Landi Renzo USA. BAF Technologies is a Ford Qualified Vehicle Modifier (QVM) for natural gas vehicles. For more than 20 years, they have supported the conversion of vehicles to natural gas. BAF offers both dedicated and bi-fuel CNG vehicle conversions, along with application engineering, extensive training and nationwide support. Greenkraft Inc, a manufacturer and distributor of different automotive products, was established in 2007 and will be offering commercial trucks with JAC chassis from China powered by an American power-train. Greenkraft has EPA-certified CNG conversion kits for Ford and GM engines that can be used for their medium-duty commercial trucks. IMPCO Automotive

designs, manufacturers and supplies alternative fuel systems to OEMs and aftermarket installers. For medium-duty delivery trucks, IMPCO has the EPA and CARB certifications for various Ford and GM 2010–2012 engines and chassis. Landi Renzo USA engineers, installs, and services CNG systems through a full turnkey approach from sales, installation, warranty, and service. Landi Renzo offers EPA- and CARB-certified Baytech Corporation dedicated CNG fuel injection systems on 2007–2011 GM engines for medium-duty delivery truck platforms. The available chassis that can use these engines are listed below, but further details on the vehicles for delivery applications are in **Appendix A: CNG Vehicles for Fleet Applications**. More information on certified SVM that can be used and dealers where they can be obtained in New York State are in **Appendix B: CNG System Manufacturers and New York State Dealers**.

Medium-Duty Engines

The three medium-duty engines that can be modified by SVMs to run on CNG for delivery truck applications include the GM Vortec 6.0-liter (L) V8, Ford 6.8L Triton V10 3-valve, and the Ford 6.8L Triton V10 2-valve.

Figure 9. General Motors Vortec 6.0-liter V8 natural gas-prepped engine

The GM Vortec 6.0L V8 (ordering code LC8) is a dedicated CNG version of the GM L96 engine, shown in Figure 9. The block has a 101.6 millimeter (mm) bore and a 92 mm stroke. Power ranges, depending on vehicle application, from 322 to 360 horsepower (hp), and torque ranges from 373 pound-foot (lb-ft) to 382 lb-ft (GM, 2012). Delivery vehicle offerings that utilize the GM Vortec 6.0L V8 include the Isuzu NPR, Workhorse (Navistar) W42, Workhorse (Navistar) W62, and the Chevy Express/GMC Savana Cutaway 4500.

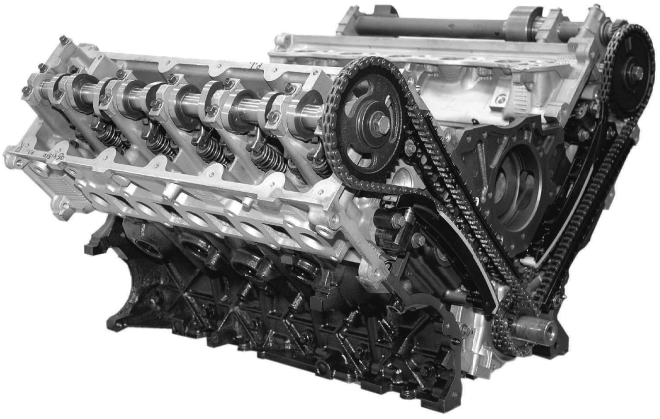

Figure 10. Ford 6.8-liter Triton V10 natural gas-prepped engine

Ford's 6.8L 3-valve single overhead camshaft with electronic fuel injection Triton V10 (ordering code 98G), shown in Figure 10, is designed for use in applications for pulling up to 20,000 lbs of gross vehicle weight rating (GVWR). It features 3 valves per cylinder (2

intake and 1 exhaust) and offers a power rating of 355 hp with 455 lb-ft of torque (Ford, 2005). The cast-iron deep-skirt engine block has a 90.17 mm bore and 105.7 mm stroke, and includes low-friction internal components for greater reliability and fuel economy. Aluminum heads improve cooling and efficiency. The engine utilizes a balance shaft to reduce vibration inherent to a 90^0 bank angle V10 engine. Ford offers an optional alternative fuel "prep package", including hardened valves and valve seats, to ease the CNG conversion process. Delivery vehicle offerings that utilize the Ford 6.8L 3-valve V10 include the F-450, F-550, F-650, and the F-59 Commercial Stripped Chassis.

Ford's 6.8L 2-valve electronic fuel injection Triton V10 (ordering code 91G) is a lower-powered variant of the 3-valve Triton previously discussed. It provides a maximum of 305 hp and 455 lb-ft of torque (Ford, 2012). The block is identical to the 3-valve Triton, with a 90.17 mm bore and 105.7 mm stroke. Delivery vehicle offerings that utilize the Ford 6.8L 2-valve Triton V10 include the E-450 Cutaway and E-450 Stripped Chassis.

Heavy-Duty Engines

CNG engines for heavy-duty applications are produced by OEM engine manufacturers and installed by chassis manufacturers. Cummins Westport Inc. (CWI) designs, engineers, and markets spark-ignited dedicated CNG engines for commercial transportation applications. CWI was formed in 2001 as a fifty-fifty joint venture between Cummins Inc. and Westport Innovations. The CWI ISL G is designed to operate on natural gas for medium and heavy-duty truck applications. The CWI ISX12 G, to be available in 2013, is designed for regional haul tractors and other larger truck applications.

The CWI 8.9L 6-cylinder ISL-G dedicated natural gas engine, shown in Figure 11, features the ability to operate on liquefied natural gas (LNG), CNG, or biomethane. The engine is available with outputs of 250–320 hp, and 660–1,000 lb-ft of torque (CWI, 2012). Compared with previous Cummins Westport lean-burn natural gas engines, ISL G torque at idle is improved over 30 percent, and fuel economy is improved by up to 5 percent. The reduction in emissions allows for a maintenance-free emissions aftertreatment system, consisting of a three-way catalytic converter. The engine is currently available in the Capacity of Texas TJ9000, Cargotec Solutions Ottawa 4x2, Freightliner M2 112, Freightliner 114 SD, Freightliner Cascadia Day Cab, International WorkStar (anticipated by 4th quarter 2012), International TranStar (anticipated by 3rd quarter 2012), International LoadStar (anticipated by 1st quarter 2013), Kenworth T440, Kenworth T470, Kenworth W900S, Kenworth T800SH, Peterbilt 365,

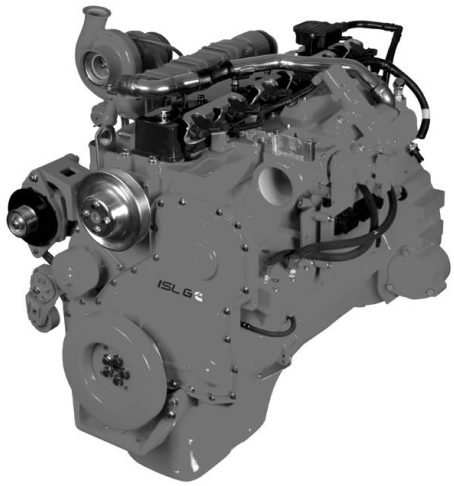

Figure 11. Cummins Westport Inc. 8.9-liter ISL-G dedicated natural gas engine

Peterbilt 382, Peterbilt 384, and Volvo VNM, and Volvo VNL.

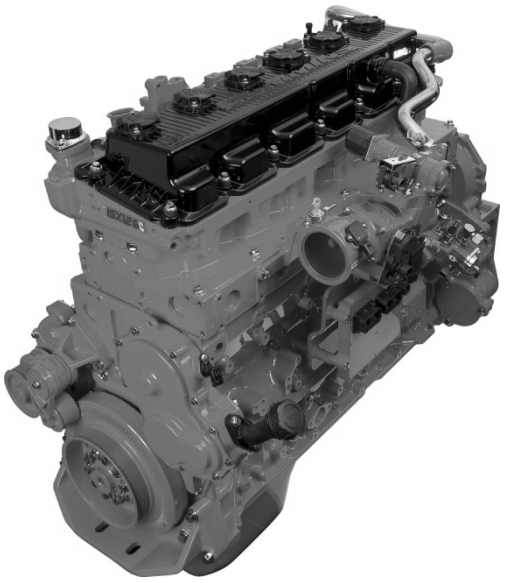

Figure 12. Cummins Westport Inc. ISX12 G dedicated natural gas engine (available in 2013)

The CWI ISX12 G natural gas engine, shown in Figure 12, is based on the Cummins ISX12 diesel engine platform, the newest member of Cummins heavy duty-engine family. The ISX12 G engine features three-way catalyst aftertreatment, which is packaged as a muffler and is maintenance free. As with the ISL G, no diesel particulate filter or selective catalytic reduction aftertreatment is required. Fuel can be carried on the vehicle as either CNG or LNG, utilizing Cummins Westport's proprietary spark-ignited, stoichiometric combustion with cooled exhaust gas recirculation technology, first introduced with the 8.9L ISL G engine. Maximum power ratings range from 330–400 hp, and maximum torque ranges from 1,150–1,450 lb-ft (CWI, 2012). Field testing is underway, and production is expected to begin in early 2013. Pending ISX12 G engine availability from the launch partner OEMs that CWI is currently working with include; Freightliner Cascadia Day Cab, Kenworth T800SH, Kenworth W900S, Mack Granite, Mack Pinnacle, Peterbilt 365, Peterbilt 384, and Volvo VNL. Cummins expects to expand OEM availability following the initial product launch.

Emissions Solutions Inc. (ESI) develops, manufactures, and markets EPA- and CARB-certified MY 2012 OEM, medium- and heavy-duty CNG engines. They currently offer the Phoenix 7.6-liter and 7.3-liter natural gas engines on a selection of Navistar vehicle platforms. ESI is in the process of developing a 9.3-liter dedicated natural gas engine that should be capable of delivering up to 350 hp and 1250 lb-ft of torque. This engine is expected to be ready for certification testing in the second half of 2012. Research and development on a spark-ignited dedicated 13-liter big bore engine is expected to commence in late 2012 or early 2013 with the support of the U.S. Department of Energy's National Renewable Energy Laboratory.

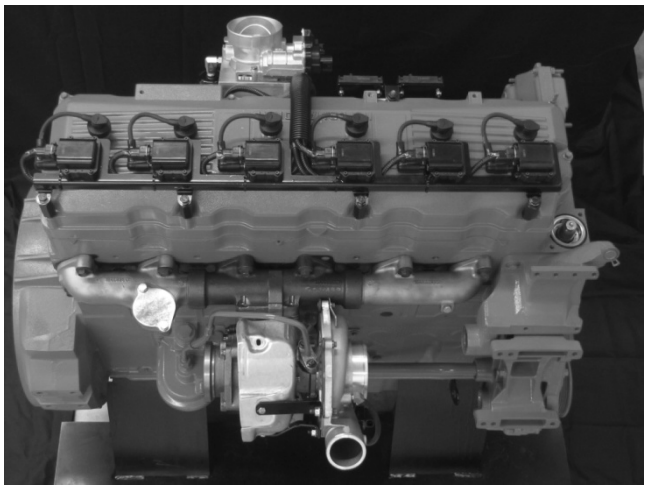

Figure 13. Emission Solutions Inc. Phoenix NG 7.6-liter dedicated natural gas engine

The ESI Phoenix NG 7.6-liter, shown in Figure 13, is a dedicated natural gas OEM engine that uses Navistar diesel engines (the DT466/MaxxForce DT engines) as the base platforms,

with the same horsepower and torque at a lower engine speed. The primary modifications are: pistons, rings, injectors, spark plugs, head, and electronics. The major combustion components are cryogenically treated to increase durability. Depending on the model, it delivers between 210–300 hp and 520–860 lb-ft of torque (ESI, 2012). It is outfitted with a three-way catalyst aftertreatment system, without exhaust gas recirculation. The ESI Phoenix NG 7.6-liter engine is currently available in International DuraStar 4300/4400 and International WorkStar 7300/7400. An ESI Phoenix NG 7.6-liter engine retrofit can be done on vehicles that have the Navistar DT466E engine.

The ESI Phoenix NG 7.3-liter engine is an 8-cylinder dedicated CNG engine emanated from the International 444 diesel engine. The engine was certified at a nitrogen-oxide level of less than .07 grams per break horsepower hour. The natural gas engine is capable of developing up to 255 hp and 650 lb-ft of torque. The ESI Phoenix NG 7.3-liter 8-cylinder engine is available today only for re-powers of existing vehicles the Navistar DT444E engine which is suitable for smaller food delivery vehicles.

7 CNG Vehicle Operation and Maintenance

Safety procedures and a safe working environment are essential when working on any vehicle, including those that operate on compressed natural gas (CNG). General measures for personal and shop safety still apply, and all personnel should be properly trained and have the correct tools for the type of vehicle they are servicing. Because of specific characteristics of natural gas vehicles, there are special safety considerations that must be taken into account. Society of Automotive Engineers (SAE) J2406: Recommended Practices for CNG Powered Medium- and Heavy-Duty Trucks provides guidance for the construction, operation, and maintenance of CNG-powered medium- and heavy-duty trucks (SAE, 2002). Some manufacturers require that mechanics working on its engines are certified by the National Institute for Automotive Service Excellence (ASE).

Similar to a gasoline- or diesel-fueled vehicle, a CNG vehicle's fuel system should be inspected periodically. In fact, the United States Department of Transportation (DOT) Federal Motor Vehicle Safety Standard 304 for CNG fuel container integrity requires a label on all CNG cylinders used on motor vehicles that states: "This container should be visually inspected after a motor vehicle accident or fire and at least every 36 months or 36,000 miles, whichever comes first, for damage and deterioration" (DOT, 2003). The Compressed Gas Association (CGA) pamphlet entitled "Methods for External Visual Inspection of Natural Gas Vehicle (NGV) and Hydrogen Vehicle (HV) Fuel Containers and Their Installations" is taken as the acceptable practice in the industry for complying with the US DOT Safety Standard 304 and the American National Standards Institute NGV2 (CGA, 2007). Qualified inspectors, following a standard developed by NGV industry engineers, will check for cuts, cracks, gouges, abrasions, discoloration, broken fibers, loose brackets, damaged gaskets or isolators, heat damage, or other problems, and recommend proper action to ensure fuel system safety (AFV International, 2009). Some CNG vehicle manufacturers, local gas utilities, and cylinder manufacturers offer cylinder inspection services by qualified inspectors. CSA is the only nationally recognized organization certifying CNG cylinder inspectors in the United States and Canada. The certification test that is required to become a CSA America Certified inspector is offered as computer-based exams through the National Alternative Fuels Training Consortium; AFV International; Natural Gas Vehicle Institute; Advanced Transportation Technology; Energy Transfer Technology; Phoenix Energy; College of the Desert; and CNG-NGV Solutions, Inc. Many of these facilities provide on-demand exam sessions allowing flexibility in taking the exam.

A CNG vehicle utilizes a gaseous fuel that is stored at high pressure and is ready to be delivered when requested by valves and regulators. As a safety precaution, a manual shutoff valve is installed to enable the fuel line between the fuel tank and the engine to be closed. When servicing the engine or fuel system, the technician should close the manual shutoff valve and release all fuel from the system downstream of that point in accordance with the Service Manual procedure.

Most natural gas engines require special oil with a lower sulfated ash limit (CWI, 2012). The use of diesel engine oil may cause valve torching, piston scuffing, and reduction in spark plug life. The primary difference between natural gas and other internal combustion engine oils is the

necessity to withstand the various levels of oil degradation caused by the gas fuel combustion process, which results in the accumulation of oxides of nitrogen. However, natural gas engine oil may not need to be changed as frequently because CNG burns more cleanly than gasoline or diesel, producing fewer deposits in the oil (Leugner, 2003). Cummins Westport recommends oil changes every 15,000 miles, 500 hours, or 6 months on the ISL G natural gas engine. Spark plug changes should be scheduled after 60,000 miles, 1,500 hours, or 24 months, but there should be an initial overhead adjustment after the first year (CWI, 2012).

Natural gas is typically filtered and dried as it enters the compressor station from the pipeline. A vehicle CNG filter located prior to the engine ensures a flow of clean natural gas. Coalescing filter elements are specially designed to remove liquid contaminants from gaseous flows. Coalesced liquid (water and oil) collects in the bowl awaiting drainage, while clean air or gas exits the housing through the outlet port. Particulate contaminants are captured and held in the media. Grade 6 filter elements have a coalescing efficiency of 99.97% and are used when "total removal of liquid aerosols and suspended fines" is required. This is the filter that is recommended by most manufacturers for natural gas vehicle applications. Grade 10 filter elements only have a coalescing efficiency of 95%, which allows more carryover oil and contaminates to pass through. Filter housings have a drain port to remove excess water that was filtered from the gas. CNG vehicle drivability problems can result from failing to maintain the coalescent filter, so it is important to adopt a coalescent filter inspection and maintenance schedule. The recommended CNG filter change interval is every 15,000 miles under normal operating conditions and every 5,000–10,000 miles under severe operating conditions. The quality and cleanliness of the CNG at the local fueling station determines whether the vehicle is operating under "normal" or "severe" conditions (i.e., whether there is a dryer and if the station filter is regularly changed).

Maintenance facilities for CNG vehicle service might need to be modified or constructed to conform to safety requirements related to the unique properties of natural gas. However, some modern maintenance facilitates with sufficient ventilation have been approved to repair and maintain CNG vehicle with no required modifications so it is important to discuss with your local fire marshal and electrical inspector. Existing vehicle maintenance facilities are constructed to ensure safety when dealing with liquid fuels which, when leaked, pool on the ground. Natural gas, on the other hand, rises in the event of a leak because it is lighter than air. This primary difference is the principle behind the requirements for CNG vehicle maintenance facility modifications. The National Fire Protection Association (NFPA) is the overarching organization responsible for the standards that govern CNG vehicle maintenance facilities and typically become adopted as code. NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages applies to motor fuel dispensing facilities located inside buildings and at fleet vehicle motor fuel facilities, as well as motor vehicle repair garages. This code is recommended for use as the basis for legal regulations and its provisions are intended to reduce the hazards of motor fuels to a degree consistent with reasonable public safety, without undue interference with public convenience and necessity (NFPA, 2012). Within New York State, enforcement of safety regulations for a CNG vehicle maintenance facility fall to the local fire marshal and electrical inspector who will use their interpretation of the Building Code of New York State, Fire Code of New York State, and Fuel Gas Code of New York State (which reference NFPA 30A for CNG applications) to determine if a facility is approved for use (ICC, 2010). As mentioned, the codes

can be interpreted differently, but they are applied based on the unique characteristics of each facility.

