Low Carbon HGVs - Market Background Study

Prepared for the Low Carbon Vehicle Partnership/Department for Transport

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Executive Summary

This project is the second in a programme of five studies being carried out on behalf of the Low Carbon Vehicle Partnership (LowCVP) Commercial Vehicle Steering Group, supported by the Department for Transport (DfT). The programme aims to understand the benefits of applying low carbon vehicle technologies to medium and heavy commercial vehicles, and will provide an improved understanding of how the efficiency improvements from low carbon technologies achieved in test conditions, compared with the efficiencies achieved in service. The desired outcome is to help identify those technologies, which if supported, could subsequently deliver the greatest carbon reductions from these vehicle types. The technology scope was aimed primarily at those measures which would be suitable for retro-fitting to existing vehicles, or which could be easily specified as a factory option.

This project (the Low Carbon HGV Market Background study) aims to provide an initial understanding of the views of fleet operators regarding the investment in, and use of, these technologies, along with an appreciation of any incentivisation measures that may increase uptake where market failures exist. It also aimed to provide an assessment of the cost effectiveness of several examples of the technologies. It would provide the programme with a model for making this assessment and also for assessing the basic cost-benefit of an incentive scheme.

Semi-structured telephone Interviews were carried out with 30 HGV operators from a range of sectors. The project aimed to target small and medium-sized enterprises (SMEs) – 62% of those interviewed fell into this category. The interviews produced several key findings:

- Operators generally have a good understanding of what constitutes a low-carbon HGV technology, and the range of things available to them;
- There is a fair amount of practical experience of using some of these technologies – usually driven either by a desire for greater vehicle efficiency, or through regulations.
- Where an upfront investment is required by the operator, a payback is generally expected at most within around two years – less is preferred.
- The additional capital cost of low carbon vehicle technologies can be a barrier to uptake. If the payback is short then some operators will consider trialing; where a greater investment is required and the payback is longer (e.g. electric vehicles) financial support may be needed.
- Operators are reluctant to invest in a technology where this payback period is unproven, or where they cannot identify some kind of confirmation of savings that are independent of the manufacturers' claims.

The main conclusion of the survey is that while operators seem to have a good understanding of their vehicles and potential efficiency measures, they need greater confidence of the payback if they are to make an additional investment in new technologies. This suggests that an independent accreditation scheme would be effective in helping operators to make this decision, and could therefore lead to an increase in uptake of certain low carbon technologies. It is also suggested, however, that there is a role for providing financial support for those technologies where the payback is beyond that needed by the operators.

In order to understand the current cost effectiveness of these kinds of technologies, the study also undertook to produce a cost effectiveness calculator. This allowed the overall payback potential to be determined, both in terms of the financial/CO_2 savings to the operator over the life of the vehicle, and the savings to society using two uptake scenarios out to 2020.

On the basis of test data on fuel savings supplied by the Millbrook/TRL testing project for several technologies, and using available information on costs, the calculator was able to show significant

savings potential (both fuel and CO_2) within a short enough payback period to be of interest to fleet operators. However, for measures such as light-weighting of vehicle bodies, the payback has been shown to be far less appealing, further suggesting the need for financial support if high levels of uptake are desired.

The project also included a review of global incentive schemes in order to provide a summary of those that might be relevant in the context of increasing the uptake of low carbon technologies for HGVs in the UK. This review identified an extensive list of schemes around the world. In most cases these were targeted at providing financial support for investment in measures capable of significant savings, but where the capital cost is currently very high in relation to a standard vehicle – such as the large number of electric vehicle schemes.

The review identified several schemes directly targeting HGVs. The most significant is running in the United States - the EPA Smartway scheme provides accreditation for manufacturers of low carbon vehicles and for 'Upgrade' packs for retrofitting. Financial support is provided through a loan scheme to help with upfront investment costs.

However, schemes were also identified from other sectors that may be considered as a potentially suitable model that could be adapted for use in a HGV context (such as the Enhanced Capital Allowance scheme).

To help with future assessments of incentive schemes, the cost effectiveness model includes a basic cost benefit analysis calculator, which can be used to get an idea of the potential costs and benefits to society of a particular incentive scheme. To give an indication of how the calculation works, the costs of the ECA scheme were included, in relation to uptake scenarios for two of the technologies tested.

The study concluded overall that:

- Operators want to save fuel and are therefore aware of technology solutions.
- A short payback period is important – particularly to smaller fleets.
- They need independent proof that the payback is there – confirming a need for a technology certification scheme.
- Some technologies have been clearly shown to deliver a short payback through the cost effectiveness tool – others are longer or do not payback at all.
- Where the payback period is too long or the upfront costs too high, financial incentives will be needed in order to help operators to invest in these technologies until such time that costs come down and payback periods reduce to an acceptable level.
- Schemes which combine an accredited list with financial assistance could be applied to address both the need for verification and a short payback period – indications are that if focused on the most cost effective technologies, they could provide a good cost-benefit to society.

To achieve increased uptake of Low Carbon HGV technologies, this research suggests that two key actions are required: the introduction of an independent certification scheme; and the provision of subsidies to increase uptake of technologies where payback/Return on Investment is weak. This suggests a clear role for Government in order to support the introduction of these measures, which are unlikely to happen if left to the market alone. Some evidence was found to suggest that in some cases non-financial interventions (e.g. provision of advice/information; demonstration trials) could help, but the study did not specifically set out to assess this type of policy intervention so would require further analysis to build a better understanding of their suitability.

Contents

1 Introduction

1.1 Background

This project is part of a programme of work to measure the benefits of applying low carbon vehicle technologies to medium and heavy commercial vehicles. The programme consists of five separate, but related projects that will collectively provide the Freight, Insurance and Licensing Division of the Department for Transport (DfT) with an improved understanding of how the efficiency improvements from low carbon technologies achieved in test conditions compare with the efficiencies achieved in service. The desired outcome is to help identify those technologies, which if supported, could subsequently deliver the greatest carbon reductions from these vehicle types.

The five projects are as follows:

Project 1. Technology road map project (Ricardo)

Project 2. Low carbon HGV market study (AEA)

Project 3. Technology testing project (TRL/Millbrook)

Project 4. Low carbon HGV technology accreditation and whole vehicle integration (TRL)

Project 5. Low carbon HGV efficiency modelling

This work is directly linked to the DfT's strategy to ensure that transport delivers the required carbon savings towards the Government's obligations under the UK's carbon budgets to 2022. Recognising that freight emissions account for approximately 30 per cent of all domestic transport emissions, and that HGVs contribute over 20 per cent, the DfT is assessing what can be achieved through measures targeted at increasing the uptake of low carbon technologies by HGV operators.

An initial focus is to understand more about those technologies that have the capability to deliver significant carbon reductions, that are either currently available, or near to market. In this respect, other work within the programme will aim to understand from a supply side perspective, the technologies that will be available for deployment across the sector, and their measured/calculated CO_2 saving potential. However, to complete the picture, an understanding from a demand side perspective of the readiness of the market to take up these technologies is also needed, along with an appreciation of any measures that may increase deployment where market failures exist.

