UK Market Review

The Role of Natural Gas in Road Transport

March 2015

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Executive Summary

This report reviews the role for natural gas in reducing Greenhouse Gas (GHG) emissions from road transport and in improving air quality. The report provides a summary of the UK transport market, trends in vehicle growth and energy demand, and an overview of legislation and Government initiatives intended to influence a reduction in vehicle GHG emissions.

The report identifies the areas where natural gas / Biomethane can provide significant GHG reductions in the short term using existing technology (15 – 30% for Natural Gas and >70% for Biomethane).

The commercial fleet and public service road vehicle markets have remained largely static over the last decade. Some 3.9 million light goods (LGVs), buses, and heavy goods vehicles (HGVs) account for 36% of road transport emissions.

The conclusions of this Market Review are as follows:

- The larger vehicle market has fewer options than for smaller vehicles due to payload and range requirements
- Biodiesel, biomethane, CNG and LNG are likely to remain the most applicable options available to larger commercial vehicles
- Buses are suitable vehicles for having electric hybrid systems alongside the diesel/gas engine
- CNG in dual fuel and dedicated tractors (HGV) with gas supplied from the high pressure Local Transmission System (LTS) networks grid offers significant benefits in terms of GHG reductions (10-30%) and has the advantage of being available today.
- CO_2 savings from dual fuel vehicles and LTS supplied refuelling is estimated at 168,000 tonnes per annum based on 20% shift of articulated tractor units (@44te GVW and 400km per day) to CNG-diesel dual fuel by 2020
- LNG is the preferred fuel for some dual fuel tractors because its storage density provides the vehicle with a longer range

- LNG and LCNG refuelling stations have lower capital costs than grid connected ones and therefore are useful to provide fuel to smaller fleets for which gas grid connection may be too expensive or if there is no gas grid nearby

- Biomethane production is forecast to increase across the UK to 195 million kg injected into the gas grid by mid 2015 and there is scope for Biomethane to replace CNG as a transport fuel, through the use of Green Gas Certificates.

- Liquid biomethane is a premium fuel that can deliver significant CO2 savings of 88% (RTFO figures) but it currently has limited supplies.

- Gas as a vehicle fuel reduces both nitrous oxides (NOx) and Particulate Matter emissions which would help the UK and Local Authorities achieve their Air Quality targets. NGV trucks also offer a 50% reduction in noise compared to diesel

- LNG is part of the UK strategic energy supply and is shipped to the UK mainly from the Middle East. In future some LNG is expected to come from the USA because of the abundance of shale gas.

- Avonmouth LNG plant is due to close in 2016

- An LNG road tanker loading facility at Isle of Grain is due to open in September 2015 which would be very attractive for Southern based users of LNG. The current infrastructure already exists along the main motorways and truck routes due to the relative low cost of LNG refuelling station.

- CBM and LBM direct into trucks give the greatest benefit reduced well to wheel GHG reduction.

- With respect to Euro VI dual fuel tractor units, the space available for CNG storage on the tractor may become restricted due to the extra SCR equipment to control diesel exhaust emissions. One solution may be to move the gas storage to the trailer, reducing the advantages of LNG over CNG. For 6 x 2 tractor units LNG storage is the best current option for achieving the necessary range however future technology developments may change that situation (e.g. additional CNG storage behind cab or on trailers)

- The absence of a national CNG/CBM-LNG/LBM refuelling infrastructure for trucks is not a barrier in the short term as initial market focus is on larger fleet operators with a “back to depot” operational structure. The development of dedicated fleet refuelling stations could be an attractive option due to the potentially short capital payback (3-5 years)

- CNG/LNG fuel duty currently provides an economic advantage to diesel for HGVs.

  The current (2015) fuel duty charges for diesel are 57.95p per litre and for Natural Gas/Biomethane it is 24.70p per kg. In autumn 2013 the UK Treasury fixed the fuel duty differential between Diesel and Natural Gas for a ten year period from April 2014 to March 2024. This provides clarity and certainty for investors in the fuel stations and associated vehicles.

- At present the cost of natural gas is around 70% of the cost of oil on an energy bas (the recent fall in oil prices has reduced the gas – oil differential) .DECC forecasts indicate that energy in natural gas form is likely to remain cheaper than in oil form and hence fuelling trucks on gas would benefit the UK economy by reducing import costs

Road transport remains the largest demand for energy across the transport sector (six times larger than aviation across the EU, and 3 times as large within the UK). Whilst Natural Gas in or Biomethane (in particular LNG) may have a role in other sectors such as shipping, this study focuses on the role of gas in economically reducing road transport GHG emissions.

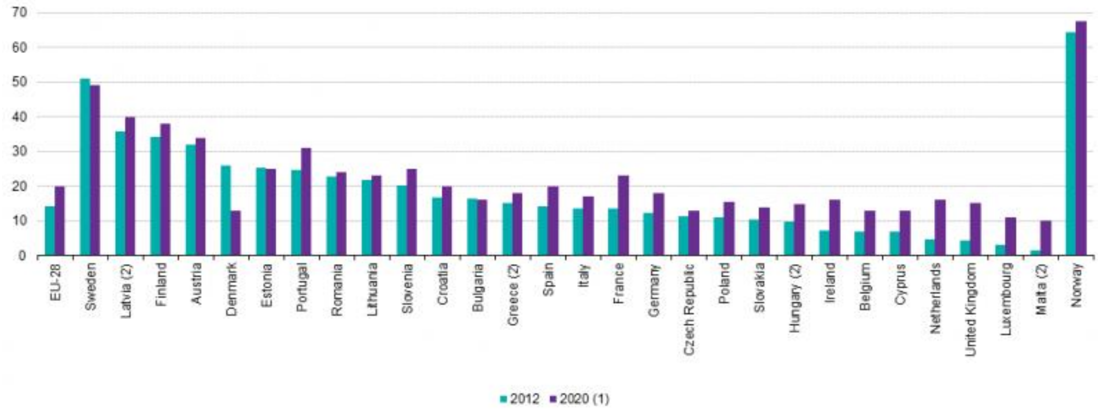
In conclusion, the report identifies that CNG, CBM, LNG and LBM could provide a benefit by reducing GHG emissions, reducing fuel costs, and improving air quality, primarily for the HGV market which to date has limited alternative options

1. Introduction

1.1 Road Transport Emission Reduction Targets

The EU Renewable Energy Directive (RED) requires the UK to provide at least 15% of its energy from renewable sources by 2020. Within that remit, road transport must achieve 10% replacement with renewable energy (approx. 13-15% by volume) from renewable sources (biofuels including Biomethane), electric vehicles or renewable hydrogen.

In 2012 the UK renewable contribution to energy consumption was 4%, the third lowest within the European Union (EU).



(¹) Legally binding targets for 2020.
(²) 2012: estimate.
Source: Eurostat (online data code: t2020_31)

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[1] European Statistics on behalf of the European Commission records UK emissions at 18% lower than 1990 levels in 2008 (including shipping and aviation allocation) – DECC records emissions at 21% lower excluding none domestic aviation and shipping. Emissions significantly fell in 2009 and stand at 28% lower than 1990 levels with reductions across all sectors. The sharp reduction is assumed related to wider economic factors.

Through the Climate Change Act 2008, the UK has legislated targets for reducing GHG emissions by at least 80% by 2050 compared with a base level set during 1990. By 2008, the UK had reduced emissions by 21% (excluding international shipping and aviation)[1]. More broadly and across the 27 EU countries, GHG emissions have reduced by approximately 11% since 1990 through significant reductions from the energy sector (excluding transport), industry, agriculture, and waste treatment sectors. Transport remains the only major sector with growing GHG emissions across the EU, an increase of 24% since 1990, and represented 19.5% of the total GHG emissions in 2008.

With a backdrop of increasing transport demand, the EU has, through the Fuel Quality Directive (FQD), committed to reducing GHG emissions by 10% on all transportation fuels by the end of 2020 compared to 2010 levels. This reduction should amount to at least 6% by 31st December 2020, compared to the EU-average level of life cycle GHG emissions per unit of energy from fossil fuels in 2010, obtained through the use of biofuels, alternative fuels and reductions in flaring and venting at production sites. However, UK flaring from Gas fields is tightly controlled by a licence arrangement and therefore further reductions are not possible without compromising safety systems. Subject to a review, it should comprise a further 2% reduction obtained through the use of environmentally friendly carbon capture and storage technologies and electric vehicles and an additional further 2% reduction obtained through the purchase of credits under schemes such as the Clean Development Mechanism established through the EU following the Kyoto Protocol. These additional reductions should not be binding on Member States or fuel suppliers on entry into force of this Directive. The European Parliament suggests that such levels will be achieved to both support the Renewable Energy Directive and wider Climate Change targets.

Throughout the European Union, emissions have declined across all sectors with the exception of Transport. Figure 1 shows how all sectors have exhibited reductions within the UK but transport emissions are only marginally lower than 1990 levels.