Regardless of whether an existing facility is being modified for CNG vehicle maintenance, or a new facility is being constructed, there are three primary considerations: ventilation, heating, and potential ignition sources. Because natural gas is lighter than air, NFPA defines the Class 1 Division 2 Group D area in CNG vehicle maintenance facilities as the area extending from the ceiling downward 18 inches. In these facilities, air must be introduced at a lower level and exhausted at the ceiling (the reverse of facilities designed for liquid-fueled vehicles). However, if there is a minimum of four air changes per hour there may be no need for ventilation system modifications. Measures or equipment to ensure appropriate ventilation for CNG vehicle maintenance include methane detectors; modified heating, ventilation, and air conditioning systems; supplemental exhaust systems; and appropriate exhaust fan(s) over the vehicle maintenance bays where CNG vehicles will be maintained. In a facility where CNG vehicles will be maintained, NFPA codes indicate that open flame heaters are not allowed within the top 18 inch cavity. NFPA further indicates that if an open flame heater is mounted below 18 inches from the ceiling, it is considered to be located in a general purpose area and is allowed. However, best practices recommend that CNG vehicles never be parked below any open flame heater area under any circumstances. To meet the code requirements for heating systems in CNG vehicle maintenance facilities, sealed combustion, catalytic, or infrared heaters with a skin temperature below 800°F may be used. The ignition temperature of natural gas is approximately 1,200°F, which allows these heaters to operate safely. No potential source of ignition that could create an arc or spark that would ignite natural gas should be located 18 inches from the ceiling or higher in a CNG vehicle maintenance facility. This includes lighting systems. Special lighting systems can be used, or traditional lighting can be pendant mounted below the 18 inch cavity from the ceiling. Also, general electrical equipment should not be located within the 18 inch space below the ceiling. For example, motors that operate roll-up electrical doors that are located in that 18 inch space must either be relocated or must be Class 1 Division 2 Group D rated. (Thomason, 2011)

It is good practice not to bring a vehicle into the maintenance facility with a full CNG tank if it is expected to be in the garage overnight or an extended period of time. For this reason, a safe and properly grounded defueling venting stack or defueling nozzle to transfer fuel from a vehicle to be maintained to another vehicle is something to consider installing. The vehicles must also have a defueling receptacle to utilize this feature.

Emergency buttons, an example of which is shown in Figure 14, that can be used by personnel if they detect a gas leak or suspect potential hazardous conditions are also required in CNG vehicle maintenance facilities and fueling infrastructure. Depending on the control system, various automatic responses can be integrated into the emergency button. For maintenance facilities, this could involve opening all doors to vent out the gas, activating high-mounted exhaust fans, cutting off power to certain equipment, or stopping any potential gas flows. At fueling

Figure 14. Emergency shut-off buttons for compressed natural gas maintenance facilities and fueling infrastructure

facilities, this action will shut down the station, turn off the gas, and cease fueling operations. Pressing the emergency button may also activate an alarm, flash lights, or notify a call center that could automatically dispatch emergency vehicles if the call center operator is not able to confirm that the situation is under control. Once pressed, the emergency button locks into position and does not reset until manually reset by the operator.

8 Public Fueling Options

New York State currently has 34 public compressed natural gas (CNG) fueling stations and all except 3 are always open. Twenty stations are in the Long Island and New York City vicinity, while the other 14 are primarily found in the other major cities across the state.

Figure 15. Public compressed natural gas fueling stations in Upstate New York (DOE, 2012)

Figure 16. Public compressed natural gas fueling stations in Long Island and New York City vicinity (DOE, 2012)

Clean Energy operates the majority of these stations, with gas utilities operating most of the remainder. A few stations are owned and operated by private companies. Almost all of these stations are able and willing to accommodate local delivery fleet vehicles that can conveniently pass by the stations on their route. **Appendix F: CNG Stations in New York State** has detailed information and regional maps of these public stations throughout New York State. It is recommended that fleets visit the station and talk to the operator if they are considering using it for regular fueling. While most can handle the overall increased CNG demand, stations with more limited storage capacity may provide quicker fueling at certain times of the day. Also, more than half of the operators use individual key cards and account payments that would need to be coordinated prior to using the station. Table 1 lists a few websites and smartphone apps maintain an interactive database of CNG stations with up-to-date information on the sites, including operational status and prices in some cases.

Table 1. Listing of online interactive databases of compressed natural gas stations

US DOE Alternative Fuels and Advanced Vehicles Data Center Alternative Fueling Station Locator	Location, station details, directions, contact	www.afdc.energy.gov/afdc/locator/stations/
Alternative Fuel Prices and Fill Stations Map	Location, prices, customer comments	www.altfuelprices.com
CNG Now Stations Map	Location, prices, directions, customer ratings	www.cngnow.com/stations/Pages/information.aspx
MapMuse CNG Fuel Stations Location Map	Location, details, customer reviews	http://find.mapmuse.com/map/cng
CNG Prices Map	Location, price, details, reviews	www.cngprices.com/station_map.php
CNG Now Fuel Finder App	Location, prices, pressure, directions, customer ratings	www.cngnow.com/app/Pages/information.aspx
MapMuse Alternative Fuel Finder App	Location, directions, photos, reviews	http://find.mapmuse.com/apps/alt-fuel

In addition to the publicly accessible CNG stations, there are 82 private CNG fueling sites in New York State. See **Appendix F: CNG Stations in New York State** for a listing of New York State private CNG stations. These stations were designed and built to service only vehicles within the fleet of the organization that installed the station and may only have time-fill capability for fueling of vehicles during extended periods. These station owners may not have chosen to allow public fueling because of site or corporate restrictions, or to minimize station costs. However, with expressed interest from other fleets, these locations may be willing to consider installing a publicly accessible CNG dispenser or sharing the station with a limited number of other fleets if sufficient interest is generated. Because these stations currently possess the staff and expertise to operate a station, if there is enough known demand, they may be willing to invest or look for funding to add public fueling. Many of the private CNG stations in New York State are owned by the New York State Department of Transportation (NYSDOT). Where feasible, some of the

NYSDOT stations have been expanded and made available for public fueling. Clean Energy operates those sites and has first right of refusal on any additional NYSDOT site that is slated for adding public access.

Due to the increased interest in CNG and its significantly lower operating costs, additional CNG stations are being considered or in the process of being planned. Waste Management recently announced that it is pushing forward on a nationwide plan to convert all of its 18,342 trucks to CNG (Shauk, 2012). That means that all Waste Management locations in New York State may have CNG fueling in the near term. Waste Management's facility in West Seneca (Buffalo) currently has time-fill CNG for its trucks and a public station outside its fence. A high-volume nozzle was included on that station to service its trucks if necessary, as well as other heavy-duty trucks in the area. The Waste Management facility in Rochester is the next site planned for adding CNG fueling. As the company continues to transition to CNG, new fueling infrastructure in Binghamton, Liverpool, Utica, Kingston, Albany, Fort Edward, Black River, and Yonkers may present further collaboration opportunities for delivery fleets in those areas. Awareness of additional CNG demand from fleets in these locations may help Waste Management decide whether public fueling should be incorporated into its stations.

Fueling at a public CNG station significantly minimizes the risk for a delivery vehicle fleet that is interested in pursuing this alternative fuel. By eliminating the initial capital cost of a CNG station and the associated need to generate significant cost savings to offset that cost, a fleet has more flexibility to gradually transition to a CNG fleet as vehicles are replaced. Beyond negotiating with a private station to provide public access, multiple fleets, both private and municipal, could "pool" their CNG demand to encourage a third party to build and operate a CNG station that would service all of the fleets. However, in many places, reasonably priced land in a central location that is easily accessible by fleets may not be easy to find, so a fleet in the "pool" may wish to offer space at its facility on which to build the station. In addition, combined time-fill (for the fleet at the station location) and fast-fill (for other fleets) fueling is often a cost-effective approach to balance the CNG demand and minimize needed on-site storage. The local Clean Cities Coordinators can facilitate collaboration in coordinating CNG demand from delivery fleets and working with third-party CNG station operators that might be interested in building a station.

9 CNG Station Basics

In situations where a compressed natural gas (CNG) program would make financial sense for a fleet, but no public CNG fueling is currently available or planned, it may be necessary for a fleet to build its own infrastructure. Large fleets, especially those that already manage on-site liquid fueling facilities, may choose to build a CNG station for convenience, greater economic benefit potential, and to leverage existing capabilities within the company. This section contains a brief overview of the factors to consider when installing CNG infrastructure. A fleet should consult experts in the field, listed in **Appendix D: Vendors for Natural Gas Equipment and Services**, before committing to this undertaking because an improperly designed, sized, or operated fueling station can impact the use of the CNG vehicles and potentially negate the economic savings that could be realized through a CNG vehicle program.

CNG stations are usually time-fill capable, fast-fill capable, or a combination of both. Time-fill stations dispense fuel to multiple vehicles over an extended period of time. This is an excellent fueling methodology for vehicles that park in the same exact spot at the end of every work shift for an extended period of time (typically at least 10-16 hours). Time-fill system compressors raise the pressure of the entire fueling apparatus as a unit, including any vehicles that are connected. The vehicle connected with the lowest pressure (emptiest) will receive all the CNG from the compressor until the system pressure is raised to that of the truck with the next lowest pressure, at which time that truck will begin fueling. As the system pressure rises, eventually all connected vehicles will receive fuel until all of them reach the CNG pressure limit of 3,600 pounds per square inch (psi) at 70^{o} F (or 3,000 psi at 70^{o} F on older stations). Provided the vehicles are parked long enough, a time-fill station will always fill the vehicle tanks completely because the slower rate allows the gas to fully equalize its temperature inside each tank. Time-fill systems do not include on-site CNG storage, which lowers the installation cost, and the compressors operate for an extended period of time from when the first vehicle is connected until the entire fleet is filled (then the compressors may remain off for a long period of time until the vehicles return from route). Having the compressors operate only once per day reduces maintenance and extends the life of the equipment. Time-fill systems may be able to reduce electric costs to operate compressors by filling trucks during off-peak hours, thus eliminating any demand charges and enabling an off-peak electric rate if provided by the utility. Fuel management (except for the main utility gas meter) and payment systems are not necessary if the station is not fueling vehicles outside of the fleet, which further reduces station costs.

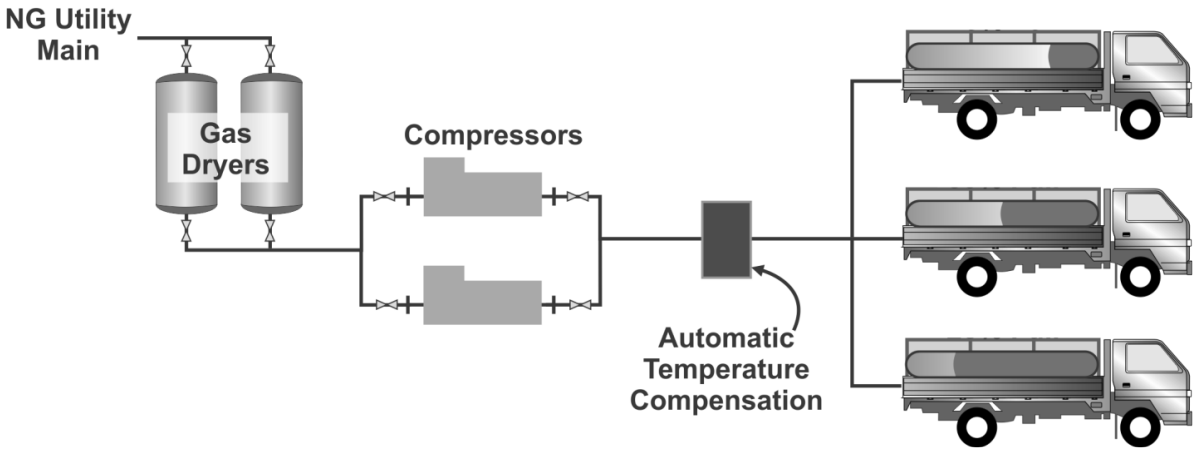

Figure 17. Schematic of a time-fill compressed natural gas fueling system

Fast-fill stations are designed to provide fill rates comparable to liquid fueling stations for conventional fuels. This is necessary for any station with public accessibility. CNG is metered and dispensed similar to ordinary liquid fuel dispensers. A typical dispenser has two hoses and stations can have multiple dispensers so more than one customer can fuel their vehicles simultaneously. The dispensers can also incorporate different nozzles from the same system that provide 3,000 psi gas, 3,600 psi gas, or higher volume fueling with a CT5000 nozzle (transit and large truck applications). Many fast-fill systems can incorporate a card reader, which accepts universal fuel cards or credit cards, for authorizing, dispensing, and storing the transaction for billing, although some only permit specialized cards or keys that route fueling information to the station operator who would bill the fleet directly for fuel costs. When set up with this system, public-access CNG stations can be unmanned and open to the public 24 hours a day and 7 days a week. Fast-fill stations require less space for construction and dispensing, but they need to have onsite storage tanks. In New York City, CNG fuel dispensers must have a person with a Certificate of Fitness "line of Sight" C-99 on the property at all times fueling is being performed. Additionally, the New York City Fire Department requires all personnel that fuel to be trained and carry a "CNG Awareness Fuel Training Card." Free training is provided by National Grid and Con Ed.

There are two storage configuration designs for fast-fill stations; cascade or buffered storage. Cascade systems are generally used in situations where a number of smaller vehicles (10-30) are filled in a peak fueling period (30-90 minutes), or where a few large vehicles are fueled sporadically throughout the day. A cascade fast-filling station typically has banks of storage; low, medium or mid, and high and a priority panel that directs the flow of gas to the banks. When a vehicle is fueling, it will first draw CNG from the low bank, provided the cylinder pressure of the vehicle's tank is lower than that of the low pressure storage bank. Once the vehicle's tank pressure equalizes that of the low pressure bank, the system will switch to the medium pressure bank to fuel the vehicle's tank up to its level. Finally, the high pressure bank will be used to ensure that the vehicle is fueled up ("topped off") to its maximum allowable pressure. This configuration ensures that the desired filling pressure will be available as long as the mid or high pressure bank has a higher pressure than the cylinders on board the vehicle. When the compressor

comes on, it prioritizes the flow of gas to fill the banks in the reverse order, from high to mid to low bank so that the high bank always has enough pressure to fill or "top off" the vehicle. The priority panel can also direct the high pressure CNG directly to the vehicle from the compressor (bypassing the storage banks), but the flow rate is limited by the output size of the compressor. In addition to always maintaining a reservoir of high pressure CNG, the cascade system uses the low bank to fuel vehicle tanks first, which is more cost effective and helps address some thermodynamic concerns that will be discussed later.

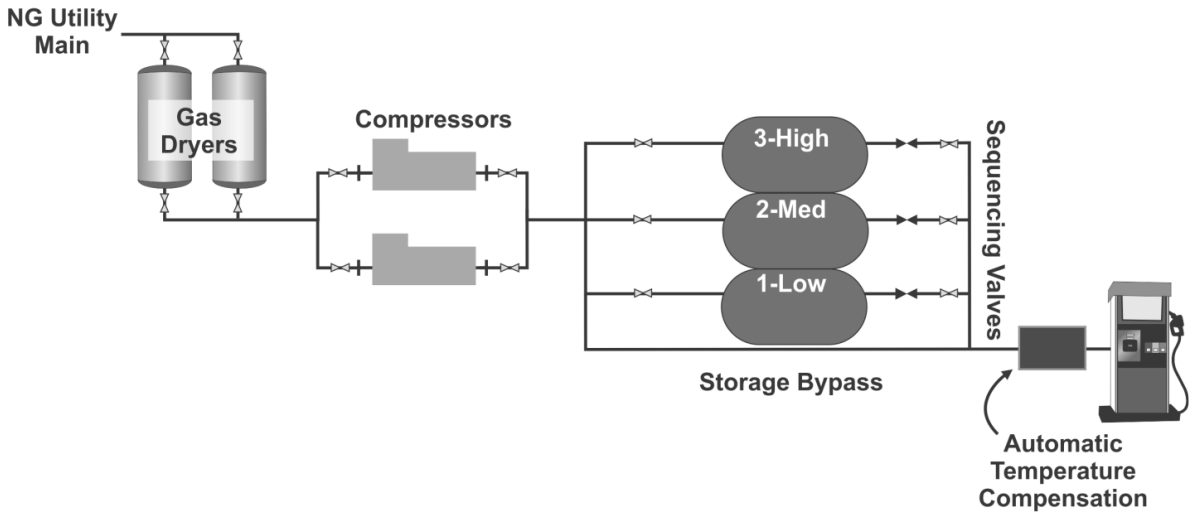

Figure 18. Schematic of a fast-fill cascade compressed natural gas fueling system

Buffered fast-fill is generally used in situations where large vehicles are fueling on a continuous basis. Unlike cascade systems that primarily fill vehicles from stored gas, the buffer system provides most of the vehicle fill directly from the compressor, which is sized accordingly to deliver a high flow rate. The buffer storage is utilized to allow the compressor to continue to run between vehicle fueling (commonly referred to as "dwell" time) to fill the buffer tanks with CNG that can be used to increase the rate of fill for the next vehicle. The buffer system tanks are all maintained at the same pressure and are used only when their pressure is higher than that of the vehicle storage tanks. In a buffer fill methodology, the highest pressure to "top off" the vehicle's tanks must always come directly from the compressor.