The Low Carbon Vehicle Partnership (LowCVP) has played an important role in supporting the DfT's strategy in this area, and helped form the Commercial Vehicle Steering Group to oversee and inform specific strategy for HGV technologies. This group is made up of a range of trade associations, vehicle manufacturers and other stakeholders, and has been important in shaping the direction of the work.

1.2 Aims and objectives

This study has the overarching objective of providing greater clarity on the market situation for low carbon HGV technologies.

It aims to achieve this through three key areas of work:

- It aims to explore current attitudes towards certain low carbon HGV technologies, particularly among Small and Medium–sized Enterprise (SME) HGV fleet operators. This looks into the reality of the reported resistance to these technologies, and identifies barriers or preconceptions put up by operators in this category - e.g. concerns over the return on investment (ROI). This includes information on those measures that may be needed to incentivise operators to take up low carbon technologies in the case of market failure.
- It aims to undertake a review of the incentives available to Government and industry that could increase uptake of low carbon technologies for HGV operators across SME and large organisations. This includes an assessment of their relative strengths and weaknesses, and aims to include any which may be outside of the existing measures used in this context.
- It aims to consider the cost effectiveness of several of the most significant technologies. This will enable the DfT to better appreciate the carbon savings feasible to 2015 and 2020, and the level of uptake needed to achieve them. This will also summarise the fuel/financial savings potential to operators, and can therefore be related to any ROI concerns expressed in the SME survey. It will also provide information which could be used to inform the possible scale of any incentives required. Related to this, a framework will be developed through which incentivisation measures can be assessed from a cost-benefit perspective.

We hope that this report will provide a useful contribution to the first phase of this important programme of work and that it will help the DfT, the LowCVP and the Commercial Vehicle Steering Group to better understand the actual situation, and provide a starting point for thinking about suitable and effective policy measures to help increase uptake of Low Carbon technologies by HGV operators.

1.3 HGV Technology

In this programme of work, a ‘low-carbon HGV technology’ is considered to be a vehicle-based measure that has the capability to deliver measurable improvements in the direct fuel efficiency of an HGV (>7.5 tonnes), and therefore lead to reduced CO_2 emissions. Technologies can range from design and specification related measures such as lightweight bodies and in-built aerodynamic shaping, to retrofit devices such as add-on aerodynamic kits and low rolling resistance tyres (LRRTs). In addition, engine modification and alternative powertrains also represent distinct low carbon HGV technology options.

Within the freight transport sector, there are a range of other measures HGV operators can employ that can deliver efficiency improvements and fuel savings such as driver training, route optimisation and measures to reduce empty running. However, these are not directly related to the vehicle itself and are therefore not within the primary aims of this study.

Between these two groups lie measures that can be considered a change to the vehicle, but do not directly reduce the fuel used in that vehicle. They can however, reduce the need for journeys and therefore help to improve overall fuel use within a particular fleet. Double-deck trailers for example, can enable increased loads to be carried where volume would normally be a limiting factor.

In March 2010, Ricardo completed a review of Low Carbon Technologies for Heavy Goods Vehicles for the Department for Transport. The review provides a detailed grouping of the types of low carbon HGV technology available – these are summarised in Table 1 below. This table serves to illustrate the range of technologies that are either currently available or under development, and that could therefore arise during the course of this market study.

As part of this current work programme, Ricardo is providing a more detailed ‘Roadmap’ (through Project 1) of these technologies, indicating expected market introduction timings.

Table 1: Range of low carbon HGV technology and spectrum with reported CO_2 benefit/ abatement potential (from Ricardo review/ market and industry reports)

Technology		**Reported CO_2 benefit/ abatement potential (where available)** [1]
Aerodynamic Trailers (Various)		Average: 12.2%
Aerodynamic Trailers	Aerodynamic trailers (box)	Range: 4 - 23.7% Average: 11.2%
	Aerodynamic trailers (curtain side)	Range:5.6 – 14.7% Average: 8.6%
	Aerodynamic trailers (double & lifting decks)	Average: 16.7% (no further details provided)
Aerodynamic kits and additions	Aerodynamic Fairings (Trailer)	Range: 0.1 - 6.5%
	Aerodynamic Fairings (Cab Fairings)	Average: 17t rigid: 4.8% 40t Artic: 3.7% 40t drawbar: 2.3%
	Aerodynamic Fairings (Cab Collar & roof fairing)	Average: 17t rigid: 6.5% Artic (ex roof fairing): 0.6% 40t drawbar: 3.2%
	Container front Fairing	Average: 17t rigid: 3.6% 40t Artic: 1.8% 40t drawbar: 0.7 – 1.6%
	Chassis/ Trailer side panels	Average: 17t rigid: 1% 40t Artic: 0.4% 40t drawbar: 0.7%
	Trailer roof tapering	Average: 17t rigid: 0.5% 40t Artic: 0.3% 40t drawbar: 0.1 – 0.3%
Low Rolling Resistance Tyres		Range: 4.72 – 13%[2]
Automatic Tyre Pressure Adjustment		Range: 7 - 8% Average: 7%
Vehicle Platooning * Important safety considerations in the UK/ EU		Average: 20%
Predictive Cruise Control		Range: 2 – 5.2%
Single Wide Tyres* *Uptake limited by legislation which requires twin wheels on the drive axle of vehicles over 40 tonnes		Range: 2 - 10% Average: 6%
Spray reduction mud flaps		Range: 2 – 3.8%

[1] CO_2 abatement potential sourced from Ricardo's *Review of Low Carbon Technologies for Heavy Goods Vehicles* available at http://www.dft.gov.uk/pgr/freight/lowcarbontechnologies/lowcarbon.pdf plus additional sources as indicated.
[2] Figure of 13% obtained from Freight Best Practise, *Save Fuel with Lower Rolling Resistance Tyres* Case Study available from http://www.freightbestpractice.org.uk/case-studies

Technology		Reported CO_2 benefit/ abatement potential (where available) [1]
Vehicle Bodies – electric or alternative fuel power sources for vehicle bodies (e.g. refuse trucks/ refrigerated trucks)	Refrigerated trailer – e.g. Eco-fridge	20%
	Refrigerated trailer – e.g. Electrimax	15%[3]
	Electric motor - plug in refuse truck body to drive the lifting and compacting mechanisms allowing the engine to be stopped during collection. Charges overnight (plug-in) and during operation.	20% - 30%[4]
	Volvo refuse truck (Asda trials) one also uses an electric motor which is charged through regenerative braking or plug in. The 26-tonne FE-series rigid is fitted with diesel and electric power sources and carries a waste-collection body and also has the potential to run on biofuel.	10% (stated as the additional CO_2 saving over a standard hybrid refuse truck)[5]
Lightweight Bodies	Roadlite	-
	Other – e.g. manufacturer design and build according to customer specification	-
Alternative fuels	FAME (1st Generation Biodiesel)	Range: -5 – 90% GHG – Well to Wheel (WTW)
	Biodiesel	Range: -5 – 90% (GHG – WTW)
	BTL (2nd Generation Biodiesel)	Range: 60 – 90% (GHG – WTW)
	HVO (2nd Generation Biodiesel)	Range: 40 – 60% (GHG – WTW)
	CNG *CO2 emissions compromised to meet with NOx regulation.	Range: 7 – 20%[6]
	Biomethane *Strongly influenced by combustion type (e.g. bi-fuel/dual fuel) * Theoretical maximum could go beyond 100% if using feedstock which avoids release of methane from certain sources.	Range: <41-65%[7]
	Hydrogen * infrastructure issues	Zero tailpipe emissions
Electric & Hybrid	Example: Volvo parallel hybrid truck	Range: 15 - 30% GHG Diesel engine auto switch off to avoid idling.
	Example: Smith electric vehicle Commercially available in 7.5, 10 and 12 tonne GVW with a maximum range of 150 miles. Batteries available as Lithium Ion Iron Phosphate or Sodium Nickel Chloride Zebra Z5 and features regenerative braking along with mains charging (8 hours)	Zero tailpipe (fully electric)
CO_2 abatement potential sourced from Ricardo's *Review of Low Carbon Technologies for Heavy Goods Vehicles* available at http://www.dft.gov.uk/pgr/freight/lowcarbontechnologies/lowcarbon.pdf plus additional sources as indicated		

