Biomethane for Transport - HGV cost modelling

Prepared for

LowCVP

by

Transport & Travel Research Ltd

in partnership with

JouleVert

and

TRL

Part 1 Report

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EXECUTIVE SUMMARY

In November 2010, DEFRA published a framework document on Anaerobic Digestion (AD), outlining their plans to deliver a rapid expansion of the sector. Following on from this, DEFRA produced a joint Industry-Government AD Action Plan in June 2011. Within the action plan is a Biomethane in Transport work-stream, which has been coordinated by LowCVP (The Low Carbon Vehicle Partnership).

In order to prepare for this work-stream and help with development of the strategy LowCVP commissioned Transport & Travel Research Ltd (TTR), working in partnership with JouleVert and Transport Research Laboratory (TRL). The aims were to model the costs for different fleet operations of switching from diesel to dedicated and dual fuel vehicles, specifically in Heavy Goods Vehicle (HGV) fleets. In addition, the study was to identify barriers to uptake and review a range of incentives to address these. A second strand of the work examines the impact of incentives on the uptake of gas as a transport fuel and forecast CO_2 reductions.

There are significant potential benefits of developing a larger UK gas vehicle sector fuelled by biomethane:

- Use of UK indigenous fuel supplies
- Effective route to generate renewable energy from waste
- Insulation from rising diesel prices (if gas price disconnects)
- Significant well-to-wheel CO_2 reductions compared to diesel vehicles
- Wider use of low polluting fuels for air quality – reduced emissions of NO_x and PM_{10} and $PM_{2.5}$

This report is the main output of the Part 1 work. The data used in the model is taken from public sources, previous studies and new data from gas vehicle operators, vehicle manufacturers, refuelling station equipment suppliers, their customers and key industry associations. Interviews were conducted with a wide range of stakeholders to gather information on their operational experience and real-life cost data. A summary of the results from the cost modelling is outlined below.

Cost of operating dedicated and dual fuel gas vehicles compared to diesel

Gas vehicles are fuelled with either Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG), two different forms of a gas largely comprised of methane. Biomethane, a renewable form of gas, can be supplied in equivalent forms to CNG and LNG, and used in the same vehicles. Gas refuelling stations designs are available to supply either types of gas as vehicle fuel.

Gas vehicles are produced in two main forms: dedicated gas, where only gas is stored on-board and used in adapted engines; and dual fuel, where a diesel engine has been modified to accept a mixture of gas and diesel and the vehicle has both gas and diesel storage tanks on-board.

A cost model was used to assess the costs of operating dedicated gas and dual fuel vehicles with the variety of gas fuels. In addition, refuelling stations of different capacities were modelled to quantify the cost benefits for HGV operators using various sizes of refuelling infrastructure.

The modelling results indicate that HGV operators with average vehicle mileages and access to large capacity refuelling stations should make a cost saving against an equivalent diesel vehicle within the first-user lifetime of the vehicle. With CNG refuelling this result applies to different types of gas vehicle (dedicated and dual fuel) and for all vehicle weights modelled. Depending on vehicle type the cost saving for the operator range between £7,000 and £51,000 compared to the diesel equivalent at 2010 prices. This means a break-even time for paying back the additional capital cost of the vehicle compared to diesel operation of between 6.6 and 2.8 years.

The key conclusion is that operating heavy commercial vehicles on gas can lead to lower costs compared to operating on diesel for an important sector of the UK economy.

Capacity of refuelling stations

The costs of operating dedicated or dual fuel trucks are most attractive where operators can access a 10,000kg/day refuelling station (sufficient for 50-100 trucks), with 5,000kg/day stations also returning similarly attractive values. Reducing the station size to one of 2,000 kg/day or below quickly makes dedicated or dual fuel less attractive as the costs for operating dedicated or dual-fuel vehicles exceed their diesel equivalents.

Smaller operators (which make up the majority of the HGV industry) will struggle to make gas vehicles pay-back when using small capacity filling stations. On their own these operators cannot utilise the largest capacity refuelling stations so cannot realise the cost savings possible in the longer term from using dedicated and dual-fuel gas vehicles.

The capacity of infrastructure has a significant effect on the price of the fuel provided to vehicles. Economies of scale mean that larger fuelling stations can provide cheaper fuel to the extent that it significantly changes the potential payback time and first-user total costs of operating gas vehicles.

Using biomethane

Biomethane is currently available from one UK supplier for purchase by vehicle operators in the form of liquefied biomethane gas (LBG), at a cost similar or slightly higher than LNG. Therefore, the costs of using biomethane from this supplier will be as per LNG refuelling stations, in combination with dedicated or dual fuel vehicles. There will be biomethane producers, distant from the gas grid or abstracting otherwise waste gas from landfill, who continue to have the option of liquefaction for clean-up and / or transport (from stranded assets), but this is likely to be a smaller part of the market. UK pilot projects of grid injection (e.g. Thames Water, Didcot) are supply biomethane into the gas grid.

It is likely, in the current incentive regime, that biomethane from the growing number of producers will be priced at a premium because they can access the gas grid for grid injection and achieve a high value (due to the Renewable Heat Incentive). For it to make financial sense for operators to use biomethane in vehicles the incentives currently on offer across different sectors require harmonisation.

If incentives to inject biomethane into the grid are successful, a certificate trading scheme could be used to encourage the use of a natural gas and biomethane mix as vehicle fuel.

Rising fuel prices

The predicted rise in future diesel vehicle capital and fuel costs make dedicated and dual fuel HGVs increasingly attractive and the break-even time on additional upfront costs shorten considerably. However, savings over diesel equivalent operations can only be made if there is investment in the refuelling infrastructure so it is available and accessible to a range of HGV operators.

In reality there will continue to be non-cost barriers in place unless the market for gas refuelling is kick-started.

Barriers

Interviews with stakeholders confirmed a range of factors that act as barriers and suppress the take up of dedicated and dual fuel vehicles. The barriers that need addressing are:

- Refuelling infrastructure (lack of), compounded by;
  - Fleet size (many are small);
  - Return to base frequency (many do not);
- Supply and servicing of gas vehicles;
- Uncertainty about fuel incentives;
- Short-termism in an industry under pressure;
- Financing;
- Availability of biomethane.

Stakeholders gave the clear message that stimulating a growth in refuelling infrastructure would have the greatest effect of all factors on take up of gas as a transport fuel to enable out-based fleets to refuel.

Incentives and recommendations

If large capacity refuelling infrastructure is in place and matched to demand from appropriate fleets the cost modelling indicates that cost effective operation of HGVs using gas in dedicated and dual fuel vehicles is possible. This is at prices that also give reasonable payback times for investors in large-capacity refuelling infrastructure.

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

- Large capacity refuelling stations are crucial, ideally in CNG configuration linked to the gas grid to achieve lowest fuel costs, and tap into growing biomethane content;

- Ensure the cost benefits of gas operation are not just for the largest fleets. 3rd party access to private sites and/or encouraging investors to open commercial vehicle refuelling stations with public access will be vital. This will also help support a second user market.

Taking into account the collective opinions of stakeholders, and the barriers discussed above, we recommend that to encourage biomethane as a transport fuel in the UK the development of the infrastructure for own-depot fuelling and in public refuelling stations should be prioritised. The short term advantages would be to reduce the effective price seen by all operators.

The industry as a whole prefers easily legislated incentives that are within the domain of the national Government. In addition, the industry needs a long term position to be taken by Government to allow for the necessary investments to take place.

A more streamlined approach is to put in place incentives that encourage use of gas (and therefore interest in refuelling stations) and that are also within the control of UK Government (Treasury). Examples of such policies would be:

- Long term fuel duty incentive for both natural gas and biomethane as road transport fuel – preferably zero rated to 2020 (as is given to electricity and hydrogen);
- Green gas certificates to allow for book and claim system for biomethane gas after grid injection;
- Reduced VED rates for natural gas/biomethane vehicles;
- 100% first year capital allowance on the cost of refuelling stations;
- 100% first year capital allowance on the cost of natural gas/biomethane vehicles.

A Part 2 report from this study will examine the impact of such incentive regimes on potential uptake of dedicated and duel fuel gas vehicles, the costs and benefits of doing so as well future reductions in CO_2 emissions.

1. INTRODUCTION

1.1 Background

In November 2010, DEFRA published a framework document on Anaerobic Digestion (AD), outlining their plans to deliver a rapid expansion of the sector. Following on from this, DEFRA produced a joint Industry-Government AD Framework for May 2011. Within the Framework is a Biomethane in Transport work-stream, which has been coordinated by LowCVP (The Low Carbon Vehicle Partnership).

In order to prepare for this work-stream and help with development of the strategy LowCVP commissioned Transport & Travel Research Ltd (TTR), working in partnership with JouleVert and the Transport Research Laboratory (TRL), to undertake cost modelling to demonstrate the predicted effects of different operating scenarios of dedicated and dual fuel vehicles, specifically in Heavy Goods Vehicle (HGV) fleets.

The objectives of this strand of work have been to:

- Determine industry awareness, understanding and concerns regarding the use of HGVs fuelled with natural gas / biomethane (including non-financial barriers);
- Compile baseline data on current UK HGV numbers, costs etc;
- Undertaking cost modelling, to compare different natural gas / biomethane fuelled vehicles with their diesel equivalents in typical fleet operations;
- Report the study findings, including information that illustrates the opportunities for gas vehicle operation, current re-fuelling options, expansion of gas vehicle fleets, operating patterns to achieve pay-back and addressing non-financial barriers.

This report is the main output of the Part 1 work and is accompanied by a cost model developed with data from interviews with a range of stakeholders to gather operational and cost data. The data used for the model during the production of this report is based on previous studies, combined with data from gas vehicle operators and refuelling station equipment suppliers and buyers. The cost model allows many adjustments to the conditions and a set of assumptions have been made to generate results for this report. However, any individual operator will experience differences in fuel consumption, substitution rate, duties, annual mileage, and so forth.

A second strand of the work was to examine the potential for incentives to increase the uptake of gas as a transport fuel (and the impact on carbon emissions), which will be reported separately in a Part 2 report.

1.2 Current HGV fleet and usage of gas

At the end of 2009 there were 415 thousand goods vehicles over 3.5 tonnes registered in Great Britain. Of these, 278 thousand were HGVs over 7.5 tonnes: 112 thousand of these were articulated vehicles and 166 thousand of rigid chassis design. Around 7 per cent of total good vehicles were first registered in 2009, indicating the recent annual turnover rate of the fleet.[1] The vast majority are fuelled with diesel.

Table 1.1 – Number of vehicles by type (Thousands)

Year	Up to 7.5 tonnes	Over 7.5 tonnes up to 15 tonnes	Over 15 tonnes up to 18 tonnes	Over 18 tonnes up to 26 tonnes	Over 26 tonnes	Total
Rigid Vehicles						
2009	137.7	27.9	58.6	48.1	30.5	302.9
	Up to 26 tonnes	**Over 26 tonnes up to 34 tonnes**	**Over 34 tonnes up to 38 tonnes**	**Over 38 tonnes up to 40 tonnes**	**Over 40 tonnes**	**Total**
Articulated Vehicles						
2009	2.3	11.9	15.3	5.3	77.7	112.4

Note: excludes vehicles where weight not known.
Source: Vehicle Licensing Statistics, DfT

Further division of the freight vehicle parc can be seen in Table 1.2 below, where fleet size data for the total HGV fleet is given.

