Independent, not-for-profit, low emission vehicle and energy for transport experts

Options Report

A report in part requirement of the LoCITY Technical Research on Alternative Fuels and Retro-fit Equipment Project

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Contents

Table of Abbreviations

AQ	Air quality
BEV	Battery electric vehicle
CCZ	Congestion charge zone
CI	Compression ignition
DEFRA	Department for Environment and Rural Affairs
EV	Electric vehicle
FAME	Fatty acid methyl ester
FC-REEV	Fuel cell range extended electric vehicle
GTL	Gas-to-liquid
GVW	Gross vehicle weight
H_2	Hydrogen
HEV	Hybrid electric vehicle
HVO	Hydrogenated vegetable oil
LNG	Liquefied natural gas
LPG	Liquified petroleum gas
LowCVP	Low Carbon Vehicle Partnership
NO_2	Nitrogen dioxide
N_2O	Nitrous oxide
OEM	Original equipment manufacturer
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate matter
RCV	Refuse collection vehicle
REEV	Range Extended Electric Vehicle
RTFO	Renewable transport fuel obligation
SCR	Selective catalytic reduction
SI	Spark ignition
SUV	Sports utility vehicle
TTW	Tank-to-wheel
WLC	Whole life cost
WTW	Well-to-wheel

1 Executive Summary

Cenex was commissioned by the LoCITY programme to undertake technical research on the financial and environmental benefits of alternative fuels and retrofit equipment for commercial vehicles. The scope of the study was limited to equipment that provides motive power. Based on this research Cenex developed an Excel calculator tool (the LoCITY Fleet Advice Tool) which allows a user to understand the cost impact and emission benefits of operating low emission commercial vehicles over a range of operating conditions and duty cycles.

This report draws on research undertaken by Cenex during the project, and uses the cost and emissions calculator Tool developed as part of the research to highlight areas where different low emission vehicles can offer operators financial and environmental savings. The LoCITY Fleet Advice Tool is due to be launched as an interactive website in 2018 Q1.

Information on technology status was received between January and March 2017, any changes to technology status post March 2017 has not been captured in this report.

1.1 Technologies Reviewed

Technologies available in the UK were split into two groups (in-scope and out-of-scope) as presented in the table below. Technologies meeting Euro VI/6 emission standards, capable of evidencing operational experience (fleet testimonials for real-world reliability and performance from at least two operators) and capable of operating at similar costs to a diesel truck were in-scope, and eligible for inclusion in the LoCITY Fleet Advice Tool. The main UK low emission technologies and their status on inclusion eligibility is shown below in Table 1.

Table 1 – Technology inclusion eligibility

Technology Status Key E = Emission Test Data Not Available or Insufficient O = Operational Data Not Available or Insufficient	
Out-of-Scope Technologies In Development or Insufficient Evidence Base (status)	In-Scope Technologies Technology Inclusion (evidence)
Dual-fuel methane (E) **Dual-fuel vegetable oil** (E) **Dual-fuel diesel/H2** (E, O) **Capacitor hybrid** (E, O) **Hydraulic hybrid** (E, O) **On-board H2 generator** (E) **Range Extended Electric Vehicle** (REEV) (O)	**Hydrogen Fuel Cell Range Extended** Electric Vehicle (H_2 FC REEV) (Zero emission)– information pending **Electric Vehicle (EV or BEV)** (Zero emission) **Hybrid (non-plug in) Electric Vehicle (HEV)** (Euro VI certified) **Plug-in Hybrid Electric Vehicle (PHEV)** (Euro VI certified) **Dedicated gas** (Euro VI certified) **Dedicated LPG** (Independent emission tests) **Dual-fuel LPG** (LowCVP emission test) **Biodiesel B20 FAME** (LowCVP emission test)

This report focuses mainly on in-scope technologies, which are included within the Tool.

1.2 Emission Performance

The environmental performance of the in-scope technologies is shown in Table 2. The performance is classified into three groups:

- **Tailpipe emissions**: these represent the emissions of CO_2 emitted directly from the tailpipe of the vehicle[1]
- **Scope 1 emissions**: (also known as **tank-to-wheel (TTW)** emissions), these are the emissions which a transport operator is responsible for under UK Greenhouse Gas Reporting Guidance [2]
- **All scope emissions**: (also known as **well-to-wheel (WTW)** emissions), these represent a complete picture of the carbon intensity of a fuel supply chain, and provide a more holistic view

of the environmental impact of a fuel choice. These emissions include fuel extraction, processing, transportation, dispensing and final combustion.

The performance is shown in terms of % savings from a diesel Euro 6/VI comparator diesel. Where available, DEFRA[2] CO_2 emission factors have been used unless stated otherwise. The range of emission performance figures presented in the table below represents variation in emissions performance of the vehicles over different drive cycles, from urban to motorway, compared to a diesel Euro 6/VI vehicle.

Table 2 – Emission performance of in-scope technologies

Key

Key	Tailpipe	Scope 1 (TTW)	All Scope (WTW)	Air quality
Emission Savings Summary of Alternative Fuels and Powertrains compared to Diesel Euro 6/VI				
Red	Worse emission (> 10%)			Not applicable
Amber	Similar (+/- 10%) or drive cycle dependent			Similar air quality (AQ) performance or zero emission capable. Due to performance variation in emission factors, test results and vehicle makes and models, a range of +/- 10% is considered as similar performance to a diesel vehicle.
Green	Better emissions (> 10%)			Zero emission

Emission Savings Summary of Alternative Fuels and Powertrains compared to Diesel Euro 6/VI					
Low Emission Technology	Tailpipe savings	Scope 1 (TTW) savings	All Scope (WTW) savings	Air quality savings	Comment
BEV	100%	100%	30-50%	100%	WTW CO_2 emissions savings vary by drive-cycle from circa 30% in a motorway cycle to circa 50% on an urban cycle. Fuel efficiency performance were taken from the LowCVP Emission Testing of Urban Delivery Vehicles[3]
HEV	< 20%	< 20%	< 20%		Fuel and CO_2 savings range from circa 20% in an urban drive cycle to around 1% on a motorway cycle. Fuel savings performance data were taken from a blend of real-world trial results from Fuso Canter Hybrid and regen testing of EVs[4]
PHEV	100% to negative	100% to negative	Better to negative	Zero emission capable	Emission savings when in zero emission mode only. If electric drive is not used emission savings diminish and can become negative due to low efficiency petrol engine used. Fuel consumption performance taken from independent testing by Cenex at Bruntingthorpe Proving Ground over Artemis Urban and Artemis Road cycles[5]
FC REEV	100%	100%	Dependent on H_2 supply	100%	100% WTW CO_2 emission savings available from renewable fuels, savings deteriorate with brown H_2 use (generated from fossil fuels). Modelling of small panel van emissions in the Tool show the best case 50% WTW savings to worse case emissions being similar to a diesel van assuming that fuel use is split 50%/50% between EV and H_2 FC operation. Savings derived from JRC-CONCAWE emission factors applied to H_2 energy consumption (provided by vehicle manufacturer).[6]
Dedicated gas	-4 to 2%	-4 to 2%	-10 to 2%	~40% NO_2	Similar tailpipe and Scope 1 CO_2 performance (-4% to 2% from urban to motorway cycles respectively) compared to a diesel vehicle. The WTW emission factor of liquefied natural gas (LNG) varies significantly across different studies. UK emission factors from DEFRA show LNG increases WTW CO_2 emissions of a dedicated gas truck by around 10% (when modelled using diesel to gas vehicle efficiency differences as reported in the LowCVP Emission Testing of Gas-Powered Vehicles[7]. Independent emission testing by the LowCVP also showed an average of 40% reduction in NO_2 compared to Euro VI diesel.
Dedicated Biomethane	-4 to 2%	~100%	~85%	~40% NO_2	As per dedicated gas tailpipe emissions. Up to 85% WTW CO_2 savings for biomethane supply. Independent testing by the LowCVP showed an average of 40% reduction in NO_2 compared to Euro VI diesel. Efficiency performance of gas vehicles were taken from the LowCVP Emission Testing of Gas-Powered Vehicles[7]

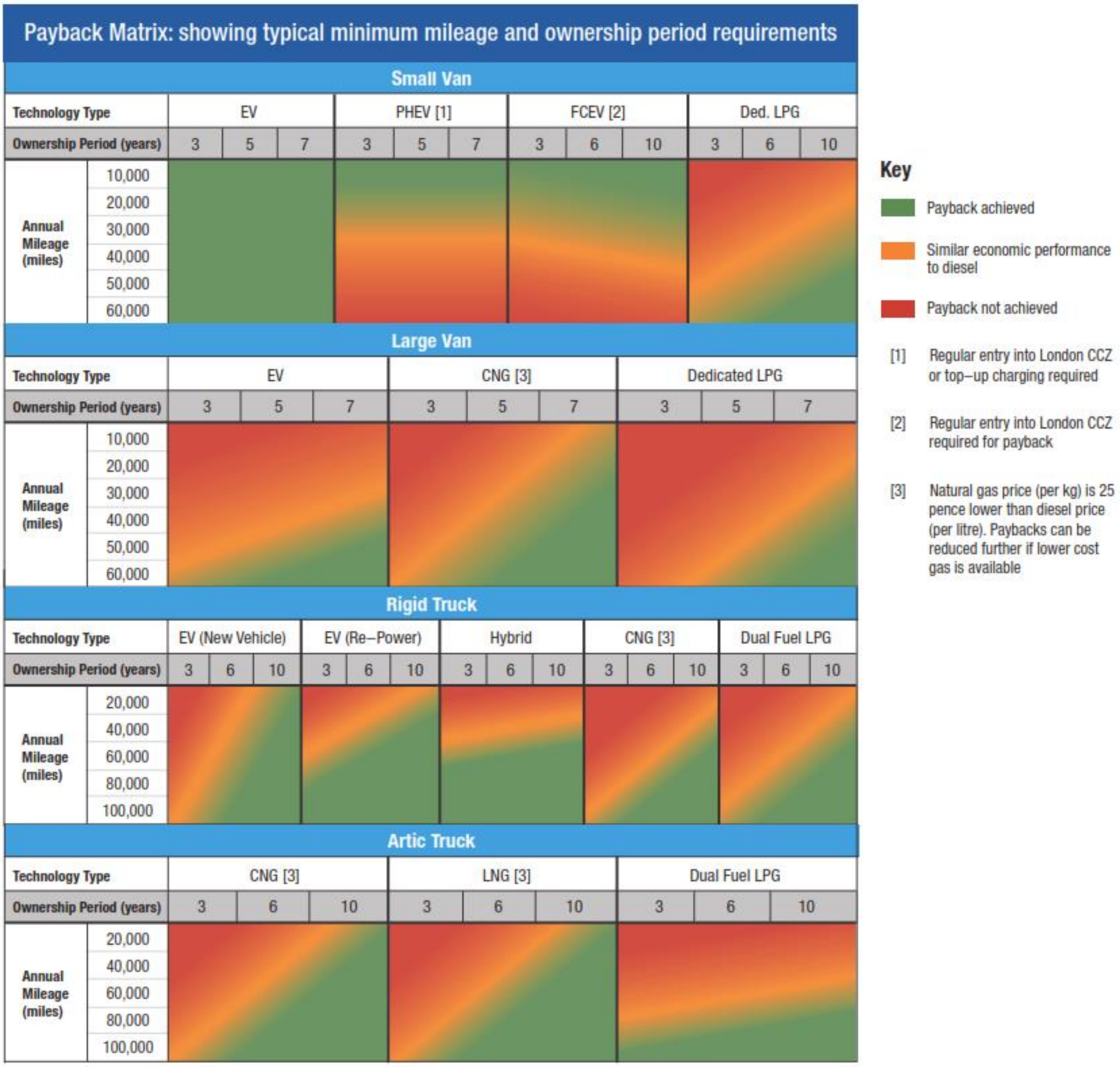
Dedicated LPG	-1 to -9%	-1% to -9%	-1% to 6%	Similar to petrol	Similar CO_2 emissions due to reduction in engine efficiency compared to diesel. Variation in the emission performance presented is due to variation in fuel energy content across different LPG supplies. Independent test data on vehicle efficiency across different duty cycles were not available, therefore average efficiency loss of 19% compared to diesel was applied[8]. Technology provides similar NOx and PM performance to petrol vehicles.[9]
Dual-fuel LPG	< 7%	< 7%	< 7%		Up to ~ 7% TTW/WTW CO_2 saving across different driving cycles. Fuel consumption performance were taken from the LowCVP Emission Testing of Gas-Powered Vehicles which also showed an average of 25% reduction in NO_2 compared to Euro VI diesel.[7] However due to variation across multiple repeat test results the average NO_2 reduction was not statistically significant.
Biodiesel B20 (FAME)		20%	16%		WTW savings improve linearly with increased biodiesel blend. This analysis was undertaking using a B20 (20%) FAME blend across urban to motorway driving cycles. Engine efficiency assumed the same between compression ignition engine using biodiesel and fossil diesel..