[3] According to trial reports by the manufacturer – available from: http://www.johnsontruckbodies.com/refrige/electrimax.asp

[4] Figure of 30% savings from a report, by the manufacturer based on ongoing trials in Sweden, available from: http://www.geesink.nl/frameset.asp?intLangId=1&CountryCode=GB

[5] According to manufacturer trials in conjunction with Asda – information available from http://www.advantagehgv.co.uk/news/2008/04/21/volvo-launches-new-hybrid-hgv/

[6] Feasibility Study for a Road Vehicle Biomethane Demonstration Project, Report for the DfT by AEA, 2010

[7] Feasibility Study for a Road Vehicle Biomethane Demonstration Project, Report for the DfT by AEA, 2010

Whilst there is clearly a wide range of low carbon HGV technology available, this study was to have a particular focus on those identified in the Ricardo study as having the greatest potential for achieving CO_2 savings potential. During the early stages of this project, these were agreed to be:

1. Aerodynamic measures (cab deflectors and side skirts)
2. Low rolling resistance tyres
3. Aerodynamic trailers
4. Lightweight bodies

These would be the subject of cost-effectiveness analysis, and would be explored in more detail with operators where they had particular experience of their use, or pre-conceptions on their efficacy.

1.4 Structure of this report

This report is structured around the three key work packages within the project.

Section 2 will summarise the survey of commercial vehicle operators, in terms of the approach taken and the types of operator interviewed, and will draw out the key themes from their responses.

Section 3 covers the review of international incentive schemes used to drive the uptake of low carbon technologies – predominately in a road transport context, but those used in an energy context are also considered.

Section 4 gives an overview of the work carried out to calculate the cost effectiveness (in terms of £ per tonne of CO_2) of four technology types. The model created to perform the calculations is explained and the assumptions set out; the calculations themselves are then presented and the results discussed. The model used to carry out the calculations has been passed to the DfT for their future use.

Section 5 summarises work carried out to develop a basic cost-benefit framework to allow the evaluation of such schemes – one of which has been analysed, the results of which are also discussed in this section.

Section 6 attempts to pull together the findings of these three packages of work in order to draw some conclusions on the market readiness for low carbon HGV technologies, and to make some initial suggestions on how barriers to uptake may be overcome.

Additional detail about the operator interviews and incentive schemes reviewed, and the modelling approach can be found in the appendices.

The spreadsheet model for calculating cost effectiveness and a detailed summary of the operator survey have been provided separately to this report.

2 Operator Survey

A central aim of this project was to give an idea of market attitudes towards low carbon HGV technologies, through targeted interviews with HGV fleet operators. This was an initial investigation based on a low sample size, and should therefore not be thought of as being fully representative of the views of a large and diverse sector. However, it has served to provide confirmation on the aspects of the LowCVP work programme, and to act as a 'reality-check' for some of the other projects – e.g. in having confidence over the suitability of the types of technologies on test in the Millbrook/TRL project. It also provides a feel for certain issues, which will be of use in developing the later phases of the programme – e.g. the importance of testing and accreditation to operators, and views on financial incentives.

Of main interest to the DfT/LowCVP are the views of SME (Small and Medium-sized Enterprise) operators. An SME is often defined as a business with <250 employees or a turnover of less than or equal to a certain amount (€50 million according to a definition by the European Commission).

This study aimed to hold one-to-one, semi-structured telephone interviews with 25 operators from a range of sectors. It was hoped that these could be targeted to include a range of operator sizes within the SME category, ranging from 'micro' (fewer than nine members of staff which also encompasses businesses with only one staff member – usually an owner-driver) through to medium-sized transport providers'. For the purposes of this study, HGV fleet size was used as an indicator of business size in order to gain an accurate depiction of operator perceptions of low carbon HGV technologies. The small sample size would aim to give an initial view on the issues, in order to help inform other tasks within the work programme and reality-check some of the assumptions made in modelling work.

In order to get a feel for how SME operators compare to some of the larger fleet operators who were likely to be more familiar with these technologies, we also aimed to carry out five further interviews with those with far bigger operations.

The intention was to speak to fleet managers or those that would be involved in the decision-making for fleet replacement/enhancement. The following steps were taken to complete the interview process:

1. A matrix of target sectors/operator types/vehicle types was proposed to ensure a broad coverage.

2. An interview script was designed, including introductory pre-amble and a list of key questions (approved by the DfT/LowCVP). (See Appendix 1)

3. Possible participants were identified through consultation with the trade associations, the Commercial Vehicle Steering Group, and other industry/DfT contacts.

4. Initial telephone calls were made outlining the purpose of the programme and attempted to schedule interview dates and times with operators.

5. Telephone interviews were carried out, with all responses captured using a pre-designed spreadsheet. In some cases, respondents were happy to be interviewed on the spot and so steps 4 and 5 were combined.

6. Survey responses were analysed, highlighting common themes and responses that contribute to answering the project aims.

2.1 Targeting of respondents

The initial intention was to seek respondents over as broad and representative a section of HGV operators as possible. The target respondents were classified initially into fleet size in order to determine which sub-category they belong to:

Owner/Driver	1 vehicle
Micro	9 vehicles or less
Small Fleet Operator	10 – 25 vehicle fleet operator
Medium Fleet Operator	26 -50 vehicles
Large Operator	Greater than 50 vehicles in fleet

The approach to classification by size of operator was informed by the method used in the DfT's Road Freight Statistics publication. Operators with 50+ vehicles were identified as 'large' operators for the purposes of this study due to the proportionally small number of operators at that size and the SME focus of this study. Whilst it could have been possible to break down the 'micro' SMEs into groups more in line with the DfT Road Freight Statistics, it was recognised that smaller operators are a hard to reach group for participation in studies of this nature.

The second element considered was the type of operation the organisation carries out, as this has a direct influence on the type of vehicle that the organisation will use. The full range of organisations considered for participation was scoped, along with types of vehicle they are considered likely to operate. Some operations were not recommended for participation due to the overly niche and/or task specific nature of their operations and vehicle types that would mean responses would not be representative of the HGV operations sector (e.g. agriculture has not been included as a distinct category, however the primary reason for on-road HGV vehicle movements – e.g. livestock movement was not discounted when seeking interviews with operators).

