U.S. and Canadian Natural Gas Vehicle Market Analysis:

Compressed Natural Gas Infrastructure

Final Report

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Abbreviations

AGA	American Gas Association
ANGA	America's Natural Gas Alliance
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
Btu	British thermal unit
CNG	Compressed natural gas
DGE	Diesel gallon equivalent (=131.7 cubic feet of natural gas)
EPAct	Energy Policy Act
ESD	Emergency shutdown device
GGE	Gasoline gallon equivalent (=115.6 cubic feet of natural gas)
LDC	Local distribution company (gas utility)
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NGV	Natural gas vehicle
NIST	National Institute of Standards and Technology
OEM	Original equipment manufacturer
OSHA	Occupational Safety and Health Act
ROI	Return on investment
SAE	Society of Automotive Engineers
scfm	Standard cubic feet per minute
UBC	Uniform Building Code
UFC	Uniform Fire Code
UL	Underwriters Laboratory
UPC	Uniform Plumbing Code

Lower Heating Value Energy Content Conversion Factors

Gasoline	113,602 BTU/gal
Diesel	129,488 BTU/gal
Natural gas	983 BTU/cubic foot (=131.4 BTU/gal of volume)

Source: Argonne National Laboratory, "Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation," 1.8c

Preface

Identifying the most productive and effective means to increase the use of natural gas vehicles.

With the primary objective of identifying the most productive and effective means to increase the use of natural gas vehicles (NGVs) in the U.S. and Canada, the TIAX team has conducted a thorough and independent assessment of the NGV market. To highlight the major opportunities to spur the market's development and expansion, this assessment examines the key technical, economic, regulatory, social, and political drivers and challenges that shape this market. TIAX has partnered with The CARLAB, Clean Fuels Consulting, the Clean Vehicle Education Foundation, Jack Faucett Associates, the Natural Gas Vehicle Institute, and St. Croix Research to provide perspective and insights into the development of the future NGV market.

TIAX's overall approach relies on six key stages

- Segmentation of the vehicle market
- Identification of market decision drivers
- Assessment of market development actions
- Analysis of competing technologies
- Analysis of market scenarios
- Integration of overall market development opportunities

The market perspectives for which decision drivers and opportunities have been identified and assessed are: light- and medium-duty vehicle ownership and production; heavy-duty vehicle ownership and production; compressed natural gas infrastructure; liquefied natural gas infrastructure; and government.

Drawing on the respective expertise of each team member, TIAX presents an integrated assessment of the U.S. and Canadian NGV market in a collection of nine reports (Figure P-1). Each report is capable of standing alone while integrating the data, ideas, and themes of the other eight reports. The collection of reports in this TIAX analysis of the NGV market is supported by America's Natural Gas Alliance and is intended to be transparent and accessible to a broad audience.

Executive Summary

Today, approximately 1,000 CNG stations in the U.S. compete with approximately 120,000 retail gasoline stations. That is a ratio of 1 CNG station for every 120 retail gasoline stations.

Driven by the alternative fuel vehicle mandates of the Energy Policy Act of 1992, compressed natural gas (CNG) fueling infrastructure development in the U.S. accelerated in the early 1990s. The total number of U.S. stations peaked in 1997, experienced a decade of decline, and has grown slightly since 2006 to its current total of 1,000. Canada currently reports 74 stations. The majority of CNG stations in the U.S. are private access, while the majority of CNG stations in Canada are public access.

In 1995, the Natural Gas Vehicle (NGV) Industry Strategy called for a focus on high fuel use fleets, such as transit agencies, refuse trucks, and delivery fleets. This focus helped increase demand for natural gas in transportation threefold between 1997 and 2009. Demand in 2009 was 3.2 billion cubic feet, or 27.7 million gasoline gallons equivalent.

Four main approaches to CNG infrastructure development have been used in the U.S., including onsite private fueling for captive fleets, onsite private fueling with public dispensing, offsite private fueling (cardlock stations), and public fueling. Two of the four approaches have focused on onsite fueling to serve high fuel use fleets. Today, the 1,000 CNG stations in the U.S. compete with 118,756 retail gasoline stations. The majority of diesel trucks of all classes fuel at public fueling stations. Following the same model, to be competitive, the CNG industry will benefit greatly from a focus on developing public fueling infrastructure equivalent to 10 to 20 percent that of traditional liquid fuels, or between 16,000 and 32,000 CNG stations.

Because they dispense high pressure gas, CNG stations are distinct from gasoline and diesel stations. They must be sized and designed to accommodate the fuel demand and pattern of the vehicles that will fuel at the sites. They include unique components such as gas dryers and high pressure storage systems and are built to conform to codes specially developed for high pressure gas. The cost to build CNG stations varies widely depending on size. The average costs identified in this study ranged between $600,000 and $1,000,000 per station.

Business models for CNG infrastructure also vary widely depending on a variety of factors, including the profit motive of owners, the cost of gas, and capital costs. The business case is negatively influenced by both supply-side and demand-side factors. On the supply side, the upfront cost of CNG stations is significant. On the demand side, building fuel demand to achieve positive cash flow is often a lengthy process. Thus, the return on investment for CNG stations can be negative or very low for several years if measures are not taken to offset these influencing factors.

CNG infrastructure developers include compressor manufacturers/suppliers/packagers, engineering and construction companies, and CNG retailers. Interviews with these developers found that annual demand for new CNG stations in 2010 in the U.S. is estimated to be between sixty and eighty stations. The current infrastructure developer base is relatively small and can meet current low demand levels. Developers anecdotally report the need to triple annual demand in order to stabilize their businesses. There will need to be both expansion of existing companies and new companies entering the market if the industry is to grow significantly to achieve a 16,000 to 32,000 station goal.

Table ES-1

CNG infrastructure stakeholders can take these specific actions to expand the use of CNG as a transportation fuel in North America.

CNG Infrastructure Stakeholders	Actions and Opportunities for CNG Infrastructure Development
Compressor manufacturers/suppliers/ packagers Engineering and construction companies Natural gas supply chain companies • Exploration and production companies • Pipeline companies • LDCs CNG retailers • LDCs • Private retailers Government	• Implement measures to ensure competitive CNG pricing, including establishing specific tariffs for natural gas for transportation and reasonable margins by retailers • Obtain or provide capital offsets for CNG infrastructure in the form of grants, low-cost capital and other financial incentives • Work collectively to achieve favorable government policies, including long-term incentives • Create a North American branding and awareness program for CNG • Effectively market the use of CNG • Purchase maximum numbers of NGVs for use in stakeholder fleets • Provide high pressure gas to stations whenever possible to reduce compression costs • Ensure pipeline infrastructure is capable of accommodating additional natural gas capacity for transportation

CNG retailers are currently dominated by local distribution companies (LDCs) and a single company, Clean Energy. The LDCs own approximately 40 percent of the existing retail CNG stations in the U.S., and Clean Energy owns or operates 29 percent.

The major challenges reported by CNG infrastructure developers include low and unstable demand, conflict regarding equipment specifications between engineering companies and suppliers, unreasonable customer expectations regarding lead times and budgets for CNG stations, and lack of standardization of design components. The opportunities reported by these companies are based on the competitive advantages of CNG in the areas of price, energy security, and environment impacts.

While there are numerous stakeholders in the CNG infrastructure development process, three groups have the greatest influence: natural gas supply chain companies (including exploration and production companies, pipeline companies, marketers, and LDCs), federal governments, and CNG retailers. The most important actions these stakeholders can take to help accelerate the development of CNG infrastructure are summarized in Table ES-1.

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1 Introduction

Development of compressed natural gas (CNG) infrastructure has a history of proven success, and current market conditions indicate that there exists potential for renewed and expanded need for CNG infrastructure.

In 1997, the U.S. achieved its maximum number of CNG fueling stations to date of just over 1,400. Over 1,000 stations were brought online in the five years after the Energy Policy Act (EPAct) of 1992 was passed, which required federal, state government, and utility company fleets to purchase significant quantities of light-duty alternative fuel vehicles, including natural gas vehicles (NGVs). At that time, commercial markets and infrastructure for alternative fuels and vehicles, including natural gas, were expected to be substantially boosted using the legislative mandates to create baseline demand.

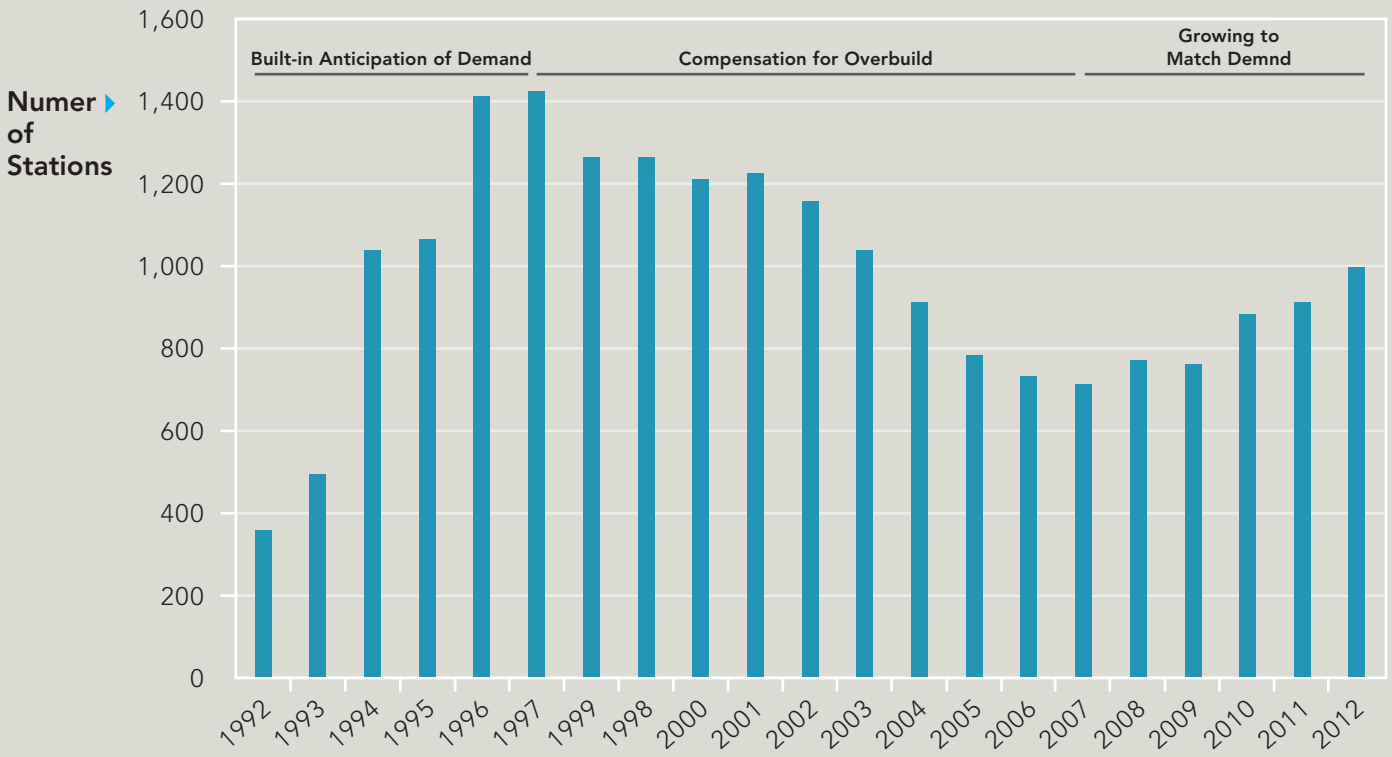
In 1995, the Natural Gas Vehicle (NGV) Industry Strategy called for a focus on high fuel use fleets, such as transit agencies, refuse trucks, and delivery fleets.[1] A significant percentage of these fleets required fueling infrastructure sized and designed specifically to dispense larger quantities of fuel, required or preferred onsite fueling, and had little or no potential to fuel at the typical CNG stations that had been constructed to date. As a result, there began an upswing in the quantity of natural gas for transportation sold each year, but a corresponding decline in the number of CNG stations operating in the U.S. The decline in the number of CNG stations in the U.S. began in 1997 but held relatively steady until 2001 when the total number was approximately 1,200. By 2004, the number of CNG stations had dropped below 1,000 for the first time in a decade. The number of CNG stations in the U.S. began to level off in 2006, and modest growth has been seen in recent years. Figure 1-1 illustrates the history of CNG station population in the U.S.

This report draws from the Natural Gas Vehicle Institute's decades of experience with NGVs and stakeholders. As one of North America's leading providers of training and consulting on natural gas as a transportation fuel, the Natural Gas Vehicle Institute has contacted and interviewed numerous market players (Table 1-1) to derive the insights presented in this report. This assessment begins with a discussion of the development of CNG infrastructure to date in Section 2. Section 3 delves further into the design and safety requirements for CNG infrastructure and shows that these requirements are established by various codes and standards. Section 4 examines the approaches to infrastructure development, including historical lessons, current developers and stakeholders, market positions and thresholds, and business models. Finally, Section 5 identifies the actions and opportunities for natural gas supply chain companies, government, and retailers to expand CNG infrastructure to grow the NGV market. The focus of this report is on the CNG infrastructure needed to support CNG vehicles, the technologies and appropriate market segments of which are discussed in greater detail in the Light- and Medium-Duty Vehicle Ownership and Production, Heavy-Duty Vehicle Ownership and Production, and Market Segmentation reports of the overall TIAX assessment.

1 Acurex Environmental Corporation, Planmetrics Inc., Thomason and Associates Inc. "NGV Industry Strategy." Prepared for National Gas Vehicle Coalition, Gas Research Institute, American Gas Association. May 1995.

Figure 1-1

Following a peak and decline in station population, CNG infrastructure appears once again to be growing.[2]



2 U.S. Department of Energy Alternative Fuels and Advanced Vehicles Data Center, as updated by ANGA/AGA Natural Gas Transportation Fuel Collaborative, March 30, 2012.

Table 1-1

Many key CNG infrastructure stakeholders were contacted and interviewed to provide insights into this assessment.

Companies Interviewed	Other Companies Contacted (No Response)
Anonymous CNG Retailer	AVSG
AE Com	Burnett & Burnette
Allsup Corporation	Clean Energy
Amtek	EFS West
ANGI Energy Systems	Engineered Energy Solutions
Bauer	GESI
ET Environmental	Greenfield Compression
Fuel Solutions	Kraus Global
IMW	Raymundo Engineering
JW Operating Co.	
Knox Western	
Las Vegas Valley Water District	
Marathon Technical Services	
Phoenix Energy	
Pinnacle CNG Systems	
Questar Gas	
T. Mitchell Engineers, inc	
Weaver Inc.	
Zeit Energy	

2 CNG Fueling Infrastructure to Date

2.1 Stations

The increasing CNG consumption and decreasing CNG station count to date indicate a consolidation of fueling infrastructure that has been driven by high fuel use fleets and influenced by vehicle availability.

Today, there are 1,000 CNG stations operating in the U.S.[3] 36 states have five or more stations, and California has the highest station population at 228, with New York, Utah, and Oklahoma having the next highest populations at 107, 82, and 70, respectively. For the U.S. as a whole, 54 percent of stations are private access, and 46 percent are public access. In contrast, the large majority of the CNG fueling stations in Canada are public access.[4] Canada reports 74 stations, 69 percent of which offer public access.4 All of these public stations are located in four provinces: Alberta (12 stations), British Columbia (22 stations), Ontario (7 stations), and Saskatchewan (10 stations).

Between 1999 and 2008, the amount of natural gas consumed by NGVs nearly tripled, attributable largely to a focus on high fuel use fleets. One clear example is the transit segment, which represents perhaps the largest contributor to the growth of natural gas transportation fuel sales in the U.S. However, during the same time, the number of natural gas fueling stations significantly declined. Figure 2.1-1 compares CNG station counts between 1997 and 2008 and the total natural gas consumption in transportation during that same time period.

