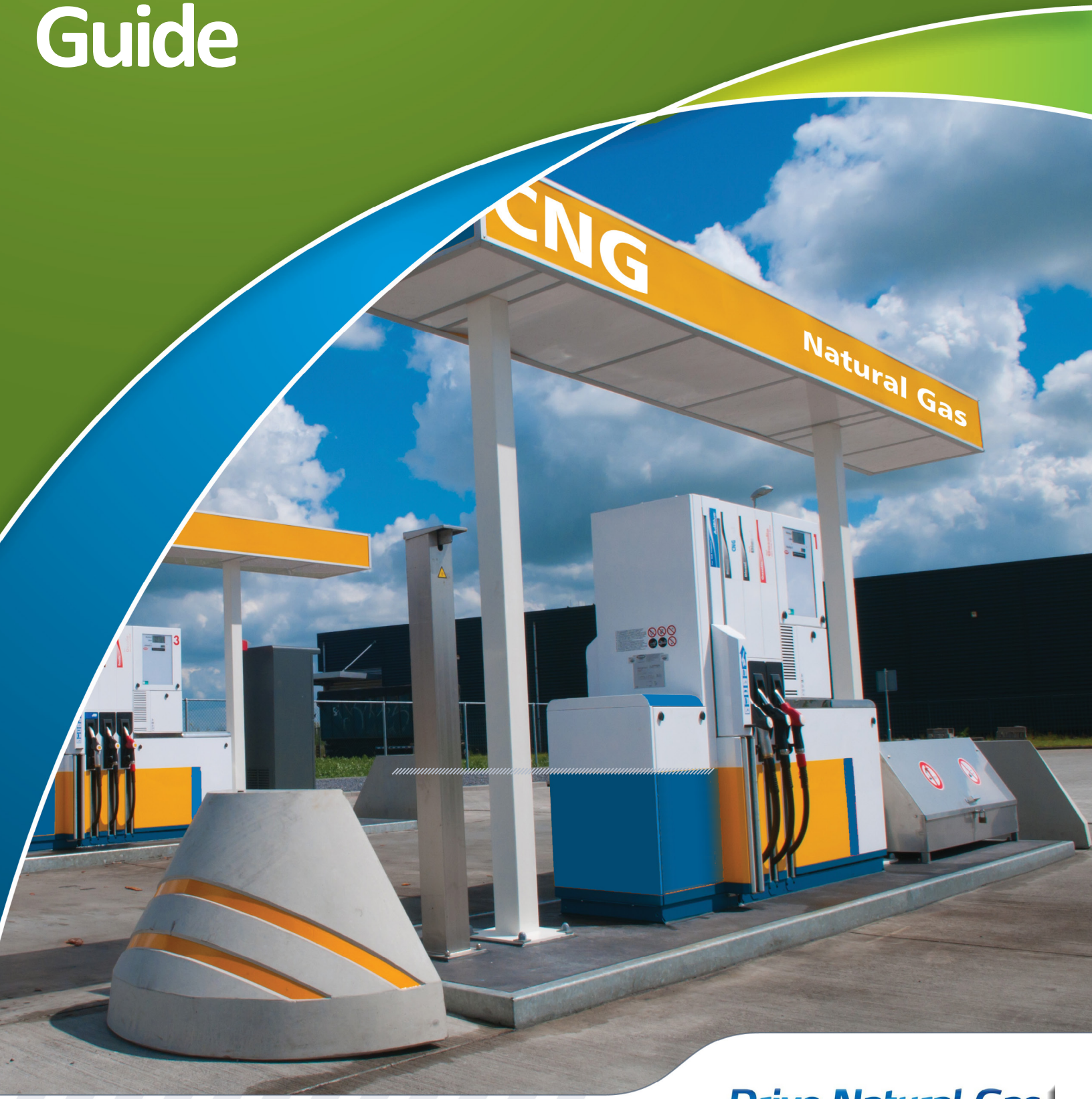
CNG Infrastructure Guide

FOR THE PROSPECTIVE CNG DEVELOPER



Prepared by the

Drive Natural Gas INITIATIVE

Guide at a Glance

Introduction

Increased national interest in the development, operation, and use of Compressed Natural Gas (CNG) as an alternative vehicle fuel creates a need for an expanded CNG vehicle refueling infrastructure. The Drive Natural Gas Initiative (Drive Nat Gas) offers this primer to help those desiring to get started in pursuing CNG development.

Prospective station owner/operators, fleet managers, and those involved in the conversion and maintenance of natural gas vehicles will benefit from this document.

CNG Infrastructure History and Future Goals

There are approximately 1,200 public and private CNG stations located in the United States. This compares to over 120,000 retail gas stations, creating a ratio of approximately 1 CNG station to every 100 retail gasoline stations.

During the early 1990s the country's CNG refueling infrastructure experienced a period of growth, largely driven by the alternative fuel vehicle mandates of the Energy Policy Act. Following its peak in 1997, national CNG refueling infrastructure declined for approximately a decade, and since 2006 is trending upward. Approximately half of the CNG stations in the U.S. are public access and these numbers are expected to continue to increase in the coming years. CNG stations are also in the early stages of development in Canada, currently reporting 56 stations that are primarily listed to have public access.

The NGV Coalition published the Natural Gas Vehicle (NGV) Industrial Strategy in 1995 that helped increase the demand for natural gas in the transportation sector. The focus of the NGV strategy was transit agencies, delivery trucks, refuse trucks and other fleets with high fuel usage. Between 1997 and 2009 demand grew by threefold to 3.2 billion cubic feet, or 27.7 million gasoline gallon equivalent.

The CNG industry will benefit from the continued expansion of the public fueling infrastructure. It is estimated that between 12,000 and 24,000 CNG stations, equivalent to 10 to 20 percent of traditional liquid fuels, will make CNG competitive.

CNG stations are distinct from gasoline and diesel stations because they dispense high pressure gas. These stations are built to conform to codes specifically developed for high pressure gas, and include unique components such as gas dryers and high pressure storage systems. Creating a seamless process for the CNG consumer means appropriately sizing and designing the station to meet demand and the refueling patterns of vehicles that will service the site.

Introduction (continued...)

A variety of factors, including the cost of gas, the profit motives of station owners, and the cost of capital influence the station's business model. CNG station owners recognize that the business case is subject to supply-side and demand-side factors. For example, the upfront cost for a CNG station is significant and building the fuel demand to become profitable is often a lengthy process. Measures are often taken to offset these influencing factors, otherwise the return on investment for a CNG station can be negative or very low for several years.

A variety of stakeholders are investing in the CNG refueling infrastructure including CNG retailers, construction and engineering companies and compressor manufacturers/ suppliers/packagers. Qualitative data collected from these groups found that in 2010, new CNG station demand was expected to be between 60 and 80 stations annually. This is expected to be met by the existing infrastructure development base. Anecdotal data yielded the need to triple demand to stabilize their business. The expansion of existing and new companies entering the market is also a necessity for meeting the goal of 12,000 to 24,000 stations.

About Drive Natural Gas

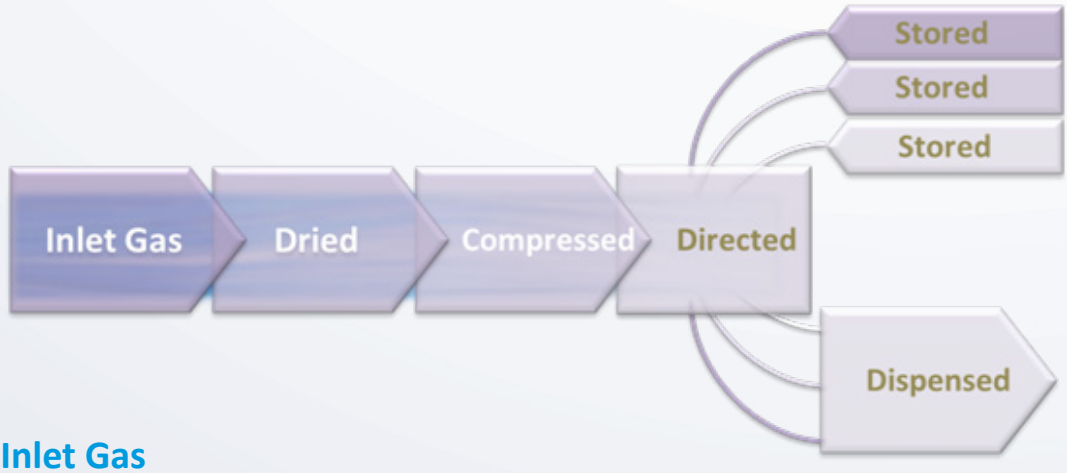
The Drive Natural Gas Initiative (Drive Nat Gas) is a membership-based, collaborative effort of natural gas utilities and producers seeking to further develop the use of clean, domestic, affordable natural gas as a transportation fuel. Through Drive Nat Gas, over 50 natural gas industry members work to expand the role natural gas can play in enhancing national and energy security, improving air quality, and providing America with a more affordable and reliable source of transportation fuel.

Drive Nat Gas creates standing committees, co-chaired by producer and utility representatives, and focuses on activities such as Infrastructure Development, Vehicle Production/OEM Outreach, Advocacy, Marketing and Education. A sub-committee focuses on developing an economic home refueling device.

Natural Gas Overview

A number of excellent sources exist in the public sphere that describe the basics of natural gas and the burgeoning natural gas supply made available by new methods of extraction . Thereby, this document addresses natural gas from a fueling infrastructure perspective and is oriented to a prospective station owner/operator or fleet manager.

From a fueling infrastructure view, the process begins at the gas utility connection of the site where fueling of natural gas vehicles is to be accomplished. The gas is metered at this connection, and there are several steps typically required to make the gas "vehicle ready".



Inlet Gas

The municipal "inlet" gas connection will require sufficient flow rate and pressure for the designed application. Many CNG infrastructure applications can use the standard low pressure available in municipal gas lines, but it is good to know the pressure available at the line and if the envisioned application will require a larger line or more pressure. It is recommended that potential station owners/operators check with the local utility and/or gas supplier to determine the "guaranteed" minimum inlet pressure available at your selected location.

Gas Quality – Drying and Filtering

The quality of inlet gas primarily concerns moisture content, and scale or other foreign matter that may be contained in the inlet line. Moisture content in natural gas is measured in millions of parts per cubic foot. Inlet gas with high moisture content will require "drying" in order to make it serviceable for fueling vehicles, and dryers are standard equipment in most fueling applications. Further, a filter may occasionally be necessary if there is a quantity of pipe scale or foreign matter in the gas line. Filters come standard on many models of compressors.

Natural Gas Overview (continued...)

