

NATURAL GAS VEHICLES

Due mostly to the initial dominance of gasoline and the proliferation of gasoline infrastructure, natural gas has lagged considerably behind gasoline and diesel as a transportation fuel. As natural gas becomes more readily available to consumers for transportation use at a low cost, natural gas can have a brighter future in the United States. Natural gas as a U.S. transportation fuel has some advantages over gasoline, including:

- **Abundance.** The International Energy Agency estimates that enough natural gas is resting beneath US soil to take us well into this century.¹
- **Low cost.** Compressed Natural Gas and Liquefied Natural Gas both compare favorably to the price of gasoline.²
- **Clean.** Natural gas is a cleaner burning fuel than gasoline, resulting in healthier environments through reduced pollution.³
- **Domestic.** 98% of the natural gas consumed in the United States is produced domestically. In contrast, only 55% of gasoline consumed in the United States is produced domestically.⁴

History of Natural Gas

Natural gas came to the United States in the early 19th century as a lighting fuel. By the 1930s, technological improvements in storage and transmission made natural gas available to large urban sections of the country. Automobile manufacturers and consumers, however, had already committed heavily to gasoline as the preferred fuel. Production lines were dedicated to gasoline-powered vehicles, which could easily refuel at rapidly growing selection of gas stations across the country. Just as electric vehicles and steam engines could not contend, natural gas was subdued by gasoline's transportation monopoly.⁵ Natural gas did find limited uses in small urban markets, but did not prove competitive.

The oil and gasoline crises of the 1970s spurred consumer interest in alternative fuels and fuel efficiency, though ultimately consumers turned in the short term to more

CNG vs. LNG: Alternative Forms of Alternative Fuels

Natural Gas can fuel vehicles in two basic forms: Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG). Both of these fuels operate just like gasoline, combusting to power a vehicle's engine. However, these forms of natural gas offer consumers a reduction in cost at current natural gas prices, as well as a potential reduction in carbon pollution over gasoline.

CNG is comprised mostly of methane. Methane is often captured as a byproduct of petroleum extraction, but it also occurs independently and can be extracted from rock formations. Natural gas is shipped across the country compressed in pipelines or stored in tanks. Vehicles store natural gas at high pressures in specialized tanks.

LNG, as the name suggests, is simply natural gas that is liquefied using freezing temperatures, which can be as low as -270 degrees Fahrenheit. The equipment is more expensive, heavier, and quite specialized, but the energy density of LNG is comparable to diesel. Consequently, LNG is used mostly by heavy-duty vehicles.

Vehicles that use only natural gas are called "dedicated," whereas vehicles that have natural gas tanks in addition to gasoline or diesel tanks and are commonly called "bi-fuel." Bi-fuel technology uses only one fuel at a time, with the driver responsible for switching between sources, which contrasts "dual-fuel" technology that co-fires diesel with natural gas or ethanol blends. Bi-fuel systems offer drivers the potential cost savings of natural gas and the availability of gasoline or diesel.



mandated clean fleets, and increasing Corporate Average Fuel Efficiency (CAFE) standards resulted in increased efficiency of gasoline vehicles, not a paradigm shift in consumer fuel sources. Major auto manufacturer attempts to capture the natural gas market have been fleeting; Honda is the only major auto manufacturer that sells a factory-built natural gas sedan in the American light duty market. Smaller niche firms have also built engines to work in major automobile makers' frames, but the scope has been very limited.⁶

Under Pressure: The Present State of Natural Gas as a Transportation Fuel

Natural Gas currently powers approximately 120,000 US vehicles, the vast majority of which run in fleets. Fleets are a natural fit for natural gas technology because they overcome some of the most significant barriers facing natural gas vehicles:⁷

- **Lack of Refueling Stations:** Only 1,000 natural gas refueling stations exist within the United States, and only half of those are available to the public.⁸
- **High Price Premium:** The up-front cost of a natural gas vehicle is typically much higher than gasoline-powered counterparts, though natural gas vehicles' operating costs are typically lower. A company or municipality can bear the burden of a higher initial price better than an individual.
- **Reduced Storage Space:** CNG and LNG tanks can take up more space in a trunk, which can affect the consumer more markedly than fleet operators.