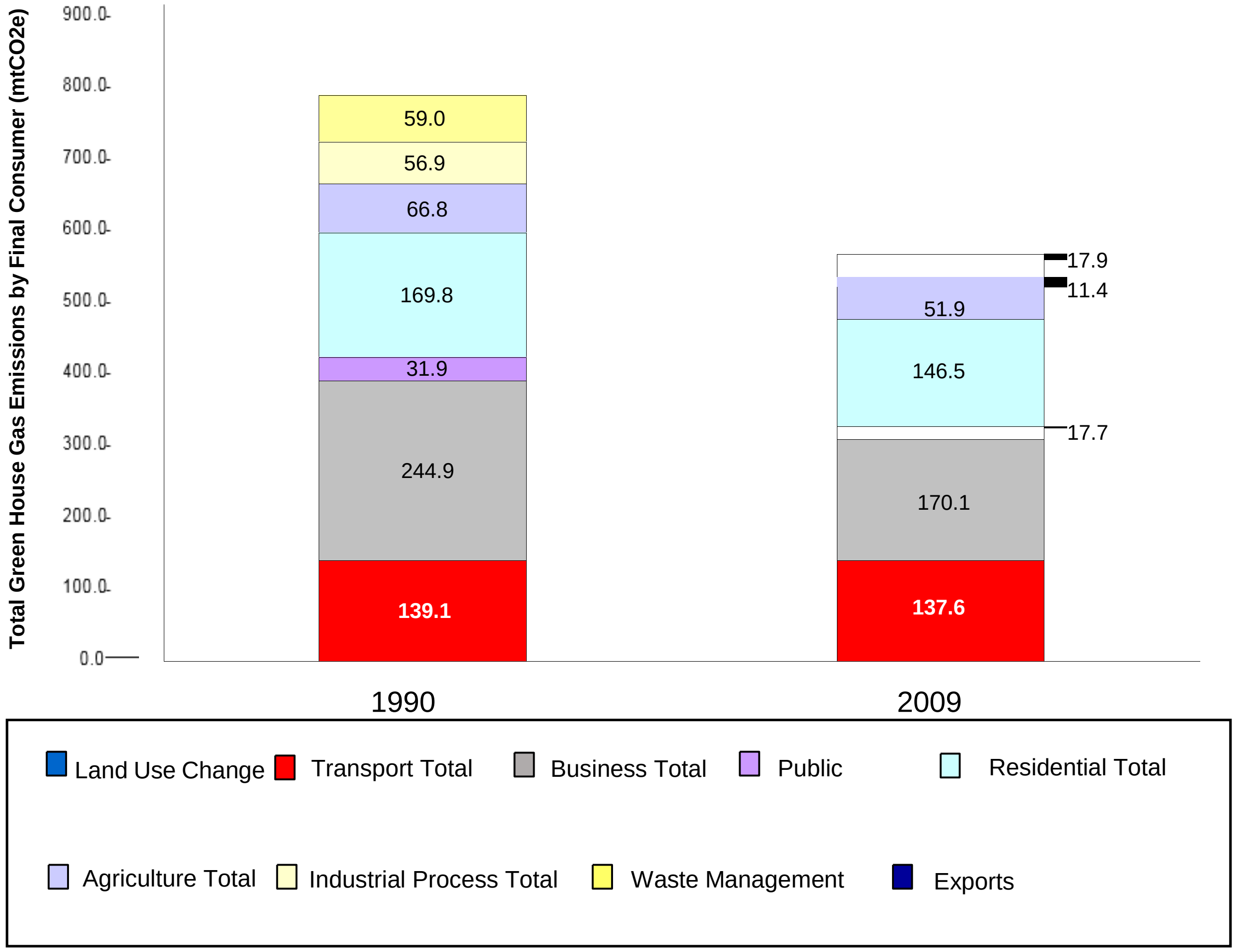


Figure 1: Total GHG emissions by final consumer, 1990 to 2009

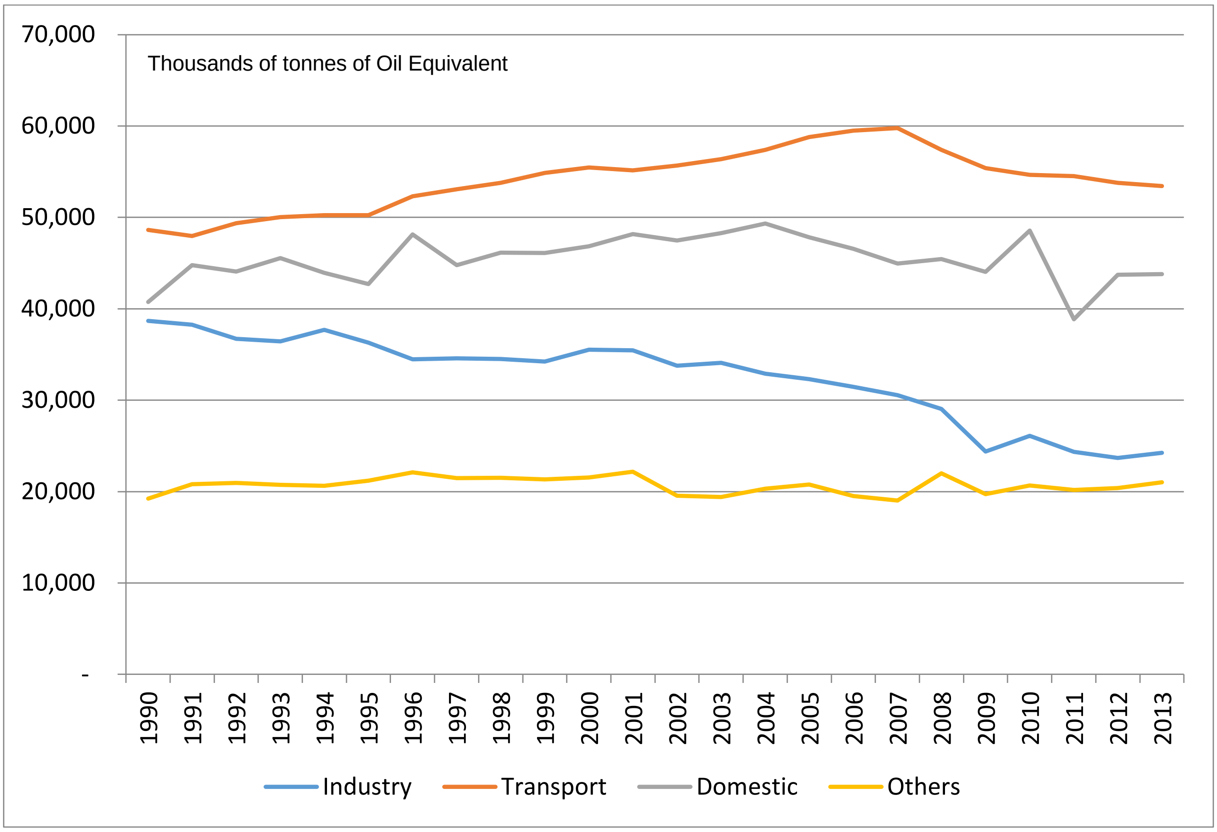
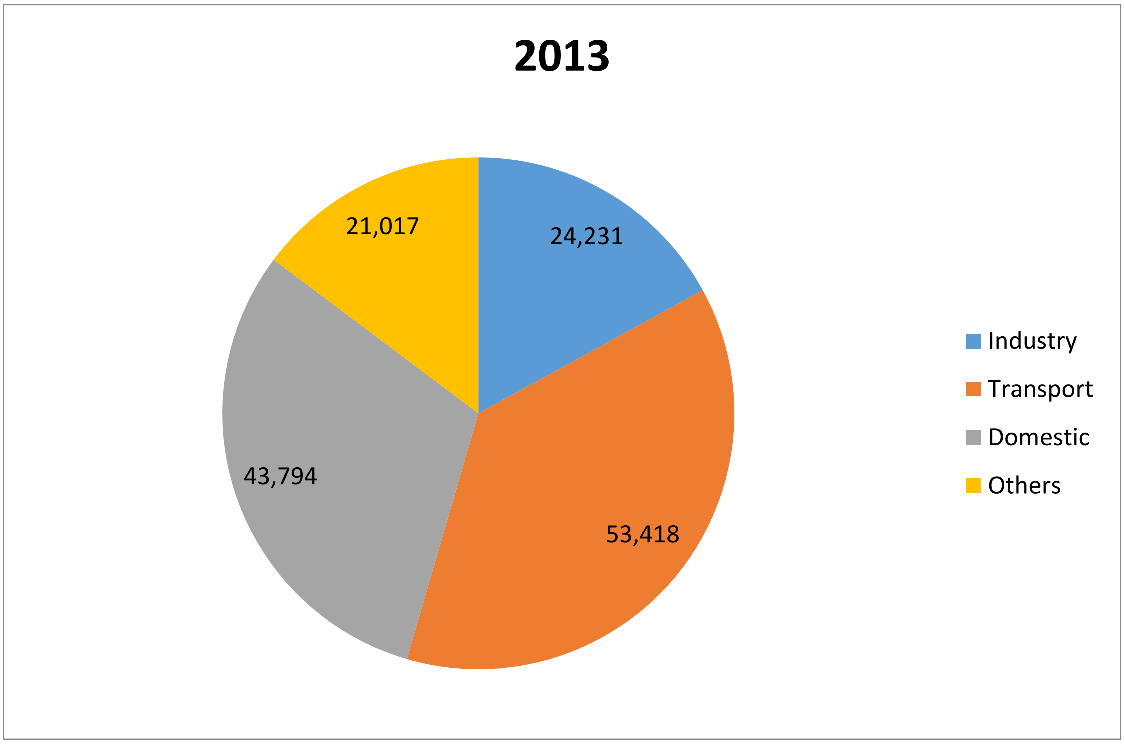


Fig 2: GHG emissions by sector, 1990 to 2009



Thousands of tonnes of Oil equivalence

Fig 3: UK vehicle parc by vehicle type (by thousand)

Transport accounted for 24.4% of UK GHG emissions in 2009. Of this 1.9% is associated with civil domestic aviation, rail, national navigation shipping, and military vehicles. The vast majority of transport emissions come from road transport, which accounts for 22.5% of UK GHG gas emissions. Overall, in the road transport sector passenger cars accounted for 14.0% of UK Green House Gas emissions, Light Goods Vehicles (LGVs) account for 3.1%, Heavy Goods Vehicles (HGVs) 4.1% and buses 1.0%.

It is evident that a range of factors influence the emissions from the road transport sector, including: growth in vehicle numbers; the average annual distance travelled by each vehicle; the retention or "churn" rate of vehicles; the efficiency of new vehicles compared to those replaced; and the opportunity to displace oil with alternative lower Carbon fuels. Given these factors, it appears that efficiency gains, or measures designed to reduce emissions, are currently being offset by increasing vehicle numbers, mileage travelled, and associated fuel usage.

Global demand for oil is predicted to increase to 99 million barrels per day by 2035 (up from

84 million barrels per day in 2009) and the cost is predicted to rise to $113 per barrel (up from $60 per barrel in 2009) however this figure has been exceeded already during 2013 although it has slipped back to the $105-110 level for Brent Crude. However during the latter part of 2014 the price of crude more than halved due to a combination of economic slowdown (China etc.), political plays (squeezing Russia's income), and an attempt to halt new (more expensive) oil exploration. New sources of crude along with increased Gas supplies (US Shale) has led to a supply/demand imbalance. With OPEC not wanting to reduce supplies to stabilize prices the cost of oil has halved.

In parallel though, there is a requirement of around 50 million barrels per day of new capacity to compensate for the decline of existing fields. Such figures suggest significant opportunity for the transfer of low carbon, high efficiency transport technology from an economic perspective in addition to the environmental drivers associated with international commitments to minimising global emissions.