Gas Compression

Dried and filtered inlet gas is compressed by one or more compressors and often stored in tanks, or delivered directly to a fuel dispenser. This pressurized gas is now "Compressed Natural Gas" ready for vehicle fueling.

Priority Distribution

Moving the CNG from the compressor to storage tanks or directly to the vehicle requires directed control, and this function is supplied by a computerized "priority panel". Priority panels direct the flow of CNG from the compressor to on-site storage tanks. Sequential panels direct the flow of CNG from the compressor or tanks to fuel dispenser units and/or vehicles. Based on the pressure measured in the vehicle tank, the priority panel switches between the low, medium, and high pressure tanks to ensure a complete fill.

Gas Storage

Fast fill CNG applications will require pressurized gas to be stored in high pressure tanks to accommodate more vehicles fueling faster. CNG storage tanks often come in cascades of up to three tanks in a "bank" or in spheres. Cascade banks are most often maintained at three different pressure levels (high, medium, low) to accommodate faster vehicle refueling, and ensure a proper fill. Natural gas storage tanks are required by law to be installed above ground.

Dispensing CNG

CNG dispensers come in many different sizes, shapes, and varieties. However, they all conform to either a fast fill or a time fill configuration and are available in different hose configurations and with different flow rates and methods of metering.

Time fill units typically dispense fuel through a fixed pressure regulator. When the fuel flow reaches a minimum rate, the fuel flow is shut off. Fast fill units measure the pressure in the tank, then a small amount of precisely measured fuel is dispensed into the tank and the pressure rise is measured. From these figures, the volume of the tank is calculated and the tank is filled rapidly to this level. When the tank is full the flow is shut off. Many dispensers come with temperature compensators that ensure a complete fill in cold environments.

CNG Station Business Models

Introduction

The models outlined in this section are intended to assist in the initial stages of developing a CNG station business plan. The models represent traditional and current paradigms of ownership and business strategy, but are not all inclusive.
The business models are considered from the perspective of:

- Who owns the CNG station
- The nature of the fuel delivery service at the station (time fill vs. fast fill vs. combination)
- Who maintains and/or operates the CNG station
- The availability of access at the station (public vs. private vs. limited)
- How the station is funded, and how it will charge for fuel

Three types of ownership models are discussed in this section: Fleet or End-User Ownership, Local Distribution Company (LDC) Ownership, and Third-Party Ownership.

Fleet or End-User Ownership

Several variants exist for a Fleet or End-User Ownership model. These models typically apply to entities that have vehicles that require fueling and desire to own the station that provides that fuel.

The "Own and Operate" model applies to entities that will own and operate the CNG station. In some cases, the ownership could be shared among multiple entities using the same station or with a utility in a hybrid arrangement.
Variations include the following:

1) Ownership Differences:
   a) The ownership entity uses its own personnel for operation and maintenance of the facility
   b) The ownership entity contracts with a third-party for operation and maintenance of the facility
2) Fueling Sources:
   a) The ownership entity contracts with a utility for the regulated transportation and sale of natural gas to the station
   b) The ownership entity contracts with a third party for the natural gas commodity and the utility entity provides regulated transportation service to the delivery point

CNG Station Business Models (continued...)

Fleet or End-User Ownership

Case Study - Apache Corporation

by Frank Chapel
Director Natural Gas Transportation Fuels,
www.apachecorp.com

Apache Corporations' mission is to promote natural gas as the alternative transportation fuel of choice. To accomplish this, Apache is transforming its U.S. fleet to natural gas power and constructing supporting CNG fueling stations. Apache will have a total of 20 CNG fueling stations in operation by year-end 2012. Six of these stations are public access--Tulsa, OK, Lafayette, LA, Andrews, TX, Houston, TX and Midland, TX (2). The remaining 14 private CNG stations are made available to other area CNG fleets with the execution of a "Compressed Natural Gas Bulk Sales Agreement". About 400 of Apache's 1,000+ U.S. fleet (primarily Chevrolet Silverado pickup trucks) have been transformed to CNG-power with an objective of 80% by year-end 2015.

Local Distribution Company (LDC) Ownership

Local Distribution Company (LDC) Ownership occurs when the natural gas utility or LDC owns the CNG station and operates it for the benefit of others. LDC models follow a rate-based or non-rate based model. The "rate base" refers to how much money utilities have invested in facilities and equipment to ensure service to the utility's customers.

Most LDC ownership relies on a rate-based model in which the capital investment is made by the LDC and is reimbursed through a regulated rate (typically set by a public utility commission) charged to the customer.

It is possible in some cases for the LDC to capture a rate of return where a profit is realized. These models are seldom used. Unregulated affiliates of LDCs also pursue natural gas vehicle infrastructure where the rate of return is based on the project risk and potential profits are not limited.

CNG Station Business Models (continued...)

In 2010, the American Gas Association surveyed its membership to determine how many natural gas utilities offered natural gas for sale under a special natural gas vehicle (NGV) tariff or pursuant to a compressed natural gas (CNG) tariff. Of the 32 utilities that responded to AGA's 2010 survey, 53 percent of the utilities had a special NGV or CNG rate.

Further, of the nearly 450 public CNG stations in the U.S. currently, approximately 35% are owned by LDCs.

LDC	*Number of Retail Stations Reported*	*Estimated Market Share*
Questar Gas	29	6%
Pacific Gas & Electric	24	5%
Oklahoma Natural Gas	23	5%
National Grid	15	3%
Southern California Gas	13	3%
Other LDCs	40	9%
Total	156	35%

LDC ownership in a facility can be full or partial and this will often affect the access type - public access, private access, or limited access.

A full versus partial ownership model is a hybrid where a regulated natural gas utility owns a portion of the CNG facilities (generally the compressor, storage and auxiliaries) under a rate-based model and a third party commercial retailer owns the dispensing means (along with the land, card-reader, and retail transaction functions) using an unregulated model. The LDC recovers its investment in facilities and associated operations and maintenance costs through a "compression services" fee that is charged to the retailer. The retailer charges its customers for the delivered CNG under an unregulated price per fuel unit. Examples of this model include the Atlanta Gas Light Company (AGL), the regulated LDC serving a portion of the Georgia market.

CNG Station Business Models (continued...)

LDCs also own public access stations, and provide CNG service at stations that are part of their facilities, or a nearby public location. The user pays for the fuel consumed based on a dispensed published rate per unit (typically a thermal unit or Gasoline Gallon Equivalent (GGE), as established by the regulatory authority. The utility may also fuel its own company vehicles at the same location. Examples of this model include Questar Gas, PSNC Energy, and Piedmont Natural Gas.

LDCs also own limited access stations, often located at a customer location, and provide CNG service to a limited number of vehicles. The vehicles are typically owned by one or more fleets, and generally do not include vehicles used by the general public. They may be filled using a time-fill approach if appropriate. The user pays for the fuel consumed based on a per unit basis, and may be subject to a take-or-pay contract to assure a return on the utility investment.

Local Distribution Company (LDC) Ownership Case Study - Questar Gas

by Brad Markus
General Manager Customer Relations
www.Questargas.com

Operating in states where a rate-based NGV program has increased the adoption of NGVs, Questar has created a sustainable model. Questar currently owns and operates 29 public CNG stations within Questar Gas' service areas in Utah and Wyoming. The utility first experimented with NGVs in 1981 when it first converted 25 vehicles and built their first compressed natural gas station. By the mid -1990s, Questar's NGV fleet grew to over 700 vehicles.

Common to many LDCs, the CNG infrastructure costs are recovered through their rate base. The Public Utilities Commission of Utah allows Questar Gas to sell CNG at a rate slightly below cost of service. The ratepayer subsidized rate helps incentivize the market as lower prices can be offered at the pump.

CNG Station Business Models (continued...)

The gas commodity price is passed through to the ratepayer and Questar pays for the distribution non-gas costs such as the station capital, electricity, maintenance, etc.

Not only are they committed to building out the infrastructure, but providing infrastructure related services such as compression and dispensing. Marketing and educational activities also surround their involvement in expanding the use of these stations to the public.

Local Distribution Company (LDC) Ownership Case Study - Piedmont Natural Gas

by Greg Johnson
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www.piedmontng.com

Charlotte, NC based Piedmont Natural Gas owns, operates and maintains 12 combined public and private CNG stations in North Carolina, South Carolina and Tennessee. They are executing a plan to build more CNG fueling stations in their service area for use by their vehicle fleet as well as by third party customers. Currently, approximately 13% of Piedmont's vehicle fleet uses CNG. They have over 300 customer vehicles using company CNG stations. Within two years, Piedmont anticipates that up to 33% of their fleet may be capable of using CNG. They also actively pursue other commercial fleets to utilize company CNG stations and have had discussions with commercial customers for fueling stations at customer sites where there is sufficient demand.

CNG Station Business Models (continued...)

Local Distribution Company (LDC) Ownership Case Study - Atlanta Gas Light

by Ian Skelton
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www.atlantagaslight.com/cngplan

Universal Service Funds (USF) have been used in a number of states to provide assistance to low-income and hardship customers. The USF in Georgia may also be used by Atlanta Gas Light to install infrastructure to serve customers or communities who do not have gas service or are underserved.

In November 2011, the Georgia Public Service Commission (GPSC) approved a plan submitted by Atlanta Gas Light to invest $11.57 million from the company's Universal Service Fund (USF) to install, own, and maintain natural gas compression and storage equipment at newly proposed CNG fueling stations. Atlanta Gas Light will provide this service to station owners under a new rate approved by the Public Service Commission. The initiative is the first state-sponsored investment program in the Southeast that allows the utility to add infrastructure to its market without rate impacts on current customers.

All site development costs as well as any costs to operate the equipment will be paid by the station owners and their respective CNG customers. Station owners must meet certain criteria to be considered for participation under the program, including having access to land on which to locate the fueling equipment and having fleet customers who will utilize approximately 20 percent of the station's fueling capacity in the first year of operation.

The majority of the funds approved by the Georgia Public Service Commission will go to support public access stations that will serve fleet customers as well as the general public. Funds were also approved to construct limited access stations that will support fleets providing a public benefit, such as municipal buses or garbage truck fleets. Access to these stations will be limited to customers with agreements with the station owner.

CNG Station Business Models (continued...)

Third Party or Commercial Ownership

Third-Party Ownership, also known as a Commercial Operator, is an unregulated commercial business entity which owns the CNG station on a for profit model. These models are typically found in non-rate based, economically viable areas. The entity is not subject to utility regulation and is separate from the owner/operator of the vehicle. Commercial business models have the most flexibility in terms of the type of ownership interests, the means of financing, and the range of associated activities needed to operate a CNG station. There are two mechanisms for this type of model: "Own and Operate" and "Operate Only".