Table 1.2 – Fleet size for HGV fleets

Size of goods vehicle fleet (number)	Number of operators (Thousands)	Number of vehicles (Thousands)
0 [1]	13.2	0.0
1	41.3	41.3
2	14.4	28.9
3	6.9	20.9
4	4.3	17.2
5	2.8	14.2
6-10	6.2	47.7
11-20	3.2	46.6
21-50	1.8	57.0
51-100	0.5	31.8
101-500	0.3	46.2
501+	0.0	9.3
Total	**94.9**	**361.1**

1. A zero fleet size occurs where an operator has a licence but does not specify any vehicles on it, for example if vehicles are only required for short periods and are therefore hired in.

Source : Vehicle and Operator Services Agency

[1] Road Freight Statistics 2009, DfT (2009)

Table 1.2 shows that the majority of HGV fleets (95%) have fewer than 10 vehicles. In fact, approximately 50% of operators (45,000) licence only 1 vehicle. Such operators will not be able to justify their own gas refuelling stations, and would have to access another operator's facility by agreement, or make use of the currently limited public refuelling.

At the other end of the spectrum, 300 operators (0.3%) have fleets of over 100 vehicles, but because of the large fleet size these operators account for 15% of all HGV numbers and total some 46,200 vehicles. These vehicles are very likely to practise own-tank diesel refuelling when returning 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. This points to a relatively small number of operators which, if a high proportion adopted natural gas or biomethane, would comprise a significant number of vehicles and fuel usage.

Note that the total number of vehicles shown in Table 1.2 is lower than the total shown in Table 1.1. This may be due to DfT drawing on different agencies for the data.

Gas vehicles are fuelled with either Compressed Natural Gas (CNG) (stored at 200/250bar) or Liquefied Natural Gas (LNG) (stored at -162 deg C), two different forms of a gas largely comprised of methane. Biomethane, a renewable form of gas, can be provided in equivalent forms to CNG and LNG, and used in the same vehicles as natural gas.

There are very low levels of natural gas use in the UK goods vehicle fleets, numbering a few hundred vehicles and less than 20 refuelling stations.

From an analysis of the available data, reports from relevant associations and discussion with stakeholders we estimate that the number of (methane) gas commercial vehicles is a few hundred in number (and no more than 500), with approximately 75% being dual-fuel at this time.

In terms of 'public refuelling' there is currently a network of 9 LNG refuelling stations throughout the UK (close to motorways and operated by Chive Fuels) but current throughput is small and it is used by dual fuel 3 axle articulated vehicles that are of a trial size within existing fleets (i.e. Sainsbury's and Stobart).

Gas compatible models are available across each of the main commercial vehicle types/weights from a small number of manufacturers. Not all vehicle/trailer configurations can be supplied with dedicated or dual-fuel, due to the positioning of tanks, and the range of vehicles at each weight / type is limited, partly due to the low demand. Operators wishing to use a dedicated gas configuration are able to choose from a number of smaller commercial vehicles, heavier rigid chassis vehicles and up to 40 tonne gross vehicle weight (gvw) artic HGV. Dual-fuel tends to be fitted to larger commercial vehicles, generally artic HGV. Biomethane can be used in all vehicles that are designed to run on natural gas (methane), either in dedicated or dual fuel configurations.

Some established operators are therefore using gas vehicles, but it is not an easy choice to make when compared to the lower risk of diesel fuelled operations. Barriers faced by UK HGV operators wishing to use gas include: very low levels of refuelling infrastructure; vehicle supply and servicing issues (a smaller range of OEM vehicles compared to diesel equivalents); weaker residual values compared to diesel vehicles; higher up-front capital costs for both vehicles and refuelling stations; and uncertainty about Government's long-term support for natural gas / biomethane as a road transport fuel.

The benefit of gas vehicle operation can be lower running costs for the operator (through cheaper fuel), and reduced carbon and air pollutant emissions (both NO_x and PM).

Natural gas vehicle technology is well-established and proven in front line operations around the world. There are currently 13.2 million gas vehicles worldwide and 18,700 refuelling stations[2]:

- Some countries have significant proportions of their fleet operating with natural gas, for example Pakistan (35m vehicles / 80% of fleet); Brazil (1.64m / 5%); Argentina (1.9m / 23%) and India (1.1m / 8%)
- In Europe, Italy leads (with 740,000 vehicles / 2% fleet and more than 800 refuelling stations), but there are also significant, and growing numbers in Germany (90,000 vehicles / 900 stations), Sweden (23,000 vehicles / 900 stations) and France (10,000 vehicles / 125 stations).

There is growing interest, and practice, in replacing fossil fuel natural gas with renewable biomethane, produced from organic waste streams. Sweden is particularly active at developing biomethane production facilities and due to the lack of a gas grid structure has focussed on using this for commercial and public service vehicle fuel. In the UK there is small scale biomethane injection into the gas grid (by Thames Water in Didcot) along with one facility producing liquefied biomethane and transporting it by truck to a number of commercial vehicle fleet operators.

The refuelling and vehicle infrastructure requirements for these gaseous fuels have much in common, and vehicles designed for use with CNG (or LNG) can be operated with biomethane equivalents.

1.3 Carbon benefits of biomethane

The principle environmental benefit of biomethane as a vehicle fuel relates to the well-to-wheel (or lifecycle) greenhouse gas reductions compared to fossil fuels. Throughout the lifecycle of biomethane there both emission sources and sinks that balance to create a net reduction in greenhouse gas emissions compared to diesel. Greenhouse gas emissions from the combustion of diesel are avoided when biomethane is used as an alternative fuel source. This is due to biomethane capturing emissions from decomposing organic materials, the CO_2 emitted is considered to be part of the natural carbon cycle and no net increase in greenhouse gas emissions occur.

[2] NGVAE, Gas Vehicles Report (2011)

Biomethane's well-to-tank lifecycle results in far fewer emissions than diesel. Fossil fuel production includes extraction and processing of natural gas, which is avoided in the use of biomethane. Methane abatement takes place during the manufacture of biomethane. Methane from organic waste would typically decompose anaerobically and release methane into the atmosphere. Capturing this methane prevents it from contributing to global warming. This is especially important as methane has a global warming potential 23 times that of carbon dioxide.

Well-to-wheel analysis of automotive fossil fuels and powertrains carried out by CONCAWE[3] identify biomethane produced from municipal waste to achieve GHG savings of approximately 50% compared to conventional fossil fuels. When manure is the feedstock emission savings elevate to over 80%. Several biomethane vehicle trials co-ordinated by CENEX[4] in the UK have encompassed the quantification of lifecycle CO_2 savings. Coca-Cola Enterprises Ltd's trial involved a 26 tonne Iveco Stralis gas vehicle operating on biomethane derived from landfill gas. Well-to-wheel CO_2 savings of 60% compared to a diesel Stralis truck was achieved. Leeds City Council and the London Borough of Camden have undertaken similar biomethane vehicle trials. Lifecycle CO_2 reductions of 49% and 63% respectively were reported.

Overall biomethane has the lowest carbon intensity of road transport fuels. Further environmental credentials include the avoidance of indirect land use changes associated with certain first generation biofuels during the production of biomethane, large reductions in air quality related pollutants notably PM_{10}, $PM_{2.5}$ and NOx and lower noise emissions during vehicle operation.

1.4 Contents of this report

After this brief introduction Chapter 2 of this report contains a description of the methodology used, with the key data inputs from operators and suppliers of vehicles and refuelling infrastructure that form the basis of the cost estimations.

Presentation of key results from the cost modelling follows in Chapter 3, along with a case study and review of current refuelling infrastructure.

Chapter 4 presents the barriers to operating gas HGVs, including significant non-cost barriers, and recommendations on how to address many of these, suggestions on targeted support and a summary of the benefits that could be realised.

Conclusions on the results of the cost modelling and the review of barriers are contained in Chapter 5, together with recommendations on designing incentives that industry would find attractive and workable.

[3] CONCAWE/EUCAR/JRC, Well-to-Wheels analysis of future automotive fossil fuels and powertrains in the European Context (2007/8)

[4] CENEX – Centre of Excellence for Low Carbon and Fuel Cell Technologies - http://www.cenex.co.uk

2. METHODOLOGY

2.1 Overview

The methodology for the study can be broadly described as five related strands:

- Gathering background data from public sources and previous studies.
- Interviews with stakeholders to gather the data required in order for the vehicle and fuelling station costs to be as accurate as possible, and to collect additional information and perspectives on the existing barriers to biomethane use in transport.
- Development of the overall cost model to manipulate these data according to user-defined inputs and produce the results required for the study.
- Use of the model to generate results and demonstrate the:
  - costs involved with the purchase and running of natural gas or biomethane powered vehicles (in both dedicated and dual-fuel configurations) and in comparison with diesel equivalents;
  - costs involved in future years (2015 and 2020);
  - Impact of changing refuelling station size, fuel price and vehicle costs.
- Draw conclusions on the opportunities to kick-start a growing market for gas HGVs.

The key data inputs and findings from the stakeholder interviews are described in each of the sub-sections that follows; these helped build the cost model and form the basis for the Part 1 and subsequent Part 2 report results.

2.2 Stakeholder inputs

A series of interviews were completed with stakeholders that included vehicle manufacturers, vehicle operators, and companies involved in producing fuel and fuelling infrastructure. A significant number of organisations were contacted about the study and telephone contact made on repeated occasions to encourage input to the study. This totalled 12 truck manufacturers, 18 gas vehicle operators, 12 standard vehicle operators and 3 other organisations. In total TTR and JouleVert interviewed the following number of organisations:

- 4 vehicle / dual fuel manufacturers;
- 10 vehicle operators (6 with gas vehicle experience and 4 without);
- 2 commercial vehicle operator representative organisations (FTA and RHA);
- 13 fuel station equipment suppliers (10 provided direct comments); and
- 3 gas fuel suppliers.

The interviews were used to supplement the publicly available data and that from previous studies to ensure the full range of base data needed to build an accurate model. Interviewees were asked to comment on their experiences of gas vehicles (in dedicated and dual fuel configuration), and how they believed that use of these vehicles could be encouraged.

For the vehicle related questions (manufacturers and operators) an interview guide with the questions asked by the interviewers was sent to stakeholders beforehand.

This first set of interviews was carried out with organisations already involved with the use of gas in vehicles in order to get an understanding of the current situation experienced by those who have decided to adopt gas technology already. While these interviewees were best placed to comment on the experiences of gas vehicles in the real world, they were by definition pre-selected to be the early adopters of gas fuelled vehicles in the UK.

An initial default data set was created before interviews took place. Vehicle data for many of the fields was available through the Freight Transport Association (FTA) cost tables, which are collected by quarterly surveys of the FTA members[5]. In addition, we referred to Road Haulage Association data[6], DfT sourced data and Transport Engineer data tables to verify and fill gaps or address anomalies that can arise from FTA survey-based data. This provided a 'default' data set. There were a number of gaps, and these were mostly for gas vehicles and specifically on issues such as maintenance costs, where stakeholders provided information.

