COMPRESSED NATURAL GAS AS A VEHICLE FUEL – AN ATTRACTIVE ALTERNATIVE

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In the United States, we are seeing accelerated interest in use of compressed natural gas as a vehicle fuel. This is spurred by recent developments including new methods of drilling that have greatly increased its supply and by environmental pressure to reduce greenhouse gasses. For potential CNG station developers, there are important issues to understand first. This first series will define key terms that are essential for companies considering converting to CNG vehicles or installing CNG stations. It will also touch on two of four key reasons why the use of natural gas as a vehicle fuel is a practical fuel substitute.

The following should be understood by anyone considering installing a Compressed Natural Gas fueling station.

- Compressed natural gas (CNG) is natural gas that has been highly compressed to reduce its volume to make it practical for application as a vehicle fuel. New CNG vehicles store natural gas at 3,600 psig. Older ones may use 3,000 psig.
- One standard cubic foot (SCF) of natural gas will have the same fuel value regardless of the actual pressure.
- To fairly compare the costs of CNG to gasoline, gallons of gasoline equivalent (GGE) is used. GGE is the amount of natural gas that would have the same energy content as one gallon of gasoline.

Why natural gas

The reasons that natural gas is an excellent choice for vehicle fuel may be summarized as follows – abundance, clean burning, low cost, and safety. Part-one will discuss abundance and clean burning.

Abundance– This must be viewed as availability relative to need. In 2009, the United States consumed 94.6 quads (quadrillion Btu = 10E15 Btu) [1]. Of the total usage, 28 percent was used in transportation of which 12 percent of that was used in aviation. Assuming that aviation would be the least likely transportation segment to switch to natural gas, then the total fuel usage for ground and water transport was 94.6(.28)(1-.12) = 23.3 quads.

Oil usage was 37 percent of the total energy usage, or 35.0 quads (20.0 quads being imported). Now, 70 percent of oil is used for transportation or 24.5 quads. Furthermore, coal usage was 21 percent of the total energy consumption or 19.9 quads.

A reasonable assumption might be that we wish to replace half of the non-aviation transportation segment and half of the coal consumption with natural gas. Then the demand for natural gas would be 23.3(.5) + 19.9(.5) = 21.6 quads added to the current demand of 23.4 quads or 45.0 quads. For simplicity, we have assumed a one-for-one replacement of natural gas for oil or coal.

The supply of natural gas within the United States is estimated at 2,590 trillion standard cubic feet (TSCF) [2]. This includes both unproved and proved reserves. At roughly 1,000 Btu/SCF, then we have 2,590 quads available. Thus, using the future demand scenario described above, we have a 2,590/45 = 58 year supply of natural gas.

Clean burning– The transportation sector is one of the greatest contributors to air pollution in the United States. According to the Department of Energy (DOE), about half of all air pollution and more than 80 percent of air pollution in cities are produced by cars and trucks in the United States.

Natural gas can reduce these high levels of pollution from gasoline and diesel powered vehicles. According to the EPA, compared to traditional vehicles, vehicles operating on compressed natural gas have reductions in carbon monoxide emissions of 90 to 97 percent and reductions in carbon dioxide (greenhouse gas) emissions of 25 percent. Nitrogen oxide emissions can be reduced by 35 to 60 percent, and other non-methane hydrocarbon emissions could be reduced by as much as 50 to 75 percent. In addition, because of the relatively simple makeup of natural gas in comparison to traditional vehicle fuels, there are fewer toxic and carcinogenic emissions from natural gas vehicles, and virtually no particulate emissions [3].

Low cost - In addressing the cost of CNG, to be fair, one must look at, not just the cost of natural gas, but the costs of compression and dispensing and the added cost of the CNG vehicle. The gas itself can be purchased by the station at around $10.00 per MSCF. However, taxes and equipment costs increase the price at the dispenser beyond this value. For the first quarter of 2011, average pricing for fuel in the United States were [5]:

Gasoline	$3.69/gal
Diesel	$4.04/gal
CNG	$2.06/GGE

This represents a savings of $1.63/gal over gasoline and $1.98/gal over diesel fuel.

