SHANNON KIEFHABER

Natural Gas – Affordable, Abundant and American

Making the case for natural gas in the transportation sector

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Introduction

Due to the recent Gulf oil spill, a collective conscious has begun to ponder the question: When will we stop using oil as a base for transportation fuel, and what will replace it? While it is unlikely that conventional, petroleum-based fuels will be completely replaced in the next decade; it is possible that the ever increasing demand for energy in the transportation sector could be met by a variety of fuels and technologies. The most likely options include biodiesel, ethanol, compressed natural gas (CNG) and electrification.

One of the primary reasons for pursuing alternative fueled vehicles is to decrease emissions of environmentally harmful pollutants into the atmosphere. As legislation like the renewable-fuels standards and low-carbon fuel standards intensify, a niche market for alternative fuels is beginning to emerge. The importance of reducing energy demand and carbon intensities of fuels is going to greatly impact the type of vehicles and choices of fuels expected to be manufactured in the future automobile industry. Natural gas, as an alternative, is very attractive due to its low price and low carbon intensities. Per unit of energy, natural gas contains less carbon than any other fossil fuel, and thus produces lower carbon dioxide (CO2) emissions per vehicle mile traveled. While there is a current lack of infrastructure that has greatly limited natural gas use to captive public fleets, commercial industries are beginning to invest in alternative fuel vehicles.

Making America less dependent on foreign oil is a national priority. President Obama, in accepting his party's nomination, established his own clear goals: "For the sake of our economy, our security and the future of our planet, I will set a clear goal as president: in 10 years, we will finally end our dependence on oil from the Middle East." While the United States imports more than 60 percent of the oil it uses, 98 percent of the natural gas used in the U.S. was produced in North America. Every gallon equivalent of natural gas used in vehicles is one less gallon of petroleum that has to be imported. (Federal NGV Tax Incentives, 2010)

Despite the recent growth in interest of natural gas, there is still significant obstacles natural gas vehicles face in order to capture a major share of the market. Concerns amount around economics-whether the equivalent gasoline or diesel vehicle is cheaper, as well as concerns about safety and availability of refueling stations. This paper investigates evidence around all of these concerns as well as identifies markets where natural gas vehicles would be the most efficient.

Defining Natural Gas

"It is a clean burning domestic energy source that powers our economy" (Energy API)

Natural gas is a combustible mixture of hydrocarbon gases found in oil fields, isolated natural gas fields and coal beds. It is primarily formed of methane but can also include ethane, propane, butane and pentane before it is refined for the end-user. Before natural gas can be used as a fuel it must undergo processing to remove all materials other than methane leaving the gas colorless, odorless, and shapeless. The often misconceived "rotten egg" smell associated with natural gas is an odorant called mercaptan that is added to the gas before it reaches the end-user. This is vital for the detection of natural gas leaks. Natural gas is a vital component of the world's energy supply because it is combustible, abundant in the United States and when burned, it gives off a great deal of energy with few emissions.

The Energy Information Administration (EIA) estimates that "the current recoverable resource estimate provides enough natural gas to supply the U.S. for the next 90 years." According to the EIA, in 2008 natural gas accounted for 22 percent of the United States energy use and 2.2 percent of the energy used for U.S. transportation. The following gives a sector comparison of common natural gas uses:

- 76% of the residential and commercial sectors energy needs such space-heating, water heating, cooking, air conditioning, and on site power generation
- 40% of the industrial sector's energy needs; gas is a dominant fuel for paper, metal, chemical and food processing industries
- 17% of electricity generation because most of the new power plants built in the U.S. use natural gas since it is a clean-burning fuel
- 2% of the transportation sector's energy needs with over 110,000 transit buses, taxi cabs, package delivery trucks and other vehicles fueled with natural gas

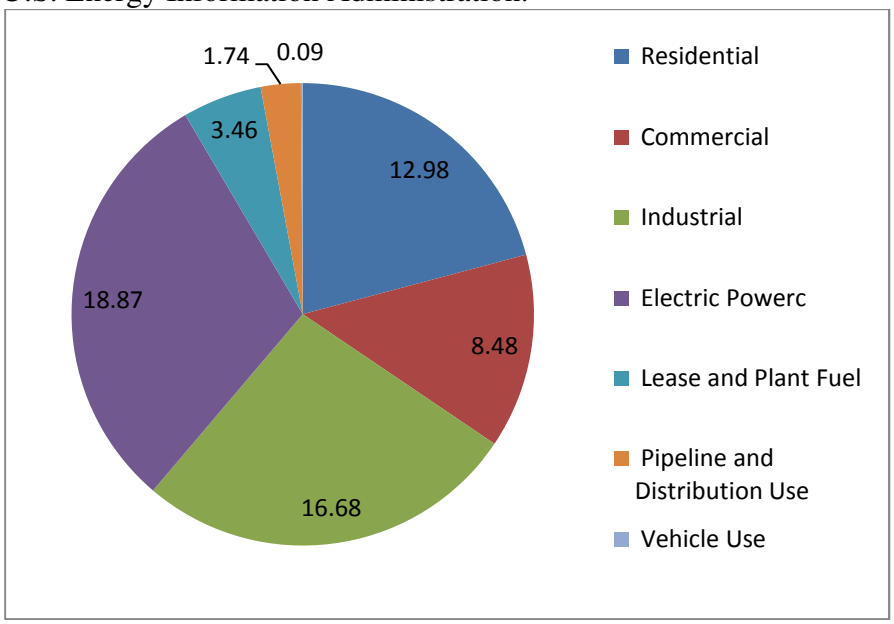
In the United States, quantities of natural gas are measured in standard cubic feet. One standard cubic foot of natural gas produces around 1,028 British Thermal units (BTU). Retail sales are often in units of therms (th); 1 therm = 1,000 BTU.

Finding and Extracting Natural Gas

Natural gas is a fossil fuel, meaning it is essentially the remains of plants, animals and microorganisms that lived millions of years ago. The formation of methane occurs through organic processes know either as thermogenic or biogenic methane. Thermogenic methane is formed when organic matter is compressed under the earth at very high temperatures for a very long time. At low temperatures (shallower deposits), more oil is created, at higher temperatures, more natural gas is created. Natural gas can also be formed through the transformation of organic matter by tiny microorganisms, a process known as biogenic methane. In this process methanogens, tiny methane-producing microorganisms, chemically break down organic matter to produce methane. An example of biogenic methane is landfill gas. New technologies are allowing natural gas from the decomposition of waste materials to be harvested and used as an alternative fuel. Once natural gas has formed within the earth it rises towards the surface due to its low density. The gas can permeate through layers of porous sedimentary rock but gets trapped by denser, impermeable rock layers underground which create a natural gas reservoir. To successfully bring the gas to the surface, a hole must be drilled through the impermeable rock to release the fossil fuels under pressure. A way to improve the flow of gas through a reservoir is by creating tiny cracks in the rock called fractures that serve as open pathways, enhancing the flow of gas. This technique, known as “hydraulic fracturing”, which forces high pressure fluids that contain a “propping agent” like sand to prop open the fractures when the pressure is decreased (Fossil Energy). Modern technology in hydraulic fracturing and horizontal drilling has “transformed shale formations from marginal sources of natural gas to substantial contributors to the natural gas supply portfolio, ushering in a robust resurgence in domestic natural gas production” (You've Got Shale: The "where" and "what" of shale gas formations). Once natural gas is harvested from underground rock formations, it is treated, sent by pipelines to storage facilities and then travels by a smaller distribution system to residences and industries.

Growth in the domestic natural gas production is largely a result of the economic growth and advances in exploration and production technology. Improvements in technology reduce natural gas drilling and production costs. "Advances in horizontal drilling and hydraulic fracturing techniques—as well as improved drill bits, steering systems, and instrumentation monitoring equipment—have contributed to higher success and recovery rates, reduced cycle times, lower costs, and shorter times required to bring new shale gas production to market" (Annual Energy Outlook 2010 with Projections to 2035 , 2010). In 2009 the United States consumed 62.3 Billion cubic feet of natural gas per day. Figure 1 below categorizes the total US consumption to provide a better picture of the sectors that currently consume the most natural gas. While natural gas is utilized across all sectors, in varying amounts the graph below shows that the power generation sector accounts for the greatest proportion of natural gas use in the United States. The industrial sector is second; residential is third and vehicle use is last. The surprising reliance on natural gas from the power industry to generate electricity is in response to strengthened regulations surrounding the emissions of power plants. "While coal is the cheapest fossil fuel for generating electricity it is also the dirtiest, releasing the highest levels of pollutants into the air" (Electric Generation Using Natural Gas, 2004-2010).