The default data set was summarised and provided to stakeholders along with a series of interview questions so they could comment or validate the default data and provide their own data where they had it. This process built up the overall model data set with new information from actual vehicle operation.

The approach did lead to variation in input data, which the study team has then adjusted if significant 'outliers' were found to be producing illogical results.

In order to understand what level of payback might encourage a more general shift to gas powered vehicles, a second set of interviews was undertaken with a sample of vehicle operators drawn from the wider population of goods vehicle operators. These short interviews asked the goods vehicle operators to comment on what level of first-user cost or break-even time (for the additional cost compared to diesel) would convince them to think seriously about converting most of their fleet to run on gas (in dedicated or dual fuel configuration). The analysis of these data will be presented in the Part 2 report.

2.3 Background and baseline data

2.3.1 Vehicle prices

2.3.1.1 New vehicle prices

New vehicle prices have been estimated using the average (mean) price from the available data sources. For standard diesel vehicles FTA cost tables are used. An uplift for dedicated and dual fuel vehicles has been applied (based on previous work

[5] Manager's Guide to Distribution Costs (2010), available to FTA members by subscription
[6] RHA Cost Tables 2010 (2010).

by Cenex) to reach 'default' data for these vehicles. Finally, data from interviewees was added, either where they supplied data for their own vehicles, or where they confirmed the study team's initial cost estimates.

Diesel vehicles are the lowest cost, dual-fuel is somewhat higher (due to additional tanks for gas storage and delivery systems) and dedicated gas vehicles are (with niche engine design and gas storage tanks) generally the most expensive.

Dedicated and dual fuel vehicles cost more than their diesel equivalents in the UK due largely to the lower volume production and additional equipment required. Costs can be £15,000 to £35,000 more, depending on the size of vehicle.

The vehicle prices used in the study are contained in Annex A1.

2.3.1.2 Future vehicle prices

Diesel vehicles

Indications are that the relative price of diesel vehicles will rise in the near-future (around 2015). This is driven by the requirements for Euro VI standards and particularly the emission control elements.

Based on the stakeholder interviews and feedback from LowCVP we have assumed that Euro VI standard diesel HGV will cost 5% more than Euro V standard vehicles.

Attaining Euro VI also risks increasing fuel consumption. All truck manufacturers will be attempting to work around this tendency, but it is thought likely that fuel consumption penalties will apply to some vehicles.

For the cost model we have applied 3% uplift to diesel vehicle consumption for 2015 and 2020 to account for Euro VI changes, and applied a 3% uplift in fuel consumption for the diesel portion of the dual-fuel consumption.

Dedicated and Dual-fuel vehicles

Dedicated gas powered vehicles will not require engine management and exhaust treatment to meet Euro VI standards and for this reason new vehicle prices are not anticipated to increase. Dual fuel vehicles, based on Euro VI diesel vehicles, are assumed to increase in cost in line with diesel vehicles.

In addition, the current premium on dedicated and dual fuel vehicles would reduce if they reach sufficient a market share to move them into mass production. The extent to which these changes will affect the relative prices of the different vehicle types has been explored through the interviews.

For the purposes of the cost model design and reporting we have not applied any reduction in vehicle price for future years 2015 and 2020.

2.3.1.3 First-user life and vehicle residual values

Diesel vehicles

Commercial vehicles are on average kept between 5.1 and 6 years by the first user, according to FTA data (from member survey results). Operators of gas vehicles tend to keep vehicles for slightly longer on average than diesel vehicles, but for the purpose of cost modelling the ownership period of diesel vehicles was used for all vehicles.

In addition to the upfront capital costs, calculations involving the first-user cost of the vehicle must take account of the residual value remaining in the vehicle when an operator has finished using it. The residual value of a vehicle varies with age and mileage, and will also vary quite widely with the state of the second hand market at the time of sale. The values used are averages prices. The vehicle residual values used in the study are contained in Annex A1.

Dedicated (CNG)

Dedicated CNG vehicles are assumed by most operators to have little to no residual value at the moment, as there is a limited second hand market for them in this country. A strategy adopted by some operators is to keep dedicated gas vehicles for longer than their diesel counterparts to help off-set the lack of residual value to some degree. For the cost modelling a uniform first-user life has been applied for a type of vehicle across the three fuel options.

If the demand for gas vehicles grows the residual value of gas vehicles will be strengthened, as gas vehicles become an option considered by a wider range of vehicle operators.

The cost model currently includes the assumption that the residual value of dedicated vehicles in 2015 and 2020 is actually 50% of the residual value of the equivalent diesel vehicle.

Dual-fuel (LNG)

There is currently no strong second user market to make dual-fuel vehicles more valuable than their diesel equivalents. Most operators plan to convert their vehicles back to diesel at the end of service for selling on.

It is possible to remove the dual fuel conversion kit and reuse it on the next vehicle (at around 50% of the normal additional cost). There is not a lot of experience of this practice, and it has therefore not been accounted for in the modeling.

For the cost modeling we have assumed a dual-fuel vehicle has the same residual value as a standard diesel vehicle.

2.3.2 Fuel and refuelling station costs

2.3.2.1 Diesel

Diesel is widely available at public filling stations, bunkered facilities (where commercial operators gain access to bulk fuel priced fuel) and vehicle operators' own refuelling facilities at depots or at partner's facilities.

FTA[7] data on bulk and retail fuel prices as of 1 October 2010 indicate costs as follows:

- bulk (for own-tank dispensing) at 98.10 pence per litre;
- retail at 101.37 pence per litre.

Updated FTA[8] data on bulk and retail fuel prices as of 1 January 2011 indicate costs as follows:

- bulk (for own-tank dispensing) at 105.99 pence per litre;
- retail at 108.85 pence per litre.

It is probably most appropriate to consider retail prices as the operator must add the cost of storage and dispensing on site to bulk price so the difference is partly closed. For the purposes of the cost modelling in 2010 we have used 100 pence per litre as the 2010 cost of diesel.

For diesel vehicles we have assumed the addition of Adblue (for NOx reduction in SCR utilising vehicles) at a rate of 5% of fuel volume, and a cost of 30p/litre.

Estimates of diesel costs in future years are taken from the Department of Energy and Climate Change (DECC) central and high-high estimates, which provide forecasting for 2015 and 2020.

2.3.2.2 Natural gas and biomethane as vehicle fuel

Gas vehicles are fuelled with either Compressed Natural Gas (CNG) (stored at 200/250bar) or Liquefied Natural Gas (LNG) (stored at -162 deg C), two different forms of a gas largely comprised of methane. Biomethane, a renewable form of gas, can be provided in equivalent forms to CNG and LNG, and used in the same vehicles as natural gas.

Natural gas is available via the national gas grid in many parts of the UK. While the grid is dense in urban areas this is not the case elsewhere so refuelling stations need planning appropriately. Two important elements determine site viability – availability of a gas main at the correct pressure (Intermediate or Medium Pressure Main) and 3 phase (11kV) electricity. Should these utilities not be in close proximity then additional costs apply.

The cost of base natural gas in 2010 varied around 55p/therm (approx 25p/kg). For the cost modelling we have used 28p/kg to include an additional 3p/kg to account for

7 FTA Managers Guide to Distribution Costs_vehicle operating costs October 2010 update
8 FTA Managers Guide to Distribution Costs_vehicle operating costs January 2011 update

transport (a charge made by the gas carrier). The future prices for gas are drawn from DECC (central) estimates.

Liquefied natural gas or LNG is natural gas that has been converted temporarily to liquid form for ease of storage or transport. The natural gas is condensed into a liquid by cooling it to approximately −162 °C (−260 °F). The energy density of LNG is 2.4 times greater than that of CNG; this makes it more economical to transport gas in the form of LNG long-distances by ship. LNG is generally then moved over land by road-tanker to the refuelling station, which gives more flexibility over locating the infrastructure. The price of the base LNG gas is generally higher than CNG due to liquefaction, storage at low temperatures and transport.

LNG is available for road distribution from one site in the UK (Avonmouth). This facility is scheduled to close in 2018 due to the expanded use of grid gas and the development of new terminals for the import of LNG (South Wales / Isle of Grain). As yet it is uncertain whether the availability to fill UK road tankers with LNG will exist beyond 2018.

Biomethane (as Liquefied Biomethane Gas, LBG) for vehicle refuelling is currently available from one UK supplier at the Aldbury landfill site. The selling price is currently benchmarked between fossil-based LNG and diesel. The Aldbury site is not located near a gas main and therefore cannot take advantage of recent incentives for grid injection. LBG is transported by tanker to a number of UK customers to use in fleets, which have included Leeds City Council, Coca Cola distribution and Camden Borough Council, and exported to mainland Europe. The RFA Year 2 Annual Report[9] showed that between 15 April 2009 and 14 April 2010 there was 195,797 kg of biomethane supplied under the RTFO. There also is small scale biomethane injection into the gas grid (by Thames Water in Didcot).

There is a high degree of uncertainty over the future pricing of biomethane as a transport fuel. For example, LBG from the Aldbury is being sold at a price somewhere around (or slightly over) the price of LNG, but this does not indicate the price that a producer would necessarily sell it if they had access to other markets.

Currently a producer of biogas could fuel a generator to produce electricity and earn up to 74p/kg of gas used if they can feed into the electricity grid, via renewable power incentives. If the same biogas is destined for road fuel then via the Renewable Transport Fuel Obligation a producer can in theory earn up to 15p/kg on top of the cost of producing biogas and upgrading it, if the certificates have a value at the time. Upgrading the gas to fuel quality (i.e. biomethane) will normally earn the producer less than burning the raw biogas to produce electricity for feeding into the grid. In the UK this is one reason why there is little biogas upgraded to vehicle fuel quality biomethane. More recently, with the Renewable Heat Incentive (RHI), payments for biomethane injected into the gas grid could be as much as 98 p/kg. This then determines the likely selling price of biomethane for use as a vehicle fuel, a value much higher than base natural gas at 28 p/kg (ex VAT).

[9] 24_RFA_verified_report_RTFO_year_two_v1.0.0_0

Gas refuelling station costs

To enable a comparison with diesel price at the pump an important task in the study was to gather cost data for gas refuelling stations of varying sizes, so this could be factored into the cost of gas as a fuel. This was done for stations able to dispense natural gas (or biomethane) in either liquefied or compressed forms.

The study has generated cost tables for three types of gas refuelling station operating at different capacities and therefore suitable for a range of fleet sizes. The three types of station are Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG) and Liquefied Compressed Natural Gas (LCNG).

CNG stations use mains gas as their feedstock so are only limited by the compressor throughput, LNG stations on the other hand are limited by the size of their liquefied storage and pump throughput. LCNG stations are supplied the gas in Liquefied form and therefore can provide either LNG or CNG, but are more expensive than LNG only stations. They are limited by the size of their Liquefied Storage tank and associated deliveries. The cost of fuelling using LCNG has therefore been estimated for information and comparison, but not used in the cost modelling reported to date. The three types of refuelling station are technically able to supply the appropriate variant of biomethane (compressed or liquefied).

The study has drawn on 2010 base gas prices and DECC forecasts on how gas and diesel prices will rise in future years, to enable forecasting forward of base fuel prices.