In considering whether or not a CNG vehicle would be cost-effective for the consumer, the main consideration is how much fuel will be burned annually. Currently, the added cost of CNG power is such that, on economic considerations alone, only vehicles with high annual fuel usage can justify the cost. Additionally, since there are relatively few CNG filling stations available, vehicles with a predictable daily travel pattern are best considered for CNG. These two criteria, high fuel consumption and predictability are best met by fleet vehicles such as transit buses, trash compactors, delivery trucks, airport shuttles, taxis, etc. and such vehicles often show paybacks of less than two years on the added cost of the vehicle.

It is our belief that, as more fleet vehicles are converted and fleet filling stations allow for public fill options, the criterion of predictable travel pattern will diminish. Furthermore, as CNG becomes more the norm for vehicle fuels, the added cost of the vehicles will be reduced. Considering the supply situation discussed earlier, CNG prices at the pump are expected to be more stable than gasoline well into the future. Government, both state and federal, subsidies for CNG fueling stations and CNG vehicles are aimed at addressing these issues, providing incentives to enable crossover to a CNG-based infrastructure.

Safety - CNG is one of the safest transport fuels available, being generally regarded as safer than gasoline or diesel. In its natural state, methane is odorless. As a safety measure, the gas is odorized with mercaptans prior to distribution to provide a ready means of leak detection.

CNG has a high ignition temperature, about 1,200 degrees Fahrenheit, compared with about 600 degrees Fahrenheit for gasoline. It also has a narrow range of flammability, that is, in concentrations in air below about 5 percent and above about 15 percent, natural gas will not burn. The high ignition temperature and limited flammability range make accidental ignition or combustion of CNG unlikely. A leak, causing fuel contact with hot engine surfaces is much less likely to result in a fire if CNG is the fuel

CNG has no known toxic or chronic physiological effects (it is not poisonous). Exposure to a moderate concentration may result in a headache or similar symptoms due to oxygen deprivation but it is likely that the smell would be detected well in advance of concentrations being high enough for this to occur.

CNG fuel systems are sealed which prevents any spills or evaporative losses. If a leak occurs due to an accident, maintenance procedure or fitting malfunction in an NGV fuel system, the natural gas will dissipate into the atmosphere because it is lighter than air. Natural gas is not toxic or corrosive and will not contaminate ground water. CNG combustion produces no significant air toxins, which are a concern in gasoline and some other alternative fuels.

CNG Fuel storage cylinders are much, much stronger than diesel or gasoline tanks, with the result that they are less likely to rupture in an accident.

In most circumstances, natural gas is delivered via underground pipeline networks. This method eliminates the need for road tankers to deliver fuel from the refinery, further enhancing the overall safety of CNG as a fuel [4].

Note however, that the fact that natural gas is lighter than air leads to special problems in vehicle repair facilities that must be addressed. The vapors of liquid fuel are denser than air and tend to hover near the floor. Therefore, safety issues are related to eliminating ignition sources close to floor level. If natural-gas-fueled vehicles are to be repaired, then the emphasis is on eliminating ignition sources near the ceiling or to maintaining proper ventilation. Furthermore, the heating system may have to be replaced to eliminate hot surfaces that could become ignition sources.

GENERAL FUELING APPROACHES

There are two general approaches to filling vehicles with compressed natural gas – time fill and fast fill.

Time Fill – As implied by the name, time fill takes place over a period of hours, say overnight. The main reason for using this approach is to reduce the cost of equipment. One to several dozen vehicles are simply connected to the compressor output and left to fill overnight. This approach is generally applicable to small fleets which are returned to a central location daily. For larger fleets, the compressor size may approach that of a fast-fill system and the need for multiple dispensers may reduce or eliminate the cost savings in the dispensers. Still, logistics may favor time-fill. When a large number of vehicles such as trash compactors return to home base at approximately the same time, they can be simply parked, connected to the fill system and left for the night, eliminating the need for queuing at the fast-fill dispensers.

Fast-Fill – Fast-fill systems are, from the consumer's point of view, very similar to gasoline dispensing system. The customer scans his credit card, waits for approval, then removes the nozzle from the dispenser body and connects it to his vehicle fill port. Filling takes place over a period of a few minutes, then stops automatically when required vehicle pressure is reached. There are two types of fast-fill systems, buffer and cascade. A qualified engineering partner can help identify which system is more appropriate for a given operation.

With a natural gas supply that could range between 50 and 110 years, depending on use levels, potential to minimize air pollution, win-win savings for both consumer and supplier, and a more safe, reliable way to transport fuel, it is easy to justify CNG as a preferred alternative as a vehicle fuel.