1.2 UK Road Transport Sectors

UK vehicle numbers have steadily increased over the past decade and there are now over 34 million vehicles on UK highways: an additional 5 million vehicles compared to 10 years ago. LGVs represent the second largest sector with over 3.2 million vehicles and there are roughly 418,000 HGVs.

1.2.1 HGV Vehicles

HGVs represent less than 1.5% of road vehicles yet account for over 20% of road emissions (and 4% of UK total emissions).

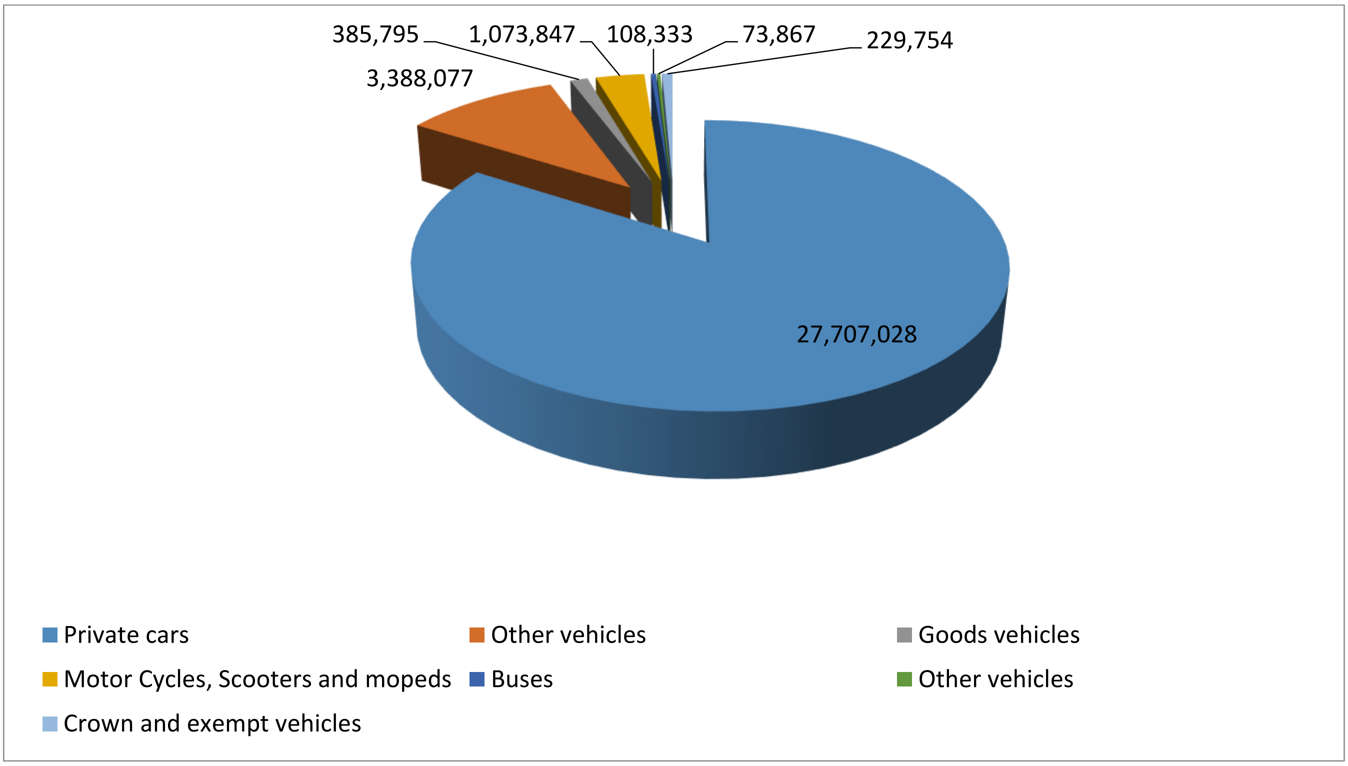


Figure 4: Number of UK vehicles on the road (millions)

The number of vehicles that are scrapped each year is less than the number of new registrations, resulting in a steady increase in numbers on the road. The increase in numbers is a contributing factor to the growth in emissions particularly over the 1990s and early 2000s in vehicle emissions.

1.2.2 Commercial Vehicles

The commercial vehicle sector has a number of segments:

- Light goods vehicles (LGVs) up to 3.5 tonnes (vans)
- Heavy goods vehicles (HGVs)
  - Rigid trucks from 6.5 to 28 tonnes
  - Articulated tractors 32 to 44 tonnes
- Buses and coaches

Analysis of the Commercial fleet sector shows the total number of LGVs growing by 28% since 2000. LGV emissions peaked in 2007 at 18.0 $MtCO_2e$, up from 10 $MtCO_2e$ in 1990; buses peaked at 6 $MtCO_2e$ in 2007 up from 4.3 $MtCO_2e$ in 1990.

Annual totals of commercial vehicles on UK roads 2003-2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LCV	2,979,759	3,109,744	3,227,461	3,420,620	3,545,724	3,600,116	3,534,664	3,566,460	3,614,664	3,631,595
HCV	587,862	580,718	586,129	595,266	598,447	589,129	558,076	563,295	563,872	557,128
Bus and coach	101,069	102,978	103,175	102,401	103,817	95,961	88,779	90,700	91,105	90,355
Total CV	**3,668,690**	**3,793,440**	**3,916,765**	**4,118,287**	**4,247,988**	**4,285,206**	**4,181,519**	**4,220,455**	**4,269,641**	**4,279,078**

Source: SMMT *Fig 5: Number of HGV registrations (thousands)*

In the commercial vehicle sectors the annual new sales figures are as follows:

Annual UK van and truck registrations

Year	LCVs up to 3.5t	% change on year before	Rigids	% change on year before	Artics	% change on year before
2003	303,755	14.0%	36,788	4.7%	18,802	12.0%
2004	329,599	8.5%	37,461	1.8%	18,851	0.3%
2005	322,930	-2.0%	38,957	4.0%	19,884	5.5%
2006	327,162	1.3%	36,973	-5.1%	18,601	-6.5%
2007	337,741	3.2%	35,614	-3.7%	15,133	-18.6%
2008	289,463	-14.3%	38,651	8.5%	18,759	24.0%
2009	186,386	-35.6%	24,973	-35.4%	9,773	-47.9%
2010	222,915	19.6%	22,383	10.4%	12,075	23.6%
2011	260,153	16.7%	24,524	9.6%	18,420	52.5%
2012	239,641	-7.9%	28,605	16.6%	17,097	-7.2%

Source: SMMT *Fig 6: HGV and bus/coach new registrations (thousands)*

New registrations for HGVs stood at roughly 55,000 per year until 2009 when sales fell to around 34,000. The market exhibited a growth between 1999 and 2008 of 21,000 vehicles over the base line of 416,000. However, in 2009 the total fleet dropped back to 415,000 vehicles. The HGV CO_2e level has tracked the vehicle numbers and remained relatively static at around 25 $MtCO_2e$, peaking in 2007 at 27 $MtCO_2e$ before falling back in 2009 to 23.4 $MtCO_2e$ due to the recession.

1.3 Transport Statistics

1.3.1 Vehicle Mileage

The mileage covered by the different vehicle types is shown below. In recent years the total mileage marginally decreased by less than 1%; however, in certain sectors such as the HGV market it has declined more significantly as a result of the reduction in economic activity.

Table 1: Mileage covered by different vehicle types

Vehicle Type	Billion vehicle Miles				
	1997	2002	2007	2010	2013
Cars and taxis	227.3	242.7	247.3	239.8	240.0
Buses and Coaches	3.2	3.2	3.4	3.1	2.8
Light vans <3.5te	30.2	34.0	41.9	41.0	42.6
HGVs >3.5te	16.7	17.6	18.2	16.4	15.7

There is no strong evidence to suggest distances per vehicle have increased which may contribute to increased fuel consumption and higher emissions. The vehicle records published by the Department for Transport suggest that vehicle distances have marginally reduced. This trend appears to be consistent across sectors. For example, the average distance travelled per HGV vehicle in 2000 was 67,900km, in 2007 the distance marginally reduced to 66,100km and in 2009 the distance fell to 63,200km. However, these figures are reduced by the 7.5te sector and so it is worth noting that typical annual mileages for an Artic Tractor unit is of the order of 100-120,000km and for 18-26te Rigids it is around 80,000km. It appears that the 13% reduction in CO_2 emissions has arisen from 7% reduction in vehicle numbers, 4.5% reduction in distance per HGV implying around 2% reduction due to fuel efficiency.

1.3.2 Vehicle Efficiency

For LGVs (vans) new EU agreed CO_2 targets have been reached. Each manufacturer's target is based on the weight of each new LGV it registers in the EU in a given year. The initial target and phase-in stage (2014 to 2017) will see 175g/km CO_2 as the fleet average target (phased in with 70%, 75% and 80% of each manufacturer's fleet complying in 2014-16 respectively and 100% from 2017 onwards). The long-term target for 2020 is 147g/km, to be confirmed in a review in 2013. Indicative current van emissions are as follows:

Mediums car derived vans (e.g. VW Caddy) - 129 to 195g/km CO_2

Large size Vans (e.g. Vauxhall Movano) - 189 to 224g/km CO_2

Bus and HGV CO_2 emissions are not recorded but their mpg has fallen slightly in the last 5 years. The mileage covered by bus services has remained static since 1995 at 1.624 million miles per annum (giving an average bus mileage of 30,000 per annum).

The table below shows the average fuel consumption for HGVs in miles per gallon split by vehicle size which indicates that there has been little change over the decade, possibly reflecting a slight reduction in fuel efficiency associated with tighter regulation of tail pipe emissions.