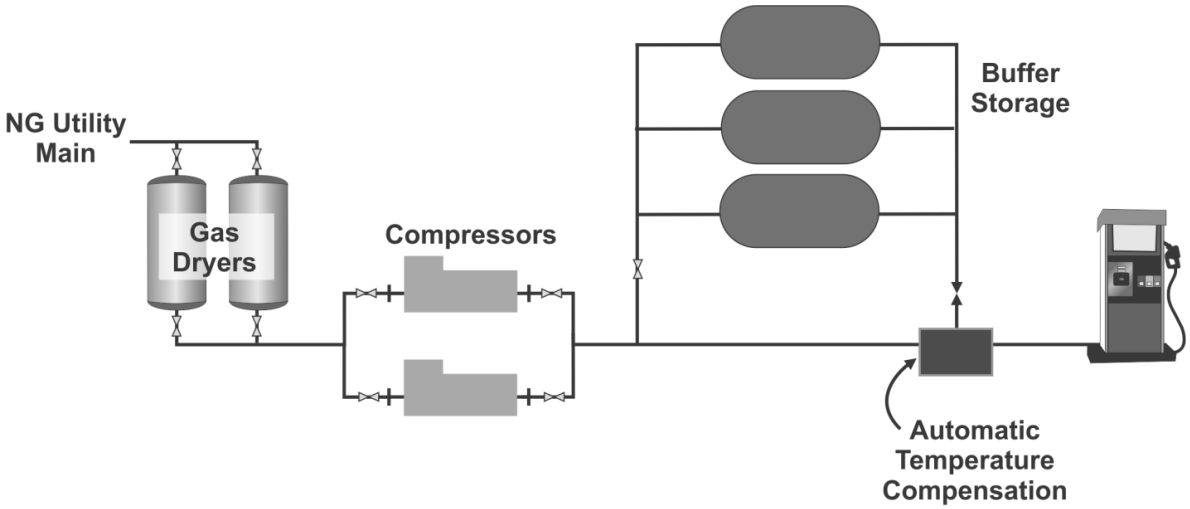

Figure 19. Schematic of a fast-fill buffered compressed natural gas fueling system

Combination stations combine the features of a fast-fill system and a time-fill system. When there is an opportunity to do so, it is very efficient to perform fast-fill dispensing operations during the daytime along with time-fill operations during the nighttime. This combination allows high utilization of the station compression capacity during the daytime and nighttime.

Under-filling of CNG vehicle storage cylinders during fast-fill fueling operations can occur at fueling stations. This is partially the result of the fueling station dispenser control system either failing to compensate for, or inaccurately estimating, the elevated CNG storage cylinder gas temperatures, which occur during fueling, due to compression, mixing, and other complex and transient thermodynamic processes. Most modern CNG dispensers have controls with temperature compensation to account for this, but fast-fill fueling may not result in a completely full tank after the CNG has time to "settle" in the tank. The customer is still provided an accurate measurement and cost for the fuel that was provided, but the tank pressure may not be at its maximum limit, which can slightly reduce the vehicle's range. The industry has worked on this thermodynamic factor and the Gas Technology Institute has a temperature compensated, full fill algorithm that is available to any dispenser manufacturer or fuel station developer.

Pipeline gas from the utility may contain moisture and other impurities. Excessive moisture can affect the operation of the CNG compressors and even the vehicles, so it is important to use a gas dryer to "clean" the gas to provide high-quality fuel. Within the gas dryer, the natural gas first flows through a series of filters to remove any particulate matter from the gas stream. Then the gas runs through a desiccant drying bed to remove moisture. When the desiccant bed in a gas dryer becomes saturated, the dryer must be "regenerated." The regeneration process heats up the desiccant in order to remove the liquids from the dryer bed. CNG station owners should be aware that the effluent from the dryer is classified as hazardous waste and must be handled and disposed of properly. A gas dryer may be a single- (one desiccant bed) or twin- (two desiccant beds) tower design. A single-tower design keeps costs low and is appropriate for small to medium CNG projects, such as a time-fill refuse station. The main drawback to a single-tower design is that the dryer must be taken off-line during the regeneration process and fuel may not be available during

this time (depending on storage). In the twin-tower design, when one side of the dryer is saturated, the gas flow will automatically be directed to the second side. This type of dryer is typically used in stations that require operational redundancy, such as fast-fill transit CNG stations. Dryers with manual regeneration require a technician to monitor the dryer operation and perform the process. Systems that regenerate automatically have computers on board that determine when the system needs to be regenerated and carry out the process without the intervention of a technician. (Trillium, 2010)

Natural gas compressors transform ordinary, low-pressure gas into a high-pressure fuel stream for vehicles. Most natural gas compressors are classified as positive displacement compressors. Two main types of compressors in this category are reciprocating (includes single-acting and double-acting designs, as well as diaphragm compressors) and rotary (includes lesser-used types such as scroll, screw, and liquid ring compressors). In the more common reciprocating designs, gas is compressed in cylinders by pistons, which are driven by a crankshaft. The cylinders are arranged in "stages," typically numbering between two to five, to compress the gas for vehicular use. The number of compression stages required will depend on the suction pressure provided by the gas utility and the size of the primary mover (motor) in terms of horsepower. Natural gas compressors come in a wide array of sizes and are rated by the amount of CNG they discharge in standard cubic feet per minute (SCFM). As a rough estimate, dividing the compressor's SCFM at its rated inlet psi by two will equal the gasoline gallon equivalents (GGEs) per hour that it can produce. Inaccurately estimating the station's desired GGE per hour of output could result in under-sizing (leading to poor fills or over use) or over-sizing (leading to station reliability issues and increased power costs) of the compressors. Most equipment manufacturers have CNG calculations that can be used to accurately size the station.

Though it is certainly possible to successfully operate a CNG fueling station with a single compressor, in most cases fleets require fueling redundancy to prevent potential fueling downtime and missed fleet rollouts. A CNG station with "full redundancy" must have at least two compressors and the station's compression capacity must equal or exceed twice the amount of the fleet's daily fuel use. In the event of a malfunction with one compressor, the fleet would still be able to fuel its entire fleet within the fueling window. A two-compressor system can also balance wear on individual compressors and extend the life of the fueling system. At larger CNG stations, it is often more efficient and cost-effective to design with partial redundancy. For instance, a large transit CNG station might require two active compressors to meet SCFM requirements, but the addition of a third compressor could provide sufficient redundancy if the station receives dedicated maintenance. Though such a design does not provide complete redundancy, the control system would promote balanced wear and increased equipment longevity. (Trillium, 2010) If there is another CNG fueling facility accessible to your fleet along the route your vehicle travels, then that station could be considered as the "redundant" station, thus eliminating the need for a redundant compressor on your property, which will lower the cost.

NFPA 52: Vehicular Gaseous Fuel Systems Code, applies to the design, installation, operation, and maintenance of CNG engine fuel systems on vehicles of all types and for fueling vehicle (dispensing) systems and associated storage (NFPA, 2010). While many of these requirements are integrated into the equipment that is purchased, there are some site-specific codes that must be

adhered to for the local fire marshal and electrical inspector to approve the permit. There are also a number of standards listed in the following table that apply to CNG stations. Station owners and operators should be aware of these standards so that all equipment purchased is compliant with these requirements.

Table 2. Standards for compressed natural gas fueling infrastructure and components (ANSI, 2009)

American National Standards Institute (ANSI)/IAS NGV4.1-99/CSA 12.5-M99(R09) **Natural Gas Vehicle Dispensing Systems**	Applies to the mechanical and electrical features of newly manufactured systems that dispense natural gas for vehicles, where such a system is intended primarily to dispense the fuel directly into the fuel storage container of the vehicle.
ANSI/IAS NGV4.2-99/CSA 12.52-M99(R09) **Hoses for Natural Gas Vehicles and Dispensing Systems**	Applies to compressed natural gas hose assemblies that are used for natural gas vehicle dispensing stations to connect the dispenser to the fueling nozzle, or used as part of a vehicle onboard fuel system and for gas lines that carry vented gas back to a safe location.
ANSI/IAS NGV4.4-99/CSA 12.54-M99(R09) **Breakaway Devices for Natural Gas Dispensing Hoses and Systems**	Applies to newly produced compressed natural gas vehicle dispenser shear valves and fueling hose emergency breakaway shutoff devices.
ANSI/IAS NGV4.6-99/CSA 12.56-M99(R09) **Manually Operated Valves for Natural Gas Dispensing Systems**	Applies to manually operated valves for high-pressure natural gas.
NGV 4.8-2002/CSA 12.8-2002 (R07) **Natural Gas Fueling Station Reciprocating Compressor Guidelines**	Details construction and performance requirements for natural gas compressors for use in compressed natural gas fueling stations service. The compressor package should include, but not be limited to, all necessary equipment from the inlet connection immediately upstream from the isolation valve to the packager-specified discharge connection.

10 Funding Options for Vehicles and Infrastructure

Grants, tax incentives, and low-interest loans can ease the cost burden of converting a diesel fleet to compressed natural gas (CNG) vehicles. Grant awards and tax incentives are available for the purchase of CNG vehicles and infrastructure through federal and state agencies. State tax exemptions can lower the fuel cost of operating a fleet of CNG vehicles compared to a diesel-based fleet.

Grants and Low-Interest Loans

Federal and state grant funds are available to entities that are willing to put in the extra effort needed to prepare successful applications. Federal agencies such as the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Transportation (DOT) all provide grants aimed at providing economic aid for the adoption and use of alternative fuel vehicles and infrastructure. In New York State, the New York State Energy Research and Development Authority (NYSERDA) also issues several opportunities that encourage the adoption of alternative clean vehicle technologies.

Successful grant applications often include several elements; inclusion of these elements in your proposal will ensure that you have the most competitive proposal possible. Grants are often administratively cumbersome; the prospective awardees must meet deadlines for filing, submit appropriate forms and schedules and back-up documentation, and format the application as required. Failure to meet application requirements reflects poorly on the applicant's ability to manage the process. Additionally, ongoing reporting of project completion and vehicle usage/fuel displacement is a typical administrative requirement of all grants.

It is important to speak to the area of interest and the evaluation criteria of the agency funding the grant. DOE and state energy offices often focus on petroleum reduction and energy efficiency. The EPA and state environmental offices focus primarily on pollution reduction and air quality benefits affecting the greatest number of population. Economic development agencies' proposals should focus on jobs created and tax revenues generated for the state.

Clearly spell out the proposed benefits, the criteria by which you plan to measure those benefits, and the action plan and the proposed processes in place to manage resources and take corrective action mid-stream to achieve the goal(s). Show that measurement of performance and the ability to adjust are critical to your process.

Successful partnering is also important. Letters of support from any regional organizations or groups that could benefit are looked upon favorably, including but not limited to your local gas utility and any potential project partner or supporter. Collaboration with Clean Cities is also highly favorable. Clean Cities may even be able to help coordinate collaboration with another organization that could make the project larger and more favorable to the funders. Consultants or

university partners that regularly write grants can help strengthen your proposal, and for a portion of the funding they may manage the measurement and administrative aspects of the project.

DOE's Clean Cities Program

DOE's Clean Cities Program is designed to accelerate the use of alternative fueled, in a fuel neutral manner, and petroleum reduction strategies in the transportation sector throughout the country. The overall mission of the program is to improve our national energy security while providing environmental benefits through emission reductions of greenhouse gases, particulate matter, and other criteria pollutants. Clean Cities grants have expanded the use of natural gas vehicles in a variety of applications, such as school buses, transit buses, airport vehicles, taxis, refuse, delivery, and municipality fleets. Grants have also been used to build fueling infrastructure, with a focus on locations that provide public access, as this provides the opportunity to further increase the number of vehicles using natural gas. The program works through a network of 90 volunteer coalitions headed by Clean Cities Coordinators that develop public-private partnerships. Support for the various Clean Cities coalitions is provided through DOE's State Energy Program Special Projects. Stakeholders of the Clean Cities Coalition can apply for DOE's Special Projects grants. Becoming a stakeholder is free and is as simple as filling out an application. These grants, awarded competitively, can be used to cost-share up to 75% of the proposed project. They can cover the incremental cost of purchasing natural gas vehicles and the cost of installing fueling equipment. For more information, contact your local Clean Cities Coalition, which are listed in **Appendix E: Resources for Additional Information**.

DOT's Congestion Mitigation and Air Quality Improvement Program

DOT's Congestion Mitigation and Air Quality (CMAQ) Improvement Program funds projects and programs that reduce transportation-related emissions in areas, such as New York City and Long Island, that do not meet the EPA's National Ambient Air Quality Standards for healthy air. NYSERDA works very closely with the New York State Department of Transportation and the local Metropolitan Planning Organizations to administer and assist in making these funds available for the alternative fuel vehicle programs. CMAQ provides grants that can pay for the incremental cost of purchasing natural gas vehicles and can be used to fund alternative fuel fueling projects, although they must have 20% local or regional co-funding, and funding is allowed for private-public partnerships. More information on this DOT program administered by the Federal Highway Administration and the Federal Transit Administration can be found here: www.fhwa.dot.gov/environment/air_quality/cmaq/.

EPA's Clean Diesel Program

The EPA's National Clean Diesel Funding Assistance Program awards competitive grants to fund projects that reduce emissions from existing diesel engines through a variety of strategies. These strategies include cleaner fuels, engine upgrades or replacements, and vehicle or equipment replacements. Under this grant program, funding is restricted to the use of technologies, fuels, and engines that have been verified or certified by the EPA or the California Air Resources Board (CARB).

Diesel Emissions Reduction Grants

On January 4, 2011, President Obama signed legislation (H.R. 5809) reauthorizing Diesel Emission Reduction Act (DERA) grants to eligible entities for projects that reduce emissions from existing diesel engines. The bill authorizes up to $100 million annually for fiscal year (FY) 2012 through FY2016 and allows for new types of funding mechanisms. Congress appropriated $29.9 million for FY2012. Seventy percent of the funds each year are direct federal grants and 30% is set aside as funding for state programs. CNG projects that qualify for DERA funding include repowering of diesel vehicles with a natural gas engine (75% of cost), or complete diesel vehicle replacement with a new natural gas powered vehicle (25% of cost). The grants do not cover normal fleet turnover or expansion, but they do cover early replacement of vehicles (old engines must be scrapped, rebuilt, or disabled). More information on the DERA grants program can be found here: www.epa.gov/cleandiesel/grantfund.htm.

EPA's SmartWay Clean Diesel Program

The EPA's SmartWay Clean Diesel Program issues competitive grants to establish national low-cost revolving loans or other financing programs that help fleets reduce diesel emissions. The program offers innovative financing programs to buyers of eligible diesel or alternatively fueled vehicles and equipment, with a focus on long-haul trucks. These innovative financing projects include those where the loan recipient receives a specific financial incentive (e.g., better than current market rates or conditions) for the purchase of eligible vehicles or equipment. Particular emphasis is on establishing low-cost loan programs for the retrofit of used highway vehicles with pre-2007 diesel engine and non-road equipment with EPA- or CARB-verified emission control technologies. There will be no SmartWay Finance competition in 2012, but visit this site for future opportunities: www.epa.gov/cleandiesel/prgfinance.htm

NYSERDA

NYSERDA's Transportation Research Program sponsors a wide variety of product development efforts aimed at improving efficiency and increasing the use of alternative fuels. Program Opportunity Notices (PONs) are issued periodically to solicit proposals for cost-share development efforts leading to the manufacture and sale of innovative products that provide energy, environmental, and economic development benefits. Current funding opportunities can be found here: www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities.aspx.

One example of a relevant funding opportunity is PON 2571 with proposals due July 16, 2012, which will fund transportation projects that improve the efficiency and reduce emissions related to the movement of goods and services in and around major commercial centers (e.g., hubs, ports, markets, industrial parks) within a region, including vehicle idling reduction projects. Funding may also address the installation of equipment to dispense alternative transportation fuels (that reduce greenhouse gas emissions), or the incremental purchase cost of vehicles capable of operating on alternative fuels, for fleets that move goods or services around major commercial centers within a region, or that represent one of the key industries or industry clusters identified in that Region's Strategic Plan. For more information, go here: www.nyserda.ny.gov/Funding-

Opportunities/Current-Funding-Opportunities/PON-2571-Regional-Economic-Development-and-Greenhouse-Gas-Reduction-Program.aspx?sc_database=web.

Two other transportation related PONs are typically opened each year. The first funds advanced transportation technologies, for which conventional CNG systems would not be eligible; however, if there is a special application or system component that is being developed for your fleet to better utilize CNG, then this funding opportunity may apply. The other transportation PON supports underutilized commercial transportation technology. Again, conventional CNG systems are not eligible, but an innovative approach or application may be considered. Contact the assigned technical manager on the PON to verify.

NYSERDA's New York City Private Fleet Alternative Fuel/Electric Vehicle Program helps private sector companies and nonprofit entities operating vehicles within the five boroughs of New York City to acquire alternative fuel vehicles. Funding is available for eligible project activities that include acquiring new medium- or heavy-duty vehicles powered by electricity or CNG, including dual fuel technology (80% CNG), or converting medium- or heavy-duty vehicles to electric, hybrid, or natural gas. For more information, contact Patrick Bolton with NYSERDA at (518) 862-1090 extension 3322 or ppb@nyserda.org.

National Fuel Gas Distribution Corporation

The National Fuel Gas Distribution Corporation established a program in 2011 to advance funds to help its customers buy-down the cost of installing CNG fueling stations and/or purchasing new CNG vehicles, thereby lowering their payback. Proposed typical buy-downs per customer are expected to be in range of $10,000–$200,000. Actual buy-down is calculated based on the incremental margin received from each project. The pilot program has an initial term of three years, with an annual cap of $1 million per year, for a total of $3 million. See www.natfuel.com for more information. Other New York State utilities may consider using similar incentive programs for their customers.

Navistar-Clean Energy Incentive Program

Truck maker Navistar International Corp. and natural gas fuel supplier Clean Energy Fuels Corp. are offering an incentive program (Fuel and Truck) that will mitigate or equalize the cost of a natural gas vehicle with its diesel equivalent. Under the program, a user would purchase a CNG vehicle manufactured by Navistar and then commit for five years to buying 1,000 gallons of natural gas per month. In return, Clean Energy would offer the user a $500 monthly rebate, which, over the five-year span, would offset the estimated $28,000 per-unit differential between buying a CNG truck and a new diesel-powered vehicle. In addition, the user would pay for natural gas fueling at a price 60 cents a gallon below the prevailing price of diesel fuel as calculated each week by the DOE's Energy Information Administration (EIA). Customers would be able to opt out of the agreement at any time without penalties. For more information, visit: www.internationaltrucks.com/trucks/naturalgas.

