Technical Note: Biomethane

This technical note supports the transport chapter of the report *Meeting Carbon Budgets - 2016 Progress Report to Parliament.*

Reducing emissions from HGVs: Natural gas, biomethane and longer-term options

HGVs are difficult to decarbonise due to their requirements for high power and long range. Natural gas and biomethane have been proposed as potential options to decarbonise HGVs, but our analysis suggests that emissions reductions from these options are likely to be limited. This note sets out CCC analysis on the use of natural gas and biomethane across the economy and to fuel HGVs, alongside our assessment of lower-emissions options for HGVs that could be used in the longer term.

Use of natural gas in HGVs

Natural gas fuelled HGVs could offer tailpipe emissions savings of around 10% compared to diesel fuelled HGVs, but higher lifecycle emissions and emissions of methane from the vehicle could reduce these savings:

- Lifecycle emissions from the extraction and transportation of natural gas can vary widely depending on the source. In some cases it can have higher lifecycle emissions than diesel.
- There is evidence that methane can leak through the exhaust while the HGV is in-use (methane slip), particularly in retrofitted dual-fuel vehicles. As methane has a global warming potential 25 times greater than CO_2, even a small amount of methane slip can offset other savings. A study[1] for DfT found that a dual-fuel vehicle substituting 60% of its diesel for LNG has well-to-tank GHG savings of around 6%, but if more than 2% of the methane entering the tank leaves the vehicle unburned this would completely offset the GHG saving.

Biomethane could be used to displace some of this natural gas to offer more significant savings, but in the long term supply will be limited and there will be competition from other sectors. In the sections below, we demonstrate that using natural gas in HGVs would mean a net increase in fossil methane across the economy, even if HGV natural gas demand were partly met by biomethane.

The implication of this is that policy makers must be able to justify the use of fossil methane in HGVs as a replacement for diesel before considering whether to replace the fossil methane with biomethane. This includes ensuring that lifecycle emissions and methane slip do not significantly erode any GHG savings.

[1] Ricardo-AEA (2014) Waste and Gaseous Fuels in Transport.

Use of natural gas across the economy to 2050

Our analysis of the cost-effective path to meeting the UK's 2050 emissions target suggests that use of natural gas in industry, buildings and power could fall from around 700 TWh in 2030 to around 370 TWh in 2050[2]:

- The continued use of natural gas for heat in older buildings on the gas grid and for high-grade process heat in industry reflects the fact that these applications do not currently have cost-effective, low-carbon alternatives.[3]
- The continued use of natural gas in the power sector could help to provide valuable, flexible generating capacity, but relies on the availability of Carbon Capture and Storage (CCS).

Use of biomethane to 2050

Biomethane is typically produced from anaerobic digestion of waste organic material and can be used in a variety of applications. Production is currently from landfill sites and increasingly from dedicated anaerobic digestion plants making use of food and farm waste and sewage. The total potential supply of biomethane from waste in the UK is limited by the amount of waste that can be cost-effectively accessed.

Biomethane is used in our scenarios to displace some residual natural gas demand across the economy. The Department for Transport[4] and freight sector groups[5] are investigating biomethane as an option to decarbonise large HGVs. However, our assessment suggests that the total biomethane resource is likely to remain significantly lower than total natural gas demand, such that any increase in demand for gas from HGVs would be met by fossil natural gas at the margin:

- We estimate that the fleet of large HGVs (large rigid and articulated) would require around 60 TWh of natural gas in 2030 and 70 TWh in 2050, taking account of increases in demand and improvements in vehicle and operational efficiency. This is in line with an alternative scenario for the transport sector, "EV success / No hydrogen", which is set out in our report on the fifth carbon budget.[6] In this scenario, it is necessary to offset residual emissions from natural gas fuelled HGVs with full electrification of the car and van fleet in order to meet the transport sector's central contribution to meeting the 2050 target.
- Our central estimate of the available biomethane resource is around 20 TWh[7], which could displace about 5% of fossil natural gas in 2050. Table 1 illustrates the result of switching the large HGV fleet to natural gas and using all of the available biomethane resource, which would be a net increase in fossil gas demand. Even if the available biomethane resource were double the current estimate, this would remain the case.

[2] This is the CCC Central scenario, but all scenarios have significant residual natural gas consumption in 2050. For example, if abatement in line with our "Max" scenario was achieved in buildings, total natural gas consumption would fall to around 290 TWh in 2050.

[3] For example, in some homes with solid walls, abatement costs for installing a heat pump can be over £300/tCO_2.

[4] DfT (2014) Low Emission HGV Task Force: recommendations on use of methane and biomethane in HGVs.

[5] Freight Transport Association (2016) Logistics Carbon Review.

[6] CCC (2015) Sectoral scenarios for the fifth carbon budget – Technical report (Chapter 5).

[7] There is a range of estimates for the future availability of biomethane, depending on assumptions of accessibility. Estimates of the resource that might be available in 2030 are in the range 20-40 TWh (AEA 2010, SKM 2011).

- As cost-effective options in industry and buildings have been exhausted in this scenario, taking any amount of the available biomethane and using it in HGVs would result in more fossil natural gas being used in industry or buildings i.e. the net result is that using biomethane in HGVs would be unlikely to reduce UK emissions overall.
- As noted above, using natural gas in HGVs would mean a net increase in fossil methane across the economy, even if HGV natural gas demand were partly met by biomethane. Policy makers must therefore be able to justify the use of fossil methane in HGVs as a replacement for diesel before considering whether to replace the fossil methane with biomethane.

Table 1: Total gas demand, biomethane resource and fossil gas demand in 2030 and 2050, CCC Central scenario.

