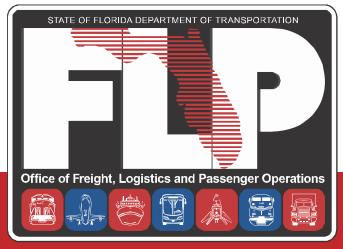
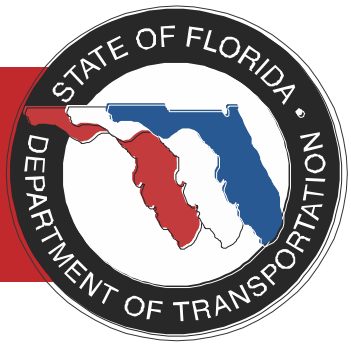
White Paper
Alternative Transportation Fuels





November 2013

Table of Contents

Background

Introduction to Alternative Transportation Fuels

The U.S. Department of Energy reports that more than a dozen alternative fuels are in production or under development for use in alternative fuel vehicles and advanced technology vehicles. The continuing growth in the use of alternatives to gasoline and diesel stems from a number of motivating factors, including reduced dependence on foreign oil, diversification of the transportation fuel supply, reduced air emissions and cost considerations. Primary examples of alternative fuels include:

- ***Biodiesel*** - A domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant grease for use in diesel vehicles. The physical properties of biodiesel are similar to those of petroleum diesel, but it is a cleaner-burning alternative.
- ***Electricity*** - Electricity can be used to power all-electric vehicles and plug-in hybrid electric vehicles. These vehicles can draw electricity directly from the grid and other off-board electrical power sources and store it in batteries.
- ***Ethanol*** - Ethanol is a renewable fuel made from various plant materials collectively known as "biomass." More than 95% of U.S. gasoline contains ethanol in a low-level blend to oxygenate the fuel and reduce air pollution.
- ***Natural Gas*** - Two forms of natural gas are used in vehicles: CNG and LNG. Both are clean-burning, domestically produced, relatively low priced, and widely available. Because of the gaseous nature of this fuel, it must be stored onboard a vehicle in either a compressed gaseous (CNG) or liquefied (LNG) state.
- ***Propane*** - Also known as liquefied petroleum gas (LPG), propane is a clean-burning, high-energy alternative fuel that is produced as a by-product of natural gas processing and crude oil refining.
- ***Hydrogen*** - Hydrogen is a potentially emissions-free alternative fuel that can be produced from domestic resources for use in fuel cell vehicles. Although not widely used today as a transportation fuel, researchers are working toward the goal of clean, economical, and safe hydrogen production and hydrogen fuel cell vehicles.

The following discussion examines alternative fuels within the context of HB 599 (2012), and the resulting Freight Mobility and Trade Plan (FMTP). The 2012 legislation directed the Florida Department of Transportation and its partners to develop the FMTP to define policies and investments that will enhance Florida's economic development efforts into the future. The legislation specified that one of the goals of the FMTP is to increase the implementation of natural gas and propane energy policies that reduce transportation costs for businesses and residents located in the state. As a result, this white paper focuses principally on issues surrounding the deployment of these alternative transportation fuels for freight and goods movement.

Natural Gas and Propane Fundamentals

There are currently 15 million natural gas vehicles in use worldwide. Iran, Pakistan, Argentina, Brazil, and India presently operate the largest natural gas vehicle fleets. Similarly, there are

approximately 15 million propane vehicles in use around the world. The market for these types of alternative fuel vehicles is growing. Navigant Research has forecasted that the number of natural gas vehicles on roadways worldwide will reach nearly 35 million by 2020.[1] Within the U.S. there are approximately 135,000 natural gas vehicles and 270,000 propane vehicles currently in use.