"Own and Operate" models are just that – a commercial operator owns and operates the CNG station. That operator may or may not own the land on which the facilities are located. The operations functions may include the commodity purchasing, maintenance, retail transaction management or these may be outsourced to other entities under some type of contractual arrangement (fee for service, lease, etc.)

In an "Operate Only" model, the ownership of the facilities is separate from the responsibility of operation.

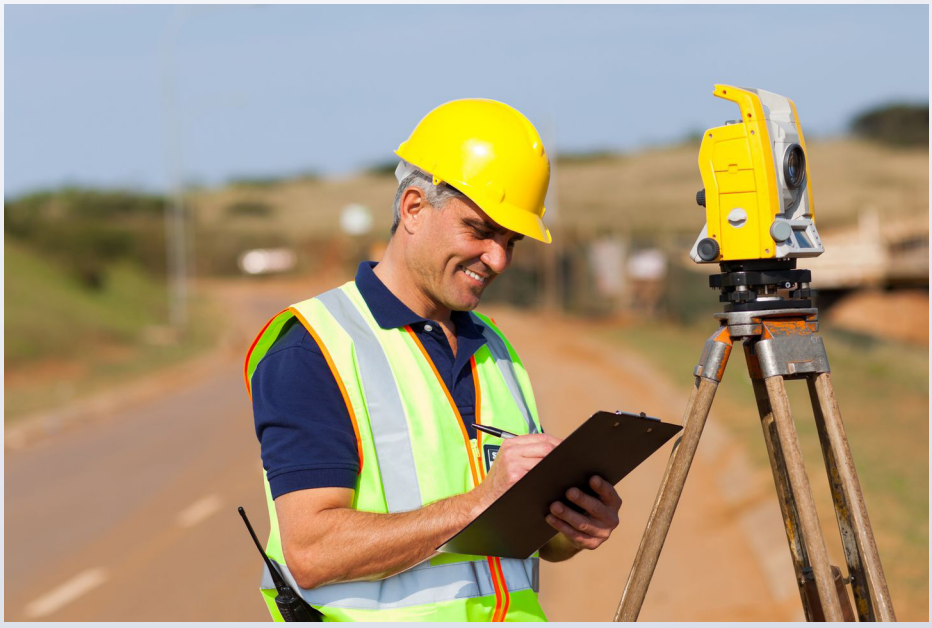
Constructing the CNG Station

With each potential business model covered in the previous section, consideration must be given to the types of vehicles to be fueled, and the fueling and access requirements those vehicles will need.

A small fleet of CNG cars needing fast refueling will have different requirements than a large fleet of CNG school buses or refuse trucks that can be refueled on a time fill system. These too will be different from a commercial CNG station requiring larger equipment, greater redundancy, fuel storage, and multiple dispensers. To properly size a CNG fueling station it is important to know as much as possible about the vehicle fueling rates and arrival patterns. In particular, the designer will need to know the peak hourly fueling rate, not just the daily or weekly usage.

Public or private access considerations will assist to refine site selection and the required station footprint.

As each of these areas is defined, they help drive decisions regarding the intended station type.



CNG Station Configurations

The physical properties of gas, in comparison to liquids, create a novel refueling experience for natural gas vehicle owners/operators. Despite the different equipment used to refuel a CNG vehicle, natural gas is simple to use and the process is similar to that of conventional liquid fuels.

Unlike liquid fuels where the fuel is stored on site, natural gas is generally delivered to the site via pipeline and compressed on demand. An amount of storage may be included in order to facilitate faster filling, but CNG storage is expensive so the demand is primarily by the hourly flow rate of the compressor(s).

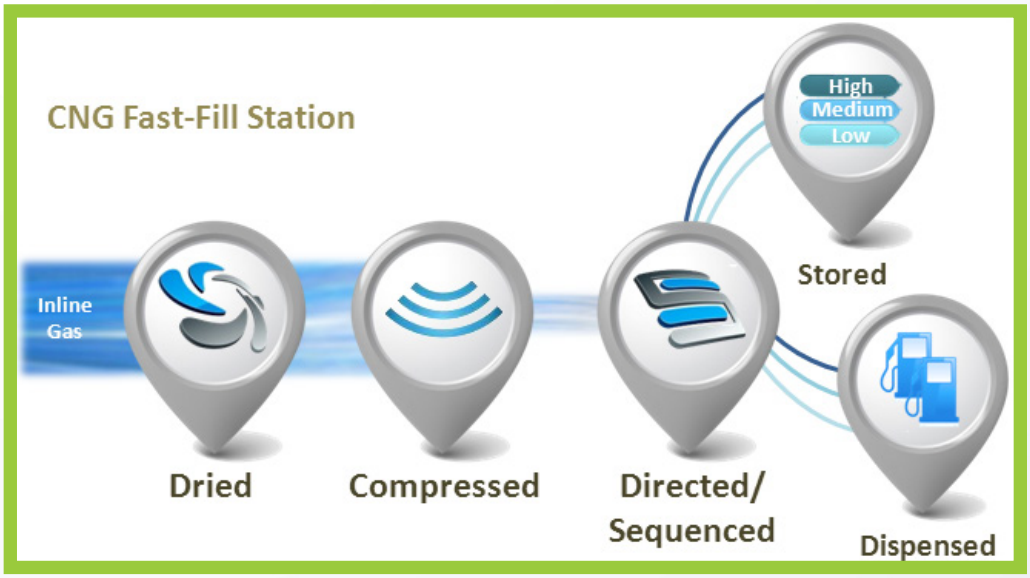
During the early years of infrastructure development, CNG refueling stations are encouraged to consider redundancy. This is accomplished by installing more than one compressor and insures that a station can continue to operate even if one compressor fails. While the density of CNG stations is relatively low, and an alternate refueling station may not be easily located, redundancy improves system reliability and customer satisfaction. With an increase in CNG station density, the need for redundancy may be diminished.

There are four predominant configurations of CNG stations in North America:

1) Cascade Fast-Fill
2) Buffer Fast-Fill
3) Time-Fill
4) Combination-Fill, which combines two of the three configurations

These configurations are described in this section.

CNG Station Configurations (continued...)



Cascade fast-fill stations primarily fill from storage tanks and are typically used for retail applications or vehicles that require refueling at varying times. Some fleet operations and most public CNG stations are examples of a cascade fast-fill configuration.

Cascade fast-fill systems include:

1) **Dryer** - removes water or water vapor from the natural gas supply prior to compression. Dryers work via a desiccant material and some dryers require the desiccant periodically be replaced, while others will regenerate the desiccant.

2) **Compressor** - compresses natural gas to the appropriate pressure required to deliver a fully temperature compensated fill to the vehicle. Compressors come in multiple sizes and are often "ganged" to provide redundancy and consistent pressurized operation.

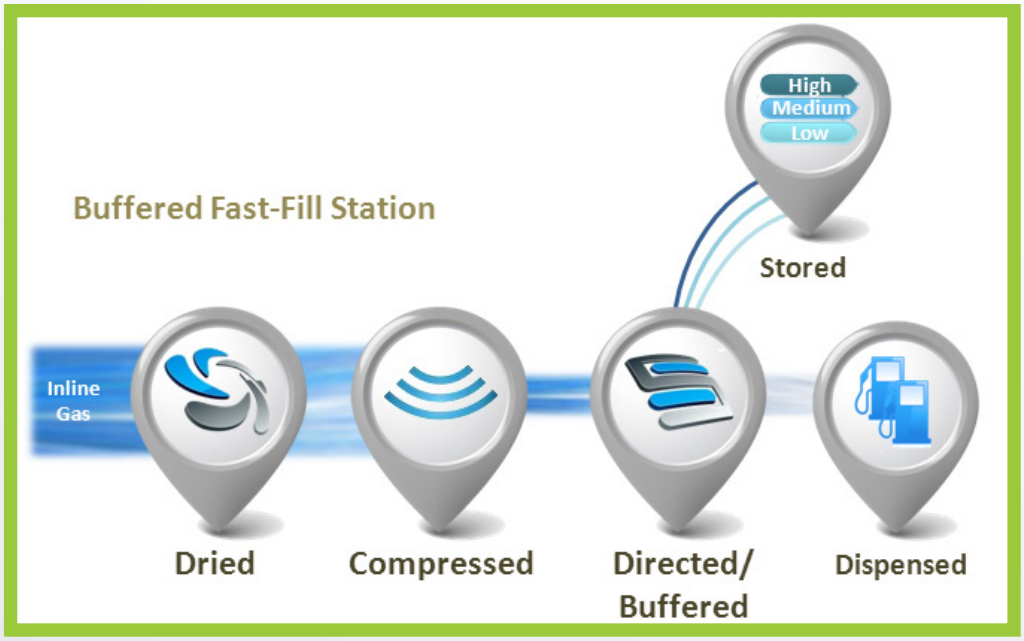
3) **Priority-Sequential Panels/Buffer/Time fill valve** - determines the priority and sequence of flow of CNG from the compressor into storage or directly to the dispenser. These valve systems are often custom built to requirements.

4) **Storage** - American Society of Mechanical Engineers (ASME) storage tanks are used as the current acceptable standard to store compressed natural gas. Tanks are configured as banks of tubes, or as spheres.

CNG Station Configurations (continued...)

5) **Dispenser** - dispenses natural gas into vehicles. There are many types of dispensers available on the market today and many offer similar features of metering and charging of conventional fuel dispensers.

a. **Temperature compensation system** - uses an algorithm to adjust for ambient temperature and temperature of compression into the vehicle fuel tank to ensure that vehicles receive a complete fill. Most CNG fuel dispensers perform this function.