This would provide a guaranteed savings over diesel fuel for five years, but may not provide the best return on investment. On April 9, the national average price for a gallon of diesel fuel stood

at $4.148, according to EIA data. Thus, a customer would have paid $3.55 a gallon for the first 1,000 gallons consumed during the month (after the first 1,000 gallons are purchased the customer would purchase fuel at Clean Energy's the "retail" rate). Total monthly savings are $600 for the fuel and $500 with the rebate for $1,100. Without the program users would be purchasing CNG at Clean Energy's "retail" rate, which was about $2.90 a gallon at that time. Total monthly savings for 1,000 gallons of CNG would have been $1,250 and it could have been bought at any CNG location. Fleets may be able to get an even lower CNG price with a long-term fueling agreement, which would result in even greater savings without the incentive program. However, this savings varies with the cost differential between diesel and CNG while through the Navistar-Clean Energy program it is fixed as long as the user purchases 1,000 gallons of fuel from a Clean Energy station each month.

Tax Incentives

New York State

New York State Tax Law provides an Alternative Fuel Tax Exemption for E-85, CNG, Hydrogen, and a partial exemption for B-20 when that alternative fuel is used exclusively to operate a motor vehicle engine. On a gasoline gallon equivalent (GGE) basis, the exemption amounts to approximately $.44 per GGE comprised of savings of approximately: $.08/ GGE in Motor Fuels Tax, $.16/GGE in Petroleum Business Tax and $.20 in NY State & Local Sales and Compensating Use Taxes and fuel use taxes. Compared to petroleum fuels, CNG adopters can realize significant fuel cost savings. However, this exemption expires on September 1, 2012. Contact your local legislator for further information (Reference Assembly Bill 4011, 2011, and New York Tax Law 1111 and 1115). Information regarding the NYS Alternative Fuels Tax Exemption can be found in TSB-M-11(13)S. For additional information regarding how the sales and use tax exemptions apply to alternative fuels, including applicable definitions and situations where an exemption document may be required, see TSB-M-06(10)S, *Sales Tax Exemptions and Reductions for Certain Alternative Fuels Beginning September 1, 2006*. Except as modified by this TSB-M, all the information in TSB-M-06(10)S remains in effect.

Federal

The federal incentives to encourage the use of natural gas vehicles have expired, including the vehicle credit (December 31, 2010), along with the fueling infrastructure credit and 50-cent fuel credit (December 31, 2011).

A bipartisan team of Senators is attempting to retool the *New Alternative Transportation to Give Americans Solutions Act* (S.1863/H.R.1380), known as the NAT GAS Act, to gain greater congressional support.

If passed, the NAT GAS Act would provide tax credits of up to $7,500 toward the purchase of consumer CNG and LNG vehicles, and as much as $64,000 for heavier-grade commercial trucks. It would also provide a 50-cent per gallon discount on the federal fuel tax, a 50% tax credit (maxing out at $100,000) toward the installation of CNG/LNG pumps at public and private filling

stations, and a $2,000 credit toward the installation of home fueling appliances. The NAT GAS Act would also allow the natural gas vehicle and natural gas fueling infrastructure credits to count against the Alternative Minimum Tax provision in both cases of business use or personal use. Additionally, it allows for these credits to be transferred to the manufacturer, seller or lessee.

11 Business Case Analysis for a Natural Gas Program

Unlike personal vehicles whose purchase is driven by many factors (including some that can be intangible), medium-duty and heavy-duty vehicles are purchased for business purposes by fleet owners who are seeking a vehicle to complete a job effectively and efficiently. For this reason, new technologies are of interest to a fleet owner if that technology can prove to be economically beneficial. Most fleets have their own internal processes and procedures (with varying levels of detail) for determining the business case or payback period for any capital cost investment, so this booklet will not endeavor to replace those processes. However, the following is some broad information about the contributors to a positive business case for compressed natural gas (CNG) vehicles in fleet applications to consider when investigating a CNG vehicle program.

Economic Aspects of Natural Gas Vehicles – Simple Payback

As has been noted elsewhere in this booklet, CNG vehicles are usually sold at an increased cost relative to conventional gasoline or diesel vehicles as a result of their lower production volumes and unique natural gas components (mainly storage cylinders), among other factors. This incremental cost represents a capital investment on the part of the fleet buyer. Additional capital costs may also be incurred, including any garage facility upgrades or investments in fueling facilities, if those prove necessary.

These capital investments can be recouped through several means, including grant funding or tax credits to offset a portion of the incremental vehicle cost or fueling station costs, and through operational cost savings resulting from reduced fuel costs. Some types of vehicles may yield maintenance cost savings through increased oil drain intervals or the removal of the need to clean diesel particulate filters, but these savings are not seen in all cases and will not be considered here. In the simplest case, an economic payback can be calculated by knowing the following factors:

- Incremental cost of the natural gas vehicle relative to the conventional vehicle it would replace
- Amount of grant or tax credit funding applied to reduce the incremental cost of the vehicle (if any)
- Annual mileage traveled and fuel economy (miles per gallon [mpg]) for the conventional vehicle (or total gallons used per year for that vehicle)
- Annual mileage and fuel economy (miles per diesel gallon equivalent [mpdge]) expected for the natural gas vehicle (or total projected diesel gallon equivalent [DGE] use for the natural gas vehicle)
- Cost per gallon for conventional fuel
- Cost per DGE for CNG

If these factors are known, then the simple payback for the natural gas option on a given vehicle is simply the total incremental cost to be paid back, divided by the yearly cost savings from fuel use. To demonstrate a simple payback calculation, here is an example for a delivery vehicle such as a step van in New York:

- Incremental cost for a new CNG truck = $28,000
- Amount of grant or tax credit = $0 (for this illustrative example)
- Annual mileage = 30,000 (identical for both diesel and CNG trucks)
- Fuel economy of diesel truck = 6 mpg
- Fuel economy of CNG truck = 6 mpdge
- Cost per gallon of diesel in Central Atlantic region = $3.98 (DOE, 2012)
- Cost per DGE of natural gas in Central Atlantic region = $2.54 (DOE, 2012)

Based on this information, this vehicle would incur fuel costs of about $19,900 per year with diesel fuel (30,000 miles/year divided by 6 miles/gallon times $3.98 per gallon) and $12,700 per year with CNG (30,000 miles per year divided by 6 mpdge times $2.54 per DGE), or a fuel cost savings of $7,200 per year. This would result in a simple payback of approximately 3.9 years in this conservative estimate ($28,000 divided by $7,200 per year). Tax credits or grant funding, examples of which are outlined in the prior section **Funding Options for Vehicles and Infrastructure** would improve this payback time considerably by reducing the incremental cost of the CNG truck.

Retrofitting or repowering an existing vehicle with a new CNG engine can have a greater incremental cost because it does not offset the cost of the new diesel engine that would have been purchased in a new vehicle. A conversion on an existing vehicle may cost between $60,000 and $70,000, minus any value from the old engine which is likely very minimal. However, this may still be economically viable if the vehicle will be in service for many more years.

An additional resource accompanying this guidebook is a tool that will allow a fleet to estimate its economic return on investment from using CNG by entering some basic information about the vehicles and operations. More details are provided in **Appendix G: Cost Evaluation Tool for Fleet Analysis**, including a link to where this Excel tool can be downloaded from the internet.

Other factors may need to be considered when examining the payback of a CNG vehicle program, such as more or less staff time necessary to fuel the vehicles (depending on how this changed from previous operations) or differences in training between diesel and natural gas technologies. These factors may not be included in all cases.

Because the major influence on payback is the cost savings per gallon of fuel used, the best business case will result from fleet vehicles using a large amount of fuel per year. In the example above, doubling the amount of fuel used (by doubling the amount of miles traveled to 60,000 per year) will cut the payback period in half, to approximately 2.0 years, all else being equal.

The example above shows a very simple payback calculation that can help fleets identify at a high level whether their vehicles are good candidates for conversion to natural gas. These basic factors concerning vehicle cost and fuel usage would also be used in more complex calculations (internal

rate of return, cash flow, net present value, etc.) that a fleet may consider in making final business decisions about moving forward with a CNG vehicle program.

It should be noted that this example uses prices from the DOE Alternative Fuel Price Report, which reports on retail at-the-pump prices including all taxes and fees. The CNG price includes the pipeline delivery fees and the retailer's cost to purchase the gas and compress it to the required pressure for delivery, as well as the retailer's costs for purchasing and depreciating the capital equipment (compressors, dispensers, etc.) and for maintaining the station equipment. If a fleet chooses to build and operate its own station and incur these costs, the calculations for simple payback will need to include those in the analysis.

Economic Aspects of Natural Gas Fueling Stations

In 2010, the National Renewable Energy Laboratory (NREL) published a report on their Vehicle and Infrastructure Cash-flow Evaluation tool describing how the tool would be used in fleet decision-making for natural gas use. Part of the tool includes an algorithm for the relationship between natural gas fueling station monthly throughput and the resulting cost of that station, assuming buffered fast-fill technology for the station for quickly fueling a large number of high-capacity vehicles. Separate relationships were developed for transit buses, school buses, and refuse trucks, based on their differing fueling characteristics (available window for fueling, equipment type needed, etc.). The algorithm, based on cost calculators created by Marathon Technical Services, estimates costs for stations up to 300,000 DGE monthly throughput (accounting for very large fueling station designs). NREL used the Marathon calculator to develop a linear approximation for the fueling station cost as a function of monthly throughput for the three cases studied. CNG stations for refuse applications, which should be similar to delivery applications, were reported to cost between $1.25 and $2 million result for a small station (less than 50,000 DGE per month) and just under $5 million for the largest stations (300,000 DGE per month). Although these costs are for a large throughput station, NREL states that "the calculator takes into account the reduction in equipment needed by reducing the overall cost of the station close to that of a comparable time-fill station. Therefore, the cost estimate is realistic over a wide range of station sizes." (Johnson, 2010)

Other Externalities – Energy and Environment

CNG vehicles can offer value to a fleet beyond the simple dollars-and-cents world of fuel cost savings and incremental purchase costs. In many cases, CNG vehicles can demonstrate emissions benefits relative to their existing fleet vehicles, which may make a natural gas vehicle program eligible for grant funding for emission reductions. If these emission benefits could be monetized, they could be included as a cost savings in the payback calculations as an income stream. This is not usually done in fleet analyses as it is difficult to place a cost on these emission benefits.

Similarly, energy benefits may also offer value to a fleet: the New York Clean Cities coalitions are frequently seeking ideas for new projects that would reduce energy consumption within the state, and may have the ability to connect fleets with grant funding sources that would offset all or

part of the incremental cost of CNG vehicles. Similarly to environmental benefits, if the energy security benefits could be monetized, they could also be included as a cost savings in the payback calculations as an income stream.

Finally, public relations benefits may accrue from the use of CNG vehicles. Communities may view a delivery fleet's use of CNG as a positive "green" step toward being a better corporate citizen within the community. These benefits are very difficult to convert to a monetary basis, but fleets should be aware that CNG vehicles can provide these benefits to the company, should this be necessary for senior management buy-in. These benefits could provide a sales and marketing advantage over a competitor company still using petroleum based fuels.

Other Resources

A number of resources are available online that could provide additional information for the fleet user. These references offer much more complex and detailed analysis efforts than have been outlined in this booklet, so the reader is encouraged to review these reports at the links below for additional details.

Deal, Anna Lee. *What Set of Conditions Would Make the Business Case to Convert Heavy Trucks to Natural Gas? – a Case Study*. National Energy Policy Institute, April 2012. www.nepinstitute.org/wp-content/uploads/2012/05/Natural-Gas-for-Heavy-Trucks-201205011.pdf.

International Energy Agency. *World Energy Outlook: Are We Entering a Golden Age of Gas?* Paris: International Energy Agency, 2011. www.iea.org/weo/docs/weo2011/WEO2011_GoldenAgeofGasReport.pdf.

Johnson, Caley. "Natural Gas Vehicles, Fueling Infrastructure and Economics." Presentation at the EESI Natural Gas Briefing, National Renewable Energy Laboratory, Golden, CO, March 16, 2011. http://files.eesi.org/johnson_031611.pdf.

Johnson, Caley. *Business Case for Compressed Natural Gas in Municipal Fleets*, NREL/TP-7A2-47919. Golden, CO: National Renewable Energy Laboratory, June 2010. www.afdc.energy.gov/afdc/pdfs/47919.pdf.

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12 Best Practices – Successful CNG Fleet Deployments in Delivery Applications

Compressed natural gas (CNG) vehicle program success stories illustrate good fleet deployment approaches and examples of good fleet practices in adopting these vehicles. A few local best practice examples are summarized below, and the contact identified is willing to share further advice and information if desired.

Manhattan Beer Distributors

Manhattan Beer Distributors, headquartered in the Bronx, New York operates a fleet of more than 500 trucks, vans, sedans, and forklifts. The company initiated a CNG vehicle program in 2001 with a pilot fleet of 15 trucks and one station. It now has 45 CNG trucks and 3 CNG stations. The driving force for the project was Manhattan Beer's desire to prove the viability of dedicated CNG engines in a private delivery fleet application and **reduce the pollution** in the South Bronx community where it is headquartered.

Figure 20. Manhattan Beer compressed natural gas beverage delivery truck in environmental wrap

Manhattan Beer also believes that the **environmental benefits to employees** are an important factor that cannot be ignored. The reduction of diesel emissions from the trucks, which are loaded and unloaded inside the warehouse, is a quality-of-life issue for their workers that the company believed it could improve. It realized the hidden costs associated with the environment in which workers operate. In addition, according to Mike McCarthy, Manhattan Beer's Vice-President, "it's just the right thing to do." The scope of Manhattan Beer's CNG vehicle program includes the following:

- Phase 1: Bronx
  - First CNG truck delivered (12/2001)
  - First private fast-fill station opened (4/2002)
  - 15 vehicles converted to CNG (5/2002)
- Phase 2: Brooklyn
  - An additional 15 trucks converted to CNG plus a second private fast-fill CNG station opened
- Phase 3: Wyandanch (2006)
  - An additional 15 trucks converted to CNG and a third private fast-fill CNG station opened

Figure 21. John Deere compressed natural gas engine used to repower Manhattan Beer delivery trucks

Figure 22. Compressed natural gas tanks installed on Manhattan beer trucks

Manhattan Beer repowered International Harvester 4700 Series Trucks with dedicated CNG John Deere 6068 HFN, a 6.8 liter engine that delivers 225 horsepower and 640 foot-pounds torque (no longer available). The fuel system includes 4 Lincoln Composite fuel cylinders mounted inside the body of the truck for a total capacity of 42 diesel gallon equivalents (DGEs) at 3,600 pounds per square inch. Manhattan Beer has found that the CNG vehicles start up effortlessly in cold weather conditions, require less warm up time, and are much less noisy compared to diesel engines. In addition, Manhattan Beer's fuel costs are about 40% less than diesel, oil change intervals are only needed every 25,000 miles, and spark plug changes are only needed every 50,000 miles. Project funding to offset some of the incremental cost of the repowers and the CNG fueling stations in Brooklyn and the Bronx were awarded by the New York State Energy Research and Development Authority through the New York City Private Fleet Alternative Fuel Vehicles Program, which awards federal Congestion Mitigation Air Quality (CMAQ) funds through a partnership with the New York City Department of Transportation. Project funding to offset some of the incremental cost of the re-powers and the CNG fueling station in Wyandanch were awarded by the Greater Long Island Clean Cities Coalition through their CMAQ grants in cooperation with NYSERDA. It was estimated that 30 CNG beer delivery trucks would displace roughly 108,000 gallons of petroleum per year. Manhattan Beer has a goal of eventually having 100% of its fleet powered with CNG, but the company is not comfortable doing so until there is a backup fueling option (capable public station nearby or agreement with another private CNG station in the vicinity) that can be used to maintain vehicle operations if the Manhattan Beer CNG station is out of service.

Figure 23. Manhattan Beer compressed natural gas fast-fill fueling infrastructure

Juan Corcino, Director of Fleet Operations
718-292-9300 x1136 | jcorcino@ManhattanBeer.net

Frito-Lay (PepsiCo)

Frito-Lay, a division of PepsiCo, operates the seventh largest private delivery fleet in the United States. The major reasons Frito-Lay initiated a CNG vehicle program is for improved economics, greenhouse gas reduction, and to support national and regional energy security. It began with a pilot trial in Rancho Cucamonga, California with two CNG class 8 tractors. Over 18 months, Frito-Lay expanded the testing to 2 more sites and purchased 16 additional vehicles. Forty-nine additional CNG tractors are on order and scheduled for delivery by July 2012. Frito-Lay has found that the economic benefit of CNG is very favorable on its larger delivery trucks that have 300–500 mile routes. The tank configuration being used can support that range and additional saddle tanks may be added to get up to 150 gasoline gallon equivalents for a range of 700 miles. CNG is seen as a win-win for Frito-Lay both in terms of its sustainability strategy and reducing costs. The company retires approximately 125 tractors a year and plans to replace as many of them as possible with CNG vehicles. Frito-Lay's CNG vehicle program includes the following:

- Freightliner M2 112 trucks with Cummins Westport ISL-G engines
  - 18 in use within the fleet, 49 more being added in 2012
- Multilocation deployment
  - Pilots in Rancho Cucamonga (California), Irving (Texas), and Phoenix (Arizona)
  - Plans to expand to facilities in Indiana, Wisconsin, North Carolina, and a second site in Arizona
- Primarily utilize existing public CNG stations for fueling
  - Established minimum criteria to identify suitable stations and are able to negotiate a strategic pricing contract due to their high usage
  - Limited public CNG stations restrict expansion to all locations
  - First corporate-owned station is under construction in Wisconsin; the station will be a private fast-filling system with 1,200 standard cubic feet per minute or a 8.7 DGE per minute throughput capacity
- Investigation into a medium-duty CNG solution for the company's 24-foot straight dry box trucks (23,000 gross vehicle weight rating) is underway

Frito-Lay estimates that the payback for the extra cost of the natural gas trucks is a year and a half. Generally, the trucks have a 50% increase in capital per acquisition, but an approximate 40% cost per mile reduction. The 67 CNG trucks will save the company about 900,000 gallons of diesel fuel annually. The company now wishes it had embraced CNG sooner.

Figure 24. Frito-Lay compressed natural gas trucks

Initially there were some questions and minor apprehension from vehicle operators. However, by incorporating them into the team that piloted the technology and made the decision on implementing a CNG vehicle program, the vehicle operators ended up becoming advocates for the CNG program. The drivers now act as "ambassadors" for CNG, and they embrace the environmental benefits and enjoy the quieter operation of the CNG trucks. All CNG trucks have information sheets shown in Figure 25 for drivers to share with any interested party they encounter on their routes. Much of Frito-Lay's success stems from its ability to develop and execute a strong change management process and having senior leadership team buy-in, alignment, and support.