Natural gas and propane vehicles have represent a number of benefits compared to conventionally fueled vehicles. Both utilize domestically produced fuels that reduce U.S. dependence on foreign oil and increase energy security. Compared with vehicles fueled by conventional diesel and gasoline, natural gas and propane vehicles produce lower levels of emissions (including greenhouse gases), depending on vehicle type, drive cycle, and engine calibration. Heavy-duty natural gas and propane vehicles are significantly quieter than comparable diesel vehicles and generally experience lower maintenance costs. Finally, natural gas and propane vehicles are similar to conventionally fueled vehicles in terms of power, acceleration, and cruising speed (although driving ranges and fueling infrastructure currently limit some applications).

Natural gas and propane vehicles generally come in one of two fuel configurations: dedicated or bi-fuel (also operate on gasoline or diesel). While there are a limited number of natural gas and propane vehicles currently available from original equipment manufacturers, the number is growing. Vehicle conversions provide alternative fuel options beyond what is available from original equipment manufacturers. In general, natural gas vehicles which operate on CNG are good choices for high-mileage, centrally-fueled fleets that operate within a limited area. The energy density of LNG is greater than for CNG so more fuel can be stored onboard. As a result, LNG is often the preferred choice for vehicles needing to travel long distances. The following discussion profiles popular alternative fuel options for heavy-duty vehicle applications:

- ***School Bus*** - CNG and propane are increasingly popular alternatives to gasoline and diesel fuel for school buses. Hybrid electric buses and plug-in hybrid electric buses are also available.
- ***Shuttle Bus*** - CNG, propane, hybrid electrics, and fuel cells are potential options for shuttle buses and large passenger vehicles that provide transportation on standard routes.
- ***Transit Bus*** - Hybrid transit buses, along with those powered by CNG or LNG, are available. Fuel cell demonstrations are also in progress.
- ***Refuse Truck*** - Many fleets have refuse trucks with CNG engines, and they can even run on landfill gas where biomethane processing facilities are in operation. Regular routes and stop-and-go operation make refuse haulers a good application for hybrid operation as well.
- ***Tractor-Trailer*** - CNG and LNG systems are increasingly attractive options for this application. Diesel electric hybrids offer fuel-saving hybrid operation with the convenient availability of diesel.

[1] *Market Data: Natural Gas Vehicles (Global Natural Gas Vehicles Sales and Refueling Infrastructure 2013-2020)*, Navigant Consulting, 2013

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

According to the U.S. Department of Energy (DOE) there are more than 10,000 alternative fuel stations across the nation, compared to approximately 160,000 gasoline stations. This total includes 1,069 CNG facilities, 146 LNG facilities, and 2,670 propane facilities. There are two types of CNG infrastructure: fast-fill and time-fill. Fast-fill stations are generally best suited for retail situations where light-duty vehicles, such as vans, pickups, and sedans, arrive randomly and need to fill up quickly. Time-fill stations are used primarily by fleets. This type of facility is ideal for vehicles with large tanks that refuel at a central location every night. LNG stations are similar to gasoline and diesel stations, because they both deliver a liquid fuel. There are three options for LNG fueling: mobile, containerized, and customized large stations. Because LNG is stored and dispensed as a super-cooled, liquefied gas, protective clothing and gloves are required when fueling a vehicle. Finally, propane fueling facilities are similar to gasoline and diesel infrastructure, the key difference is that propane is delivered to the vehicle under pressure so it remains a liquid.

Economic Considerations

Any discussion of alternative transportation fuels must include an analysis of the costs of vehicles and fueling infrastructure. In terms of natural gas and propane, the conventional wisdom is that lower fuel costs are significantly offset by higher up-front vehicle and fueling station costs. The July 2013 Clean Cities Alternative Fuel Price Report (summarized below in **Figure 1**) confirms that, based on a national average, CNG costs about $1.51 less than gasoline on a per gasoline gallon equivalent basis. Similarly, CNG costs about $1.52 less than diesel on a per diesel gallon equivalent basis. The report indicates that propane was about 92 cents per gallon less than gasoline, and $1.18 less per gallon than diesel. These figures reflect the fact that in recent years oil prices have risen sharply while natural gas prices have actually decreased. This differential makes natural gas and propane vehicles increasingly economical from the perspective of fuel costs.