The following matrix illustrates the spread originally intended:

Table 2: Intended spread of survey

	Fleet size of operator				
Type of operator	**1**	**2-9**	**10-25**	**26-50**	**50+**
Haulage	4	3	3	1	2
Construction and Demolition		2	3	1	
Oil and Gas			1	1	1
Waste Management				1	
Retail				1	1
Manufacturers (Suppliers)			3	1	1
Sub-total for each category	**4**	**5**	**10**	**6**	**5**

Total number of operators to interview - 30 (25 SMEs and five large operators)

This approach was approved by the DfT before being circulated to trade association members of the Commercial Vehicle Steering Group for approval. Interviews were generated from a range of contacts provided to the study team, but needed to be supported with a campaign of 'cold-calling' by AEA to generate sufficient interview numbers. The final spread is shown in Table 3, below.

Table 3: Operator interviews

	Fleet size of operator (vehicles)				
Type of operator	**1**	**2-9**	**10-25**	**26-50**	**50+**
Haulage		4	4	6	7
Construction and Demolition	1	1	1		
Oil and Gas*					
Waste Management					
Retail		1			3
Manufacturers (Suppliers)					1
Sub-total for each category	**1**	**6**	**5**	**6**	**11**

* An interview had been scheduled within this operator category; however media coverage of an off-shore incident prevented the participation of the respondent.

One participant in the study was unable to confirm the number of HGV vehicles in their fleet; however the website for this national courier firm strongly indicates that they fit into the 50+ category of operators.

Within each group of operator type outlined above, there are further distinctions that can be made, which have a critical influence on the nature or operations and the type of vehicle – and therefore potential low carbon technologies required. An example would be operators who transport temperature controlled goods – or operators who fall into more than one operator type category – such as construction and demolition (C&D) retailers who transport their own goods to customers and regularly carry out off-road construction site activities. In the latter case, the operator has been classed according to the operations type most likely to significantly influence vehicle type – in the example given; this would be construction and demolition.

2.2 Summary of responses

A detailed summary of the operator perceptions of low carbon HGV technologies has been provided separately to this report. However this section provides an overview of the key findings and key themes resulting from the survey, which were as follows:

- What constitutes low carbon HGV technology?
- What proportion of operators has integrated low carbon technology into their fleet?
- How effective are these technologies thought to be?
- What are the perceived barriers to investing in low carbon HGV technology?
- How can these barriers be overcome?

The operator interviews were carried out using a semi-structured interview pro-forma. Initially the interviewer was required to avoid leading the operator by describing types of low carbon HGV technologies in order to gain a more representative overview of what operators themselves regard as low carbon technologies. In some cases, operators stated that they did not utilise low carbon technologies, however during the course of the interview, they answered "yes" to using certain equipment such as aerodynamic kits / lightweight bodies. The primary motivation to use this equipment influences whether the operator regards it as low carbon technology or not; in many cases the stated aim of investing in technology was to reduce operational costs rather than emissions.

For example, one construction and demolition operator with a range of HGVs stated ‘no’ to using low carbon HGV technology – vehicles are not bought new but procured second-hand through an agent. However, upon further discussion he revealed that they’re currently trialing B10 biodiesel blends, they always specify lightweight bodies in order to gain from increased payload capacity and they also specify aerodynamic equipment as appropriate wherever possible. No retrofitting of aerodynamic equipment was taking place; however he regarded aerodynamic cab deflectors and side deflectors as representative of standard specification.

Interviewee responses were heavily influenced by the operational requirements of the HGVs in use – some required multi-purpose HGVs and other required specialised vehicles not suited to certain types of low carbon HGV adaptation. Trials were, or had, been ongoing at a number of operators, however some expressed the opinion that research and design into appropriate HGV technology did not move from ‘suspected savings’ to ‘proven savings’ quickly enough. Procurement processes also impact heavily on the purchasing patterns of operators. Some operators buy equipment new and direct from the manufacturer, some use an agent to source equipment to exact specifications and others buy second-hand vehicles and so are reliant on finding vehicles that are ‘fit for purpose’ before they can consider additional specifications.

A number of the key findings can be summarised as follows:

- 83% of respondents had previous experience of using low carbon technologies – whether they had trialled certain technologies or had actually integrated the technology into their fleet.
    - Only one operator from the sample group interviewed had researched low carbon HGV technology, but had not implemented any fleet changes.
- 85% of respondents from very small organisations (<10 vehicles) had integrated one or more of what they consider to be low carbon HGV technology into their fleet – only one operator has not integrated any low carbon technology into the fleet in any way.
- Responses from 20% of operators indicated that the inclusion of low carbon technologies in their fleet was incidental rather than a specific company policy. One operator explicitly stated that environmental considerations would not promote investment in low carbon technologies for their business, however fuel consumption reductions and cost savings would.
- One respondent actually experienced increased running costs as a result of their desire to run cleaner burning engines but company policy is to continue to reduce emissions.
- 100% of respondents from the largest organisations (those with over 751 HGVs) had integrated low carbon HGV technologies into their fleets. The technology type chosen varied widely according to operations, however all had invested in one or more technology that could lead to carbon savings.

Table 4: Operators' with experience of low carbon HGV technologies

Operator size	No. of respondents	Yes	No	Currently being investigated	Unclear
1	1	1	-	-	-
2 - 9	6	6	-	-	-
From 10 - 25	5	4	1	-	-
26 - 50	6	6	-	-	-
51 - 150	4	4	-	-	-
151 - 350	1	1	-	-	-
351 - 750	2	2	-	-	-
751 +	4	4	-	-	-

It is important to note that respondents were answering "yes" or "no" to using what they themselves would describe as low carbon technology. Operators' perceptions of what constitutes low carbon technology varied widely and included;

- Euro standard engines (complying with - and required upgrades in order to meet these standards)
- Automatic gearboxes
- GPS and telemetry
- Fuel additives
- Biofuels
- Stop start technology
- Fleet monitoring & diagnostic equipment
- Active route planning software
- Lubricants
- Tyres
- Cleaner burning engines
- Scheduling software

Driver training and behavioural change were explicitly discussed by eight respondents as factors in reducing HGV emissions from HGV operations – mechanisms to promote this ranged from managing driver behaviour through training and education to using bespoke or tailored software and telematics technology to provide reporting.

The information collected through the telephone interviews was grouped into some key themes. Responses under each theme have been arranged to summarise some of the more interesting comments made.

Table 5: Operator responses to key themes

<table>
<tr><th>Theme</th><th>Key responses</th></tr>
<tr><td>Barriers to investing in new technologies</td><td>Operators commonly cited associated costs as the main barrier to them investing in new low carbon technologies. A close second was the need to ensure that technologies were operationally suitable for their business needs and the third most commonly stated barrier was the lack of real proof that certain technologies actually work and can save money.