To the cost of base gas must be added:

- Capital cost of the station
- Day to day operating and maintenance costs
- Operator’s profit (if it is not owned by the user)
- Fuel duty rate

An estimate has also been made and included to account for typical planning requirements, civil engineering, connection to gas main, connection to 3 phase electricity, station design and project management costs.

The fuel station cost modelling drew on previous experience of working in the industry, but took a ‘blank sheet’ approach to ensure the data was driven by up to date inputs from key stakeholders. Confidential cost information was supplied by a number of contacts in the UK gas refuelling industry, and their customers. The data from different sources and covering various aspects of refuelling infrastructure was assembled into costed descriptions of refuelling stations of the three types across a range of capacities. The resulting cost tables were sent to all stakeholders contacted during the study (whether or not they input) to comment and validate. The feedback received validated the accuracy of the results, within the margins of expected variability.

The key conclusion was that gas pricing depends significantly on the throughput of the station itself, as shown in Table 2.3.

Table 2.3 Gas refuelling CNG station costs and fuel price

Station Size (kg/day)	CNG Station Fuel Price (p/kg)	LNG Station Fuel Price (p/kg)	LCNG Station Fuel Price (p/kg)
500	117.15	122.15	143.15
1000	95.15	107.15	120.15
2000	84.15	100.15	113.15
5000	77.15	93.15	106.15
10000	75.15	92.15	101.15

Fuel prices for CNG ‘at the nozzle’ are generally in the band 72 to 114 p/kg before VAT, with a small capacity station supplying considerably more expensive fuel. LNG is in the range 92p/kg to 122p/kg before VAT. Note that the CNG costs include around 10p/kg profit for the station owner, whereas LNG stations include profit in the price of LNG supplied.

It should be noted that the refuelling station costs are estimated taking into account all capital and running costs at full market price, and including payback on capital of 10 years. It shows that large capacity gas refuelling stations of all types can provide fuel at a competitive price to diesel.

A full breakdown of the refuelling station costs and key assumptions are presented in Annex A2.

2.4 Development of the cost model

The cost model combines default (publicly available) data with new data gathered from vehicle operators and manufacturers as part of this study. It includes a refuelling station section, which incorporated the work done on the infrastructure costs.

The cost model allows the user to input vehicle type, lifetime and annual mileage, as well as capital and fuel costs. It also allows both capital and fuel price incentives to be added to the calculations.

The model was built to provide a comparison between a default diesel vehicle and both a dedicated and a dual fuel (diesel/gas) alternative. Using the information gained from the stakeholder interviews and data input by the user the model calculates the first-user cost for each of the three fuel types, as well as the break even time for dedicated or dual fuel vehicles compared to diesel equivalents.

The model also includes the ability to save and load scenarios, and to input a range of vehicles in to a fleet, and then perform calculations on the fleet as a whole. The cost model includes the facility to load incentive scenarios that apply subsidies to one or both of capital (vehicle) costs and fuel prices.

The cost model was produced as an MS Excel file and a short note produced describing its functions and use.

2.5 Assumptions used for reporting

The completed cost model was used to generate the results shown in this report, based on a number of assumptions about vehicles and their operation:

Vehicle replacement costs (new vehicle price):

- Diesel vehicle price as per FTA and other sources modified by stakeholder inputs;
- Gas and dual-fuel vehicles, as per Cenex study and modified by stakeholder inputs.

For details of new vehicle costs see Annex A1.

Vehicle residual values:

- Diesel vehicle values as per FTA and other sources, plus modified by stakeholder inputs;
- Dual-fuel gas vehicle has the same residual as a standard diesel vehicle;
- Dedicated gas vehicle assumed 50% of the residual value as the equivalent diesel vehicle;
- First-user ownership time of between 5 and 7 years, varies by vehicle type, as per FTA data and modified by stakeholder inputs.

Future vehicle costs (in 2010 prices):

- Dedicated gas vehicles price as per 2010 values;
- Diesel new vehicle price increased by 5% for 2015 and 2020;
- Dual-fuel includes diesel vehicle base price increased by 5% for 2015 and 2020;
- Diesel fuel consumption increased by 3% for 2015 and 2020, with rate applied to diesel consumption of dual-fuel;
- No reduction in gas and dual-fuel vehicle purchase price for future years 2015 and 2020.

Fuel:

- Cost modelling in 2010 uses 100 pence per litre for diesel;
- Estimates of fuel costs in future years are taken from the Department of Energy and Climate Change (DECC) (central and high-high) estimates, which provide forecasting for 2015 and 2020 for diesel and base gas;
- For diesel vehicles we have assumed the addition of Adblue (for NO_x reduction in SCR vehicles) at a rate of 5% of fuel volume, and a cost of 30p/litre.

The cost model allows the user to vary the values and therefore assumptions applied to the cost estimates.

3. RESULTS

3.1 Introduction

Results are presented from the cost modelling for the 2010 situation:

- Dedicated gas vehicles first-user total costs and break-even time for vehicle operation, refuelling from CNG station;
- Dual fuel vehicle first-user total costs and break-even time for vehicle operation, refuelling from CNG station;
- Dual fuel vehicle first-user total costs and break-even time for vehicle operation, refuelling from LNG station
- A range of refuelling stations capacities, to understand impact on first-user total costs and break-even time for vehicle operation.

Results are also presented from the cost modelling for the 2015 and 2020 first-user costs and break-even time for vehicle operation taking into account the following factors:

- DECC central prices for diesel and natural gas;
- DECC high-high price estimates for diesel and natural gas;
- Diesel vehicles with increased fuel consumption and additional capital cost, due to Euro VI type approval requirements from 2015.

All costs are based on 2010 prices, i.e. inflation has not been factored into the future scenarios for 2015 and 2020 other than for specific items under consideration (fuel cost and vehicle replacement cost).

The tables of results show the cost of dedicated and dual fuel gas HGVs with the current incentive regime in place (reduced duty on road fuel gas). For each vehicle type the total first-user cost of the vehicle is shown (in £000's) based on the assumed duration of diesel vehicle ownership of between 5.1 and 5.5 years, adjusted to vehicle type.

The tables also include a first-user cost comparison with the equivalent diesel vehicle, shown by a value (in £000's) indicating the difference between the dedicated or dual-fuel vehicle cost and the diesel vehicle cost. The difference in cost is shown next to the total first-user cost (in brackets).

In addition, for each gas vehicle the break-even time in years is shown - this indicates the length of time needed to recover the additional capital cost of the dedicated and dual-fuel gas vehicles over the diesel equivalent. The recovery of upfront costs is achieved, when it happens, through lower refuelling costs. The break-even time takes into account residual values, with assumptions as per section 2.5.

Payback on the capital cost of the gas refuelling station is included in the price of each kg of fuel. A CNG refuelling station is the basis for much the modelling, using the largest modelled capacity (10,000 kg/per day), sufficient for 50 – 100 trucks. A LNG station of the same capacity has also been modelled in some cases, to illustrate the difference in cost. This size of station will provide gas fuel at the lowest price per kg from those modelled, and was chosen to illustrate the cost of gas given large, potentially public, refuelling facilities. It is the most optimistic scenario, but realistic in a growing market (which has been achieved in other countries). Conversely, smaller refuelling stations translate into a higher cost of gas fuel at the nozzle, and higher vehicle operating costs overall.

3.2 First-user costs and break even point for dedicated gas and dual fuel vehicles

Tables 3.1 and 3.2 show a range of vehicle types with costs estimated for dedicated vehicles and relevant dual-fuel gas vehicles types. Table 3.1 shows the model results from a range of dedicated and dual fuel HGVs refuelled from a 10,000 kg / day CNG station. Table 3.2 shows the results from modelling of a 10,000 kg / day LNG station (with dual fuel vehicles) to assess the cost impact of this refuelling option.

Table 3.1 indicates that an HGV operator of average vehicle mileage with access to high capacity, refuelling stations should make a cost saving against an equivalent diesel vehicle for all types of gas vehicle.

The modelling shows that the cost saving varies by vehicle type, and is generally proportionally less for lighter vehicles than for heavier vehicles. Selecting higher annual mileages typically improves the cost saving against the diesel equivalent and quickens the time to break-even.

From Table 3.1 – dedicated gas vehicles – the example of a 7.5 tonne commercial vehicle shows total first-user costs of £111,000 (£7,000 less than diesel equivalent) and a 40 tonne gvw artic tractor unit to incur costs of £369,000 (£40,000 less than diesel equivalent). The difference in cost, compared to diesel equivalent, is clearest when examining the column of values termed break-even time (years), with the lowest times due to the better cost performance of a dedicated gas vehicle over diesel equivalents. In this view it becomes clear that 18 and 26 t gvw rigid vehicles achieve only marginally lower costs than their diesel equivalents under the assumptions used in the modelling.

The dual fuel vehicles, relevant from 32 tonne to 44 tonne types, show a similar pattern in cost saving and beak-even time to dedicated vehicles, but with slightly lower cost savings over their diesel equivalents.

Table 3.1 Dedicated and Dual Fuel vehicles (refuelled from 10,000 kg/day CNG station)

Vehicle Type		Dedicated		Dual Fuel	
Weight	km/year	First-user Cost / (cost difference to diesel) £,000	Break Even Time - years	First-user Cost / (cost difference to diesel) £,000	Break Even Time - years
7.5t	54,730	111(-7)	4.8	N.a.	
18t	88,739	212(-4)	6.6	N.a.	
26t	94,400	270(-6)	6.5	N.a.	
32t	103,854	417(-29)	4.3	436(-10)	3.7
40t	140,582	369(-40)	3.1	391(-18)	3.3
44t	154,455	383(-51)	2.8	406(-28)	2.4

Table 3.2 shows the modelled results of dual fuel vehicles refuelling from LNG stations to show the impact of this option. The costs rise, as would be expected from a higher price per kg at the nozzle for the same capacity station. For a 44 t gvw artic tractor there are only small savings against the diesel equivalent and in some cases higher costs e.g. 40t artic covering 140,582 km p.a. is estimated to cost the average first-user £412,000 (£3,000 more than diesel equivalent) over the average first-user life (around 5.5 years). The break-even time is longer, at 6.1 years, because if the user keeps the vehicle for longer than average they will reach equivalent costs to the diesel vehicle and eventually make savings.

Table 3.2 Dual Fuel (refuelled from 10,000 kg / day LNG station)

Vehicle Type		Dual Fuel	
Weight	Km/year	First-user Cost / (cost difference to diesel) £,000	Break Even Time - years
32t	103,854	454(8)	9.1
40t	140,582	412(3)	6.1
44t	154,455	428(-7)	4.2

The analysis shows that the lowest cost option, if a refuelling station can link to the gas grid, is to use CNG refuelling stations. Whether it is dedicated or dual fuel vehicles that are most cost-effective will be influenced by the assumptions made on residual values and at what point in market development the estimate applies. What is probably more important is whether the vehicle characteristics meet the specific operator's requirement, as both types of vehicle have their advantages in the right circumstances. The key conclusion is that operating the heaviest commercial vehicles on gas can lead to lower costs for an important sector of the UK economy.

The results presented to this point are based on 2010 fuel costs when diesel was averaging 100ppl, and the impact of higher fuel prices is assessed in a later section of the report.