EQUIPMENT SELECTION & STATION DESIGN

Many factors must be considered when selecting and specifying the equipment and infrastructure for a CNG fueling station. All equipment should be designed and selected by an experienced engineering partner and in accordance with applicable codes. The major equipment components to be considered in planning a new CNG fueling station include the odorizer, gas dryers, compressors, storage vessels, dispensers, and point of sale systems. Gas delivery pressure from the gas supplier will vary due mainly to demand from all users on given supply line. However, the gas company can usually provide gas at a given normal pressure, and this is the point for which the equipment is selected.

The piping design should be handled by a qualified professional engineer, and not left to a plumber to work it out. Generally, the piping scope of work starts at the meter. Once the gas has been compressed, it is usually transported via stainless steel tubing to reduce corrosion and erosion.

Design of a CNG station is best accomplished in collaboration between the prospective owner and an experienced engineering team. The owner best understands his needs and the engineer can best translate those needs into an orderly and cost effective installation.

The first step in the design process should be to develop a "Design Criteria" document that lists all of the expectations of the Owner. This will provide a basic road map for the project so that engineers and designers are not reliant on word of mouth instructions or randomly sent emails. The next step is to develop a preliminary layout, based on assumed equipment sizing. Meanwhile, equipment specifications are developed and put out for bid. Once equipment has been selected and certified drawings are received, the actual equipment drawings are placed on the layouts. These will show piping and electrical connection locations. Now, piping, electrical and concrete drawings can be completed.

PERMITTING

Various permits are required for CNG stations. The geographical location of the facility and the "Authority Having Jurisdiction" will affect the number and types of permits required. Each site will have different issues and will require different permits. Most permits will be those required by state and local entities. A qualified engineering partner will know the various permitting requirements.

Overall the construction of a CNG fueling facility is a relatively clean construction process and requires fewer permits than a liquid fuel operation. As previously stated, the accidental release of natural gas would not pollute the ground or water as would a spill from a liquid fuel stations. Liquid fuel facilities require permitting of the discharge of water used for setting the underground liquid fuel tanks. CNG fueling facilities use above ground tanks and do not require water to ballast the tanks negating the need for that permit.

GOVERNMENT INCENTIVES

There are a number of incentives and grants that are available. Their purpose is to stimulate an infrastructure conversion that will make owning CNG vehicles more attractive, thereby reducing atmospheric pollution and dependence on foreign oil. Assuming success of the programs, it can be assumed that they will be phased out as the conversion takes hold.

State incentives vary. Currently, the state of Louisiana offers a 50% refundable tax credit with no limit for the incremental cost of CNG fueling equipment and vehicle conversion or purchase. Dual fuel and dedicated both qualify.

At present the Federal Government offers 30% tax credit up to a limit for purchase or conversion of a vehicle to dedicated CNG. Dual fuel vehicles do not qualify. Some credit for fueling facilities is available, but more important 100% depreciation is allowed in 2011 for CNG fueling equipment purchased and put in service in 2011. That drops to 50% for 2012. There is other significant legislation pending at the federal level. In addition, there may be grant money available from DOE (Department of Energy) and DNR (Department of Natural Resources). Engineering firms that provide CNG design services may provide assistance in grant application.

TIME TO DEVELOP

Generally, the time required to develop a CNG station will be about eight (8) months from the time the Engineer is given the green light to proceed until startup. Time is often limited by equipment delivery, which may be 4 to 6 months after placement of order. Allow about six weeks at the beginning to prepare bid packages, send them out and evaluate bids. The balance of the station should be complete by the time the equipment is delivered so that all is required is to set the equipment in place, hook it up and go through the start-up and training procedures. Allow one month after delivery for equipment installation and connection.

CONCLUSION

A CNG fueling station can, in some situations, be an attractive opportunity for return on investment. Current economics and infrastructure favor stations designed primarily to service fleet vehicles that use large quantities of fuel and have a predictable daily circuit.

A public option can add to the income of a station, while at the same time, making CNG vehicle ownership more attractive to some private vehicle owners. State and federal incentives are available to help jump-start the industry by providing the infrastructure funding required to make a transition from an oil-based to a natural-gas-based economy possible.

An experienced engineering partner can help to ensure the optimal selection of equipment, careful layout and design, and proper permitting. All of these items are key to a safe, efficient, and successful CNG fueling station project. For more information on CNG fueling stations or to read this article in its entirety, please visit www.hga-llc.com and click the CNG banner.

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