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Natural Gas Passenger Vehicles: Availability, Cost, and Performance

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Summary

Higher gasoline prices and concerns over U.S. oil dependence have raised interest in natural gas vehicles (NGVs). Use of NGVs for personal transportation has focused on compressed natural gas (CNG) as an alternative to gasoline. Consumer interest has grown, both for new NGVs as well as for conversions of existing personal vehicles to run on CNG. This report finds that the market for natural gas vehicles will likely remain limited unless the differential between natural gas and gasoline prices remains high in order to offset the higher purchase price for an NGV. Conversions of existing vehicles will also continue to be restricted unless the Clean Air Act (CAA) is amended or if the Environmental Protection Agency (EPA) makes changes to its enforcement of the CAA.

Introduction. Congressional and consumer interest in natural gas vehicles (NGVs) for personal transportation has grown rapidly in recent months, especially in response to higher gasoline prices, concerns over the environmental impact of petroleum consumption for transportation, and policy proposals such as the "Pickens Plan."[1] Although natural gas passenger vehicles have been available for years, they have been used mostly in government and private fleets; very few have been purchased and used by consumers. Larger NGVs — mainly transit buses and delivery trucks — also play a role in the transportation sector, especially due to various federal, state, and local incentives for their use. However, high up-front costs for new NGVs, as well as concerns over vehicle performance and limited fuel infrastructure, have led to only marginal penetration of these vehicles into the personal transportation market.

Current Market. The Energy Information Administration (EIA) estimates that there were roughly 116,000 compressed natural gas (CNG) vehicles in the United States

[1] On July 8, 2008, T. Boone Pickens announced a plan calling for reduced petroleum imports through the expanded use of natural gas in transportation. For an analysis of this plan, see CRS General Distribution Memoradum, *The T. Boone Pickens Energy Plan: A Preliminary Analysis of Implementation Issues*, by Jeffrey Logan, William F. Hederman, and Brent D. Yacobucci.

in 2006, and roughly 3,000 liquefied natural gas (LNG) vehicles.[2] Roughly two-thirds of NGVs are light-duty (i.e., passenger) vehicles. This compares to roughly 230 million conventional (mostly gasoline) light-duty vehicles.[3] Further, of the roughly 16.5 million new light-duty vehicles sold in 2006, only about 2,000 (0.01%) were NGVs.[4] For model year (MY) 2008, only one NGV was available for purchase by consumers — the CNG-fueled Honda Civic GX.[5]

Life-Cycle Cost Issues. Currently, natural gas vehicles are significantly more expensive than comparable conventional vehicles. For example, the incremental price between a conventional Honda Civic EX and a natural gas-powered Honda Civic GX is nearly $6,000,[6] although some of this difference is made up through a tax credit for the purchase of new alternative fuel vehicles. If a taxpayer qualifies, he or she may claim a credit of up to $4,000 for the purchase of a new Honda Civic GX.[7] This tax credit is set to terminate at the end of 2010. It should be noted that with higher production, this incremental cost should decrease, but the likely extent of that decrease is unclear.

Since the number of natural gas refueling stations is limited — only about 400 to 500 publicly available nationwide,[8] compared to roughly 120,000 retail gasoline stations[9] — the purchaser of a new NGV would likely also install a home refueling system. According to Consumer Reports, a FuelMaker Phill system costs $3,400 plus roughly $500 for installation.[10] Natural Gas Vehicles for America (NGVAmerica) estimates that the Phill system costs roughly $4,500 plus installation.[11] However, a taxpayer can offset

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[2] U.S. Energy Information Administration (EIA), *Alternatives to Traditional Transportation Fuels 2006*, May 2008. Tables V1 and V4.

[3] Stacy C. Davis, Susan W. Diegel, and Robert G. Boundy, *Transportation Energy Data Book: Edition 27*, 2008. Tables 4.1 and 4.2.

[4] Davis, et al., op. cit. Tables 4.5 and 4.6; EIA, op. cit. Table S1.

[5] For MY2004, there were eight CNG models (from Ford, General Motors, and Honda). This number dropped to five in MY2005, and one in MY2006. U.S. Department of Energy (DOE), *Fueleconomy.gov Website*. Accessed September 16, 2008.

[6] 2008 Honda Civic EX MSRP: $18,710. 2008 Honda Civic GX MSRP: $24,590. $24,590 - $18,710 = $5,580.

[7] Energy Policy Act (EPAct) of 2005. P.L. 109-58, Sec. 1341.

[8] Roughly half of the 800 to 1,000 natural gas refueling stations are privately owned or are located at government sites closed to the public (e.g., military bases). Of the public CNG refueling stations, many require a keycard or other prior arrangement with the station operator.

[9] DOE, Alternative Fuels and Advanced Vehicles Data Center (AFDC), *Alternative Fueling Station Locator*. [http://www.eere.energy.gov/afdc/fuels/stations_locator.html]. Accessed September 16, 2008.

[10] "The natural-gas alternative: The pros & cons of buying a CNG-powered Honda Civic," *Consumer Reports*, April 2008.