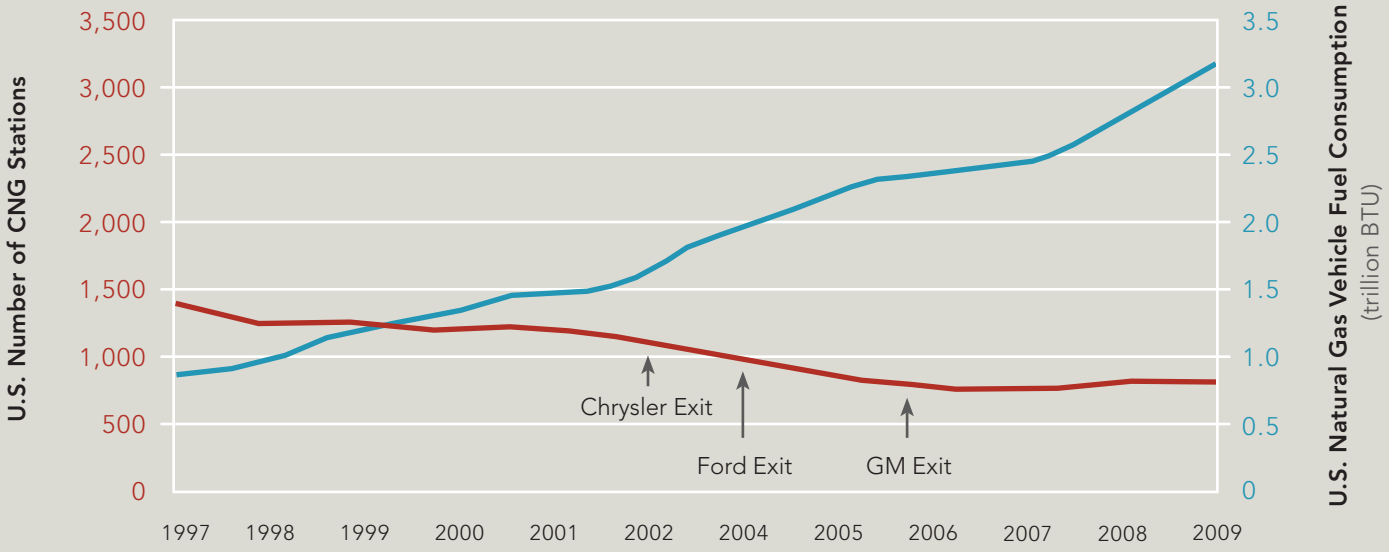
During the early 1990s, two important influences for natural gas as a transportation fuel emerged. First, many local distribution companies (LDCs) became involved in marketing natural gas as a transportation fuel to fleet customers and used NGVs in their own fleets. These LDCs applied significant pressure to original equipment manufacturers (OEMs) to offer NGVs. Second, EPAct 1992 required federal, state, and utility company fleets to purchase light-duty alternative fuel vehicles, including NGVs. The CNG infrastructure built between the early 1990s and the mid-2000s was established to meet anticipated demand from mandated fleets. Unexpectedly, the market for natural gas that was predicted to emerge due to EPAct mandates did not materialize. Instead, many EPAct-mandated fleet managers preferred flex-fuel ethanol vehicles because of their convenience and zero incremental cost. Furthermore, many EPAct-mandated fleets that operated NGVs were not required to actually use natural gas in bi-fuel vehicles. This resulted in much lower natural gas consumption than originally predicted.

By 2006, Chrysler, Ford, and GM's discontinuation of NGVs sent a market message that there was limited demand for OEM NGVs. However, major component suppliers and upfitters continued to supply the market. The correlation between the discontinuation of OEM NGVs and the number of CNG stations is shown in Figure 2.1-2. Chrysler departed the market in 2002, and a decline in CNG infrastructure was measured in 2003. Similarly, Ford and GM announced their departures in 2004 and 2006, respectively, followed by further decreases in the number of CNG stations. Given this correlation between natural gas infrastructure and OEM vehicle availability, recent announcements by OEMs regarding NGV market re-entry are encouraging.

3 U.S. Department of Energy Alternative Fuels and Advanced Vehicles Data Center, as updated by ANGA/AGA Natural Gas Transportation Fuel Collaborative, March 31, 2012.
4 Canadian Natural Gas Vehicle Alliance. "Where to Refuel." http://www.cngva.org/wheretorefuel.htm. March 2012.

Figure 2.1-1

OEMs influence CNG infrastructure development, as evidenced by decreases in station population in the years following Chrysler, Ford, and GM discontinuation of NGV products. While CNG station population declined, NGV fuel consumption increased, suggesting a consolidation of stations to serve high fuel use fleets.[5,6]



5 U.S. Department of Energy Alternative Fuels and Advanced Vehicles Data Center, as updated by ANGA/AGA Natural Gas Transportation Fuel Collaborative, November 30, 2010.
6 U.S. Energy Information Administration. "Natural Gas Navigator." http://www.eia.doe.gov/dnav/ng/hist/n3025us2a.htm. October 2010.

2 CNG Fueling Infrastructure to Date

2.2 Comparison of CNG Fueling Infrastructure to Gasoline/Diesel

The current number of CNG stations in North American is less than one percent that of gasoline and diesel retail outlets. CNG fueling infrastructure equivalent to a modest ten to twenty percent of the number of retail gasoline stations would require between 16,000 and 32,000 CNG stations in the U.S.

The NGV industry has been successful at beginning to penetrate markets for high fuel use fleets, such as transit agencies, refuse companies, and delivery fleets. As stated earlier, these fleets often fuel at onsite stations and do not rely on public fueling infrastructure to a significant degree.

However, if CNG is to become widely accepted and the market for fueling infrastructure is to grow beyond these high fuel use fleets, accommodating a variety of vehicle classes and fueling needs, and ultimately connecting fueling infrastructure between cities, counties, regions, and states, retail and truck stop outlets need to be developed in numbers that allow reasonably convenient access to CNG. This does not mean that CNG infrastructure needs to be equivalent to gasoline and diesel, but it does need to be increasingly more available and convenient for fleets and the general public.

Currently, 118,756 gasoline retail outlets in the U.S. are estimated to sell 138 billion gallons of gasoline annually.[7,8] In addition, approximately 5,000 truck stops in the U.S. are responsible for 54 percent of all on-road diesel consumption.[9] The Canadian fueling infrastructure may be approximately 10 percent that of the U.S. Figure 2.2-1 compares the current U.S. CNG infrastructure to gasoline. Public fueling infrastructure for CNG in the U.S. is approximately 0.2 percent that of gasoline.

When the diesel industry decided to expand the market for its fuel beyond heavy-duty trucks and began developing public infrastructure, it determined that the quantity of stations required to be competitive was equal to a minimum of 10 percent of the gasoline stations. This ratio was thought to be able to create a fueling network that would be convenient enough to encourage and facilitate the transition to diesel fuel.

While this assessment does not presume to determine the exact number of CNG stations required to be competitive, a ratio of CNG to gasoline and diesel stations similar to the minimum ratios established for diesel may be an effective starting goal. Achieving this goal would mean establishing between 16,000 and 32,000 CNG stations, or at least twenty times the total number of current CNG stations (Figure 2.2-2). Working toward achieving this goal for CNG infrastructure will make an impact on CNG availability and market penetration for NGVs.

7 U.S. Census Bureau. "Economic Census." 2007.
8 Alternative Fuels and Advanced Vehicles Data Center. "Infrastructure." http://www.afdc.energy.gov/afdc/data/infrastructure.html. October 2010.
9 TIAX LLC. "SCR-Urea Implementation Strategies Update." Prepared for Engine Manufacturers Association. June 2006.

Figure 2.2-1

Public fueling infrastructure for CNG in the U.S. is less than 1 percent that of gasoline.[10]

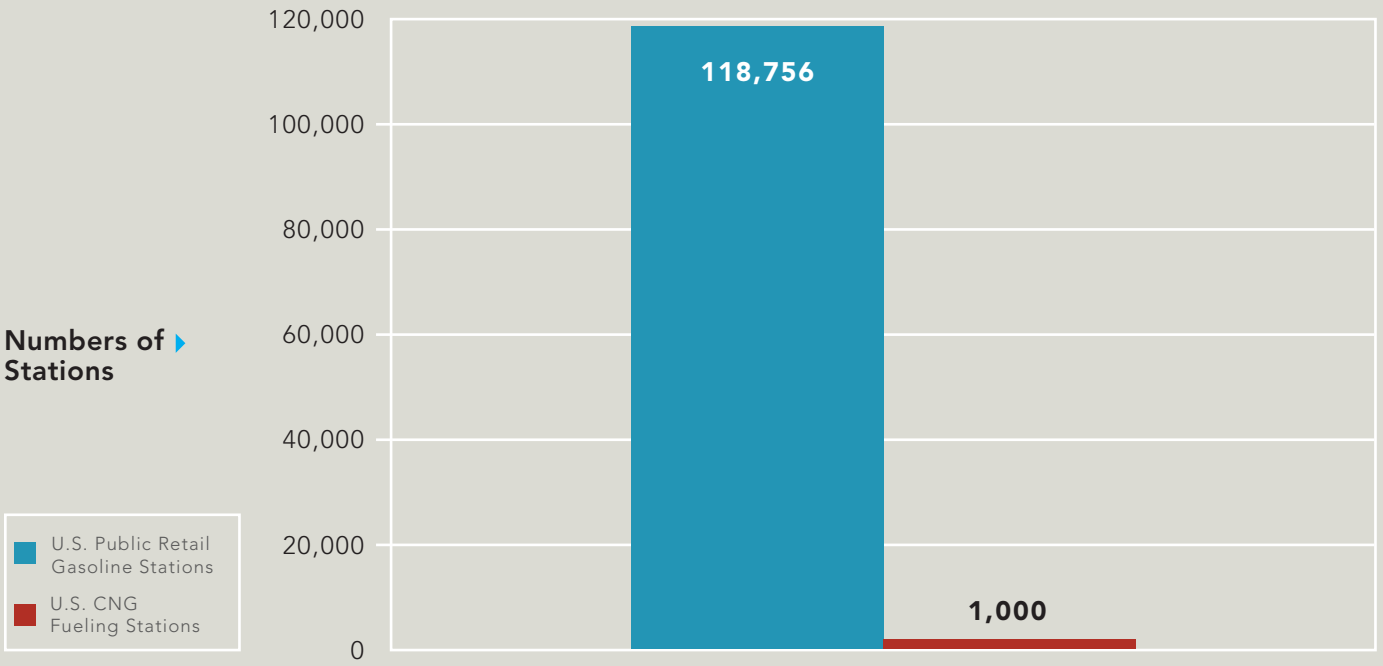
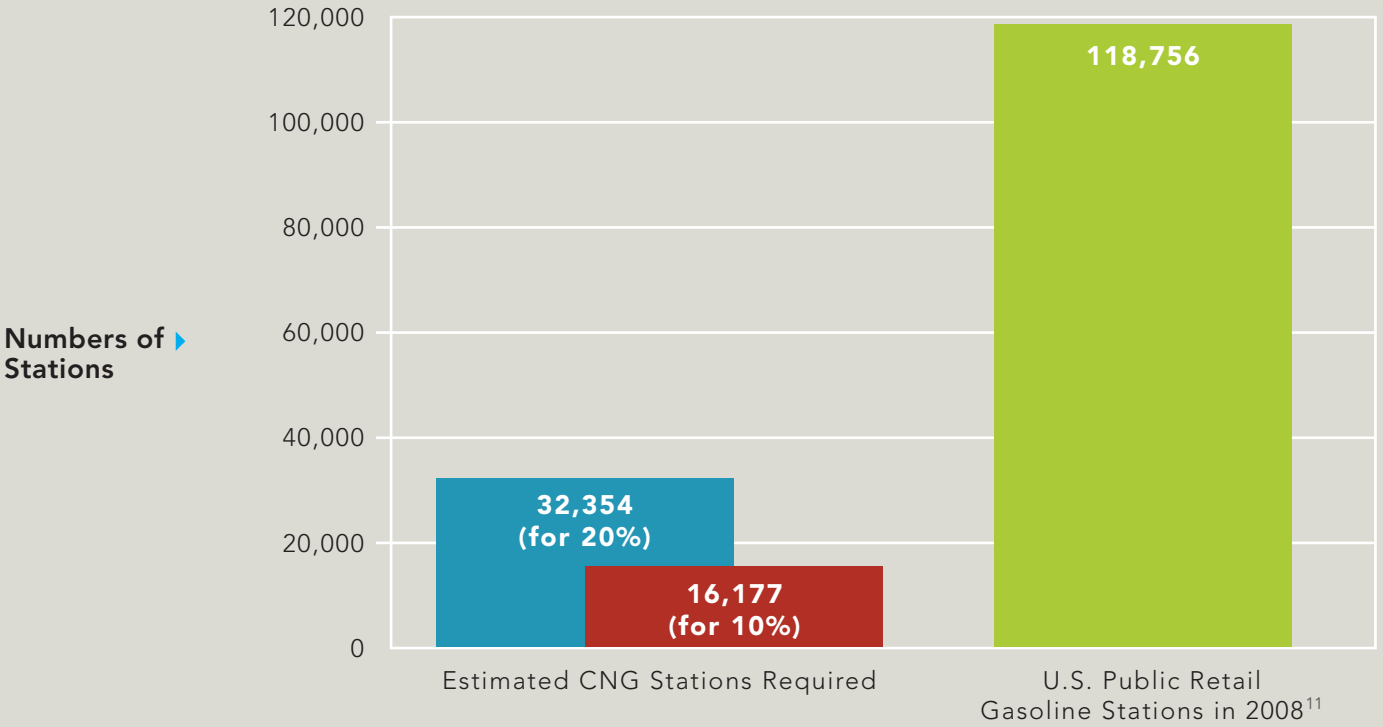


Figure 2.2-2

Following the diesel industry's model for expanding public infrastructure, if CNG station development is targeted at 10 to 20 percent of gasoline stations, the industry will need to establish 16,000 to 32,000 stations.



10 Alternative Fuels and Advanced Vehicles Data Center. "Infrastructure." http://www.afdc.energy.gov/afdc/data/infrastructure.html. October 2010.
11 *Ibid.*

3 CNG Station Design

3.1 Design and Safety Requirements

There are design and safety requirements unique to CNG infrastructure due to the physical properties of high pressure gas. The design requirements prescribe four configurations of CNG stations, depending on the fueling requirements and pattern of the vehicles utilizing the stations.

The major difference between CNG fueling and conventional liquid fueling of vehicles stems from variances in physical properties between gases and liquids. Conventional fuel retailers, fleet fueling operators, and drivers are accustomed to fueling vehicles with liquid fuels. Natural gas is similarly simple to use, though different from conventional fueling. While liquid fuels such as gasoline or diesel must be transported to stations via over-the-road trucks, CNG is made from natural gas that is typically transported to the station via an underground pipeline and then compressed. CNG fueling stations can be designed to accommodate any size vehicle and fuel demand.