Emerging Evidence suggests that diesel Euro VI vehicles, with Selective catalytic reduction (SCR) systems emit high levels of N_2O (nitrous oxide) which is a powerful greenhouse gas. Early and limited testing by the LowCVP estimates this could increase the overall GHG emissions of a diesel vehicle by 1-2%[7]. This has not been factored into the GHG emissions shown above due to the limited testing that has been undertaken. In terms of natural gas vehicles, the Energy Technology Institute (ETI) have undertaken a (currently unpublished) study of UK specific WTW emissions of natural gas pathways, the publication of this report and the testing of the latest generation of Euro VI gas vehicles under the current OLEV / Innovate UK funded Low Emission Freight and Logistics trial may improve the emission factors and savings presented from the natural gas vehicles in the table above.

1.3 Payback Performance

Table 3 below shows the typical mileage and payback period required for economic performance of the studied vehicles under typical driving and duty cycle conditions.

Table 3 – Low emission vehicle payback matrix



A summary of the suitability of the available low emission technologies is described below:

- **Electric**: Small electric vans show a compelling environmental and economic proposition for use in London. Large vans and rigid trucks offer good environmental savings but deployment will be limited as payback is challenging as high mileage and long ownership periods are required. Using a re-power truck (new electric drive train fitted into a second hand truck) helps to decrease capital costs and offers a compelling payback proposition for higher mileage EV trucks
- **FC REEV**: The combination of entry in to the London Congestion Charge Zone (CCZ) and an additional grant[10] available through a European Union funding stream (applied by the manufacturer, limited to 200 applications) allows strong environmental and economic proposition for fuel cell range extended small vans in London

- **PHEV**: A strong economic case exists for Plug-in hybrid vehicles when entry into the London CCZ or opportunity recharging during the day takes place
- **Hybrid**: Hybrid trucks (7.5t) are available and can offer up to 20% emission savings in urban drive cycles. Economic operation is available for high mileage urban applications
- **Natural Gas**: Gas trucks offer similar CO_2 emissions to diesel, unless biomethane can be used which results in significant WTW CO_2 emission savings. Some NO_2 savings are available compared to Euro VI diesel. High annual mileages and high capacity gas stations providing low cost gas supply are required for good economic performance
- **Dual Fuel LPG**: Can offer cost savings for high mileage trucking operations, with similar emissions to diesel trucks
- **Dedicated LPG:** Costs savings are available with high mileage duty cycles. Similar CO_2 performance when using a fossil LPG
- **Biodiesel B20 (FAME)**: Reduced WTW CO_2 emission savings with similar air quality performance. Biodiesel use often increases fleet costs due to increased fuel consumption, vehicle and storage tank maintenance

The economic and environmental performance of key potential technologies that do not yet meet tool acceptance criteria are summarised below:

- **REEV**: 7.5t range extended trucks are available and suitable for reducing emissions from urban areas. Currently only supplier led trial activity has been undertaken, with first commercial sales taking place during 2017. For economic payback, the REEV trucks require a mix of high mileage (~30,000 MPA) and regular entry into the congestion zone, or very high mileage (~60,000 MPA) without London CCZ entry
- **Hydrogen dual fuel**: Enables hydrogen use in a wide variety of vehicles. Current deployments require additional grant funding assistance due to higher cost of vehicles and fuel. Emissions not yet Euro VI compliant (at the time of writing). Best performance (H_2 to diesel substitution ratio) is available in urban applications. H_2 refuelling infrastructure required. Vehicle can operate on 100% diesel if H_2 infrastructure is not available
- **Hybrids:** Hydraulic hybrids are in early customer trials and capacitor hybrids are also in development. These technologies will be ideal for reducing CO_2 emission from urban vehicles. Euro VI compliance not tested
- **Biofuels**: BioLPG is due to be introduced in 2017, which will reduce the WTW CO_2 emission from LPG vehicles. Drop-in fuels such as hydrogenated vegetable oil (HVO) and gas-to-liquid (GTL) are widely supported by commercial vehicle manufacturers under standard servicing and warranty regimes and can significantly reduce the WTW CO_2 impact of heavy vehicles. Currently the fuels are limited in supply and are more expensive than diesel.

2 Introduction

Cenex was commissioned by the LoCITY programme to undertake technical research on the financial and environmental benefits of alternative fuels and retrofit equipment for commercial vehicles. The scope of the study was limited to equipment that provides motive power. Based on this research Cenex developed an Excel calculator tool (the LoCITY Fleet Advice Tool) which allows a user to understand the cost impact and emission benefits of operating low emission commercial vehicles over a range of operating conditions and duty cycles. The Tool was developed with guidance and input from, and endorsed by the LoCITY working groups, which represent a diverse group of fleet users as well as fuel and vehicle suppliers.

This report draws on research undertaken by Cenex during the project, and uses the cost and emissions calculator Tool developed as part of the research to highlight areas where different low emission vehicles can offer operators financial and environmental savings. The LoCITY Fleet Advice Tool is due to be launched as an interactive website in 2018 Q1.

3 Technologies Reviewed

This chapter presents the methodology used to determine the technologies that can be assessed using the LoCITY Fleet Advice Tool.

Available technologies were split into two groups as presented in Table 4 below. Technologies meeting Euro VI/6 emission standards, capable of evidencing operational experience (fleet testimonials for real-world reliability and performance from at least two operators) and capable of operating at similar costs to a diesel truck are in-scope and eligible for inclusion in the Tool. The main UK low emission technologies and their status on inclusion eligibility is shown below.

Information on technology status was received between January and March 2017, any changes to technology status post March 2017 has not been captured in this report. The test and development status of low emission technology changes continuously and will need to be assessed on a periodic basis to ensure the LoCITY Fleet Advice Tool maintains up-to-date technology information.

Table 4 – Technology selection matrix for the LoCITY Fleet Advice Tool

Technology Status Key **E = Emission Test Data Not Available or Insufficient** **O = Operational Data Not Available or Insufficient**	
Out-of-Scope Technologies **In Development or Insufficient Evidence Base (status)**	**In-Scope Technologies** **Technology Inclusion (evidence)**
Dual-fuel methane (E) **Dual-fuel vegetable oil** (E) **Dual-fuel diesel/H2** (E, O) **Capacitor hybrid** (E, O) **Hydraulic hybrid** (E, O) **On-board H2 generator** (E) **Range Extended Electric Vehicle** (REEV) (O)	**Hydrogen Fuel Cell Range Extended** Electric Vehicle (H_2 FC REEV) (Zero emission) – information pending **Electric Vehicle (EV)** (Zero emission) **Hybrid (non-plug in) Electric Vehicle (HEV)** (Euro VI certified) **Plug-in Hybrid Electric Vehicle (PHEV)** (Euro VI certified) **Dedicated gas** (Euro VI certified) **Dedicated LPG** (Independent emission tests) **Dual-fuel LPG** (LowCVP emission test) **Biodiesel B20 FAME** (LowCVP emission test)

This report focuses mainly on technologies which are included within the Tool. Technologies included within the Tool were also ranked by maturity. The maturity level is an indication of the uncertainty around technology performance and reliability, due to a low level of market experience or potential variability in the performance of products offered via a variety of retro-fit companies. The maturity rankings and their descriptions, from Low to High are presented in Table 5 below.

Table 5 – Maturity level explanation and ranking

Maturity level	Description	Technologies included at maturity level
High	OEM supplied vehicles. These vehicles will typically have high levels of reliability, warranty and service support.	BEV (OEM), HEV, PHEV, Dedicated gas vehicles
Medium	Non-OEM, low volume supplied vehicles. These vehicles will typically have variable real-world performance dependent on the convertor/supplier.	BEV (low volume), LPG, Biodiesel
Low	Non-OEM supplied vehicles. Variable real-world performance dependent on the convertor/supplier. Very limited, but positive, real-world performance data and testimonials and/or vehicles deployed in a low (< 5) number of fleets.	FC-REEV – information pending

4 Technology Availability

This chapter shows the availability of the in-scope technologies across the main commercial vehicle weight classes and configurations.

4.1 In-Scope Technologies

The availability of in-scope low emission technologies are shown below, segregated by vehicle class and axle configuration.

Table 6 – Vehicle availability

Low Emission Vehicle Availability **Key O = OEM vehicle, R = Retrofit vehicles or low volume manufacturer available**										
Low Emission Technology	Small van (2 axles, 2.2t)	Large van (2 axles, up to 3.5t)	Large van (2 axles, > 3.5t)	Rigid Truck (2 axles, 7.5t)	Rigid Truck (2 axles, 18t)	Rigid Truck (3 axles, 18 - 26t)	Rigid Truck (4 axles, 32t)	Articulated Truck (4x2, 36t)	Articulated Truck (6x2, 44t)	Articulated Truck (6x4, 44t)
BEV	O	O, R	O, R	R	R	R	R			
HEV				O						
PHEV	O									
FC REEV	R									
Dedicated gas		O	O		O	O		O		
Dedicated LPG	R	R								
Dual-fuel LPG		R		R	R	R	R	R	R	R
Biodiesel B20	O	O	O	O	O	O	O	O	O	O

4.2 Out-of-Scope Technologies

Other technologies considered by the study, (but not included in the Tool) and their level of development at the time of study (March 2018) are shown in Table 7 below.

Table 7 – Emission summary for technologies not in the LoCITY Fleet Advice Tool

Key E=Emission Test Data Not Available or Insufficient, O = Operational Data Not Available or Insufficient	
Technology	**Status**
Dual-fuel methane (E, O)	Unsuitable for tool inclusion as testing by the LowCVP showed that the technology increases overall greenhouse gas (GHG) emissions[7] due to 'methane slip'. Retro-fit companies are currently investigating options to catalyse methane.
Dual-fuel vegetable oil (E)	Conversions available for most truck sizes (UK conversion experience is in the > 26t vehicle weight).
Dual-fuel diesel/H2 (E, O)	Transit vans and refuse collection vehicles (RCV) currently in operation. Conversions available for most vehicle classes.
Capacitor hybrid (E, O)	In development phase.
Hydraulic hybrid (E, O)	In low volume UK trials, available from 7.5t – 32t GVW.
REEV (O)	Currently in demonstration projects and ramping up to low volume production.

5 Environmental Performance

The typical environmental performance of low emission technologies and fuels are summarised in this section.