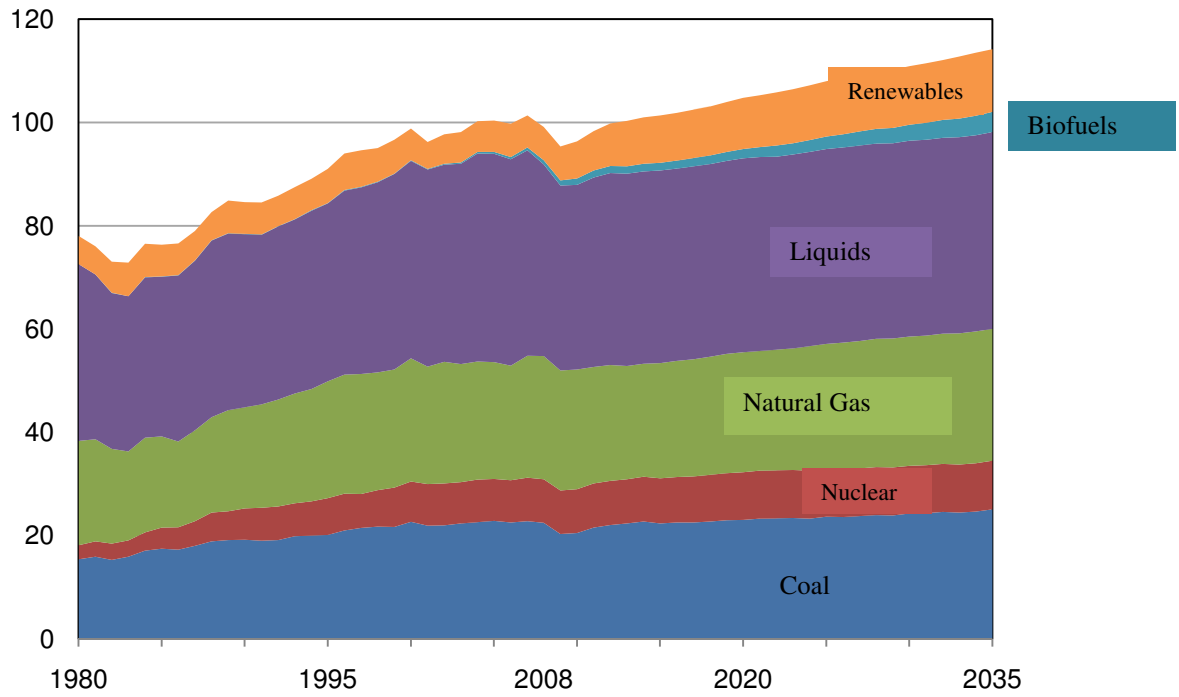
Figure 1: U.S. natural gas consumption (Billion cubic feet per day) in 2009 from the U.S. Energy Information Administration.



EIA Table 5a. U.S. Natural Gas Supply, Consumption and Inventories: http://www.eia.doe.gov/emeu/steo/pub/cf_tables/steotables.cfm?tableNumber=15&loadAction=Apply+Changes&periodType=Annual&startYear=2009&endYear=2009&startMonthChanged=false&startQuarterChanged=false&endMonthChanged=false&endQuarterChanged=false&noScroll=false

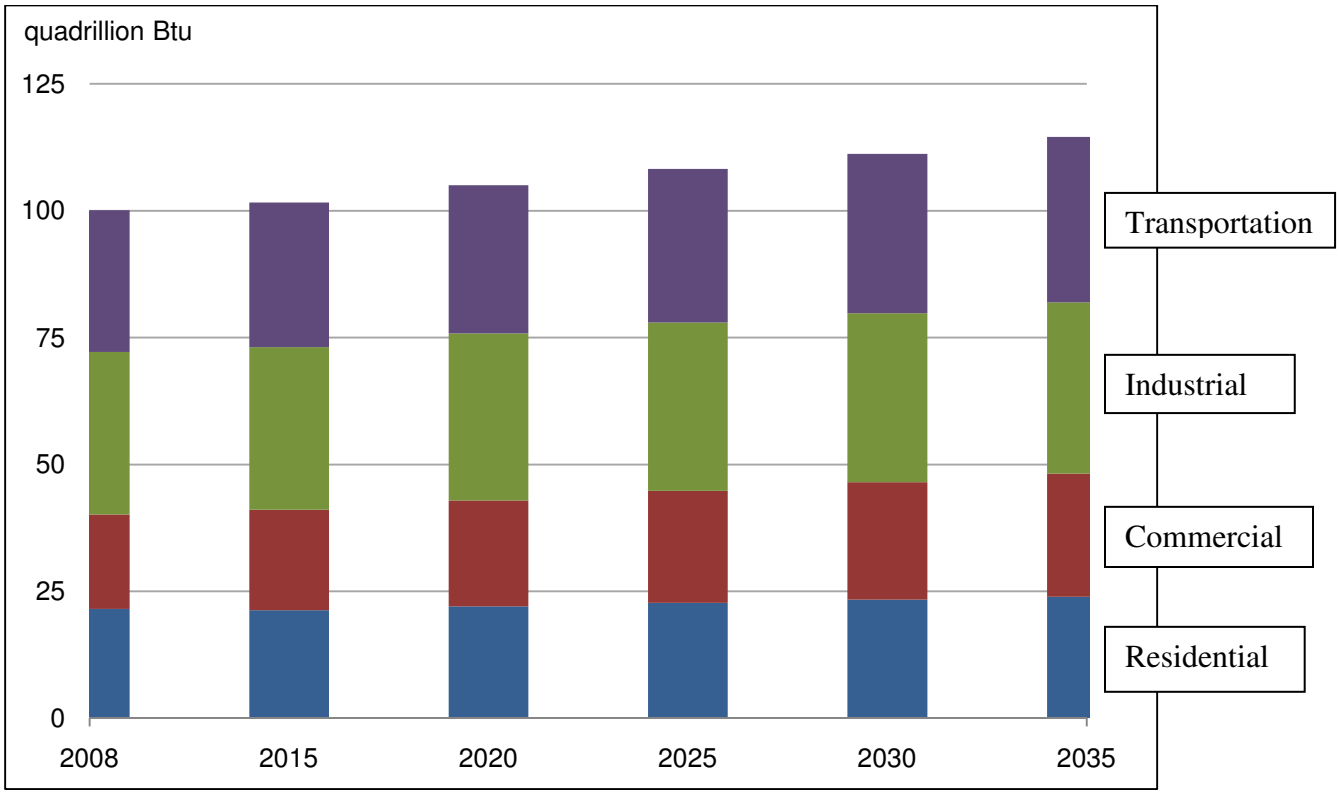
Natural gas is generally recognized as the fuel that produces the blue flame and heats food, water, homes and buildings. Nevertheless it is also considered an alternative fuel that is rapidly gaining attention from the transportation sector; where only about one tenth of one percent is used as transportation fuel. Figure 2 displays the United States energy use by fuel from 1980 to 2010 with a forecasted use through 2035. The U.S. EIA estimates that "the aggregate fossil fuel share of total energy use falls from 84 percent in 2008 to 78 percent in 2035 as renewable fuel use grows rapidly" (Annual Energy Outlook 2010 with Projections to 2035 , 2010). The renewable energy's share of use increases from 8 percent in 2008 to 14 percent in 2035, likely in response to the expansion of Federal tax credits for renewable electricity generation and capacity. It is inevitable that total energy consumption will grow from 2008 to 2035 but widespread growth of renewable energy use in the transportation sector lead by Federal incentives could impact the mix of fuels used in the future. The transportation sector consistently accounts for the second most energy use by sector immediately behind the industrial sector (Figure 3). Targeting the transportation market with emissions standards, mandatory increases in fuel economy and tax credits will help to decrease petroleum's share of liquid fuel use.

Figure 2: Primary energy use by fuel, 1980-2035
U.S. Energy Information Administration, Annual Energy Review 2008, DOE/EIA-0384(2008) (Washington, DC, June 2009). Projections: AEO2010 National Energy Modeling System, run AEO2010R.D111809A.



Growth in U.S. population is linked to growth in U.S. energy use through increases in demand for housing, commercial floor space, transportation, manufacturing, and services. This affects not only the level of energy use but also the mix of fuels and consumption by sector. As our population increases it is possible to direct future energy use to alternative fuel sources, reducing the burden on coal and liquid fuels.

Figure 3: Primary energy use by end-use sector, 2008-2035 in quadrillion Btu
http://www.eia.doe.gov/oiaf/aeo/demand.html



Natural Gas Vehicles

The transition to natural gas vehicles (NGVs) across North America are giving public and private fleets a proven technology choice that meets strengthening emissions standards and reduces the country's dependence on foreign oil. NGVs used in both the public and private sector are fueled exclusively with compressed natural gas (CNG), liquefied natural gas (LNG) or are capable of natural gas and gasoline fueling (bi-fuel NGVs). Both CNG and LNG are considered alternative fuels under the Energy Policy Act of 1992 and qualify for alternative fuel vehicle tax credits (Alternative Fuels & Advanced Data Center, 2010).

One benefit touted by proponents of natural gas vehicles is the increased fuel economy over vehicles that run on traditional gasoline or diesel. The *Natural Gas Vehicles for America* webpage advertizes that "natural gas costs, on average, one-third less than conventional gasoline at the pump" (Federal NGV Tax Incentives, 2010). The U.S. Department of Energy's Clean Cities program distributes a quarterly Alternative Fuel Price Report that summarizes the prices of alternative and conventional fuels in the U.S. The summaries of prices shown in Table 1 below were collected between October 4, 2010 and October 14, 2010 from across the country. This table validates the statement that natural gas is more economical at the fuel pump, costing an average of $0.85 less than traditional gasoline.

	Nationwide average price in gasoline gallon equivalents	Nationwide average price in diesel gallon equivalents	Nationwide average price in dollars per million BTU
Gasoline	$2.78	$3.10	$24.12
Diesel	$2.75	$3.07	$23.87
CNG	$1.93	$2.15	$16.68
Ethanol (E85)	$3.45	$3.84	$29.85

Table 1: October 2010 overall average fuel prices on energy equivalent basis
U.S. DOE Clean Cities Alternative Fuel Price Report October 2010

When comparing the prices of differing fuels, the energy content per gallon can vary making the price paid per unit of energy content differ from the price paid per gallon of fuel. The price must be normalized to a price per gasoline gallon equivalent (GGE), per diesel gallon equivalent (DGE), or per million Btu of energy. To make the aforementioned conversions, the nominal lower heating values in BTU per gallon of fuel were used, displayed in Table 2 below.