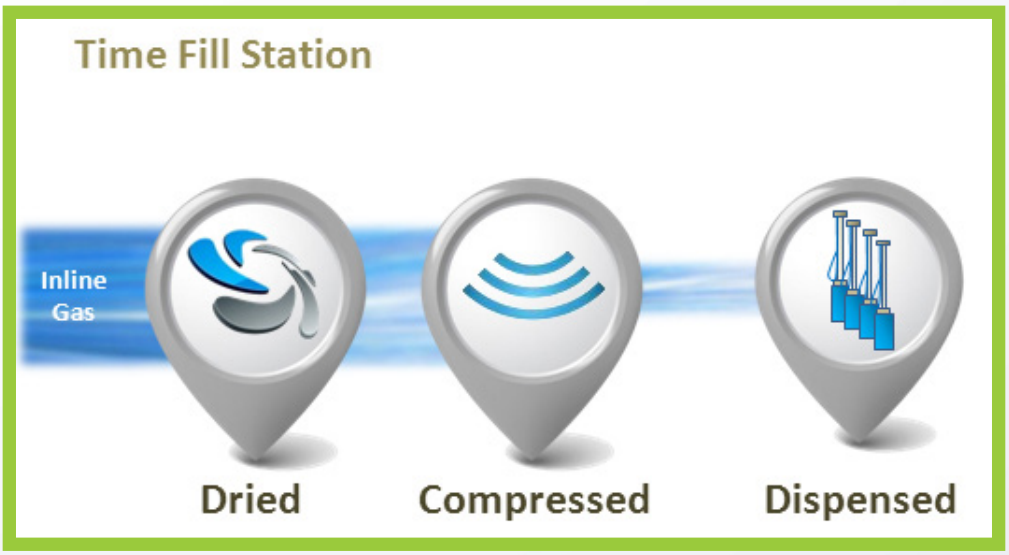


Buffer fast-fill stations are ideal for high fuel use vehicles that require immediate refueling, one after another. Taxis and transit buses frequently utilize this configuration due to their need to sequentially refuel and also because of the overall fuel demand of these types of vehicles. Buffer systems primarily fuel directly from the compressor into the vehicle and therefore require a smaller quantity of storage.

These stations typically serve a captive fleet and are designed and sized for the needs and fueling patterns of the specific fleet. They are often located onsite and allow for large quantities of fuel to be dispensed in a relatively short period of time.

CNG Station Configurations (continued...)

Typical components of a buffer fast-fill CNG system include those for a fast-fill with the priority panel and sequencing valves replaced by a **Buffer Control Panel** that routes fuel directly from the compressor(s) to the dispensers using stored fuel only if compressor capacity is exceeded.

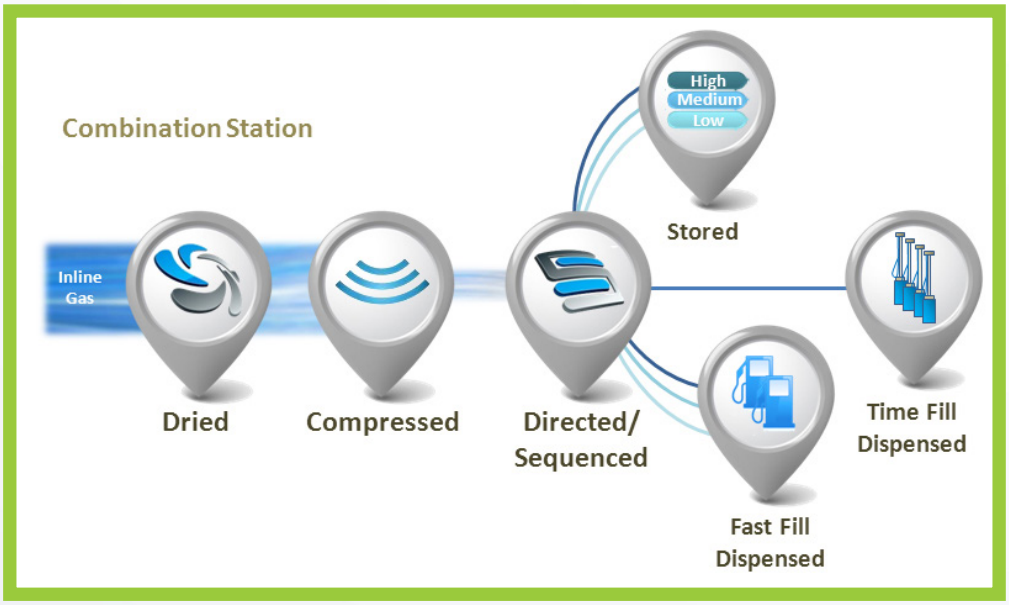


Fleets of vehicles that return to central locations for periods of time frequently utilize the time-fill configuration. This is a lower cost option and is a preferred method of refueling refuse trucks, school buses and other fleets with similar refueling requirements. Time-fill stations have significantly lower equipment and installation costs because they do not require storage, priority, or sequential refueling components.

Time-fill applications provide fuel to the vehicle directly from the compressor and are ideal for fleets that return to a central location for an extended period of time. This station configuration is easily modified to also accommodate vehicles requiring a fast-fill with the addition of a small amount of storage and fast-fill dispensing equipment.

Typical components of a time fill CNG system include gas drying and compressor systems. As fuel flows directly from the compressors to the vehicles, complex dispensers are not required and most time fill applications use multiple **Single Hose Fueling Posts.**

CNG Station Configurations (continued...)



A combination station uses both fast fill and time fill technology to accommodate both fueling types. Combination stations offer maximum flexibility for fleet types that have requirements for both fast fill and time fill solutions.

Safety and Code Requirements

CNG fueling stations must meet a number of codes and standards that ensure safety and influence design and construction.

Construction Codes

There are a variety of national and local codes and standards to which CNG stations must adhere. This includes, but is not limited to, the addition of fire extinguishers in key locations and multiple emergency shut off valves. Additionally, the construction and permitting process is subjective and can vary based on the code official's knowledge and familiarity with CNG fueling applications. The process of complying with existing codes and standards is further complicated by the number of code forming organizations with codes affecting CNG refueling stations:

- 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)

A partial list of codes and standards that apply to U.S. CNG stations is included on the following pages.

Safety and Code Requirements (continued...)

Code Agency/Organization	*Primary Function*
American National Standards Institute (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.
American Society of Mechanical Engineers (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.
American Society for Nondestructive Testing (ASNT)	Tests components for safety.
National Electrical Manufacturers Association (NEMA)	Establishes standards for electrical component manufacturing.
National Fire Protection Association (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/National Electrical Code (NEC)	Defines the electrical classification of the hazardous areas within a CNG station

Note. From "Natural Gas Vehicle Market Analysis," by TIAX, 2012 CNG Infrastructure , Table 3.4.1-1 .

Safety and Code Requirements (continued...)

Code Agency/Organization	*Primary Function*
Occupational Safety and Health Administration (OSHA)	Regulates occupational safety and health in the work environment.
Society of Automotive Engineers (SAE)	J1616 establishes the recommended practice for fuel quality and water content.
Uniform Building Code (UBC), Local Jurisdiction	Regulates structures that contain CNG fueling equipment.
Uniform Fire Code (UFC)	Some states and/or localities use this code; often contains NFPA 52 within it
Uniform Plumbing Code (UPC)	Governs the plumbing components of CNG stations.
National Institute of Standards and Technology (NIST)	Establishes the unit of measurement for custody transfer of CNG from the retailer to the customer.
Underwriters Laboratories (UL)	Tests components and publishes lists according to compliance.

Note. From "Natural Gas Vehicle Market Analysis," by TIAX, 2012 CNG Infrastructure , Table 3.4.1-1 .

Site Selection Criteria

Land and Access

Land is a significant component in building a CNG station. Requirements for land begin at approximately ½ acre of property for a light duty station, and increase with larger applications. The decision will need to be made to build on a new site, or incorporate CNG fueling at an existing site such as an existing station. If civil design work is needed for new construction, a geotechnical site evaluation will likely be required. This evaluation will provide critical soil composition information necessary for concrete foundations and electrical grounding systems. Considerations must be given to road access (public or private) and utility connections. Easy access to major trunk highways is always a great idea, or partnering with a convenience store is another workable plan as well.

Utilities

An adequate natural gas supply accessible to your location is critical. Contact your local gas distribution company early in the site selection process. Not having adequate gas supply, or pressure or distance to the gas supply could be a deal breaker. Keep the local distribution company involved and updated on the progress of the station, as this organization may be your primary source of natural gas.

Further, high capacity electrical service will be required at most CNG fueling installations to run the equipment necessary to prepare, store, and dispense CNG to waiting vehicles. Contact your local utility provider to confirm adequate power is available or can be provided.

Other Pre-Construction Considerations

It is extremely important to contact the local Fire Marshall and Building Inspector. They provide guidance through the permitting process to make sure the station is designed and constructed in accordance with all applicable local, state, and federal laws, rules, regulations, codes and standards.

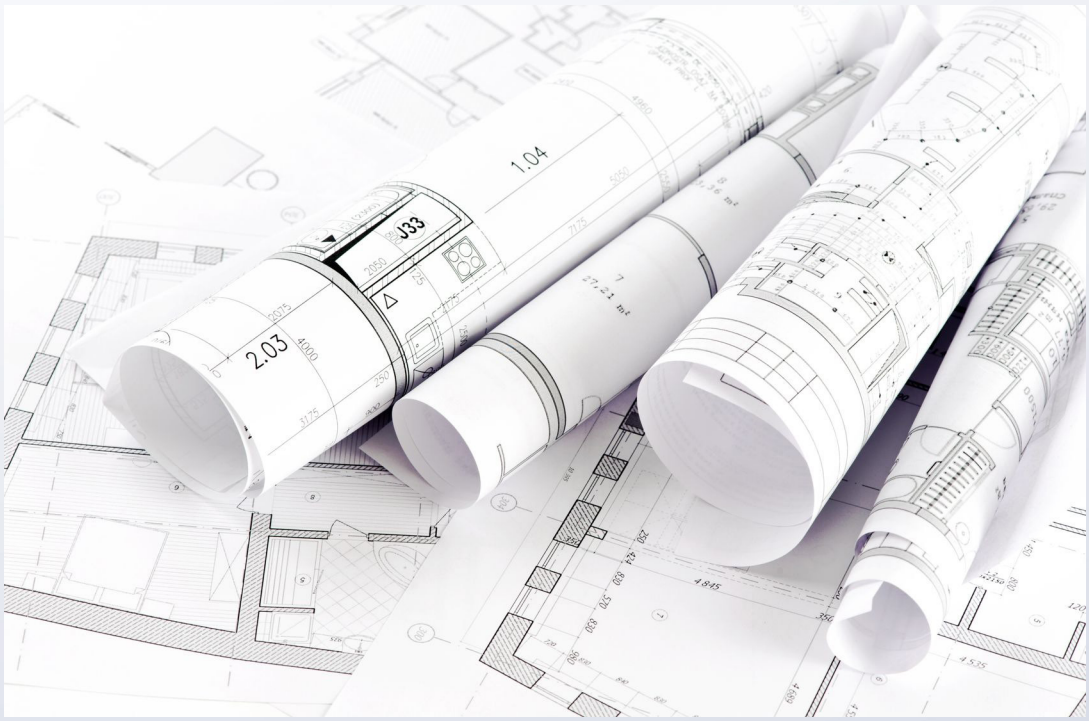
Site Selection Criteria (continued...)