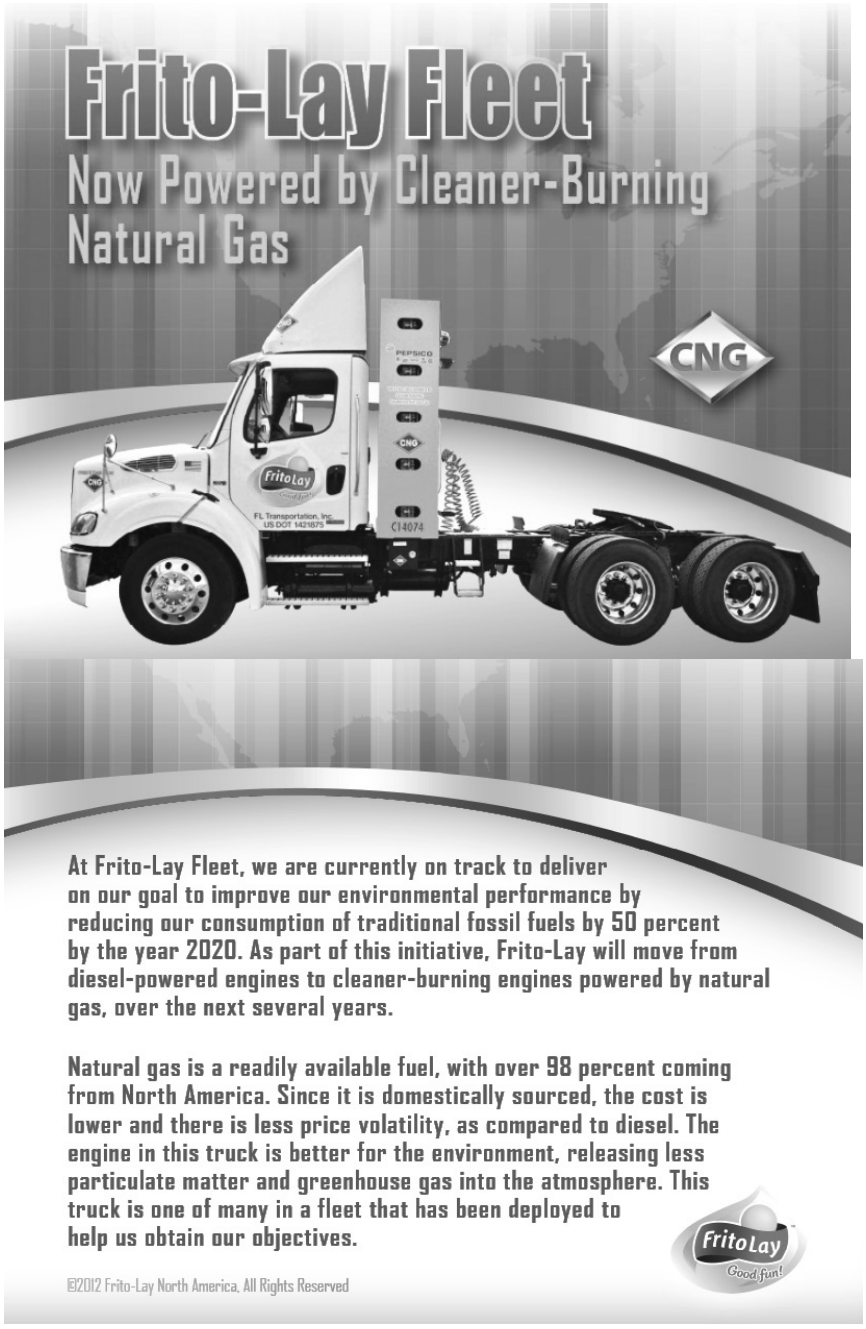

Figure 25. Frito-Lay compressed natural gas information sheets carried in each truck

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14 List of Appendices

Disclaimer: The lists contained in this guidebook are for informational purposes only, and are not intended to be comprehensive. The reader is encouraged to review all available source material before making any purchase decisions about natural gas vehicles or equipment.

Appendix A: CNG Vehicles for Delivery Fleet Applications

Appendix B: CNG System Manufacturers and New York State Dealers

Appendix C: Local Utilities in New York State

Appendix D: Vendors for Natural Gas Equipment and Services

Appendix E: Resources for Additional Information

Appendix F: CNG Stations in New York State

Appendix G: Cost Evaluation Tool for Fleet Analysis

Appendix H: Natural Gas Vehicle Project Planning Checklist

Appendix A. *CNG Vehicles for Fleet Applications*

Disclaimer: The lists contained in this guidebook are for informational purposes only, and are not intended to be comprehensive. The reader is encouraged to review all available source material before making any purchase decisions about natural gas vehicles or equipment.

Small Volume Manufacturers

Chevrolet Express Cutaway 4500

Engine
General Motors 6.0L Vortec V8
Transmission
Allison 3000 automatic
Chassis GVWR
14,200 lbs

Photo courtesy of General Motors

	Certified Dedicated CNG Upfit		
	2010	***2011***	***2012***
IMPCO Automotive (www.impcoautomotive.com)	-	-	EPA/CARB
Landi Renzo USA/Baytech (www.landiusa.com)	-	-	EPA/CARB

Ford E-450

Engine
Ford 6.8L Triton V10
Transmission
Allison 3000 automatic
Chassis GVWR
14,500 lbs

Photo courtesy of Ford Motor Company

	Certified Dedicated CNG Upfit		
	2010	***2011***	***2012***
BAF Technologies (www.baftechnologies.com)	-	-	EPA/CARB
IMPCO Automotive (www.impcoautomotive.com)	-	EPA	EPA/CARB

Ford F-450/550/650

Engine
Ford 6.8L Triton V10
Transmission
Ford TorqShift 5 or 6-speed automatic
Chassis GVWR
Up to 26,000 lbs

Photo courtesy of Ford Motor Company

	Certified Dedicated CNG Upfit		
	2010	***2011***	***2012***
BAF Technologies (www.baftechnologies.com)	-	-	EPA/CARB
IMPCO Automotive (www.impcoautomotive.com)	-	EPA	EPA/CARB

Ford F-59 Stripped Chassis

Engine
Ford 6.8L Triton V10
Transmission
Ford TorqShift 5 or 6-speed automatic
Chassis GVWR
16,000 to 19,500 lbs

Photo courtesy of Ford Motor Company

	Certified Dedicated CNG Upfit		
	2010	***2011***	***2012***
BAF Technologies (www.baftechnologies.com)	-	-	EPA/CARB
Landi Renzo USA/Baytech (www.landiusa.com)	-	-	EPA/CARB

Freightliner MT45/55

Engine
General Motors 6.0L Vortec V8
Transmission
Allison 1000 or 2100 Highway Series automatic
Chassis GVWR
Up to 23,000 lbs

no photo available

	Certified Dedicated CNG Upfit		
	2010	***2011***	***2012***
Landi Renzo USA/Baytech (www.landiusa.com)	-	-	EPA/CARB

Isuzu NPR

Engine
General Motors 6.0L Vortec V8
Transmission
Aisin automatic / Isuzu manual
Chassis GVWR
18,000 to 20,500 lbs

Photo courtesy of Isuzu Motors

	Certified Dedicated CNG Upfit		
	2010	***2011***	***2012***
IMPCO Automotive (www.impcoautomotive.com)	-	-	EPA/CARB
Landi Renzo USA/Baytech (www.landiusa.com)	-	-	EPA/CARB

Workhorse W62

Engine
General Motors 6.0L Vortec V8
Transmission
General Motors 6L90 automatic
Chassis GVWR
18,000 to 20,500 lbs

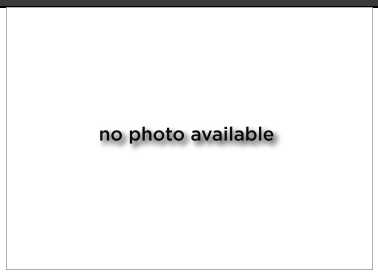
no photo available

	Certified Dedicated CNG Upfit		
	2010	***2011***	***2012***
Landi Renzo USA/Baytech (www.landiusa.com)	-	-	EPA/CARB

OEM CNG-Equipped Vehicles

Capacity of Texas TJ9000

Engine
Cummins Westport ISL G
Transmission
Allison 3000 Rugged Duty Series automatic
Chassis GVWR
--
Website
www.capacitytexas.com/Products/TJ9000_CNG.aspx



Cargotec Solutions LLC Ottawa 4x2

Engine
Cummins Westport ISL G
Transmission
Allison 3000 Rugged Duty Series automatic
Chassis GVWR
--
Website
www.ottawatrucksna.com/resources-links/brochures


Photo courtesy of Ottawa Trucks

Freightliner M2 112

Engine
Cummins Westport ISL G
Transmission
Eaton manual / Fuller automatic / Allison automatic
Chassis GVWR
Up to 62,000 lbs.
Website
www.freightlinertrucks.com/Trucks/Alternative-Power-Trucks/Natural-Gas/M2-112-NG


Photo courtesy of Daimler

Freightliner 114 SD

Engine
Cummins Westport ISL G
Transmission
Allison 3000 automatic
Chassis GVWR
Up to 62,000 lbs.
Website
www.freightlinertrucks.com/Trucks/Alternative-Power-Trucks/Natural-Gas/114SD-NG


Photo courtesy of Daimler

Freightliner Cascadia Day Cab

Engine
Cummins Westport ISL G
Cummins Westport ISX12 G (Coming Soon)
Transmission
Eaton manual or automated manual / Allison 3000, 4000, or 4500 automatic
Chassis GVWR
Up to 60,600 lbs.
Website
www.freightlinertrucks.com/Trucks/Alternative-Power-Trucks/Natural-Gas/114SD-NG


Photo courtesy of Daimler

International DuraStar

Engine
Emissions Solutions Phoenix 7.6L
Transmission
Allison 3000 automatic
Chassis GVWR
Up to 32,000 lbs.
Website
www.internationaltrucks.com/StaticFiles/internationalTrucks/pdf/cng/durastar_cng.pdf


Photo courtesy of Navistar

International TranStar

Engine
Cummins Westport ISL G (Coming Soon)
Transmission
Allison 3000 automatic
Chassis GVWR
Up to 66,000 lbs.
Website
www.internationaltrucks.com/StaticFiles/internationalTrucks/pdf/cng/transtar_cng.pdf


Photo courtesy of Navistar

International LoadStar

Engine
Cummins Westport ISL G (Coming Soon)
Transmission
Allison 3000, 4000, or 4500 Rugged Duty Series automatic
Chassis GVWR
Up to 66,000 lbs.
Website
www.internationaltrucks.com/trucks/trucks/series/loadstar


Photo courtesy of Navistar

International WorkStar

Engine
Emissions Solutions 7.6L Phoenix
Cummins Westport ISL G (Coming Soon)
Transmission
Fuller manual / Allison 3000 automatic
Chassis GVWR
Up to 62,000 lbs.
Website
www.mena.internationaltrucks.com/pdf/WorkStar_7300.7400_Sell%20Sheet.pdf

Photo courtesy of Navistar

Kenworth T440

Engine
Cummins Westport ISL G
Transmission
Allison Highway Series or Rugged Duty Series automatic
Chassis GVWR
33,000 to 68,000 lbs.
Website
www.kenworth.com/trucks/t440.aspx

Photo courtesy of PACCAR

Kenworth T470

Engine
Cummins Westport ISL G
Transmission
Allison Highway Series or Rugged Duty Series automatic
Chassis GVWR
33,000 to 68,000 lbs.
Website
www.kenworth.com/trucks/t470.aspx

Photo courtesy of PACCAR

Kenworth W900S

Engine
Cummins Westport ISL G
Cummins Westport ISX12 G (Coming Soon)
Transmission
Allison Rugged Duty Series automatic
Chassis GVWR
33,000 to 68,000 lbs.
Website
www.kenworth.com/trucks/w900.aspx

Photo courtesy of PACCAR

Kenworth T800

Engine
Cummins Westport ISL G
Cummins Westport ISX12 G (Coming Soon)
Transmission
Allison Rugged Duty Series automatic
Chassis GVWR
33,000 to 68,000 lbs.
Website
www.kenworth.com/trucks/t800.aspx


Photo courtesy of PACCAR

Peterbilt 365

Engine
Cummins Westport ISL G
Cummins Westport ISX12 G (Coming Soon)
Transmission
Fuller manual / Fuller automatic / Allison automatic
Chassis GVWR
Class 7-8 weight rating
Website
www.peterbilt.com/voc365.1.aspx


Photo courtesy of PACCAR

Peterbilt 382

Engine
Cummins Westport ISL G
Transmission
Fuller manual / Allison automatic
Chassis GVWR
Class 7-8 weight rating
Website
www.peterbilt.com/pdf/382.pdf


Photo courtesy of PACCAR

Peterbilt 384

Engine
Cummins Westport ISL G
Cummins Westport ISX12 G (Coming Soon)
Transmission
Fuller manual / Allison automatic
Chassis GVWR
Class 7-8 weight rating
Website
www.peterbilt.com/aero384.1.aspx


Photo courtesy of PACCAR

Volvo VNM

Engine
Cummins Westport ISL G

Transmission
Fuller manual or automated manual / Allison 3000 or 4000 / Volvo AT or ATO automatic

Chassis GVWR
Class 7-8 weight rating

Website
www.volvotrucks.com/SiteCollectionDocuments/VTNA_Tree/ILF/Products/VN%20Series/Daycab%20-%20VNM/VNM_ss_web.pdf

Photo courtesy of Volvo Trucks

Volvo VNL

Engine
Cummins Westport ISL G

Transmission
Fuller manual or automated manual / Volvo AT or ATO automatic

Chassis GVWR
Class 7-8 weight rating

Website
www.volvotrucks.com/SiteCollectionDocuments/VTNA_Tree/ILF/Products/VN%20Series/Daycab%20-%20VNM/VNM_ss_web.pdf

Photo courtesy of Volvo Trucks

Appendix B. *CNG System Manufacturers and New York State Dealers*

Engine OEMs

Cummins Westport

Cummins Westport Inc. designs, engineers, and markets 6 to 12 liter spark-ignited automotive natural gas engines for commercial transportation applications such as truck and buses. The dedicated 100% natural gas engines are manufactured by Cummins and available as a factory-direct option from leading truck and bus manufacturers.

Website www.cumminswestport.com

Contact David Powers, Territory Manager
315-410-7517 | dave.powers@cummins.com

Emissions Solutions

Emissions Solutions (ESI) develops, manufactures, and markets EPA and CARB certified engines for new and repower applications. ESI offers natural gas options for 7.3 and 7.6 liter Navistar engines.

Website www.emissionsolutionsinc.com

Contact Jim Moore, President
972-369-0092 | jimmoore@emissionsolutionsinc.com

Ford Powertrain

To support customers who seek to operate their fleet on either CNG or LPG, Ford is offering a suite of vehicles with engine prep packages that are capable of operating on these fuels. These engines come with hardened exhaust valves and valve seats for improved wear resistance and durability for gaseous fuel systems.

Website www.fleet.ford.com/showroom/environmental_vehicles/CNG_LPG.ASP

General Motors Powertrain

General Motors Powertrain designs, engineers and manufactures engines, transmissions, castings, and components for General Motors vehicles and other automotive, marine and industrial original equipment manufacturers. It has operating and coordinating responsibility for General Motors' powertrain manufacturing plants and engineering centers in North and South America, Europe and the Asia-Pacific region, with global headquarters in Pontiac, Michigan. The General Motors Powertrain team includes 86 facilities, 17 countries, and approximately 48,700 members.

Website www.gmpowertrain.com

Small Volume Manufacturers

BAF

BAF, a Clean Energy Company, is a major provider of natural gas vehicles. Founded in 1992, and headquartered in Dallas, the company supports global clients with vehicle conversions, alternative fuel systems, application engineering, service and warranty support and research and development.

Website www.baftechnologies.com

Contact Gerry Glenn, Business Development Manager
214-729-7577 | gglenn@baftechnologies.com

Greenkraft Inc.

Greenkraft is a manufacturer and distributor of different automotive products located in Santa Ana, California. Greenkraft Inc was created to introduce clean, green, efficient, automotive products that have a price advantage and have American performance.

Website greenkraftinc.com/alternativeFuelKits.html

Contact sales@greenkraftinc.com

IMPCO Automotive

IMPCO Automotive designs, manufacturers and supplies alternative fuel systems to original equipment manufacturers and aftermarket installers which allow fleet and vehicle owners to enjoy the many benefits of clean burning CNG or propane.

Website www.impcoautomotive.com

Contact Rob Lykins, Director of Sales & Marketing
765-964-6009 | rlykins@impcotechnologies.com

Landi Renzo

Landi Renzo USA engineers, installs and services fuel systems. The Torrance facility offers a full turnkey approach from sales, installation, warranty and service. A network of installation partners offers full coverage across the United States. They create optimal system layouts and provide high quality system components from tanks to injectors, backed with warranty and service support.

Website www.landiusa.com

Contact Jed Tallman
303-868-7404 | jtallman@landiusa.com

Chassis OEMs

Capacity of Texas, Inc.

Capacity of Texas builds terminal tractors customized to the jobs they will perform. Capacity operates in all 50 states and many foreign countries in addition to supplying a number of government agencies.

Website www.capacitytexas.com

Cargotec/Ottawa

Cargotec offers an expanding portfolio of eco-friendly Ottawa terminal tractors including machines powered by gasoline and alternative fuels, such as CNG and LNG. Ottawa is a brand of terminal tractors that is part of Cargotec, a company with over 10,000 employees worldwide.

Website www.ottawatrucksna.com; www.cargotec.com

NYS Dealer	*Dealer Website*	*CNG Expert*
Stadium International	www.stadiumtrucks.com	Brandon Baldassari 856-816-4597 | Brandon.baldassari@navistar.com

Ford Motor Company

Ford sells a wide variety of CNG fleet vehicles. Most Ford dealers in New York State offer the CNG F-450/550/650, E-450, and F-59.