	2030	**2050**
Total gas demand from industry, buildings, and power (TWh)	700	370
Total gas demand, plus gas demand from HGVs under transport alternative scenario (TWh)	760	440
Biomethane resource in (TWh)	20	20
Total fossil gas demand from industry, buildings, and power, regardless of where biomethane is used (TWh)	680	350
Total fossil gas demand from industry, buildings, power and HGVs, regardless of where biomethane is used (TWh)	740	420

Source: CCC analysis.

The decision on where to use the available biomethane should aim to maximise the emissions reduction at least cost, taking into account the energy required to convert and transport the fuel and whether different uses have very different costs. Assuming the biomethane is displacing fossil natural gas, the end-use abatement should be broadly similar for different applications with differences mainly due to emissions in the supply chain. Biomethane could potentially be used in transport in circumstances where lifecycle emissions savings compared to fossil methane are found to be the same or higher than in other applications (e.g. if methane slip from vehicles can be avoided).

The contribution of HGVs to meeting the 2050 target

The extent to which HGVs will need to decarbonise by 2050 depends on progress in other sectors of the economy. An important example of this is Carbon Capture and Storage (CCS), a key technology in our scenarios to meet the 2050 target. If the UK does not have CCS in 2050, meeting the 2050 target would require near-full decarbonisation of buildings and surface transport, including HGVs:

- CCS is used in our scenarios for fossil power generation, in heavy industry and with bioenergy, as well as being the primary option for hydrogen production (should we deploy it).
- If the UK develops CCS, as in the CCC Central scenario, there may be scope for some residual emissions in surface transport in 2050. In that case, it may be possible to meet the 2050 target with natural gas fuelled HGVs as in the "EV success / No hydrogen" transport sector scenario described above. However, this would be likely to require full electrification of the car, van and small HGV fleets, alongside maximum feasible improvements to freight logistics.
- The CCC Central scenario already makes full use of the available biomethane resource by injecting it into the gas grid, so shifting some biomethane to HGVs would not significantly change emissions overall.
- As set out in our fifth carbon budget advice, the absence of CCS would require a significant amount of additional abatement (around 35 $MtCO_2$/year) to meet the 2050 target. This would require near-full decarbonisation of buildings and surface transport. In this case, it would be likely that fuel cell or electric HGVs would be needed to meet the 2050 target (not having CCS would also mean hydrogen would have to be produced by electrolysis, which is typically more expensive).
- It is likely that UK emissions will need to fall even beyond the 80% target enshrined in the Climate Change Act, whether by 2050 (as the Paris Agreement suggested an ambition to pursue efforts to limit the global temperature increase to 1.5°C) or subsequently (in order to reach net-zero global emissions in the second half of the century, as required under a 2°C pathway). This suggests that there will be a strong need to deploy zero-emission HGVs by 2050.

Whilst development of zero-carbon technology for HGVs is uncertain, there are a number of emerging options:

- Hydrogen fuel cells could potentially be used to power larger HGVs in the future:
  - Bottom-up cost calculations of hydrogen fuel cell vehicles based on cost projections for the component technologies, suggested they might become a cost-effective option in the 2030s.[8]
  - Feasibility and cost-effectiveness would be improved if hydrogen was used more widely in the economy and produced in bulk using Steam Methane Reformation (SMR) with CCS, rather than electrolysis.[9]
  - Fuel energy density is currently a barrier to the deployment of fuel cell HGVs but innovative approaches to this problem are emerging. For example, new vehicle manufacturer Loop Energy has developed a zero-emission 36 tonne electric HGV with a range extended to around 320 km using a hydrogen fuel cell.
- Whilst current battery technology does not have sufficient energy density to power long-distance HGVs, it is possible that they could be dynamically recharged whilst on the move:
  - Sweden is trialling a 2 mile stretch of highway with overhead cables manufactured by Siemens to electrically power hybrid trucks manufactured by Scania.[10]

[8] AEA (2012) A review of the efficiency and cost assumptions for road transport vehicles to 2050.
[9] E4tech/UCL/Kiwa Gastec for CCC (2015) Scenarios for deployment of hydrogen in contributing to meeting carbon budgets and the 2050 target.

– Highways England is planning a trial of a contactless, inductive recharging system for hybrid trucks in the UK over the next few years.[11]

– Whilst both of these options would require upfront investment in infrastructure, a targeted approach could have a significant impact. Motorways and dual carriageways make up only 3% of the UK road network but carry over 70% of HGV traffic.[12]

Summary

- **Biomethane availability is limited**. Using biomethane in HGVs is unlikely to reduce emissions overall as there is a limited amount of biomethane available, which would otherwise be used to displace fossil methane in other applications. Policy makers must therefore be able to justify the use of fossil methane in HGVs as a replacement for diesel, as there will be an increase in fossil methane use at the margin.
- **Use of biomethane should maximise lifecycle emissions reduction**. Biomethane could be used to displace fossil methane in HGVs in the short term, provided it demonstrates similar lifecycle emission benefits to other uses of biomethane (e.g. no methane slip). However, it is important that the decision on whether to use biomethane in HGVs in future considers the opportunity cost of not using the biomethane in another application.
- **Zero-emission options for HGVs should be developed**. Policy makers must be aware of the potential need to fully decarbonise surface transport by 2050 and work with industry in the near-term to explore options for zero-carbon road freight. There is a risk of technology 'lock-in' if natural gas is considered the solution for HGVs in 2050 - vehicle manufacturers could take this as a signal not to invest in R&D for the zero-carbon solutions that could be needed if CCS is not available in 2050.

[10] See: http://www.siemens.com/press/en/feature/2015/mobility/2015-06-ehighway.php?content%5B%5D=MO
[11] TRL for Highways England (2015) Feasibility study: Powering electric vehicles on England's major roads.
[12] DfT (2015) Road Lengths Statistics; DfT (2015) National Road Traffic Survey.