Figure 1: July 2013 Overall Average Fuel Prices on Energy Equivalent Basis

Fuel Type	National Average Price In Gasoline Gallon Equivalents	National Average Price In Diesel Gallon Equivalents	Nationwide Average Price in Dollars Per Million Btu
Gasoline	$3.65	$4.07	$31.60
Diesel	$3.50	$3.91	$30.36
CNG	$2.14	$2.39	$18.54
Ethanol (E85)	$4.57	$5.10	$39.59
Propane	$3.77	$4.20	$32.66

Biodiesel (B20)	**$3.55**	**$3.96**	**$30.79**
Biodiesel (B100)	**$4.13**	**$4.61**	**$35.78**

Source: Clean Cities Alternative Fuel Price Report, U.S. Department of Energy, July 2013

Alternative fuel vehicles (both production models and conversions) and fueling facilities continue to entail significant initial costs. For example, the Honda Civic GX (the first production sedan to run solely on CNG) costs approximately $7,000 more than its gasoline-powered equivalent. CNG conversion cost for new light-duty vehicles generally range from $12,000 - $18,000. As previously noted, manufacturers are producing a growing number of mid- and heavy-duty vehicles that are either dedicated or bi-fuel. However, these vehicles typically include an incremental cost increase. For example, a 2010 Department of Energy (DOE) study found that a representative heavy-duty CNG truck costs $63,600 more than a diesel equivalent prior to incentives.[2] In terms of infrastructure, DOE reports that costs for installing a CNG fueling station can range from $10,000 to $2 million depending on the size and application. The cost for an LNG fueling site can range from $1 to $4 million. The Department reports that the cost of purchasing and installing the necessary equipment for dispensing propane typically runs from $37,000 to $175,000, but varies based on situation and need.

Other Freight-Related Applications

While much of the focus on alternative fuels in the context of freight mobility has centered on vehicles, other transportation modes are increasingly embracing new energy fuels and technologies. For example, new clean air regulations have forced the shipping industry to rethink their fueling options. Emissions controls, introduced by marine environment protection committees, combined with the introduction of emission control areas in European, U.S. and Canadian territorial waters, will have considerable impacts on international shipping over the coming years. Two areas the maritime industry has been focused on are LNG and Automated Shore Power.

The U.S. is becoming an active participant in maritime applications of LNG as an alternative marine fuel. Examples of current vessel conversions include many dual-fuel offshore platform supply vessels. A U.S. company, Totem Ocean Trailer Express, is converting two of its container ships that trade between Puget Sound and Alaska to operate on LNG and is building two new container ships for trade between Port of Jacksonville and San Juan that are LNG powered. Once in service these ships will be the largest using LNG as a fuel in the world. Shell Oil Corporation has acquired the Norwegian LNG fuel company Gasnor and announced plans for construction and operation of LNG bunkering facilities in the Gulf of Mexico region and in the Great Lakes region.

Shore power systems, or cold ironing, serve the cruise ship and sea transportation industries by reducing/eliminating harmful emissions while in port. Based on the ship's specific voltage requirements, power is transferred to the ship and synchronized through a closed transition process monitored and controlled by the ship's systems. When a cruise ship or ocean transport vessel equipped to receive shore power docks in port, uniquely designed automation

[2] *Issues Affecting Adoption of Natural Gas in Light- and Heavy-Duty Vehicles*, U.S. Department of Energy, 2010

systems determine the proper operating parameters. The shore-side operator simply selects the ship to be connected and shore power and maintains a precise record of the ship's power consumption for monitoring purposes. Once connected, all of the ship's systems run on shore electricity instead of its diesel engines, virtually eliminating fuel emissions from the ship while in port.