Website www.fleet.ford.com

Freightliner

Freightliner Trucks is the largest division of Daimler Trucks North America. Freightliner manufactures Class 5-8 trucks that serve a wide range of commercial vehicle applications.

Website www.freightlinertrucks.com

Contact Michele Geitz, NGV Sales Manager
803-578-3161 | michele.geitz@daimler.com

NYS Dealer	*Dealer Website*	*CNG Expert*
Mohawk Valley Freightliner	www.mvfreightliner.com	Rick Woods 315-736-3330 | rwoods@mvfreightliner.com
New York Freightliner (Diehl's Truck World)	www.nyfreightliner.com	Doug Austin 718-846-8150 | doug@nyfreightliner.com
Tracey Road Equipment, Inc.	www.traceyroad.com	David Holzwarth 800-872-2390

General Motors

General Motors Fleet sells a wide variety of vehicles, including a CNG version of the Chevy Express Cutaway. The CNG Chevy Express Cutaway is available to order through most General Motors dealers in New York State.

Website www.gmfleet.com

Isuzu

For the North American market, Isuzu produces low cab forward medium-duty trucks for a variety of vocations in Classes 3 through 5, and also offers chassis for commercial medium-duty vans.

Website www.isuzucv.com

Kenworth

Kenworth, a PACCAR company, offers heavy-duty trucks for the vocational and over-the-road markets in Classes 5 through 8.

Website www.kenworth.com

Contact Andy Douglas, National Sales Manager – Specialty Markets
425-828-5250 | Andy.Douglas@PACCAR.com

Mack Trucks

Founded in 1900, Mack is one of the largest producers of heavy-duty trucks in North America. Mack, a division of Volvo, offers trucks for the vocational and over-the-road markets.

Website www.macktrucks.com

Contact Curtis Dorwart, Vocational Marketing Product Manager
336-291-9147 | curtis.dorwart@macktrucks.com

Navistar Inc. (International)

Formed in 1902, International is a leading producer of medium trucks, heavy trucks, severe service vehicles. Their products, parts and services are sold through a network of nearly 1,000 dealer outlets in the United States, Canada, Brazil, and Mexico and more than 60 dealers in 90 countries throughout the world.

Website www.internationaltrucks.com

Contact Nadine Haupt, Director, Alternative Fuels
331-332-2701 | nadine.haupt@navistar.com

Peterbilt

Based in Denton, Texas, Peterbilt Motors Company combines world renowned design, innovative engineering and fuel efficiency solutions, with superior quality to build a custom-engineered truck that stands as the "Class" of the industry.

Website www.peterbilt.com

Contact Steve Weiner
940-594-9651 | Steve.Weiner@PACCAR.com

Volvo Trucks North America

Volvo Trucks North America is a division of Volvo Truck Corporation, one of the leading heavy truck and engine manufacturers in the world. Today, Volvo Trucks manufactures a broad line of Class 8 trucks and tractors-both on-highway and vocational-under the Volvo brand. Each new or used purchase is supported by a strong dealer network and by industry-leading parts and service programs to smooth your ride on the road to success.

Website www.volvotrucks.com

Workhorse Custom Chassis

Workhorse Custom Chassis, a Navistar company, produces strip chassis, available in the route delivery and step van industry, and is the exclusive supplier of the General Motors Vortec engine and powertrain for these applications.

Website www.workhorse.com

NYS Dealer	*Dealer Website*	*CNG Expert*
Stadium International	www.stadiumtrucks.com	Brandon Baldassari 856-816-4597| Brandon.baldassari@navistar.com

Appendix C. *Local Utilities in New York State*

Central Hudson Gas and Electric

Through several subsidiaries and affiliates, Central Hudson Gas and Electric offers electricity, natural gas, propane, fuel oil and other petroleum products, along with energy services for residential and business customers.

Website www.cenhud.com

Contact John Maserjian
845-486-5282 | jmaserjian@cenhud.com

Consolidated Edison Company of New York

Consolidated Edison Company of New York (Con Edison), a regulated utility, provides electric service in New York City (except for a small area of Queens), and most of Westchester County. The company provides natural gas service in Manhattan, the Bronx, and parts of Queens and Westchester. Con Edison also owns and operates the world's largest district steam system, providing steam service in most of Manhattan.

Website www.coned.com

Contact Fortunato Gulino, Transportation Manager
718-204-4427 | gulinof@coned.com

Corning Natural Gas

Corning Natural Gas Corporation is an investor owned local Distribution Company that provides natural gas, transportation, storage and other unbundled energy services.

Website www.corninggas.com

National Fuels

National Fuel Gas Distribution Corporation sells or transports natural gas to more than 728,000 customers through a local distribution system located in western New York and northwestern Pennsylvania, and provides interstate natural gas transmission and storage for affiliated and nonaffiliated companies through an integrated gas pipeline system that extends 2,972 miles from southwestern Pennsylvania to the New York-Canadian border at the Niagara River.

Website www.natfuel.com

Contact Cliff Mason, General Energy Consultant
716-857-7025 | masonc@natfuel.com

National Grid

National Grid is an international electricity and gas company and one of the largest investor-owned energy companies in the world. National Grid provides energy to millions of customers across the northeastern U.S. and Great Britain.

Website www.nationalgridus.com/NewYork

Contact John Gilbrook, Project Manager Transportation
781-907-2253 | john.gilbrook@nationalgrid.com

Stacey L. Hughes, Albany Area
518-433-3817 | Stacey.hughes@nationalgrid.com

Glynn L. Matthews, Syracuse Area
315 452-7709 | Glynn.mattews@nationalgrid.com

Mark Infranco, Metro New York Area
631-755-5327 | Mark.infranco@lipangrid.com

New York State Electric and Gas

New York State Electric and Gas (NYSEG), a subsidiary of Iberdrola USA, serves 878,000 electricity customers and 261,000 natural gas customers across more than 40% of upstate New York. Iberdrola USA, a subsidiary of global energy leader Iberdrola, S.A., is an energy services and delivery company with more than 2.4 million customers in upstate New York and New England.

Website www.nyseg.com

Orange and Rockland Gas

Orange and Rockland Utilities, Inc. (O&R), a wholly owned subsidiary of Consolidated Edison, Inc., is an electric and gas utility headquartered in Pearl River, NY. O&R and its two utility subsidiaries, Rockland Electric Company and Pike County Light & Power Co., serve a population of approximately 750,000 in seven counties in New York, northern New Jersey and northeastern Pennsylvania.

Website www.oru.com

Rochester Gas and Electric

Rochester Gas and Electric, a subsidiary of Iberdrola USA, serves 367,000 electricity customers and 303,000 natural gas customers in a nine-county region centered on the City of Rochester.

Website www.rge.com

St. Lawrence Gas

St. Lawrence Gas, a wholly owned subsidiary of Enbridge Gas Distribution in Canada (the Enbridge Connection) was incorporated in 1957. St. Lawrence Gas served its first natural gas customer in 1962. With assets of more than $40 million, the Company distributes natural gas to approximately 13,800 residential customers, 1,600 commercial customers, and 23 industrial customers.

Website www.stlawrencegas.com

Valley Energy

Valley Energy is an investor owned company regulated by the Pennsylvania Public Utility Commission and the New York Public Service Commission. Service is provided to 11 communities in Bradford County, Pennsylvania and Chemung and Tioga Counties in New York. Natural gas is supplied to more than 7,600 residential, commercial and industrial customers through a 165-mile pipeline distribution system.

Website www.valley-energy.com

Appendix D. *Vendors for Natural Gas Equipment and Services*

Equipment Providers

Name	Location	Phone	Website
Air-N-Gas Process Technologies	Connecticut	203-374-1795	www.air-n-gas.com
ANGI Energy Systems	Wisconsin	800-955-4626	www.angienergy.com
Cobey Energy	New York	716-362-9550	www.cobey.com
Quantum Technologies	California	949-399-4500	www.qtww.com

Fuel Providers

Name	Location	Phone	Website
Hess	New York	212-997-8500	www.hess.com
Northville Natural Gas LLC	New York	631-293-4700	www.northvillenaturalgas.com
Sprague Energy	New Hampshire	800-225-1560	www.spragueenergy.com

Infrastructure Providers

Name	Location	Phone	Website
Advance Fuel Systems Corporation	Illinois	866-725-0801	www.advancefuelsystems.com
American Natural Gas	New York	866-264-6220	www.americannaturalgas.com
Beavers Petroleum	New York	607-739-1790	www.beaverspetroleum.com
Chesapeake Energy	Oklahoma	405-935-8000	www.chk.com
Clean Energy Fuels Corp	California	562-493-2804	www.cleanenergyfuels.com
Clean Fuel Connection, Inc.	California	888-890-4638	www.cleanfuelconnection.com
CNG Source, Inc.	Pennsylvania	814-673-4980	www.cngsource.com
CNGasGroup	Florida	866-403-0102	www.cngasusa.com
Cobey Energy	New York	716-362-9550	www.cobey.com
Engineered Energy Solutions	New York	631-656-0566	www.energysolutionsli.com
Integrys/Trillium	Utah	800-920-1166	www.trilliumusa.com
P.C. McKenzie Company	Pennsylvania	877-244-4883	www.mckenziecorp.com
Vocational Energy	Florida	813-261-0820	www.vocationalenergy.com

Other Contacts

Name	Location	Phone	Website
Agility Fuel Systems	California	949-236-5520	www.agilityfuelsystems.com
Chautauqua Energy Management	New York	716-326-4977	www.cemny.com
Clean Vehicle Solutions	New Jersey	800-495-2270	www.cleanvehiclesolutions.com
Cummins Power System, LLC	New York	855-812-2278	www.powersystems.cummins.com
North American Equipment Upfitters	New Hampshire / New York	603-624-6288	www.naeuinc.com
Wendel	New York	716-688-0766	www.wendelcompanies.com

Appendix E. *Resources for Additional Information*

Alternative Fuels and Advanced Vehicles Data Center

The Alternative Fuels and Advanced Vehicles Data Center (AFDC) provides information, data, and tools to help fleets and other transportation decision makers find ways to reduce petroleum consumption through the use of alternative and renewable fuels, advanced vehicles, and other fuel-saving measures.

Website www.afdc.energy.gov

America's Natural Gas Alliance

America's Natural Gas Alliance promotes the economic, environmental and national security benefits of greater use of domestic natural gas. The Alliance represents 30 of North America's largest independent natural gas exploration and production companies and the leading developers of the shale plays now transforming the clean energy landscape.

Website www.anga.us

American Clean Skies Foundation

American Clean Skies Foundation (ACSF) was founded in 2007 to advance America's energy independence and a cleaner, low-carbon environment through expanded use of natural gas, renewables and efficiency.

Website www.cleanskies.org

American Gas Association

The American Gas Association (AGA) represents more than 200 companies delivering natural gas to customers. AGA provides information and services promoting efficient demand and supply growth, and operational excellence, in the safe, reliable and efficient delivery of natural gas.

Website www.aga.org

American Trucking Associations

The American Trucking Associations (ATA), founded in 1933, is the largest national trade association for the trucking industry. Through a federation of other trucking groups, industry-related conferences, and its 50 affiliated state trucking associations, ATA represents more than 37,000 members covering every type of motor carrier in the United States.

Website www.trucking.org

American National Standards Institute

The American National Standards Institute (ANSI) oversees the creation, promulgation and use of thousands of norms and guidelines that directly impact businesses in nearly every sector, including natural gas vehicles and infrastructure. ANSI is also actively engaged in accrediting programs that assess conformance to standards – including globally-recognized cross-sector programs such as the ISO 9000 (quality) and ISO 14000 (environmental) management systems

Website www.ansi.org

Clean Cities

Clean Cities is the U.S. Department of Energy's (DOE) flagship alternative-transportation deployment initiative, sponsored by the Vehicle Technologies Program. Clean Cities has saved more than 3 billion gallons of petroleum since its inception in 1993.More than 10,400 stakeholders contribute to Clean Cities' goals and accomplishments through participation in nearly 100 Clean Cities coalitions across the country. Private companies, fuel suppliers, local governments, vehicle manufacturers, national laboratories, state and federal government agencies, and other organizations join together under Clean Cities to implement alternative-transportation solutions in their communities.

Website www.cleancities.energy.gov

Contacts

Position	Name	Phone Number	Email/Website
National Clean Cities Director	Dennis A. Smith	202-586-1791	dennis.a.smith@ee.doe.gov
Northeast Region	Mike Scarpino	412-386-4726	michael.scarpino@netl.doe.gov
Capital District Clean Communities (Albany)	Deborah Stacey	518-458-2161	www.ipool2.net/CC/cdcc.htm
Central New York Clean Cities (Syracuse)	Barry Carr Amy DeJohn	315-278-2061 315-447-8179	www.cc-cny.com
Clean Communities of Western New York (Buffalo)	William A. Pauly Steve Carr	716-839-6717 315-278-6928	billpauly@roadrunner.com scarrccwny@hotmail.com
Genesee Region Clean Communities (Rochester)	David Keefe	585-301-2433	www.grcc.us
Greater Long Island Clean Cities	Rita D. Ebert	631-504-5771	www.gliccc.org
New York City and Lower Hudson Valley Clean Communities	Christina Ficicchia	212-839-7728	www.nyclhvcc.org

CNG for Upstate New York

The mission of CNG for Upstate NY is to foster learning, collaboration and action on CNG vehicle fueling and infrastructure as it relates to the Upstate New York region and natural gas utilization for transportation. CNG for Upstate NY hosts quarterly events, including seminars, CNG fueling station tours, and networking events to bring together interested fleet owners and potential station owners/investors.

Website www.cngupstateny.com

CNG Now

CNG Now is a leading internet site for information, news, and blogs advocating the use of compressed natural gas.

Website www.cngnow.com

Clean Vehicle Education Foundation

The Clean Vehicle Education Foundation coordinates and implements a variety of public awareness, education, market research, codes and standards and technology programs at the national level. The Clean Vehicle Education Foundation activities help achieve national goals of cleaner air, reduced dependence on imported oil and accelerated development and deployment of alternative fuel vehicles.

Website www.cleanvehicle.org
Douglas Horne, President | dbhorne@cleanvehicle.org

Energy Information Administration

The U.S. Energy Information Administration (EIA) collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment.

Website www.eia.gov

Environmental Protection Agency

The mission of the Environmental Protection Agency (EPA) is to protect human health and the environment by regulating air pollution from motor vehicles, engines, and the fuels used to operate them, and by encouraging travel choices that minimize emissions. These "mobile sources" include cars and light trucks, heavy trucks and buses, nonroad engines, equipment, and vehicles. EPA also has authority over natural gas conversion kits, and maintains a listing of kits that are approved for sale in the United States.

Website www.epa.gov/otaq

National Alternative Fuels Training Consortium

The National Alternative Fuels Training Consortium (NAFTC) is a pioneer and national leader in developing, managing, and promoting programs and activities that desire to cure America's addiction to oil, lead to energy independence, and encourage the greater use of cleaner transportation. The NAFTC is the only nationwide alternative fuel vehicle and advanced technology vehicle training organization in the United States.

Website www.naftc.wvu.edu

National Fire Protection Association

The mission of the National Fire Protection Association (NFPA) is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks.

Website www.nfpa.org

National Institute for Automotive Service Excellence

The non-profit National Institute for Automotive Service Excellence (ASE) works to improve the quality of vehicle repair and service by testing and certifying automotive professionals. Auto technicians and other professionals who want to become ASE certified can take one or more of ASE's 40-plus exams. The Alternate Fuels Certification Test (F1) is used to identify and recognize those Technicians who can demonstrate knowledge of the skills necessary to diagnose, service, and repair compressed natural gas vehicles. The Compressed Natural Gas Vehicle (F1) test contains 55 scored questions on vehicle inspection, equipment installation, leak testing and repairs, emissions, system diagnosis, maintenance and repair, and cylinder safety. Technicians must retest every five years to retain their certification. The Alternate Fuels CNG Vehicle recertification test (F1R) is about half as long as the initial certification test.

Website www.ase.com

NaturalGas.org

Naturalgas.org is presented as an educational website covering a variety of topics related to the natural gas industry. The purpose of this website is to provide visitors with a comprehensive information source for topics related to natural gas, and present an unbiased learning tool for students, teachers, industry, media, and government.

Website www.naturalgas.org

Natural Gas Vehicle Journal

The Natural Gas Vehicle Journal (NGVJournal) is the new portal of NGV Communications Group. It presents the latest news on the NGV industry, multimedia content, statistics and all the journalistic material produced by the Group, in addition to their institutional data and contact information.

Website www.ngvjournal.com

Natural Gas Vehicles for America

Natural Gas Vehicles for America (NGVAmerica) is a national organization dedicated to the development of a growing, profitable, and sustainable market for vehicles powered by natural gas or biomethane. NGVAmerica represents more than 100 companies, environmental groups, and government organizations interested in the promotion and use of natural gas and biomethane as transportation fuels. NGVAmerica member companies are those that produce, distribute, and market natural gas and biomethane across the country; manufacture and service natural gas vehicles, engines, and equipment; and operate fleets powered by clean-burning gaseous fuels.

Website www.ngvamerica.org

New York State Division of Code Enforcement & Administration

The New York State Division of Code Enforcement & Administration (DCEA) provides a variety of services related to the state's Uniform Fire Prevention and Building Code and the State Energy Conservation Construction Code. In close coordination with community officials, DCEA oversees the enforcement practices of local governments in matters pertaining to building construction, fire prevention, and energy conservation. Division staff also provides technical and educational assistance to local jurisdictions, administers variances, and serves as secretariat to the State Fire Prevention and Building Code Council.

Website www.dos.ny.gov/DCEA

New York State Energy Research and Development Authority

New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created in 1975 under Article 8, Title 9 of the State Public Authorities Law through the reconstitution of the New York State Atomic and Space Development Authority. NYSERDA's earliest efforts focused solely on research and development with the goal of reducing the State's petroleum consumption. Today, NYSERDA's aim is to help New York meet its energy goals: reducing energy consumption, promoting the use of renewable energy sources, and protecting the environment. For transportation, NYSERDA focuses on emission reductions, petroleum displacement, training and new AFV technology deployment. Project participants include state, municipal, school and private fleets all across the state.

