Natural gas in vehicles – on the road to nowhere

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Summary

On February 18, the European Commission released a proposal to guarantee its gas supply security and is preparing another one to implement the EU's 2030 climate targets for the transport, buildings and agriculture sectors (so-called 'effort sharing' sectors). It is also developing a communication to decarbonise the road transport sector, to be announced this summer.

To understand what role natural gas could have in achieving these objectives, Transport & Environment commissioned a study from Ricardo Energy & Environment to assess the impacts of large-scale use of natural gas in the transport sector.

The study concludes that the increased use of natural gas in road transport is largely ineffective in reducing greenhouse gases or air pollution. The immediate benefits are small or non-existent; while the environmental costs, societal costs and costs to operators are negative for almost all vehicle categories. Expanding the use of natural gas in vehicles also runs counter to efforts to reduce EU's gas imports and energy dependence.

In the mid to long-term the substitution of fossil oil with fossil natural gas can have no role to play in a decarbonised transport sector. Although sustainable biomethane could deliver greenhouse gas benefits, it cannot be generated in sufficient volumes to power more than a niche market and would be very expensive.

Natural gas is not a 'bridge fuel', as claimed, but an expensive dead-end on the pathway to decarbonising transport. Similar to biofuels and diesel, it needs significant support (including subsidies or tax breaks) to survive. The evidence shows such support is not justifiable and is better spent on long-term solutions: fuel efficient, electricity-powered and shared transport.

1. This briefing

This briefing summarises the key outcomes of a study commissioned by Transport & Environment to examine the cost and environmental effectiveness of the use of natural gas (CNG/LNG), including biomethane, as a road transport fuel. The study has been performed by the independent UK consultancy Ricardo Energy & Environment.

The study compares for natural gas vehicles and conventional petrol and diesel vehicles the greenhouse gas (GHG) emissions on a full well-to-wheel approach (including emissions arising in production and distribution of the fuel as well as emitted from the tailpipe). It also compares air pollution emissions and calculates the costs to vehicle operators, the environment and society of using natural gas.

Comparisons of the environmental effects are made between conventional liquid fuels (petrol and diesel) and both fossil natural gas and sustainable bio-methane (from waste and residues). A range of road transport vehicles have been considered to obtain representative results: passenger cars (petrol and diesel), diesel vans (light commercial vehicles - LCV), small rigid trucks, large rigid trucks (26 t), articulated trucks

(>32 t), buses and coaches. For cars and vans it was assumed CNG – compressed natural gas – (or biomethane) would be used. For trucks, buses and coaches LNG – liquefied natural gas.

Different production pathways and origins for the different fuels are considered. During production and distribution of natural gas / biomethane leakage occurs – essentially unburnt methane escaping into the atmosphere. Methane has a global warming potential that is 30 times higher than CO2 and methane leakage therefore significantly undermines the potential GHG savings that may occur during the operational stage when the fuel is burnt in the engine producing tailpipe emissions. In this study, low, medium and high well-to-tank emission scenarios have been developed.

2. Vehicle emissions

The table below compares the emissions (on a well-to-wheel basis) for the key emissions (carbon dioxide – CO2, nitrogen oxides – NOx, and particulate matter – PM for different categories of vehicles. It also summarises the environmental costs.

Vehicle	Comparison	Carbon dioxide (CO2)	Nitrogen oxides (NOx)	Particulate matter (PM)
Metric		WTW emissions	Emissions reduction for a 5% NGV share	Emissions reduction for a 5% NGV share
Petrol car	CNG	-18%	0%	-4.0%
Diesel car	CNG	+6%	-3.5%	-4.5%
Van	CNG	+8%	-3.6%	-4.0%
Small rigid truck	CNG	+13%	0%	-4.5%
Large rigid truck 26t	LNG	+16%	0%	-3.2%
Articulated truck >32t	LNG	+2%	0%	-1.8%
Coach	LNG	+15%	0%	-4.4%
Bus	LNG	+6%	0%	-5.4%

Source: Ricardo Energy & Environment, 2016

There are **no GHG benefits** in shifting from diesel cars to CNG. Compared to petrol cars, carbon emissions are lower but the benefits are significantly less than those achieved by a shift to petrol-hybrid or electric cars using renewable energy. A shift to gas would also create a risk of technology lock-in, diverting scarce (public) funds away from these technologies with the potential to decarbonise light-duty vehicles. Natural gas vehicles (NGV) emit **less noxious emissions** than diesel cars, notably nitrogen oxide NOx emissions. However, the introduction of real-world tests and further tightening of emission standards will reduce the current comparative advantage and the likely overall impacts small and not cost effective. Compared to petrol cars, CNG-cars offer **no air pollution benefits**.