The freight rail industry is also considering alternative fueling options. BNSF Railway Co., one of the biggest U.S. consumers of diesel fuel, plans this year to test using natural gas to power its locomotives.[3] GE has developed a natural gas retrofit kit, which allows GE Evolution series locomotives to operate with dual fuel capabilities. This allows the use of natural gas, which both reduces emissions and potentially reduces fuel costs by 50%. The retrofit allows locomotives to run on both diesel fuel and liquid natural gas (LNG) with up to 80% gas substitution or 100% diesel.[4] However, railroads take about five years to decide if they want to adopt a significantly changed technology, and implement at about 0.8 to 1.0% per year. LNG locomotives could be widespread by 2016 or 2017.[5]

Alternative Transportation Fuels in Florida

Current Vehicle Fleet

According to the U.S. Energy Information Administration (EIA) there were 1,187,925 alternative fuel vehicles in the U.S. in 2011. In terms of state comparison, Florida ranked 5th with 44,531 alternative fuel vehicles behind California (176,619), Texas (118,913), Arizona (52,323) and New York (45,103). Within Florida, Ethanol 85 represented 80% (36,032) of the alternative fuel vehicles, followed by propane (12% or 5,211 vehicles), CNG (6% or 2,518 vehicles), and electric (2% or 770 vehicles). While the number of alternative fuel vehicles in Florida is relatively small, it is growing. Between 2007 and 2011, the number of applicable vehicles in Florida increased by almost 49%.

The EIA data indicates that the 7,729 natural gas and propane vehicles in Florida in 2011 were concentrated in three vehicle categories: heavy-duty trucks, pick-up trucks and vans. Moreover, the data reflects that approximately 70% of fuel consumption for natural gas and propane vehicles was accounted for by heavy-duty trucks. In terms of ownership, private-sector firms and local governments operated more than 87% of the natural gas and propane vehicles. These Florida-specific findings are generally consistent with national studies that have found that the most attractive use of natural gas (especially CNG) is to fuel return-to-base fleet vehicles that are driven a large number of miles per year, such as delivery trucks, shuttle vans, refuse trucks and buses.

Florida has recently taken several steps to increase the number of natural gas and propane vehicles in service. For example, in 2013 the Legislature enacted HB 579 which provides beginning January 1, 2014, the state will offer a rebate for up to 50% of the incremental cost of an original equipment manufacturer natural gas or propane vehicle or of the cost of converting

---

[3] *Berkshire's BNSF Railway to Test Switch to Natural Gas*, The Wall Street Journal, March 05, 2013

[4] *GE Transportation Touts Engines, Fuel Technology and Web Applications at Railway Interchange 2013*, GE, 2013