Table 2: Average annual HGV fuel consumption

HGV	Net weight (tonnes)	Miles per gallon		
		2000	2005	2010
Rigid vehicles	Over 3.5t to 7.5t	13.4	13.7	12.8
	Over 7.5t to 14t	11.6	11.6	11.1
	Over 14t to 17t	9.6	10.1	9.7
	Over 17t to 25t	8.6	10.0	9.4
	Over 25t	6.7	6.9	6.5
Artic vehicles	Over 3.5t to 33t	8.8	9.3	8.5
	Over 33t	7.8	8.0	7.6

1.3.3 Fuel Usage

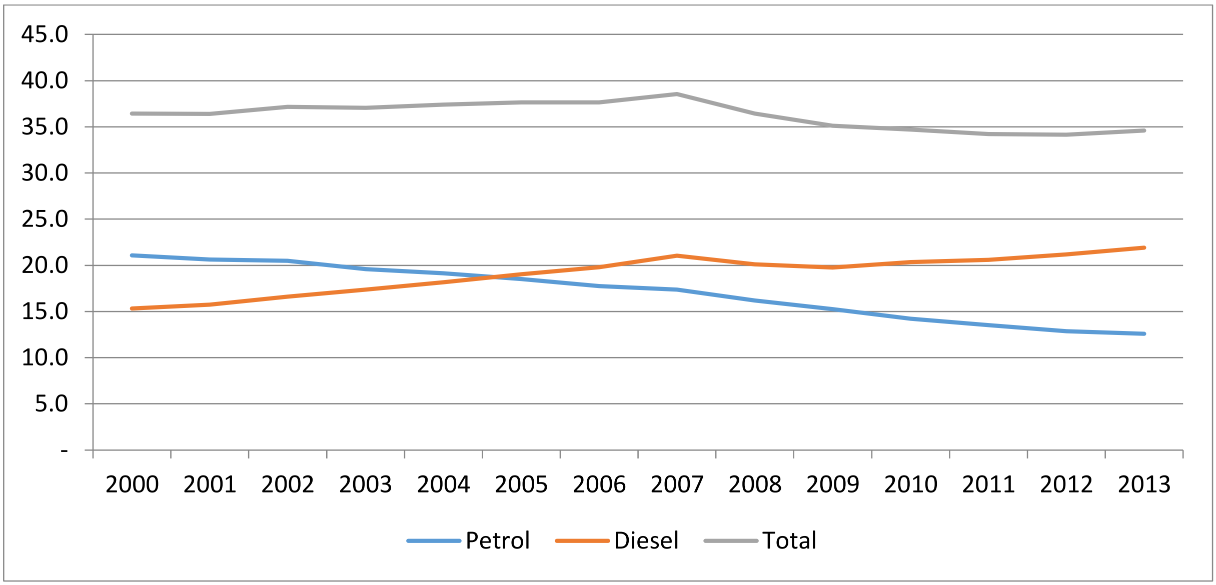


Figure 7: UK Road Transport Fuel Usage Volume (million tonnes)

Petrol and Diesel dominate the road transport fuel mix within the UK, accounting for over 99% of transport fuels consumed. Moreover, the UK has experienced a shift from petrol to diesel since 2000.

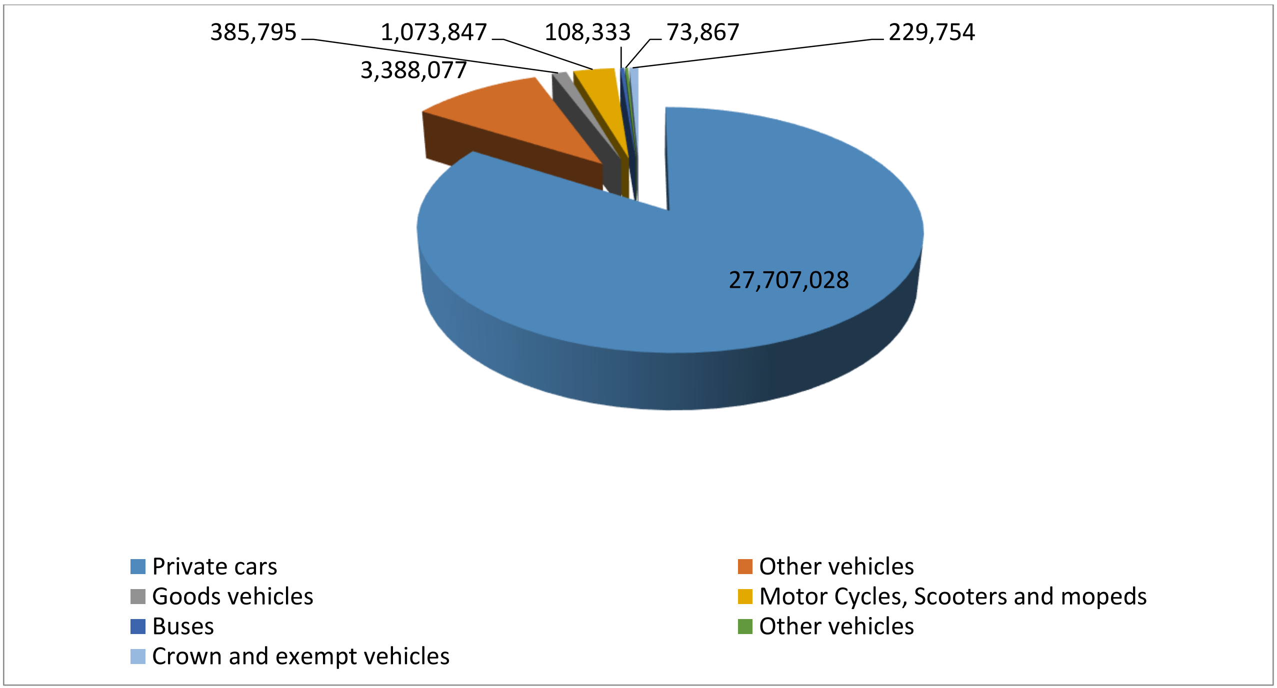


Figure 8: Total fuel consumption by vehicle type

In 2010 around 55.2% of all fuel consumed was diesel, petrol was 44.5% and LPG 0.3%. Virtually all of the petrol is consumed by passenger cars with a smaller proportion used by LGVs, motorcycles and mopeds. Diesel is more widely utilised by LGVs, buses and HGVs but has also become a more prominent fuel for passenger cars.

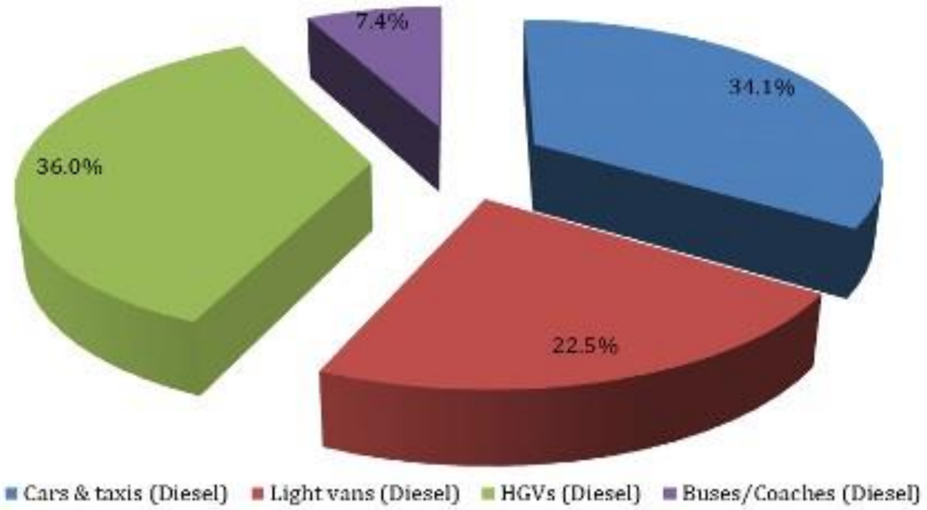


Figure 9: Diesel consumption by vehicle type

However, in the UK, 66% of diesel fuel is consumed by HGVs, LGVs, and buses. Moreover, virtually all HGVs and buses and the vast majority of LGVs depend on diesel.

When this is coupled with the total number of vehicles profiled in section 2.6 below then a picture emerges of a relatively small number of commercial vehicles using a large amount of diesel. This provides an opportunity to target such users with alternative fuels, with lower per unit infrastructure investment and a quicker impact due to the high mileages/high fuel consumption compared to the passenger car market.

1.3.4 Fleet Operators

In the passenger car market the vast majority of existing vehicles are owned by individuals with growth of around 1 million per year in fleet/ business and 1 million in the private sector. Over time, the fleet/ business vehicles move to the private sector and hence, of the approximately 30 million cars on the road, around 90% are privately owned. It is much harder to change the behaviours of 25 million individuals than it is to target 500 fleet managers.

The majority of the 47,000 buses are owned and operated by five major bus companies and their pattern of usage is very consistent from year to year. Coaches account for a further 23,700 with minibuses accounting for 15,000 vehicles. Since 2000 the bus figures have remained largely the same with a growth in coaches (13%) and minibuses (41%). Bus mileages on average are 46,000 miles outside London and 35,000 miles within London. Typical fuel consumption is 6-9mpg for single deck buses depending on vehicle length and engine size and 6-8mpg for double deck buses.

The 3.5 million LGVs and 418,000 HGVs are split across a number of operators. There are a total of 94,900 HGV fleet operators in the UK; however, the majority (94%) have less than 10 vehicles. In fact, approximately 50% of operators (45,000) are 'owner drives' who licence only 1 vehicle. At the other end of the spectrum, just 300 operators (0.3%) have fleets of over 100 vehicles, and because of the large fleet size these operators account for 15% of all HGV numbers and total around 46,200 vehicles. These vehicles are very likely to practise own-tank diesel filling from return to base or via a depot network. The next fleet size category, of 51 to 100 vehicles is also a promising basis for own-depot fuelling and totals some 31,456 vehicles in 750 fleets. There are approximately 5,000 operators with between 10 and 50 vehicles.

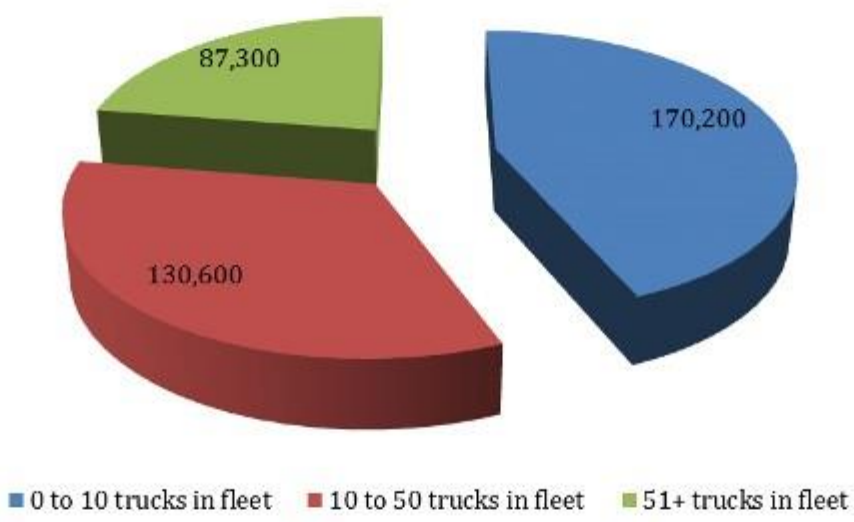


Fig 10: Fleet sizes

The major logistics providers (DHL, Ceva Logistics, Wincanton etc.) and supermarkets (Tesco, Asda, Sainsburys, Waitrose, Morrisons) all have large fleets with over 1,000 tractors (over 32 tonnes). Feedback from these companies was received in the LTS Connection Study (see Appendix A) which indicated a large number of depots which have over 50 tractors with high mileage (typically >100,000 km per tractor per annum) and that return to depot a number of times per day.