	Lower Heating Value
Gasoline	115,400 BTU/gal
Diesel	128,700 BTU/gal
CNG	960 BTU/cubic foot or 20,268BTU/lb
Ethanol	75,670 BTU/gal

Table 2: Standard lower heating values for fuels from the Transportation Data Book

Compressed Natural Gas

The interest in natural gas as an alternative transportation fuel can be attributed to its clean burning qualities, domestic abundance and commercial availability. In order to transport natural gas it must be converted to either a compressed gaseous or liquefied state. Compressed natural gas must be stored onboard a vehicle in tanks at high pressure and compressed to less than one percent of its volume at standard atmospheric pressure (What is CNG?, 2010). Most natural gas vehicles operate using compressed natural gas (CNG). The compressed gas is stored similarly to a car's traditional gasoline tank, "attached to the rear, top, or undercarriage of the vehicle in a tube shaped storage tank" (Natural Gas in the Transportation Sector, 2010). The storage tank can be filled in a similar manner and amount of time, to a gasoline tank. Also similar to traditional gasoline cars, the natural gas fuels a combustion engine; however, in NGV's several components require modification to allow the engine to run efficiently on natural gas. As gasoline prices have continued to rise, America's interest in CNG has also continued to rise. Compared to gasoline CNG costs about 30 percent less, emits up to 90 percent less and is an abundant domestically produced natural resource. Natural gas is flammable, however only at very limited concentrations. "When released, CNG will mix with air and become flammable only when the mixture is within 5 to 15 percent natural gas" (Consumer Energy Center, 2010)

Liquefied Natural Gas

Liquefied natural gas (LNG) is simply natural gas in liquid form. The gas is converted to a liquid form by cooling it to -260 degrees Fahrenheit. This process reduces its volume by a factor of more than 600 making it much easier to transport large quantities (About LNG, 2010). Currently the overwhelming purpose of liquefying natural gas is for shipping gas from countries that export natural gas to countries that import it. While the demand for natural gas in the U.S. has been increasing, domestic production is falling. To supplement the growing demand for natural gas, LNG is imported on specially built ships which transport the liquid to US ports. LNG is imported from countries such as Trinidad, Tobago, Egypt, Norway Nigeria and Qatar (About LNG, 2010). Upon arrival, LNG is stored in tanks and eventually warmed to it gaseous state and transported to consumers through the distribution system. The changing energy climate and advances in technology however, have created a likely new sector to target LNG use: the transportation sector. LNG is emerging as an economically and environmentally viable substitute for diesel fueled trucks in the heavy-duty long-haul trucking industry.

Benefits of Natural Gas Vehicles

Environmentally

There are many factors that attribute to the increasing abundance and popularity of natural gas vehicles throughout the globe. One of the most persuasive arguments for the use of natural gas in the transportation sector is the vehicles are cleaner than traditional vehicles, producing up to 90 percent fewer emissions than gasoline or diesel. "When used as transportation fuel, natural gas can reduce greenhouse gas emissions by 20 – 29 percent compared with diesel and gasoline fueled vehicles, respectively, according to studies by the California Air Resources Board and other organizations" (Federal NGV Tax Incentives, 2010) . They greatly reduce pollutants from emissions such as CO and NOX which are key ingredients in the production of greenhouse gases. "Compared to vehicles fueled with conventional diesel and gasoline, natural gas vehicles can produce significantly lower amounts of harmful emissions such as nitrogen oxides, particulate matter, and toxic and carcinogenic pollutants as well as the greenhouse gas carbon dioxide" (Alternative Fuels & Advanced Data Center, 2010).

In the U.S. stringent new federal and state emissions laws are requiring improvement in vehicle emissions. Since natural gas is the cleanest burning alternative transportation fuel available today, it offers an opportunity to meet these standards. The transportation sector as a whole is responsible for over half of the emissions of carbon monoxide pollution released into the atmosphere, which contribute to smog pollution, and increase the levels of dangerous ground level ozone (Natural Gas in the Transportation Sector, 2010). The actual emission benefits observed will vary depending on the type of NGV (CNG or LNG), base for comparison (light-duty vehicle or heavy-duty vehicle) and fuel type (gasoline or diesel). The most significant reduction in emissions will be realized by fleets that replace in-use medium and heavy duty diesel vehicles with new natural gas vehicles simply because they emit more. One thing is for certain, "per unit of energy, natural gas contains less carbon than any other fossil fuel, and thus produces lower carbon dioxide (CO2) emissions per vehicle mile traveled" (Federal NGV Tax Incentives, 2010).

Vehicle testing has been performed by various agencies to compare the emissions of heavy-duty natural gas vehicles (fueled with CNG or LNG) versus heavy-duty diesel vehicles. A summary of the data collected by the U.S. Environmental Protection Agency on the potential benefits of LNG versus diesel are LNG:

- Produces half the particulate matter of average diesel vehicles
- Significantly reduces carbon monoxide emissions
- Reduces nitrogen oxide and volatile organic hydrocarbon emissions by 50% or more
- Potentially reduces carbon dioxide emissions 25% depending on the source of the natural gas

- Drastically reduces toxic and carcinogenic pollutants, and
- Increase methane emissions (not a benefit)

Safety and Security

Natural gas vehicles are very safe, for not only do they have all the same standard safety equipment as conventional cars (passive restraints, air bags, head restraints and anti-lock brakes), they are subjected to the same crash safety tests as well. When used as an automobile fuel, compressed natural gas (CNG) is stored onboard vehicles in tanks that meet stringent safety requirements (Natural Gas in the Transportation Sector, 2010). The fuel systems are sealed, which prevents spills or evaporative losses. "The gas is lighter than air, and in the event of an accident natural gas would dissipate up into the atmosphere instead of forming a dangerous flammable pool on the ground like other liquid fuels" (Natural Gas in the Transportation Sector, 2010). Because compressed natural gas (CNG) fuel systems operate at pressures in excess of 3000 PSI, the fuel tank and associated plumbing have to be incredibly rugged and strong enough to contain that pressure. The on-board tanks are made of steel up to one half-inch thick and often wrapped in protective reinforced fiberglass sheathing. Natural gas also has a high ignition temperature, about 1,200° Fahrenheit, compared with about 600° Fahrenheit for gasoline.

Natural gas in its liquid form is also safe as an odorless, non-toxic and non-corrosive liquid. If spilled, LNG would not result in a slick and as long as there is not an ignition source, the liquid evaporates quickly and disperses, leaving no residue. "There is no environmental cleanup needed for LNG spills on water or land." (About LNG, 2010). LNG transported across the ocean has a proven record of safety with more than 50 years of commercial LNG use and no major accidents or security problems occurring in port or at sea. "The LNG industry carefully follows requirements set forth by the International Maritime Organization, Federal Energy Regulatory Commission, Department of Transportation, and the U.S. Coast Guard and works closely with the Department of Homeland Security to ensure its operations are safe and secure" (About LNG, 2010).

Economically

Natural gas also has an economic incentive compared to gasoline and other transportation fuels. “Traditionally, natural gas vehicles have been around 30 percent cheaper than gasoline vehicles to refuel and in many cases the maintenance costs for NGVs is lower than traditional gasoline vehicles” (Natural Gas in the Transportation Sector, 2010). Recent shale discoveries and advances in technology project a 100 year domestic natural gas supply at current usage levels, news which serves to increase the cost advantage of natural gas over oil and gasoline. Another benefit of the onset of shale gas development is production has been diversified across the country making supply closer to demand centers. The abundance of natural gas can also help relieve our dependance on foreign oil and vulnerabilty to weather-related shortages, thereby redcuing volitility in supply. As previously shown in Table 1, at current prices, natural gas can be $0.85 cheaper than traditional gasline. There have also been numerous tax credits and incentives for infrastructure, new vehicle purchase, research and development in the natural gas industry. Taking advantage of these tax credits and other incentives available from Federal and state governments, public agencies and private companies can realistically make converting to NGVs an economical opportunity.

Legislation

The federal government has been instrumental in developing government policies that not only stimulate the development of Alternative Fueled Vehicles (AFVs) but also remove regulatory barriers. The federal government promotes the use of NGVs by classifying natural gas as an alternative fuel, making it eligible for all AFV tax credits.

“The Internal Revenue Service (IRS) defines alternative fuels as liquefied petroleum gas, compressed natural gas, liquefied natural gas, liquefied hydrogen, liquid fuel derived from coal through the Fischer-Tropsch process, liquid hydrocarbons derived from biomass, and P-Series fuels. Biodiesel, ethanol, and renewable diesel are not considered alternative fuels by the IRS. While the term "hydrocarbons" includes liquids that contain oxygen, hydrogen, and carbon and as such "liquid hydrocarbons derived from biomass" includes ethanol, biodiesel, and renewable diesel, the IRS specifically excluded these fuels from the definition. (Reference 26 U.S. Code 6426)”

Working together with state, regional and local governments, incentives such as tax deductions/credits, reduced license fees, reduced vehicle sale taxes, and lower registration fees all encourage the purchase and use of AFVs. Existing federal incentives in place for AFV and specifically natural gas vehicles include:

Income Tax Credits for Alternative Fuel Vehicles:

The Energy Policy Act of 2005 provides an income tax credit for business and individuals that acquire new, dedicated alternative motor fuel vehicles. The credit ranges from $2,500 to $32,000 depending on the size and emissions performance of the vehicle. "The tax code provides a minimum credit equal to 50 percent of the incremental cost for any new, dedicated NGV that meets federal EPA or CARB emissions standards. In addition, there is a maximum credit equal to 80 percent of the incremental cost for NGVs that have been certified as meeting the most stringent emission standard (other than zero emissions) available for that particular type vehicle" (Federal & State Incentives & Laws, 2010). This credit is effective on purchases made after December 31, 2005 and expires on December 31, 2010. The table below displays the relationship between the size of the vehicle, incremental cost of the vehicle, and the emission performance of the vehicle.