[11] Stephe Yborra, NGVAmerica, *Frequently Asked Questions About Converting Vehicles to Operate on Natural Gas*, Washington, DC. Accessed October 15, 2008. [http://www.ngvc.org/pdfs/FAQs_Converting_to_NGVs.pdf].

$1,000 of this by claiming a tax credit for installing new alternative fuel refueling infrastructure.[12]

Offsetting the higher up-front costs are likely annual fuel savings in switching from gasoline to natural gas. Using recent average retail gasoline and residential natural gas prices, annual fuel cost savings could be nearly $800.[13] Between July 2008 and October 2008, the price of both gasoline and natural gas have declined substantially, but the spread between them has remained relatively steady. Assuming a 7% discount rate, the current payback period for the CNG vehicle is just over eight years. Depending on how long a consumer keeps a new vehicle, this payback period may or may not be acceptable to that consumer.

Assuming a smaller differential between natural gas and gasoline prices, or the expiration of the existing tax incentives can significantly increase this payback period; assuming a larger difference in fuel prices, assuming a smaller discount rate, or assuming incremental natural gas vehicle prices decrease in the future, this payback period could be shorter.

Other Potential Benefits and Costs. In addition to the life-cycle cost difference between CNG and conventional vehicles, there are other costs and benefits associated with natural gas vehicles which may not have a defined price tag. For example, any reduction in petroleum dependence (beyond the per-gallon cost savings) is not represented in the above payback period estimate. Some consumers may place a value on displacing petroleum consumption, and thus, imports.[14] Further, natural gas vehicles in general have lower pollutant and greenhouse gas emissions than comparable gasoline vehicles, although this may or may not be true for specific vehicles and pollutants.[15]

A key potential benefit raised by proponents of NGVs is that while the United States imports the majority of the petroleum it uses, most natural gas is domestically produced. Further, domestic output is higher than once thought, likely due to recent growth in unconventional natural gas sources (e.g., coal mine methane, shale gas).[16]

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[12] EPAct 2005. P.L. 109-58, Sec. 1342.

[13] Savings based on the following assumptions: 15,000 annual miles traveled (both vehicles); 29 miles per gallon (mpg) fuel economy for gasoline vehicle; 28 mpg equivalent for natural gas vehicle; $3.84 national retail average for regular gasoline; $18.31 per thousand cubic feet of residential natural gas; 121.5 cubic feet of natural gas per gasoline gallon equivalent. Therefore, current residential natural gas prices are roughly $2.21 per equivalent gallon. Fuel economy estimates from DOE, *Fueleconomy.gov*. Fuel price estimates are from EIA.

[14] However, it should be noted that a reduction in domestic consumption will likely not lead to a one-to-one reduction in imports, since reducing domestic consumption is also likely to reduce domestic petroleum production.

[15] DOE, AFDC, *Natural Gas Benefits*. [http://www.eere.energy.gov/afdc/fuels/natural_gas_benefits.html]. Accessed September 16, 2008.

[16] It should be noted that high natural gas prices may be needed to sustain some of this output. Otherwise, the United States may need to import natural gas to meet growing demand.

But, there are also several potential and measurable drawbacks to natural gas vehicles, many related to vehicle performance and acceptability. For example, CNG engines tend to generate less power for the same size engine than gasoline engines. Thus, NGVs tend to have slower acceleration and less power climbing hills.[17] Also, because CNG has a lower energy density than gasoline, CNG vehicles tend to have a shorter range than comparable gasoline vehicles.[18] In addition, for passenger vehicles, the larger natural gas storage tanks often occupy space that would otherwise be used for cargo — generally in the trunk of a sedan and in the bed of a pickup truck.[19] Again, these considerations may or may not play into a individual purchaser's decision, but could affect the overall marketability of the vehicles.

NGV Conversions. A key question raised by those interested in the expansion of natural gas for automobiles is whether existing vehicles can be converted to operate on natural gas. From a technical feasibility standpoint, there are few problems with converting a vehicle to operate on natural gas. Most existing engines can operate on the fuel, and most conversions involve changes to the fuel system, including a new fuel tank, new fuel lines, and modifications to the vehicle's electronic control unit.[20]

However, converting an existing vehicle is more problematic from a practical standpoint. In the United States, NGV conversions — or any other fuel conversion — can potentially run afoul of the Clean Air Act (CAA). All new vehicles (gasoline or otherwise) must pass rigorous tests to prove they will meet emissions standards over the life of the vehicle. These tests tend to be very expensive, although the marginal cost spread over a full product run — thousands to hundreds of thousands of vehicles — are minimal. After a vehicle has been certified by the Environmental Protection Agency (EPA), any changes to the exhaust, engine, or fuel systems may be considered tampering under the CAA. Section 203(a)(3)(A)[21] states that it is prohibited

> for any person to remove or render inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations under this title prior to its sale and delivery to the ultimate purchaser, or for any person knowingly to remove or render inoperative any such device or element of design after such sale and delivery to the ultimate purchaser.