The van sector (up to 3.5te) travels around 66 billion kilometres per annum. The greater than 3.5te to 17te rigid trucks travel around 13.5 billion kilometres per annum and the largest rigid vehicles (17te to 26te) covering 1.6 billion kilometres per annum.

In the articulated vehicle sector, trucks plated up to 33Te travel just 1.4 billion kilometres per annum, with the 33te to 40te tractors doing 5.9 billion kilometres per annum and the 40te to 44te units covering 5.6 billion kilometres per annum.

Examining the weights the vehicles carry though shows that the greater than 3.5te to 17te rigid trucks move 7% of total freight weight with the largest rigid vehicles (17te to 26te) carrying 34%. The articulated vehicles up to 33Te carry just 4% of the total freight weight with the 33te to 44te tractors carrying 56%. These are the tractors concenterated in the ownership of the major logistics providers and supermarkets.

The type of freight is 52% industrial products, 26% food, drink and tobacco products, and 22% comprising other sectors.

Splitting the HGVs out further shows the number of vehicles in each of these categories and therefore how a potential impact from addressing a focussed group of vehicles can bring about significant change in a relatively more cost effective way.

Table 3: Number of Rigid HGVs according to weight and axle base

Rigid HGVs			
(tonnes)	**2 axles**	**3 axles**	**4 axles**
> 3.5 < 16	165,618	284	76
> 16 < 24	58,254	6,746	48
> 24 < 28	554	40,280	770
> 28 < 32	130	131	26,745
> 32 < 37	29	19	224
> 37 < 38	35	76	446
> 38	177	306	1,906
Total	**224,852**	**47,843**	**30,215**

This table clearly shows the number of ‘heavy’ vans and 7.5te trucks (two axle) that are operating. These tables show there are just 250,000 HGVs that are greater than 7.5te GVW.

Table 4: Number of articulated HGVs according to weight and axle base

Articulated HGVs		
(tonnes)	**2 axles**	**3 axles**
> 3.5 < 16	189	74
> 16 < 24	1,006	44
> 24 < 28	5,975	376
> 28 < 32	3,515	275
> 32 < 33	302	86
> 33 < 37	2,053	548
> 37 < 38	11,931	3,097
> 38	5,357	77,607
Total	**30,328**	**82,107**

The table above shows the split of tractors by axle configuration and shows the volumes that may apply to those vehicles that are capable of switching to natural gas in compressed or liquid form. Space for pressurised fuel cylinders and cryogenic tanks is easily available on rigid vehicles. In terms of available space for CNG tanks on articulated trucks a 2-axle tractor unit (4 x 2) has more space than a 3 axle (6 x 2) unit. LNG tanks can be relatively easily fitted to both 4x2 and 6x2 tractor units. There are four types of CNG cylinder all with different properties which must be considered when choosing the fuel system. All LNG tanks consist of a basic dual stainless steel skin with insulated layer to maintain cryogenic conditions. The only variation is volume. The reason hauliers tend to specify 6 x 2 configuration is that tractor unit can have a gross vehicle weight of 44 tonnes whereas a 4 x 2 is limited to 40 tonnes. However the above also shows the number of ‘urban’ tractors (24 to 33 tonnes) that operate within city centres or for supermarket deliveries. Discussion in relation to CNG and LNG is set out in section 6 below.

The conclusions of the above analysis are that:

- There is a very high level of diesel consumption from large tractors (>32 tonne) that have high annual mileage per tractor
- Such tractors are concentrated in a relatively small number of fleets with significant back to depot operation
- Introduction of CNG/LNG fuelling infrastructure at such depots may provide a relatively low cost of ‘filling station infrastructure’ per vehicle

1.4 Fuel availability and Infrastructure

The availability of refuelling infrastructure for both traditional fuels and their alternatives is characterised by a generally static position for larger commercial vehicles but significant changes for passenger cars and vans.

Petrol and diesel have a well-established distributor network of forecourts. There are 8,892 retail forecourts in the UK (Dec 2010) with site closures averaging 4-500 per annum. This is a fall of around 60% from the period 20 years ago when there were in excess of 21,000 forecourts in the UK. The development of supermarket filling stations has represented the major change and, according to Experian Catalist's Fuel Market Review, supermarkets such as Tesco, Asda and Sainsbury's, operate 14% of UK service stations but have a 37% market share of fuel sales. The figure below shows the car forecourt operators.

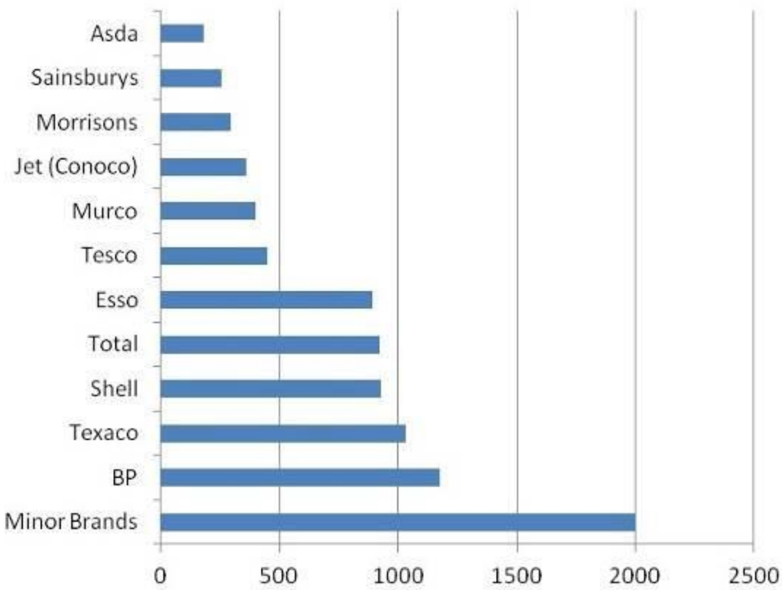


Fig 11: Number of forecourts by company (2010)

The market for transport fuels in the UK amounts to about 53 million tonnes per year, equivalent to about 49 billion litres. Demand for road transport fuels equates to 56 million litres of petrol and 68 million litre of diesel per day. Other than jet fuel, the market for transport fuels is mature with little overall growth in demand and in the case of retail fuels sold on the forecourt, this sector is virtually stagnant having grown by 1% since 1999.

There is a network of bunkered diesel fuel sites throughout the UK with facilities specifically set up for refuelling HGVs. There are approximately 700 sites some of which are standalone and some which are sited on larger forecourts or Motorway services. These are operated by the major brands (such as Esso and BP), by independent companies (Diesel Direct, Key Fuels, RHA Fuel Card) and by individual hauliers.

1.4.1 UK CNG Stations Closed from 2002 to 2006

The following CNG stations operated in the period 1996 - 2006 but have all been closed. All were supplied with gas from low pressure or medium pressure (typically 250 mbar).

- British Gas - Old Kent Rd, British Gas - Slough, British Gas - Bristol
- British Gas - Warrington
- British Gas Research Centre Loughborough
- West Oxfordshire District Council - Witney
- London Borough of Merton - Morden, London
- London Borough of Sutton - Sutton, London
- GKN - Birmingham
- Bournemouth Borough Council - Bournemouth
- Travel West Midlands - Walsall
- Mersey Travel - Liverpool
- First Hampshire (Citybus) - Southampton
- Hadley Group (3 sites) - Smethwick
- Ash & Lacey – Smethwick
- Atofina - Stalybridge

- DTS Logistics - Enfield
- Safeway- Ayleford
- Safeway - Aylesford
- ACC Distribution (Co-op) - Alfreton
- ACC Distribution (Co-op) - Cumbernauld
- Tesco – Harlow

The reasons for closure are as follows:

1. A number had issues with wet gas (e.g. sited on gas holder sites with wet gas)
2. Lack of vehicle availability
3. British Gas developed the first CNG vans and they and the CNG stations were not very reliable as they had no back up fuel and were conversions not OEM Product
4. BSOG making buses on CNG very expensive

1.4.2 UK Refining Capacity

In 2015 there are 6 UK Oil refineries in operation as the Murco refinery has closed in 2014. They are ConocoPhillips (Humber), Exxon Mobil (Fawley), Ineos Refining (Grangemouth), Essar (Stanlow), Total (Humber), Valero (Pembrokeshire). The Petroplus facilities at Teesside, Murco (Milford Haven), and Petroplus (Coryton) have been closed.