In North America, there are four predominant configurations of CNG stations:

- Cascade Fast-Fill
- Buffer Fast-Fill
- Time-Fill
- Combination-Fill

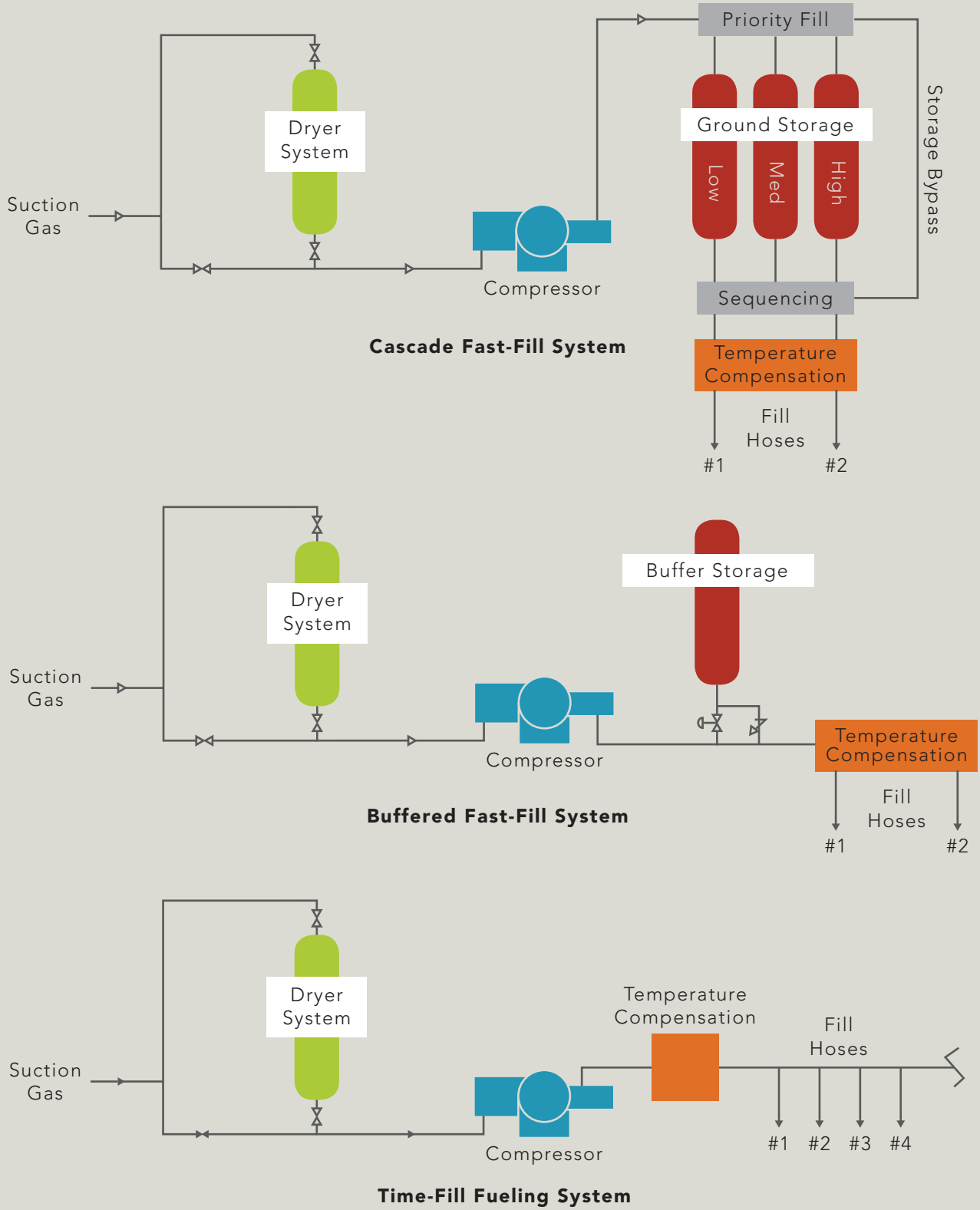
Simplified schematics for the first three configurations are illustrated in Figure 3.1-1. Combination-fill, as its name suggests, combines fast- and time-fill configurations to offer flexibility in meeting fueling needs. These configurations are described in the following sections.

While construction of gasoline and diesel stations has some requirements common to CNG, CNG fueling stations have three unique safety requirements, primarily designed to manage potential fires. These requirements are:

- Two emergency shutdown devices (ESDs) are required. One must be located within 10 feet of the dispensing area and another between 25 to 75 feet from the dispensing area. For gasoline and diesel, a single ESD can be 25 to 75 feet from the dispensing area.
- An ESD is also installed at the compressor location to provide additional control and safety.
- Fire extinguishers must be located both in the dispensing area and close to the compressor enclosure.

Figure 3.1-1

CNG stations use four predominant configurations: cascade fast-fill, buffer fast-fill, time-fill, and combination-fill, which combines fast- and time-fill configurations.



3 CNG Station Design

3.2 Station Types and Equipment

3.2.1 Cascade Fast-Fill Station

A cascade fast-fill CNG station is typically used for retail applications or when vehicles arrive randomly for refueling.

The pattern of use of a cascade fast-fill station is comparable to that of a retail gasoline or diesel station. There may be peak periods of fueling, such as early morning before work hours or evening after work hours, but the station also fuels vehicles that arrive in a random fashion throughout the day. These CNG stations must be designed to have enough storage to handle peak fuel demand. They also must have a compressor that is sized appropriately to meet the fueling pattern and adequately replenish the storage in a given amount of time.

Especially in public fueling applications, it is important to consider redundancy, which is accomplished by installing more than one compressor, to provide a continuous supply of fuel and ensure customer satisfaction. This allows the station to continue to operate in case one of the compressors fails, improving reliability and customer satisfaction. This is even more important during the early years of infrastructure development when the density of CNG stations is relatively low and an alternate CNG fueling station may not be easily located.

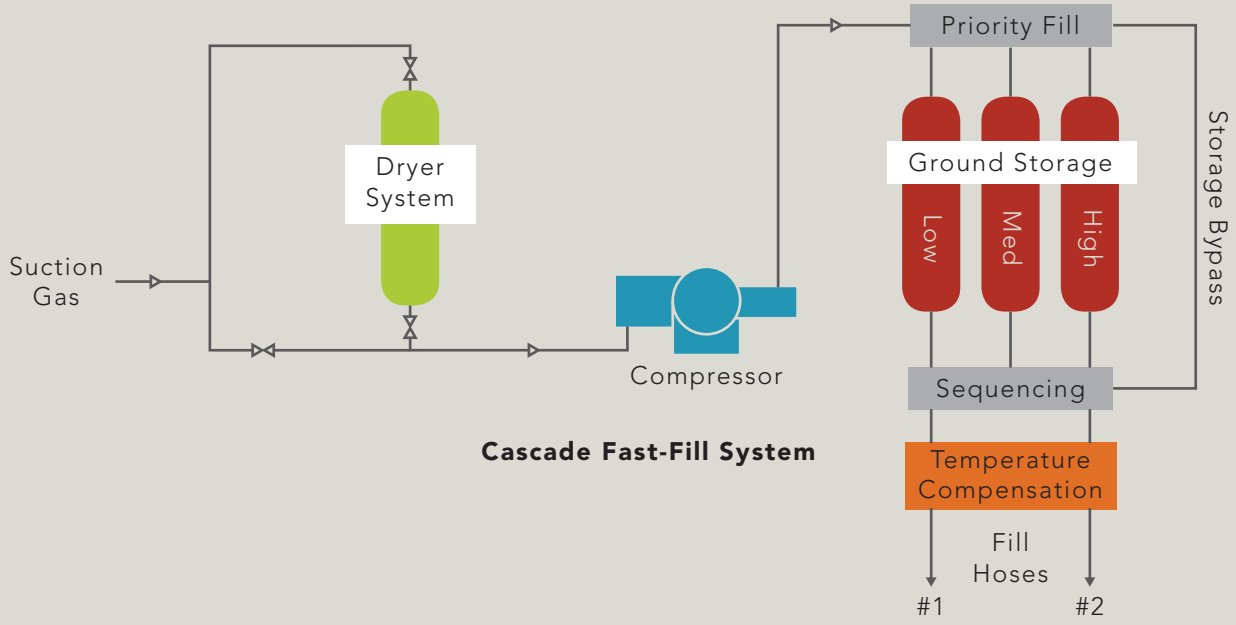
Typical components of a cascade fast-fill system include:

- Dryer – removes water or water vapor from the natural gas supply prior to compression
- Compressor – compresses natural gas to the appropriate pressure required to deliver a fully temperature compensated fill to the vehicle
- Priority valve panel – determines the sequence of flow of natural gas from the compressor into storage
- Storage – American Society of Mechanical Engineers (ASME) vessels used to store compressed natural gas
- Sequential valves – determines the sequence of flow of natural gas from storage into the vehicle
- Temperature compensation system – uses an algorithm to adjust for ambient temperature and temperature of compression into the vehicle fuel storage system to ensure that vehicles receive a full fill
- Dispenser – dispenses natural gas into vehicles

Figure 3.2.1-1 demonstrates a typical public access cascade fast-fill station.

Figure 3.2.1-1

The cascade fast-fill CNG station configuration allows for fueling similar to retail gasoline and diesel stations. Two key components of the cascade fast-fill configuration are compressed gas storage and CNG dispensers.



Cascade Fast-Fill System

3 CNG Station Design

3.2 Station Types and Equipment
3.2.2 Buffer Fast-Fill Station

A buffer fast-fill CNG station is typically used for sequential fueling of high fuel use vehicles one immediately after another.

Examples of the most frequently required applications for buffer fast-fill stations are transit buses and taxis. The main difference between buffer fast-fill and cascade fast-fill systems is that buffer systems primarily fuel directly from the compressor into the vehicle and use a smaller quantity of storage.

These stations are typically onsite fueling stations that serve a captive fleet and are sized and designed specifically for the needs and fueling patterns of that fleet. They allow large quantities of fuel to be dispensed in a relatively short time period, which can be important for fleets such as taxi cabs whose operating characteristics require relatively short dispensing periods.

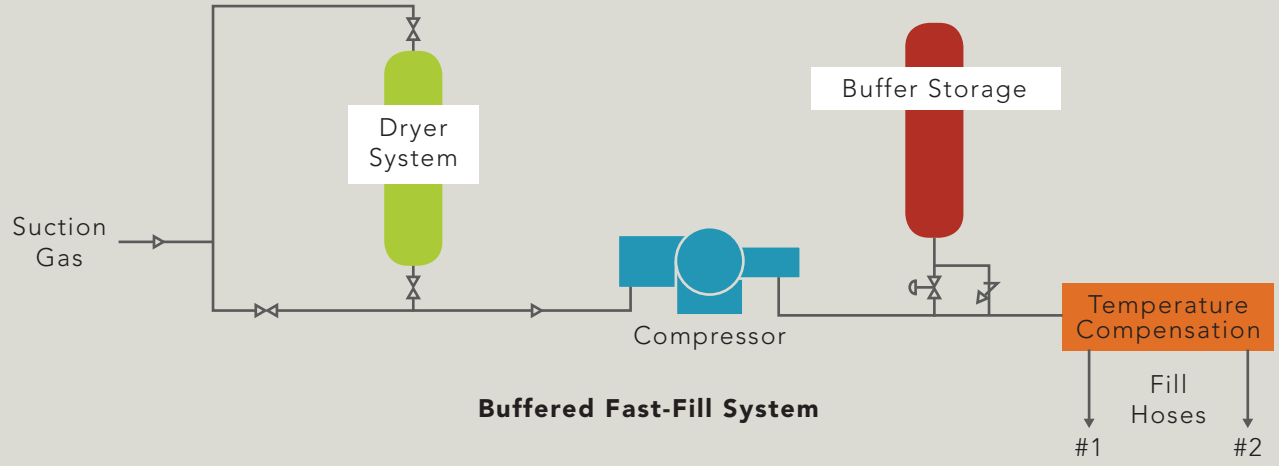
Typical components of a buffer fast-fill CNG system include:

- Dryer – removes water or water vapor from the natural gas supply prior to compression
- Compressor(s) – compresses natural gas to the appropriate pressure required to deliver a fully temperature compensated fill to the vehicle
- Buffer control panel – determines the flow of fuel from the compressor(s) either to the vehicle or to ASME storage vessel(s)
- Temperature compensation system – uses an algorithm to adjust for ambient temperature and temperature of compression into the vehicle fuel storage system to ensure that vehicles receive a full fill
- Dispenser – dispenses natural gas into vehicles

Figure 3.2.2-1 depicts a buffer fast-fill system that fuels transit buses.

Figure 3.2.2-1

Buffer fast-fill systems primarily fuel directly from the compressor into the vehicle in a short amount of time and typically serve specific captive fleets.



Buffered Fast-Fill System

3 CNG Station Design

3.2 Station Types and Equipment

3.2.3 Time-Fill Station

Time-fill fueling is a lower cost option designed for fleets of vehicles that return to central locations for a variable period of time, depending on fleet requirements.

The most popular application of this type of fueling system is school buses and refuse trucks. The primary advantage of time-fill fueling is significantly lower equipment and installation cost because no priority, storage, and sequential fueling components are necessary. In a time-fill application, vehicles are fueled directly from the compressor into the vehicles. Time-fill fueling is ideal for fleets whose vehicles return daily to central locations. A small amount of storage and fast-fill dispensing equipment can be added to these stations to accommodate vehicles in the fleet that need fast-fill fueling, although the costs to build the station will increase slightly.

Figure 3.2.3-1 demonstrates time-fill CNG fueling for a refuse company. Dispensing occurs from the slim posts with hoses located in front of each vehicle.

Typical components of a time-fill CNG fueling system include:

- Dryer – removes water or water vapor from the natural gas supply prior to compression
- Compressor(s) – compresses natural gas to the appropriate pressure required to deliver an ambient temperature compensated fill to the vehicle
- Multiple single hose fueling posts – dispenses natural gas into vehicles

Figure 3.2.3-2 shows two components of CNG fueling: a gas dryer and a compressor package.

Figure 3.2.3-1

Time-fill systems are ideal for fleet vehicles that return daily to a central location.

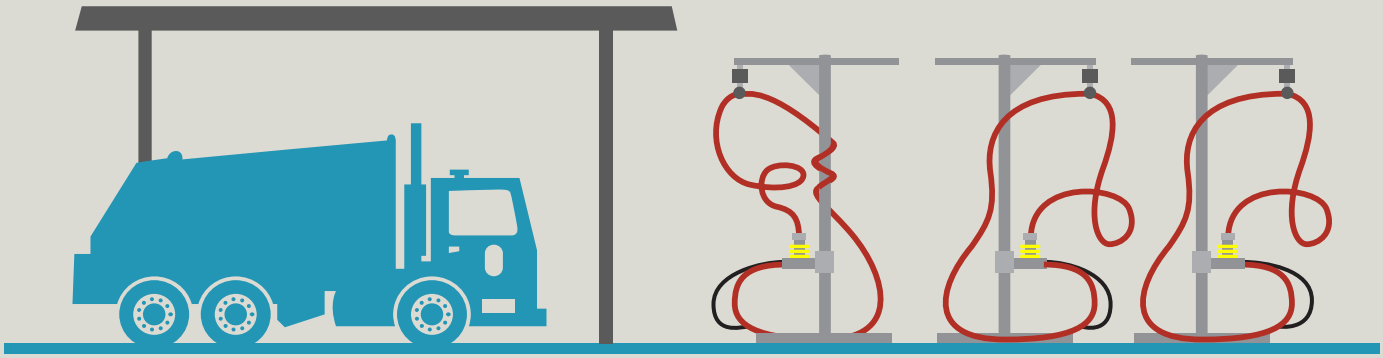
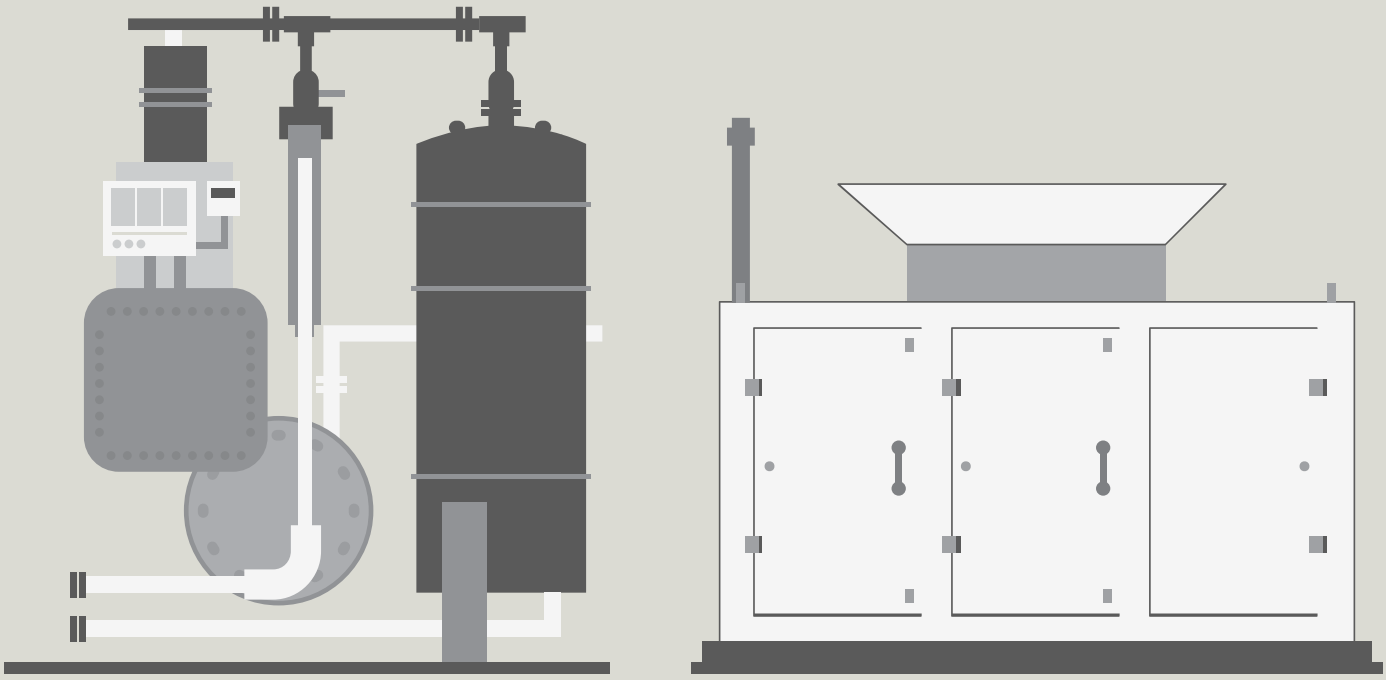


Figure 3.2.3-2

Two key components of the time-fill configuration are CNG dryers and CNG compressor packages.