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[17] The CNG Honda Civic is rated at 113 horsepower (hp), while the gasoline Civic EX is rated at 140 hp (both have 1.8 liter engines). Cars.com vehicle comparison. [http://www.cars.com]. Accessed September 16, 2008.

[18] 170 miles for the Civic GX vs. 345 miles for the gasoline Civic. DOE, *Fueleconomy.gov Website.* Accessed September 16, 2008.

[19] All current natural gas vehicles are modified versions of conventional gasoline vehicles. Presumably, if there were enough consumer demand, a natural gas vehicle designed from the ground up could address the problem of cargo capacity.

[20] NGV Conversion, Inc., *Frequently Asked Questions*. Accessed October 10, 2008. [http://ngvus.com/p/index.html].

[21] 42 U.S.C. 7522(a)(3)(A).

EPA generally interprets this to mean that any change to a vehicle's engine or fuel systems that leads to higher pollutant emissions constitutes "tampering" under Section 203.

In 1974, EPA issued guidance ("Memorandum 1A") to automaker and auto parts suppliers on what constituted tampering in terms of replacement parts under routine maintenance.[22] The guiding principle EPA has used in enforcing the anti-tampering provisions for alternative fuel conversions is that such changes are allowed as long as the dealer has "reasonable basis" to believe that emissions from the vehicle will not increase after the conversion. Instead of requiring all converted vehicles to undergo testing equivalent to new vehicle testing, EPA allowed vehicle converters flexibility in certifying their emissions.

However, in the 1990s, EPA received data from the National Renewable Energy Lab that many vehicles converted to run on natural gas or liquified petroleum gas (LPG) and certified under the flexibility provisions might be exceeding emissions standards.[23] Therefore, in 1997 EPA issued an addendum to Memorandum 1A tightening the testing standards for these conversions. The original decision required compliance with new testing procedures starting in 1999. Subsequent revisions extended the deadline thorough March 2002.

Currently, certifying vehicle conversions can be very expensive for small producers, since each vehicle must be independently certified. For example, a converter must test the emissions of the conversion of specific "engine families" (e.g., MY2008 4.6L V8 Ford vehicles). Each different engine/emissions system combination must be tested independently (e.g., MY2009 vehicles, or vehicles with different engines). Therefore, the production and use of universal "conversion kits" is effectively prohibited under the EPA enforcement guidance.[24] To allow a market for conversion kits, the CAA would need to be amended to allow for these conversions regardless of vehicle emissions, or EPA would need to conclude that the conversions do not increase emissions. NGVAmerica estimates that it can cost as much as $200,000 to design, manufacture, and certify a conversion for a single engine family.[25]

Some companies have completed the required testing on a limited number of vehicles and offer conversions. NGVAmerica maintains a list of the companies that currently sell NGV conversion equipment, and the vehicles that have been certified by those companies.[26] In addition to the Civic GX produced by Honda, NGVA lists four

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[22] EPA, Office of Enforcement and General Counsel, *Mobile Source Enforcement Memorandum 1A*, June 25, 1974.

[23] EPA, Office of Enforcement and Compliance Assistance, *Addendum to Mobile Source Enforcement Memorandum 1A*, September 4, 1997.

[24] To make a conversion kit that would work for all vehicles, a manufacturer would need to certify the emissions of the conversion on every engine family for all model years — an very expensive proposition.

[25] Stephe Yborra, op. cit.

[26] NGVAmerica, *Guide to Available Natural Gas Vehicles and Engines*, Updated September 3, (continued...)

companies that convert Ford and General Motors vehicles — mostly light-duty trucks such as pickups and vans. According to EPA requirements, vehicles must be converted by the original manufacturer of the conversion equipment, or by a retrofitter trained and qualified by the conversion manufacturer. NGVAmerica estimates that converting a passenger vehicle can cost over $10,000 (e.g., they estimated $13,500 for a Ford Crown Victoria), although specific costs would be determined by the manufacturer and/or retrofitter.[27] Conversions would be eligible for the $4,000 alternative fuel vehicle tax credit (see p. 2).

Some have questioned whether a vehicle conversion would void the original manufacturer's warranty. However, only those vehicle systems directly modified by the conversion would raise warranty concerns. In those cases, the conversion manufacturer's warranty would warranty the modified systems. For systems not affected by the conversion (e.g., suspension, climate control), the original manufacturer's warranty would still apply.[28]

Conclusion. Higher gasoline prices and concerns about U.S. oil dependence have raised interest in NGVs. Energy policy proposals such as the Pickens Plan have further raised interest in these vehicles. However, currently the number of new vehicles capable of operating on natural gas is relatively low, and there are limited opportunities for converting existing gasoline vehicles to run on natural gas.

The market for natural gas vehicles will likely remain limited unless the differential between natural gas and gasoline prices remains high in order to offset the higher purchase price for a natural gas vehicle. Conversions of existing vehicles will also continue to be restricted unless the CAA is amended or if EPA makes changes to its enforcement of the CAA.

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[26] (...continued)
2008. [http://www.ngvc.org/pdfs/marketplace/MP.Analyses.NGVs-a.pdf].

[27] Stephe Yborra, op. cit.

[28] Ibid.