The environmental performance of the technologies is shown below. The emission performance is presented in three groups.

- **Tailpipe emissions**: these are the emissions of CO_2 from the tailpipe of the vehicle.
- **Scope 1 emissions**: (also known as tank-to-wheel emissions), these are the emissions which a transport operator is responsible for under UK Greenhouse Gas Reporting Guidance[2].
- **All scope emissions**: (also known as well-to-wheel emissions), these represent a complete picture of the carbon intensity of a fuel supply chain and offer a holistic indication of the environmental impact of a fuel. These emissions include fuel extraction, processing, transportation, dispensing and final combustion.

The emission performance of the technologies listed in Table 8 are those calculated by the Tool. The references and verification for technology performance of the Tool are covered in a separate unpublished report to the LoCITY programme[11].

5.1 In-Scope Technologies

Table 8 below shows the average performance of each technology compared to a Euro VI/6 diesel vehicle using the key show below. The performance is shown in terms of % savings from a diesel Euro 6/VI comparator diesel. Where available, DEFRA[2] CO_2 emission factors have been used.

Table 8 – Emission summary of alternative fuels and powertrains

Key				
Emission Savings Summary of Alternative Fuels and Powertrains compared to Diesel Euro 6/VI				
Key	**Tailpipe**	**Scope 1 (TTW)**	**All Scope (WTW)**	**Air quality**
Red	Worse emission (> 10%)			Not applicable
Amber	Similar (+/- 10%) or drive cycle dependent			Similar air quality (AQ) performance or zero emission capable. Due to performance variation in emission factors, test results and vehicle makes and models, a range of +/- 10% is considered as similar performance to a diesel vehicle.
Green	Better emissions (> 10%)			Zero emission

Emission Savings Summary of Alternative Fuels and Powertrains compared to Diesel Euro 6/VI					
Low Emission Technology	**Tailpipe savings**	**Scope 1 (TTW) savings**	**All Scope (WTW) savings**	**Air quality savings**	**Comment**
BEV	100%	100%	30-50%	100%	WTW CO_2 emissions savings vary by drive-cycle from circa 30% in a motorway cycle to circa 50% on an urban cycle. Fuel efficiency performance were taken from the LowCVP Emission Testing of Urban Delivery Vehicles[12]
HEV	< 20%	< 20%	< 20%		Fuel and CO_2 savings range from circa 20% in an urban drive cycle to around 1% on a motorway cycle. Fuel savings performance data were taken from a blend of real-world trial results from Fuso Canter Hybrid and regen testing of EVs[13]
PHEV	100% to negative	100% to negative	Better to negative	Zero emission capable	Emission savings when in zero emission mode only. If electric drive is not used emission savings diminish and can become negative due to low efficiency petrol engine used. Fuel consumption performance taken from independent testing by Cenex at Bruntingthorpe Proving Ground over Artemis Urban and Artemis Road cycles[14]
FC REEV	100%	100%	Dependent on H_2 supply	100%	100% WTW CO_2 emission savings available from renewable fuels, savings deteriorate with brown H_2 use (generated from fossil fuels). Modelling of small panel van emissions in the Tool show the best case 50% WTW savings to worse case emissions being similar to a diesel van assuming that fuel use is split 50%/50% between EV and H_2 FC operation. Savings derived from JRC-CONCAWE emission factors applied to H_2 energy consumption (provided by vehicle manufacturer).[15]
Dedicated gas	-4 to 2%	-4 to 2%	-10 to 2%	~40% NO_2	Similar tailpipe and Scope 1 CO_2 performance (-4% to 2% from urban to motorway cycles respectively) compared to a diesel vehicle. The WTW emission factor of liquefied natural gas (LNG) varies significantly across different studies. UK emission factors from DEFRA show LNG increases WTW CO_2 emissions of a dedicated gas truck by around 10% (when modelled using diesel to gas vehicle efficiency differences as reported in the LowCVP Emission Testing of Gas-Powered Vehicles[16]. Independent emission testing by the LowCVP also showed an average of 40% reduction in NO_2 compared to Euro VI diesel.
Dedicated Biomethane	-4 to 2%	~100%	~85%	~40% NO_2	As per dedicated gas tailpipe emissions. Up to 85% WTW CO_2 savings for biomethane supply. Independent testing by the LowCVP showed an average of 40% reduction in NO_2 compared to Euro VI diesel. Efficiency performance of gas vehicles were taken from the LowCVP Emission Testing of Gas-Powered Vehicles [7]
Dedicated LPG	-1 to -9%	-1% to -9%	-1% to 6%	Similar to petrol	Similar CO_2 emissions due to reduction in engine efficiency compared to diesel. Variation in the emission performance presented is due to variation in fuel energy content across different LPG supplies.

					Independent test data on vehicle efficiency across different duty cycles were not available, therefore average efficiency loss of 19% compared to diesel was applied[17]. Technology provides similar NOx and PM performance to petrol vehicles.[18]
Dual-fuel LPG	< 7%	< 7%	< 7%		Up to ~ 7% TTW/WTW CO_2 saving across different driving cycles. Fuel consumption performance were taken from the LowCVP Emission Testing of Gas-Powered Vehicles which also showed an average of 25% reduction in NO_2 compared to Euro VI diesel.[7] However due to variation across multiple repeat test results the average NO_2 reduction was not statistically significant.
Biodiesel B20 (FAME)		20%	16%		WTW savings improve linearly with increased biodiesel blend. This analysis was undertaking using a B20 (20%) FAME blend across urban to motorway driving cycles. Engine efficiency assumed the same between compression ignition engine using biodiesel and fossil diesel..

Emerging Evidence suggests that diesel Euro VI vehicles, with SCR systems emit high levels of N_2O (nitrous oxide) which is a powerful greenhouse gas. Early and limited testing by the LowCVP estimates this could increase the overall GHG emissions of a diesel vehicle by 1-2%[Error! Bookmark not defined.]. This has not been factored into the GHG emissions shown above due to the limited testing that has been undertaken. In terms of natural gas vehicles, the Energy Technology Institute (ETI) has undertaken a (currently unpublished) study of UK specific WTW emissions of natural gas pathways. The publication of the ETI report and the testing of the latest generation of Euro VI gas vehicles under the current Low Emission Freight and Logistics trial may improve the emission savings presented from the natural gas vehicles in Table 8.

5.2 Out-of-Scope Technologies

Table 9 below gives a brief summary of the emission performance of low emission vehicles that were not taken forward for inclusion in the Tool.

Table 9 – Emission performance of alternative powertrains

Technology	Status
Dual-fuel methane	Methane (a powerful greenhouse gas) slip from dual fuel engines has been shown to eliminate any CO_2 savings on an CO_2 equivalence basis[Error! Bookmark not defined.] Testing of retro-fit Euro V trucks in the Low Carbon Truck Trial[19] concluded that *Air quality performance was variable with some systems showing reductions in all air quality pollutants (CO, NO, NO_2, PM, NOx) and other systems showing increases in CO and variable PM performance.*
Dual-fuel vegetable oil	Savings of up to 84% WTW CO_2 emissions were reported from the Low Carbon Truck Trial when recycled cooking oil was used as feedstock. There has been no independently verified emission testing of Euro VI conversions.
Dual-fuel diesel/H_2	WTW CO_2 emissions dependent on H_2 source. No independently tested AQ data from Euro VI conversions.
Capacitor hybrid	In development, performance unknown however up to ~20% fuel (and CO_2) savings are likely from a hybrid operating in an urban environment. AQ performance unknown.
Hydraulic hybrid	Manufacturer claims circa 15 – 30% fuel (and CO_2) reduction on suitable urban drive cycles. AQ performance unknown.
On-board H_2 generator	No independently verified emission testing of Euro VI.
REEV	Zero emission capable, however at the time of writing only operational UK REEV commercial vehicle operates with a Euro V engine. The vehicle is capable of around 100 miles per charge in zero emission mode, therefore the overall net AQ effect of operating the Euro V engine compared to a Euro VI truck is dependent on the fleet operating patterns (e.g. daily mileage) and where the range extender engine operates.

5.3 Fuels

The following fuels are the main near market renewable fuels and have the potential to significantly reduce WTW carbon emissions from vehicles.

Table 10 – Near future alternative fuels status

Fuel	Status
BioLPG	Calor gas is planning to introduce a renewable version of LPG during 2017. BioLPG will be the same chemical composition as LPG and therefore able to be substituted into an LPG engine. Calor gas estimate this product to have circa 70% WTW CO_2 saving compared with fossil LPG.[20]
HVO/GTL	HVO (hydrogenated vegetable oil) / GTL (gas-to-liquid) fuels are classed as Drop-In fuels which can be substituted for EN590 diesel at blends up to 100%. Drop-in diesel fuels are also known as renewable diesel. Commercial vehicle manufacturers are currently testing and approving their vehicles for use with renewable diesel fuels. WTW CO_2 savings range from 36% up to 91% dependent on feedstock and associated transportation pathways.[21]
BioLNG	At the time of writing bioLNG is not currently available in the UK. However, LNG suppliers are investigating the supply of bioLNG via the national gas pipeline (registered through the renewable transport fuel obligation (RTFO) scheme), which will allow fleets to legitimately claim the green credentials of biomethane (savings up to circa 85%) when purchasing LNG.

6 Whole Life Cost Performance

This section presents analysis on the whole life cost (WLC) performance of alternative drivetrains and fuels analysed within the LoCITY Fleet Advice Tool.

WLC information is presented in the following format:

- **WLC Case Studies:** Section 6.1 below presents three case studies showing the comparative WLC information across the different alternative fuel and emission technologies within the Tool. A case study for a small panel van, medium truck and heavy truck are presented
- **WLC Summary Tables:** Section 6.2 presents a summary table per technology providing more information about the WLC factors, operational characteristics and any uncertainties relevant to each alternative technology within the Tool
- **WLC Sensitivity Analysis:** Appendix A provides a series of sensitivity analysis tables showing the WLC savings available from each technology when key operational factors such annual mileage, ownership period, fuel cost etc. are altered

Whilst not detailed in this report, the financial information and fuel efficiency data input into the Tool were verified through interviews and consultation with a range of technology and fuel suppliers, fleet operators and industry consultants. More detailed information on Tool input and verification data has been supplied to LoCITY in a separate unpublished report.[11]

6.1 WLC Case Studies

The WLC performance of the study technologies were determined using the LoCITY Fleet Advice Tool. When reviewing the case studies below it is important to consider the following points:

- Typical fuel consumption performance was used. Therefore if fleet vehicles have an unusually high fuel consumption (driven aggressively, high payload, operate in hilly environments, have high auxiliary loads etc.) then this increases fuel consumption, which in turn would improve the shown payback period and economics of alternative technologies
- The analysis does not include factors for the practicalities of operating the low emission trucks e.g. payload loss in heavy EV vehicles
- The case studies were based on real driving cycles presented to the study team by an operator during the Tool's validation phase
- All costs presented exclude VAT