Additional factors that prevent investment in new low carbon technologies include;
• When fleets need replacing they are more likely to investigate new technologies
• Effectiveness of technologies being impacted by road congestion
• Manufacturer warranty – they do not want to unwittingly invalidate the warranties on their vehicle fleet with retrofitted devices
• Prohibitive taxation
• Lack of support from senior management
• Lack of level playing field with Europe in terms of vehicle design harmonisation</td></tr>
<tr><td>What would help you to overcome barriers to investing in new low carbon technologies?</td><td>• Confidence that they will see a reduction in running costs
• Manufacturer collaboration
• Provision of information
• Reductions in cost - upfront
• Impartial case studies and practical examples relating to business types
• Confidence that new technologies won't adversely impact operations
• Reduced taxation
• Scrappage style schemes
• Greater design harmonisation
• More regulated and proven testing by an authorised body</td></tr>
<tr><td>What would encourage you to invest in low carbon technologies?</td><td>Evidence
• Access to evidence of payback periods and return on investment – operators are aware that many manufacturers make claims about pay-back but are unsure about whether these claims are justified or not.
• One operator stated the belief that the trade-off is that the difference between a good driver and a bad driver can be 15-20% on the MPG figure. As yet there is no hard evidence of a single technology that can give that sort of reduction and so industry tends to focus on the driver as it's more tangible.
• Proof that the technology works before they take the vehicle on. Would be willing to trial vehicles on behalf of the manufacturer - but the respondent needs the proof before he will invest company money on a design. He believes that a lot of claims of fuel savings have been blown out of all proportion -</td></tr>
</table>

Theme	Key responses
	manufacturers cannot substantiate their claims in a lot of cases. **Technological advancements** • A focus on getting the engine right for the job rather than simply having to pass some government tests that do not take vehicle and engine use into account. • Manufacturers fitting low carbon technologies as standard to their vehicle specifications. • Technology advances are required but there needs to be involvement from a body that the industry believes/has confidence in and that could prove the technology. **External (to the industry) intervention** • Some sort of grant scheme to get the older HGVs off the road - similar to the passenger car Scrappage scheme. • Educational - Incorporate technology considerations on Driver CPC. • Financial incentive, not necessarily subsidy of cost of technology but tax investigation. • Parcel funding that could be applied in a sensible and sustainable way. They know that some grants are currently available but securing them in a way that makes business investment more sensible is not that easy. • Reductions in fuel costs. Operator thinks the fuel could be cheaper for those who run more efficient vehicles - this would enable them to renew their fleet more regularly and would also free up capital to invest in R&D or trial newer technologies. Would also enable UK hauliers to compete on a more equal playing field with European operators. • Reduction in road tax would be an incentive. • More to do with transport infrastructure and congestion control rather than financial incentive. **Regulation** • Operator recently had to invest in new trucks when moving from Euro 2 to Euro 3 at a cost of £25,000 per lorry, and while the old vehicles still did the job, they did not meet the new standards that were brought in. This was expensive to achieve, however was required of the business. **Client-led** • Competitive tendering / gaining a market advantage to investing in low carbon technologies as part of their fleet. • Costs keep going up and he thinks everyone should work together to decide on the prices - customers need them but they need their customers.

Theme	Key responses
	Nothing • Nothing – it's a gradual process that they consider as and when they renew the fleet.
Where do you go for information about low carbon HGV technology?	• Freight Transport Association • DfT websites and publications (e.g. Freight Best Practice). • Other operators • Discusses pioneering technology with his suppliers and manufacturers and body builders, plus looks for information about these technologies in magazines. • Road Haulage Association • Chartered Institute of Logistics and Transport • Motor Transport • Trade press • Manufacturer / suppliers / agent that sources vehicles according to their specification • Institute of Transport Engineers • Institute of Mechanical Engineers • Association of Road Transport Engineers • General internet searches for information

Essentially, while there was some variation in the feedback received from operators in relation to low carbon HGV technology, the financial implications of using new/additional technology was one of the most frequently cited issues. This was in two respects:

- For some, the need for any additional upfront investment can be a significant barrier – particularly for smaller operators with less ability to face increased capital outlay costs.
- Where the initial costs can be borne, it is critical that the technology has the ability to reduce running costs, and payback within an acceptable period.

This indicates that for some operators, it will always be difficult to find the additional investment, even where there is the potential for an ongoing payback; while for others where the additional upfront capital can be found, there is a strong need for it to deliver a satisfactory cost saving. Where this can not be achieved through the technology alone, operators would require a financial incentive to help reduce the payback period.

Manufacturers & suppliers also have a key role to play in increasing uptake of new technologies, whether this is through improved research and development with externally verified claims or by enabling warranty of retrofitted low carbon technology.

2.3 Discussion of main findings

Following discussions with HGV operators, it has become clear that most operators have investigated the value of investing in low carbon HGV technologies, but will not consider any technology that is not 100% compatible with the nature of their operations.

In some cases, it has also become clear that there is a level of reliance on manufacturers and suppliers to provide information to operators. However, at the same time, cynicism exists about the veracity of manufacturer claims. Many operators expressed the need for there to be independent verification of manufacturer and supplier claims in order to increase confidence that investments will have advantages for them. One respondent in particular felt that his company had been “duped” into investing in a particular technology by a manufacturer – in practice this technology did not match up to expectations and therefore negatively affected their bottom line.

Whilst the financial costs and operational needs were at the forefront of operators’ responses, there was a stated need for more readily available information. Additionally, in response to the question about what would encourage them to invest in low carbon technology, some operators did suggest a number of non-financial solutions. Operators also rely on one another to verify the claims of manufacturers with regard to new HGV technology. In one example, two (large) operators who compete for business in the market place had established a mutually beneficial relationship where they worked together to influence HGV vehicle suppliers to improve vehicle specifications.

As a result, there is evidence from this sample group that key strands were supported by operators from a range of fleet size and business type;

- Independent verification of manufacturers’ claims from a trusted source is sought by operators – this is linked to research and development given that there is a call to relate scientific, technical discoveries’ to operational needs and verify findings from an operational perspective.

- Confidence that reduced running costs of the fleet would be achieved was highlighted more frequently than lump-sum financial support for the industry to encourage investment in low carbon HGV technologies.

- Agents and manufacturers are relied on to some extent by a range of operators.

- Whilst the majority of operators had a clear understanding of what constitutes low carbon HGV technology, some were unaware of the carbon emissions reduction advantages inherent in equipment they were already using.

- Driver behavioural change was highlighted by 27% of operators as being fundamental to reducing fleet running costs; one operator stated, “*The industry works on a low margin which is why people don't invest that much in the new technologies that come along…the trade-off is that the difference between a good driver and a bad driver can be 15-20% on the MPG figure… there is no single technology that can give that sort of reduction and so industry tends to focus on the driver as it's more tangible.”*

3 Review of Incentive Schemes

An important objective of this initial phase of the LowCVP HGV programme is to gain an increased understanding of the incentive schemes that could be adapted/replicated to help increase uptake of low carbon HGV technologies. This initial review sets out to:

- Understand the various schemes that have been used globally to incentivise the uptake of low carbon technologies. This review has examined those applicable to transport relating to any sector (e.g. public transport and passenger cars as well as HGV operations) and alternative energy sources before undertaking a scoping exercise based on HGV applicability.
- Determine those that may be applicable to help incentivise uptake of Low Carbon HGV technologies by considering adaptability and applicability to HGV vehicle and operation types. This has been informed in part by an understanding of HGV operator requirements from their vehicle technologies and views and opinions expressed by survey participants in relation to their industry requirements.
- Give a view of relative strengths and weaknesses of various incentive schemes.
- Develop a basic cost-benefit analysis framework to understand the potential carbon savings in relation to scheme costs (Section 5).