Vehicle Size	Incremental Cost Cap	50 % Credit	80 % Credit
8,500 GVWR or less	$5,000	$2,500	$4,000
8,501 - 14,000 GVWR	$10,000	$5,000	$8,000
14,001 – 26,000 GVWR	$25,000	$12,500	$20,000
26,001 GVWR &>	$40,000	$20,000	$32,000

Table 3: A summary of Natural gas vehicle credits.

Income Tax Credits of Alternative Fuel Infrastructure:

The Energy Policy Act of 2005 provides an income tax credit equal to 30 percent of the cost of natural gas refueling equipment, up to $30,000 in the case of large stations and $1,000 for home refueling appliances. The intent of this tax credit is to expand the availability of natural gas refueling stations, increase the use of natural gas as a motor vehicle fuel and reduce demand for petroleum motor fuels. Converted and/or retrofitted equipment will qualify for the tax credit as long as it was not previously used to refuel alternative motor vehicles. This credit is effective on purchases made after December 31, 2005 and expires on December 31, 2010 (Federal & State Incentives & Laws, 2010).

Excise Tax Credit to the Seller of CNG or LNG:

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users provided an incentive for CNG and LNG when used as a motor vehicle fuel. The $0.50 per gasoline gallon equivalent credit is provided to business and individuals that sell, or, in some cases, use the fuel. Generally the credit goes to the seller in the case of retail transactions, however, if the CNG or LNG is dispensed using a private fueling station, the credit may go to the user of the fuel. The credit for CNG and LNG took effect on October 1, 2006 and expired on December 31, 2009. (Federal NGV Tax Incentives, 2010)

Amendments to the Clean Air Act (CAA)

While the CAA does not directly call for the use of NGVs, it has created an environment that is favorable for alternative fuel vehicles. Amendments to the CAA in 1990 established national ambient air quality standards for pollutants, classified areas depending on their level of air quality and required states to develop implementation plans that reduce air pollution levels. The law addresses vehicle emissions by "establishing stringent emission standards for all new motor vehicles, regulating the properties of gasoline and diesel motor fuels, and requiring most non-attainment areas to adopt inspection and maintenance programs" (Government Policy). Many states have emission concentrations exceeding the standards updated by EPA and are classified as non-attainment areas. Accelerating the turn-over of older, dirtier vehicles to low emitting NGVs can help take advantage of the emission reduction benefits to meet federal emission standards.

Congestion Mitigation and Air Quality Improvement Program (CMAQ)

The CMAQ program "is one of the largest sources of funding available for alternative fuel projects, funding hundreds of millions of dollars in investments in alternative fuel projects since its inception in 1991" (Government Policy).The program is designed to help communities meet or maintain their compliance with the federal air quality standards. Funds from this program can pay for the incremental cost of purchasing natural gas vehicles; however they must have a 20 percent local or regional match. The Federal Highway Administration and Federal Transit Agency administer the program which must give priority in distributing funds to diesel engine retrofits, and other cost-effective emission reduction and congestion mitigation activities that provide air quality benefits.

Clean Cities Program

The Clean Cities Program seeks to advance the energy, economic, and environmental security of the U.S. by supporting local decisions to adopt practices that reduce the use of petroleum in the transportation sector. Nearly 90 local, geographically-based coalitions work to expand alternative fuel and advanced technology markets to reduce petroleum consumption by 2.5 billion gallons by 2020. (Clean Cities)

Vehicle Acquisition and Fuel Use Requirements for Federal Fleets

Executive Order 13514, issued in October 2009, requires each federal agency to develop, implement, and annually update a Strategic Sustainability Performance Plan. Federal agencies must measure, reduce, and report their greenhouse gas (GHG) emissions, with an overall federal government GHG emissions reduction goal of 28 percent by 2020, relative to a 2008 baseline. Federal fleets of 20 vehicles or more must reduce petroleum consumption by a minimum of 2percent per year through the end of FY 2020 as compared to 2005 baseline usage and increase alternative fuel use by 10 percent per year relative to the previous year. Reductions may be achieved through a variety of measures including the use of AFVs, and fleet optimization efforts (Federal Energy Management Program, 2010).

The future growth and expansion of NGV into the mainstream marketplace will be directly affected by the federal programs and regulatory issues passed by the House and Senate during the 113th Congress. Allowing current federal programs that potentially have the most effect on the future of NGVs to expire is severely detrimental to the progress that has been made in the last decade. "A strong national incentive program that encourages the purchase and retrofit of 3.5 million heavy vehicles to run on natural gas—along with the construction of refueling facilities—could allow us to displace 1.2 million barrels of oil per day by 2035, saving at total of 3.7 billion barrels of oil from 2011 to 2035" (American Fuel).

Disadvantages

Natural gas has long been a part of our nation's energy portfolio but has recently come under scrutiny for the methods used to extract the gas. Hydraulic fracturing used by gas producers to stimulate wells and recover natural gas from sources such as coalbeds and shale gas formations has raised concerns about environmental safety. The expansion of "fracking" over a wider diversity of geographic regions is increasing concerns about its potential impacts on drinking water resources, public health, and environmental impacts in the vicinity of working facilities. "The fracking chemicals used with sand and water to fracture the rock and release natural gas can be toxic and contaminate drinking water supplies" (Hydraulic Fracturing, 2010). The proper installation of well casing and careful monitoring can prevent underground leaks however residents have raised concerns that the process isn't regulated enough. The EPA has recognized that there are serious concerns from citizens and their representatives and have identified the need for a focused study on this topic. From 2010-2012 the EPA's Office of Research and Development will be conducing a scientific study to investigate the possible relationship between hydraulic fracturing and drinking water (Hydraulic Fracturing, 2010). While the EPA was directed by Congress to focus efforts on drinking water, the study will take a comprehensive look at hydraulic fracturing in the United States. This study which is currently underway will hopefully find conclusive evidence about the environmental impacts of fracking techniques and lead to industry standardization surrounding safe practices.

Natural Gas in the Transportation Sector

"Nearly two-thirds of U.S. oil consumption goes to road transportation, with more than two-thirds of that for gasoline and one-fourth for diesel fuel" (American Fuel).

Natural gas vehicles have been used in global fleets for decades, with more than 12 million vehicles used worldwide. Industry data shows that over the past six year's vehicular natural gas in America has nearly doubled, displacing more than 300 million diesel gallon equivalents. A vast majority of the estimated 110,000 NGVs currently used in the United Sates are trucks and fleet vehicles including public buses. This sector is conducive to CNG and LNG technology because the vehicles can be refueled at a single or a few designated locations. "Public transportation fleets and long-haul truckers often travel predictable routes, meaning that the infrastructure for a CNG truck fleet could be concentrated in certain specific areas, whereas the widespread use of CNG in passenger cars would require a much more extensive and costly refueling infrastructure" (Krupnick, 2010). For this reason public transit and commercial fleets represent the most likely targets for mainstream acceptance in the transportation industry. Fleet vehicles used in public transportation would benefit from the use of CNG, and heavy-duty long-haul trucks would benefit from the use of LNG, both of which would have otherwise been fueled by diesel.

Historically, two perceived drawbacks of natural gas use have been a shorter driving range compared to diesel fuel and limited infrastructure for refueling. Modern CNG buses can travel roughly 300 miles per fueling—a distance more than adequate for most daily transit applications. LNG increases driving range to about 400 miles per fueling, making it adequate for the long-haul trucking industry. (A typical diesel bus has a potential driving range of 400 miles per fueling.) Limited infrastructure for both public and private industries looking to convert to natural gas can appear to be a barrier to entry. Nationwide there are around 1,500 natural gas vehicle stations, about half of which sell to the public (Alternative Fuels & Advanced Data Center, 2010). Fleets that have made the transition to natural gas typically work with local fuel providers to install personal fueling docks. This topic will be explored further in the public and private transportation sections to follow.

NGV Fueling

At CNG stations, the gas is typically taken from the local gas utility's line at low pressure, compressed, and then dispensed into the vehicle's storage tanks at high pressure. There are two basic types of fueling equipment: fast-fill and time-fill. Fast-fill systems combine a compressor and a high-pressure storage system. The storage system, called a cascade, fills the vehicle's fuel tank in about the same time it takes to fuel a regular vehicle. Time-fill systems do not have a storage system and typically refuel vehicles overnight at a rate of about one gallon per hour. Public CNG stations are currently limited, but individual consumers or public/private fleet operators often install their own CNG fueling stations (Natural Gas Fleet Vehicles, 2010).

Business Case for CNG in Municipal Fleets

An essential market for the expansion of alternative fuel vehicles into mainstream America is the public transportation sector, which currently accounts for 66 percent of all vehicular natural gas use. In this sector natural gas vehicles have achieved the most market penetration. According to the American Public Transit Association in 2009, about 18 percent of transit buses ran on natural gas (CNG or LNG) and 26 percent of all new transit bus orders were for natural gas (About NGVs). The market share is much higher in other countries like Argentina and Brazil which have two of the largest fleets of CNG vehicles in the world. Like numerous other countries, a large portion of their public transportation system has been converted to CNG, a practice that is encouraged by government-enforced financial incentives. Municipal governments are well suited for CNG vehicles because "they drive circular routes that enable refueling at the same station" (Johnson, 2010). Another reason CNG is a good alternative fuel for the public transportation sector is "transit buses equipped with model year 2004 CNG engines produced 49 percent lower nitrogen oxides emissions and 84 percent lower particulate matter emissions versus transit buses equipped with model year 2004 diesel engines" (Alternative Fuels & Advanced Data Center, 2010).