3.2.1 Using biomethane

As noted in the methodology section biomethane for purchase by vehicle operators is currently available from one UK supplier in the form of liquefied biomethane gas (LBG), at a cost similar or slightly higher than of LNG. Therefore, the costs of using biomethane from this supplier will be as per LNG refuelling stations (Table 3.2), in combination with dedicated or dual fuel vehicles.

It is likely, in the current incentive regime, that biomethane purchased from suppliers that can access the gas grid will be at a premium for use in vehicles because of the value to the producer of grid injection. If a premium of 50ppkg or more above the base cost of natural gas is available for grid injection it will cost the same for a vehicle operator to purchase from the same source. This price raises the price of gas sufficiently so that the model predicts a payback time of longer than 10 years, and therefore predicts very little or no uptake of this option.

Note that for all subsequent analysis we consider use of natural gas only, and not biomethane, in order to limit the number of combinations for analysis purposes and remove the need to forecast biomethane prices for use as vehicle fuel.

3.3 Fuelling infrastructure scale and impact on costs

If public infrastructure remains at the current levels then operators who wish to use gas in vehicles will have to install their own refuelling infrastructure or encourage an existing supplier to set up a site to serve them. The capacity of any future infrastructure has a significant effect on the pricing of the fuel provided to vehicles. Economies of scale mean that larger fuelling stations can provide cheaper fuel to an extent that significantly changes the potential payback time and first-user costs of the vehicles. These economies are illustrated in this section of results and analysis.

A range of refuelling station capacities are included in the cost model, from 500 kg/day to 10,000 kg/day. The throughput of the stations can be matched to different sized fleets, for example a small (10 vehicle) rigid truck fleet would utilise a 500 kg . day station whereas a large, 50+ artic vehicle fleet would utilise a 10,000 kg / day capacity station.

The number of vehicles by type/size that are appropriate to match to various capacities of refuelling station is shown in Table 3.3.

Table 3.3 – Filling station capacity for vehicle refuelling

Vehicle Size	Dedicated			Dual Fuel		
	1,000kg/day	5,000kg/day	10,000kg/day	1,000kg/day	5,000kg/day	10,000kg/day
4 Axle Rigid - 32t	11	56	112	19	93	186
2 Axle Combination - 40t	8	41	83	14	69	138
3 Axle Combination - 44t	8	38	76	13	63	126

For the following analysis of refuelling station capacity and its impact on cost a 40t (2 axle) tractor unit has been used as the common vehicle, set up in a dedicated and dual fuel gas configurations (see Table 3.4). The table includes refuelling stations modelled at different capacities for both CNG and LNG formats.

Table 3.4 Refuelling station capacity impact on cost (40t artic vehicle, in dedicated and dual fuel configuration, with CNG and LNG refuelling)

Fuelling Station		Dedicated		Dual Fuel	
Fuel	Capacity (kg/day)	First-user Cost / (cost difference to diesel) £,000	Break Even Time - years	First-user Cost / (cost difference to diesel) £,000	Break Even Time - years
CNG	500	442(33)	> 10	467(58)	> 10
	1000	415(6)	7.2	416(7)	8
	2000	402(-7)	4.3	390(-19)	4.3
	5000	394(-15)	3.5	374(-36)	3.3
	10000	391(-18)	3.3	369(-40)	3.1
LNG	500	448(39)	> 10	479(70)	> 10
	1000	430(21)	> 10	444(35)	> 10
	2000	421(12)	> 10	428(18)	> 10
	5000	413(4)	6.4	411(2)	6.9
	10000	412(3)	6.1	409(0)	6.5

The economies of scale associated with operating a larger refuelling station have a large effect on both the total first-user cost and the time taken to break-even when running dedicated or dual fuel vehicles. The costs of operating dedicated or dual fuel trucks are lowest combined with refuelling from a 10,000kg/day refuelling station (sufficient for 50-100 trucks), with 5,000kg/day stations also returning similarly attractive figures. Reducing the station size to one of 2,000 kg/day or below quickly makes dedicated or dual fuel less attractive in cost terms.

As already noted in the methodology section CNG stations are estimated to be able to provide fuel at a lower cost than LNG, due to the comparably high base cost of LNG supplied. In this analysis we see that high LNG cost feeding through into the higher total operating costs of dedicated and dual fuel vehicles compared to CNG refuelling.

The majority of HGVs are operated in fleets of fewer than 50 vehicles (around 273,000 vehicles in total) and 216,000 vehicles are in fleets of under 20 vehicles. On their own these operators would find it difficult to set-up the largest capacity refuelling and so would not be able to access the longer term cost savings possible from gas and dual-fuel operation. In terms of UK haulage competitiveness this is important, particularly if other countries in Europe are working on gas refuelling infrastructure to support commercial vehicle operations.

The impact on cost of refuelling station scale shows how the lack of a gas infrastructure is a major barrier to widespread gas vehicle uptake beyond the largest fleets. Smaller operators (which make up the majority of the HGV industry) will not be able to afford to operate their own filling stations as the economies of scale put payback time beyond them, even if they operate return to base duties. This analysis indicates a successful strategy could be based on targeting the largest fleets, where economies of scale in refuelling can be realised, but in parallel ensure those facilities can be used by 3rd parties, such as smaller operators and there is public refuelling to cover gaps in availability.

3.4 Impact of future fuel and vehicle prices

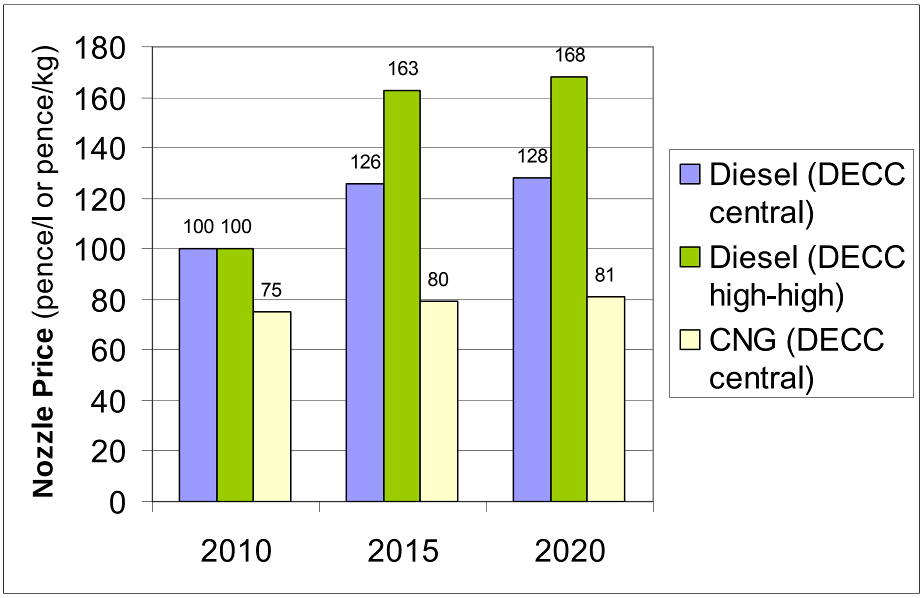
To give a better understanding of how a biomethane for transport economy might develop, the study has investigated the impact of future fuel prices and diesel vehicle capital costs on the first-user costs and pay back time for both dedicated and dual fuel vehicles.

Actual fuel prices were used for diesel and natural gas for 2010. Future fuel price predictions from DECC were used to provide a standard way of predicting future prices in 2015 and 2020. The DECC central estimate was used for both diesel and gas in the main modelling.

Some analysts have reported a disconnect between gas and diesel prices[10] as oil prices rise and therefore a sensitivity analysis has been done showing DECC high-high for diesel combined with DECC central for gas prices.

Figure 3.1 illustrates the potential changes in fuel prices over the coming decade. From the central estimates both diesel and gas rise slowly. For the high-high rates of diesel the price of diesel rises sharply in real terms. The impact this has on the first-user costs and payback times of gas and dual fuel vehicles is shown in Tables 3.5 and 3.6 below.

Figure 3.1 Fuel prices in baseline and future years



In addition, it is anticipated that in future years the price of standard diesel vehicles will increase due to measures required to attain type approval to Euro VI standards (largely for pollutant emissions). An assumption of 5% increase on capital costs has been made and a fuel efficiency penalty of 3% on diesel vehicles.

10 http://www.icis.com/heren/

Table 3.5 shows the total impact of fuel price increases in 2015 and 2020 plus Euro VI driven capital and fuel consumption penalty for diesel vehicles on the first-user costs and break even time of vehicles. For 2015, the impact of rising fuel prices to 126ppl diesel and 80ppkg for gas improves the total first-user costs (and break-even time) for gas and dual fuel vehicles compared to standard diesel. For example, in 2015 a dedicated gas vehicle has some £112,000 lower costs for the first-users compared to diesel (with a total of £376,000). The break-even point in this assessment is shortened to just 1.5 years. This has improved the cost performance compared to the situation in 2010, and at this point more operators will be interested in considering gas vehicle operations.

Table 3.5 Impact of future fuel (DECC central) and Euro VI costs on First-user Cost and Break Even point (40t artic fuel and year)

Vehicle and Year		No Incentives	
Fuel	Year	First-user Cost / (cost difference to diesel) £,000	Break Even Time
Dedicated (CNG)	2010	369(-40)	3.1
	2015	376(-112)	1.5
	2020	380(-114)	1.5
Dual Fuel (CNG)	2010	391(-18)	3.3
	2015	425(-63)	1.3
	2020	429(-66)	1.1

Analysis of applying DECC high-high prices for diesel are shown in Table 3.6, which further increase the cost advantage dedicated and dual fuel vehicles have over standard diesel vehicles in 2015 and 2020.

Table 3.6 Impact of fuel (DECC high-high diesel) and Euro VI costs (40t artic by fuel and year)

Fuelling Station		No Incentives	
Fuel	Year	First-user Cost / (cost difference to diesel) £,000	Break Even Time
Dedicated	2010	369(-40)	3.1
	2015	376(-210)	0.9
	2020	380(-220)	0.9
Dual Fuel	2010	391(-18)	3.3
	2015	468(-118)	0.8
	2020	475(-126)	0.7

This analysis demonstrates the potential impact of rising capital and fuel costs of diesel vehicles, and the corresponding attractiveness of dedicated or dual fuel vehicles. A steeply rising diesel price compared to a gas price that rises only slightly in real terms means that dedicated or dual fuel vehicles would become much more attractive to operators in future years.

In addition, a sharp rise in diesel prices will have the effect of increasing the relative attractiveness of dedicated gas vehicles when compared to dual fuel vehicles, as the additional capital expenditure on a gas vehicle is offset by the increased gas consumption in place of (expensive) diesel.

As previously noted, this cost modelling assumes that large capacity refuelling is in place and accessible to HGV operators.

3.5 Improving supply and cost effectiveness of refuelling infrastructure

3.5.1 Introduction

This sub-section illustrates the cost-effectiveness of specifying larger filling stations with spare capacity (for 3rd party access), outlines issues over 3rd party access and reviews examples of successful deployment. It starts with an illustrative case study of how access to high-capacity refuelling can significantly change the operating costs for smaller HGV operators.