It was not within the scope of this review to make a recommendation on the most suitable scheme for implementation, or to suggest a particular policy approach. However, where schemes appear particularly suitable and/or they fit with other findings in the project, they have been highlighted.

3.1 Review of global schemes

The following sources were reviewed at UK, EU-wide and international levels in order to produce an initial long-list of schemes:

- Government websites and policy publications
- Trade association websites

These were then assessed and categorised as follows:

- Transport within EU
- Transport outside EU
- Energy within EU

The complete long-list of schemes is contained in Appendix 2. The nature and global distribution of the schemes identified are illustrated in the tables below – at this stage, the schemes considered included those across all vehicle types. Is should be noted that information on the schemes implemented by EU member states came mainly from central European sources, as a full appreciation of each country's policies would need to overcome language barriers and a deeper level of survey than included in the scope of this project. This could give the impression that there are significantly more schemes in the UK than other EU countries, which may not actually be the case.

Table 6: Incentive schemes in the EU

Scheme specific to	Level	Number of schemes
Low emission zones	Member State*	6
Heavy Goods Vehicle	Member State	4
Electric vehicle	Member State	18
Low emissions cars	Member State	1
Modal shift	Member State	2
Energy labelling	Member State	1
Energy incentive scheme	EU	2

***** These are often sub-Member State level – e.g. London LEZ

Table 7: EU Member State specific schemes

EU Country	Number of incentive schemes
Austria	2
Belgium	1
Cyprus	1
Czech Republic	1
Denmark	2
France	2
Germany	2
Greece	2
Italy	1
Ireland	1
Netherlands	2
Portugal	1
Romania	1
Spain	1
Sweden	2
UK	11

Table 8: Incentive schemes outside the EU

Scheme specific to	Country	Number of schemes
Tax incentive	China	1
Tax incentive	Japan	3
Fee/Levy	Switzerland	1
Rebate – 5 schemes Discounts – 8 schemes Tax – 7 schemes Carpool – 1 schemes Parking – 7 schemes	California, US	28
Electric vehicle and hybrid incentive schemes	29 other states, US	29

3.2 Assessment of schemes appropriate to incentivise HGV technologies

The first part of the review demonstrated that there are a significant number of schemes aimed at changing behaviour in relation to vehicle purchase and usage, from an emissions perspective. The next step was to reduce this long-list to examples of low carbon/efficient vehicle incentive schemes where they may be suitable for development to apply to the HGV operator sector in the UK.

The list of global incentive schemes was reviewed to determine:

- Relevance in a Heavy Goods Vehicle context
- Extent to which it relates to operator feedback received during the operator survey
- Applicability to current low carbon HGV technologies

Whilst there are many variations in the mechanisms to incentivise the up-take of new technologies, the basic principles have been summarised in Table 9, below. In most cases a means of determining the eligibility of technologies for inclusion in a particular incentive scheme would also be required. This is best achieved through a means of certifying the fuel/carbon saving benefits claimed, and is why the broader objectives of the LowCVP programme are so important if these policy measures are to be considered.

Table 9: Summary of existing incentivisation tools

Scheme Type	Basic summary of the different styles of incentive
Taxation - tax reduction / exemption	• Based on vehicle/technology type (e.g. electric/ Euro engine efficiency rating) • Based on fuel type (e.g. biodiesel/ electric)
Grants	• One off purchase grants to accelerate the technology / vehicle replacement cycle • Subsidised purchasing of more efficient technologies and/ or vehicles
Taxation – polluter pays	• Calculated according to vehicle mileage • Charged according to zones or routes travelled • Increased taxes on inefficient vehicles
Commercial incentives	• Reduced insurance premiums on the basis of vehicle emissions • Reduced electricity tariff for electric vehicle charging by energy providers
Socially driven	• Labelling/Certification (with no penalty or associated monetary objective for the purchaser or user) to encourage consumer choice towards low carbon options.
Non-monetary	• Training/information on the use of new technologies • Provision of adequate infrastructure • Demonstration projects and independent technology trials

Typically, the majority of incentives identified in this review have been found to be aimed towards reducing the financial cost of investing in newer, less polluting technologies, either in the form of one-off assistance or longer term subsidies.

However, the operator surveys demonstrate that financial assistance is not the only route to incentivising low carbon HGV technologies. Operators confirmed that although financial assistance would be a major incentive, having greater confidence that new technologies will suit their business needs and more evidence that particular low carbon technologies will actually save them money were also key motivators. This therefore aligns with the need for labelling/certification and other non-monetary measures such as information provision, and is discussed in more detail in sections 3.4 to 3.7.

3.3 Details of suitable financial incentive schemes

Table 10 below summarises the incentive schemes identified during the review, which could potentially be replicated/adapted to help increase uptake of low carbon HGV technologies in the UK. Attempts have been made to give an idea of the relative strengths and weaknesses of such schemes, but it should be noted that this is an initial review and not a detailed policy assessment - it would be expected that any schemes to be considered for application in the UK would be subject to a more detailed impact assessment.

Table 10: Overview of the relevant low carbon incentive schemes implemented worldwide

Scheme type	Features	Key motivational incentive	Strengths/Weaknesses in Low Carbon HGV context
Vehicle Excise Duty reduction/ exemption (UK and others)	• Annual road tax amount is based on CO_2 emissions. • Banding system relative to CO_2 performance. • Full exemption for Ultra-low emission vehicles Schemes can be devised to take the ongoing vehicle efficiency into account. For example, the available tax reduction decreases as the technology becomes older, less efficient or is surpassed by newer technologies on the market in order to encourage increased fleet turnover.	Reduced annual running costs.	+ Facilitates ongoing savings for vehicle users throughout the life of the low carbon technology. - HGV VED ranges from around £165 p.a. for small rigid vehicle to in excess of £2,000 pa for the heaviest tractor and trailer combinations. Works on a 'banding' basis according to weight – could therefore involve significant complexity if further stratification by CO_2 emissions introduced. - The need to reflect tractor–trailer combinations would complicate further. - Would not be suitable for retrofit technologies. - Would not be suitable for individual measures - CO_2 savings likely to be too small to lead to significant VED reductions. - Would need an approach to establishing CO_2 performance for a broad range of technologies and combinations. + Could introduce a straight exemption for Electric trucks.
Initial vehicle registration tax – reduction/exemption (UK and others)	Reduction in tax applied at point of new car registration, based on CO_2.	One-off saving that could amount might help offset additional upfront cost of low carbon vehicles.	- UK initial registration tax is only £55, so potential saving to operators is minimal.
Enhanced Capital Allowances (ECA) (UK)	ECA includes schemes such as the water and energy technology lists (WTL and ETL) and works on the principle that businesses can claim 100% first-year capital allowances on their spending on qualifying plant and machinery. Plant and machinery qualify after assessment by a technical expert, in some cases accredited testing by a third party and can even be self-certified by an ISO 9001 certified organisation. Once verified, a uniquely identifiable label is made available for manufacturers and suppliers who market the products. Technologies include Energy-saving plant and	Businesses can write off the whole of the capital cost of their investment in these technologies against their taxable profits of the period during which they make the investment. This can deliver a helpful cash flow boost and a shortened payback period and provides the incentive for the	+ Helps to reduce payback of technology investment to Operators. + Operators can see which technologies have been certified as having potential to deliver savings – which can act as an incentive in itself. + Manufacturers & suppliers benefit from inclusion on 'approved list'. - Gives a fixed benefit to a business (based on the net present value of earlier cashflow) and can't be tailored to the amount required to incentivise uptake if it is more or less than that amount. - Needs to be tied-in with a product assessment against