In the U.S. the number of natural gas vehicles is growing with nearly one in five buses on order today projected to run on natural gas. States with the highest consumption of natural gas for transportation are California, New York, Texas, Georgia, Massachusetts and D.C. (What is CNG?, 2010). The rapid growth is due largely in part to global economic factors and the current energy crises, but is also attributed to increasing environmental awareness. Diversification of fuels can help agencies withstand fluctuations in fuels supply and price as well as reduce our nation's dependence on imported petroleum. Another incentive for moving to alternative fuels in the public transportation sector is the growing air quality regulations in large metropolitan areas. Many transit agencies have adopted alternative fuels to help meet compliance standards in designated nonattainment areas. The U.S. Environmental Protection Agency has designated many urban areas as nonattainment for certain critical pollutants. Because natural gas burns cleaner than gasoline or diesel, conversion of public transit fleets to natural gas can help reduce emissions.

In 2009 the U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) commissioned a survey to collect and analyze experiential data from U.S. transit agencies nationwide with varying degrees of CNG bus and station experience. This study was conducted "to illustrate the lessons learned by CNG transit agencies and to help focus future support of the CNG market" (Adams & Horne, April 2009 - April 2010). The quantitative and qualitative information collected about CNG transit fleets including vehicle and engine information, operational information, vehicle and engine modifications to support the natural gas system, fueling and facility information. The survey included 10 transit agencies with fleet sizes of 15-2,509 CNG buses. A total of 4,071 CNG buses were surveyed with a focus on 35-60 ft buses. To facilitate comparison with diesel data, CNG consumption was converted to diesel gallon equivalents (DGE) using the conversion of 137 standard cubic feet (scf) or 1.37 therms of CNG per DGE. The survey intended to focus on the problems, mistakes, and lessons learned the hard way hoping that others can learn from the experience.

The average natural gas fuel cost for commodity gas delivered to a refueling site was $0.85/DGE; and was based on the commodity purchasing plans used by the transit agencies. Station power costs were collected based on the electrical cost to operate a CNG station. "The costs include energy and demand charges, metering charges, and any penalties for peak-period operation" (Adams & Horne, April 2009 - April 2010). The average cost was $0.18/DGE. A comprehensive station maintenance cost was calculated on a per DGE basis for agencies not currently contracting on this bases and was compared to agencies that did contract on a per-unit-of –throughput basis. The average cost was $0.18/DGE but may not be reflective of the current market because of current long-term maintenance contracts. The study cited that a more current cost of contract would be in the $0.20-$0.30/DGE range. A total delivered CNG cost was computed based on the factors above and assuming that a sum of average costs is a valid total cost. The average compressed cost of CNG at the nozzle is $1.30/DGE using $0.27/DGE for maintenance simulating better accuracy in today's market. Since diesel and CNG have different fuel economies, a 20 percent efficiency penalty for CNG was used for accurate comparison to diesel. The result was an-energy and efficiency equivalent cost of $1.63/DGE for CNG. The current $0.50 per gasoline gallon equivalent (GGE) fuel tax credit which would reduce this cost by $0.57/DGE to give a net energy and net efficiency equivalent cost of $1.06/DGE. Evidence from the report suggests that the industry still needs influential government policy and assistance to expand. The $0.50/GGE fuel subsidy has made the business case for many agencies to remain with and expand CNG use in their fleet much more compelling. Their concern is with the government continuing this incentive over the long term since the transition to CNG is a 12-15 year commitment.

Respondents were also asked to identify any unexpected benefits of CNG use in their transit agencies. Responses were positive and noted that "fuel costs were sometimes much lower than diesel and then further subsidized by the federal rebate of $0.50/GGE" (Adams & Horne, April 2009 - April 2010). Other comments were that the cost of CNG was much more stable than the cost of diesel and there is optimism that the cost of CNG is projected to remain low for some time to come. Agencies liked the fact that there were no issues of diesel spills and respondents noted much improved air quality and cleanliness in their garages.

Not all public transit agencies are well suited for CNG investment and operation. It is both critically important and challenging for agencies attempt to predict whether a project is financially sound before the initial investment. To assist fleets and businesses in evaluating the profitability of potential CNG projects, the National Renewable Energy Laboratory built a CNG Vehicle and Infrastructure Cash-Flow Evaluation (VICE) model. This model demonstrates the relationship between project profitability and fleet operating parameters. "Decisions made on equipment purchases, capital upgrades, and fuel contracts have long-term impacts on the operational success of the fleet" (Johnson, 2010). The impacts of these decisions and other fleet parameters have been modeled using the VICE system which can be used to analyze future fleet projects. Results from the model show that the most profitable and resilient fleets tend to be larger transit and refuse fleets (75+ vehicles) because "the miles driven by the fleet overall use enough fuel to magnify the benefits of the lower-price CNG to offset the entry costs of CNG (vehicles incremental costs and infrastructure costs)" (Johnson, 2010). Large transit or refuse fleets have the potential to remain profitable unless:

- Diesel drops below $2.025/gal
- CNG vehicle maintenance costs increase 50%
- VMT drops below 26,000 miles per year (transit) or 14,000 miles per year (refuse)
- Vehicle incremental costs double
- Any combination of the above

Smaller transit fleets (<75 vehicles) and school bus fleets tend to be marginal because they are heavily influenced by many factors. If VMT drops below 10,000 miles per bus the profitability deteriorates rapidly because of the overall low fuel use of the fleet. "Diesel prices are also a powerful indicator of profitability given that natural gas prices are relatively consistent" (Johnson, 2010). A school bus project does not make economic sense until the diesel price approaches $4/gallon for 100-bus fleets and $5/gallon for 50-bus fleets. "For transit and refuse fleets, the size and fleet type become increasingly irrelevant as the price of diesel increases past $2.50" (Johnson, 2010). The average U.S. diesel fuel cost as of December 6, 2010 was $3.197 which makes project economics for CNG look resilient. A big portion of the cost of CNG fuel is subsidized by the federal tax credits. The synergies with the vehicle and fuel tax credits reduce the payback period of a project more than the sum of both their impacts. "Taking either one of the tax credits away makes school projects not pay off. If a fleet pays taxes on diesel but not CNG, their payback period is reduced by 22 percent" (Johnson, 2010). Somewhat surprisingly were the factors that didn't have much effect on project profitability. These included the efficiency difference between CNG and diesel engines, change in vehicle/project life, maintenance costs for CNG stations and garage upgrades. Infrastructure tax credits also have a significant influence on the profitability of marginal projects such as school fleets. The model found that "in general, a 50% increase in station cost results in a 30% increase in payback years" (Johnson, 2010). The expiration of the infrastructure and fuel tax credits by the federal government in December 2010 could be make-or-break for many school fleets and smaller (<50 vehicle) transit and refuse fleets.

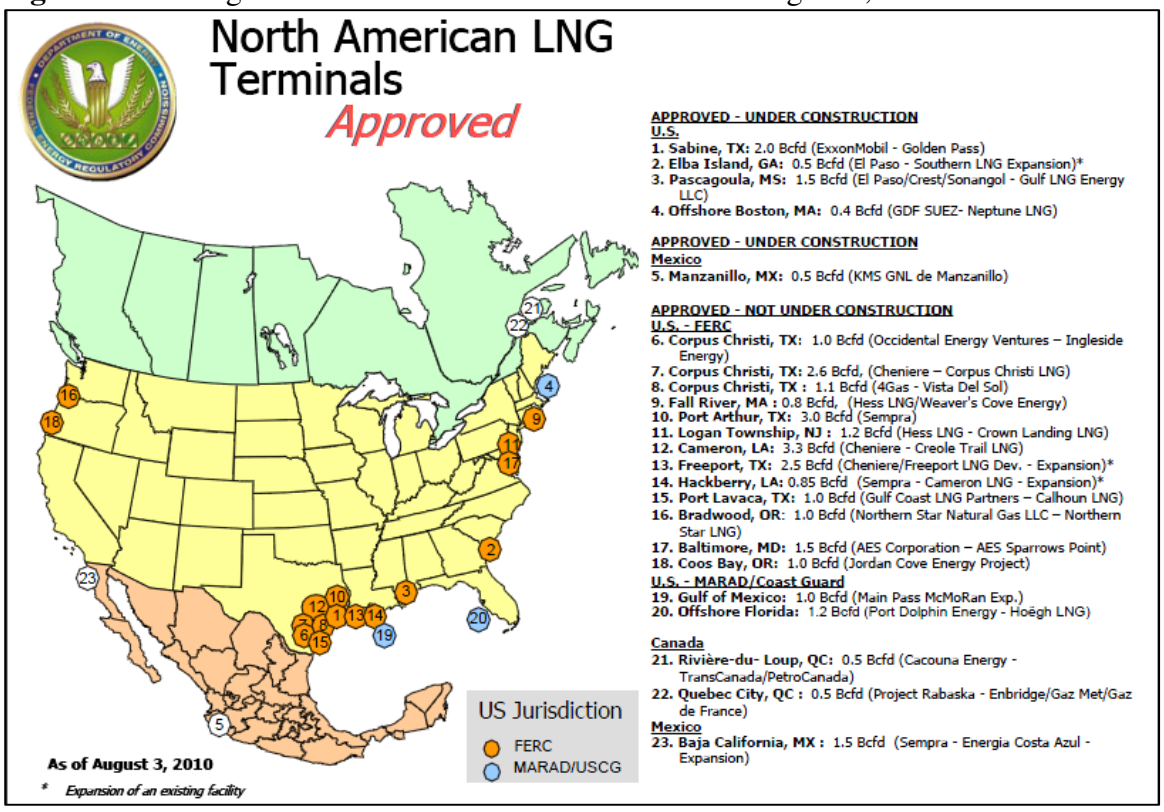
Business Case for LNG in the Private Transportation Sector

While natural gas is emerging as a viable fuel alternative in the public transportation sector, it still only accounts for two percent of the total transportation sector's energy needs. One way to increase the use of natural gas is to target the nation's heavy duty, long-haul tractor trailers. "There are 2.2 million heavy-duty, long haul trucks in the United States, representing less than 1 percent of vehicles on the road, but they are responsible for nearly 10 percent of total domestic oil consumption and for more than half of all domestic diesel consumption" (Krupnick, 2010). In the privatized industry of long-haul trucking, evidence can be found that supports both social and economic benefits of using LNG trucks compared to their diesel counterparts. Companies like UPS, AT&T and Waste Management have already begun transitioning their fleets to natural gas taking advantage of government incentives and the recent hype of "green" branding.