Table 5: UK Refinery processing capacity (end 2010)

(Symbols relate to Map 3A)		Distillation	Reforming	Cracking and Conversion
				Million tonnes per annum
❶	Stanlow – Shell UK Ltd	11.8	1.5	3.9
❷	Fawley – ExxonMobil Co. Ltd	16.8	3	5.2
❸	Coryton – Petroplus International Ltd	8.8	1.8	3.4
❹	Grangemouth – Ineos Refining Ltd	9.8	2	3.3
❺	Lindsey Oil Refinery Ltd – Total (UK)	11.2	1.5	4.4
❻	Pembroke – Chevron Ltd	10.1	1.5	6.1
❼	Killingholme – ConocoPhillips UK	11.1	2.1	9.5
❽	Milford Haven - Murco Pet. Ltd	6.5	0.9	2.0
①	Harwich – Petrochem Carless Ltd	0.4	-	-
②	Eastham – Eastham Refinery Ltd	1.1	-	-
③	Dundee (Camperdown) – Nynas UK AB	0.7	-	-
Total all refineries		88.3	14.3	37.8

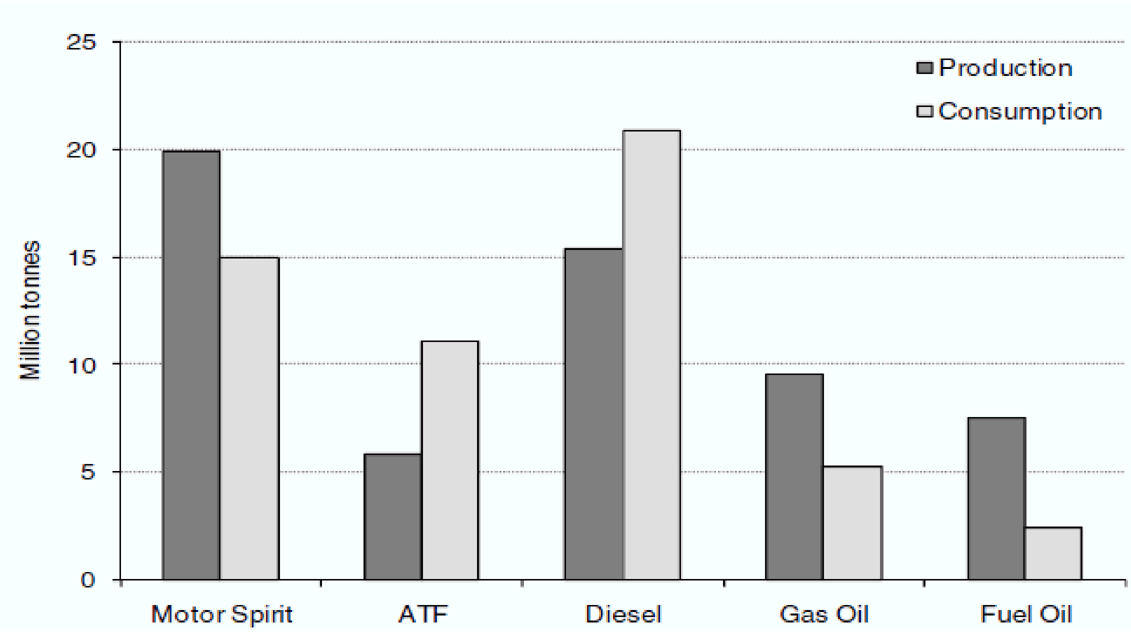


Fig 12: Production and consumption of key petroleum products (2010)

There is a deficit in the production of Aviation Turbine Fuel (ATF) and diesel in the UK which requires the importation of finished product.

The importation of biofuels (either as base material or ready blended in fuel) is managed by the UK import terminals for fuel products.

Oil Refineries in Europe are mainly set up to maximise the yield of petrol with diesel and jet fuel (kerosene) being secondary products. However, given the changes in the vehicle parc towards diesel power, this has created an imbalance in supply and demand for petrol and diesel in Europe. As a result the European refineries are exporting petrol to the USA and Far East and importing diesel to balance the shortfall. Current EU demand is 1.8:1 in favour of diesel with a prediction from the EU for it to move to 3:1 with continued dieselisation of the vehicle parc. This will make the older EU refineries uncompetitive with newer built global ones. It is therefore predicted that up to 10% of EU refineries will close by 2025. In turn the price of diesel will likely further disassociate itself from petrol due to supply/demand imbalances.

Around 200 million tonnes of diesel are needed in the EU annually and, of this, around 32 million tonnes are imported from the former Soviet Union, with the USA providing a further 10-15 million tonnes. This EU diesel shortfall is expected to grow to 89 million tonnes by 2025. The USA is beginning to champion the benefits of diesel for larger passenger vehicles and therefore this is likely to mean that further supply constraints will emerge which in turn will affect the value attached to diesel. In addition the tightening of the fuel specification for diesel in terms of sulphur and poly-aromatic hydrocarbons, along with greater desulphurisation of

marine fuels, is leading to higher refining costs and a greater carbon footprint associated with the higher energy costs of production. The inclusion of biodiesel will help to reduce the impact of the potential diesel shortfall provided sufficient sustainable product can be produced and supplied to European fuel providers.

The inclusion of bioethanol into petrol to help with its decarbonisation will tend to exacerbate the supply imbalance going forward as less refinery supplied petrol will be required. However, petrol hybrid cars, such as the Toyota Prius, that offer similar fuel efficiency to diesel cars, will also work in favour of reducing the demand for diesel particularly in the smaller vehicle sector where diesel engines are being phased out.

Outside of traditional fuels, natural gas has an opportunity to supply road transport due to the extensive gas grid network that can be tapped into to provide a refuelling site. This is discussed further in Section 3 with particular focus on using the High Pressure gas grid.

For natural gas refuelling there are a number of options currently available. Tenens (a logistics provider) have opened three refuelling stations for CNG at their depots in Andover, East London and Boston, the former is an LCNG facility utilising Liquefied Biomethane and the latter two are Grid connected. Hardstaff Group have 2 refueling stations based at their operations centres (that can dispense both LNG and CNG) available for third party refuelling, however in early 2015 they went into administration and therefore the future of these facilities is in doubt. The largest public access CNG Station is owned by CNG Fuels Ltd in Crewe. There are a further three refuelling stations in private use , Müller Wiseman Dairies, Camden Council

(Gasrec LCNG) and Veolia (Sheffield). Roadgas have a further two LCNG refueling stations. Gas Bus Alliance have four stations supplying dedicated buses in Runcorn, Darlington, Beccles, and Reading.

There are also a number of open to third party LNG filling stations operated by Calor-Chive Fuels Ltd (7), Gasrec (3), and BOC Ltd (4) The largest third party LNG facility (with some CNG refuelling capability) is the Gasrec site at DIRFT (Daventry). It supplies a blend of Liquefied BioMethane (approx. 15%) and LNG (85%).

Veolia run 10 Mercedes Benz Econic Refuse collection vehicles in Sheffield and have their own dedicated LCNG station to refuel them.

Under the Governments Low Carbon Truck grant programme further stations are being installed at Scunthorpe (CNG), Avonmouth (LCNG), Swindon (CNG), Alcester (LNG).

2. Natural Gas Overview

Natural gas has the benefit of greater reserves globally (compared to oil) with the development of the shale gas resource in the US appearing to cause a fundamental change in the reserve availability. In the UK, the BGS has estimated that the gas in place in the Bowland shale resource could be around 1,500 trillion cubic feet (tcf). To put this in context, the UK's largest gas field South Morecambe was around 6 tcf, which is around 172 billion cubic meters (BCM) of gas or equivalent to 69 billion therms, with a value of around £40 billion in 2011 money. The UK consumes in total around 80 BCM per annum. So, South Morecambe contained around 2 years' worth of UK demand.

Even if only 10% of the 1500 tcf Bowland shale resource was recoverable then this would represent a major source of gas for UK at 150 tcf, around 4300 BCM, sufficient to provide approximately 50% of the UK's gas needs for around 100 years.

Natural gas combustion leads to 28% lower CO_2 than oil combustion. However, the extent of the benefit of natural gas takes into account a number of key issues:

- Where does the natural gas come from? (according to Prof Mackay, DECC's Chief Scientist, Bowland shale for example can be expected to have a lower carbon footprint than LNG imported from the Middle East)

- For natural gas used as a vehicle fuel in liquid form, how was the liquid made and transported to the vehicle?
- What gas grid pressure is used to supply the CNG station?
- What sort of engine is used to burn the natural gas?

Natural gas contains around 90% methane with other hydrocarbons such as ethane and propane, with the balance made up of inert gases. Both spark ignition and diesel cycle engines can be adapted to use it. In OECD countries the use of NGVs (natural gas vehicles) has been in improving air quality (such as most buses in Paris, Madrid, Rome and Los Angeles). However, the key issue in having an NGV market is generally the availability of a natural gas grid.

Whilst Natural gas prices have been rising they appear to have significantly disassociated themselves from crude oil pricing. On an energy basis, natural gas costs around 50% of the cost of oil. This is illustrated by the price of gas oil to an off grid industrial customer of around £1.60/therm, over double the cost of natural gas.

Globally, natural gas vehicles covering cars, Vans, Buses and trucks are well established. The UK is believed to around 700 commercial vehicles on CNG (compressed natural gas) or LNG (liquefied natural gas).

Whilst world-wide the majority of NGVs are cars, there is evidence from Germany that in EU markets the use of natural gas for cars may not be gaining significant market traction. In year 2000, the German Government reached a tri-partite agreement with the German gas industry and car-makers. In return for a 20 year period with CNG taxation at the EU minimum (6p/kg), the car companies would bring to market new CNG cars and the gas companies would install CNG stations. However, despite 900 stations being built and new purpose designed CNG vehicles, sales have been disappointing and there only around 90,000 CNG cars on the road.

If each car fills on average once a week, then this means that each CNG station only has around 14 cars filling up per day so stations are operating at a loss. The limited sales for CNG cars are due to the increased performance of diesel vehicles in the last 10 years. Together with petrol hybrids, these have resulted in the low CO_2 and air quality benefits that were expected to be the target for CNG cars.

The conclusions are as follows:

- There does not appear to be a strong case for CNG for cars in the UK because of high capital costs relative to fuel consumption and as a result of the development of electric vehicles, petrol hybrids and low emission diesel cars.

- CNG (compressed natural gas) in dual fuel and dedicated tractors (HGV) with gas supplied from the high pressure Local Transmission System (LTS) networks grid offers significant benefits (10 – 30%) in terms of GHG reductions and is available today.

- CO_2 savings from dual fuel vehicles and LTS estimate at 168,000 tonnes per annum based on 20% shift of tractors to CNG-diesel dual fuel by 2020 (assuming 15% CO_2 reduction on average). This is equivalent to approximately 3% reduction in HGV transport emissions.

- The UK has an extensive LTS network (around 6,000 km) which operates at 10 – 40 bar, providing a number of benefits:

    - Requires smaller compressors yet delivering very high throughput, with significant reduction in the number of running hours and hence maintenance costs
    - The reduction in compressors further reduces the scale of transformer assets and reduces electricity usage by up to 80%
    - Provides very dry gas associated (no gas drier needed)
    - Has a low leakage of fuel in distribution to refuelling site (avoids leakage typically associated with older metallic low pressure gas networks)

- The use of LNG (liquefied natural gas) for long distance haulage and heavier HGVs is also attractive. However, for the best GHG benefit this route would require LNG road tanker loading to be made available from the UK's LNG importation terminals such as at the Isle of Grain or Milford Haven facilities. The use of these LNG importation terminals avoids energy loss in vaporisation from such terminals into the gas grid and re-liquefaction at the Avonmouth LNG storage facility which currently supports LNG tanker supplies. National Grid have announced that they will provide an LNG Road tanker loading facility at their Isle of Grain LNG importation terminal from summer 2015. This is a major boost to the NGV market in the UK.