3.5.2 Illustrative case study of small operator constraints

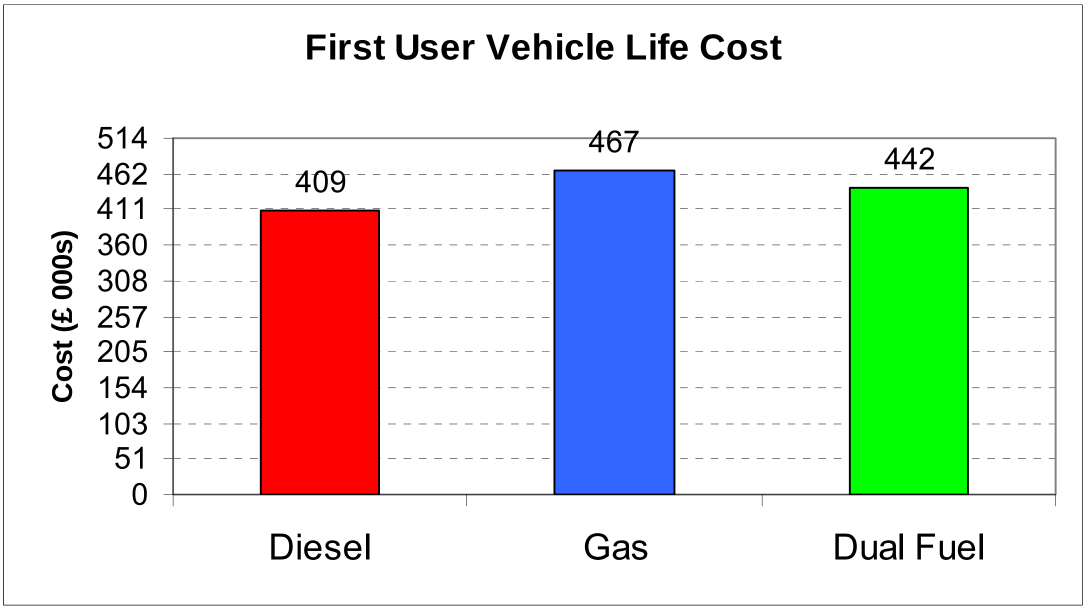
Presented here is a case study to illustrate constraints on a smaller operator from lack of access to high-capacity filling stations.

A small haulage company runs five 40 tonne gvw artic HGVs that each travel 140,582 km/year. They are able to return to base each day. Generally they refuel with diesel at a bunker depot near their base for a lower price than at forecourt prices, which they also use as a back-up. They will keep their vehicles for 5 to 6 years.

The company would like to use gas in either dedicated or dual fuel vehicles, and have considered installing a small station providing 500kg of fuel per day, which is sufficient to fuel their 5 trucks.

The first-user cost per vehicle without incentives is shown in Figure 3.2 below.

Figure 3.2 – First-user total costs for 40t artic HGV with 500kg/day CNG station



The total cost of switching to gas or dual fuel operations for this operator would be significant at some £58,000 more than the diesel equivalent vehicle. The initial capital cost of the gas or dual fuel vehicles would be significantly more expensive, and the fuel cost from a small station would account for the remaining difference in costs. This suggests a need to access high-capacity gas refilling stations in order to achieve an economically viable price per kg.

Figure 3.3 below shows the same operator in a position to access a 10,000 kg/day station. They are able to reduce their overall operating costs by choosing a dedicated or dual fuel gas vehicle over the diesel equivalent.

Figure 3.3 – First-user total costs for 40t artic HGV with 10,000 kg/day CNG station

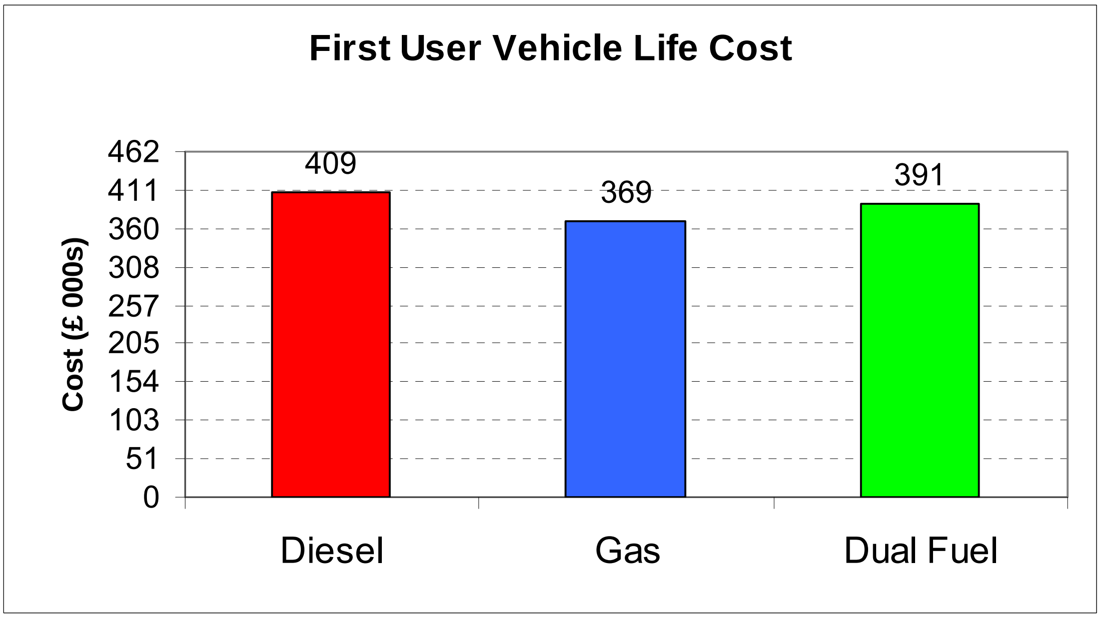
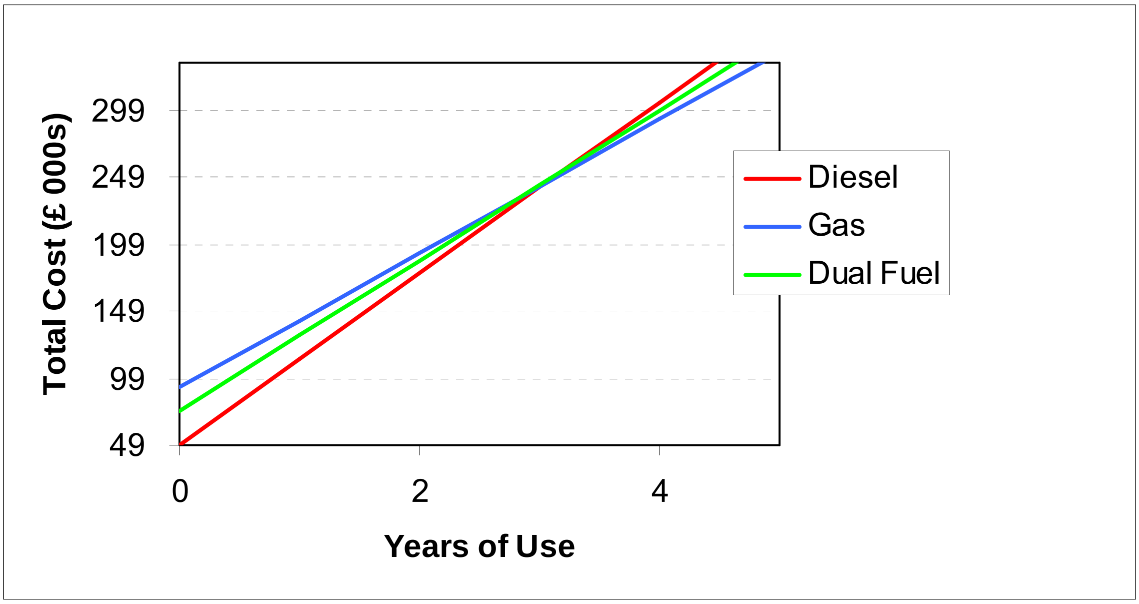


Figure 3.4 shows the break-even time (to payback the additional costs over the diesel equivalent) as between 3 and 4 years.

Figure 3.4 – Break-even point for dual fuel and dedicated vehicles (10000kg/day station) vs. diesel vehicle



Although the vehicles return to base frequently enough that the operator could run them on gas from a private fuelling facility, with only five vehicles it is impossible to realise the economies of scale necessary to make a private station economically viable. To persuade this operator to consider gas vehicles they would need the certainty of an accessible gas filling station infrastructure. Facilitating a greater number of high capacity filling stations with public or pre-arranged third-party access would enable more operators to reduce their operating costs.

3.5.3 Factors affecting cost effectiveness of stations

Any station build will incur basic costs regardless of size. These include surveys, planning applications, assessing local gas and electricity access and access suitability. These costs will be incurred regardless of size of the finished refuelling station.

For the end 'through the nozzle' price to be as low as possible a large CNG station connected to the gas grid can ensure continued supply at high throughputs and thus lowest pricing. Large capacity stations can afford to be built with back-up systems and redundancy, to manage break-downs better. This replicates what has happened in the liquid fuel markets, where higher throughputs per site have been the only way to profitability.

LNG stations can offer low fuel costs but it is worth noting that it requires road tanker distribution to replenish them. Plus the carbon savings are not as effective as a gas grid linked CNG facility because the carbon cost of distributing the fuel by tanker mitigates some of the inherent carbon benefits of the fuel itself.

Currently, the only UK produced biomethane for road vehicle use is supplied in liquefied form (equivalent to LNG). This form of production may be repeated by other facilities that follow if there are stranded assets that are too remote from the gas grid and cannot produce and export electricity locally. However, in the growing biomethane industry the dominant form of biomethane is likely to be compressed gas, for distribution through the existing gas grid.

Given that trucks offer the largest fuel usage potential for CNG/biomethane (closely followed by vans) it is quickly evident that focussing on locations from which multiple haulage companies operate - e.g. such as a facility at Daventry International Rail Freight Terminal (DIRFT), a rail port and logistics centre located near Rugby - would allow for a single large centralised station to be built and to be utilised by numerous haulage operators. This in turn would offer the lowest price fuel while guaranteeing the most reliable stations with associated redundancy/backup.

3.5.4 Examples of successful refuelling station deployment

It is quite difficult to give examples of successful deployment in this country as there are relatively few HGVs operating on gas. The recently curtailed Infrastructure Grant Programme enabled a number of hauliers to install refuelling stations for up to 10 trucks so they could assess the potential at half the outline cost (grants were in the order of 50%). The cessation of these grants has once again meant that investment has stopped.

The largest station that allows for third party access is the Hardstaff station at Gotham in Leicestershire. This station can supply both LNG and CNG. It was installed principally to fuel the in-house Hardstaff vehicles, converted using the Hardstaff OIGO dual fuel system. This system has been sold to other local hauliers and so their trucks have been using the Hardstaff depot to refuel (an example of third party access agreements). Certain local hauliers have installed refuelling stations (under Hardstaff guidance) as their fleet conversions have grown and these in turn also allow third party access.