Some aspects of the construction require certain licenses or permits, so contact a qualified contractor who specializes in building CNG stations.

Secure and review a current National Fire Prevention Association Code (NFPA-52) and/or an International Fire Code (IFC) guideline for compressed natural gas vehicle fuel systems. These codes apply to all CNG stations and facilities.

Depending on a fleet application, or commercial venture, research into the requirements of the class of vehicles (light, medium, heavy) to be fueled will be helpful. Each type will have its own impact on the design and performance of your station.

Contact the state and local municipal agencies to determine what permits or licenses are required to dispense CNG.



CNG Station Economics

The cost associated with constructing a CNG refueling station can vary significant depending on size and application and ranges from $675,000 to $1,000,000 or more depending on flow through. Developing to a standard station size within the North American market, enables developers to reduce cost by utilizing economies of scale.

The table below provides estimates of equipment and installation costs for one time-fill and two fast-fill stations, and illustrates several scenarios for the number and type of vehicles that can be refueled at the station. Please note that land costs vary and therefore were not considered in this document. Since it is recommended that fast-fill stations incorporate redundancies in their design, the table also shows a fast-fill station with two compressors. It is also important to note that the costs associated with combination-fill stations will incorporate the costs of both fast and time-fill 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
Source: "Natural Gas Vehicle Market Analysis," by TIAX, 2012 CNG Infrastructure , Table 3.3-1 .

Other CNG Installations

Mobile Refueling

A number of vendors are developing and offering mobile fueling options for CNG, LNG, and sometimes both within the same unit. Depending on the application, time and space requirements, and other factors, a mobile fueling option may be useful.

Mobile fueling typically involves equipment such as the CNG dryer, compressor, control panels and dispensers being installed on a mobile skid or flat-bed vehicle trailer. These systems are most often fast-fill and are appropriate for light, medium, and heavy-duty applications. They save on infrastructure costs and can be installed anywhere there is a gas line.

Don't have space or a gas line available? Some companies offer scheduled mobile fueling where the fueling truck arrives at regular intervals to refuel vehicles.

Single Unit CNG Home or Fleet Refueling

There are single unit time-fill systems available for the individual or small fleet owner who wants the ability to refuel a small number of vehicles. These systems are primarily made for light-duty CNG vehicles and refuel a single vehicle on a time-fill using an existing gas connection.

Fast-fill single unit systems are also under development.

CNG Maintenance Facilities

Maintenance facilities are typically designed with liquid fuels in mind, and constructed to meet basic safety requirements related to the physical properties of gasoline and diesel. Facilities constructed to service CNG vehicles must consider the differences between gaseous and liquid fuels, while ensuring the same level of safety. For example, natural gas is lighter than air and in the event of a leakage will rise, instead of pooling on the ground and must be considered in facility design.

Other CNG Installations (continued...)

NGV maintenance facilities are governed by the National Fire Prevention Association (NFPA) and required to consider the following in facility modification/ construction:

Heating System

Maintenance facilities that service gasoline and/or diesel vehicles typically mount overhead heaters near the ceiling. Since natural gas is lighter than air and auto ignites at a temperature of 1080 degrees Fahrenheit, open flame heaters are prohibited from use in NGV maintenance facilities. As an alternative, the code requires the usage of infrared, sealed combustion or catalytic heaters with a skin temperature below 800 degrees Fahrenheit. Although industry best practices suggest that NGVs should never be parked below an open flame, NFPA states that an open flame heater may only be located in a general purpose area and mounted below 18 inches from the ceiling.

Potential Ignition Sources, Including Lighting and General Electrical Equipment

In NGV maintenance facilities, potential ignition sources (i.e., anything that could create an arc or spark that would ignite natural gas in either the on or off position) should not be located 18 inches from the ceiling. Traditional lighting should be pendant mounted below the 18-inch cavity or sealed lighting systems should be utilized in NGV maintenance facilities. It is also stated that general electrical equipment should not be located within the 18-inch space below the ceiling. Class 1 Division 2 Group D rated motors are approved for usage or electrical door(s) located within the 18-inch space should be relocated.

Ventilation

NFPA defines the area extending from the ceiling down 18 inches as the Class 1 Division 2 Group D hazardous area in NGV maintenance facilities. Ventilation air is introduced at higher levels and exhausted in the lower 18 inches of the facility to prevent electrical sparks from igniting fuels. This compares to facilities for diesel and/or gasoline that have the defined Class 1 Division 2 Group D defined from the floor to 18 inches above the floor. The difference between designations is based on the characteristics of the varying fuels and where they will gather or pool during a leak.

Other CNG Installations (continued...)

The table below compares the recommendations for modifying an existing facility with specifications for a new facility.

Requirement/ Recommended Practice	Existing Facility Modification	New Facility Design
Ventilation		
Methane detection	Add methane detection	Specify methane detection for new facility
HVAC systems	Replace existing system or add supplementary exhaust system	Specify to function counter flow to HVAC conventional system to include no open flame heaters
Supplementary exhaust	Add supplementary exhaust fans that are Class 1 Div 2 Group D rated	N/A
Class 1 Div 2 Group D fans	See above	Specify for new facility
Heating Systems		
Space heaters	Replaced with sealed combustion, infrared or catalytic heaters with skin temperature less than 800°F	N/A
Potential Sources of Ignition		
Pendant mount lighting	Pendant mount below 18 inches from ceiling	N/A
Class 1 Div 2 Group D lighting	Install Class 1 Div 2 Group D lighting	Specify Class 1 Div 2 Group D lighting
Other Ignition Sources within Class 1 Div 2 Group D area (motors, switches, etc.)	Move below 18 inches from ceiling or replace with Class 1 Div 2 D rated equipment	Specify Class 1 Div 2 Group D rated equipment

Note. From "Natural Gas Vehicle Market Analysis," by TIAX, 2012 CNG Infrastructure, Table 3.4.2-1.

Appendix A
Routes to CNG Fueling Facility Development

(Select an Engagement Model, and then follow the outline below beginning with General information)

Engage an Engineering Firm
- Develop specification
- Submit to customer
  - Construction company develops bids and builds station

Engage a Construction Company
- Develop specifications
- Acquire bids
- Provide turnkey CNG fueling facility

Engage a Manufacturer/Packager
- Acquire bids
- Submit to construction company and/or customer
  - Construction company builds station
  - Customer manages construction in-house

Engage a CNG Retailer
- Develop specifications
- Acquire bids
- Submit proposal to customer
- Provide Turnkey CNG Fueling Facility

1. General information

   a. Pre-select potential CNG station locations based upon

      i. Potential Customer Base

      Ii. Fuel Product Availability

      iii. Contact LDC and/or Pipeline Company to determine natural gas availability and flow rate (pressures)

      iv. Determine Political Jurisdictions

         1. Contact Local Fire Authority

         2. Contact Permitting Agency

Appendix A

Routes to CNG Fueling Facility Development (continued...)

2. Codes and Regulations relating to CNG Stations (partial Listing)
   a. American National Standards institute (ANSI) — Pressure Vessel Code 8
   b. American Society of Mechanical Engineers (ASME)—B31.3 Piping
   c. American Society for Nondestructive Testing (ASNT)
   d. National Electrical Manufacturers Association (NEMA)
   e. National Fire Protection Association (NFPA)
      i. Code 52 – Boundaries
      ii. Code 70 - National Electrical Code
      iii. Code 30A — Use of Multiple Fuels
   f. National Electric Code mac) - Also NFPA 70
   g. Occupational Safety and Health Act (OSHA)
   h. Uniform Building Code, Local Jurisdiction (UBC)
   i. Uniform Fire Code (UFC)
   j. Uniform Plumbing Code (UPC)
   k. National institute of Standards and Technology (NIST)
   I. Society of Automotive Engineers (SAE) — J1616 Fuel Quality
   m. Underwriters Laboratory (UL)
3. Equipment Selection based upon demand
   a. Sizing
   b. Station Design
      i. Dryer
      ii. Compressor
      iii. Priority valve panel
      iv. Storage
      v. Sequential
      vi. Temperature compensation
      vii. Dispenser - dispenses natural gas into vehicles
      viii. Fuel and Communications lines, conduit, etc.

Appendix A
Routes to CNG Fueling Facility Development (continued...)

4. Budgeting
    a. Preliminary Estimates based upon bids for
        i. Site preparation
        ii. Equipment
        iii. Logistics
        iv. Project Management
        v. Permitting
        vi. Contingencies
    b. Payback based upon known or contracted throughput
5. Obtain Financing (if Applicable)
6. Award bids and Purchase Equipment
7. Permitting & Construction
8. Start - up with Equipment Manufactures
9. Maintenance per Manufacturers recommendations

Source: A portion of the outline above is an adaptation from "Natural Gas Vehicle Market Analysis," by TIAX, 2012 CNG Infrastructure, Table 3.4.1-1.

Appendix B – Station Footprint Examples

This appendix includes five CNG station designs that illustrate the space generally required for dispensing unit islands, vehicle access and egress, and CNG vehicle refueling equipment (compressor, storage vessels, dryers and other equipment).

Given the wide variety of vehicle types, applications, and duty cycles, there is no single formula for designing a CNG vehicle refueling station and estimating the associated footprint. However, significant impacts on space requirements may be avoided by leveraging existing gasoline or diesel fueling infrastructure or, in the case of "time fill" applications, existing vehicle parking spaces.