3 CNG Station Design

3.3 Economics

The cost to build a compressed natural gas fueling station varies significantly, depending primarily on the capacity needed. Standardization of station size across North America will enable developers to reduce costs through economies of scale.

The smallest CNG refueling system was, until two years ago, produced by FuelMaker, a Canadian company. "Phill" was sold primarily for single vehicle use at a cost of about $4,000 ($5,000 installed). In 2009, the company was sold to Fuel Systems Solutions Inc., a California-based company. On the larger end of the size spectrum, installed natural gas fueling stations may range from $675,000 to $1,000,000 per station (Table 3.3-1).[12] Two of the estimates in the table are estimates for public access fast-fill stations, and one is an estimate for a fleet that can use a time-fill station. The fast-fill stations differ only in that one has one compressor and the other has two, providing redundancy. The costs of combination-fill stations will depend on the configuration of fast- and time-fill components and may be expected to incorporate costs from both types of stations.

There are several scenarios that determine how many vehicles can fuel at the example stations, depending on the fueling pattern and quantity of fuel required. Fast-Fill Station I may fuel:

- Fifteen light-duty vehicles with 15 gasoline gallons equivalent (GGE) per vehicle in a one-hour peak period (vehicles arriving one after another), with a thirty-minute period for the compressor to replenish the storage system
- Randomly arriving light-duty vehicles filling an average 10 GGE per vehicle throughout the day, with the storage system replenished periodically as needed
- Ten heavy-duty vehicles with 20 diesel gallons equivalent (DGE) per vehicle in a one-hour peak period, with a thirty-minute period for the compressor to replenish the storage system
- Randomly arriving heavy-duty vehicles filling an average 10 DGE per vehicle throughout the day, with the storage system replenished periodically as needed

Fast-Fill Station II may fuel:

- The same vehicles as Fast-Fill Station I, with a redundant compressor to act as backup if the primary compressor fails. A redundant compression system is needed in situations where there is not another CNG fueling station in close proximity (within three to five miles).

Time-Fill Station may fuel:

- Forty vehicles with 38 GGE per vehicle in a ten-hour period. This same time-fill fueling station could fuel forty vehicles with 33 DGE per vehicle in a ten-hour period.

12 Estimates provided by ANGI Energy Systems, 2010.

Table 3.3-1

CNG fueling stations with the same compressor flow rate have different costs and/or vehicle fueling capabilities. Combination-fill stations will incorporate cost elements from these stations.

	Fast Fill Station I:	Fast Fill Station II:	Time Fill Station:
	Natural gas dryer, one 300 scfm compressor, 3 ASME vessel high-pressure storage systems, 1 two-hose fast-fill dispenser (no redundancy)	Natural gas dryer, two 300 scfm compressors, 3 ASME vessel high-pressure storage systems, 1 two-hose fast-fill dispenser (with redundancy)	Natural gas dryer, one 300 scfm compressor, 20 two-hose, time-fill dispensers (no redundancy)
Component Cost	$500,000	$650,000	$375,000
Installation Cost*	$300,000	$350,000	$300,000
Total Cost	$800,000	$1,000,000	$675,000
Vehicle Fueling Scenarios	15 light-duty/15GGE consecutively fueling in a 1-hour peak period or Randomly arriving light-duty/10 GGE or 10 heavy-duty/20 DGE consecutively fueling in a 1-hour peak period or Randomly arriving heavy-duty/DGE	15 light-duty/15 GGE consecutively fueling in a 1-hour peak period or Randomly arriving light-duty/10 GGE or 10 heavy-duty/20 DGE consecutively fueling in a 1-hour peak period or Randomly arriving heavy-duty/10 DGE	40 vehicles/38 GGE in a 10-hour period or 40 vehicles/33 DGE in each vehicle in a 10-hour period

*Note that installation costs vary by region and permitting bureau

3 CNG Station Design

3.4 Facility Modification Requirements

3.4.1 Codes and Standards

In the U.S. and Canada, CNG fueling stations are designed and constructed to meet a number of codes and standards, which are established to ensure safety.

In the U.S., there are a variety of codes and standards to which CNG stations must conform. These include national as well as local codes. The codes and standards are subject to a significant degree of interpretation by code officials, who often are not well informed or experienced with CNG fueling applications. This situation can create significant delays throughout the permitting and construction process. The codes have been developed over a significant amount of time. Some have been adapted from other similar codes, while others have been developed from the ground up.

While this is not an exhaustive list, the primary organizations publishing codes that affect CNG fueling stations in the U.S. include:

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- American Society for Nondestructive Testing (ASNT)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- National Electric Code (NEC)
- Occupational Safety and Health Act (OSHA)
- Uniform Building Code, Local Jurisdiction (UBC)
- Uniform Fire Code (UFC)
- Uniform Plumbing Code (UPC)
- National Institute of Standards and Technology (NIST)
- Society of Automotive Engineers (SAE)
- Underwriters Laboratory (UL)

Table 3.4.1-1 presents a partial list of some of the functions or purposes of each code organization.

In Canada, the Canadian Standards Association is the primary regulatory agency for all natural gas fueling stations and related equipment.

Table 3.4.1-1

A number of codes and standards govern U.S. CNG fueling station design and operation; a partial list is provided below.

Code Agency/Organization	Primary Function
ANSI	Facilitates the development of certain codes and standards that govern the use of CNG and the manufacturing of CNG fueling components, including nozzles, receptacles, dispensers, hoses, breakaway devices, valves, and other related fueling components
ASME • Boiler and Pressure Vessel Code Section 8 • ANSI/ASME B31.3 Chemical Plant and Conventional fuel Refining Piping	Regulates high-pressure CNG storage vessels and piping • Section 8 is the manufacturing standard for the pressure vessels used in the CNG station B31.3 establishes the specifications for the piping throughout the CNG station
ASNT	Tests components for safety
NEMA	Establish standards for electrical component manufacturing
NFPA • NFPA 52 • NFPA 70 • NFPA 30A	Regulates the use of natural gas as a vehicle fuel, including stations and vehicles • Defines the boundaries of the hazardous areas inside the fueling station • Establishes the NEC • Governs the use of multiple fuels in one location
NFPA 70/NEC	Defines the electrical classification of the hazardous areas within a CNG station
OSHA	Regulates occupational safety and health in the work environment
SAE	J1616 establishes the recommended practice for fuel quality and water content
UBC, Local Jurisdiction	Regulates structures that contain CNG fueling equipment
UFC	Some states and/or localities use this code; often contains NFPA 52 within it
UPC	Governs the plumbing components of CNG stations
NIST	Establishes the unit of measurement for custody transfer of CNG from the retailer to the customer
UL	Tests components and publishes lists according to compliance

3 CNG Station Design

3.4 Facility Modification Requirements
3.4.2 Maintenance Facilities

Vehicle maintenance facilities where CNG vehicles are serviced must be modified or constructed to conform to safety requirements related to the unique properties of natural gas. These modifications must meet the basic safety requirements and do not need to be expensive.

Existing vehicle maintenance facilities are constructed to ensure safety when dealing with liquid fuels that, 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 difference is the principle behind requirements for NGV maintenance facility modifications. While there are others, NFPA is the overarching organization responsible for the codes that govern NGV maintenance facilities. Table 3.4.2-1 compares the recommendations for modifying an existing facility with specifications for a new facility. Depending on the number of maintenance bays in an existing facility, the costs may be less than $10,000. Regardless of whether an existing facility is being modified for NGV maintenance or a new facility is being constructed, there are three primary considerations.

Ventilation

In a maintenance facility designed for liquid fueled vehicles, NFPA defines the area from the floor to 18 inches above the floor as a Class 1 Division 2 Group D area, in which special precautions must be taken to prevent electrical sparks from igniting fuels. In these facilities, ventilation air is introduced at a higher level and exhausted in the lower 18 inches area inside the facility. In contrast, because natural gas is lighter than air, NFPA defines the Class 1 Division 2 Group D area in NGV maintenance facilities as the area extending from the ceiling down 18 inches. In these facilities, air must be introduced lower and exhausted at the ceiling.

Heating System

In a normal gasoline or diesel maintenance facility overhead heaters are used that are mounted at or towards the ceiling. In a facility where NGVs will be maintained, NFPA codes indicate that open flame heaters are not allowed within the 18-inch ceiling 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 NGVs never be parked below any open flame heater area under any circumstances. To meet the code requirements for heating systems in NGV maintenance facilities, sealed combustion, catalytic or infrared heaters with a skin temperature below 800°F may be used. The autoignition temperature of natural gas is 1080°F, which allows these heaters to operate safely.

Potential Ignition Sources, Including Lighting and General Electrical Equipment

No potential source of ignition should be located 18 inches from the ceiling or higher in an NGV maintenance facility that could create an arc or spark that would ignite natural gas. This includes lighting systems that could create a spark when the light is turned off or on. There are Class 1 Division 2 Group D rated sealed lighting systems available or traditional lighting can be pendant mounted below the 18-inch cavity from the ceiling. General electrical equipment also 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 a Class 1 Division 2 Group D rated motor.

Table 3.4.2-1

Establishing new CNG facilities offers benefits over modifying existing liquid fuel facilities in that certain incremental requirements and recommended practices would not be necessary; some examples are listed below.

Requirement/Recommended Practice	Existing Facility Modification	New Facility Design
Ventilation		
Methane detection	Add methane detection	Specify for new facility
HVAC systems	Could replace existing system but would be costly and unnecessary if supplementary exhaust system is added	Specify to function counter flow to HVAC conventional system to include no open flame heaters
Supplementary exhaust	Add supplementary exhaust fans that are Class 1 Div 2 Group D rated	Would not be necessary
Class 1 Div 2 Group D fans	See above	Specify for new facility
Heating Systems		
Space heaters	Replaced with sealed combustion, infrared or catalytic heaters with skin temperature less than 800°F	Would not be necessary
Potential Sources of Ignition		
Pendant mount lighting	Pendant mount below 18 inches from ceiling	Would not be necessary
Class 1 Div 2 Group D lighting	Install Class 1 Div 2 Group D lighting	Specify Class 1 Div 2 Group D lighting
Other Ignition Sources within Class 1 Div 2 Group D area (motors, switches, etc.)	Move below 18 inches from ceiling or replace with Class 1 Div 2 D rated equipment	Specify Class 1 Div 2 Group D rated equipment

4 CNG Infrastructure Options

4.1 Historical Approaches to Development

4.1.1 Overview

Over the past two decades, four main approaches have been used to develop CNG infrastructure. These approaches have attempted to address the needs of a wide variety of fleets, including those that require onsite fueling stations and those that fuel at public sites.

While other variations exist, there are four main approaches that have been used to develop CNG fueling infrastructure. The industry has long recognized the differences in fueling infrastructure development strategies and the targets and implications of each. There has been a simultaneous need to maximize natural gas sales, which points towards a focus on high fuel use fleets, while somehow providing enough publicly accessible CNG infrastructure to serve fleets that require this method of fueling.

The four strategies used historically have attempted to accomplish both goals and include:

- Onsite private fueling for fleets – In this model, CNG fueling infrastructure is usually constructed at the fleet's operating site, and fueling is available only for that customer's vehicles.

- Onsite private fueling for fleets that includes public dispensing – Under this scenario, CNG fueling infrastructure that is constructed at a fleet's operating site includes and offers CNG to the public either through the same dispensing system that the fleet uses or a dispenser located in a separate area designated for public use.

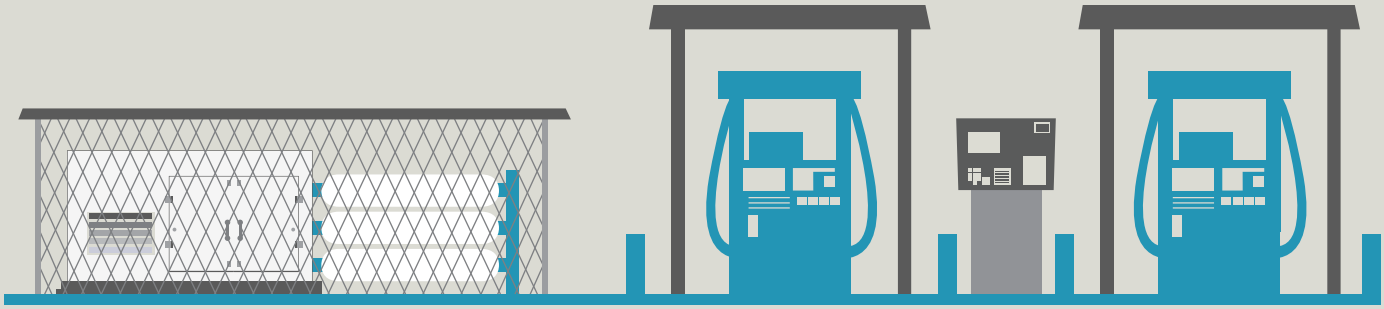
- Offsite private fueling – These stations are generally cardlock type stations owned/operated by a third party where fleets or private consumers can purchase CNG using a branded key card, a fleet fuel purchasing card, or regular credit card.

- Public fueling – In this model, CNG fueling is located in an area convenient for fleets and private consumers and is not limited in access. It may use an "anchor fleet" (one or more fleets that purchase enough fuel at the station to provide base load demand) but is not dedicated to that fleet exclusively.

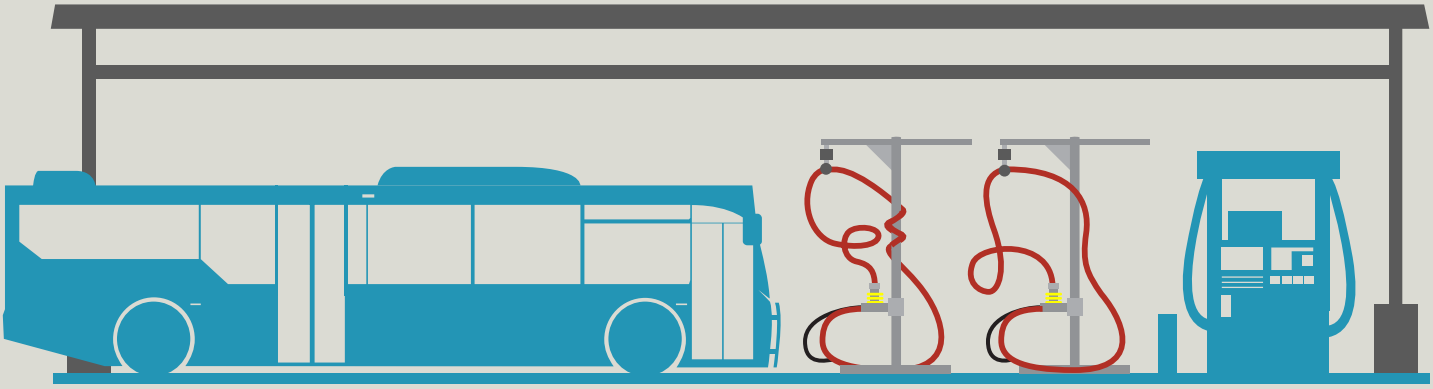
Figure 4.1.1-1 shows offsite private fueling, onsite private fueling, and public fueling stations.