The other successful deployment is the LNG refuelling stations operated by Chive Fuels. Chive Fuels have installed 9 LNG refuelling stations at Motorway services or close to truck stops. In the late 90's there were more natural gas HGVs on the road that used these facilities but with the withdrawal of the OEMs from the market when purchase support grants ceased in the early 2000s the viability of these stations has meant that Chive have mothballed about half of them. However, with the re-emergence of OEM product in the last two years, hauliers have started to order trucks in small batches to trial them and the Chive network allows them to do so cost effectively. Companies such as Sainsbury's (10 vehicles) and Stobarts (6 vehicles) have been using the Chive stations at Oust (Severn Bridge), Castleford, and Flamstead (M1Junct 9). These stations have also allowed for some second user operation of the older vehicles which has helped residual values.

3.5.5 Third party access

There are a number of issues that can arise when trying to widen access to a single HGV operator's site that can be a barrier to third party access, such as:

- Restrictions on vehicle movements on and off the site;
- Restrictions on night time movements;
- Restrictions due to site security i.e. bonded warehouses such as tobacco or alcohol storage;
- Restriction due to HazChem regulations i.e. refineries and fuel distribution depots;
- Simple unwillingness by operators to have other visiting operators on site.

An example of this was the original Safeway CNG refuelling facility at Welwyn Garden City (WGC), which was unable to grant third party access because it was a bonded warehouse. Thus a smaller station was installed just to provide facilities for the truck operating at the site. By contrast, the Safeway site at Aylesford had space to allow access and was a general site so a station some 3 times the size of WGC was installed with associated economic benefits.

3.5.6 Other considerations

In the traditional 'heating' market use of gas changes significantly between summer and winter. In comparison, haulage is a 24/7 operation, and thus gas use is more consistent year round which makes it potentially attractive to gas suppliers who can supply for a consistent market demand.

Consideration should be given to the mode of operation of large haulage fleets. They typically return to base late afternoon and require refuelling one after another. Unless a large compressor station is specified the refuelling cannot cope with such a peak in demand. Therefore, the large multi compressor stations are needed to pull gas from the grid and put it straight into the vehicle (the banks of storage cylinders are there solely as maintenance time back up).

Finally, the difference in cost between a 10 truck a day unit to a 50+ truck a day unit is 20p/kg (before VAT), whilst the capital cost is only 3 times as much but with much better reliability and fill times.

4. BARRIERS AND INCENTIVE SCHEMES

4.1 Barriers to be addressed

Interviews with stakeholders confirmed a range of factors that are barriers and will influence the take up of dedicated or dual fuel vehicles for use with natural gas and biomethane. Barriers include those on the demand side and supply-side, both financial and non-financial. These are summarised here.

- Infrastructure

A major factor influencing take up of biomethane vehicles is the availability of widespread refuelling facilities for dedicated and dual fuel vehicles. Without 3rd party or public access to large capacity refuelling many operators face high running costs from smaller private infrastructure. This makes gas less competitive as a fuel compared to diesel. In addition, it excludes certain fleets from using gas at all, if they work away from their base.

There are two sub-factors of particular importance related to infrastructure:

- Fleet size

  The price of private refuelling stations does not increase linearly with the number of vehicles supplied – there are economies of scale that mean gas can be competitive as a road fuel for an operator with a large fleet, but extremely uncompetitive for a smaller operator with low capacity requirements. The options for a smaller operator are then to use the small number of public refuelling stations (along the M1 Motorway) or secure access to another operator's facility, of which there are only a few.

- Return to base frequency

  Whether a vehicle returns to base during its duty is vitally important in determining if it might be easily replaced with a gas vehicle. Whilst there is little public fuelling infrastructure operators are reliant on their own private station, and if a vehicle's duty cycle takes it away from base for several days in a row, it will either run dry (if dedicated) or revert to running purely on diesel (if dual fuel), neither of which are desirable outcomes.

- Supply and servicing of gas vehicles

Gas fuelled vehicles are operated in their many millions world-wide, however there are currently only a few hundred in the UK. This makes them a niche choice, which limits the range of vehicles available from OEM and impacts on the type of operations that can reasonably use them.

For example, major haulage contracts are invariably operated to very high specification and challenging criteria. Many contracts require the operator to meet demanding delivery windows. Some companies practice 24 servicing and maintenance to reduce down-time for vehicles and value reliable vehicles over other considerations. In these circumstances there is a requirement for very reliable vehicles that can be supported by mechanics at any time of day or night, and whatever the vehicle's location. Such a service is not currently available for gas vehicles due to their more specialist nature, and would not be practicable until a sufficient market for repair/servicing had developed. As a larger market developed then repair/serving operations would follow, and the choice of OEM products would continue to grow.

- Short-termism in an industry under pressure

Several stakeholders remarked that goods vehicle operators could not currently take the longer term view and consider whole vehicle life costs, when the industry is under such pressure. For many goods vehicle operators the break even time on dedicated or dual fuel vehicle is critical, and minimising this time as much as possible was uppermost in their thinking, before considering how much could be saved over a vehicle lifetime. There needs to be a considerable amount of confidence that other barriers are being addressed for this risk-aversion to be overcome and investment made that can deliver longer-term savings.

- Uncertainty about fuel incentives

Current duty derogation on natural gas and biomethane is set at a rolling three year horizon. Given that it can take 12-18 months to build a refuelling station there is a risk that an operator only has 18 months of operation. The desire for a 5 years minimum guarantee on fuel duty incentives was clear from stakeholder interviews. However, a longer (15 or 20 year) horizon would be preferable, and Germany and Italy were cited as examples of countries with longer guaranteed periods. Removing all fuel duty for natural gas and biomethane until 2020 would be a strong incentive and bring it into line with zero duty on electricity and hydrogen fuels. This would be within the scope of the Government without the need to gain State Aid approval.

- Financing

Access to capital is proving difficult for many commercial companies, and this is affecting the investment bus, HGV and other transport operators are making in their fleets.

There will be a difference in attitudes between an operator who buys his trucks and one who leases them. The major fleets are generally leasing and the 'second' user tends to buy, but for gas vehicles major fleets sometimes make arrangements to purchase or lease for longer in order to achieve pay-back in their (extended) ownership.

Uncertainty over the future market for gas vehicles means that residual values can be weak and this affects both the cost of operation for the first-user and the ability (and cost) of dealing with leasing companies.

- Availability of biomethane

The above factors are the most prominent issues affecting the take up of gas vehicles, and by extension the use of biomethane in vehicles. However, even given a widespread acceptance and market penetration of vehicles capable of running on gas fuel, it is by no means guaranteed that there will be a similar rise in the take up of biomethane. Currently, incentives in other sectors are anticipated to draw the majority of biomethane away from transport use, except in the case of specific facilities where selling into the transport market is the best alternative.

Feedback from stakeholders was of a wish to use biomethane, but to ensure certainty all their preparation and planning was based on natural gas due to the greater reliability of supply.

Within the current incentives regime biomethane will continue to be sold at a premium, largely influenced by incentives in other sectors (rather than production costs of biomethane). This needs addressing if the transport sector is to benefit from this low-carbon fuel and it falls within the remit of incentive design to direct where the biomethane is used.

4.2 Incentive schemes

The strongest message from the stakeholders interviewed was that provision of a public refuelling infrastructure would have the greatest effect on take up of gas as a transport fuel to enable out-based fleets to refuel. It should be noted that the stakeholders interviewed were from the own-account and haulage industries (as per the project objectives), rather than local authorities whose fleets tend to be return-to-base operations.

It was also remarked that incentivising vehicle manufacturers/fuel producers was not the best way to spend resource. One interviewee offered the view that buying a vehicle got you a single vehicle lifetime of emission reductions, but putting in place the infrastructure to make gas vehicles attractive had much further reaching benefits.

Growing the market in a limited way could be achieved by targeting larger operators (who can support large refuelling stations alone). However, a healthy market will need to involve second-users of dedicated and dual-fuel vehicles. Therefore, issues of public/third-party access to refuelling will need addressing for long-term success.

The positive impact on costs from accessing high capacity filling stations can be seen in the cost modelling results chapter of this report.

By way of further illustration we can consider a £ spent on increasing the capacity of a refuelling station compared to subsidising vehicle purchases, see Box 1:

Box 1 – Benefit of funding refuelling infrastructure vs. subsidy of vehicles

Cost of equipment and civils for a 10,000 kg/day station is £840,000, compared to £260,000 for a 1,000 kg/day station, but the gas is 20 pence per kg lower cost. This 20 p/kg cost saving can be delivered at a rate of 10,000 kg per day (£2,000 saving) which totals some £730,000 per year. This has equalled the additional capital investment in the larger station of £580,000 within the first year, and will continue for up to 10 years on average.

The impact of a 10,000 kg/day station over a 1,000 kg/day station is (as seen in table 3.1) to shift a dedicated gas HGV from having £7,000 additional costs compared to the diesel equivalent vehicle to having £40,000 lower costs for the first-user (a period of about 5 years). If the additional refuelling station costs would have been used to subsidise vehicles to achieve this same impact (reducing costs by £47,000) then approximately 12 trucks would benefit. In comparison, a 10,000 kg/day refuelling station will benefit between 50 and 75 trucks of the same size.

The industry as a whole prefers easily legislated incentives that are within the domain of the national Government. In addition, the industry needs a long term position to be taken by Government to allow for the necessary investments to take place.

A more streamlined approach is to put in place incentives that encourage use of gas (and therefore interest in filling stations) and that are also within the control of UK Government (Treasury). Examples of such policies that do not require EU approval would be:

- Long term fuel duty incentive for both natural gas and biomethane as road transport fuel – preferably zero rated to 2020 (as is given to electricity and hydrogen);
- 100% first year capital allowance on the on cost of natural gas/biomethane vehicles;
- 100% first year capital allowance on the on cost of refuelling stations;
- Reduced VED rates for natural gas/biomethane vehicles;
- Green gas certificates to allow for book and claim system for biomethane gas grid injection.

As natural gas/biomethane vehicles deliver CO_2 and pollutant emission reductions local incentives are appropriate, such as:

- Zero congestion charging;
- Access to low emission zones;
- Planning approval preferences where natural gas /biomethane vehicles are used or stations provided for their use;
- Preferential parking/delivery rights;
- Night time delivery restrictions reconsidered for natural bas /biomethane vehicles due to lower noise levels, as an important component of an overall quiet delivery package.

Grant funding filling stations is another route to providing financial support for refuelling infrastructure. This is however is more challenging to adopt and this needs to be addressed in any future strategy.

EU state aid approvals needed for grant funding stations or vehicles have significant drawbacks:

- Takes about 18 months to go through the approval process within the EC;
- Limits the amount given to any operator (via restrictions on funding allowable to SME/Corporations);
- Is time constrained to any one tax year;
- Budget awarded on first come, first served basis.

The process of grant funding once agreed by the EC is still problematic for operators:

- Grant funding that requires extensive paperwork delays speed of investment;
- Grants that are restricted to a single tax year (April to March) restrict investment when:
    - o there are long vehicle lead times (up to 6 months);
    - o it takes up to 18 months for the building of a refuelling station[11].