6.1.1 Case Study 1: Small Panel Van

Key Model Inputs

Vehicle: Small panel van

Annual mileage: 10,000 MPA

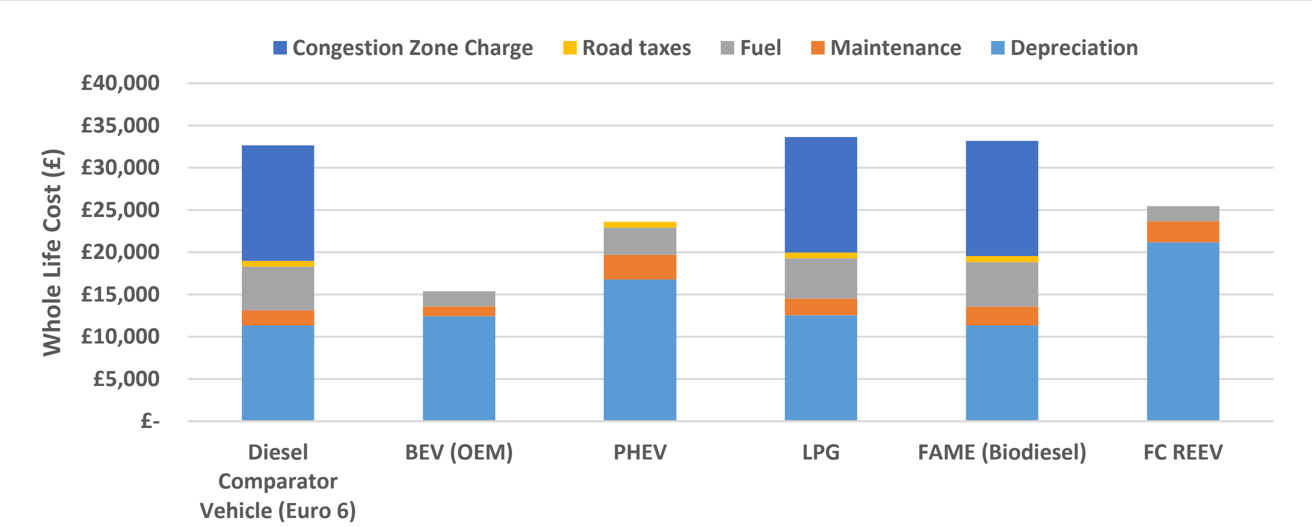
Woking pattern: Used six days per week undertaking 35 miles per day with daily entry into the London CCZ

Ownership period: 5 years

Ownership model: Outright purchase


Source: Nissan

Whole Life Cost Results



Diesel small panel van costs the operator a total of £32,000 over 5 years, of this the congestion charge contributes £13,650.

Battery electric van allows a WLC savings of over £17,000 to be realised. Even without entry into the London CCZ the battery electric van would allow over £3,000 WLC saving. The predicted range of circa. 70 miles (for a 24-kWh battery) leaves plenty of contingency for the required 35 miles per day.

PHEV is a premium SUV vehicle with a petrol engine and shows higher deprecation and fuel costs compared to an efficient diesel small panel van, however with entry into the London CCZ a cost saving of over £5,500 can still be realised by operating this vehicle in London.

LPG vans can be operated at similar costs to the diesel. If greater annual mileage was required, the lower fuel costs would allow the additional cost of the LPG conversion to be recouped and earn WLC savings for the operator.

Biodiesel (B20) vans could be operated at a similar cost to the diesel van.

FC REEV: can offer WLC savings of up to £7,000, this is ideal if access to hydrogen is available and the van would have to undertake the occasional long journey which is above the estimated 70-mile real-world range of the electric van

See *Appendix A* for a sensitivity analysis on technology payback periods.

6.1.2 Case Study 2: Medium Goods Vehicle

Key Model Inputs

Vehicle: 14t Delivery truck

Annual mileage: 35,000 MPA

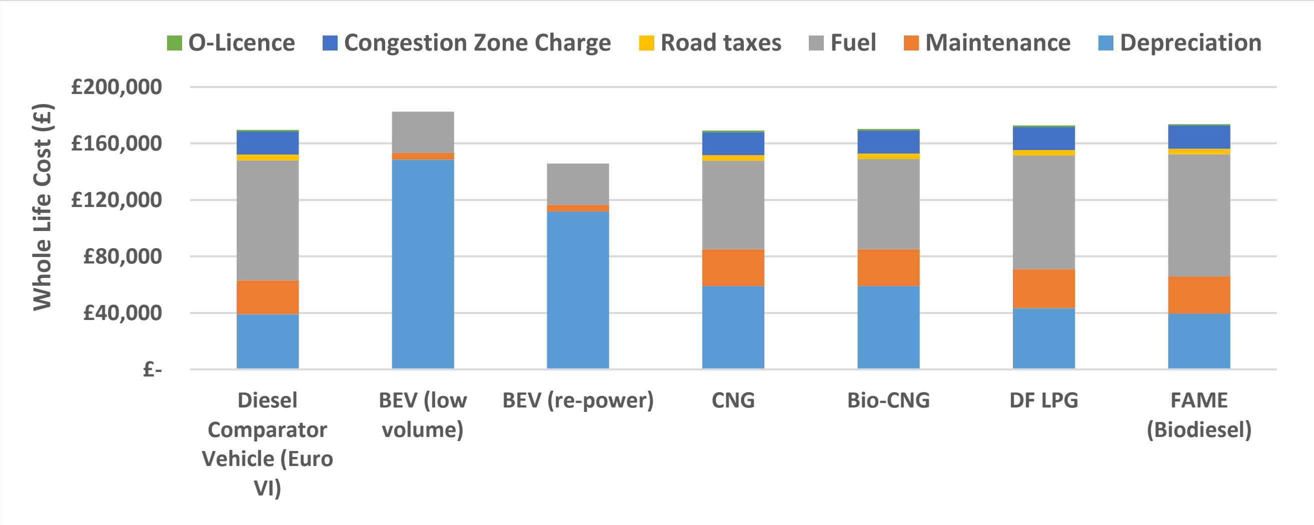
Woking pattern: Used two shifts per day, seven days per week, undertaking 50 miles per shift, daily entry into the London CCZ

Ownership period: 6 years

Ownership model: Outright purchase

Source: Transport Engineer

Whole Life Cost Results



Diesel truck costs the operator a total of £170,000 over 6 years.

Battery electric truck fuel and congestion zone savings combine to allow a re-powered BEV offer WLC savings of £25,000. A brand-new battery electric truck is operated at a greater cost to diesel in this case study, however if a lower capacity battery (reducing the battery from 200 kWh to 125 kWh, reducing the overall capital cost of the truck by £20k) were used and the truck recharged between shifts then WLC savings could also be available from a new BEV truck.

CNG truck allows a marginal WLC saving, assuming a large capacity grid connected station suppling CNG at 70p/kg. Savings for CNG trucks would increase for higher mileage or longer ownership periods. Bio-CNG is not currently available in the London area, therefore in this example the operator purchases a green certificate at 3p/kg to offset the carbon emissions.

DF LPG offers a similar WLC, if greater annual mileage was required, the lower fuel costs would allow the additional cost of the LPG conversion to be recouped and earn WLC savings for the operator.

Biodiesel (B20) trucks could be operated at a similar cost to the diesel truck.

See Appendix A for a sensitivity analysis on technology payback periods.

6.1.3 Case Study 3: Large Goods Vehicle

Key Model Inputs

Vehicle: 36t 4x2 Artic truck

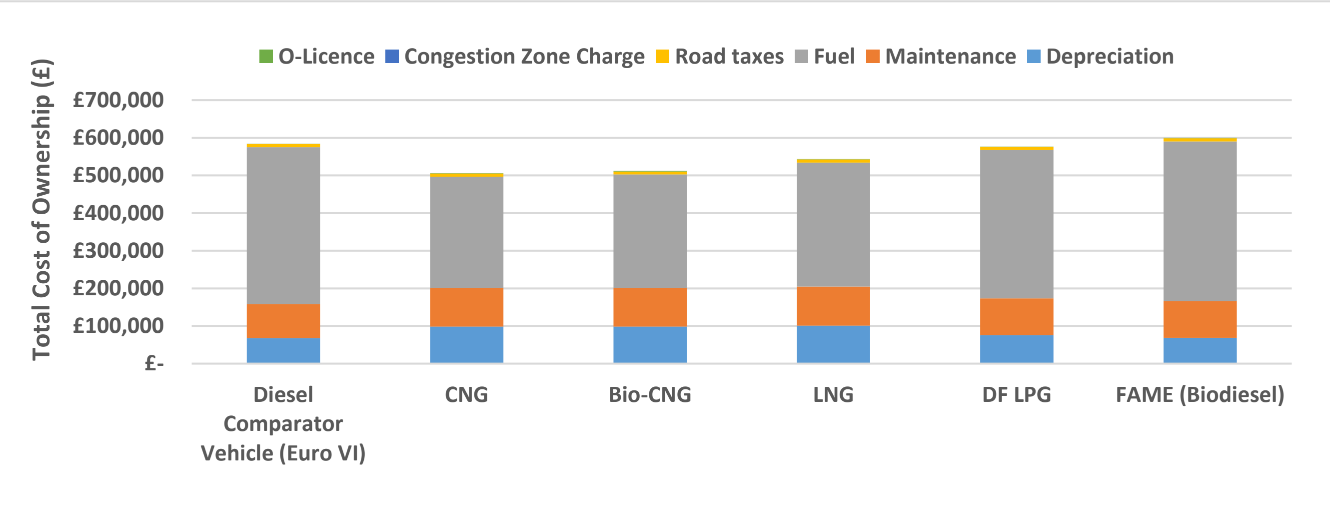
Annual mileage: 110,000 MPA

Woking pattern: Daily deliveries into regional distribution centres in the greater London area

Ownership period: 7 years

Ownership model: Outright purchase

Whole Life Cost Results



Diesel truck costs the operator nearly £600,000 over 7 years.

CNG truck allows a WLC saving of £80,000, assuming a large capacity grid connected station suppling CNG at 70p/kg. Savings for CNG trucks would increase for higher mileage or longer ownership periods. Bio-CNG is not currently available in the London area, therefore in this example the operator purchases a green certificate at 3ppkg to offset the carbon emissions. Lower cost CNG (available outside of the London area) would improve the economic performance further.

LNG truck allows a WLC saving of £40,000, assuming a large capacity station suppling LNG at 75p/kg. Savings for LNG trucks would also increase for higher mileage or longer ownership periods. Using LNG would mean the operator only has to refuel once a day, as opposed to CNG use where the operator may need to refuel twice a day – depending on truck supplier and tank options.

DF LPG trucks allow around £8,000 WLC saving and retain the ability to run on diesel if travelling beyond the LPG tank range. In this scenario the operator has a large capacity LPG tank supplying a fleet of trucks with LPG at 35p/litre.