For smaller trucks and vans a shift to gas engines would result in significantly **higher overall GHG emissions**. For bigger (articulated) trucks a shift to LNG powered trucks would in all cases result in **higher overall GHG emissions**. Compared to modern EURO VI trucks, gas powered trucks (CNG or LNG) perform only marginally better when it comes to **air pollution**. For passenger cars there are reductions in environmental damage costs associated with a shift from petrol/diesel cars to CNG-powered vehicles, but that for heavy-duty vehicles, the environmental damage costs are higher for gas vehicles than conventional diesel vehicles. This is why Ricardo Energy & Environment concludes "that the overall air quality benefits of using methane to power road vehicles would be very limited."

3. Bio-methane

Using sustainable bio-methane could deliver significant GHG savings for all vehicle categories. However, the very limited availability of sustainable sources (e.g. waste) means bio-methane can only be used in niche applications. Any scaling up of production would require crop-based bio-methane which raises issues related to direct and indirect land-use change and reduced greenhouse gas benefits. The air quality benefits of biomethane are small and the same as natural gas. Policymakers also need to reflect on whether the limited amount of sustainable bio-methane would not be better used in other sectors (for example, heating).

4. Cost effectiveness of shifting to natural gas

The study considered three types of costs: operating capital cost of the vehicle; operating costs of buying the fuel and infrastructure costs. Costs were also considered from the perspective of the operator, the environment and society as a whole. **Capital costs for methane powered vehicles are typically higher**. **Operating costs showed mixed results** when analysed on a pre-tax/no duty basis. Petrol cars having slightly lower operating costs, vans and small trucks slightly higher and much higher for articulated trucks. **Infrastructure costs can be very significant.** The study shows that in virtually all cases the infrastructure refuelling costs outweigh the benefits. Costs were calculated for operators, for society and for the environment and compared for fossil liquid and gaseous fuels.

Vehicle	Comparison	Operator costs	Environmental costs	Societal costs
Metric		Annualised marginal capital and operating costs relative to conventional petrol/diesel vehicles (€ per year)	Total damage costs (€/veh/yr) CO2e Central estimate	Total marginal costs (€ per vehicle per year) Low and High refuelling infastructure costs Central estimate
Petrol car	CNG	9	-29	27 - 215
Diesel car	CNG	36	-15	73 - 262
Van	LNG	101	0	249 - 801
Small rigid truck	LNG	1,364	197	2,228 - 4,703
Large rigid truck 26t	LNG	722	615	1,904 - 9,056
Articulated truck >32t	LNG	1,666	206	3,219 - 21,662
Coach	LNG	1,524	538	1,657 - 8,525
Bus	LNG	575	249	3,970 - 12,078

Source: Ricardo Energy & Environment, 2016

Once fuel taxes are removed the annualised marginal capital and operating costs for gas-powered vehicles are higher than for conventional petrol and diesel vehicles. The economic attractiveness of switching to methane is therefore solely based upon receiving a tax break – effectively a fossil fuel subsidy. Operator costs do not take into account the costs associated with providing and operating refuelling infrastructure for methane-powered vehicles and once these are considered deploying natural gas as fuel is not cost effective from a societal perspective.

5. Natural gas in road transport is not a bridge, it is a dead-end

The results of the Ricardo analysis clearly show a shift to gas in road transport would have very limited benefits. For petrol cars there is a small CO_2 benefit; and for diesel cars lower air pollution emissions. For all commercial vehicle categories a shift to gas would **increase greenhouse gas emissions**. The much touted air pollution benefits of heavy-duty natural gas vehicles are non-existent. An increase in hybrid and ultimately electric vehicles would deliver a bigger improvement.

Encouraging the use of natural gas in transport would **increase the EU's dependence on gas imports**, at a time when EU policy is overwhelmingly focused on reducing this dependency. A shift to gas is also **expensive**; in virtually all cases the costs (which exclude utility loss due to the larger tank) outweigh the benefits. Without (unjustifiable) fuel tax break, gas is not economically viable for hauliers.

Natural gas is not a bridge fuel towards future decarbonised vehicles. Although waste based **bio-methane** can deliver significant GHG savings, it can only be supplied for **niche applications**, due to the limited sustainable supply. Any scaling up of production would require crop based bio-methane which raises now-familiar issues of direct and indirect land-use change. The investment to develop refuelling infrastructure for what is essentially a niche fuel is high, and sustainably produced bio-methane can be used far more cheaply in other sectors such as heating.

Subsidies, tax breaks, infrastructure investments and lower tolls for gas vehicles are bad policy and poor uses of scarce public funds. They repeat the mistakes of previous fuels policies for diesel and biofuels that were incentivised without delivering meaningful environmental benefits. The evidence shows **that the expected June 2016 communication on decarbonisation should not endorse public support for gas vehicles**. Investments and policy incentives should instead be focused on solutions that deliver significant benefits – fuel efficient, electricity-powered and shared transport.

Further information

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