Scheme type	Features	Key motivational incentive	Strengths/Weaknesses in Low Carbon HGV context
	machinery, Low carbon dioxide emission cars and natural gas and hydrogen refuelling infrastructure, Water conservation plant and machinery.	end-user/ buyer.	criteria and an assessment methodology - Would lead to some reduction in tax revenue - Management costs - The product application process can be quite drawn out and has been reported to put off some applicants (mainly impacts upon suppliers/ manufacturers) - The tax claims for end-users can also be problematic and lead to complications which could discourage some users
Reduced Pollution Certificates (UK)	In the UK the Reduced Pollution Certificate enables drivers and owners of larger, older diesel vehicles and buses to get tax incentives to help them lower their vehicle's pollution. By modifying a vehicle to cut its emissions, it may be able to take the test for a Reduced Pollution Certificate (RPC). An RPC reduces the cost of vehicle excise duty. It also means that the vehicle could achieve a level required for exemption from the London Low Emission Zone (LEZ) daily charge. Currently this is £200 a day.	Reduced annual running costs.	- Difficult to test vehicles directly for CO_2 performance; incurs significant costs, or requires a comprehensive modelling system.
Congestion Charge exemption (London)	Alternative fuel cars vehicles are exempt from the £8 a day charge. Cars exempt from the charge include: • Electric Cars • Hybrid Cars • Alternative Fuel Cars • LPG Converted Cars To qualify for exemption of the London Congestion Charge, individuals register with Transport for London (TfL). Exempt vehicles are listed on the Transport for London website.	London commuters driving in and out of the city centre can save over £1,600 in Congestion Charges.	+ Operators working regularly in London can see a significant financial benefit. + Can significantly impact on cost effectiveness of certain technologies with a high marginal cost – e.g. Electric Trucks when based in London. - Limited in impact nationally - Would be limited in technology scope – currently targeted at technologies with high carbon saving potential. - Would need an approach to establishing CO_2 performance for a broad range of technologies and combinations.

Scheme type	Features	Key motivational incentive	Strengths/Weaknesses in Low Carbon HGV context
Low Emissions Zones (Various EU member states)	Vehicles entering the zone are checked against a database of registered vehicles which meet the LEZ emissions standards. These are exempt from the charge or are registered for a 100% discount.	Exemptions from charge.	**+** Operators working regularly in the zone can see a significant financial benefit. **+** Can significantly impact on cost effectiveness of certain technologies with a high marginal cost – e.g. Electric Trucks when based in London. **-** Limited in impact to those cities which implement a scheme - Would need an approach to establishing CO_2 performance for a broad range of technologies and combinations.
Low Emissions Vehicle Grant /Rebate Schemes (UK, Europe, US)	A large number of schemes exist, or are in the planning phases globally, to give direct financial support for the purchase of low emissions vehicles – either technology specific (EVs/PHEVs) or on the basis of CO_2 emissions performance.	Subsidised purchase price of a vehicle.	**+** Helps offset the marginal cost over a standard vehicle where these are more expensive (e.g. EVs). - Requires significant state funding and ongoing management/administration.
Low Emissions Vehicle Loan Schemes (US)	Provision of loans for approved low carbon vehicles or technology packages. **US EPA Smartway** programme includes private sector loans provided through EPA scheme as initial contact point.	Subsidised purchase price of a vehicle or package of technology measures.	**+** Helps offset the marginal cost over a standard vehicle where these are more expensive. **+** Helps reduce payback period for additional investment **+** No requirement for large amounts of state funding - Would need an approach to establishing CO_2 performance for a broad range of technologies and combinations. - Operators would still need to be convinced of payback potential before making investment.
Scrappage/replacement schemes (e.g. Greece – includes MGV/HGV; UK – Cars only)	Some incentives are designed to accelerate the fleet replacement cycle and see older/ less efficient vehicles replaced with newer vehicles that meet strict specifications – whether alternative or traditional technologies.	Grant – lump sum to assist with initial purchase.	**+** Helps offset the marginal cost over a standard vehicle where these are more expensive (e.g. EVs). **+** Encourages replacement of a vehicle before it would have been replaced without the incentive. - Requires significant state funding and ongoing management/administration. - Embodied carbon associated with vehicle manufacture will reduce the carbon savings which can be achieved.

Scheme type	Features	Key motivational incentive	Strengths/Weaknesses in Low Carbon HGV context
Insurance Discounts (US - California)	Insurance companies are offering discounts on the insurance on vehicles that meet certain efficiency and performance criteria.	Reduced annual running costs.	+ Industry based so no requirement for state funding. - Many UK operators Self-insure. - Would need an approach to establishing CO_2 performance for a broad range of technologies and combinations.
Schemes to reduce operating costs for EVs (US)	A number of incentives have focused on specific technologies such as incentivising the purchase and use of electric vehicles by helping to reduce running costs and the cost of initial infrastructure arrangements.	Reduced operating costs.	- Limited to EVs only.

3.4 Multi-faceted programmes and non-financial schemes

While the primary focus of this review was financial incentives, other measures are used in the context of incentivising individuals to change their behaviour. A fully comprehensive review of these schemes has not been undertaken as part of this project; however, we have identified and provided examples of some of those in use.

It is important to note that in many cases these approaches are used alongside other measures, or as part of a broader campaign to change behaviour. For example, in the United States the EPA Smartway programme includes specific measures to increase the uptake of low carbon HGVs as part of a much larger programme to reduce carbon emissions from transportation generally.

It has an accreditation scheme for low carbon trucks and 'upgrade' kits (for retrofit to existing vehicles) to enable operators to have confidence in which vehicles/technologies might help them to save fuel and reduce emissions. This is tied-in with a financing scheme where private sector organisations provide loans to help with the investment in the additional costs[8].

In Japan the 'Top Runner' programme sets energy consumption targets across a range of product types (e.g. electrical appliances, vehicles – including trucks) - the most efficient model available on the market is used to set the standard to be attained within four to eight years. By the target year, each manufacturer must ensure that the weighted average of the efficiency of all its products in that particular category is at least equal to that of the top runner model. This approach is said to eliminate the need to ban specific inefficient models from the market, while at the same time, manufacturers are made accountable and are stimulated to voluntarily develop products with an even higher efficiency than the top runner model[9]. Failure by a manufacturer or importer to comply will result in a succession of sanctions (see Appendix 2 for more detail).

