Natural Gas Vehicles and Climate Change
A Briefing Paper

This is a summary of the issues related to the use of natural gas vehicles to reduce emissions of greenhouse gases. It has been prepared to inform delegates to COP-9 on the benefits that natural gas vehicles offer in the quest to reduce greenhouse gas emissions. It also discusses issues related to implementation of natural gas vehicle programs which will thus achieve these benefits.

This document has been prepared by the International Association for Natural Gas Vehicles.

Natural gas in relation to other fossil fuels

Apart from hydrogen, the fuel used in motor vehicles is a source of carbon dioxide. Natural gas (predominantly methane) is the fuel which has the lowest carbon to hydrogen ratio as it has only one carbon atom to three hydrogen atoms per methane molecule. Inherently, natural gas has the potential to produce less carbon dioxide per kilometer of travel than other carbon based fuel.

Efficiency

The other important factor is how efficient are the processes whereby natural gas is extracted and converted into motive power – the well to wheels efficiency. Thus, if methane produces less carbon dioxide per kilogram of fuel, but more fuel is used, the net effect may be that there is more discharge of carbon dioxide per kilometer of travel.

Reduction of GHG

There have been a number of studies in recent years which compare the well to wheels, efficiency of various fuel and engine combinations. For instance, a current study for the European Commission[1] shows that the well to wheels efficiency of a natural gas vehicle is 2.7 – 3.0 MJ/km for natural gas vehicles (NGVs) compared with 2.1 MJ/km for diesel and 2.5 MJ/km for gasoline. The greenhouse gas emissions are 166 – 183 gm CO2 eq/km for NGVs, 164 gm CO2 eq/km for diesel and 182 - 195 gm CO2 eq/km for gasoline. A similar study at Argonne National Laboratory[2] showed CNG with CO2 emissions of 140 gm CO2 eq/km, gasoline at 176 gm CO2 eq/km, and diesel at 147 gm CO2 eq/km. A life cycle study for Methanex[3] showed greenhouse gas emissions are 308

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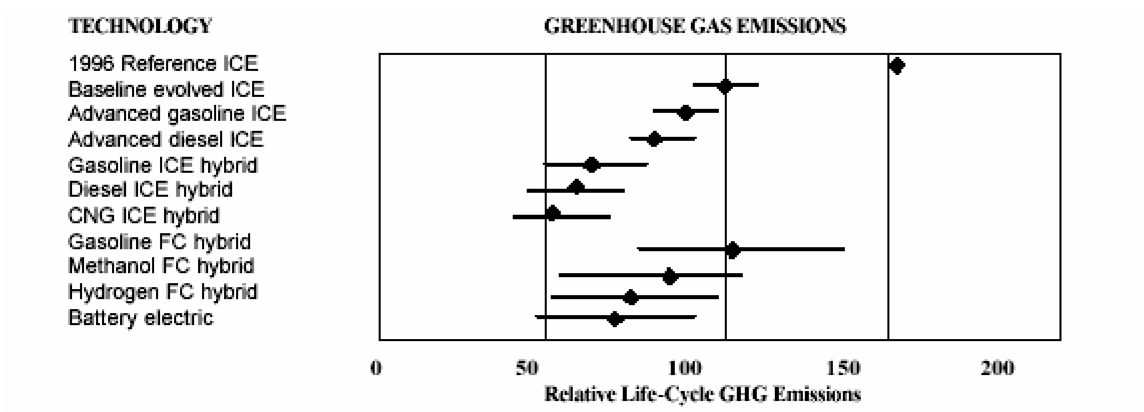
1 Alternative Fuels Contact Group of the European Commission, Interim Report 31 March 2003
2 Well to Wheel Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems – Executive Summary Report. General Motors Corporation, Argonne National Laboratory, BP, ExxonMobil, Shell. June 2001.
3 Assessment of Greenhouse Gases from Fuel Cell Vehicles. Prepared by $(S\&T)^2$ Consultants for Methanex Corp, June 2000.

gm CO2 eq/km for gasoline conventional engine versus 149 gm CO2 eq/km for methane in a fuel cell vehicle.[4]

It should be noted that the discharge of carbon dioxide is dependent on the vehicle and its engine, as well as they condition of the engine.

As mentioned, there may be significant variations between exactly similar vehicles, because of the state of maintenance of the vehicle, whatever the fuel.

Considering future fuels and future engines, a study by MIT on a variety of future engines and fuels looked at life cycle aspects of greenhouse gas emissions ie emissions arising from vehicle manufacture plus emissions due to extraction, conversion, distribution and use of fuel over the vehicle life. The results of the study are given in the following diagram:



The MIT study draws the following conclusions:

The results of this study depend importantly on the methodologies and assumptions we chose. The following broad conclusions are drawn from calculations for specific combinations of technology as used in a mid-size passenger car operated over the standard US urban/highway driving test cycles.

All our quantitative results are subject to the uncertainties expected in projecting 20 years into the future, and those uncertainties are larger for rapidly developing technologies like fuel cells and new batteries.

- *A valid comparison of future technologies for passenger cars must be based on life cycle analysis for the total system, which includes assessment of fuel and vehicle manufacture and distribution in addition to assessment of vehicle performance on the road.*
- *Successful development and penetration of new technologies requires acceptance by all major stakeholder groups: private-sector fuel and vehicle suppliers, government bodies at many levels, and ultimate customers for the*

[4] The above figures from different studies are for a variety of vehicles and the tests between studies may not be truly comparable.

products and services. Therefore, the economic, environmental, and other characteristics of each technology must be assessed for their potential impacts on each of the stakeholder groups.