Convenience Store

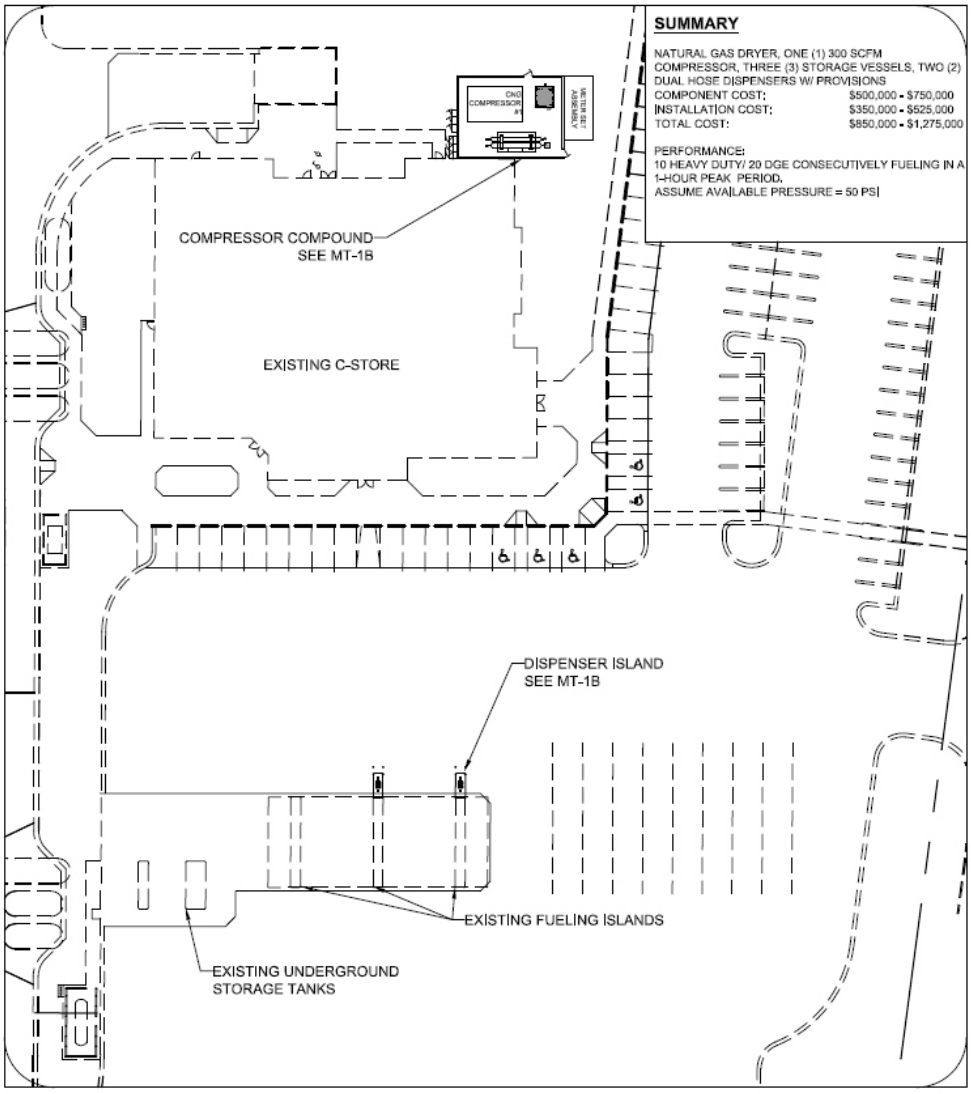
Existing convenience stores usually supply traditional fuels and often have space available for CNG expansion. The design minimizes the space impact on existing operations by placing the CNG vehicle refueling station in a separate location that does not impact parking spaces or convenience store access. Two (2) dual hose dispensers are added to the existing gasoline dispenser islands to enhance and leverage existing vehicle fueling space.

The station footprint is approximately 34' by 55' and includes all CNG vehicle refueling station equipment; including a single 300 standard cubic feet per minute (scfm) compressor, gas dryer, 36,000 standard cubic feet (scf) of storage, control equipment, and gas utility meter set assembly.

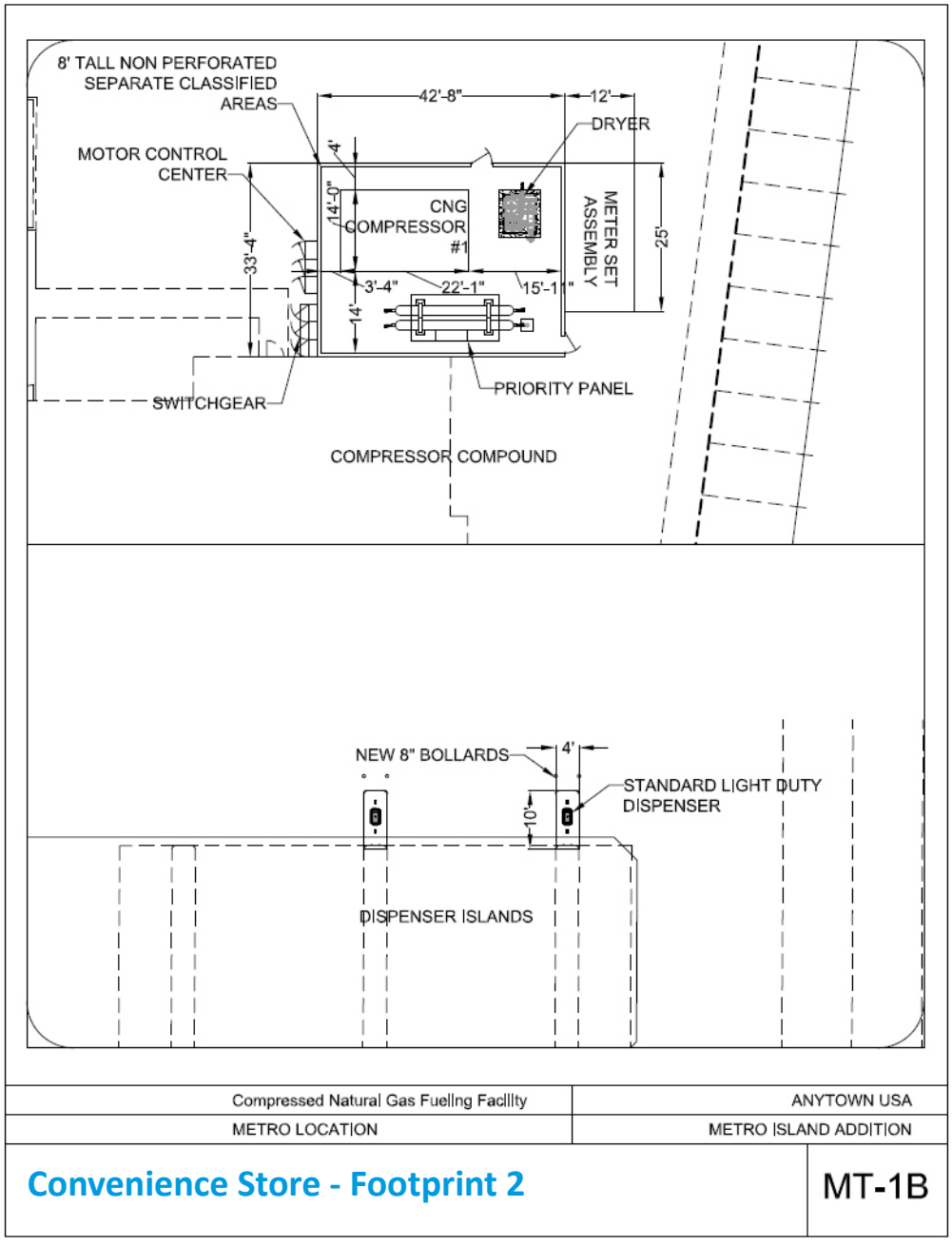
Total estimated cost for equipment and installation is $850,000 but may range from $500,000 to over $1,000,000. This design is capable of fueling up to 10 heavy-duty vehicles requiring an average of 20 diesel gallon equivalents over a one hour peak period.

Example layouts of the convenience store model are shown on the following two pages.

Appendix B – Station Footprint Examples (continued...)



Appendix B – Station Footprint Examples (continued...)



Appendix B – Station Footprint Examples (continued...)

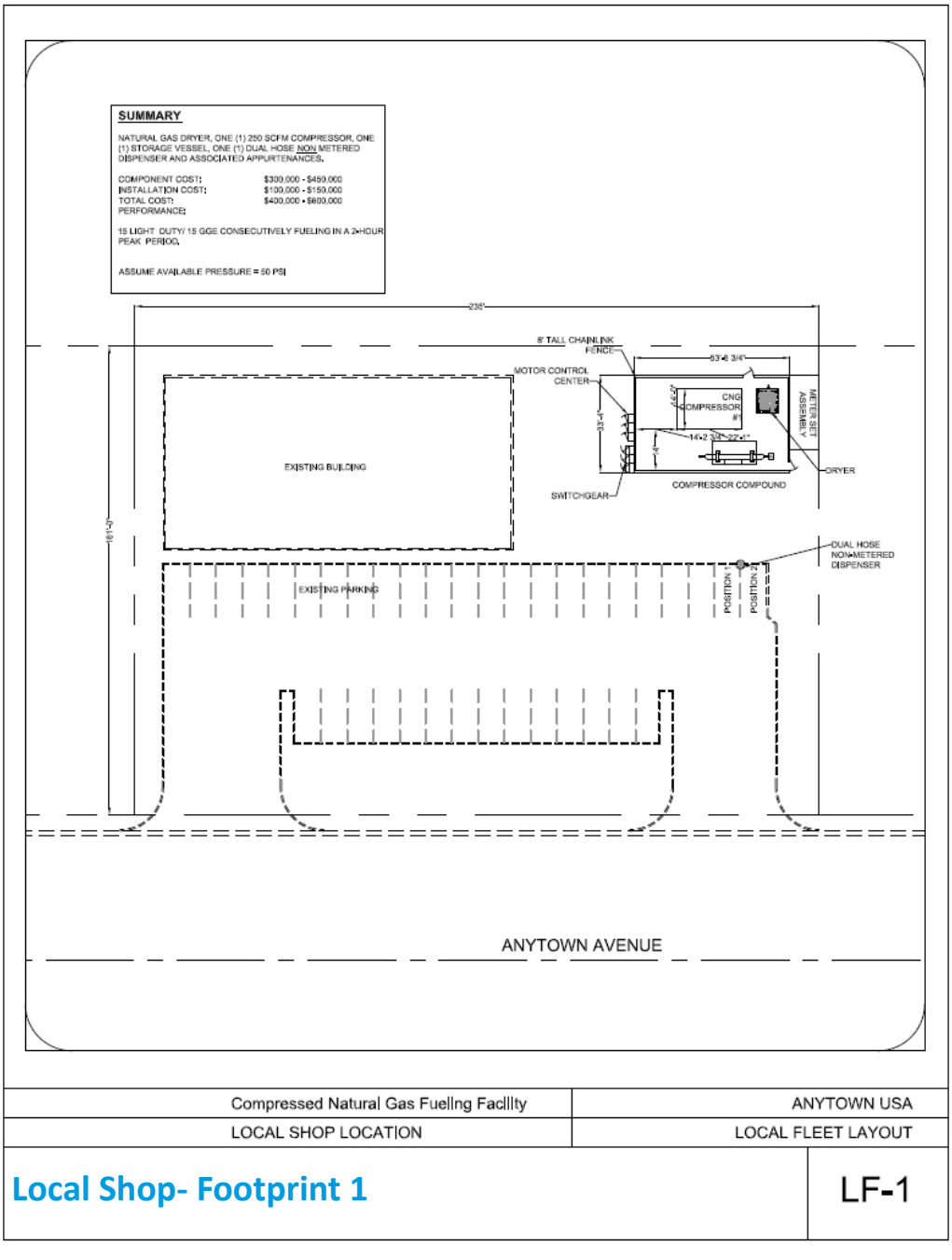
Small, Private Access Station for Local Fleet

This CNG station layout is intended for a small fleet of light duty vehicles who will be adding CNG fueling to an existing parking lot. The station will be for their own private use (not publicly accessible) so there is no need to meter the fuel dispensed into the vehicles like in a retail situation. To minimize cost, the station is simply designed with a dual-hose fill post as the fast fill dispenser. The system would operate as a buffer system so only one storage vessel is required.