In the long haul trucking industry, LNG is more prevalent over CNG due to the demands of the business model. Long-haul trucks require the ability to carry a large quantity of fuel in order to reduce the frequency of stops. Compressed natural gas is not as good a fit for the industry due to the weight of gas that would be required to meet capacity during the long movements. Recent government attention given to NGVs through incentives and legislation has significantly increased their market share in the public sector, but this is just the tip of the ice burg. The private heavy-duty trucking industry represents the largest opportunity to replace foreign oil with homemade natural gas as a transportation fuel. Commonly referred to as "semis" or "18 wheelers" heavy trucks include Class 7 and Class 8 trucks weighing more than 26,000 pounds and are used for freight transportation. "The Energy Information Administration estimates that there are currently 4.8 million heavy trucks on the road, consuming more than 1.6 million barrels of oil per day, mostly in the form of diesel fuel" (Annual Energy Outlook 2010 with Projections to 2035 , 2010). Due to the trucks heavy weight, they have an average fuel economy of only about six miles per gallon. "If just 3 million heavy trucks converted to natural gas by 2035, they could eventually displace up to 1 million barrels of oil per day, or 45 percent of the projected oil consumption of heavy trucks by 2035" (American Fuel)

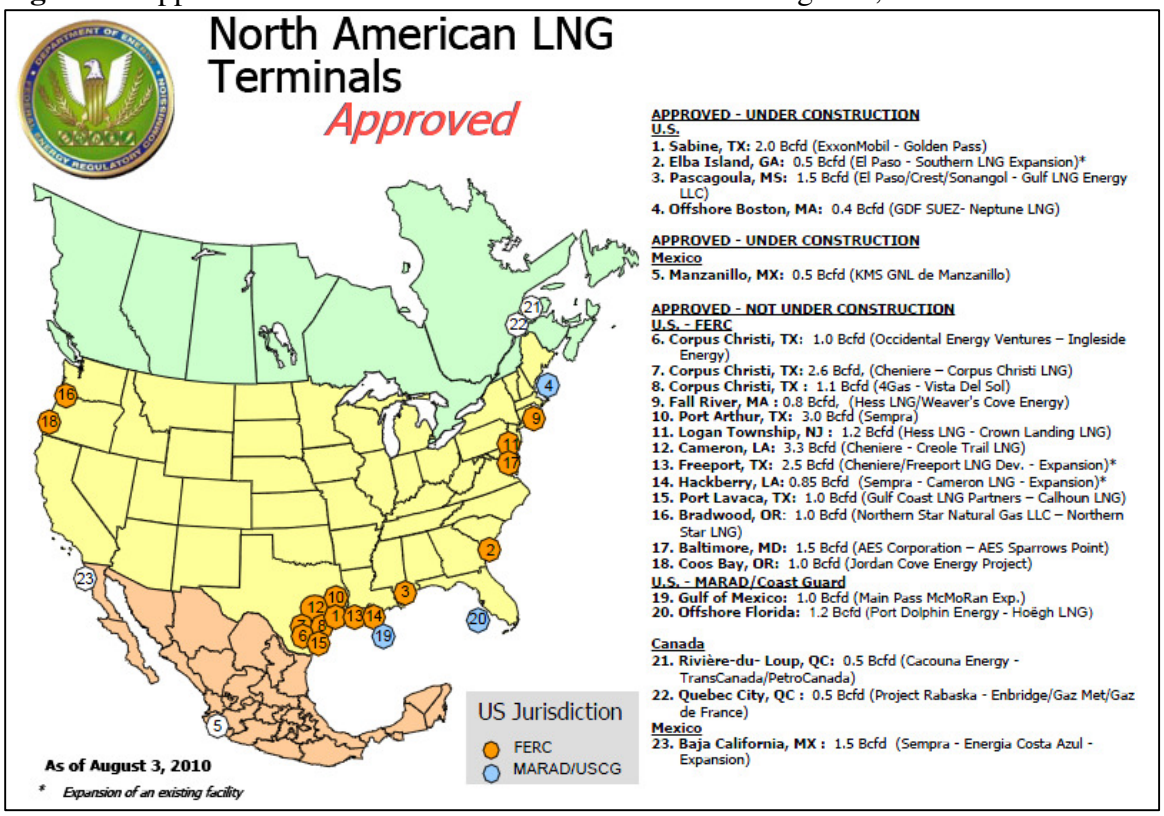
As the U.S. struggles to meet a growing domestic energy demand, LNG has a critical role to play in the mix of energy choices necessary to provide clean energy when and where it is desired. In order to ensure American citizens and businesses are not disadvantaged when competing for global energy supplies, the U.S. must invest in a well-developed LNG infrastructure. Today there are only nine U.S. facilities capable of importing LNG. Figure 4 below displays the existing North American LNG terminals. The terminals are predominantly located along the east coast in Georgia, Virginia and Maryland and in Texas and Louisiana. Growth in the industry as a result of technological advances and increased demand has led to the expansion of North American LNG terminals. Figure 5 displays a list of approved LNG terminals as of August 3, 2010. Expansion into the northwest region of the United States as well as a proliferation of terminals in Texas indicates a growing business case for LNG infrastructure. The ability for NGVs to compete with tradition fuels like gasoline and diesel depends on the availability of infrastructure along interstate corridors. In order to persuade businesses with high volumes of freight trucking to convert to LNG their must be an economic incentive. A recent joint venture between an Atlanta based Natural Gas Distribution Company and a Texas based natural gas producer provides a potential business model that could make LNG trucking a reality in the southeast.

Figure 4: Existing North American LNG Terminals as of August 3, 2010



http://ferc.gov/industries/gas/indus-act/lng.asp

Figure 5: Approved North American LNG terminals as of August 3, 2010



http://ferc.gov/industries/gas/indus-act/lng.asp

The greatest barrier to widespread use of LNG in the private transportation sector is infrastructure and distribution. A recent partnership between AGL Resources and El Paso Corporation could play an essential role in expanding the availability of natural gas as an alternative to diesel fuel for heavy duty fleet use including long-haul trucking. The joint venture announced July 28, 2010 will facilitate the distribution of liquefied natural gas across the southeastern United States targeting the heavy-duty transportation market, which includes heavy-duty trucks, buses, and waste haulers. The new 50/50 joint-venture called Southeast LNG Distribution Company plans to own and operate a fleet of LNG-fueled tankers and distribution facilities to support the use of LNG as a fuel source for this emerging market segment (About Us, 2010). “The 18-wheeler or freight movement market in general, is definitely the holy grail when it comes to potential energy savings” said Peeples the companies Vice President of Sales and Marketing.

Southeast LNG plans to provide distribution facilities and gas supply contracts to both the public and private sectors as the market develops. “Approximately 25 percent of the nation’s tractor-trailer traffic occurs in the southeastern U.S.,” said Hughes the companies President. “We plan to develop infrastructure to fuel and service this market segment with LNG, providing significant environmental and economic benefits” (Hughes, 2010). Southeast LNG will custom design, build, own and maintain fueling centers for companies or municipalities. Targeted companies for LNG use are heavy duty trucks used for regional distribution: UPS, FedEx, Wal-Mart, Sysco, JB Hunt, Averitt Express, SE Freight and SAIA Freight. The initial target market area includes Florida, Georgia, Alabama, Tennessee, South Carolina and North Carolina with emphasis on the corridor from the Port of Savannah to Atlanta, Georgia. “Providing companies with greater access to this alternative fuel will enable cost savings and operational efficiencies that can benefit both consumers and the environment” (Peeples, 2010). Recent infrastructure improvements on Elba Island have been made to expand its liquefied natural gas (LNG) terminal to serve growth markets in the Southeastern United States. “The current Elba Island expansion is expected to add 8.4 billion cubic feet (Bcf) of storage capacity at the facility and 900 million cubic feet per day (MMcf/d) of send-out capacity, doubling the storage and send-out capabilities of the facility. The initial phase includes installation of a new 4.2 Bcf storage tank and modification of the docking facilities to accommodate new, larger delivery vessels. This phase of the expansion was placed in service in July 2010” (Elba Projects, 2010).

In 2004, the Environmental Protection Agency (EPA) launched a brand that would distinguish companies that used environmentally cleaner and more fuel efficient transportation options. The SmartWay brand “identifies products and services that reduce transportation-related emissions” (SmartWay, 2010) however the impact of the brand is much greater. “The SmartWay brand signifies a partnership among government, business and consumers to protect our environment, reduce fuel consumption, and improve our air quality for future generations.” To earn a SmartWay designation, vehicles are chosen from the “Green Vehicle Guide” which ranks vehicles 1-10 by an Air Pollution Score and a Greenhouse Gas Score. To achieve the designation the vehicle must receive a 6 or better on both scores, and have a total score of at least 13. The SmartWay designation for vehicles means they are very good environmental performers relative to other vehicles. The best environmental performers are those vehicles who receive score of 9 or better on both scores and earn the designation of SmartWay Elite. Natural gas is considered an alternative fuel option and is able to earn SmartWay certification. Of the many SmartWay truck carriers, logistics and shipping partners are three well know brands previously mentioned for their investment in the natural gas transportation industry.