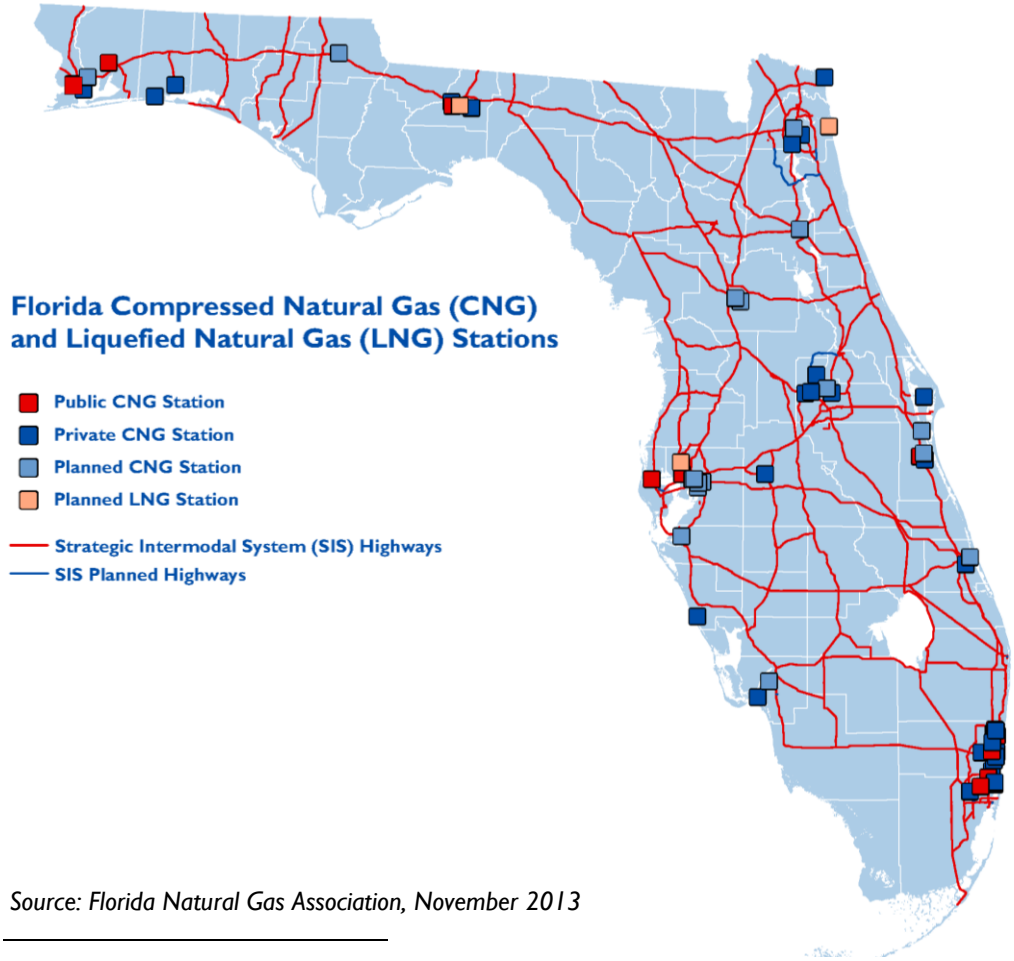
[5] *Feeling "real good" about LNG,* Railway Age, October 2013

a vehicle to run on natural gas or propane, up to $25,000 per vehicle and $250,000 per applicant per fiscal year. To qualify, the dedicated or bi-fuel vehicle must be part of a public or private fleet and must be placed into service on or after July 1, 2013. Of the funds available for these rebates, 40% will be reserved for government applicants; the remaining funds will be allocated to commercial applicants.[6]

Supporting Infrastructure

Florida is served by an extensive network of natural gas transmission and distribution pipelines. According to the Florida Natural Gas Association 59 of Florida's 67 counties have natural gas available for use in industrial, commercial and residential applications. Approximately 97% of Florida's population and commercial establishments are located in counties which are served by natural gas. Florida also has an extensive propane infrastructure that extends throughout the state. Currently there are 170 bulk storage facilities for propane and 1,225 dispensing facilities in operation in Florida.

Figure 2: Natural Gas and Propane Fueling Facilities



Source: Florida Natural Gas Association, November 2013

[6] HB 579 also repealed the annual decal fee program for motor vehicles powered by alternative fuels effective January 1, 2014, and established a fuel tax structure for natural gas used as a motor fuel similar to that for diesel fuel beginning January 1, 2019, thereby exempting natural gas fuel from fuel taxes for five years. The bill also exempted natural gas fuel from state sales and uses taxes and expanded the definition of "energy efficiency improvement" to include "installation of systems for natural gas fuel" under uses authorized by the Local Government Infrastructure Surtax.