[11] This is confirmed by a number of stations that could not be built in time to secure the IGP grant and thus have not been built (e.g. Sheffield).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of cost modelling results

5.1.1 First user total costs and break even time for dedicated and dual fuel vehicles using LNG and CNG stations at 2010 costs

The modelling indicates that with average vehicle duties and access to large capacity CNG refuelling stations an HGV operator should make a cost saving against an equivalent diesel vehicle within the first-user lifetime of the vehicle. This would be for all types of gas vehicle (whether dedicated or dual fuel) and for all weights modelled. Depending on vehicle type cost savings for the first-user range between £7,000 and £51,000 compared to the diesel equivalent at 2010 prices. This means a break-even time for paying back the additional capital cost of the vehicle compared to diesel operation of between 2.8 and 6.6 years.

The modelling shows that the cost saving varies by vehicle, and is generally proportionally less for lighter vehicles than for heavier vehicles. Heavier HGV typically cover more miles and undertaking higher annual mileages improves the cost saving against the diesel equivalent and quickens the time to break-even.

Refuelling with LNG is not as cost-effective as CNG, due to the higher base cost of LNG supplied to the station. The modelling indicates there are fewer opportunities to make a cost saving compared to diesel operation: to do so requires the heaviest trucks undertaking very high mileages. However, CNG stations need to be sited near the gas grid so there are advantages to LNG refuelling stations in specific circumstances.

When comparing dedicated with dual fuel vehicles to understand which are most cost-effective it should be noted that the outcome is strongly influenced by the assumptions made on residual values and for what point in market development the estimate is made. What is probably more important is whether the vehicle characteristics meet the specific operator’s requirements, as both types of vehicle have their advantages in the right circumstances. The key conclusion is that operating the heaviest commercial vehicles on gas can reduce total vehicle costs for an important sector of the UK economy.

The capacity of any future infrastructure has a significant effect on the pricing of the fuel provided to vehicles. Economies of scale mean that larger fuelling stations can provide cheaper fuel, to the extent that it significantly changes the potential payback time and first-user costs of the vehicles.

The cost of operating dedicated or dual fuel truck are most attractive where operators can access a 10,000kg/day refuelling station (sufficient for 50-100 trucks), with 5,000kg/day stations also returning similarly attractive values. Reducing the station size to one of 2,000 kg/day or below quickly makes dedicated or dual fuel less attractive, and the cost of operating dedicated or dual-fuel vehicles exceed their diesel equivalents.

Approximately 50% of the 413,000 of trucks and vans in the UK are operated in fleets of fewer than 50 vehicles. Smaller operators (which form a significant part of the HGV industry) cannot afford to operate gas vehicles using small capacity filling stations as the economies of scale put payback time beyond them, even if they operate return to base duties. On their own these operators cannot justify the largest capacity refuelling stations and so are not able to access the longer term cost savings possible from dedicated and dual-fuel gas operation. This demonstrates the benefit of making large refuelling available to fleet operators.

The impact on cost of increased refuelling station scale shows how the lack of a gas infrastructure is a major barrier to widespread gas vehicle uptake beyond the largest fleets. In terms of UK haulage competitiveness this is important, particularly if other countries in Europe are working on gas refuelling infrastructure to support commercial vehicle operations.

5.1.2 Cost modelling for the 2015 and 2020 first-user costs and break-even time for vehicle operation taking into account future fuel prices

Rising diesel vehicle and fuel costs make dedicated and dual fuel increasingly attractive only with the modelled assumption that refuelling infrastructure is available and accessible. In reality there will continue to be non-cost barriers in place that will suppress this outcome, unless they are addressed.

In 2015, for example, the impact of higher fuel prices of 126ppl diesel and 80ppkg for gas reduces the total first-user costs (and break-even time) for gas and dual fuel vehicles compared to standard diesel quite considerably.

5.2 Summary of barriers and incentives

There are a number of barriers that suppress demand for gas vehicles (able to use natural gas or biomethane) even if the cost-performance may be better than for diesel equivalents. The primary factor is the lack of refuelling infrastructure which has tended to encourage installation of small capacity stations (for small/pilot fleets) which are by their nature less economical than high-capacity stations. Other barriers include:

- Supply and servicing of what are niche vehicles in the UK (despite millions being operated worldwide);
- Short termism in an industry under pressure;
- Uncertainty in industry over Government's long-term position on gas as a road fuel;
- Financing vehicles and refuelling stations;
- Availability of biomethane.

The industry as a whole prefers easily legislated incentives that are within the domain of the national Government, and a long term position to allow for the necessary investments to take place. Examples of such policies include:

- Long term fuel duty incentive for both natural gas and biomethane as road transport fuel;
- 100% first year capital allowance on the on cost of natural gas/biomethane vehicles and of refuelling stations;
- Reduced VED rates for natural gas/biomethane vehicles;
- Green gas certificates to allow for book and claim system after biomethane gas grid injection.
- Congestion charging exempt;
- Low emission zone restrictions;
- Night time delivery restrictions due to lower noise levels

5.3 Recommendations for market development

To grow the gas vehicle market the following factors are important:

- Large capacity refuelling stations are crucial, ideally in CNG configuration linked to the gas grid to achieve lowest fuel costs and tap into the growing biomethane content.
- Ensure the cost benefits of gas operation are not just for the largest fleets. 3rd party access to private sites and/or encouraging investors to open commercial vehicle refuelling stations with public access will be vital. This will also help support a second user market.

To ensure that a growing gas vehicle market can access biomethane for fuel:

- A harmonisation of incentives on offer for biomethane should address the likely price premium required of vehicle operators to purchase fuel from suppliers who can achieve a high value from grid injection.
- A certificate trading scheme could be used to encourage biomethane as vehicle fuel if there is more biomethane in the gas grid due to incentives (via the RHI), perhaps facilitating a market for blends of natural gas and biomethane (as per biodiesel).
- Some biomethane producers, distant from the gas grid or abstracting otherwise waste gas from landfill, will choose the option of liquefaction for clean-up and / or transport reasons and make direct sales to vehicle operators, although this is likely to be a smaller part of the market.

Taking into account the collective opinions of stakeholders, and the barriers discussed above, we recommend that to encourage biomethane as a transport fuel in the UK the development of the infrastructure for own-depot fuelling and in public refuelling stations should be prioritised. The short term advantages would be to reduce the effective price seen by all operators. Smaller operators would no longer need their own private stations, and this would enable vehicles that do not return to base every day to operate on gas. A second-user market for gas vehicles would be sustainable and lead to firmer residual prices, enabling new vehicles to be purchased more easily.

Annexes

A1 INPUT DATA – VEHICLE COSTS

Table A1.1 – Vehicle replacement (new) price

Vehicle type and fuel	*Diesel*	*Dedicated*	*Dual-fuel*
Lighter 2 axle rigid – 7.5 Tes	£34,749	£50,142	£50,142
Heavier 2 axle rigid – 18 Tes	£53,790	£79,188	£73,588
3 axle rigid – 26 Tes	£66,746	£92,895	£86,795
4 axle rigid – 32 Tes	£84,642	£113,979	£104,644
2 axle tractor unit – 40 Tes (in combination)	£63,094	£98,939	£89,272
3 axle tractor unit – 44 Tes (in combination).	£73,303	£109,437	£96,964

Table A1.2 – Vehicle residual value at time average first-user sells on (5 – 7 years, varies by type of vehicle)

Vehicle type and fuel	**Price**
Diesel	
Lighter 2 axle rigid – 7.5 Tes	£11,440
Heavier 2 axle rigid – 18 Tes	£20,329
3 axle rigid – 26 Tes	£25,512
4 axle rigid – 32 Tes	£32,095
2 axle tractor unit – 40 Tes (in combination)	£14,092
3 axle tractor unit – 44 Tes (in combination).	£17,808

A2 INPUT DATA – REFUELLING STATION COSTS

Table A2.1 CNG station costs and fuel price

If station payback is over 10 years then the following table gives today's 'through the nozzle' cost

Station Size (kg/day)	Ave Capital Cost	Est. Civils etc[1]	Base NG delivered[4] Price/kg	Capital payback (p/kg)	Fixed Opex[3] (p/kg)	Operator's Margin (p/kg)	Fuel Duty (p/kg)	Fuel Price (p/kg)
500	£160,000	£50,000	28	27	24	12	26.15	117.15
1000	£200,000	£60,000	28	17	14	10	26.15	95.15
2000	£250,000	£80,000	28	11	10	9	26.15	84.15
5000[5]	£350,000	£120,000	28	7	8	8	26.15	77.15
10000[6]	£700,000	£140,000	28	6	7	8	26.15	75.15

[1] – Includes approx planning costs, connection to close proximity gas main (where applicable), 3 phase electricity on site connection and civils/foundation construction.
[3] – Includes electricity usage, compressor and ancillary equipment servicing, emergency breakdown cover, cylinder re-evaluation (every 10 years)
[4] – NG price based on 55p/therm divided by 2.217 to get to kg plus 3ppkg gas transportation costs through gas main
[5] – Contains extra storage to cater for faster refuelling times
[6] – Contains extra storage and extra compressor to cater for faster refuelling times and redundancy

Table A2.2 LNG station costs and fuel price

If station payback is over 10 years then the following table gives today's 'through the nozzle' cost

Station Size (kg/day)	Ave Capital Cost	Est. Civils etc[1]	Base LNG delivered Price/kg[2]	Capital payback (p/kg)	Fixed Opex[3] (p/kg)	Fuel Duty (p/kg)	Fuel Price (p/kg)
500	£73,000	£10,000	70	11	15	26.15	122.15
1000	£93,000	£12,000	65	7	9	26.15	107.15
2000	£190,000	£20,000	62	7	5	26.15	100.15
5000[7]	£260,000	£30,000	60	4	3	26.15	93.15
10000[8]	£350,000	£40,000	60	3	3	26.15	92.15

[1] – Includes approx planning costs, connection to close proximity gas main (where applicable), 3 phase electricity on site connection and civils/foundation construction.
[2] – LNG price based on NG Therm price of 55p/therm plus 27p/therm liquefaction costs divided by 2.217 to get to kg plus transport costs plus suppliers profit
[3] – Includes electricity usage, cryogenic pump and ancillary equipment servicing, and emergency breakdown cover
[7] – Contains two medium sized storage tanks and extra dispenser
[8] – Contains two large sized storage tanks and two extra dispensers

Table A2.3 LCNG station costs and fuel price

If station payback is over 10 years then the following table gives today's 'through the nozzle' cost

Station Size (kg/day)	Ave Capital Cost	Est. Civils etc[1]	Base LNG delivered Price/kg[2]	Capital payback (p/kg)	Fixed Opex[3] (p/kg)	Fuel Duty (p/kg)	Fuel Price (p/kg)
500	£150,000	£30,000	70	23	24	26.15	143.15
1000	£200,000	£30,000	65	15	14	26.15	120.15
2000	£350,000	£60,000	62	13	12	26.15	113.15
5000	£500,000	£100,000	60	8	12	26.15	106.15
10000	£800,000	£120,000	60	6	9	26.15	101.15

[1] – Includes approx planning costs, connection to close proximity gas main (where applicable), 3 phase electricity on site connection and civils/foundation construction.
[2] – LNG price based on NG Therm price of 55p/therm plus 27p/therm liquefaction costs divided by 2.217 to get to kg plus transport costs plus suppliers profit
[3] – Includes electricity usage, cryogenic pump and ancillary equipment servicing, emergency breakdown cover, cylinder re-evaluation (every 10 years)