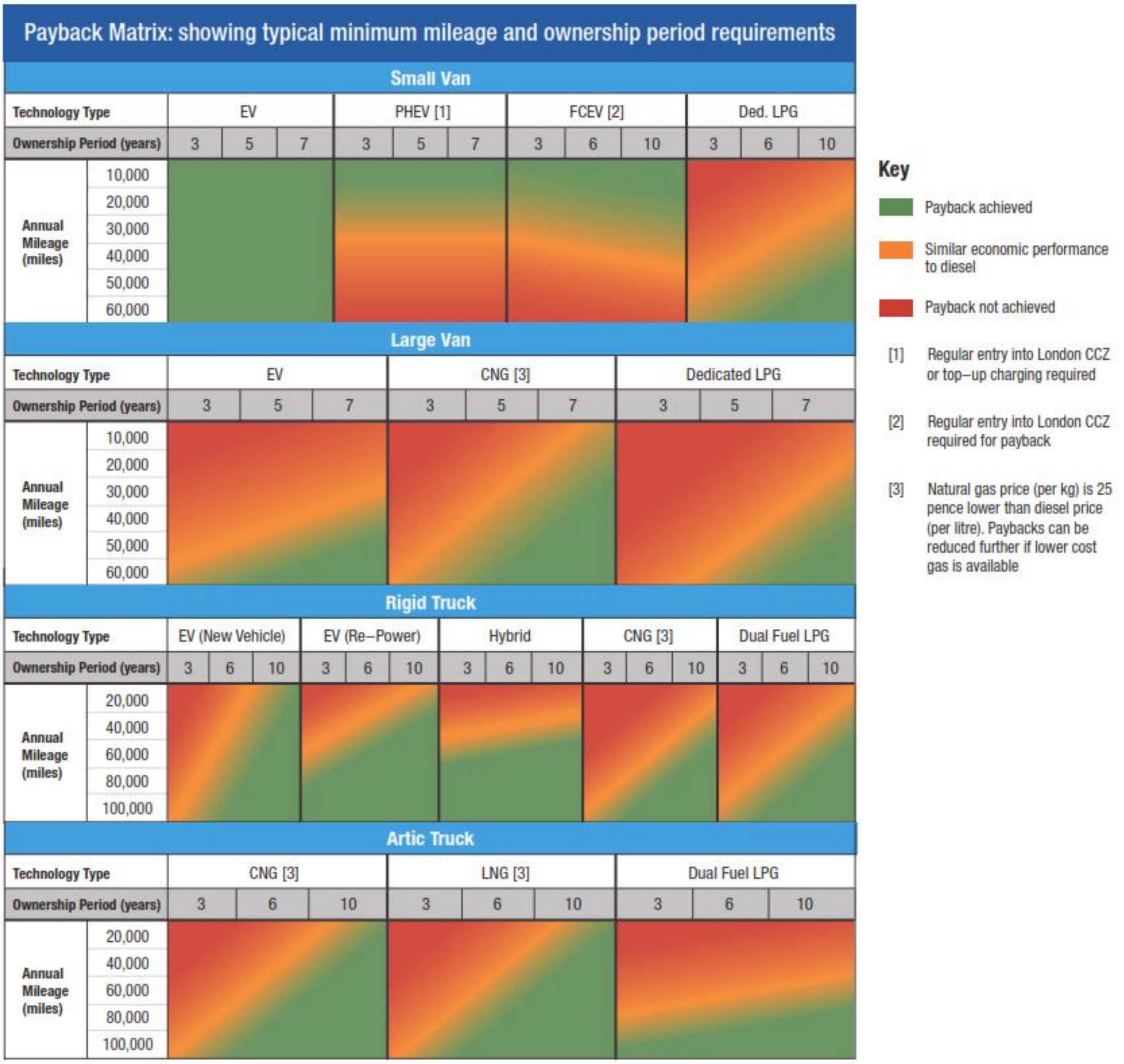
Biodiesel (B20) trucks could be operated at a similar cost to the diesel truck.

See *Appendix A* for a sensitivity analysis on technology payback periods.

6.2 WLC Summary Tables

Appendix A provides a series of sensitivity analysis tables showing the WLC savings available from each technology when key operational factors such annual mileage, ownership period, fuel cost etc. are changed. Table 11 below shows the typical mileage and ownership period required for economic performance of the studied vehicles under typical driving and duty cycle conditions.

Table 11 – Low emission vehicle payback matrix



A summary of the suitability of the available low emission technologies is described below:

- **Electric**: Small electric vans show a compelling environmental and economic proposition for use in London. Large vans and rigid trucks offer good environmental savings but deployment will be limited as payback is challenging as high mileage and long ownership periods are required. Using a re-power truck (new electric drive train fitted into a second hand truck) helps to decrease capital costs and offers a compelling payback proposition for higher mileage EV trucks
- **FC REEV**: The combination of entry in to the London Congestion Charge Zone (CCZ) and an additional grant[22] available through a European Union funding stream (applied by the

manufacturer, limited to 200 applications) allows strong environmental and economic proposition for fuel cell range extended small vans in London

- **PHEV**: A strong economic case exists for Plug-in hybrid vehicles when entry into the London CCZ or opportunity recharging during the day takes place
- **Hybrid**: Hybrid trucks (7.5t) are available and can offer up to 20% emission savings in urban drive cycles. Economic operation is available for high mileage urban applications
- **Natural Gas**: Gas trucks offer similar CO_2 emissions to diesel, unless biomethane can be used which results in significant WTW CO_2 emission savings. Some NO_2 savings are available compared to Euro VI diesel. High annual mileages and high capacity gas stations providing low cost gas supply are required for good economic performance
- **Dual Fuel LPG**: Can offer cost savings for high mileage trucking operations, with similar emissions to diesel trucks
- **Dedicated LPG:** Costs savings are available with high mileage duty cycles. Similar CO_2 performance when using a fossil LPG
- **Biodiesel B20 (FAME)**: Reduced WTW CO_2 emission savings with similar air quality performance. Biodiesel use often increases fleet costs due to increased fuel consumption, vehicle and storage tank maintenance

The economic and environmental performance of key potential technologies that do not yet meet tool acceptance criteria are summarised below:

- **REEV**: 7.5t range extended trucks are available and suitable for reducing emissions from urban areas. Currently only supplier led trial activity has been undertaken, with first commercial sales taking place during 2017. For economic payback, the REEV trucks require a mix of high mileage (~30,000 MPA) and regular entry into the congestion zone, or very high mileage (~60,000 MPA) without London CCZ entry
- **Hydrogen dual fuel**: Enables hydrogen use in a wide variety of vehicles. Current deployments generally require additional grant funding assistance due to higher cost of vehicles and fuel. Emissions not yet Euro VI compliant (at the time of writing). Best performance (H_2 to diesel substitution ratio) is available in urban applications. H_2 refuelling infrastructure required. Vehicle can operate on 100% diesel if H_2 infrastructure is not available
- **Hybrids:** Hydraulic hybrids are in early customer trials and capacitor hybrids are also in development. These technologies will be ideal for reducing CO_2 emission from urban vehicles. Euro VI compliance not tested
- **Biofuels**: BioLPG is due to be introduced in 2017, which will reduce the WTW CO_2 emission from LPG vehicles. Drop-in fuels such as hydrogenated vegetable oil (HVO) and gas-to-liquid (GTL) are widely supported by commercial vehicle manufacturers under standard servicing and warranty regimes and can significantly reduce the WTW CO_2 impact of heavy vehicles. Currently the fuels are limited in supply and are more expensive than diesel.

The following tables summarise the WLC inputs, payback and operational performance of the alternative technologies within the Tool.

6.2.1 Electric Vehicles

<table>
<tr><th colspan="4">Electric Vehicle Information Table</th></tr>
<tr><td>Availability</td><td colspan="3">~2.2t (small van) up to 32t (4 axle rigid) truck. EV trucks of 7.5t or greater are available as retrofit options only. EV drivetrains can be retro-fitted to either a new vehicle (retrofit) or a second-hand vehicle (known as re-power).</td></tr>
<tr><td rowspan="4">Costs (vs. diesel)</td><td>Capital</td><td>+</td><td rowspan="4">Cost premiums can range from around £2k (incl. PiVG) to £150k depending on commercial vehicle size. Residual values are not readily available for large vans and trucks, we have assumed residual values for 3.5t trucks and greater are the same absolute value (£) as a diesel truck. Maintenance is around 30% lower for small vans but rises to 80% lower (based on evidence from the bus market) for heavy vehicles[23].</td></tr>
<tr><td>Maintenance</td><td>-</td></tr>
<tr><td>Fuel</td><td>-</td></tr>
<tr><td>Residual value</td><td>~/-</td></tr>
<tr><td>Operational Performance</td><td colspan="3">Range between recharging is ~50 miles to 150 miles (dependent on usage/battery size).

Payload reduction of around 5 – 30% dependent on vehicle supplier and battery size.

Charging infrastructure is required (not factored into our cost analysis), high penetrations of vehicles may require electricity network upgrades or smart charging solutions.</td></tr>
<tr><td>Uncertainty</td><td colspan="3">Battery life is uncertain, the analysis allows for 2,000 complete battery cycles before battery replacement costs are factored into maintenance costs.

Reliability of product from retro-fit and low volume manufactures can be variable, especially for first-type conversions of vehicle models.

Residual values for small vans are available from the market place, however there is more uncertainty for large vans and heavier vehicles. The long ownership periods required for payback result in low residual values for vehicles anyway, therefore this minimises the impact of error associated with the residual value assumptions.</td></tr>
<tr><td>Payback</td><td colspan="3">Small Vans have strong economic performance providing cost of ownership savings both in and out of the London CCZ.

Large Vans require a combination of ownership periods from around 5-years, daily entry into the London CCZ and high annual mileage (from c. 30,000 MPA) to achieve payback.

Trucks require high mileage applications (from c. 30,000 MPA) and longer ownership periods (6 – 10 years) for payback. Using lower cost re-powered versions improves the economics significantly reducing the mileage (to 20,000 MPA) and ownership periods (closer to 5 years) required for economic payback.

See Appendix A 8.1 for full WLC saving matrix</td></tr>
<tr><td>Benefits</td><td colspan="3">Environmental Zero emission and low noise, up to circa 50% WTW CO_2 savings.

Costs Plug-in van grant offers 20% (up to £8,000) off the cost of a plug-in van, and £20,000 for compliant plug-in vehicles over 3.5t (limited to 200 grant applications). Low running costs (maintenance and fuel). London CCZ fee exempt. Zero rate annual vehicle excise duty. Fuel duty charge does not apply to electricity.

Other Positive driver feedback and good for company image and winning new work. Zero emission goods vehicles are eligible for Enhanced Capital Allowances (ECA) providing no other public funding has been used to purchase the vehicle. An ECA allows the taxable value of the vehicle to be written down against an organisations corporation tax bill. This has not been included in the WLC presented.

Key applications Small vans have very good payback characteristics and are suited to most applications that can operate within the limited range of the vehicles. The payback for larger vans and trucks is more challenging and are suited to high mileage and longer ownership applications.</td></tr>
</table>

6.2.2 Hybrid Electric Vehicles

Hybrid Electric Vehicle Information Table			
Availability	7.5t rigid truck		
Cost (vs. diesel)	**Capital**	+	Hybrid trucks are available at a capital cost increase of around £7k compared to the equivalent diesel truck. Maintenance (+5% costs) and residual values are similar.
	Maintenance	~	
	Fuel	-	
	Residual value	~	
Operational performance	**Similar** performance characteristics to a conventional truck.		
Uncertainty	**Low risk** deployment due to OEM product offering.		
Payback	**Trucks** WLC savings are available for trucks operating in mainly urban areas as the stop-start nature of urban driving is required for good fuel saving performance from the hybrid system. Savings start when annual mileage is around 20,000 MPA. **See *Appendix A 8.2* for full WLC saving matrix**		
Benefits	**Environmental** emission savings (up to 20% WTW CO_2) available due to improved fuel consumption. Lower noise from hybrid system, and low speed operation. **Other** Positive driver feedback, good for company image and winning new work, retains similar performance to conventional vehicle, no need for recharging. **Key applications** Suited to high mileage urban activity.		