Figure 4.1.1-1

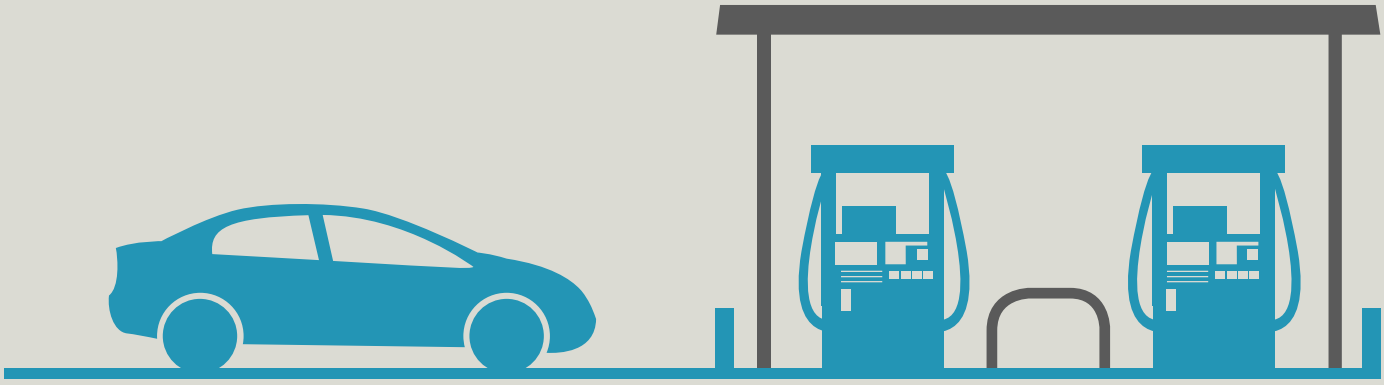
A cardlock station (top), a transit station (middle), and a public access fast-fill station (bottom) are examples of successful offsite private fueling, onsite private fueling, and public fueling, respectively.



Cardlock Station (offsite private fueling)



Transit Station (onsite private fueling)



Public access fast-fill station (public fueling)

4 CNG Infrastructure Options

4.1 Historical Approaches to Development

4.1.2 Onsite Fueling

Other than transit, the most significant quantity of transportation fuel demand comes from trucks. Diesel trucks of all weight classes use 26.5 billion gallons of fuel annually, yet two of the four historical approaches for CNG fueling infrastructure development would address only 22 percent of that demand.

Currently, 59 percent of U.S. CNG fueling infrastructure is private onsite fueling.[13] This approach has helped the NGV industry achieve natural gas sales for transportation in the past decade. However, onsite fueling does not address the majority of the potential fuel sales that occurs at public fueling sites. To illustrate, in addition to the transit and school bus segments, trucks of all weight classes are collectively the largest users of transportation fuel in North America. In 2007, the total population of diesel trucks was about 7.5 million, including trucks in Classes 1 through 8 that use diesel fuel.[14] These vehicles use 26.5 billion gallons of fuel each year and, in aggregate, can be considered high fuel use. However, only 24 percent of the total estimated diesel truck population fuel at onsite stations. This accounts for about 22 percent of all diesel fuel sold in the U.S. or 5.7 billion gallons annually (Figure 4.1.2-1).

While providing infrastructure for fleets that fuel onsite is important and helps address a segment of the market that represents large quantities of fuel, focusing too much effort on this strategy ignores the majority of the market. Growth of private stations does not address public demand nor increase CNG fueling convenience for the general public. A shift in the focus of infrastructure development that addresses the public fueling market is needed to expand NGV use.

There have been two variations of onsite fueling infrastructure development used in the U.S. The first strategy provides fuel solely for the captive fleet using the station. The station is sized and designed to meet the current and estimated future demand of that fleet and is installed at the fleet's site. The station may be operated and maintained by the fleet or by a third party. For the second strategy, in an attempt to increase public access fueling, some onsite stations include a public dispenser outside the primary customer's fueling area that is accessible by other users. This allows additional CNG users to obtain fuel at the captive customer's site while minimizing the risk of property damage. The advantages and disadvantages of each onsite fueling strategy are noted in Table 4.1.2-1.

13 U.S. Department of Energy Alternative Fuels and Advanced Vehicles Data Center, as updated by ANGA/AGA Natural Gas Transportation Fuel Collaborative, November 30, 2010.
14 TIAX LLC. "SCR-Urea Implementation Strategies Update." Prepared for Engine Manufacturers Association. June 2006.

Figure 4.1.2-1

Only 24 percent of diesel trucks fuel at private fueling stations, suggesting that a larger market exists in public fueling infrastructure.[15,16]

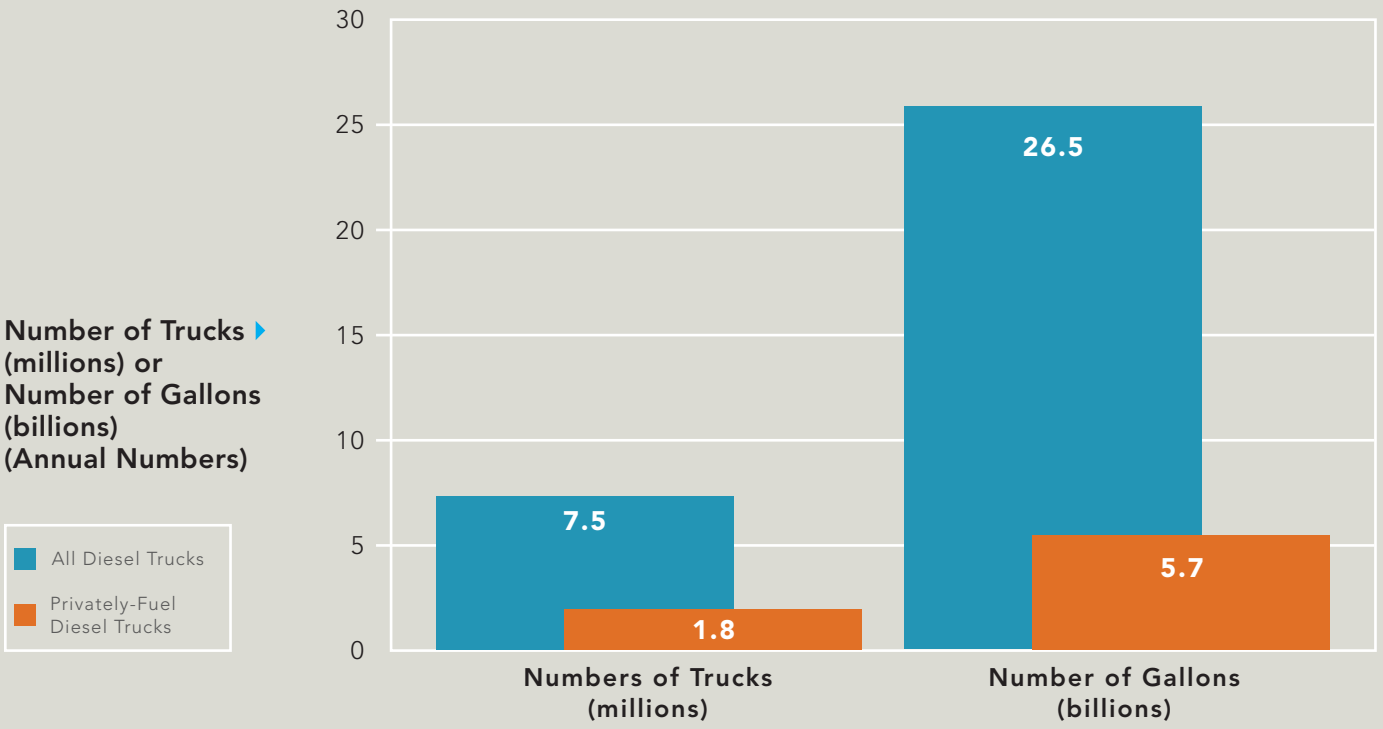


Table 4.1.2-1

Onsite private fueling with and without public dispensing both have advantages and disadvantages.

Fueling Type	Advantages	Disadvantages
Onsite private fueling without public dispensing	• Can be sized and designed to specifically meet the needs of the fleet • Station owner eligible to receive fuel station credits (if available) to help offset costs	• Does not help develop infrastructure for other users • May be significant capital costs • ROI could be lower than station with multiple users • Builds no awareness or branding for CNG
Onsite private fueling with public dispensing	• Meets the needs of the captive fleet • Provides some CNG fueling access for other customers • Station owner eligible to receive fuel tax credits (if available) to help offset costs	• Creates image that CNG is a less accessible fuel • If captive fleet begins to use maximum fuel, there may not be fuel available for other customers • Requires capital cost to be recovered mostly from a single customer • Builds no awareness or branding for CNG • Poor retail location creates inconvenient access for public fueling

15 TIAX LLC. "SCR-Urea Implementation Strategies Update." Prepared for Engine Manufacturers Association. June 2006.
16 U.S. Census Bureau. "Vehicle Inventory and Use Survey." 2002.

4 CNG Infrastructure Options

4.1 Historical Approaches to Development

4.1.3 Public Fueling

Effective strategies for obtaining a significant share of the fuel used by diesel trucks and private consumer vehicles must emphasize public CNG infrastructure development.

The overwhelming majority of private consumer vehicles today fuel at public retail stations. Furthermore, the majority of trucks in all weight classes (71 percent) and an even higher percentage of light-duty trucks fuel at public fueling stations, truck stops, and/or conventional retail stations.[17] These trucks account for approximately 19 billion gallons of fuel sold annually in the U.S. (Figure 4.1.3 1). A comparison of these statistics to the current breakdown of public and private CNG fueling infrastructure in the U.S. (with 41 percent offering public access[18]) suggests that a shift in focus to public stations will help penetrate the overall market faster and more effectively.

If CNG consumption and infrastructure are to expand significantly, strategies that focus on developing and connecting infrastructure at retail stations and truck stops is imperative. This will open up the potential to obtain a share of the 19 billion gallons of fuel sold to this market per year in the U.S.

Historically, there have been two strategies to develop CNG infrastructure that involve some level of public access: offsite private fueling and public fueling. Offsite private fueling refers to stations where users enter into pre-arrangements with the retailer for access to the fuel, often times using a cardlock system. Public fueling refers to stations that operate the same way as current gasoline stations and allow the general public to fuel without pre-arrangements. Table 4.1.3-1 presents the advantages and disadvantages of each strategy.

17 TIAX LLC. "SCR-Urea Implementation Strategies Update." Prepared for Engine Manufacturers Association. June 2006.
18 U.S. Department of Energy Alternative Fuels and Advanced Vehicles Data Center, as updated by ANGA/AGA Natural Gas Transportation Fuel Collaborative, November 30, 2010.

Figure 4.1.3-1

71 percent of diesel trucks fuel at public fueling stations, indicating that development of public CNG infrastructure will significantly expand the use of natural gas beyond current onsite fleets.[19,20]

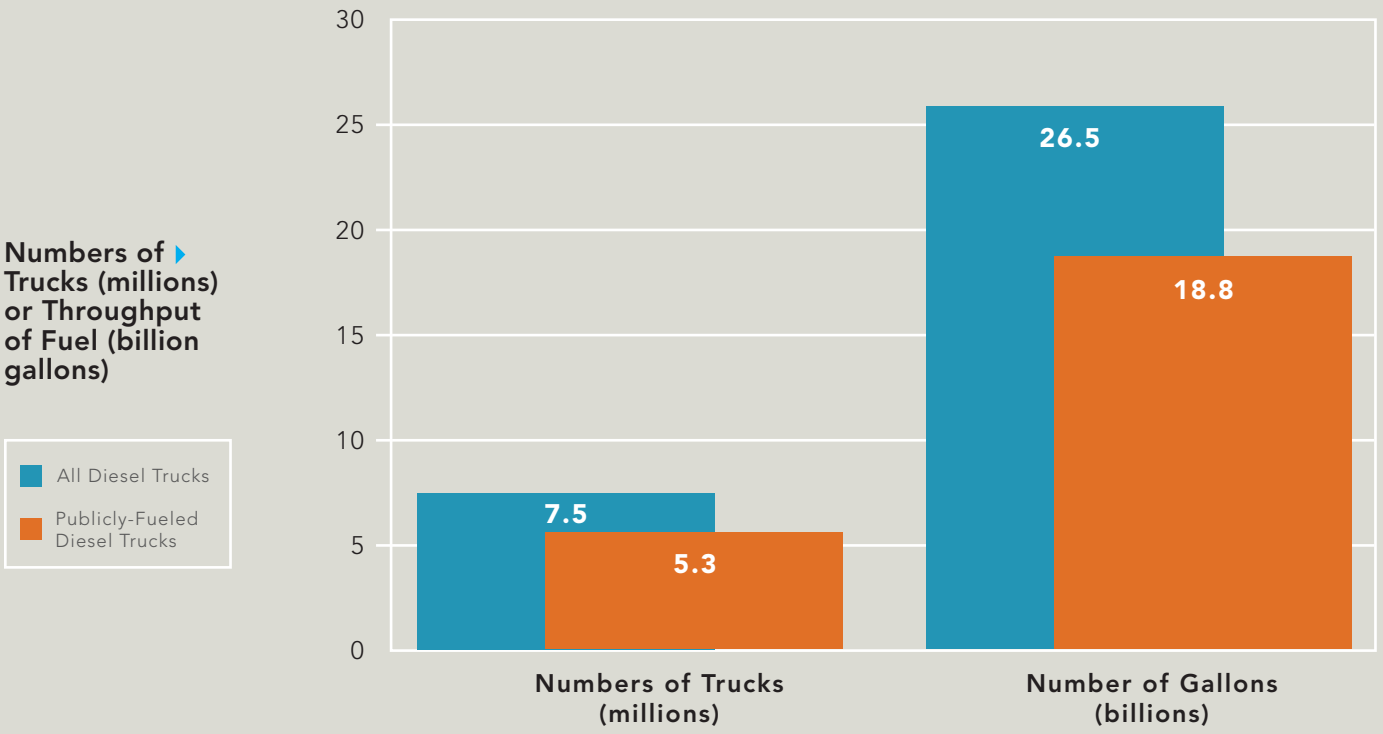


Table 4.1.3-1

Cardlock and public fueling both have advantages and disadvantages.

Fueling Type	Advantages	Disadvantages
Offsite private fueling	• Provides CNG fueling to multiple fleet users at one station • Users do not have to invest in CNG station • Station owner eligible to receive fuel station credits (if available) to help offset costs	• May be difficult to size/design due to unknown fuel demand • Entrepreneur/retailer must make the business case • Builds no awareness or branding for CNG
Public fueling	• Provides fueling to a wide variety of customers • Creates image that CNG is transparent to use just like any other fuel • Helps expand local and/or regional fueling networks • Station owner eligible to receive fuel tax credits (if available) to help offset costs • Builds awareness and branding for CNG	• Difficult to determine optimum size • Business case for investor/entrepreneur may be difficult to predict • May require significant levels of marketing

19 TIAX LLC. "SCR-Urea Implementation Strategies Update." Prepared for Engine Manufacturers Association. June 2006.
20 U.S. Census Bureau. "Vehicle Inventory and Use Survey." 2002.

4 CNG Infrastructure Options

4.2 Business Models

Business models for CNG infrastructure vary widely depending on a variety of factors, including the profit motive of owners, the cost of gas, and the cost of capital.

Summaries of the business models for three types of CNG fueling station ownership are presented in Table 4.2-1, including an actual onsite government fleet operation, an actual LDC, and an actual conventional fuel retailer who added CNG to the mix of fuels offered at an existing station. A fourth scenario for independent retailers was developed using hypothetical but realistic data. It should be noted that the surveyed companies provided data at different levels of specificity, resulting in the need to aggregate categories that reflect costs for currently operating stations built at different times in different locations. In addition, the retail CNG station operator interviewed agreed to provide information only on the basis of remaining anonymous.

Demonstrated here are the effects of at least three actions that can be taken to improve the business model and annual return on investment (ROI) of CNG fueling infrastructure. The most significant of these are:

- Establishing reasonable profit motive/margin
- Obtain the best pricing for natural gas
- Incentives/other offsets to defray capital costs

The first factor that becomes apparent is the effect of margin added to the cost elements to make up the retail price at the pump. The onsite fleet and the LDC have business models that are similar, with little or no margin added to the fuel price. In the case of the existing retailer, the specific margin was not reported, but ROI can be roughly estimated at 5 percent. For the hypothetical independent retailer, a significantly higher margin is charged, which gives an ROI estimated to be in the 36 percent range.

The cost of gas is another important factor and, in these instances, varies widely from $0.68 to $0.87 per GGE, or more than 28 percent, depending on the location of the station and the corresponding utility tariff for natural gas use in transportation. This demonstrates the effects that attractive CNG tariffs can have on overall CNG pump price.