UPS, AT&T and Waste Management are three nationally and internationally recognized corporations who have pioneered the use of natural gas as an alternative fuel in their fleets. "UPS was the first in the package industry to introduce alternative fuel tractors into its fleet." The company currently operates 11 LNG tractor-trailers within the company's West Coast fleet. Traveling from California to Nevada daily, LNG is an excellent fuel for the large trucks that need to travel long distances before refueling. UPS also has one of the largest private fleets of CNG vehicles in the U.S., with more than 1,100 package delivery vehicles. The CNG vehicles "are expected to yield a 20 percent reduction in emissions over the cleanest diesel engines available today." The company began exclusively using CNG in 1989 to help achieve a long stated goal of "minimizing dependence on fossil fuels by improving operational efficiencies and advancing new technologies, including deploying alternative fuel vehicles." The "green" fleet operates in the United States, Germany, France, Brazil, Canada, Mexico and the United Kingdom and has traveled nearly 144 million miles since 2000 (NGV Global News, 2009).

The refuse industry, waste collection, treatment and disposal, is under constant scrutiny for its environmental impact. Leading the industry in alternative fuel growth is Waste Management (WM) which has actively employed LNG trucks since 1997 and continues to grow its NGV fleet presence. Nationally, WM already has 265 CNG and 418 LNG vehicles as well as invested hundreds of millions in landfill gas to LNG plants. In 2009, Waste Management of Seattle began construction on a new CNG fueling station and unveiled a fleet of CNG fueled solid waste collection trucks. The efforts in Seattle are a part of a larger national effort to cut the company's CO2 emissions 15 percent by 2020. The company noted that the conversion to natural gas from gasoline not only made good business sense but also reduced emissions. "An independent review conducted by an environmental consulting firm, determined WM's equipment upgrades in Seattle will reduce smog-causing NOx by 97 percent, toxic diesel particulate matter by 94 percent and greenhouse gas by 20 percent" (Automotive Fleet Top News, 2010).

AT&T's commitment to environmental sustainability was strengthened this year by the deployment of their 2,000th alternative fuel vehicle and 1,500th CNG vehicle. This milestone is just one part of a $565 million planned investment to replace more than 15,000 fleet vehicles with alternative fuel models through 2018. The corporate fleet currently includes more than 75,900 vehicles. The company anticipates purchasing approximately 8,000 more CNG vehicles over a five year span at an anticipated cost of $350 million. "The new orders demonstrate AT&T's determination to significantly alter its fleet to alternative-fuel vehicles and become less dependent on foreign oil while signaling that a viable alternative-fuel choice exists today, right here in the U.S," said Andrew J. Littlefair, Clean Energy President and CEO. The alternative fuel vehicle initiative is projected to "save 49 million gallons of gasoline over the 10 year deployment period, reduce carbon emissions by 21,000 metric tons-the greenhouse gas equivalent of removing more than 38,600 traditional passenger vehicles from the road for one year" (AT&T INC., 2010).

Natural Gas Vehicle Statistics

The International Association for Natural Gas Vehicles (IANGV) was established in 1986 "to provide the NGV industry with an international forum and to foster growth, safety, product development and policy formation." Since the establishment of the IANGV, worldwide numbers of NGV have grown from almost none to more than 10 million vehicles. The organization is projecting a "five-fold increase over the next 10 years to reach a target of 50 million NGVs on the road globally by 2020" (Natural Gas Vehicle Statistics, 2010).

The following statistics were last updated April 2010 reflecting data collected until December 2009. The updated statistics indicated that there were approximately 11.2 million natural gas vehicles on the world's roads and over 16,500 natural gas fueling stations in operation at the end of 2009 (Natural Gas Vehicle Statistics, 2010). A complete listing of NGV statistics by country ranked numerically can be found in appendix A. The top 5 countries with the greatest number of NGVs as of December 2009 are Pakistan (2,300,000), Argentina (1,807,186), Iran (1,665,602), Brazil (1,632,101) and India (935,000). Table 1 below displays the average percent growth of natural gas vehicles by region since 2000. The region with the largest growth was Asia-Pacific; whose natural gas fleet grew by 51 percent. It is important to notice that the North American region actually experienced negative growth during the past 10 years. One explanation of this is that the data used for the US was submitted December 2007. The U.S. may have experienced more growth in the natural gas sector in the past three years.

Region	Average % NGV Growth since 2000
Asia-Pacific	51.0%
Europe	15.8%
North America	-0.1%
Latin America	23.5%
Africa	19.2%
TOTAL	**28.8%**

Table 4: Average percent NGV growth since 2000 by region
http://www.iangv.org/tools-resources/statistics.html

If the annual growth rate of the CNG market continues to develop at the pace listed in Table 1 above, the potential impact on oil consumption and fuel emissions could be incredibly significant as early as 2020. The annual growth rate would especially benefit from the expanded use of CNG vehicles in large countries such as the U.S. and China. As more countries rise to the challenge of meeting energy, economic and environmental demands of their homelands, new strategies are being developed to boost fleet sizes over the next decade. Many of these strategies either are or could be employed in the U.S. to drive the CNG and LNG market.

Argentina & Brazil

As previously identified, Argentina and Brazil have two of the largest fleets of CNG vehicles in the world. The conversion of a large portion of their public transportation system to CNG was encouraged by government-enforced financial incentives. "Enhancements have been made to the CNG local production and delivery infrastructures to make CNG vehicles more convenient" (What is CNG?, 2010). Through the initiative of a project called "Blue Corridors" advancements are being made in South America to connect major cities with "routes" of natural gas fueling stations.

Europe

The European Union has recently put forward a proposal to "promote the wide use of alternative fuels in motor transport by replacing petroleum fuel use in the transport sector by 20% alternative fuels by the year 2020" (Force, 2003). This is primarily in response to the recent structural changes in east European countries and their transition to a market economy. "The European Union has significantly increased the volume of motor vehicle traffic and will continue to increase in line with the substantial growth and expansion of transnational corporations" (Force, 2003). The rapid increase in vehicles has resulted in "unacceptable levels of atmospheric pollution" and the substitution of alternative forms of fuel "could play a significant role in cutting emissions" (Force, 2003).

The objective of the Blue Corridor Project "is to establish transport corridors for heavy duty transport vehicles using compressed natural gas as fuel instead of diesel, both because of its economic and environmental advantages" (Force, 2003). Two intergovernmental bodies-the United Nations Economic Commission for Europe Working Party on Gas and Inland Transport Committee set up a Task Force which selected three pilot Blue Corridors. Feasibility studies were conducted for the three pilot corridors based on traffic volumes, savings in fuel costs, reeducations in emissions and number of existing CNG fuelling stations. An example from the Moscow-Berlin corridor feasibility study with projected daily traffic of 16,000 lorries in 2010 resulted in projected fuel savings of 300 million Euros per year and harmful exhaust emissions reduced up to 60 % (based on 100% conversion to CNG) (Force, 2003).

Conclusion

"Our dependence on foreign oil distorts our foreign and military policy, threatens our economy, worsens our balance of trade, and costs us jobs here at home" (About NGVs).

Since the oil crisis of the 1970's nationwide efforts have been made to reduce the amount of oil used in residential, commercial, industrial and electricity generation. All the while research and development of alternative fuels in the transportation industry has remained relatively stagnant. Where we must use gasoline or diesel fuel, we should use it as efficiently as possible but, where we don't have to use gasoline or diesel at all, we shouldn't. We need to act today with the alternatives we have today and use our non-petroleum fuel options in applications and regions where they are most appropriate. Right now there are thousands of delivery trucks, port vehicles, airport vehicles, transit buses, school buses, trash trucks, shuttle vans, and other urban-based vehicles operating around the country solely on clean natural gas. The road to introducing large numbers of natural gas vehicles to U.S. highways is clear. It begins with commercial and municipal fleets because that's where the biggest difference can be made in displacing petroleum use and achieving meaningful emissions reductions. This is also where market demand is highest. In the United States many cities and municipalities have begun to convert their diesel buses to natural gas and often with great success. The business case targets municipal governments, which operate fleets well suited for CNG vehicles because of the circular routes that enable refueling at the same station. These fleets are transit buses, school buses, and refuse trucks. Municipal governments are also targeted because their primary goal is to improve their residents' quality of life. This goal allows the government to utilize all the advantages of CNG, including long term cost effectiveness, more consistent operational costs, increased energy security, reduced greenhouse gas emissions, reduced local air pollution, and reduced noise pollution.

Trucks and other heavy-duty vehicles offer another application where conversion to natural gas makes economic sense. The entire U.S. economic wellbeing is based on our ability to get products and goods distributed cost-effectively and on time. We must ensure that these vehicles cannot be crippled by the policies of a foreign government or some catastrophic event. By encouraging the use of natural gas fuels in heavy duty trucking vehicles and switching away from petroleum altogether, a substantial dent can be made in the amount of oil we need to import. A significant portion of heavy- and medium-duty trucks and buses are already centrally refueled. Heavy freight trucks are often refilled at truck stops along interstate highways, which could be targeted for natural gas installation and used to create natural gas refueling corridors. Following the examples of many foreign nations, Federal policymakers could examine the feasibility of creating "natural gas highway corridors" with NGV refilling facilities at truck stops along interstate highways.