Website www.nyserda.ny.gov

Northeast Gas Association

The Northeast Gas Association (NGA) is a regional trade association that focuses on education and training, technology research and development, operations, planning, and increasing public awareness of natural gas in the Northeast U.S. NGA represents natural gas distribution companies, transmission companies, liquefied natural gas importers, and associate member companies. These companies provide natural gas to over 10 million customers in eight states (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont).

Website www.northeastgas.org

NTEA, the Association for the Work Truck Industry

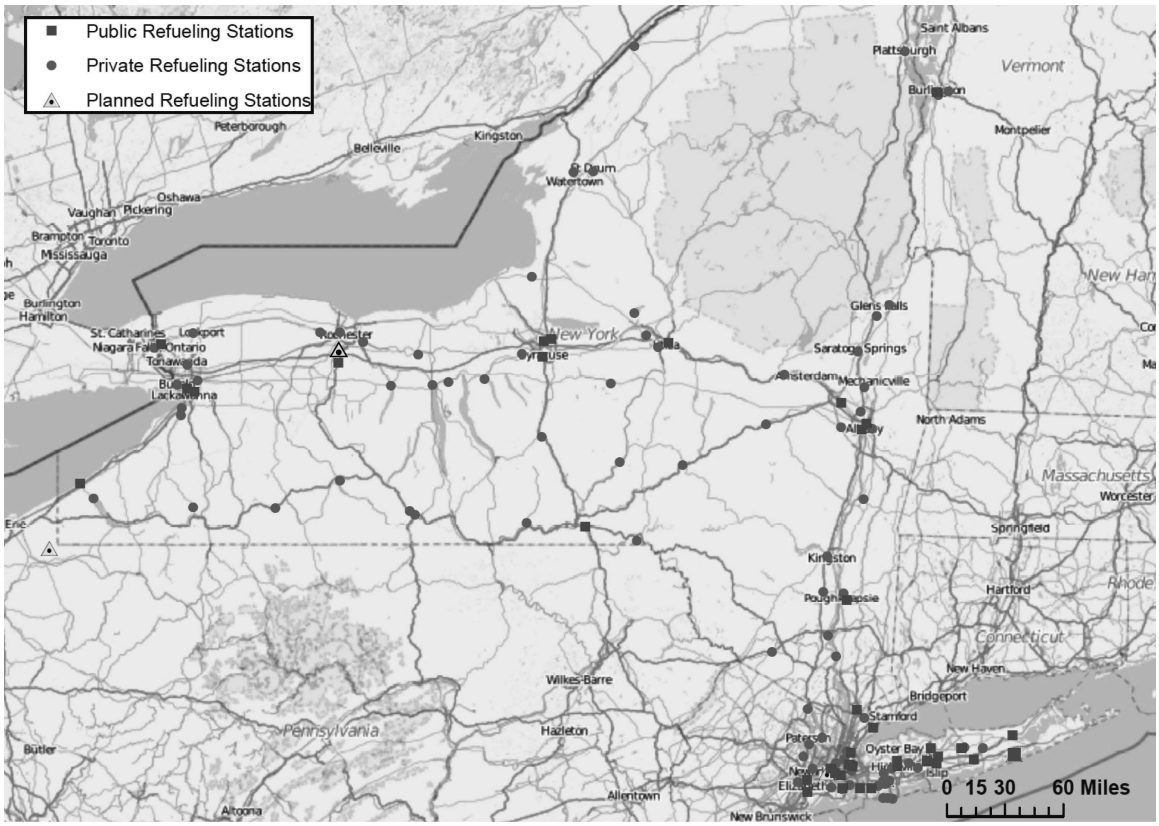
Established in 1964, NTEA, the Association for the Work Truck Industry, represents nearly 1,600 companies that manufacture, distribute, install, sell and repair commercial trucks, truck bodies, truck equipment, trailers and accessories. Buyers of work trucks and the major commercial truck chassis manufacturers also belong to the Association. NTEA provides in-depth technical information, education, and member programs and services, and produces The Work Truck Show. The Association maintains its administrative headquarters in suburban Detroit and a government relations office in Washington, DC.

Website www.ntea.com

Appendix F. *CNG Stations in New York State*

CNG Stations in New York State

There are more than 100 CNG stations throughout the state of New York as shown in the map below, according to the Department of Energy's Alternative Fuels and Advanced Vehicles Data Center (AFDC, www.afdc.energy.gov). These stations are located throughout the state, with concentrations in the major metropolitan areas. The maps and tables that follow list the refueling stations avaialble in these metropolitan areas, and include key information such as station address and equipment characteristics. The reader is encouraged to visit the AFDC Station Locator for up-to-date information on the stations that are available in the state.

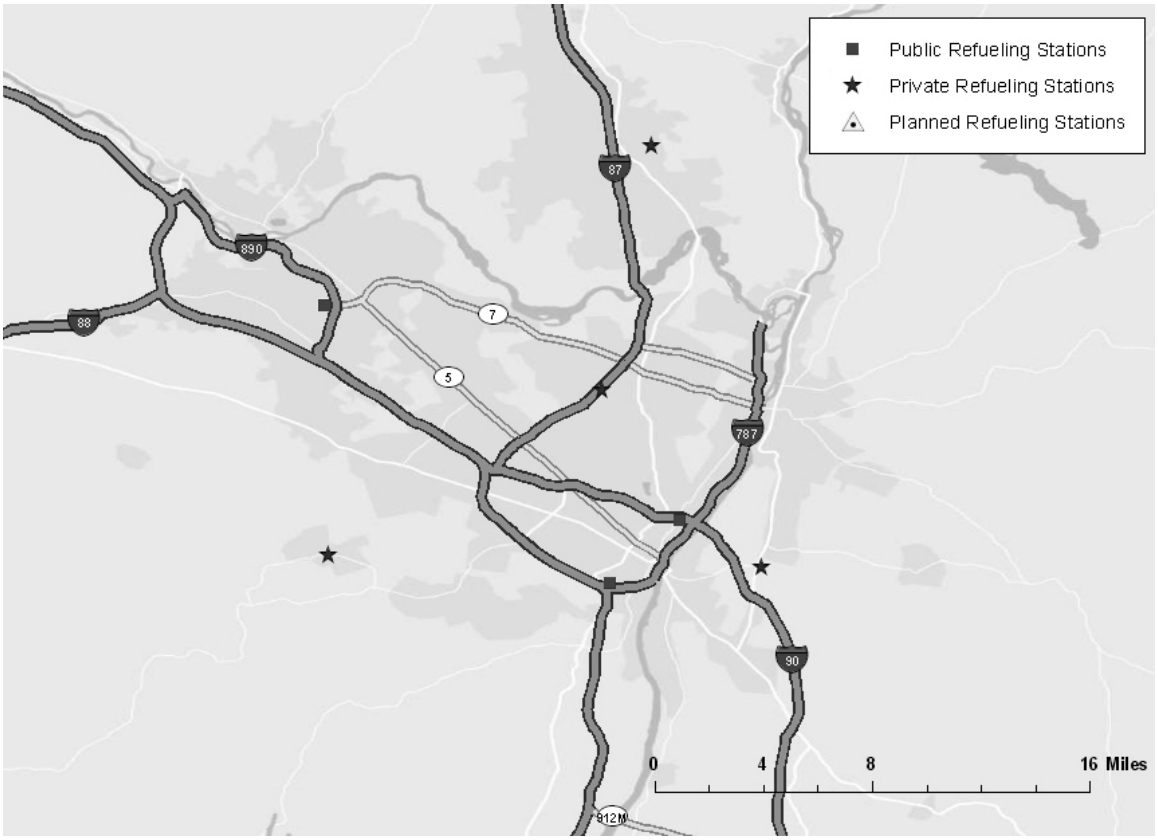


The breakdown of stations by type in New York State is:

Public stations	34
Private stations	73
Time-fill	2
Fast fill	104 (includes stations offering both time fill and fast fill)

APPENDIX F

CNG Stations: Albany Area



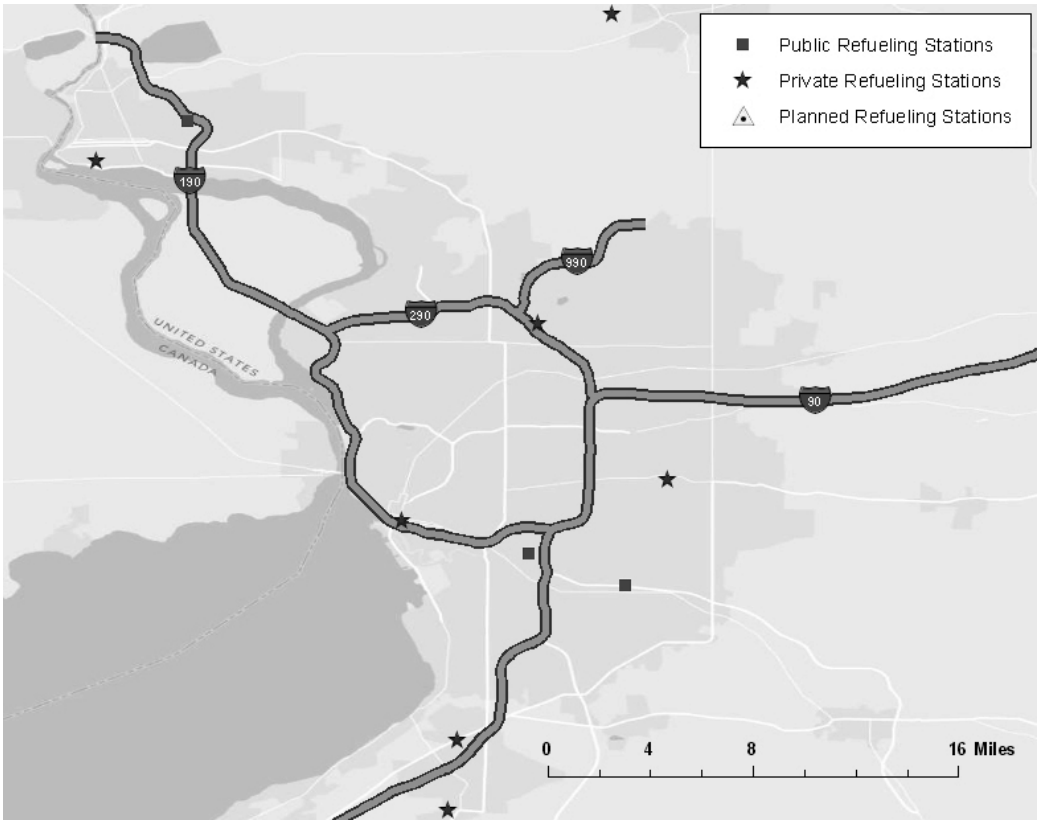
Albany Area Public CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
Clean Energy - National Grid Albany	1125 Broadway	Albany	Quick fill
Clean Energy - New York State Office of General Services	McCarty Ave & Hoffman Ave	Albany	Quick fill
Clean Energy - New York State Department of Transportation	3008 Chrisler Ave	Rotterdam	Quick fill

Albany Area Private CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
New York State Department of Transportation	14 Crew Rd	Clifton Park	Quick fill
New York State Department of Transportation	695 Watervliet Shaker Rd	Latham	Quick fill
New York State Department of Transportation	288 Troy Rd	Rensselaer	Quick fill
New York State Department of Transportation	16 Maple Ave	Vorheesville	Quick fill

CNG Stations: Buffalo Area



Buffalo Area Public CNG Stations (Sorted by City)

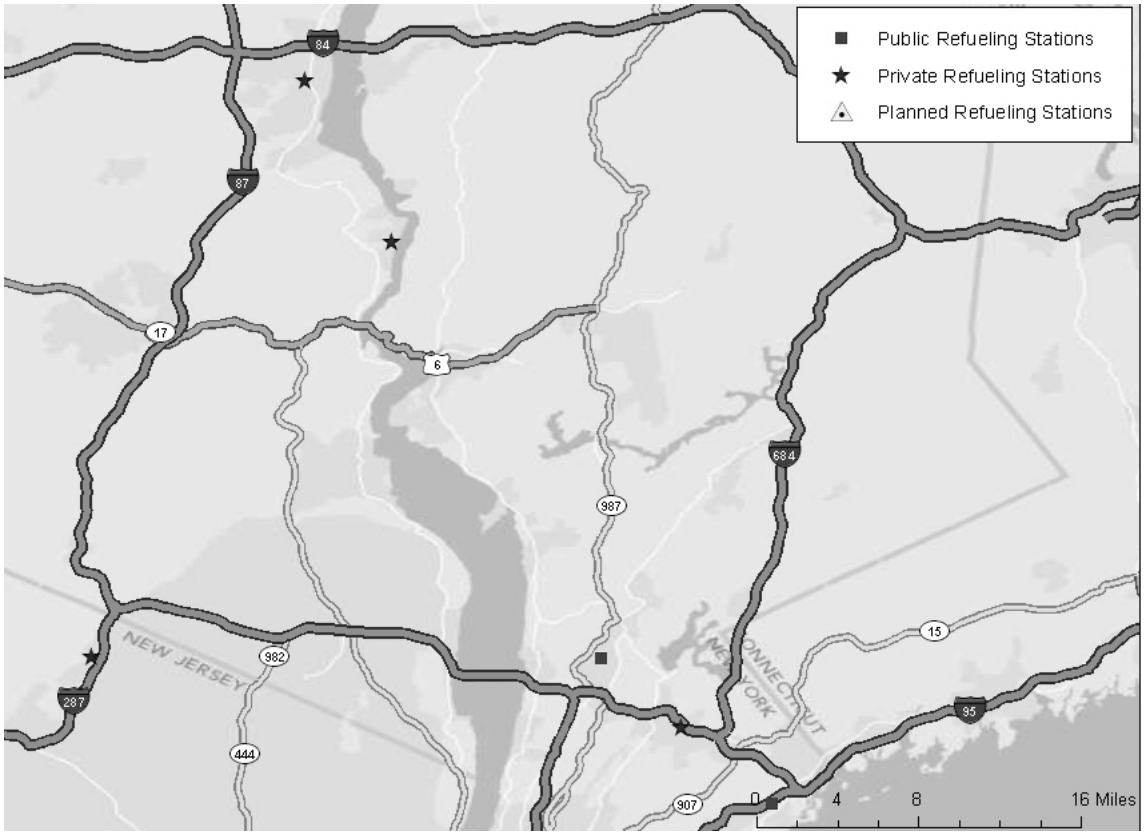
Station Name	Street Address	City	Type
National Fuels - Buffalo	365 Mineral Springs Rd	Buffalo	Quick fill
National Fuels - Niagara Falls	6250 Packard Rd	Niagara Falls	Quick fill
Clean N' Green	100 Ransier Dr	West Seneca	Quick fill

Buffalo Area Private CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
State University of New York - Buffalo North Campus	107 Helm Building	Amherst	Quick fill
New York State Department of Transportation	100 Seneca St	Buffalo	Quick fill
New York State Department of Transportation	Indian Rd & Broadway	Depew	Quick fill
New York State Department of Transportation	3754 Lakeview Rd	Hamburg	Quick fill
New York State Department of Transportation	4717 Southwestern Blvd	Hamburg	Quick fill
New York State Department of Transportation	5055 Junction Rd	Lockport	Quick fill
New York State Office of Parks, Recreation and Historic Preservation	1410 Buffalo Ave	Niagara Falls	Quick fill

APPENDIX F

CNG Stations: Lower Hudson Valley Area



Lower Hudson Valley Area Public CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
Con Edison - Rye Service Center	178 Theodore Fremd Ave	Rye	Quick fill
Clean Energy - New York State DOT	1 Dana Rd	Valhalla	Quick fill

Lower Hudson Valley Area Private CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
*Clean Energy - New York State OGS**	NYS Thruway Exit 18	New Paltz	Quick fill
New York State Department of Transportation	112 Dickson St	Newburgh	Quick fill
West Point	Building 605	West Point	
City of White Plains - DPW	140 S Kensico Ave	White Plains	Quick fill

* (In Lower Hudson Valley area, but not shown on map)

CNG Stations: New York City/Long Island Area

New York City Area Public CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
Clean Energy - National Grid Brentwood Service Center	1650 Islip Ave	Brentwood	Quick fill
*Con Edison - Van Nest Service Center**	1615 Bronxdale Ave	Bronx	Quick fill
*Clean Energy - National Grid Canarsie Service Center**	8424 Ditmas Ave	Brooklyn	Time and quick fill
*Clean Energy - National Grid Greenpoint Energy Center**	287 Maspeth Ave	Brooklyn	Quick fill
Trillium - West End Highway Facility	97 Crooked Hill Road	Commack	
*Clean Energy - BP LaGuardia Airport**	Grand Central Pkwy	Flushing	Quick fill
Clean Energy - New York State Office of General Services	250 Veterans Memorial Hwy	Hauppauge	Quick fill
*Clean Energy - National Grid Hewlett Service Center**	455 Mill Rd	Hewlett	Quick fill
Clean Energy - National Grid Hicksville Headquarters	175 E Old Country Rd	Hicksville	Quick fill
Clean Energy - Town of Smithtown	85 Old Northport Rd	Kings Park	Quick fill
*Con Edison - East 16th Street Service Center**	700 E 16th St	New York	Quick fill
*Con Edison - West 29th Street Service Center**	W 29th St & 12th Ave	New York	Quick fill
*Con Edison - College Point Service Center**	124-15 31st Ave	Queens	Quick fill
*National Grid - Port Authority of New York and New Jersey**	John F Kennedy Airport	Queens	Quick fill

Station Name	Street Address	City	Type
Clean Energy - National Grid Riverhead Service Center	117 Doctors Path	Riverhead	Quick fill
Engineered Energy Solutions	25 N Bicycle Path	Seldon	Time and quick fill
*Clean Energy - National Grid Staten Island Service Center**	200 Gulf Ave	Staten Island	Quick fill
Clean Energy - New York State Department of Transportation	500 Robbins Ln	Syosset	Quick fill
Trillium - Westhampton Airport	124 Old Riverhead Rd	Westhampton Beach	
Clean Energy - Town of Brookhaven Refuse and Recycling Improvement	350 Horseblock Rd	Yaphank	Quick fill