All factors affecting capital costs are critical in the business model. Two of the examples assessed used incentives in the form of U.S. Department of Energy funding and/or air district rebates to help offset the cost of equipment. This reduced the capital investment by 22 to 38 percent.

The length of time for depreciation, as well as the cost of capital in the form of interest, is also another critical factor. To illustrate, the capital costs of the LDC and the independent retailer are roughly the same, yet their interest expense is estimated to be significantly different because the LDC borrows money at a much lower rate.

Table 4.2-1

Actual business cases for various types of CNG retailers show that cost of gas, cost of money, capital costs, and margin drive CNG price at the pump and retailer ROI.

	Actual Onsite Government Fleet[21]	Actual LDC	Actual Existing Retailer	Hypothetical Independent Retailer
Capital Costs, Excluding Land				
Size of Station (cfm)	250	700	150	700
Total Non-Land Capital Cost ($)	1,000,000	800,000	650,000	800,000
Less: Incentives ($)	0	175,000	250,000	175,000
Net Capital Costs ($)	1,000,000	625,000	400,000	625,000
Estimated Salvage Value @ 15% ($)	150,000	120,000	97,500	120,000
Net Present Value of Salvage Value ($)		80,757	30,736	37,829
Annual Operating Costs, including fuel taxes				
Natural Gas Cost ($/GGE) (Including Transportation and Local Distribution)*	0.87	0.72	0.68	0.68
Total Natural Gas Cost ($)	79,147	226,800	102,000	214,200
Electricity Cost ($/GGE)		0.06	0.25	0.13
Total Electricity Cost ($)		18,900	37,500	18,900
Equipment Maintenance/Administration ($)		56,700	30,000	63,000
Marketing ($)				50,000
Insurance ($)				25,000
Credit Card Fees ($)			8,640	23,625
Federal Tax at $ 0.184/GGE ($)	None	57,960	27,600	57,960
State Tax ($)	None	26,775	12,000	26,775
Depreciation Expense ($)	42,500	25,250	20,167	33,667
Interest Expense/Cost of Capital ($)	20,000	12,500	32,000	50,000
All Other Expenses ($)	56,534			
Total Expenses, Including Motor Fuels Taxes ($)	198,181	424,885	269,907	563,127
Annual Revenues/Sales				
Total Quantity Gas Sold (GGE)	90,454	315,000	150,000	315,000
Price at Pump, Including Taxes ($/GGE)	2.19	1.56	1.92	2.50
Total Revenue ($)	198,181	491,400	288,000	787,500
Annual Net Income ($)	0	66,515	18,093	224,373
ROI	0.0%	10.6%	4.5%	35.9%

Assumed depreciation period: onsite fleet 20 years, LDC 20 years, existing retailer 15 years, independent retailer 15 years
Assumed interest rate: onsite fleet 2%, LDC 2%, existing retailer 8%, independent retailer 8%
Estimated depreciation and interest expenses added on to onsite fleet reported numbers
*Natural gas cost refers to the tariff and commodity cost of the gas

21 This facility was built in the mid-1990s and the high cost of capital would be lower today for this size station.

4 CNG Infrastructure Options

4.3 Major Types of Developers

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

While there are numerous manufacturers and distributors that play some role in CNG infrastructure development, there are four main categories of companies that have the most involvement: compressor manufacturers/suppliers/packagers, engineering companies, construction companies, and retailers. Their roles are shown in Table 4.3-1.

Compressor Manufacturers/Suppliers/Packagers

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

Engineering Companies

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

Construction Companies

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

CNG Retailers

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

Table 4.3-1

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

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

4 CNG Infrastructure Options

4.4 Station Procurement Process

The CNG fueling station procurement process may begin with any one of the four types of CNG infrastructure developers. Standardization of this process and station infrastructure equipment may result in efficiency gains.

A company or organization interested in procuring CNG fueling equipment and/or CNG retailer fueling may approach one or more types of CNG infrastructure developers as the initial contact. The point of initial contact is often determined by preference or policy, and in all cases, the procurement process goes through LDCs at some point (Figure 4.4-1).

For instance, many local government agencies that procure CNG fueling stations are accustomed to dealing with engineering and technical services firms that provide various services for the agencies. They may have ongoing contracts in place with specific firms with whom they do ongoing business. Those organizations are most likely to consult an engineering firm when considering the purchase of onsite CNG fueling equipment. Others may rely more heavily on construction companies that provide in-house engineering and technical services.

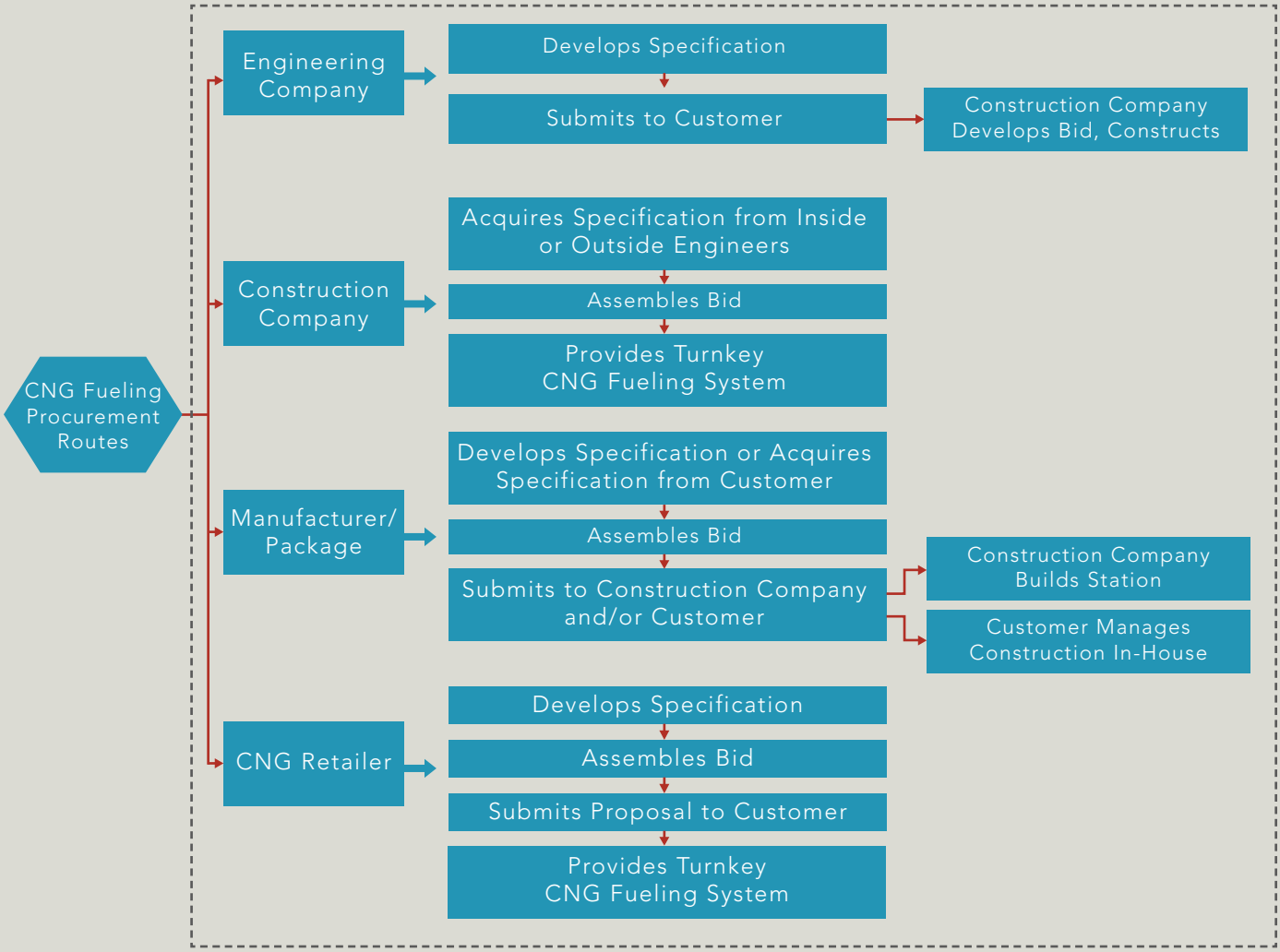
A gasoline and diesel retailer planning to add CNG fueling capability may be more experienced with the overall process and may initiate contact with compressor manufacturers/distributors/packagers. Other end users may prefer to negotiate with a CNG retailer for turnkey fueling services.

Regardless of the point of initiation, there are two types of CNG infrastructure developers that must become involved: the compressor manufacturers/distributors/packagers and construction companies. These two infrastructure developer types play the most critical roles in supplying the equipment and building the station. Generally, compressor manufacturers/distributors/packagers do not sell CNG fueling equipment directly to an end user but rather bid through a construction company.

Especially in the area of sizing and design, conflict may arise between the compressor manufacturers/distributors/packagers and outside engineering firms (or construction firms that provide engineering services). This is due to engineering firms developing specifications that go beyond performance to specifying particular brands of equipment. The result is often increased costs for the manufacturer and, in the end, the customer.

Figure 4.4-1

The basic options for CNG fueling procurement vary depending on the point of initiation.



All Pathways Must Go Through LDCs at Some Point

4 CNG Infrastructure Options

4.5 Estimated Market Positions and Thresholds

4.5.1 Compressor Manufacturers/Suppliers/Packagers

The existing CNG equipment manufacturers/packagers are adequate to support current low levels of infrastructure development (sixty to eighty stations per year) and a modest level of growth. Anecdotally, these companies report the need to triple the annual number of stations to 180 to 210 each year to stabilize their businesses. Annual demand of over 250 new CNG stations may exceed the capacity of current compressor manufacturers/suppliers/packagers.

Based on reports from these industry members, there will be approximately 100 new CNG stations brought online in the U.S. in 2012. This relatively low demand is fulfilled by a minimum of ten companies, with the average annual sales among the reporting companies being seven stations. (It should be noted that several companies declined to report these data due to their proprietary nature.) Table 4.5.1-1 summarizes basic information about the major companies involved in manufacturing and/or packaging CNG fueling station equipment.

Because a significant number of the leaders in this segment were hesitant to report hard numbers due to competitive issues, it is not possible to statistically evaluate the thresholds for this segment of the CNG fueling infrastructure industry. However, one respected and long-time member of the industry in this category of CNG infrastructure developers indicated that demand would need to increase from sixty to eighty stations per year in 2010 in the U.S. to roughly 180 to 210 stations per year to meet their more optimal business case threshold.

Several international companies are monitoring the U.S. and Canadian markets for CNG infrastructure growth and are beginning to position themselves to enter if and when demand increases. For example, it is reported that Dresser Wayne Italy is preparing to enter the U.S. market with a CNG dispenser as a precursor to manufacturing and/or packaging complete CNG stations. Aspro, a South American company, is gathering market intelligence for North America in anticipation of entering the CNG infrastructure market. These are just two examples of international companies poised to enter the U.S. and Canada if demand begins to grow. Conversely, it is also reported that several of the existing U.S. and Canadian CNG equipment providers maintain their business by selling products internationally.

While the current CNG equipment providers indicated the need to triple annual demand to stabilize their businesses, they were hesitant as a group to estimate or report the number of CNG stations per year that would cause them to exceed their current capacity. By performing some rough analysis and extrapolating the market positions of these companies relative to the total number of new stations estimated to come online in 2010, the Natural Gas Vehicle Institute's best estimate of the number of stations that would cause existing CNG equipment providers to exceed capacity is somewhere in excess of 250 new stations (Figure 4.5.1-1).

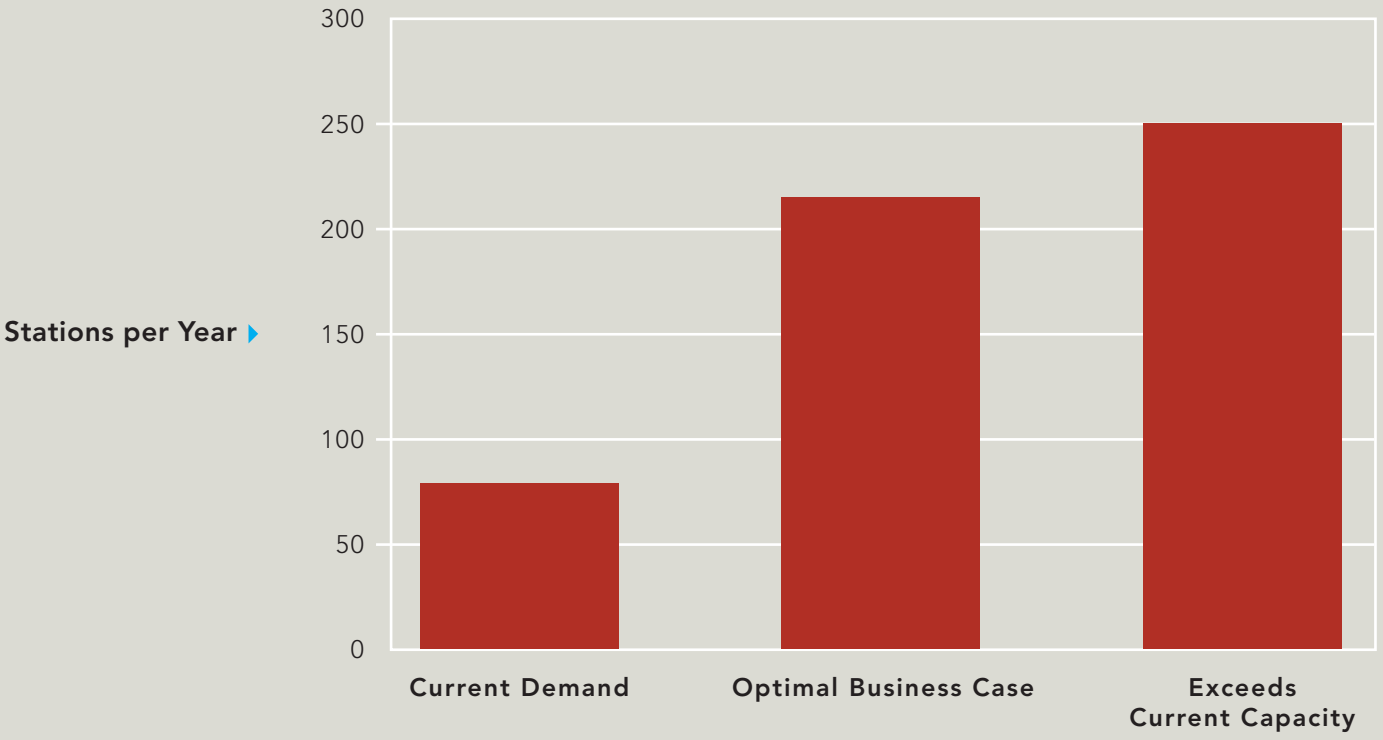
Table 4.5.1-1

Current low demand for compressor packages is met by a small number of CNG fueling station manufacturers/packagers.

Company (Location)	Manufacturer or Packager	Compressor Brand	Power Range (HP)	Specialty/Size Limitations (scfm)	Estimated Market Position	Years in Business	Current Units per Year
ANGI (WI)	Both	ANGI, Ariel	40 to 600	50 to 3,000	1	40	Proprietary
Bauer (VA)	Both	Bauer	5 to 125	5 to 161		15+	10
GESI (CA)	Package	Gardner Denver		47 to 700		12+	No Response
Greenfield Compression (TX)	Both	Greenfield		Up to 1000	2	52	No Response
IMW (BC)	Both	IMW	40 to 300		3	26	Confidential
JW Operating (TX)	Package	Ariel	18 to 1,775			40+	6
Knox Western (PA)	Both	Knox	10 to 1,600	75 to 4,000		30	Re-entering Market
Kraus Global (Canada)	Package	Ariel	18 to 1,775				No Response
Phoenix Energy (AL)	Package	Ingersoll Rand				< 1 Year	9
Pinnacle (TX)	Both	Pinnacle	200 to 450	300 to 1,200		19	4

Figure 4.5.1-1

Based on estimates of current capacity, existing manufacturers/packagers will exceed their total capacity if more than 250 stations per year are demanded.