Due to recent improvements in natural gas technologies, economic incentives are being realized in the private sector. This is apparent as companies make the investment to transition their fleets to natural gas technologies. Coupled with strong government leadership and lead by incentives from the Federal government, the U.S. could legitimately use natural gas to strengthen our energy mix. Conservation and intelligent planning by cities and municipalities make a difference but there must be a cohesive plan; a vision for the future of the United States that identifies a clear objective of energy independence and outlines the necessary steps to accomplish the goal. This vision must contain energy options that allow businesses to operate in profitable ways, for cities to stay within budget while proving essential services and educate the public on limiting environmental impact. Ironically though as the technology and interest in natural gas has grown over the past few years, the future of the industry is at a crossroads. The alternative fuel industry as a whole could become completely disabled if current tax incentives and fuel credits are allowed to expire at the end of December 2010. If natural gas as an alternative fuel in the transportation sector is to remain an important part of our clean energy solution, vehicle fuel and infrastructure tax incentives must remain in place.

Bibliography

About LNG. (2010). Retrieved September 6, 2010, from Center for Liquified Natural Gas: http://www.lngfacts.org/About-LNG/Overview.asp

About NGVs. (n.d.). Retrieved September 20, 2010, from NGVAMERICA: http://www.ngvc.org/about_ngv/index.html

About Us. (2010). Retrieved November 20, 2010, from Southeast LNG: http://www.southeastlng.com/

Adams, R., & Horne, D. (April 2009 - April 2010). *Compressed Natural Gas (CNG) Transit Bus Experience.* Golden, CO: National Renewable Energy Laboratory.

Alternative Fuels & Advanced Data Center. (2010, November 16). Retrieved November 16, 2010, from U.S. Department of Energy: http://www.afdc.energy.gov/afdc/

American Fuel. (n.d.). Retrieved November 13, 2010, from Center for American Progress: http://www.americanprogress.org/issues/2010/04/american_fuel.html

Annual Energy Outlook 2010 with Projections to 2035 . (2010, May 11). Retrieved November 23, 2010, from U.S. Energy Information Association: http://www.eia.doe.gov/oiaf/aeo/gas.html

AT&T INC. (2010, July 14). *Media Newsroom* . Retrieved 12 4, 2010, from AT&T: http://www.att.com/gen/press-room?pid=18113&cdvn=news&newsarticleid=30947&mapcode=regulatory

Automotive Fleet Top News. (2010, 1 25). Retrieved 12 4, 2010, from Automotice Fleet: http://www.automotive-fleet.com/News/Story/2010/01/Waste-Management-Deploys-New-Natural-Gas-Trucks.aspx?interstitial=1

Clean Cities. (n.d.). Retrieved August 20, 2010, from U.S. Department of Energy: http://www1.eere.energy.gov/cleancities/

Consumer Energy Center. (2010). Retrieved November 15, 2010, from California Energy Commission: http://www.consumerenergycenter.org/transportation/afvs/

Elba Projects. (2010). Retrieved November 20, 2010, from elpaso: http://www.elpaso.com/elba3/default.shtm

Electric Generation Using Natural Gas. (2004-2010). Retrieved November 6, 2010, from NaturalGas.org: http://www.naturalgas.org/overview/uses_eletrical.asp

Federal & State Incentives & Laws. (2010, 11 16). Retrieved November 6, 2010, from U.S. Department of Energy: Energy Efficiency & Renewable Energy: http://www.afdc.energy.gov/afdc/laws/laws/US/tech/3253

Federal Energy Management Program. (2010, 11 16). Retrieved 11 6, 2010, from U.S. Department of energy: http://www1.eere.energy.gov/femp/program/fedfleet_management.html

Federal NGV Tax Incentives. (2010). Retrieved August 20, 2010, from NGVAMERICA: Http://www.ngvc.org/about_ngv/index.html

Force, U. N. (2003). *Blue Corridor Project.* Geneva: United Nations.

Fossil Energy. (n.d.). Retrieved November 13, 2010, from U.S. Department of Energy: http://www.fe.doe.gov/education/energylessons/gas/gas_production.html

Government Policy. (n.d.). Retrieved November 12, 2010, from NGVAMERICA: http://www.ngvamerica.org/gov_policy/fed_regs/fed_CleanAirAct.html

Hydraulic Fracturing. (2010, 11 22). Retrieved 12 4, 2010, from U.S. Environmental Protection Agency: http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/index.cfm

Johnson, C. (2010). *Business Case for Compressed Natural Gas in Municipal Fleets.* Golden, CO: National Renewable Energy Laboratory.

Krupnick, A. (2010). *Energy, Greenhouse Gas, and Economic Implications of Natural Gas Trucks.* Washington, DC: National Energy Policy Institute.

Natural Gas Consumption. (2010). Retrieved November 20, 2010, from U.S. Energy Information Administration: http://www.eia.doe.gov/oil_gas/natural_gas/info_glance/natural_gas.html

Natural Gas Fleet Vehicles. (2010). Retrieved 11 6, 2010, from Atlanta Gas Light: http://www.aglc.info/Business/FleetVehicles.aspx

Natural Gas in the Transportation Sector. (2010). Retrieved September 12, 2010, from NaturalGas.org: http://www.naturalgas.org/overview/uses_transportation.asp

Natural Gas Vehicle Statistics. (2010, April). Retrieved 8 16, 2010, from NGV Global: http://www.iangv.org/tools-resources/statistics.html

NGV Global News. (2009, May 24). Retrieved 12 4, 2010, from NGV Global: http://www.ngvglobal.com/ups-grows-alternative-fuel-fleet-by-30-0524

SmartWay. (2010, 12 3). Retrieved 9 5, 2010, from U.S. Environmental Protection Agency: http://www.epa.gov/smartway/index.htm

What is CNG? (2010). Retrieved from CNG NOW!: http://www.cngnow.com

You've Got Shale: The "where" and "what" of shale gas formations. (n.d.). Retrieved October 16, 2010, from NaturalGas.org: http://www.naturalgas.org/shale/gotshale.asp

Appendix A

	Country	Natural Gas Vehicles	Refueling Stations	Year data received
1	Pakistan	2,300,000	3,068	2009
2	Argentina	1,807,186	1,851	2009
3	Iran	1,665,602	1,021	2009
4	Brazil	1,632,101	1,704	2009
5	India	935,000	560	2009
6	Italy	628,624	730	2009
7	China	450,000	870	2009
8	Colombia	300,000	460	2009
9	Ukraine	200,000	285	2006
10	Bangladesh	177,555	500	2009
11	Thailand	162,023	391	2009
12	Bolivia	121,908	128	2009
13	Egypt	119,679	119	2009
14	USA	110,000	1,300	2007
15	Armenia	101,352	214	2008
16	Russia	100,000	244	2009
17	Germany	85,000	860	2009
18	Peru	81,024	94	2009
20	Bulgaria	60,270	77	2009
21	Uzbekistan	47,000	43	2007
22	Malaysia	42,617	137	2009
23	Japan	38,042	344	2009
24	Korea South	25,744	159	2009
25	Sweden	23,000	104	2009
26	Myanmar (Burma)	22,821	38	2008
27	Venezuela	15,000	150	2009
28	France	12,450	125	2008
29	Canada	12,000	80	2009
30	Tajikistan	10,600	53	2006
31	Chile	8,064	13	2009
32	Switzerland	7,163	110	2009
33	Kyrgyzstan	6,000	6	2007
34	Belarus	5,500	24	2006
35	Moldova	5,000	14	2006
36	Austria	4,983	208	2009
37	Trinidad & Tobago	3,500	10	2006
38	Turkey	3,056	9	2008
39	Mexico	3,037	3	2005
40	Georgia	3,000	42	2007
41	Australia	2,750	47	2007
42	Singapore	2,656	5	2009
43	Poland	2,106	32	2010
44	Indonesia	2,000	9	2006
45	Spain	1,863	42	2008
46	Czech Republic	1,755	37	2009
47	Netherlands	1,502	50	2009

49	**Finland**	700	13	2009
50	**Greece**	520	2	2009
51	**Latvia**	500	4	2008
52	**Slovakia**	426	7	2008
53	**Portugal**	407	5	2008
54	**United Arab Emirates**	305	2	2007
55	**Belgium**	300	5	2005
56	**New Zealand**	281	12	2007
57	**England**	221	31	2007
58	**Serbia**	210	7	2007
59	**Luxembourg**	203	7	2009
60	**Norway**	180	9	2007
61	**Croatia**	152	1	2008
62	**Lithuania**	133	2	2009
63	**Algeria**	125	3	2004
64	**Hungary**	110	13	2006
65	**Lichtenstein**	101	1	2007
66	**Iceland**	77	1	2007
67	**Nigeria**	60	3	2005
69	**Macedonia**	50	1	2007
70	**Cuba**	45	1	2001
71	**Philippines**	36	3	2006
72	**Tunisia**	34	2	2007
73	**South Africa**	22	1	2005
74	**Uruguay**	20	-	2008
75	**Bosnia & Herzegovina**	7	-	2007
76	**Montenegro**	6	-	2006
77	**Korea North**	4	1	2006
78	**Mozambique**	4	1	2007
79	**Taiwan**	4	1	2005
80	**Tanzania**	3	-	2009
81	**Vietnam**	3	1	2009
82	**Ireland**	2	1	2008
83	**Dominican Republic**	1	1	2007
84	**Denmark**	-	1	2007
	Total	**11,355,785**	**16,513**	

Table 5: Natural gas vehicles ranked numerically by country as of December 2009
http://www.iangv.org/tools-resources/statistics.html