- **Safety:** Though natural gas vehicles are just as safe as gasoline powered vehicles, consumers fear accidents with CNG tanks under high pressure. Owners of fleets are generally well informed about the operational capabilities of their vehicles.

Vehicles can return to familiar and accessible refueling stations, and the high vehicle miles traveled in a fleet enables operators to take advantage of the low comparative costs of natural gas over gasoline. CNG vehicles are generally used for urban fleets that are used regularly for shorter distances at a time, whereas LNG is used more typically for long-distance fleets such as freight trucks. Municipal buses and service trucks are commonly associated with natural gas use, but private businesses such as UPS and large telecom firms are also investing in natural gas fleets. Some of large firms have purchased thousands of CNG vehicles with plans to expand.

The light-duty natural gas vehicle market is currently very limited. Only Honda sells a dedicated natural gas vehicle, the Civic GX, which runs on CNG and is comparable in most ways to gasoline-powered Civics. A handful of other light-duty vans and SUVs are slated to hit the market in 2012. Light-duty gasoline vehicles can be converted with the aid of standard kits, which are readily available on the market. Conversions from gasoline to CNG or LNG are somewhat complex, and can commonly cost from \$2,000 to more than \$5,000, which will be partially offset by fuel cost savings.⁹ Professionals or individuals with conversion kits can complete the conversion process.

Rising into the Future with Natural Gas

The abundance of cheap natural gas has led many large auto manufacturers into production of CNG vehicles. Citing consumer interest, low emissions, and cheap fuel availability, manufacturers General Motors, Chrysler, and Ford will be entering the market in 2013 with natural gas pick-up trucks. Sales of these vehicles may serve as bellwethers for the future of natural gas vehicles, but not necessarily – though Honda sold only 2,000 Civic GXs in 2011, the company anticipates that number to double this year.¹⁰

The number and types of vehicles using natural gas has grown rapidly, with new sectors experimenting with CNG and LNG. Over 30% of all new buses and 40% of all trash trucks run on natural gas. Major urban taxi fleets, airports, and municipal fleets have all been testing natural gas vehicles for the first time in recent years, enticed by cheap fuel and clean emissions. AT&T alone plans to double its fleet to 15,000 trucks within the next two years.¹¹

Waste Not, Want Not: Renewable Natural Gas

Renewable natural gas comes from anaerobic digestion in landfills and livestock operations. These sources produce biogas, a mix of methane, carbon dioxide, and other greenhouse gases. Biogas is refined to meet quality standards for use as natural gas in transportation, heating, and electricity generation.

Renewable natural gas production and consumption has already begun in some corners of the globe, as well as some corners of this country. Germany and Austria have set targets to incorporate biogas as the base for 20% of all natural gas use, with Sweden currently leading the way at over 50% of biogas use. Some individual landfills and large dairy operations have begun to collect biogas for refinement, though not on a large commercial scale. Federal and state loans, grants, and tax credits provide incentives for livestock and landfill operators to exploit this renewable resource. For more information on renewable natural gas, consult: http://www.afdc.energy.gov/afdc/fuels/emerging_biogas.htm

Clean Energy Fuels, the largest provider of transportation natural gas in the United States, has invested heavily in promoting a natural gas infrastructure. The proposed final product, "America's Natural Gas Highway," would consist of a network of LNG stations spanning the nation. 150 stations are currently being built, with nearly half on schedule to provide service by the end of 2012.¹²

Fugitive Emissions & Life Cycle Analyses

Transportation GHG emissions have typically been measured at the tailpipe. This standard of accounting measures only the results of combusting a particular fuel within a vehicle, but fails to account for the process of producing that fuel. The capture, storage, and refinement of a fuel may require a significant amount of energy, but the energy expended in making the fuel is not reflected in tailpipe emissions. Life cycle analyses, however, do take production methods into account to give a more accurate, robust picture of any fuel's overall emissions. Many fuels' emissions are elevated in a life cycle analysis. A life cycle analysis of natural gas does show elevated emissions due mostly to accounting for fugitive emissions. These emissions occur primarily because of:¹⁴