4 CNG Infrastructure Options

4.5 Estimated Market Positions and Thresholds

4.5.2 Station Engineering and Construction Companies

The current base of CNG station engineering and/or construction companies is also adequate to support current demand, but expansion will be required to support significant growth.

There is a small number of engineering and construction companies that have been working over the past years to size, design, and build CNG stations in the U.S. and Canada. These companies have developed expertise required to provide the services necessary to meet CNG fueling customer needs, and their reported information is summarized in Table 4.5.2-1.

Derived from the reported data, T. Mitchell Engineers captures the most significant market share of the engineering business at approximately 25 projects in 2010. The next closest reported number of projects was nine for Allsup Corporation. It should be noted that several firms did not respond to the survey, which affects the market shares estimated in Table 4.5.2-1.

In addition to expansions by existing companies, larger numbers of engineering companies and especially construction companies that are educated and trained in the unique aspects of CNG fueling infrastructure development will be necessary if the infrastructure is to expand significantly. These companies are critical to the success of CNG infrastructure.

Table 4.5.2-1

Current low demand for CNG stations is met by a small number of CNG station engineering and construction companies.

Company	Engineering or Construction	Estimated Market Share	Units per Year	Units per Year for Stable Business Case	Units per Year to Exceed Capacity
AE COM	Engineering	3%	2	6	8
Zeit Energy	Both	3%	2	12	16
Amtek	Both	6%	4	N/A	N/A
Fuel Solutions	Engineering	7%	5	10	14
Weaver Inc	Both	9%	6	10	14
ET Environmental	Both	10%	7	10	14
Marathon Technical Services	Engineering	12%	8	12	16
Allsup Corporation	Both	13%	9	9	12
T Mitchell Engineers Inc	Engineering	37%	25	40	54
AVSG LP	No Response				
EFS West	No Response				
Engineered Energy Solutions	No Response				
Raymundo Engineering	No Response				
Burnett & Burnette	No Response				
Total Reported			**68**	**109**	**147**

4 CNG Infrastructure Options

4.5 Estimated Market Positions and Thresholds

4.5.3 CNG Retailers

The current base of major CNG retailers is dominated by LDCs as a group and a single company, Clean Energy.

There are an estimated 450 public access retail CNG stations in the U.S.[22] As shown in Table 4.5.3-1, LDCs operate approximately 36 percent of these stations, while Clean Energy operates 26 percent. The LDC with the largest number of stations is Questar Gas with 29 stations, followed by Pacific Gas & Electric Company with 24 stations, Oklahoma Natural Gas with 23 stations, National Grid with 14 stations, Southern California Gas with eleven stations, and WE Energies with eight stations. The remaining CNG retailers in the U.S. offering more than one station include AVSG (eight stations), Trillium (estimated three public stations), and Pinnacle CNG (two public stations.)

It can be hypothesized that the reason the market is dominated by LDCs is due to their ability in some cases to provide CNG fueling infrastructure and include the capital cost in the rate base. Some LDCs (such as California companies) are prohibited from including CNG infrastructure costs in their rate base unless the infrastructure primarily serves their own fleets.

Public utilities commissions or other similar regulatory bodies in several other states allow rate-basing of CNG stations. These include regulatory authorities in North Carolina, Georgia, Oklahoma, Indiana, New York, New Jersey, Wyoming and Pennsylvania. LDCs also have expertise in dealing with natural gas, and vested interest in finding markets for natural gas that will help offset demand reductions that have occurred over the past two decades due to demand side management and/or conservation.

Clean Energy is the nation's largest independent retailer. The company is publicly owned, operating CNG stations in the U.S. and Canada. Clean Energy's approach to developing the market for natural gas as a transportation fuel is comprehensive and includes aggressive marketing, a finance subsidiary (Clean Energy Finance) that provides capital for fleet operators to lease/purchase vehicles, ownership of a vehicle conversion company (BAF Technologies), and ownership of a CNG equipment distributor (IMW). Much of Clean Energy's success can be attributed to their entrepreneurship, their access to large amounts of capital (latest reported stockholder equity is $277 million), their success at leveraging their capital with federal, state, and local grants, and their level of political influence.

22 U.S. Department of Energy Alternative Fuels and Advanced Vehicles Data Center, as updated by ANGA/AGA Natural Gas Transportation Fuel Collaborative, November 30, 2010.

Table 4.5.3-1

Public retail CNG stations are dominated by LDCs as a group and a single company, Clean Energy.

Company	Number of Retail Stations Reported	Estimated Market Share	Geographic Focus or Concentration of Stations	Company Ownership
Clean Energy	118	26%	National	Public
LDCs Total	156	35%	Local/Regional Service Areas	Public
Questar Gas	29	6%		
Pacific Gas & Electric	24	5%		
Oklahoma Natural Gas	23	5%		
National Grid	15	3%		
Southern California Gas	13	3%		
DTE	12	3%		
Other LDCs	40	9%		
AVSG	10	2%	Massachusetts	Private
Trillium	2	0.4%	Regional	Private
Pinnacle CNG	2	0.4%	National (Concentration in CA and TX)	Private
Other Retailers	162	36%		
Total Public Retail CNG Stations	**450**			

4 CNG Infrastructure Options

4.6 Challenges and Perspectives

4.6.1 Compressor Manufacturers/Suppliers/Packagers

The three major challenges faced by compressor manufacturers/suppliers/packagers are low and unpredictable demand, custom specifications for systems or equipment, and insufficient lead time.

When asked about the major challenges they face, compressor manufacturers/suppliers/packagers listed three that were most significant (Table 4.6.1-1):

1. Low and unpredictable demand – There are reportedly about sixty to eighty new CNG stations planned to come online in the U.S. in 2010. This number has varied radically in the past, making the business case for CNG fueling infrastructure equipment providers unattractive and making it extremely difficult for these companies to plan, budget and staff.

2. Custom specifications for systems or equipment – Many NGV fueling customers work with engineering firms that develop specifications that fall outside the standards developed by many CNG compressor manufacturers/suppliers/packagers. Consequently, the station becomes a "custom package," which drives up the pricing dramatically and increases the work and costs for the equipment manufacturer/packager.

3. Insufficient lead time – Customers frequently do not understand the lead times required to size, design, manufacture, and build CNG stations. They reportedly often purchase vehicles and wait until the vehicles are thirty days away from delivery before inquiring about CNG stations. In contrast, it can take about twelve to eighteen months for the entire station development process.

Based on pending favorable legislation, market indications, and overall concerns for energy security, compressor manufacturers/suppliers/packagers perceive the opportunity for the CNG fueling market to grow steadily over the next few years. Specifically, these companies highlighted the following as the greatest market opportunities for CNG infrastructure expansion in the future.

- CNG market potential for large commercial (not government) fleets
- LNG and CNG market potential for freight haulers and particularly ports
- Taking advantage of/marketing the emissions benefits of CNG – CNG equipment providers believe that with growing concern for environment and carbon footprint, natural gas has an opportunity to excel
- Promoting the domestic advantage of CNG vs. imported oil
- Competitiveness of natural gas price against rising gasoline/diesel prices
- Working with LDCs and gas producers to build critical mass with fueling infrastructure investment and fleet conversions

Table 4.6.1-1

Compressor manufacturers/suppliers/packagers face three major challenges but see significant market potential for NGVs.

Challenges	Perspectives
• Low and unpredictable demand for CNG stations • Custom specifications by engineering firms drive up CNG station prices • Unreasonable customer expectations of lead time to design, manufacture and build CNG station	• Large commercial (not government) fleets that use significant quantities of fuel offer significant market potential • Freight haulers, especially at ports, offer market potential for both CNG and liquefied natural gas • Emissions/environmental benefits of CNG should play a greater role in policy development and market development • Domestic benefits of CNG relative to imported oil should be taken advantage of in policy and pricing • Increasing gasoline and diesel prices will make CNG even more competitive • Greater interest on the part of gas producers and LDCs will help build critical mass for fueling infrastructure

4 CNG Infrastructure Options

4.6 Challenges and Perspectives

4.6.2 Engineering and Construction Companies

Like the equipment suppliers, CNG engineering and construction companies report the most significant challenge to be low and unstable demand. They also cite challenges related to lack of communication and education. Like CNG equipment suppliers, CNG engineering and construction companies believe there are significant opportunities to increase the use of natural gas as a transportation fuel.

CNG engineering and construction companies identified the following business challenges (Table 4.6.2-1):

1. Low and unstable demand – The engineering and construction companies cited low and/or unstable demand for CNG fueling as their number one challenge. It makes maintaining their business difficult and predicting the need and planning for growth nearly impossible. This challenge was also the number one challenge reported by the CNG fueling station equipment manufacturers.

2. Difficult permitting processes/diversified regulations/ local codes – This challenge was mentioned as the next most significant. They described the differences in regulations and codes from area to area as extremely difficult to navigate, and the lack of education of permitting officials and fire marshals to be an extreme barrier.

3. Unrealistic customer expectations regarding budgets – Customers frequently have unachievably low estimates of required budgets to fulfill their CNG fueling needs, and these are difficult for engineering and construction companies to handle.

CNG engineering and construction firms also offered the following perspectives:

- Government policies and programs that favor the development of CNG infrastructure, including continuation or expansion of existing and recent incentives, are necessary.
- CNG engineering and construction companies recognize the need for and the opportunity to increase their own expertise and that of all organizations involved in supplying CNG fueling.
- CNG seems to be in greater demand, due to pressure to reduce imported oil and improve the environment.
- Working with municipal waste facilities is a specific opportunity.

Table 4.6.2-1

Engineering and construction companies believe that legislation and greater familiarity within the CNG industry can lead to increased infrastructure development.

Challenges	Perspectives
• Low and unpredictable demand • Difficult permitting/diversified regulations and local codes • Unrealistic customer expectations regarding budgets	• Legislation that will extend or expand incentives to build CNG infrastructure will be important • CNG engineering and construction companies need to increase their expertise and knowledge of the industry as a whole • Pressure to reduce imported oil and improve the environment is increasing CNG demand • Municipal waste facilities as a feedstock for CNG as a specific opportunity.

4 CNG Infrastructure Options

4.6 Challenges and Perspectives
4.6.3 CNG Retailers

CNG retailers report challenges to CNG infrastructure development that range from fuel demand to qualified technicians. They also report that competitive pricing with conventional fuels offers significant opportunities.

CNG retailers are the companies that take the most financial risk in infrastructure development. They must determine optimum sites for CNG stations, develop customers to purchase fuel at their stations, size and design stations to meet current demand and some growth, and be able to control cost factors so that they can price fuel competitively with gasoline and diesel. These companies also require access to large amounts of capital if they are to provide CNG at more than a few locations, which can be difficult for many small business operators.

CNG retailers identified the following business challenges (Table 4.6.3-1):

1. Making the business case – Creating demand as quickly as possible and minimizing costs can be difficult. This business case applies to retailers that rely solely on fuel for revenue. However, integrated retailers that offer goods and services beyond fuel (e.g., food, drinks, and car washes) may not need to create demand for fuel as quickly to be viable.

2. Properly sizing stations – This challenge includes being able to size and build CNG stations that are adequate to accommodate initial demand and some growth but that are neither too large nor too small, as well as the ability to build initial station modularly so that expansion is less expensive.

3. Lack of well trained maintenance technicians – Maintenance is a critical issue because in order to provide excellent customer service, stations must operate consistently. When they fail, they need to be repaired as quickly as possible. Retailers that rely on outside contractors find a severe shortage of qualified companies to provide this service.

4. Immature manufacturer and contractor industry – This challenge refers to both the level and quality of customer service, processes for doing business with these organizations, and the lack of stocked parts for repair.

CNG retailers also offered the following perspectives:

- The market for CNG will expand as North America continues to experience the problems associated with being dependent on imported oil for transportation.
- Retailers know that the greater the differential in pricing between CNG and gasoline or diesel, the greater the potential to expand their businesses.
- More than one CNG retailer mentioned the business opportunity to become a distributor of CNG equipment, citing the immature industry, the lack of customer service, and the inability to get parts as a market driver for new distributors.
- More than one retailer noted the need for developing in-house CNG station maintenance skills, which could also translate into another business unit for these entrepreneurs as demand increases.

Table 4.6.3-1

The societal costs of gasoline use in Class 2b vans are estimated at $18,000 per vehicle over its lifetime. In contrast, the societal costs of alternatives to gasoline range from $700 to $17,000 per vehicle.

Challenges	Perspectives
• Making the business case: creating demand quickly and minimizing capital and operating costs • Properly sizing stations—figuring out what the initial demand will be and sizing the station large enough to accommodate some level of growth • Lack of well-trained maintenance technicians • Immature manufacturer and contractor industry	• CNG will be a solution to the problem of foreign sources of energy from geopolitically unstable regions of the world • Increasing differential between price of CNG and gasoline/diesel increases the potential to expand the CNG business • Creating an additional business unit and becoming a distributor of CNG equipment may provide better customer service • Developing in-house maintenance skills may provide better customer service

4 CNG Infrastructure Options

4.7 Strategies to Overcome Business Challenges

4.7.1 Supply-Side Strategies

In looking at the big picture for business development, there are both supply-side and demand-side challenges to CNG infrastructure development. For retailers, the most significant factors affecting ROI may be natural gas costs and overall station investment costs.

Strategies that reduce the operating and capital costs of CNG stations have the most effect on the competitiveness of fuel price, which influences consumer demand and ROI for the fuel retailer (Table 4.7.1-1). The price differential between the pump price of gasoline/diesel fuel and CNG is perhaps the most significant driver of demand. This, however, must be balanced with the retailers' ability to earn a suitable rate of return.

As shown in Table 4.7.1-1, natural gas may represent 38 percent of the total operating costs for the CNG retailer. This number seems reasonable, but significant increases will hamper the competitiveness of CNG with gasoline and diesel. The second highest percentage of operating costs for the CNG retailer may be the cost of capital, ranging from 9 to 12 percent. Access to low cost capital, as well as methods to reduce overall capital costs, will help minimize these costs. Depreciation expense may represent the third highest percentage of operating costs for the CNG retailer, ranging from 5 to 7 percent. Again, reducing overall capital costs will help keep these numbers in check.

Specific strategies that will help accomplish this goal of making CNG competitive with conventional fuels may include:

- Having similar or comparable tariffs for natural gas use as a transportation fuel. Also, the entire natural gas supply chain from production to transmission to distribution must work together to provide competitively priced natural gas to the transportation market.
- Special tariffs established by LDCs for the use of natural gas as a transportation fuel will help ensure cost competitiveness.
- Capital cost offsets will help mitigate investment risk and improve ROI for the fuel retailer. These may be in the form of federal tax credits, state or local incentives, or other partnership arrangements between an LDC or other appropriate member of the natural gas supply chain and the retailer.
- Standardization and/or modularization of fueling station components and packages across North America will help decrease capital cost.
- Ability to obtain high pressure gas service whenever possible at the CNG station site helps eliminate one or more stages of compression and reduces overall capital costs.

Table 4.7.1-1

Strategies that reduce operating and capital costs of CNG stations have the most effect on the competitiveness of fuel price, which influences consumer demand and ROI for the fuel retailer.

	Existing Retailer	Independent Retailer (Hypothetical)
Total Operating Expenses Including Fuel Taxes	$269,907	$563,127
Total Natural Gas Cost in GGE	$102,000	$214,200
Natural Gas as Percentage of Total Operating Expenses	38%	37%
Depreciation Expense	$20,167	$33,667
Depreciation as Percentage of Total Operating Expenses	8%	6%
Interest Expense/Cost of Capital (Assume 8%)	$32,000	$50,000
Capital Cost as Percentage of Total Operating Expenses	12%	9%
Interest and Depreciation Combined	$52,167	$83,667
Combines Interest/Depreciation as Percentage of Total Operating Expenses	19%	14%

4 CNG Infrastructure Options

On the demand-side, the most significant challenge for CNG retailers is building load quickly enough to mitigate investment risks.

Strategies that minimize the amount of time to create baseline demand at the CNG station have a significant effect on mitigating investment risk for the CNG retailer. The more quickly a significant quantity of fuel is sold at the station, the more quickly cash flow is likely to go positive for the retailer and the less the investment risk. While this seems simplistic, it is a factor that sometimes has been ignored in the past as CNG stations were built. Examples of these strategies are summarized in Table 4.7.2-1 and include:

Using Anchor Fleets to Create Baseline Load/ Demand for the Station

Under this scenario, the potential site for a CNG station is in part determined by identifying one or more fleets that provide significant demand and that will agree to purchase/use NGVs and obtain fuel at that site. It requires the potential CNG fuel supplier to identify potential targets within a specified radius of the site, canvas those fleets to determine their vehicle mix, fuel usage, and interest in using natural gas, and then proceed to obtain agreements that will provide the minimum acceptable load at the station.