6.2.3 Plug-in Hybrid Electric Vehicles

<table>
<tr><td>Availability</td><td colspan="3">2.2t small van, sports utility vehicle (SUV) derived van</td></tr>
<tr><td rowspan="4">Costs (vs. diesel)</td><td>Capital</td><td>~</td><td rowspan="4">The only PHEV van available at the time of writing is the 4Work version of the Mitsubishi Outlander PHEV. The capital cost of the PHEV version is similar to the diesel version once the PiVG has been taken into account.</td></tr>
<tr><td>Maintenance</td><td>+</td></tr>
<tr><td>Fuel</td><td>~</td></tr>
<tr><td>Residual value</td><td>~</td></tr>
<tr><td>Operational performance</td><td colspan="3">Similar functionality as a conventional van as it can operate on petrol when the battery depletes.
Maximising the electric only mileage is key to reducing costs and maximising the environmental benefits.</td></tr>
<tr><td>Uncertainty</td><td colspan="3">Low risk deployment due to OEM product offering.</td></tr>
<tr><td>Payback</td><td colspan="3">Entry into the London CCZ or multiple charging per day allows the PHEV to have a lower WLC compared with the diesel equivalent.
See Appendix A 8.3 for full WLC saving matrix</td></tr>
<tr><td>Benefits</td><td colspan="3">Environmental zero emission and low noise when operating in EV mode.
Other Good for company image and winning new work, retains similar performance to conventional vehicle.
Costs Plug-in van grant offers 20% (up to £8,000) off the cost of a plug-in van. Low running costs (maintenance and fuel). London CCZ fee exempt. Zero rate annual vehicle excise duty. Fuel duty is not applied to electricity.
Key applications Suited to duty cycles that can utilise a high proportion of EV mode driving or entry into the London CCZ.</td></tr>
</table>

6.2.4 Fuel Cell Range Extended Electric Vehicle

Fuel Cell Range Extended Electric Vehicle Information Table			
Availability	2.2t small van		
Costs (vs. diesel)	**Capital**	+	Capital cost is significantly greater than a diesel panel van, however a number of subsidies work to reduce this. A European Grant (administered by vehicle supplier) is available and the vehicle supplier offers a £2,250 buy back guarantee for the fuel cell and fuel tank at the end of the vehicles life. An additional maintenance fee of circa. £225 per annum is required for range extender equipment.[24]
	Maintenance	+	
	Fuel	~	
	Residual value	+	
Operational performance	**Hydrogen refuelling** station access is required. **Charging infrastructure** is required (not factored into cost analysis), high penetrations of vehicles may require electricity network upgrades or smart charging solutions. **Payload and load space** is reduced by around 10% due to the additional of hydrogen tank and components. **Doubles the range** of an electric only van due to the addition of a hydrogen range extender.		
Uncertainty	**Reliability and performance** testimonials have not yet been provided by the vehicle producer. **Residual values and longevity** of new product to market by retro-fit supplier are unknown.		
Payback	**Small vans** Daily entry into the London CCZ allows strong WLC savings from the fuel cell vehicle. Savings diminish once H_2 begins to be consumed, due to the current high cost of the hydrogen fuel. Under normal urban driving conditions, the EV is capable of up to around 80 miles a day (20,000 MPA) before H_2 consumption begins. **See *Appendix A 8.4* for full WLC saving matrix**		
Benefits	**Environmental** Zero emission and low Noise. **Costs** Plug-in van grant offers 20% (up to £8,000) off the cost of the base plug-in electric van, with additional financial incentives (administered through the vehicle supplier, as above) are available to allow significant reduction in the capital cost of the vehicle. London CCZ fee exempt. Fuel duty is not applied to electricity. **Other** Good for company image and winning new work. **Key applications** Ideal for a small van where occasional journey lengths above that available from a pure EV are required. Daily entry in the London CCZ and access to H_2 refuelling required.		

6.2.5 Dedicated Gas (Methane)

<table>
<tr><th colspan="4">Dedicated Gas Vehicle Information Table</th></tr>
<tr><td>Availability</td><td colspan="3">CNG: 3.5 to 7t vans, 12 to 26t (2 and 3 axle) rigid trucks, 4 x 2 artic trucks

LNG: 4 x 2 artic truck available in LNG</td></tr>
<tr><td rowspan="4">Cost (vs. diesel)</td><td>Capital</td><td>+</td><td rowspan="4">Gas vehicles attract a premium price of £5.5k to around £32k (depending on vehicle size class and gas tank size). Maintenance costs increase and the residual value of the vehicles is lower due to limited infrastructure and demand for second hand vehicles. In addition, fuel consumption increases due to a reduction in engine efficiency between a diesel compression ignition (CI) engine and petrol spark ignition (SI) engine vehicles. Fuel price, however can be significantly cheaper leading to an overall cost saving if an attractive fuel supply deal is available.</td></tr>
<tr><td>Maintenance</td><td>+</td></tr>
<tr><td>Fuel</td><td>~</td></tr>
<tr><td>Residual value</td><td>–</td></tr>
<tr><td>Operational performance</td><td colspan="3">CNG range is limited therefore public refuelling infrastructure or back-to-base operations are required. Ranges of between 300 – 800 km are available depending on vehicle size and tank options.

LNG range can be over 1,000km dependent on fuel tank sizes.

Load space is the same as diesel equivalent.

Payload is marginally reduced (by around 200kg for vans to 750kg for trucks).</td></tr>
<tr><td>Uncertainty</td><td colspan="3">Residual value of gas trucks is low due to low demand, estimated by the study team at one third the diesel truck residual value. If residual values improve with infrastructure provision the economics presented in this study will also improve.

Low risk deployment due to OEM product offering.</td></tr>
<tr><td>Payback</td><td colspan="3">Gas price dependent UK gas price typically varies by up to £0.40 per kg depending on location, contract size and supplier. Many of these factors are out of the control of fleets as they are limited to using the public refuelling stations within their operational area.

Vans and trucks at a low gas price (£0.70/kg vs £0.95p/litre diesel) WLC savings are available from vehicles travelling over around 30,000 MPA. Cost savings diminish as gas fuel price increases.

See Appendix A 8.5 for full WLC saving matrix</td></tr>
<tr><td>Benefits</td><td colspan="3">Environmental similar or better tailpipe emissions and low noise operation.

Other Positive driver feedback, good for company image and winning new work, retains similar performance to conventional vehicle.

Key applications Suited to high mileage activity with access to high capacity low-cost gas station to achieve financial payback.</td></tr>
</table>

6.2.6 Dedicated LPG

Dedicated LPG Vehicle Information Table			
Availability	Retro-fit to petrol vans only available in the UK.		
Costs (vs. diesel)	**Capital**	~/+	Retro-fit conversion costs start from around £1k, with a marginal increase in maintenance costs. LPG fuel cost is low, however fuel consumption increases due to engine efficiency loss between diesel (CI) engine and petrol (SI) engine vehicles.
	Maintenance	~	
	Fuel	–	
	Residual value	~	
Operational Performance	**Similar duties and performance** to regular vans due to the long range available between refuelling events. **Refuelling is easy**, there are nearly 1,500 refuelling stations offering LPG across the UK. **The vehicles are bi-fuel**, so they can operate on either petrol or LPG. **Payload** is similar to a regular van and the LPG tanks are normally mounted in the spare wheel cavity. If additional mileage is required tanks can also be fitted in the load space.		
Uncertainty	**Retro-fit options** available only therefore performance between systems and suppliers may vary. LPG UK (LPG trade association) maintains a list of approved system suppliers.		
Payback	**Vans** WLC savings available for medium to long ownership periods and mileage over 30,000 MPA. **See *Appendix A 8.6* for full WLC saving matrix**		
Benefits	**Environmental** similar CO_2 emissions to diesel vehicle with lower noise operation. LPG vans offer improved CO_2 emission compared to petrol vans. **Other** Positive driver feedback, good for company image and winning new work, retains similar performance to conventional vehicle. **Key applications** WLC savings available for medium to long ownership periods and mileage over 30,000 MPA.		

6.2.7 Dual Fuel LPG

Dual Fuel LPG Vehicle Information Table			
Availability	Retro-fitters are willing to provide systems for most weight classes. Most popular systems are available from 7.5t gross vehicle weight (GVW) and greater.		
Cost (vs. diesel)	**Capital**	~/+	Conversion costs range from circa £4.5k to £7.5k depending on vehicle GVW category. Maintenance costs increase by around £360 per annum.
	Maintenance	~	
	Fuel	–	
	Residual value	~	
Operational performance	**Similar duties** to regular trucks can be undertaken due to the long range available between refuelling events. **Diesel operation,** the vehicles retain the ability to operate solely on diesel if LPG is not available. **Bunkered fuel** is normally supplied at a fleet depot as a truck cannot fit under forecourt canopies. **Payload** is similar to a regular truck.		
Uncertainty	**No OEM systems**, therefore conversion quality may differ between manufactures.		
Payback	**Trucks** WLC savings were achieved after 3 years (for trucks undertaking around 100,000 MPA) or 10 years for lower mileage trucks are around 40,000 MPA). The payback information assumes the trucks will refuel from site bunkered LPG supplier (suppling a fleet of around 10 trucks). **See *Appendix A 8.7* for full WLC saving matrix**		
Benefits	**Environmental** similar or better CO_2 emissions to diesel vehicle with low noise operation. **Other** Positive driver feedback, good for company image and winning new work, retains similar performance to conventional vehicle. **Key applications** WLC savings available for medium to long ownership periods and mileage over 30,000 MPA.		

6.2.8 Biodiesel (FAME B20)

Biodiesel (FAME B20) Information Table			
Availability	Supported at various blends. Main support for B20 & B30 FAME blends, however B100 has been trialled successfully.		
Costs	Capital	~	Operating on biodiesel incurs slightly greater costs than diesel vehicles. Some manufacturers require a biodiesel upgrade package to be purchased with the vehicle which involves a negligible cost increase. Maintenance frequency also increases with biodiesel use. Fuel consumption may decrease due to the lower energy content of biodiesel.
	Maintenance	~	
	Fuel	~	
	Residual value	~	
Operational performance	**Similar** range and performance to a regular diesel vehicle, maintains the ability to run on diesel which can be used in the same tank. **Payload and load space** are unaffected. **Biodiesel blends** are normally provided as bunkered supplies to a fleet depot. Fuel is organic and has a shelf life of around 3-4 months.		
Uncertainty	**A good quality biodiesel**, manufactured to the EN 14214 standard should be used. Fuel quality and usage requires managing to ensure consistent and reliable product. This analysis has been completed using B20 (20% blend) as this is widely supported, and regarded a reliable all year-round blend of biodiesel. **OEM support** for biodiesel blends varies.		
Payback	**Biodiesel** offers good CO_2 reduction but generally increases costs (up to around 4%) as biodiesel operation sees increases in maintenance and fuel costs. **See *Appendix A 8.8* for full WLC saving matrix**		
Benefits	**Environmental** WTW CO_2 savings of up to 16% when using a B20 blend. **Other** Good for company image and winning new work. **Key applications** Good CO_2 reduction performance for fleets willing to absorb some additional management time and marginal cost increase.		

6.3 Out-of-Scope Technologies

A high-level summary of the key WLC performance information on technologies which are currently out-of-scope of the LoCITY Fleet Advice Tool are given in the table below.

Table 12 – Out of scope technologies information table

Dual-fuel methane	
Availability	Systems are currently being developed for Euro VI truck applications. Retro-fit suppliers are working to solve methane issues before systems can be a viable solution for fleets.
Costs	Capital cost of £20 - £30k for retrofit dual-fuel system, plus circa £1,000 per annum additional maintenance costs[19].
Main Limitations	Economics dependent on gas/diesel price differential and high mileage, high load duty cycle required for good economic performance. Not suitable for urban applications.
Uncertainty	Large performance variation between different retrofit systems has been reported.
Key applications	High mileage and high load operations give the best substitution ratio and economic performance. Not suited to urban operations.