- Venting or flaring on site
- Equipment leaks and evaporation
- Faulty equipment and accidents

Tracking and estimating fugitive emissions is a very difficult task, and is rife with uncertainty. The EPA estimates that approximately 2-3% of natural gas is lost during drilling and capture. The effect of these fugitive emissions is compounded by the potency of methane, the predominant compound in natural gas. Methane traps heat in the atmosphere over 20 times more efficiently than that standard bearer for climate change, CO₂. However, methane has a relatively short atmospheric lifetime of approximately 12 years.¹⁵ Therefore, fugitive methane emissions have a relatively great impact in the short-term, but have relatively diminished long-term climate impacts.¹⁶

Fugitive emissions and the potency of those emissions mean that natural gas may not provide any emissions reductions at all. With an improvement in process and equipment standards, the life cycle emissions of natural gas can be substantially improved relative to gasoline and diesel, which is a necessary step to providing demonstrable emissions improvements. The Environmental Defense Fund estimates that reducing fugitive emissions to below 1.6% would provide immediate climatic benefits in the light-duty CNG vehicle sector; the requisite leakage would need to fall below 1% for heavy-duty vehicles. The EPA has issued new rules on fracking and natural gas capture aimed at reducing fugitive emissions and ensuring a safer, cleaner process. Natural gas has great potential to reduce GHG emissions, but it first must clean up its act.

	Reduced Taxes & Regulation	Acquisition Requirements	Technical Assistance	Grants, Loans, & Rebates
Maine	●			●
New Hampshire				●
Vermont	●		●	
Massachusetts	●	●		
Rhode Island			●	
Connecticut			●	●
New York	●	●		●
New Jersey	●		●	
Pennsylvania			●	●
Delaware		●	●	
Maryland				
Washington, DC		●	●	
West Virginia	●			
Virginia	●			

Untapped Potential: State Opportunities for Natural Gas Vehicles

Many states promote natural gas through subsidies, market incentives, or preferential policies. The following incentives are common in the Northeast and Mid-Atlantic:

- **Reduced Taxes & Regulation:** CNG and LNG are either taxed less or are completely exempt when used as a transportation fuel. Some states do not regulate these fuels at all.
- **Acquisition Requirements:** Most states have requirements to purchase a set percentage of Alternative Fuel Vehicles. Natural gas has established a strong foothold as a fuel for fleet vehicles through these purchase mandates.
- **Technical Assistance:** Local companies offer free technical assistance to install or advise individuals or businesses on conversions and fueling station installation.
- **Grants & Loans:** Several states offer grants or preferential loans for the purchase of clean fleet vehicles and the installation of natural gas fueling stations.

Endnotes

1. <http://www.economist.com/node/21558432>
2. <http://www.afdc.energy.gov/fuels/prices.html>
3. http://www.afdc.energy.gov/vehicles/natural_gas_emissions.html
4. http://www.eia.gov/energy_in_brief/foreign_oil_dependence.cfm
5. avt.inl.gov/pdf/fsev/history.pdf
6. Argonne National Laboratory. "Natural Gas Vehicles: Status, Barriers, and Opportunities." August 2010. Page 3.
7. Ibid. Page 28.
8. <http://www.afdc.energy.gov/locator/stations/>
9. <http://alternativefuels.about.com/od/naturalgasvehicles/bb/naturalgas.htm>
10. <http://content.usatoday.com/communities/driveon/post/2012/03/gm-chrysler-ford-look-to-cash-in-on-natural-gas-boom/1#.UCH6eZhHCHF>
11. <http://www.worktruckonline.com/Channel/Green-Fleet/Article/Story/2011/05/Are-Natural-Gas-Vehicles-Right-for-Your-Fleet/Page/1.aspx?prestitial=1>
12. <http://www.cleanenergyfuels.com/buildingamerica.html>
13. <http://www.afdc.energy.gov/laws/state>
14. IPCC. "Fugitive Emissions from Oil and Natural Gas Activities." 2006. Page 105.
15. <http://www.epa.gov/methane/scientific.html>
16. Environmental Defense Fund. "Greater Focus Needed on Methane Leakage from Natural Gas Infrastructure." February 2012. Page 4.

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