- LNG is useful for tractors with longer distances (over 400km) and for 6x2 HGV tractors that has limited space for CNG tank storage. It is noted that the space available for LNG or CNG storage tanks / cylinders on the tractor may become restricted due to pending emission control, Euro VI, HGV legislation and may lead to gas storage being moved to the trailer. Over the short term it is anticipated that Diesel/Natural Gas dual fuel technology will remain an attractive economic and lower Carbon alternative to Diesel HGVs. Traditional barriers concerning vehicle warranty are being removed with vehicle manufacturers guaranteeing approved vendor conversions as well as developing their own factory fit option.

- One UK Haulier has overcome the mileage issue with CNG by innovative placement of extra CNG tanks around the frame of their 6x2 tractor units. Other have placed extra tanks at the back of the cab on a strong frame. Both can now get in excess of a 400km daily mileage on CNG / diesel dual fuel systems.

- The absence of a national CNG-LNG refuelling infrastructure for trucks is not a barrier in the short term as initial market focus is on larger fleet operators with a “back to depot” operational structure. The typical range is less than 200 km for such vehicles and hence CNG is appropriate whatever type of vehicle is used. The development of dedicated fleet refuelling stations is potentially an attractive option due to the potentially short capital payback (3-5 years) on refuelling station assets particularly with large fleets or significant annual mileage displaced by gas.

- The current fixed fuel duty difference on CNG, relative to Diesel, makes such an option viable to certain fleet operators possibly including logistics, postal carriers and supermarket supply chains. At present CNG fuel duty provides an economic advantage to Diesel for HGVs and for larger fleet operators the fuel duty differential has led to some interest in developing dedicated CNG or LNG filling stations. The Chancellor announced in December 2013 that the Fuel duty on CNG/LNG would be linked to that on Diesel for a 10 year period. This is a highly positive step and reduces risks for investors, helping to develop a market that reduces Carbon emissions for vehicles with limited low Carbon alternatives.

- At present the cost of natural gas is around 50% of the cost of oil on an energy basis.

DECC forecasts indicate that energy in natural gas form is likely to remain cheaper than energy in oil form and hence there are material benefits to the UK economy in terms of lower cost of imports if trucks can be moved by natural gas rather than diesel

- Biomethane production is forecast to increase across the UK to around 195 million kg injected into the Gas grid and there is scope for Biomethane to replace CNG as a transport fuel. Hence in the UK as in Germany and the Netherlands, the use of Biomethane injection and Green Gas Certificates appears more appropriate, taking advantage of the gas grids that already exist. The report notes that Sweden is unique in fuelling vehicles directly on CBM as a result of there being no gas grid. It is possible that smaller vehicles may adopt CBM for small fleet operators associated with the Biomethane production and maybe an attractive option for remote producers.

- There may be a niche for Liquid Biomethane (LBM) made from landfill gas that would otherwise be flared and LBM from anaerobic digester biogas may be viable option for larger projects where a gas grid option is not available. The Gasrec Albury site is currently the only production site for Liquefied Biomethane in the UK and has an annual estimated capacity of between 2500-3000 tonnes (enough to fuel approx. 200 dual fuel trucks or 100 dedicated).

- Besides the GHG emission savings and economic advantages that CNG/LNG or CBM could bring to the HGV market, gas also delivers both low NO_x and Particulate Matter emissions leading to improved air quality benefits. Accordingly, this will help both the UK and Local Authorities achieve Air Quality targets and will be of interest to bus or fleet operators in urban environments.

- Hybrid technology will be most applicable to buses and refuse trucks and whilst the initial focus has been based around the diesel engine, it is possible to have CNG hybrids that significantly improve both stop/start performance and deliver air quality benefits. A number of CNG Hybrids are now in use across Europe. However the additional cost and potential weight penalties may rule them out. Diesel hybrid bus testing shows that the savings in real life operations are less that the laboratory tests achieved putting further strain on the payback periods.

2.1 Note on Wet Gas

On the whole the gas quality issues in the UK have been limited to wet gas. This is due in the main to the old low pressure cast iron gas pipes (<0.1 bar) being very old and having yarn joints. These will let in certain amounts of water if not properly kept moistened with Mono-ethylene-Glycol.

Low pressure gas areas are particularly bad where they are situated next to a Gas Holder, due to the gas being sealed within the holder by an oil or water ring seal. This also leads itself to a seasonal variation in gas quality as and when the holders are brought on line for the winter period.

In all cases where water is an issue, the design of the gas station takes this into account and the fitting of an appropriately sized gas drier is installed. These are typically molecular sieve desiccant granule absorption type driers.

However modern CNG stations are linked to the higher pressure mains where wet gas is not an issue for users. It is advantageous at the design stage to avoid low pressure areas or known wet gas areas.

The CNG Services station in Crewe has driers installed but they are still in original condition after 10 million kg because the gas is dry at 4 bar pressure on the Intermediate Pressure Grid.

3. Biomethane Overview

Around 3% of the UK's total greenhouse gas emissions came from waste in 2009. Around 89% of these emissions come from landfill sites where biodegradable wastes decompose to produce methane and carbon dioxide gas. The Government is increasing the level of the landfill tax to reduce the amount of waste going to landfill in the first place, promoting recycling and making use of a range of technologies such as anaerobic digestion (AD) to produce energy from waste. The Government is also working closely with the Environment Agency and industry to explore ways to increase the amount of methane that is captured from landfill sites.

There is now an active market in the development of new ADs that can use food waste, agricultural waste and local authority biodegradable waste as feedstocks. The Government rewards electricity generated by AD with a feed in tariff. In addition, from November 2011, the Government introduced the Renewable Heat Incentive (RHI), which rewards the injection of Biomethane (made by removing CO_2 and other contaminants from biogas) into the gas grid. Biomethane can also be compressed (into CBM) and used as a vehicle fuel in place of CNG, in such case the CBM earns a renewable transport fuel certificate.

There are in effect 3 options for biogas produced in an AD, shown below in increasing order of capital and operating cost:

- Limited processing, generate electricity, earn feed in tariff (FIT)
- Biogas clean-up and upgrading to make Biomethane, addition of propane and injection into the gas grid, earn renewable heat incentive (RHI)
- Biogas clean-up and upgrading to make Biomethane, compress and use as vehicle fuel, earn renewable transport fuel certificate (RTFC)

The table below summarises the income from the energy and renewable premium for the three utilisation options. In each case, a biogas flow-rate of 500 m^3/hr is assumed, with 60% methane content.

Table 6: Income from energy and renewable premiums for biogas utilisation options

Utilisation Option	Energy produced	Annual income from basic energy (£k)	Renewable incentive	Annual income from renewable incentive (£k)	Total Annual income (£k)
Electricity	10,500 MWh	600	FIT	1,000	1,600
Injection to Grid	860,000 therms	500	RHI	1,500	2,000
Vehicle Fuel (CBM)	1,800,000 kg	500	RTFC	730*	1,230

*Dependent on the market value of the certifications

Whilst the above table shows income only and not capital and operating costs, it is clear that the electricity and grid injection options are the most attractive in financial terms. In addition, there are practical issues associated with direct use of CBM in vehicles. The 1.8 million kg of gas in the table above is equal to around 2.5 million litres of diesel. This would require around 100 tractors each doing 150,000 km per annum. Whilst there are many distribution depots with that number of vehicles, the refuelling patterns are such that gas is needed at certain times of the day and it is not practical to fill such a fleet directly from CBM.

As part of the DECC/Defra AD Strategy Plan in Q1 2011, the LowCVP was commissioned to produce a report that reviewed the options to promote CBM as a vehicle fuel and concluded that it was difficult in the short term to expect much use of CBM in vehicles because of the fundamental economics.

In addition, the point was made that for replacement of natural gas as a fuel for central heating in cities such as London there are very few alternatives and Biomethane is clearly one, whereas, there are a number of alternatives for diesel in commercial vehicles, including biodiesel and CNG/LNG.

It is also possible to make Biomethane and then liquefy this gas by cooling to -160°C, making Liquid Biomethane (LBM). The UK has one source of LBM made at a landfill site at Albury in Surrey produced by a company called GasRec. This LBM is being used for road transport by a number of companies and is believed to provide a reduction in CO_2 of around 64-68% compared to diesel. The LBM is delivered by road tanker and used to fuel commercial vehicles; usually the LBM is made into CBM and stored in compressed form on the vehicle, though it can equally be stored as liquid.

Direct use of CBM can give significant CO_2 savings of in excess of 80% (dependent on feedstock and the vehicle engine efficiency).

4. Use of Natural Gas as a Vehicle Fuel

4.1 Vehicle Availability

Dedicated natural gas vehicles tend to have CNG as the fuelling storage whilst some dual fuel conversions will offer either LNG or CNG tankage. The larger 44te tractor units (such as Volvo) are initially pursuing LNG to enable sufficient fuel to be stored on the tractor unit, however there are some innovative ideas coming forth on how to site CNG tanks including having spare storage on trailers with a link to the tractor unit similar to the air and brake lines. There can also be tanks behind the cab.

A CNG dual fuel 6 x 2 tractor will have range of around 300 km on dual fuel which may be enough for most back to depot journeys.

4.2 Barriers to Natural Gas Vehicles

There are factors that act as barriers to the take up of dedicated or dual fuel vehicles. As part of their work for the DECC/ Defra AD Strategy, the Low CVP carried out a review in relation to the barriers to take up of biomethane as a vehicle fuel.

In relation to the use of CNG/LNG, it can be seen that the key barriers are as follows:

- Supply of OEM product
- For conversions, warranty issues and support
- Overall economics:

- On cost of vehicles (typically £15 - £30k)
- Cost of refuelling infrastructure
- Uncertainty about fuel duty incentive over the medium/long term
- Fleet size (many are too small to warrant own refuelling facilities)
- Residual Values

Therefore, to shape the future gas vehicle market the following factors are important:

- Large capacity refuelling stations, ideally in CNG configuration linked to the high pressure gas grid to achieve lowest fuel costs, lowest CO_2 footprint and take advantage of the LTS pressure

- Ensuring 3rd party access to private sites and encouraging investors to open commercial vehicle refuelling stations with public access will be important for smaller operators and, crucially, for the second-user market that must develop

Utilising high capacity refuelling infrastructure will provide the most economic benefits for HGV operators if a reasonably good refuelling infrastructure was accessible to them. An HGV operator should make a cost saving against an equivalent diesel vehicle within the first-user lifetime of the vehicle for all types of gas vehicle (whether dedicated or dual fuel) and for all weights modelled. Cost savings at 2010 prices for the first-user range between £7,000 and £20,000 compared to the diesel equivalent, depending on vehicle type), providing break-even times for the additional cost over diesel of between 2 and 5 years.