The Florida Natural Gas Association reports that there are currently 41 CNG fueling stations in operation, and an additional 17 in the planning or construction stages. Twelve of the 41 operational stations are available for use by the public, while the remaining stations are limited to private fleet operators. There are at least 70 propane fueling facilities in operation around the state. As the map in **Figure 2** indicates, natural gas fueling facilities are concentrated around the major metropolitan areas of the state. The limited availability of public natural gas and propane fueling facilities relative to conventional fuels is recognized as a major obstacle to expanded use of these alternative fuels, especially in the context of long-haul trucking. This issue will be examined in more detail in the following section of the white paper relating to challenges.

Challenges Associated with Alternative Transportation Fuels

While the enactment of HB 579 will certainly provide incentive to procure of additional alternative fuel vehicles, there are several continuing impediments to the expanded use of natural gas vehicles. Fortunately, public- and private-sector representatives in several states have identified strategies to overcome these obstacles. The experiences of other states offer approaches that Florida officials and industry leaders should consider in addressing the challenges associated with the use of alternative transportation fuels.

The most formidable obstacle to expanded use of natural gas and propane vehicles, especially in the context of long-haul trucking, is the limited number of publicly-accessible fueling stations. In order for trucking operators to invest in natural gas vehicles they must have confidence that the necessary fueling facilities are available along key interstate routes. A network of strategically-located, public natural gas fueling stations will ultimately be required to support wider deployment of long-distance natural gas vehicles. A complicating factor is that while the number of CNG stations across Florida is growing, there are very few LNG stations (the preferred long-distance fuel) currently in operation.

Another challenge relates to the cost premium associated with natural gas vehicles. In the case of the typical heavy-duty truck a natural gas vehicle costs $63,600 more than the diesel equivalent. This differential increases to $76,100 when sales taxes are included. While the rebates and tax incentives contained in HB 579 will certainly help reduce the cost differential, the fact remains that natural gas fueled vehicles are significantly more expensive than the equivalent gas or diesel vehicles. Finally, there are concerns relating to how increased use of alternative fuels could negatively impact existing fuel-tax-based finance systems.

Lessons Learned in Other States

The challenges associated with expanding natural gas availability are not unique to Florida. A number of states have attempted to address these obstacles through the use of innovative public/private partnerships and incentives. For example, Texas has established the *Texas Clean Transportation Triangle*, a planned network of natural gas fueling stations along a triangle of heavily-traveled interstates serving Dallas, Fort Worth, Houston, and San Antonio. A consortium of more than 200 stakeholders representing fleet operators, utilities, business

groups, universities and governments developed the strategic plan and grant funding is administered by the Texas Commission on Environmental Quality.

Similarly, the *Interstate Clean Transportation Corridor* is a collaborative effort involving four western states to develop a 1,800 mile network of alternative fuel user fleets and public access stations linking Los Angeles, the San Joaquin Valley, Sacramento, San Francisco, Las Vegas, Reno and Salt Lake City. To date this initiative has leveraged more than $63 million to develop 28 alternative fuel stations and deploy 759 heavy-duty and 160 light-duty natural gas and propane vehicles.

Continuing the Discussion

With the passage of HB 579 in 2013, Florida has established one of the most compelling natural gas vehicle incentive programs in the nation. A key challenge going forward is to leverage these vehicle incentives with the necessary investments to facilitate the development of a strategic network of public fueling stations. Experience in other jurisdictions indicates that public/private collaboration should be an integral component of this effort. With these, and your own experience, several continuing questions should be considered for further discussion:

- What role should the State of Florida play in expanding the availability of alternative transportation fuels for public adoption of these technologies?
- What can the State of Florida do to support conversion to alternative fuels across all freight transport modes?
- What key considerations should be addressed in the development of a designated network of publicly-accessible natural gas fueling facilities?
- How can Florida incentivize private sector development of natural gas fueling stations that include public access?
- Are there regulatory incentives that could induce natural gas utilities or others to expand the number of fueling facilities?
- Are there land use planning and permitting barriers to natural gas fueling facilities that need to be addressed?