The station footprint is approximately 33' by 53' and includes all CNG vehicle refueling station equipment; including one (1) 250 scfm compressor, gas dryer, 12,000 scf of storage, control equipment, and gas utility meter set assembly. Total estimated cost for equipment and installation is $400,000 – 600,000. This design is capable of fueling approximately 15 light-duty vehicles fueling consecutively over a two hour period.

Blueprint for the Local Fleet layout is shown on the following page.

Appendix B – Station Footprint Examples (continued...)



Appendix B – Station Footprint Examples (continued...)

Refuse Hauler

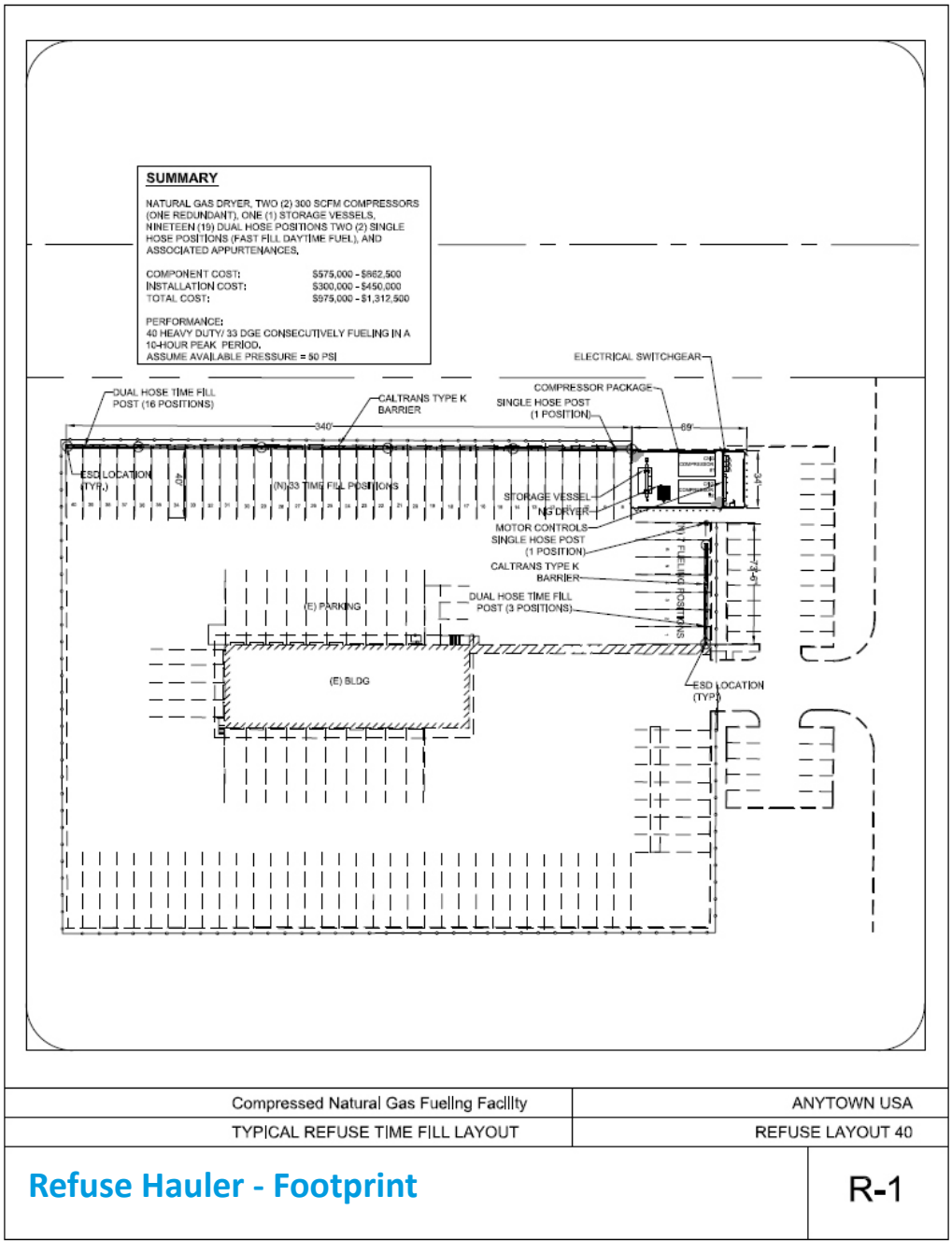
The refuse hauler station layout is intended for existing refuse hauler operators that are interested in fueling CNG refuse haulers. The design minimizes the space impact on existing operations by placing the CNG vehicle refueling station in a location that does not impact parking and uses a "time fill" system to provide fuel for thirty-eight (38) CNG refuse haulers at existing parking locations. It also provides two "fast fill" hoses and limited storage to provide daytime fueling.

The station footprint is approximately 34' by 69' and includes all CNG vehicle refueling station equipment; including two (2) 300 scfm compressors (provides redundancy), gas dryer, 12,000 scf of storage, control equipment, and gas utility meter set assembly. Total estimated cost for equipment and installation is $975,000 and over. This design is capable of fueling up to 40 heavy-duty vehicles requiring an average of 33 diesel gallon equivalents over a ten (10) hour period.

It should be noted that the primary function of this station is to provide cost-effective "time fill" refueling of refuse trucks. The fast fill hoses and single storage vessel are provided to top off refuse trucks or fill the occasional light duty vehicle but is not intended as the primary fueling outlet. The station is capable of providing "fast fill" refueling if required, but the compressors will run after a few vehicles have already used the available storage. If true "fast fill" refueling is required, a different design would be required that would likely include a larger compressor and additional storage.

An example layout of the refuse hauler model is shown on the following page:

Appendix B – Station Footprint Examples (continued...)



Appendix B – Station Footprint Examples (continued...)

Airport Transit

The airport transit CNG vehicle refueling station layout is intended for airport transit fleets, such as buses, taxis, and airport shuttles. These designs use large compressors and four (4) dual hose dispensers and two (2) dual hose transit dispensers (higher throughput) to quickly process vehicles requiring refueling through four (4) fueling lanes.

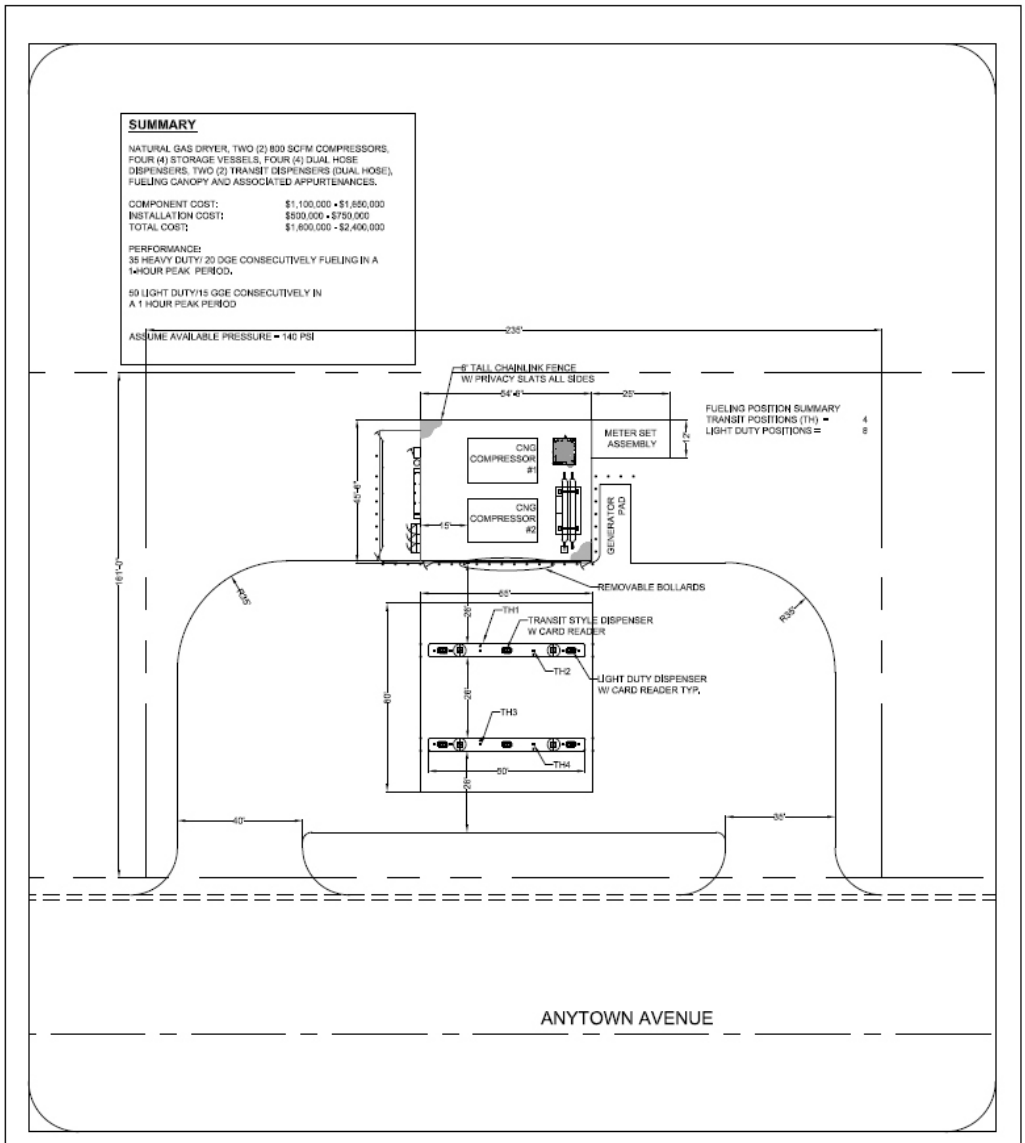
The station footprint is approximately 181' by 235' and includes all CNG vehicle refueling station equipment; including two (2) 800 scfm compressors, gas dryer, 72,000 scf of storage, control equipment, and gas utility meter set assembly.

Total estimated cost for equipment and installation is $1,800,000, which does not including site work, paving, canopies, etc. All site work has been excluded from the cost estimate as the size of these stations typically may require additional site preparation that may be extensive and may drastically alter costs.