The key conclusion is that operating heavy commercial vehicles on gas can lead to lower costs for an important sector of the UK economy as well as delivering significant reductions in NO_x and Particulates as well as CO_2.

4.3 LNG CO_2 and Methane Emissions

LNG can have a CO_2 footprint due to the energy used to liquefy and the emissions from road delivery requirement. Methane losses however can be avoided by fitting a closed loop venting system at extra cost and by maintaining high throughput. Within any conversion it is important to minimise any Methane 'bleed' from the engine by using tight fuel control and in some cases a methane catalyst.

4.4 CNG CO_2 Reductions

This comparator uses the EU data generated by EUCAR/ Concawe/ JRC[1].

Well to Tank (WTT) GHG emissions:

Diesel	15.9 g CO_{2eq}/MJ
Petrol	14.2 g CO_{2eq}/MJ
Natural Gas	
EU Mix	8.7 g CO_{2eq}/MJ
LNG to CNG	20.2 g CO_{2eq}/MJ
LNG (liquid)	20.8 g CO_{2eq}/MJ

Using the LTS removes the loss of methane through the lower pressure grid network and no energy is required for drying. However, in the above figures CO_2 is identified only for compression of the CNG. The use of LTS accounts for the reduction of 1.9g CO_{2eq}/MJ

- 1 litre diesel = 35.9MJ
  - Therefore Well-to-Tank (WTT) footprint is 570.81g CO_2 per litre

- 1 litre diesel emits 2.668kg CO_2 when burnt
  - Therefore 1 litre diesel emits 3.24kg CO_2 on Well to Wheel basis

- 1 kg CNG = 46.84 MJ
  - Therefore EU Mix WTT footprint is 407.51g CO_2 per kg

- 1 kg CNG emits 2.651kg CO_2 when burnt
  - Therefore 1 kg CNG emits 3058.51g CO_2 on Well to Wheel basis

1 litre diesel = 0.75kg CNG

[1] In their July 2011 report: *"Well-to-wheels Analysis of Future Automotive Fuels and Powertrains in the European Context - WTT APPENDIX 2 - Description and detailed energy and GHG balance of individual pathways – version 3c"*

Therefore comparative figures are:

Diesel	3238.81g CO_2	
CNG	2293.88g CO_2	(29% Saving)

For each litre of diesel saved and substituted for CNG there is a saving of **29% CO_2**

Therefore, a dedicated CNG Truck (at diesel efficiency) saves 29% CO_2 and a dual fuel truck running at 50% substitution achieves 14.5% CO_2 savings. With loss of efficiency in a dedicated CNG engine it can still be expected that there will be savings of greater than 15%.

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6. Appendix 1 CNG Vehicles in the UK

A1.1 VW Caddy

The Volkswagen Caddy is the best-selling CNG van in Germany, launched mid-2006, is built to run on CNG rather than a petrol conversion. A right hand drive is type approved for sale in UK. The model is also available at Caddy Maxi Car (7 seats). VW do not actively market this vehicle due to lack of CNG filling infrastructure. CNG Services Ltd (CSL) have a demo that is being used in Crewe.

Fig 13: VW Caddy

A1.2 MB Sprinter NGT

The Sprinter is the first time Mercedes Benz has designed a CNG vehicle from ‘first principles’ (rather than petrol conversion). It offers very low emissions (25% less CO_2 than petrol) on grid gas. The Sprinter also has petrol tank, giving a total range of 1,100 km. This van is ideal for supermarket home delivery as it is quiet, clean, long range and fast refuelling.

Figure 14: Mercedes Benz Sprinter NGT

A1.3 Iveco Daily Van

Tesco have bought 50 Iveco Daily's to run in London. It can run as a bi-fuel van (as per the MB sprinter NGT) or as a dedicated CNG van.

Figure 15: Iveco Daily Van

A1.4 MB Econic Tractor

The MB Econic is designed for distribution logistics. It offers EEV emissions and 20% lower CO_2 than diesel. The Econic has a very quiet engine so would be permitted to drive in cities at night. MB would, in principle, bring the Econic Tractor to the UK in a right-hand drive form but they have not done so due to lack of customer demand/infrastructure. The engine is 280 bhp which is light for supermarket use (they need 340 bhp).

Figure 16: Mercedes Benz Econic Tractor

A1.5 MB Econic Refuse Truck

Malmo and Lille both run fleets of Econic refuse trucks on biomethane. There is significant interest to bring this to the UK, initially on fossil CNG but migrating to Compressed Biomethane (CBM) as the AD industry develops.

In UK, there are Econic RCV Fleets in Sheffield and Leeds.

Figure 17: MB Econic Refuse Truck

A1.6 Iveco Stralis

The Stralis range covers the applications of heavy trucks from a total weight of 18 to 26 tonnes. Stralis AD260S30Y/FS-D CNG is purpose-built on the factory-line for natural gas powered applications. It features a six cylinder 7.8 litre Cursor 8 engine which produces up to 300 hp at 2,000 r/min and up to 1,100 Nm of torque between 1,100 and 1,650 r/min, driven through an Allison 3500 six-speed automated gearbox. Coca Cola are running a fleet of 12 dedicated CNG Stralis vehicles in Enfield, London.

Fig 18: Iveco Stralis

A1.7 MB Dual-Fuel Tractors

These vehicles provide the benefit of diesel efficiency but with natural gas giving 15-20% lower CO_2 emissions. The range is 400 miles at a substitution rate of 60%. Conversion is by Hardstaff Group (however they went into administration in early 2015 and there is uncertainty on whether the technology will be bought by another company for continuation).

Tenens carried out 6 month trial on trunking and multidrop routes from Andover resulting in investment:

- 12 x Actros tractor units converted running from Andover
- x Axor tractor units converted running from London
- CNG stations in Andover, London M25/A13 and Boston


Fig 19: Mercedes Benz Dual-Fuel Tractor


Fig 20: Howard Tenens Dual-Fuel Actros

Fig 21: Gist Axor Dual-Fuel at Crewe

A1.8 Volvo Dual-Fuel Tractors

Volvo launched the Volvo FM MethaneDiesel in May 2011. The truck is powered by up to 75% natural gas (stored as LNG), reducing CO_2 emissions on heavy and long-distance transport operations.
Volvo's gas technology offers a 30 to 40% higher efficiency compared to conventional gas-powered spark-plug engines, cutting fuel consumption by 25%.

Fig 22: Volvo Dual-Fuel Tractor

A1.9 Renault Premium CNG Trucks

The Clean Tech Natural Gas for Renault Trucks offers up to 2dB noise reduction, is compatible with biomethane and meets Euro V and EEV environmental standards. Two refuse collection / distribution wheelbase options are available: 4x2, GVW: 19t; and 6x2*4, CVW: 26t. The engine (Cummins Westport) specification is as follows:

- Power: 224 kW (300 hp) at 2100 rpm

- Torque: 1166 Nm at 1300 rpm
- Displacement 8.9 litres
- Allison 3000, 7-speed gearbox

Not available in UK currently

Fig 23: Renault Premium CNG Trucks

A1.10 Prins - DAF and MAN Dual Fuel Trucks

Dutch company Prins is now offering conversion of DAF and MAN trucks. They have lower substitution of CNG compared to CAP and Hardstaff (around 45%), but this allows them to have complete combustion of methane with no need for a methane catalyst. It also gives very good fuel efficiency. The torque matched software ensures there is no perceivable difference between driving these vehicles and standard diesel ones.

Fig 24: Prins dual-fuel conversion (MAN)

Fig 25: Prins dual-fuel conversion (DAF)

Fig 26: Prins 4 x 140L vertical CNG cylinder pack

A1.11 Scania CNG Trucks

Scania offer two 9.3 litre gas engine specifications: OC9 G04 Euro 5 and EEV and OC9 G05 Euro 5 and EEV, with the following specifications:

- Power at 1900 r/min: 199 kW (270 hp) for G04, 224 kW (305 hp) for G05
- Torque at 1000-1400 r/min: 1100 Nm for G04, 1250 Nm for G05

The engine technology is a 9.3 litre diesel engine platform, using the Otto combustion process with lean combustion with lambda control. Fuel tanks capacity and layout is as follows:

- 640 litres at 200 bar, 8 x 80 litres
- 4 tanks per side in composite material

Fig 27: Scania CNG Truck

A1.12 Clean Air Power: Euro 5 – Volvo FM/FH13 & Renault Magnum

Clean Air Power Dual-Fuel™ conversions produce up to 75% gas substitution, utilising diesel 'liquid sparkplug'. This delivers expected fuel cost savings of up to 20% and reduced CO2 emissions of 15% compared to an equivalent diesel model. This technology allows for 100% diesel fall back for peace of mind.

The Clean Air Power conversion products are available as an integrated design at the manufacturers, or an after-market conversion. The integrated products offer the highest gas substitution. Conversions are available for CNG or LNG depending on the operator's preferences.

A1.13 MAN EcoCity Bus

CNG powered MAN EcoCity bus specification is as follows:

- Engine: E2876, horizontal, Euro 6 prepared
- Power Output: 270-310 HP
- Transmission: Voith or ZF
- Dimensions: L 12m, W 2.5m
- Weights: GVW of 17,900 kg
- Capacity: 70 passengers

Fig 28: MAN EcoCity Bus filling at Crewe

A1.14 Scania Natural Gas Bus

Reading Buses has 20 of the vehicles on order at a cost of £3.5m and began services in May 2013. The 12m (39ft) long 40-seat vehicles will be run on both compressed natural gas and bio natural gas. Developed by Scania and Alexander Dennis Limited, they have a special compartment on the roof to store the fuel. The specification is as follows:

- Model: Scania KUB 4 x 2
- Engine: OC9 G02 – 270HP at 1900rpm, lean burn, 9litre, max. torque at 1000-1400 rpm 1100Nm
- Tanks: 8X150LTR composite roof mounted
- Gearbox: ZF 6 Speed, Ecolife, 6AP1200B, gearshift program Topodyn Eco
- Tyres: 275/70R22.5

Fig 29: Scania Natural Gas Bus

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