Dual-fuel vegetable oil	
Availability	Available as retro-fit for vehicles over 12t.
Costs	Low retro fit cost (circa £6k). However, systems have similar running costs to a diesel trucks therefore system payback is not readily achieved. Heated oil refuelling tank also required at base. Fuel costs may be reduced if operator can supply their own used oil.
Main Limitations	Challenging economics.
Uncertainly	Proven reliability in the Low Carbon Truck trial. High substitution ratio in long haul applications. Unproven and lack of experience in city environments.
Key applications	Can provide significant WTW CO_2 savings at similar or marginal cost increase for long haul applications.
Dual-fuel diesel/H_2	
Availability	Can be retrofitted to any commercial vehicle. Current experience is with 3.5t vans and 26t RCVs.
Costs	+£30 - £40k for low number of systems. The additional capital cost and higher running costs result in uneconomic operation. Current vehicles are purchased and used in grant funded activity.
Main Limitations	Challenging economics without grant funding.
Uncertainly	Reliability and operational performance information not available.
Key applications	Enable hydrogen use in wide variety of vehicles. Best performance (Hydrogen to diesel substitution ratio) in urban applications. H_2 refuelling infrastructure required. Vehicle can operate on 100% diesel if H_2 refuelling is not available.
Hydraulic hybrid	
Availability	From 7.5t
Costs	Retro-fit costs of circa £15 - £30k dependent on vehicle.
Main Limitations	High mileage, high urban operation, high payload required for best payback.
Uncertainly	Limited UK experience, first customer evaluation trials are currently underway.
Key applications	Urban freight.
Range extended electric vehicle	
Availability	7.5t truck, 14t version currently in development.
Costs	Circa £60k for re-power of existing vehicle.
Main limitations	Over ~30,000 MPA with London CCZ entry and long ownership period, OR over ~60,000 MPA with 2 charges per day without congestion zone charge.
Uncertainty	Limited experience, no operational performance or reliability data available.
Key applications	High mileage applications with multiple charging or regular entry into a congestion charging zone.

7 Appendix A: WLC Sensitivity Tables

These appendices provide a series of sensitivity analysis tables showing the WLC savings available from each technology. The performance of the study technologies were determined using the LoCITY Fleet Advice Tool.

When reviewing the tables below it is important to consider the following points.

- The analysis provides an indication of the payback performance by varying the key factors of ownership period, annual mileage, duty cycle, number of recharges per day, congestion zone entry and alternative fuel price (where a large variation in supply price can exist).
- Typical fuel consumption performance and vehicle costs were used. Therefore, if comparator vehicles have an unusually high fuel consumption (driven aggressively, high payload, operate in hilly environments, have high auxiliary loads etc.) then this increases fuel consumption which in turn would improve the shown payback period and economics.
- The analysis highlights constraints but does not include the practicalities of operating the trucks e.g. up to 1/3rd payload loss in heavy EV vehicles or whether the annual mileage required for payback is commonly achieved by trucks operating in London.
- The analysis selects appropriate duty cycles for the vehicles. For example, heavy trucks are analysed on mostly motorway cycles, whereas light duty vans are analysed on mostly urban and regional drive cycles.

The analysis examines the annual mileage required by the vehicles to achieve payback. For reference, the table below presents the daily mileage required to achieve these annual mileages.

Table 13 – Daily mileage conversion table

Annual Mileage	Daily mileage (5 days per week)	Daily mileage (7 days per week)
10000	40	30
20000	80	60
30000	120	90
40000	160	110
50000	200	140
60000	240	170
70000	280	200
80000	320	230
90000	360	260
100000	400	290

7.1 Electric vehicle sensitivity analysis

Table 14 – Electric van WLC matrix

Electric Vehicle Analysis		Electric Van vs Diesel Van WLC Savings (£)								
Drive cycle		Mostly Urban			Mostly Urban			Mostly Urban		
Vehicle type		Small Van			Large Van OEM (<3.5t)			Large Van Low Volume (<3.5t)		
Ownership period	Miles	3	5	7	3	5	7	3	5	7
0 Days entry into the Congestion Zone	10,000	£2k (13%)	£3k (17%)	£5k (22%)						
	20,000	£4k (20%)	£7k (25%)	£10k (30%)						
	30,000	£6k (25%)	£10k (31%)	£14k (33%)						
	40,000	£8k [illegible]	[illegible]	[illegible]7k (34%)						
	50,000	[illegible]	[illegible]	[illegible]%)						
5 days entry into the Congestion Zone	10,000	[illegible]	[illegible]	[illegible]%)						
	20,000	£12[illegible]	[illegible]	[illegible]k (56%)						-£3k (-5%)
	30,000	£14k (45%)	£24k (51%)	£33k (54%)					-£7k (-12%)	£5k (6%)
	40,000	£16k (45%)	£26k (50%)	£36k (52%)		-£14k (-19%)	-£2k (-2%)		-£2k (-2%)	£12k (12%)
	50,000	£18k (46%)	£29k (49%)	£39k (50%)		-£10k (-12%)	£4k (4%)	-£13k (-24%)	£4k (4%)	£17k (16%)

SPV EVs have strong cost perf. both in and out of London CCZ

Large vans require a combination of ownership periods from around 5-years, daily entry into the London CCZ and high annual mileage to achieve payback

Table 15 – Electric truck WLC matrix

Electric Vehicle Analysis		Electric Truck Retro-fit vs Diesel Truck WLC Savings (£)											
Drive cycle		Mostly Urban			Mostly Regional			Mostly Regional			Mostly Regional		
Vehicle type		Rigid Truck (7.5 t)			Rigid Truck (12 - 18t)			Rigid Truck (26t)			Rigid Truck (32t)		
Ownership period	Miles	3	6	10	3	6	10	3	6	10	3	6	10
0 Days entry into the Congestion Zone	10,000												
	20,000												-£26k (-11%)
	30,000			-£11k (-7%)			[illegible] (-3%)						£17k (5%)
	40,000			£8k (4%)			£18k (7%)			[illegible] (9%)			£61k (15%)
	50,000	-£48k (-68%)	-£12k (-8%)	£27k (11%)	-£58k (-66%)	-£9k (-5%)	£42k (14%)	-£68k (-50%)	-£8k (-3%)	£66k (15%)	-£61k (-36%)	£13k (4%)	£104k (21%)
5 days entry into the Congestion Zone	10,000												-£53k (-29%)
	20,000			(-[illegible]						[illegible]3k ([illegible]%)			£2k (1%)
	30,000			£16k (9%)						£22k (7%)		-£23k (-10%)	£45k (13%)
	40,000			£35k (15%)		-£11k (-6%)	£45k (16%)		-£13k (-5%)	£58k (15%)		£3k (1%)	£88k (20%)
	50,000	-£40k (-50%)	-£4k (-3%)	£54k (20%)	-£50k (-52%)	£8k (4%)	£69k (21%)	-£60k (-41%)	£9k (3%)	£93k (20%)	-£52k (-29%)	£29k (9%)	£131k (25%)

Without a London CCZ EV trucks rely on high mileage and long ownership periods to achieve financial payback

Daily entry into the London CCZ helps improve financial performance but high daily mileages and long ownership periods are still required

Table 16 – Re-power electric truck WLC matrix

Refit Electric Vehicle Analysis		Electric Truck Re-power (EV drivetrain fitted into a reconditioned 5-year old truck) vs Diesel Truck WLC Savings (£)											
Drive cycle		Mostly Urban			Mostly Regional			Mostly Regional			Mostly Regional		
Vehicle type		Refit Rigid Truck (7.5 t)			Refit Rigid Truck (12 - 18t)			Refit Rigid Truck (26t)			Refit Rigid Truck (32t)		
Ownership period	Miles	3	6	10	3	6	10	3	6	10	3	6	10
0 Days entry into the Congestion Zone	10,000									-£45k (-34%)			-£37k (-24%)
	20,000			-£11k (-10%)			-£0.6k (0%)			£2k (1%)		-£31k (-19%)	£19k (8%)
	30,000			£12k (7%)		-£10k (-7%)	£31k (15%)		-£9k (-5%)	£37k (13%)		£3k (1%)	£62k (19%)
	40,000		-£2k (-2%)	£31k (15%)		£10k (6%)	£55k (22%)		£13k (6%)	£73k (20%)		£29k (11%)	£106k (26%)
	50,000	-£25k (-35%)	£11k (7%)	£50k (21%)	-£22k (-25%)	£28k (15%)	£79k (26%)	-£26k (-19%)	£35k (13%)	£108k (25%)	-£23k (-14%)	£56k (18%)	£149k (30%)
5 days entry into the Congestion Zone	10,000			-£8k (-8%)			-6k (-4%)			-£18k (-11%)			-£10k (-5%)
	20,000			£16k (11%)		-£13k (-11%)	£27k (15%)		-£21k (-14%)	£29k (12%)		-£15k (-8%)	£46k (17%)
	30,000		-£0.5k (0%)	£39k (21%)		£7k (5%)	£60k (25%)		£7k (4%)	£65k (21%)		£19k (8%)	£90k (25%)
	40,000		£14k (10%)	£58k (26%)		£26k [illegible]	£82k [illegible]		£30k [illegible]	£100k (26%)		£46k (16%)	£133k (31%)
	50,000	-£17k (-21%)	£28k (16%)	£77k (29%)	-£14k [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-£15k (-9%)	£72k (22%)	£177k (34%)

Lower cost re-power options allow EV trucks to payback between 6 – 10 years and lower annual miles of 20,000 MPA

7.2 Hybrid electric vehicle sensitivity analysis

Table 17 – Hybrid electric truck WLC matrix

Hybrid Electric Vehicle Analysis		Hybrid Electric Truck vs Diesel WLC Savings (£)								
Drive cycle		Mostly Urban			Mostly Regional			Mostly Motorway		
Vehicle type		Rigid Truck 2 axles (7.5t GVW)			Rigid Truck 2 axles (7.5t GVW)			Rigid Truck 2 axles (7.5t GVW)		
Ownership period	Miles	3	6	10	3	6	10	3	6	10
Annual Mileage	10,000									
	20,000			-£0.1k (0%)						
	30,000		-£1k (-1%)	£3k (2%)			-£1k (-1%)			
	40,000	-£3k (-5%)	£1k (1%)	£7k (3%)			£1k (0%)			
	50,000	-£2k (-3%)	£3k (2%)	£10k (4%)	-£4k (-6%)	-£1k (-1%)	£3k (1%)	-£6k (-9%)	-£6k (-4%)	-£5k (-2%)

WLC savings are available for high mileage or high ownership period urban applications. Savings start from around 20k MPA

7.3 Plug-in hybrid electric vehicle sensitivity analysis

Table 18 – Plug-in hybrid WLC matrix

Plug-in Hybrid Electric Vehicle Analysis		Plug-in Hybrid Electric 4Work Van vs Small Diesel Van WLC Savings (£)					
Drive cycle		Mostly Urban			Mostly Regional		
Vehicle type		Small Van			Small Van		
Ownership period	Miles	3	5	7	3	5	7
0 Days entry into the Congestion Zone 1 charge per day	10,000	£0k (1%)	-£1.5k (-6%)	-£2.5k (-9%)	-£0k (-0%)	-£1.5k (-6%)	-£3k (-10%)
	20,000						
	30,000						
5 days entry into the Congestion Zone 1 charge per day	10,000	£8k (28%)	£12k (31%)	£16k (34%)	£8k (29%)	£12k (31%)	£16k (34%)
	20,000	£4k (12%)	£6k (14%)	£9k (15%)			
	30,000	£1k (2%)	£1.5k (3%)	£2k (3%)			
0 Days entry into the Congestion Zone 2 charges per day	10,000	£2k (8%)	£1k (3%)	£0k (0%)	£1k (7%)	£0.5k (1%)	-£1k (-3%)
	20,000	£-2k (-7%)	£-4.5k (-13%)	£-7k (-18%)	£-2k (-7%)	£-5k (-14%)	£-7k (-19%)
	30,000						
5 days entry into the Congestion Zone 2 charges per day	10,000	£10k (35%)	£14k (37%)	£19k (40%)	£10k (34%)	£14k (36%)	£18k (39%)
	20,000	£6k (19%)	£9k (19%)	£12k (20%)	£6k (19%)	£9k (19%)	£12k (20%)
	30,000	£3k (9%)	£4k (8%)	[illegible]	[illegible]	£4k (8%)	£5k (7%)