The advantages of this strategy are that it allows the fuel provider to minimize risk by obtaining a minimum level of fuel purchase commitments prior to expending the capital to build the station. It also causes the fuel provider to obtain market intelligence before siting a station, so it provides necessary input into sizing and design considerations. One challenge of this strategy is that fleets that express interest in converting are often unwilling to legally commit to CNG purchases until the station is actually constructed.

Locating CNG Stations at Existing Gasoline/ Diesel Outlets

Since fleet and retail customers are accustomed to purchasing fuel at convenient existing gasoline/ diesel stations, this model encourages CNG fueling infrastructure development at these types of stations. The fueling infrastructure developer identifies potential partners in viable locations and negotiates agreements with them to provide CNG fueling.

The advantages of this strategy are that it familiarizes existing fuel retailers with the benefits of offering CNG, hopefully stimulating them to expand CNG to other locations, and makes CNG convenient for customers. It reduces CNG fueling infrastructure costs because it has been reported that in some cases, up to 30 percent of the costs to build a new CNG station involve land and improvements. It also positions and brands CNG on par with gasoline and diesel in the minds of consumers.

The main challenge of this scenario is that sometimes the existing station does not have the right geographic footprint or layout to accommodate adequate CNG fueling equipment or the ingress and egress required for larger vehicles. Sizing these kinds of stations is challenging because they must be large enough to accommodate predicted demand and some growth but not so oversized that the developer is investing too much capital upfront.

Table 4.7.2-1

Strategies that minimize the amount of time to create baseline demand at the CNG station have a significant effect on risk mitigation for the CNG retailer and come with advantages and challenges.

Strategy	Advantages	Challenges
Obtain anchor fleets to provide baseline load for the station	• Minimizes financial risk • Helps obtain more accurate sizing and design input	• Fleets may be unwilling to commit to CNG purchases until station is purchased • Fleets may not honor commitment to purchase CNG after the station is built
Locate CNG stations at existing gasoline/diesel outlets	• Familiarizes traditional fuel retailers with the benefits of offering CNG • Reduce infrastructure costs because no additional land is required • Brands/positions CNG on par with liquid fuels	• Otherwise "odeal" station sites may not have enough geographic footprint to accommodate CNG • Sizing and designing may be challenging due to unknown usage patterns • Station may not be able to accommodate larger, higher fuel use vehicles

4 CNG Infrastructure Options

4.8 Major Stakeholders in Development

While there are other stakeholders that have interest in the market for natural gas as a transportation fuel, three groups have the greatest influence over customer adoption of NGVs: natural gas supply chain companies, federal government, and CNG retailers. Customers must share the risk with these groups in order for the NGV market to be sustainable.

Natural Gas Supply Chain Companies

Technology has allowed natural gas that was previously thought to be either too expensive or impossible to extract from deep formations underground now to be both located and produced. This has changed the energy outlook for North America, dramatically increasing supply and helping decrease price. There is also upward pressure on the cost of conventional fuels based fuels, creating an extremely competitive market for CNG. These factors combine to provide competitive pricing for CNG.

All companies within the natural gas supply chain, including exploration and production companies, pipeline companies, marketers and local distribution companies, have the greatest ability to affect and influence critical factors involving risk: pricing natural gas as competitive as possible will make CNG more competitive in price with traditional liquid fuels. Another role that the natural gas supply chain companies can fulfill is helping to provide capital to offset costs for retailers for CNG fueling stations and/or building and operating CNG stations through LDCs. The natural gas supply chain companies also have the collective ability to work with federal governments to ensure energy policies that favor North American-produced natural gas.

Federal Government

The federal governments of the U.S. and Canada have the ability to establish and create energy policies that help to initiate the conversion of transportation fuels from fuel derived primarily from imported oil to domestic fuels, including natural gas. One of the major challenges cited by participants in this study is the lack of a strong federal energy policy in the U.S. They describe the "flavor of the month" nature of U.S. energy policy—first, the focus in transportation research and development funding was on natural gas, then it switched to hydrogen, and currently it is electricity. The signals being sent by the federal government are mixed, create confusion in the marketplace, and hinder the ability of businesses to act and become sustainable without government intervention in the long term.

In addition to an overarching and coherent energy policy, federal governments have the ability to provide tax credits and other financial incentives over longer periods of time that will help the initial growth of the CNG market by reducing the capital cost of building CNG fueling stations.

CNG Retailers

CNG retailers have the ultimate contact with CNG customers. They have influence over the experience these customers have in using the fuel. They must make CNG stations convenient, reliable, and user friendly, as well as provide CNG that is significantly more cost effective than liquid fuels.

Table 4.8-1 highlights the most critical stakeholders in CNG infrastructure development.

Table 4.8-1

At present, the major stakeholders in CNG infrastructure development that can most influence customer adoption are natural gas supply chain companies, federal government, and CNG retailers.

Natural Gas Supply Chain Companies • Producers • Transmission companies • Distribution companies
Federal Government
CNG Retailers
CNG Fueling Equipment Packagers
Engineering Companies
Construction Companies
Education and Training Organizations
State and Local Government

5 CNG Infrastructure Actions and Opportunities

5.1 Natural Gas Supply Chain

5.1.1 Individual Companies

The opportunities and actions for natural gas supply chain providers involve measures that can be achieved both by individual companies and the industry at large. The individual company actions will help ensure optimum CNG pricing through tariffs and other measures, build baseline demand for CNG stations, and build CNG infrastructure where appropriate.

The actions that the natural gas supply chain can take as individual companies are summarized in Table 5.1.1-1 and include the following.

Provide Competitive Pricing and Specific Tariffs for Natural Gas for Transportation

LDCs can help ensure cost competitiveness of CNG by working with their public utilities commissions or other governing bodies to establish specific tariffs for natural gas for transportation that consider the societal benefits—not just the pure utility economics—of the fuel.

Provide Capital Offsets for CNG Infrastructure

One of the hurdles to widespread CNG infrastructure development is the significant cost of even a modestly-sized fueling station and the upfront capital required. The natural gas supply chain has the financial means and interest in market development to invest in CNG fueling infrastructure, including possible rate-basing of CNG stations by LDCs, but developing the market should not be the responsibility of solely these companies if the market is to be sustainable. This model has been successfully used by many LDCs, which have undertaken aggressive programs to install and own CNG fueling equipment at major retail gasoline outlets along major interstate corridors. Such a strategy helps make CNG broadly available at traditional fuel outlets without the need to convince retailers to invest hundreds of thousands of dollars in a currently immature market.

Use NGVs in Their Own Fleets

Natural gas supply chain companies can help create demand for fuel and vehicles by purchasing NGVs for their own fleet use. Full and long-term commitments to purchase and operate NGVs by all organizations within the natural gas supply chain will send clear messages to other fleet managers that the industry believes in its own product and will help decrease the amount of time it takes to reach critical mass for CNG sales by retailers.

Offer High Pressure Gas to CNG Fueling Facilities Wherever Possible

By offering increased inlet pressure, the compressor design requirements can be reduced from five-stage to four-stage to three-stage, depending on the inlet available. The result of this change in inlet pressure is that either the retailer's station costs will be decreased or the station will be capable of more output capacity for the same investment.

Table 5.1.1-1

There are a number of actions that natural gas supply chain companies can take individually to expand the CNG vehicle fuel market.

Opportunity	Action	Outcome
Create competitive pricing for CNG; reduce operating costs and mitigate investment risk for retailers	Implement specific and favorable tariffs for natural gas as a transportation fuel	Reduced fuel costs for users; improved ROI for retailers; reduced time to build market for NGVs
Reduce capital cost of CNG stations; mitigate investment risk for retailers	Provide capital offsets for CNG infrastructure	Reduced fuel costs for users; ability to invest in CNG infrastructure by retailers; improved ROI for retailers; reduced time to build market for NGVs
Reduce capital cost of CNG stations; mitigate investment risk for retailers	Provide high pressure gas wherever possible	Reduced capital cost for CNG retailers; improved fuel cost for users; improved ROI for retailers
Help maximize sales of CNG; support development of CNG infrastructure	Widely use NGVs in natural gas supply chain company fleets	Improved fuel demand and ROI for retailers; improved image of CNG as reliable fuel; improved vehicle demand/sales

5 CNG Infrastructure Actions and Opportunities

5.1 Natural Gas Supply Chain

5.1.2 Company Collaboration

In addition to individual company actions, the natural gas supply chain companies can work together to accomplish goals that will support CNG infrastructure development.

Lead the Industry to Obtain Longer-Term Federal Government Policies and Incentives

The natural gas supply chain companies can work with federal government to ensure long-term policies and incentives that encourage the use of domestically-produced natural gas as a transportation fuel. The goals of the incentive programs should be to help reduce capital costs and operating costs for CNG retailers for the period of time that the market will begin to be significantly penetrated, likely on the order of a decade.

Create North American Branding and Awareness Program for CNG

The natural gas supply chain—and especially the LDCs—have access to their customers in the form of education, outreach, and marketing. They are the organizations that customers considering using natural gas for transportation look to for expertise and advice. They are also the logical candidates to help create awareness and branding for CNG as a vehicle fuel within their service territories. This does not mean that elaborate advertising campaigns (that often violate utility regulatory body rules) must be implemented. It does mean that the companies within the gas supply chain should find ways to help fund education, training, and outreach to potential NGV customers by LDCs and the CNG retailers selling fuel to customers.

Effective Marketing/Sales of the Use of CNG

In addition to creating awareness and branding of CNG fueling, there must be effective and consistent marketing of CNG to help build demand for vehicles and fuel. Historically, vehicle manufacturers involved in producing NGVs created advertising and marketing materials and programs, but ultimately the sales managers did not see it as their responsibility to educate or convince customers about the benefits of NGVs unless customers asked.

In the early to mid 1990s when LDCs were more heavily involved in the NGV market, it was the responsibility of many utility marketing representatives and account executives to fulfill this customer education and demand building role. Moving forward, building maximum demand at stations as quickly as possible will be influenced by dedicated marketing and sales staff, regardless of who they work for.

Ensure Adequate Pipeline Infrastructure Capacity

The current natural gas pipeline infrastructure is designed to serve heating needs. To expand to serve the transportation sector, the natural gas supply chain must ensure that distribution infrastructure is capable of accommodating additional natural gas capacity for transportation.

Table 5.1.2-1 summarizes the actions natural gas supply chain companies can take collectively.

Table 5.1.2-1

In addition to individual actions, natural gas supply chain companies can act together to expand the CNG vehicle fuel market.

Opportunity	Action	Outcome
Reduce capital cost of CNG stations; mitigate risk for retailers	Obtain long-term federal policies	Reduced fuel costs for users; improved ROI for retailers; reduced time to build market for NGVs
Create market awareness for CNG; accelerate market acceptance	Create national branding and awareness for CNG; develop and implement effective marketing and sales efforts	Increased awareness of CNG as a transportation fuel; reduced time to build market for NGVs
Expand natural gas beyond heating to serve transportation sector	Ensure adequate pipeline infrastructure	Leveraged existing natural gas infrastructure to meet needs of a new market

5 CNG Infrastructure Actions and Opportunities

5.2 Federal Government

The opportunities and actions for government involve policies and incentives that help create long-term market benefits for natural gas as a transportation fuel.

Currently, the U.S. energy policy is considered vague and ambiguous, and the industry reports a need for more support for natural gas and clearer direction. For example, the U.S. has programs in place to promote and incentivize alternative fuels, including natural gas, yet keeping the cost of oil for transportation low is also a priority. An energy policy that clearly defines the plan for reducing America's use of oil for transportation, considers the best uses for each fuel source, and points the country in a clear direction will influence the decisions to expand CNG fueling infrastructure positively.

In the past, federal incentives have helped offset capital costs for fleet operators and purchasers of NGVs to drive the market, and their existence drive CNG infrastructure development. It can be speculated that the modest gains in the number of CNG and LNG fueling stations between 2006 and 2009 can be attributed in part to the federal tax incentives that were part of EPAct 2005.

Based on the economics of CNG infrastructure presented previously in Figure 4.2-1, effective federal incentives, at a minimum, could include extensions and improvements of those found in EPAct 2005, including:

- Federal tax credits extending on the order of a decade for the builders/owners of new CNG stations of up to $250,000 per station (EPAct 2005 limit was $50,000)
- Continued federal tax credits for CNG (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users 2005 amount was $0.50 per GGE)
- Additional incentives as needed to accommodate variations in maturity of NGV market

Table 5.2-1 summarizes the opportunities and actions for federal government.

Table 5.2-1

Federal government can take many actions to increase the use of natural gas as a transportation fuel.

Opportunity	Action	Outcome
Create effective national energy policies that help reduce dependence on foreign oil	Develop a sound energy policy based on the security and environmental benefits of fuels for transportation	Clear message to industry and fleets that natural gas has a major role to play as a transportation fuel
Reduce capital cost of CNG stations; mitigate investment risk for retailers	Provide tax credits of up to $250,000 for construction of new CNG stations for 15 years	Increased availability of CNG infrastructure; reduced upfront capital requirements for retailers; improved ROI for retailers
Reduce capital cost of CNG stations; mitigate investment risk for retailers	Work with NGV industry to analyze need for and develop additional incentives	Increased availability of CNG infrastructure; reduced upfront capital requirements for retailers; improved ROI for retailers
Reduce operating cost of CNG stations; mitigate investment risk for retailers	Provide fuel tax credits of $0.50 per gallon for up to 15 years	Increased availability of CNG infrastructure; improved ROI for retailers

5 CNG Infrastructure Actions and Opportunities

5.3 CNG Retailers

The opportunities and actions for CNG fueling retailers involve setting expectations to earn reasonable rates of return on their investment and providing excellent customer service.

For the CNG market to be viable and sustainable, both customers and retailers must adopt the long-term approach. In addition to short-term economics, customers must weigh the long-term energy security, environmental, and other societal benefits of using natural gas for transportation.

Similarly, CNG retailers must find the right balance between providing fuel that is extremely cost competitive with gasoline and diesel and earning an acceptable rate of return. In addition, retailers must help provide the optimum experience for CNG customers—especially in the early years of market penetration when problems are more likely to arise.

CNG retailers must determine an acceptable return on investment, minimizing the factors that contribute to pump price of CNG whenever possible—again, especially in the early years of market penetration. Yielding to the temptation to "make as much margin as possible" in the short term will contribute to neither an individual company's nor the industry's long-term viability.

CNG retailers also must ensure that they provide high quality fuel and reliable, convenient fueling access. This means they must choose reliable fueling equipment and implement preventative maintenance practices that eliminate oil and other contaminants from the fuel stream and minimize station downtime. It also means they must monitor station performance regularly to ensure adequate capacity. Ultimately, the evaluation of the CNG experience by customers will depend equally on the performance of the vehicles and the reliability of and customer satisfaction with the fuel.

Table 5.3-1 highlights the opportunities and actions for CNG retailers.

Table 5.3-1

CNG retailers can take many actions to enable natural gas to be competitive with conventional transportation fuels.

Opportunity	Action	Outcome
Create competitive pricing for CNG; create positive business case for CNG retailers	Establish margins to earn acceptable ROI; price CNG as competitively with gasoline/diesel as possible	Maximize fuel demand; earn acceptable ROI
Increase CNG demand by developing convenient public access fueling infrastructure	Site stations that are convenient to find and purchase fuel	Maximize fuel demand/minimize time to build demand
Reduce capital costs of CNG fueling equipment	To the extent possible, standardize the manufacturer/packager of fueling equipment used	Reduced capital costs; increased support for parts and service
Improve performance and customer service of CNG fueling	Implement preventative maintenance practices that eliminate oil carryover and other contaminants from the fuel stream and minimize downtime	Reduce operating costs; eliminate the possibility of oil carryover contaminating customers' fuel systems; increase customer satisfaction with the station and ultimately demand
Improve performance of CNG fueling stations	Monitor station capacities vs. usage to ensure adequate capacity; implement strategies to expand capacity when necessary	Increase customer satisfaction; maximize fuel demand

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