This design is intended to fuel up to 35 heavy-duty vehicles requiring an average of 20 diesel gallon equivalents (dge) over a one hour peak period or 80 light-duty vehicles requiring an average of 16 gasoline gallon equivalents (gge) over a one hour peak period.

An example layout of the airport transit model is shown on the following page:

Appendix B – Station Footprint Examples (continued...)



Appendix B – Station Footprint Examples (continued...)

Truck Stop

Existing truck stops supply traditional fuels and often have space available for CNG expansion. Since truck stalls are a major source of revenue, the design minimizes the space impact on existing operations by placing the CNG vehicle refueling station in a location that allows for CNG dispensers and canopies to be phased in over time over existing truck stalls to create fueling lanes. Up to four (4) dual hose CNG vehicle refueling station dispensers can be added as volume increases over time.

The station footprint is approximately 48’ by 70’ and includes all CNG vehicle refueling station equipment; including two 400 scfm compressors, gas dryer, 36,000 cubic feet of storage, control equipment, and gas utility meter set assembly. Each of the two canopies and associated dual hose dispensers are approximately 25’ by 36’ of additional space and convert three truck stalls into three truck fueling lanes.

Total estimated cost for equipment and installation is $1,100,000, not including any site work, paving, canopies, etc. All site work has been excluded from the cost estimate as the size of these stations typically may require additional site preparation that may be extensive and may drastically alter costs.
This design is intended to fuel up to 20 heavy-duty vehicles requiring an average of 20 diesel gallon equivalents over a one hour peak period, or eight heavy-duty trucks requiring an average of 50 diesel gallon equivalents over a one hour period.

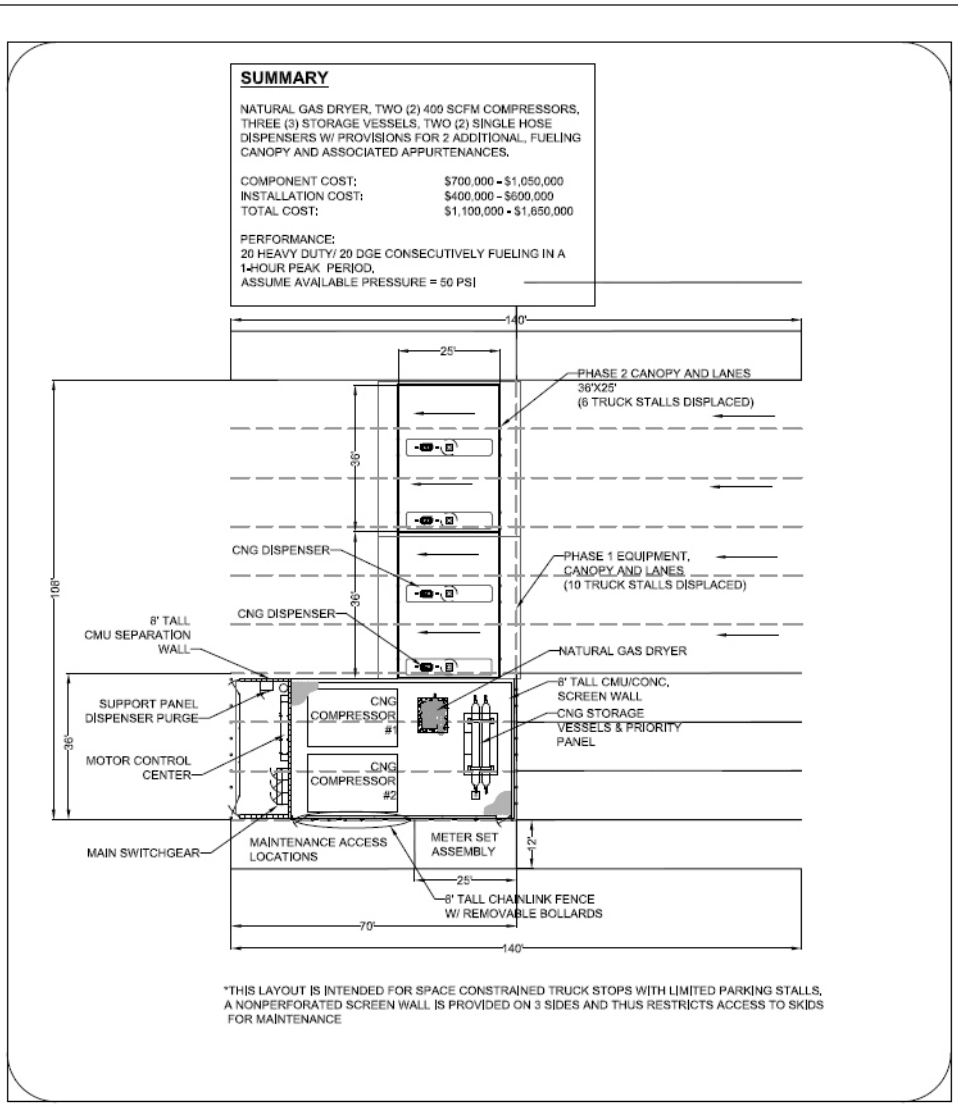
Appendix B – Station Footprint Examples (continued...)

It should be noted that this layout represents one of many options for truck stop refueling that always involve a trade-off between capital cost and providing adequate fueling capacity. This dilemma can only be resolved by knowing or accurately estimating the arrival/fueling patterns of the vehicles. In a high throughput application, such as central fueling for a fleet of trucks arriving continuously, the vehicles would be filled primarily from compression and the storage would be used mainly to limit the number of starts and stops of the compressors.

However, in an application such as a truck stop on an interstate highway with random arrival patterns, a single truck would generally fuel from the 36,000 scf (roughly 80 gallons of usable storage) storage tanks depicted in the station footprint. This amount of storage should be considered the minimum amount to install at a truck stop and the station developer should consider adding additional storage depending on the anticipated throughput and arrival patterns of vehicles.

An example layout of the truck stop model is shown on the following page:

Appendix B – Station Footprint Examples (continued...)



Appendix C – Sample Forms & Reference Pieces

Sample Project Schedule

CNG PROJECT DESIGN SCHEDULE

#	Project Division	Project Description / Notes	Completion Date	% Complete	$K Estimate	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	AS OF: Oct	Nov	Dec
1	Find and Settle Land for Station			0	$0.00													
2	Assess Gas Availability			0	$0.00													
3	Determine Line Pressure			0	$0.00													
4	Assess Tariffs or Delivered Price			0	$0.00													
5	Select CNG Equipment Vendor			0	$0.00													
6	Select Project Engineer			0	$0.00													
7	Order CNG Equipment			0	$0.00													
8	Finalize Initial Design Documents			0	$0.00													
9	Complete Local Permit Process			0	$0.00													
10	Sign Gas Delivery Agreement			0	$0.00													
11	Get Permission to Tap Line			0	$0.00													
12	Obtain Right-of-Way for Pipeline			0	$0.00													
13	Finalize Site Design/Specifications			0	$0.00													
14	Select Construction Manager/Contractors			0	$0.00													
15	Construct CNG Filling Station			0	$0.00													
16	Lay Pipeline to CNG Station			0	$0.00													
17	Deliver CNG Equipment			0	$0.00													
18	Tap Main / Transmission Line			0	$0.00													
19	Schedule Gas Delivery Volumes			0	$0.00													
20	Install Meter & Take Delivery of Gas			0	$0.00													
21	Complete Landscaping & Site Details			0	$0.00													
22	Sign Agreement with Fuel Mgt. System			0	$0.00													
23	Complete Automation and Start-Up			0	$0.00													
24				0	$0.00													
25				0	$0.00													

Appendix C – Sample Forms & Reference Pieces (continued...)

CNG Fueling Station Component Costs

Component	Estimated Costs, $
Gas Supply Line	20,000 - 150,000
Compressor Package	200,000 - 400,000
Noise Abatement	0 - 40,000
Gas Dryer	50,000 - 80,000
Storage (3 or 6 ASME)	100,000 - 200,000
Dispenser (1 or 2 00M-hose)	60,000 - 120,000
Card Reader Interface	20000- 30,000
Engineering	25,000- 75,000
Construction	300,000 — 600,000
Contingencies	10 — 150,000
Estimated Total (Excludes, land cost)	**805,000 – 1,845,000**

NOTE: These ranges are representative of the low and high costs of constructing a CNG fueling station and are suggested as general cost guidelines. Each specific site will have its unique requirements and associated costs.

Appendix C – Sample Forms & Reference Pieces

Customer Fleet Information

CUSTOMER FLEET INFORMATION SHEET

Company Name: _____

Address: _____

Contact Person: _____

Phone #s / Office/Cell: _____

E-Mail Address: _____

FLEET INFORMATION

Number of Vehicles in Fleet: _____

Types of Vehicles in Fleet: _____

Current per gallon gasoline price: _____

Current per gallon diesel price: _____

Fuel Consumption Volume(s): _____

Do vehicles return to a central place each day or are they taken home by drivers? _____

What is the normal replacement schedule for the fleet? _____years, or _____miles

Where are vehicles fueled?

Company Site _____

One Retail Site _____

Various Retail Sites _____

Number of 8 hour shifts vehicles (especially forklifts) operate: _____

_____

Date survey was completed: _____

Please use attached “Vehicle Information Sheet” to provide specific information for each vehicle.

Appendix C – Sample Forms & Reference Pieces (continued...)

Customer Vehicle Information

CUSTOMER VEHICLE INFORMATION SHEET

Vehicle Number or Company Vehicle Identifier:

_____

Make: _____

Model: _____

Year: _____

Engine Size: _____liters; _____cylinders

GVW (Gross Vehicle Weight): _____

Current Mileage: _____

Gallons of Fuel Consumed Annually:

Gasoline: _____ Diesel: _____

How often is this type of vehicle replaced? _____ years, or _____ miles

Maximum Miles Driven per Day/Shift: _____ miles

(for determining range per CNG fill, cylinder capacity, need for bi-fuel capabilities, etc.)

Vehicle typically refuels in the morning, afternoon, or at night:

_____

Vehicle refuels daily ___, every other day ___, or about every ___ days

Number of 8 hour shifts the vehicle (especially a forklift) operates: ___

Date survey was completed: _____

Appendix D – 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 (approximately 6.22 lbs. or 139,000 BTUs of natural gas)

EPAct - Energy Policy Act

ESD - Emergency shutdown device

GGE - Gasoline gallon equivalent (approximately 5.66 lbs. or 125,000 BTUs 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

PSI - Pounds per Square Inch

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