- *Continued evolution of the traditional gasoline car technology could result in 2020 vehicles that reduce energy consumption and GHG emissions by about one third from comparable current vehicles and at a roughly 5% increase in car cost. This evolved "baseline" vehicle system is the one against which new 2020 technologies should be compared.*
- *More advanced technologies for propulsion systems and other vehicle components could yield additional reductions in life cycle GHG emissions (up to about 50% lower than the evolved baseline vehicle) at increased vehicle purchase and use costs (up to about 20% greater than the evolved baseline vehicle).*
- *Vehicles with hybrid propulsion systems using either ICE or fuel cell power plants are the most efficient and lowest-emitting technologies assessed. In general, ICE hybrids appear to have advantages over fuel cell hybrids with respect to life cycle GHG emissions, energy efficiency, and vehicle cost, but the differences are within the uncertainties of our results and depend on the source of fuel energy.*
- *If automobile systems with drastically lower GHG emissions are required in the very long run future (perhaps in 30 to 50 years or more), hydrogen and electrical energy are the only identified options for "fuels", but only if both are produced from nonfossil sources of primary energy (such as nuclear or solar) or from fossil primary energy with carbon sequestration.*

Again, these conclusions are based on our assessment of representative future technologies, with vehicle attributes held at today's levels. The expectations and choices of customers may change over the next 20 years and such changes can affect the extent to which potential reductions in GHG emissions are realized.

The conclusion from the MIT study is that NGVs are shown potentially to have the lowest GHG emissions for the future vehicles examined.

It is concluded from the rankings in all the above tests that for existing and future vehicles using fossil fuels, the amount of carbon dioxide discharged by vehicles fuelled by natural gas is less than the amount discharged by similar vehicles fuelled by gasoline and diesel.

Current situation with NGVs

The use of compressed natural gas in vehicles dates from the 1930s in Italy. Since the late 1970s, there has been increased and development and use of NGVs. There are now approximately 3 million NGVs around the world, the main fleets in Argentina, Brazil, Italy, Pakistan, USA and Egypt. Most of these NGVs are gasoline vehicles which have been converted to run on natural gas.

However, the vehicle manufacturers have during the 1990s developed NGVs which can be bought from dealers in some places. The numbers are small but their performance can be exceptional and generally they match the performance of the conventional vehicles in such areas as fuel efficiency. In terms of emissions, factory built NGVs usually have lower levels.

A particularly important development over the last 5 years has been the substantial use of city buses fuelled by natural gas. The motivation for this has been the low emissions of these buses compared with diesel buses. Fleets of thousands of NGV buses are in such places as Beijing, Delhi, Korea, and US. Most of these are designed and built be vehicle manufacturers.

The successful NGV programs provide ample evidence of how an alternative vehicle program can be successfully implemented. No other alternative fuel[5] has this extensive history of implementation. The key issues for success are Government involvement and price of the NGV and the price differential between compressed natural gas and the conventional fuel. In addition, there are important issues such as safety, standards, service and fuel availability.

There are many equipment suppliers around the world manufacturing and installing refueling and vehicle conversion equipment. International standards are available for all aspects of NGVs and refueling.

Of particular interest and importance at present is a developing European program to have 10% of all vehicles running on natural gas by 2020 as part of the European effort to reduce greenhouse gases. There are ambitious programs in several Asian countries such as India and Bangladesh. The motives for such programs are reduced air pollution, improved energy security, reduced imports of oil in a gas rich country, reduced transport sector costs and lower GHG emissions with varying mixes of these motives in different countries. The effect of any successfully implemented NGV program should be a reduction of GHG.

Renewable fuels

Natural gas is predominantly a fossil fuel. It also can be manufactured, however, from renewable resources such as sewage (in the water purification process), agricultural waste sources (i.e. corn husks, wood waste, and other non-consumable residuals), as well as urban garbage. Waste materials are heated at about 30^{o}(C) for two-to-three months to produce natural and renewable methane that can be manufactured to any composition required for vehicles. Biogas can make a substantial contribution to solving several problems including clean air, waste management, and even improved crop performance,

[5] LPG fuels many vehicles but the volume of LPG available in most oil producing countries is limited. Many of the issues associated with the implementation of LPG programs are similar to those for NGV implementation.

as the residuals remaining as a result of the decomposition process can be provided back to farmers as fertilizer. There are active biogas-for-vehicles programmes in Sweden and Switzerland, and other countries are investigating the potential of renewable methane/biogas for transport sector applications.

Conclusion

Natural gas vehicles can reduce greenhouse gas emissions by as much as 20-25% over gasoline vehicles. Because of the experience gained with NGVs and NGV programs over the last 25 years, they can do so on a scale which in the short to medium term is unlikely to be matched by any other alternative fuel or engine technology. There is ample experience to ensure that large programs of NGVs can be successfully implemented in many countries thereby resulting in significant greenhouse gas reductions.

International Association for Natural Gas Vehicles
December 2003

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Appendix

CNG in New Zealand

The New Zealand CNG program commenced in 1979. By 1985, over 100,000 vehicles were on CNG and the NZ program was leading the world. All these vehicles were converted from gasoline or diesel and amounted to over 10% of the national fleet that had access to natural gas. There were 450 refuelling stations. In 1985, the Government announced the withdrawal of incentives and this resulted in the end of the vehicle conversion program. Since then, the NGVs of that era have reached the end of their useful lives and have not been replaced. There are now about 1500 vehicles on CNG including 40 buses in Hamilton and Auckland.

There is a strong NZ export industry mainly in refueling equipment but also in vehicle conversion technology and services.