Entry into the London CCZ or multiple charging per day is required to enable the PHEV 4/work van to payback. Economics worse as mileage increases due to increased use of the petrol engine

7.4 Fuel cell range extended electric vehicle sensitivity analysis

Table 19 – Fuel cell range extended WLC matrix

Fuel Cell Range Extended Electric Vehicle (REEV)		FC REEV vs Diesel Van WLC Savings (£)					
Drive cycle		Mostly Urban			Mostly Regional		
Vehicle type		Small Van			Small Van		
Ownership period	Miles	3	5	7	3	5	7
5 days entry into the Congestion Zone £10.50 /kg H2	10,000	£2k (10%)	£7k (21%)	£12k (30%)	£2k (9%)	£6k (20%)	£12k (30%)
	20,000	£3k (11%)	£9k (22%)	£16k (31%)	[illegible]	[illegible]	£15k (30%)
	30,000	£1k (5%)	£6k (14%)	£13k (22%)	[illegible]	[illegible]	[illegible]
0 days entry into the Congestion Zone £10.50 /kg H2	10,000						
	20,000						
	30,000						
5 days entry into the Congestion Zone £6 /kg H2	10,000	£2k (10%)	£7k (21%)	£12k (30%)	£2k (9%)	£6k (20%)	£12k (30%)
	20,000	£3k (11%)	£9k (22%)	£16k (31%)	£3k (10%)	£8k (21%)	£15k (30%)
	30,000	£3k (10%)	£9k (21%)	£17k (29%)	£2k (8%)	£8k (19%)	£16k (27%)
0 days entry into the Congestion Zone £6 /kg H2	10,000						
	20,000						
	30,000						

London CCZ is required to enable cost effective

The combination of London CCZ entry and high EV miles allow strong WLC savings

WLC cost savings are strong with high daily mileage in EV mode and the daily entry into the LCZ combine. Savings diminish once hydrogen begins to be consumed. In the example above the EV is capable of 80 miles a day (20,000 MPA) before H_2 consumption begins.

7.5 Dedicated gas sensitivity analysis

Table 20 – Dedicated gas van WLC matrix

Gas Vehicle Analysis		Gas Van vs Diesel Van WLC Savings (£)					
Drive cycle		Mostly Urban			Mostly Urban		
Vehicle type		CNG Large Van (<3.5t)			CNG Large Van (>3.5t)		
Ownership period	Miles	3	5	7	3	5	7
Gas price low (£0.70 per kg)	20,000	-£5k (-17%)	-£3k (-7%)	-£1k (-2%)	-£3k (-8%)	-£1k (-3%)	£0.4k (1%)
	40,000	-£2k (-5%)	£1k (2%)	£4k (5%)	-£0.4k (-1%)	£3k (4%)	[illegible]
	60,000	£0.1k (0%)	£5k (6%)	£9k (9%)	£2k (3%)	[illegible]	[illegible]
	80,000	£2k (4%)	£8k (8%)	£14k (11%)	£5k (6%)	[illegible]	[illegible]
	100,000	£4k (6%)	£12k (10%)	£19k (12%)	£7k (8%)	[illegible]	[illegible]
Gas price med (£0.85 per kg)	20,000						
	40,000	-£5k (-13%)	-£4k (-7%)	-£3k (-4%)	-£4k (-8%)	-£3k (-4%)	-£2k (-2%)
	60,000	-£4k (-8%)	-£3k (-3%)	-£1 (-1%)	-£3k (-5%)	-£1k (-1%)	£0.2k (0%)
	80,000	-£4k (-6%)	-£2k (-2%)	£0.3k (0%)	-£2k (-3%)	-£0.1k (0%)	£2k (1%)
	100,000	-£3k (-4%)	-£0.5k (0%)	£2k (1%)	-£1k (-2%)	£1k (1%)	£4k (2%)
Gas price high (£1 per kg)	20,000						
	40,000						
	60,000						
	80,000						
	100,000						

At a low gas price (£0.70/kg vs £0.95p/litre diesel) a lower WLC for vans achieving 30k-40k MPA is available

When gas and diesel price are similar, payback cannot be achieved

Table 21 – Dedicated gas truck WLC matrix

Gas Vehicle Analysis		Gas Truck vs Diesel Truck WLC Savings (£)								
Drive cycle		Mostly Regional			Mostly Motorway			Mostly Motorway		
Vehicle type		CNG Rigid Truck (3 axle 26t)			CNG Artic Truck (4x2)			LNG Artic Truck (4x2)		
Ownership period	Miles	3	6	10	3	6	10	3	6	10
Gas price low (£0.70 per kg)	20,000	-£39k (-56%)	-£19k (-14%)	-£3k (-2%)	-£51k (-86%)	-£22k (-15%)	-£6k (-3%)	-£51k (-86%)	-£22k (-16%)	-£4k (-2%)
	40,000	-£29k (-25%)	£0.2k (0%)	£26k (8%)	-£42k (-42%)	-£5k (-2%)	£21k (6%)	-£41k (-41%)	-£3k (-1%)	£26k (8%)
	60,000	-£20k (-12%)	£18k (6%)	£56k (11%)	-£34k (-24%)	£12k (4%)	£47k (11%)	-£31k (-41%)	£16k (5%)	£56k (12%)
	80,000	-£11k (-5%)	£36k (9%)	£85k (13%)	-£26k (-14%)	£27k (6%)	£73k (13%)	-£22k (-22%)	£34k (9%)	£86k (14%)
	100,000	-£2k (-1%)	£54k (11%)	£114k (14%)	-£18k [illegible]	[illegible]	[illegible]	-£13k (-6%)	£53k (11%)	£116k (16%)
Gas price med (£0.85 per kg)	20,000									
	40,000									
	60,000	-£35k (-22%)	-£13k (-4%)	£4k (1%)	-£49k [illegible]	[illegible]	[illegible]	-£46k (-33%)	-£12k (-4%)	£9k (2%)
	80,000	-£32k (-16%)	-£6k (-1%)	£16k (2%)	-£46k (-26%)	-£13k (-3%)	£5k (1%)	-£41k (-23%)	-£3k (-1%)	£23k (4%)
	100,000	-£28k (-11%)	£2k (0%)	£28k (3%)	-£43k (-20%)	-£8k (-2%)	£14k (2%)	-£37k (-17%)	£5k (1%)	£37k (5%)
Gas price high (£1 per kg)	20,000									
	40,000									
	60,000									
	80,000									
	100,000	-£54k (-22%)	-£50k (-10%)	-£58k (-7%)	-£69k (-31%)	-£59k (-13%)	-£71k (-10%)	-£60k (-27%)	-£42k (-9%)	-£42k (-6%)

Good cost savings can be achieved when a low gas price is available to fleets

When gas and diesel price are similar, pay back cannot be achieved

7.6 Dedicated LPG sensitivity analysis

Table 22 – LPG van WLC matrix

Dedicated LPG Analysis		Dedicated LPG Van vs Diesel Van WLC Savings (£)					
Drive cycle		Mostly Urban			Mostly Urban		
Vehicle type		Small Van			Large Van (<3.5t)		
Ownership period	Miles	3	5	7	3	5	7
Annual Mileage	10,000						
	20,000		-£0.7k (-3%)	-£0.4k (-1%)		-£0.9k (-2%)	-£0.5k (-1%)
	30,000		-£0.3k (-1%)	£0.1k (0%)		-£0.2k (0%)	£0.5k (1%)
	40,000		£0.1k (0%)	£0.7k (1%)		£0.4k (1%)	£1k (2%)
	50,000	-£0.2k (-1%)	£0.5k (1%)	£1k (2%)	-£0.1k (0%)	£1k (2%)	[illegible]
	60,000	£0.1k (0%)	£0.9k (2%)	£2k (3%)	£0.2k (0%)	[illegible]	[illegible]

Savings available for medium to long ownership periods and mileage over 30k MPA

7.7 Dual Fuel LPG sensitivity analysis

Table 23 – Dual fuel truck WLC matrix

Dual Fuel LPG Analysis		Dual Fuel LPG truck Vs Diesel truck WLC Savings (£)								
Drive cycle		Mostly Urban			Mostly Regional			Mostly Motorway		
Vehicle type		Rigid Truck (2 axle 7.5t)			Rigid Truck (3 axle 26t)			Artic 4x2		
Ownership period	Miles	3	6	10	3	6	10	3	6	10
Default LPG price £0.46 per litre	10,000									
	20,000									
	40,000									
	60,000			-£2k (-1%)						
	80,000			£0.2k (0%)						
	100,000		-£0.4k (-1%)	£0.2k (1%)			-£0.2k (0%)			
	120,000	-£2k (-1%)	£0.8k (0%)	£4k (1%)	-£4k (-1%)	-£1k (0%)	£2k (0%)	-£6k (-2%)	-£5k (-1%)	-£3k (0%)
LPG price £0.32 per litre (circa 10 trucks)	10,000									
	20,000						-£4k (-2%)			
	40,000			-£2k (-1%)		-£2k (-1%)	£1k (0%)			-£0.04k (0%)
	60,000		-£1k (-1%)	£1k (0%)		£2k (0%)	£7k (1%)		-£0.05k (0%)	£5k (1%)
	80,000		£0.9k (0%)	£4.5k (1%)	-£0.6k (0%)	£5k (1%)	£12k (2%)		£3k (1%)	£10k (2%)
	100,000	-£0.9k (-1%)	£3k (1%)	£8k (2%)	£1k (0%)	£8k (2%)	£17k (2%)	-£0.6k (0%)	£6k (1%)	£16k (2%)
	120,000	£0.01k (0%)	£5k (1%)	£11k (2%)	[illegible]	[illegible]	[illegible]	[illegible]	£10k (2%)	£21k (2%)

For small numbers of vehicles the cost of fuel is not low enough to allow a cost saving

High capacity bunkered fuel supply allows lower fuel costs and payback after 3 years (for 100k MPA) or 10 years for ~40k MPA)

7.8 Biodiesel B20 (FAME) sensitivity analysis

Table 24 – Biodiesel van WLC matrix

Biodiesel Analysis		Biodiesel (B20) Vs Diesel van WLC Savings (£)			
Drive cycle		Mostly Urban		Mostly Urban	
Vehicle type		Small Van		Large Van (<3.5t)	
Ownership period	Miles	5	7	5	7
Annual Mileage	20,000	-£1k (-4%)	-£1k (-5%)		
	40,000	-£2k (-5%)	-£3k (-6%)		
	60,000	-£3k (-6%)	-£4k (-6%)		
	100,000	-£5k (-7%)	-£7k (-&%)	-£5k (-4%)	-£7k (-4%)

Table 25 – Biodiesel truck WLC matrix

Costs increase with mileage as biodiesel is generally purchased at a slight premium to fossil diesel

Biodiesel Analysis		Biodiesel (B20) Vs Diesel truck WLC Savings (£)					
Drive cycle		Mostly Urban		Mostly Regional		Mostly Motorway	
Vehicle type		Rigid Truck (2 axle 7.5 t)		Rigid Truck (3 axle 26t)		Artic 4x2	
Ownership period	Miles	5	10	5	10	5	10
Annual Mileage	20,000						
	40,000						
	60,000						
	100,000	-£8k (-4%)	-£17k (-4%)	-£12k (-3%)	-£24k (-3%)	-£10k (-3%)	-£19k (-3%)

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