New York City Area Private CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
*Bronx Zoo**	2300 Southern Blvd	Bronx	Quick fill
*Manhattan Beer**	400 Rose Feiss Blvd	Bronx	Quick fill
*MTA New York City Transit - West Farms/Coliseum Depot**	1100 E 177th St	Bronx	Quick fill
*Manhattan Beer**	5700 Avenue D	Brooklyn	Quick fill
*MTA New York City Transit - Jackie Gleason Bus Depot**	36th Ave & 5th Ave	Brooklyn	Quick fill
*New York Bus Co - Spring Creek**	12755 Flatlands Ave	Brooklyn	Quick fill
Town of Brookhaven	1140 Old Town Rd	Coram	Quick fill
*City of New York - Flushing Meadows Corona Park**	11101 Corona Ave	Flushing	Quick fill
*New York Bus Co - College Point**	128-15 28th Ave	Flushing	Quick fill
Metropolitan Transportation Authority - Long Island Bus - Norman J. Levy Transit Facility	700 Commercial Ave	Garden City	Quick fill
New York State Department of Transportation	508 Duffy Ave	Hicksville	Quick fill
Long Beach Public Schools	659 Lido Blvd	Lido Beach	Time and quick fill
New York State Department of Transportation	1400 Walt Whitman Rd	Melville	Quick fill
*City of New York - Central Park**	86th St Transverse	New York	Quick fill
New York State Department of Transportation	1234 Meadowbrook Rd	North Merrick	Quick fill
Town of Hempstead - Department of Conservation & Waterways	320 Lido Blvd	Point Lookout	Quick fill
Metropolitan Transportation Authority - Long Island Bus - Rockville Center	50 Banks Ave	Rockville Center	Quick fill
Brookhaven National Laboratory	Brookhaven Ave	Upton	
*Town of Hempstead - Greenfield Cemetery**	650 Nassau Rd	Union	
New York State Office of Parks, Recreation and Historic Preservation	Jones Beach State Park	Wantagh	Quick fill
Manhattan Beer	2 Washington Ave	Wyandanch	Quick fill

* (In NYC/Long Island area, but not shown on map)

CNG Stations: Rome/Utica Area

Rome/Utica Area Public CNG Stations (Sorted by City)

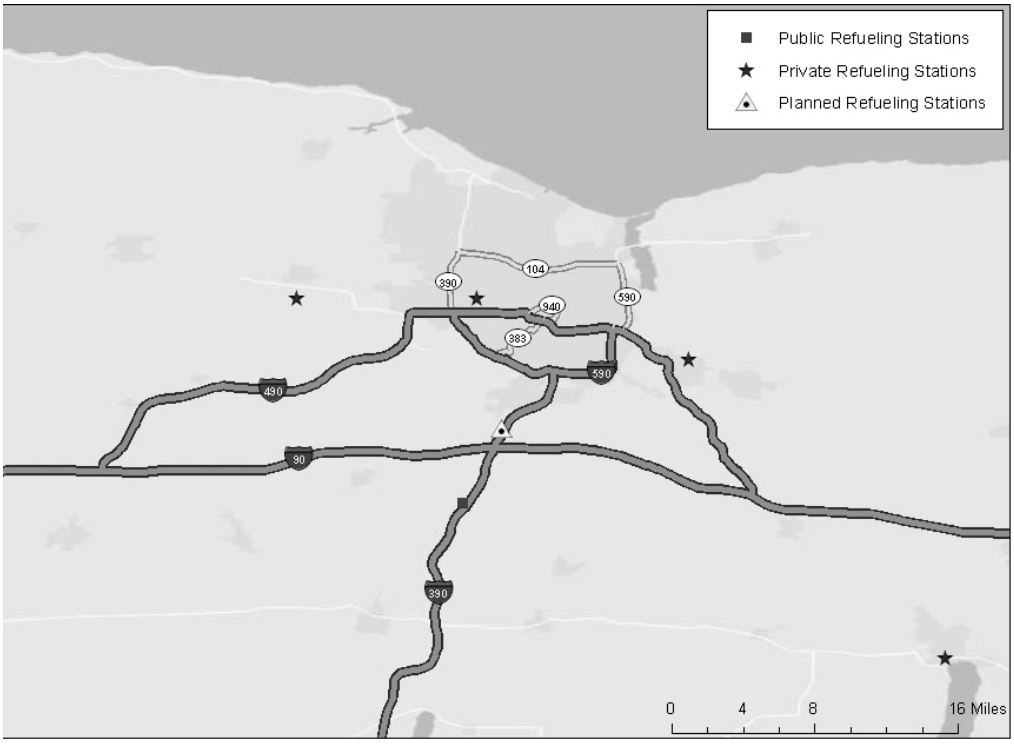
Station Name	Street Address	City	Type
Clean Energy - New York State Department of Transportation	10 Harbor Lock Rd W	Utica	Quick fill

Rome/Utica Area Private CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
New York State Department of Transportation	120 Eaton St	Morrisville	Quick fill
Daimler Buses North America	165 Base Rd	Oriskany	Time and quick fill
New York State Department of Transportation	8515 State Route 26	Rome	Quick fill
New York State Department of Transportation	2436 Chenango Rd	Utica	Quick fill

APPENDIX F

CNG Stations: Rochester Area



Rochester Area Public CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
Clean Energy - New York State Department of Transportation	1235 Rush-Scottsville Rd	Rush	Quick fill

Rochester Area Private CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
New York State Department of Transportation	125 Parrish St	Canandaigua	Quick fill
New York State Department of Transportation	938 W Linden Ave	East Rochester	Quick fill
City of Rochester	945 Mount Read Blvd	Rochester	Time and quick fill
New York State Department of Transportation	2441 S Union St	Spencerport	Quick fill

Rochester Area Planned CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
Waste Management of NY - Rochester	220 Kenneth Dr	Rochester	

CNG Stations: Syracuse Area

Syracuse Area Public CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
Clean Energy - National Grid Beacon North	7496 Round Pond Rd	North Syracuse	Quick fill
Clean Energy - New York State Department of Transportation	5430 S Bay Rd	North Syracuse	Quick fill
Central New York Regional Transportation Authority - Centro	200 Cortland Ave	Syracuse	Quick fill

Syracuse Area Private CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
New York State Department of Transportation	151 Dunning Ave	Auburn	Quick fill
New York State Department of Transportation	5700 Devoe Rd	Camillus	Quick fill
New York State Department of Transportation	5846 Scenic Ave	Mexico	Quick fill

APPENDIX F

CNG Stations: Other Areas

Public CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
Clean Energy - New York State Department of Transportation	112 Barlow Rd	Binghamton	Quick fill
Clean Energy - New York State OGS	4 Burnett Blvd	Poughkeepsie	Quick fill
HPW Energy Inc	8246 Route 5	Westfield	Quick fill

Private CNG Stations (Sorted by City)

Station Name	Street Address	City	Type
New York State Department of Transportation	310 Mineral Springs Rd	Cobbleskill	Quick fill
Fort Drum	Camp Hale Rd	Fort Drum	
Casella Waste Systems	1392 Route 9	Fort Edward	Time fill
New York State Department of Transportation	14 S Branch St	Friendship	Quick fill
New York State Department of Transportation	3059 State Highway 5 S	Fultonville	Quick fill
New York State Department of Transportation	80 Golf Course Rd	Hancock	Quick fill
New York State Department of Transportation	7100 County Rte 70A	Hornell	Quick fill
New York State Department of Transportation	730A Chemung St	Horseheads	Quick fill
New York State Department of Transportation	307 Rte 66	Hudson	Quick fill
New York State Department of Transportation	3716 Burgoyne Ave	Hudson Falls	Quick fill
New York State Department of Transportation	11 Quarry Dr	Kingston	Quick fill
New York State Department of Transportation	109 E Chautauqua St	Mayville	Quick fill
New York State Department of Transportation	3233 Route 6	Middletown	Quick fill
New York State Department of Transportation	1140 E Union St	Newark	Quick fill
New York State Department of Transportation	2317 Greene St	Ogdensburg	Quick fill
New York State Department of Transportation	4359 State Highway 7	Oneonta	Quick fill
New York State Department of Transportation	1497 State Route 96	Owego	Quick fill
New York State Department of Transportation	4480 NYS Route 12	Oxford	Quick fill
New York State Department of Transportation	3863 Meads Creek Rd	Painted Post	Quick fill
New York State Department of Transportation	81 S Peru St	Plattsburgh	Quick fill
New York State Department of Transportation	2234 Route 41	Polkville	Quick fill
New York State Department of Transportation	334 Violet Ave	Poughkeepsie	Quick fill
New York State Department of Transportation	4474 Route 353	Salamanca	Quick fill
New York State Department of Transportation	351 West Ave	Saratoga Springs	Quick fill
New York State Department of Transportation	22430 Route 342	Watertown	Quick fill
Casella Waste Systems	54 Doran Ave	Geneva	Time fill
New York State Department of Transportation	78 E River St	Waterloo	Quick fill

Appendix G. *Cost Evaluation Tool for Fleet Analysis*

A simple cost evaluation tool has been developed as a companion tool to this guidebook. The tool allows a fleet user to enter basic information about a fleet vehicle (or set of similar vehicles), including average annual mileage and fuel efficiency, and determine simple payback if these vehicles were to be converted to natural gas based on incremental capital cost of the vehicle and fuel costs for diesel and natural gas. The tool also allows the user to choose whether or not to include the capital cost of a refueling station in their project, and will provide broad order-of-magnitude estimates of fueling station capital cost based on the natural gas throughput estimated from the number of vehicles.

This tool is not intended to replace a fleet's own financial decision-making tools, nor is it intended to supplant vehicle cost/payback tools available through truck dealers and OEMs. Rather, the tool is intended to assist a fleet in making the initial determination for whether or not to pursue a potential CNG project based on rough estimates of payback.

A sample screen shot of the tool is illustrated on the next page – the complete Excel tool is available at www.nycng.org.

NATURAL GAS DELIVERY TRUCK COST CALCULATOR

v1 (June 6, 2012)

INPUTS

(User inputs in green)

Costs

1/ Initial Capital Cost of Conventional Truck	$75,000	(1)
2/ Initial Capital Cost of Natural Gas Truck	$104,000	
3/ Fuel Cost for Diesel ($/gallon)	$4.00	
4/ Fuel Cost for Natural Gas ($/diesel gallon equivalent)	$2.50	(2)

Fleet Characteristics

1/ Number of Diesel Trucks to be Replaced with CNG	200
2/ Planned Lifetime of Trucks (years)	10
3/ Average Daily Mileage per Truck (miles per day)	90
4/ Average Annual Usage per Truck (days used per year)	300
5/ Average Fuel Economy of Diesel Truck (miles per diesel gallon)	5
6/ Average Fuel Economy of Natural Gas Truck (miles per diesel gallon equivalent)	5

Vehicle Incentives (Per Vehicle)

1/ Federal Purchase Incentive	$0
2/ New York State Purchase Incentive	$0
3/ Other Purchase Incentives	$20,000

Fleet Refueling Options

1/ Will Fleet Build Refueling Infrastructure? (1=Yes/0=No)	1	(3)
2/ How Many Stations Will Be Built?	1	
3/ Average Cost per Station	$750,000	

Refueling Incentives (Per Station)

1/ Federal Incentive	$0
2/ New York State Incentive	$0
3/ Other Incentives	$50,000

OUTPUTS

Simple Payback

1/ Simple Payback of Natural Gas Incremental Costs Without Incentives (years)	**4.0**
2/ Simple Payback of Natural Gas Incremental Cost With Incentives (years)	**1.5**

Life Cycle Cost

1/ Total Life Cycle Cost of Diesel Trucks (No Incentives)	$58,200,000	
2/ Total Life Cycle Cost of Natural Gas Trucks (No Incentives)	$48,550,000	
3/ Life Cycle Cost Differential (No Incentives)	-$9,650,000	(4)
4/ Total Life Cycle Cost of Diesel Trucks (With Incentives)	$58,200,000	
5/ Total Life Cycle Cost of Natural Gas Trucks (With Incentives)	$44,500,000	
6/ Life Cycle Cost Differential (With Incentives)	-$13,700,000	(4)

NOTES

(1) Green cells are user-editable input fields.

(2) See tab CNG COSTS for source of CNG pricing.

(3) If the calculation uses the CNG price built up from components on the CNG COST tab, the user should enter "0" for building infrastructure, as cost amortization of station is already included in the cost per diesel gallon equivalent.

(4) Life cycle cost savings for the project are highlighted in green, while instances of additional cost for CNG are highlighted in red

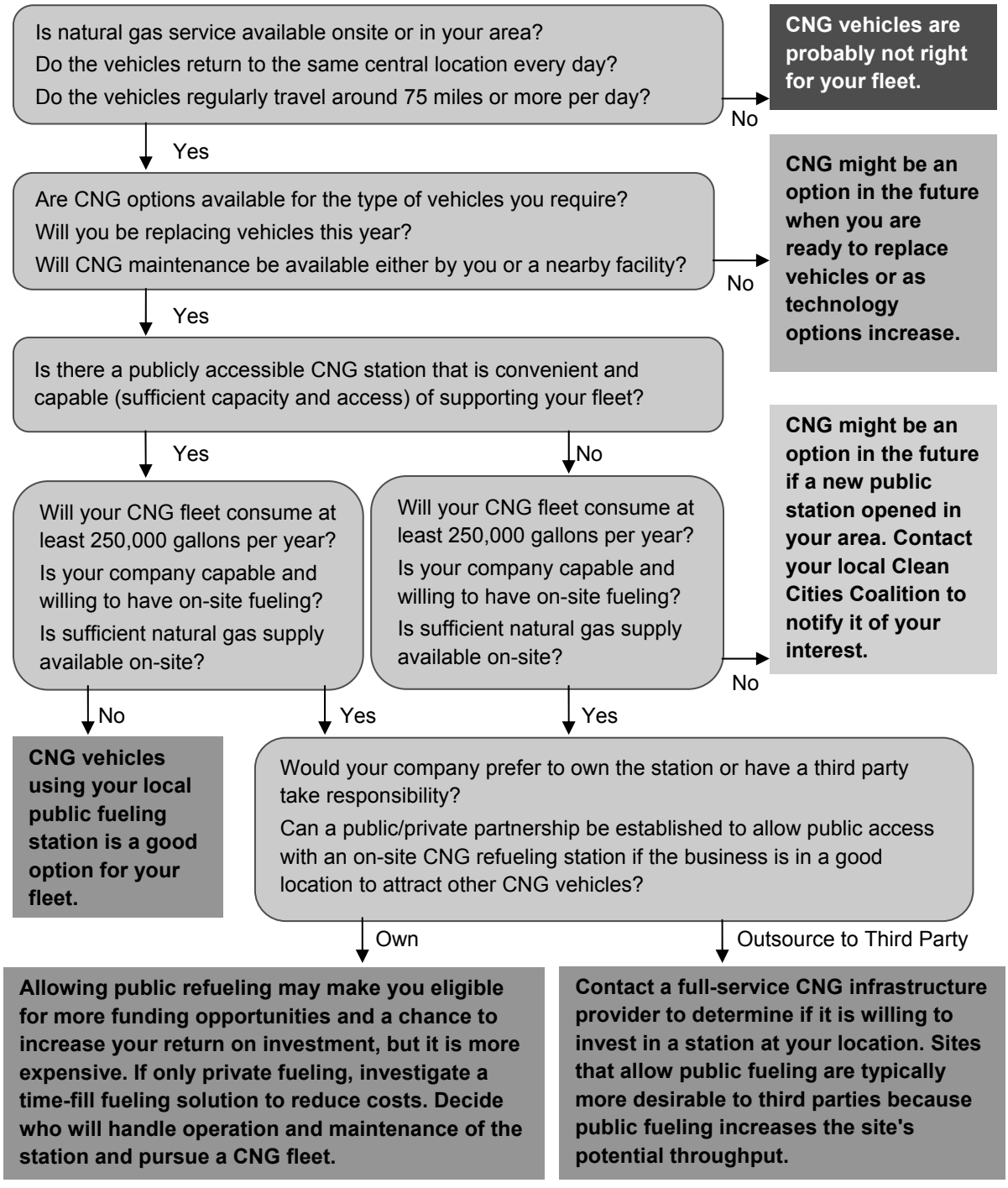
Appendix H. *Natural Gas Vehicle Project Planning Checklist*

The checklist below is intended to serve as a guide for fleet managers in adopting natural gas as a fuel for fleet vehicles. This is not an exhaustive outline of the details necessary for a successful project: rather, it provides an overview of the basic steps involved. Fleet managers are encouraged to consult with experts in the natural gas industry for additional information.

	Understand the basics of natural gas and CNG vehicles (Section 3, page 13) • Be familiar with how natural gas is used as a fuel and what characteristics differ from conventional petroleum fuels.
	Assess fleet vehicle characteristics (Section 3, page 15) • Outline vehicle route characteristics and typical vehicle use (average annual miles per year), average vehicle age of the vehicles to be replaced, etc. Are there any special characteristics with these vehicles that would make them unsuitable for natural gas?
	Review CNG vehicle options (Section 3, page 16 and Appendix A) • What make and model of vehicle does the fleet prefer to purchase? Are there CNG options available in these truck models (or similar models)?
	Evaluate existing and planned CNG infrastructure (Section 3, page 17 and Appendix F) • Is fueling infrastructure available close to the fleet operation, or is a CNG station planned for somewhere nearby? Will the fleet need to construct its own refueling?
	Assess facility property (Section 3, page 19) • If the fleet plans to build its own station, is there appropriate space available? Is there gas supply nearby? Would public access be viable?
	Understand the corporate business strategy (Section 3, page 20) • If the fleet plans onsite fueling, will it be owned or provided by a third party? Who will maintain the station? How will it be financed? What payback period is needed?
	Examine infrastructure requirements (Section 3, page 21) • What will be needed to meet fleet infrastructure needs? These must be clearly understood to issue a RFP for station construction.
	Assess the business case (Section 3, page 21) • How quickly will the fleet's investment in the CNG project be paid back with fuel cost savings? Does this fit with the fleet's typical business practices and preferences?
	Develop an implementation plan and complete it (Section 3, page 22) • Plan carefully for the number of natural gas vehicles to be purchased, the financing to be arranged for the vehicles (and infrastructure if needed), and procurement of fuel (long-term fuel purchase agreements are best if possible).

Flow Chart of Decisions – Natural Gas Delivery Vehicle Projects

The flow chart below provides an alternative look at the steps and decisions to be made in planning for a natural gas vehicle project. This supplements the prior checklist.



June 2012

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