3.5 Programmes from non-transport sectors

In the UK, the Market Transformation Programme (MTP) is a Defra funded programme that takes a coordinated approach to supporting the uptake of sustainable products. MTP promotes manufacturers and end-users uptake of sustainable products by using a range of incentives such as financial schemes (grant and subsidy provision), setting minimum standards, labelling (both voluntary and mandatory) and the Enhanced Capital Allowance scheme (ECA) which is outlined in more detail below.

MTP reduces the environmental impact of products across the product life cycle by:

- Collecting information. Stock, sales, usage and resource consumption data is gathered on household and industrial products, such as televisions, fridges and electrical motors.
- Building evidence. The information gathered is used to model how products will evolve in the market place and to estimate future environmental impacts.
- Working with industry and other stakeholders. A common understanding is reached on how these impacts can be mitigated; action plans are agreed and the measures implemented.

The EU Energy Star scheme features labelling of energy efficient office equipment. It includes a recognisable logo available for any product tested and verified as meeting certain minimum energy efficiency requirements and products can also be located using an online database. The scheme is

[8] http://www.epa.gov/smartway/transport/what-smartway/tractor-trailer.htm
[9] http://www.leonardo-energy.org/drupal/node/991

EU-wide and applicable in the USA. More detailed labelling is then made available for consumers to demonstrate the energy efficiency credentials of the product.

There appear to be no further benefits for the end-user (e.g. tax incentives) but the scheme primarily represents a marketing tool for the supplier, and the incentive for the end-user is the use of an energy efficient product and the associated energy cost savings.

Research for the MTP into "*Factors influencing the penetration of energy efficient electrical appliances into national markets in Europe"* (http://efficient-products.defra.gov.uk/cms/library-publications/) discovered that while labelling greatly increases consumer awareness and also ensures that manufacturers begin to recognise the value of energy efficiency (as a marketing tool to differentiate their product), the labelling of individual products did not appear to specifically shift market share towards the energy efficient products.

MTP also manages the Enhanced Capital Allowance scheme. ECA includes discrete schemes such as the Water and Energy Technology Lists (WTL and ETL) and works on the principle that businesses can claim 100% first-year capital allowances on their spending on qualifying plant and machinery. Plant and machinery can qualify following assessment by a technical expert, in some cases accredited testing by a third party and can also be self-certified by an ISO 9001 certified organisation. Once verified, a uniquely identifiable label (the label certification number is unique to each for specific product) is made available for manufacturers and suppliers who market the products.

Technologies include energy-saving plant and machinery, low carbon dioxide emission cars and natural gas and hydrogen refuelling infrastructure, as well as water conserving plant and machinery. Businesses can write off the whole of the capital cost of their investment in these technologies against their taxable profits of the period during which they make the investment. This can deliver a helpful cash flow boost and a shortened payback period and provides the incentive for the end-user/ buyer.

Manufacturers and suppliers can make an application for their products to be featured on ECA lists for the relevant categories. Product listing is sought after by manufacturers and suppliers as it is regarded as official endorsement of the environmental credentials of their product. It is not known, however how much use is made of the category lists by consumers and the Inland Revenue has been so far unable to report on the use of ECA. Very little is currently known about the decision making or influence that ECA has on consumer purchasing.

3.6 Operator feedback

Operator feedback has been discussed in detail in Section 2. A recurring theme during the operator interviews related to the importance of operational advantages (for example fuel efficiency rather than carbon reductions as a 'selling point') and the need for increased industry confidence in manufacturer claims about the advantages of individual low carbon HGV 'products'. In this instance, HGV 'products' refer to the range of low carbon technologies available to manufacturers, from devices that can or have to be retrofitted (such as aerodynamic kits, low rolling resistance tyres) to those that must be incorporated during the design, specification, and manufacturing stages (such as aerodynamic trailer design, lightweight bodies, powertrain technology). The variability of requirements for HGV operators is based on a wide variety of factors, including but not limited to;

- The nature of goods to be transported – e.g. liquids, perishables, weight or volume measured;
- Operational area – e.g. trunking, inner city, long distance, short haul, multi drop, radial;
- Operational distance – e.g. city to city, intra urban only, national, international;

- The importance of the fleet to the primary business activity (e.g. retailers may regard consumers' perceptions of their business more highly than other operators, and invest in positive and recognisable low carbon vehicle modifications)
- Operator experiences –e.g. has the operator invested previously in a low carbon technology to find that manufacturer claims did not match reality?
- Operation size;
- Vehicle procurement – e.g. brand new vehicles built to specification and direct from the manufacturer or through an agent and specified 'fit for purpose'.

In spite of the level of variability inherent in the HGV operator industry, a recurring theme of the operator interview indicated strongly that they would value a trusted and reliable source of information to verify manufacturer claims about products.

This kind of information can be provided in a number of ways:

- A Government backed certification/labelling scheme (e.g. the US EPA programme). This would very likely require Government involvement of some sort to establish a scheme with recognised independence and credibility. Once in place, this could be delivered by private sector organisations on a commercial basis.
- Guides, publications and case studies from Government programmes (e.g. Freight Best Practice).or from industry bodies (e.g. the RHA or the FTA).
- Demonstration programmes such as those funded through the Technology Strategy Board or other agents on behalf of the Government, where financial support is provided to assist with the additional cost of the technology with data collected on real-world performance. This is either paid to the manufacturer, where support is being provided to help with R&D, or can be paid in the form of a grant to operators, with an agreement to share data with the trial operators.

3.7 Key findings

Looking globally, the most common existing incentives for new vehicle technologies focus on tax reductions or exemptions, with a variety of schemes currently in operation in particular in Europe and in the United States (both on a federal and a state level). Direct grant support is much less common than tax incentives,

'Polluter pays' schemes including low emission and congestion zones are growing in popularity, in particular in Europe. These schemes tend to focus more on air quality emissions than carbon reduction and are by definition regionally focussed so would not provide a universal incentive to operators unless they were implemented on a wider scale.

Many of the schemes identified look to promote particular types of technology (e.g. plug-in electric or hybrid vehicles), however when considering the most effective form of incentivisation for the HGV fleet operator market, it is necessary to take into account the sheer diversity of operational requirements.

During discussions with operators, it has become clear that some have investigated their options and have had to rule out some of the more commonly cited solutions as they do not suit their business needs. A clear message has been that operational requirements by necessity will come first for the HGV user. Therefore, it seems appropriate that any HGV low carbon technology incentive scheme should feature a high level of flexibility – avoiding a 'one size fits all' model that would severely restrict uptake to a few operators. It may therefore be necessary to develop a collection of incentives in order to adequately address the requirements for all operators.

4 Cost effectiveness analysis

This section outlines the development of an analysis model to assess the potential cost effectiveness of low carbon HGV technologies. Cost effectiveness calculations are presented for three technologies that were tested in Project 3 of this programme of work. They serve to illustrate the functionality of the model and should be taken as indicative figures only as they are based on carbon saving data from one set of tests. However, the model has been devised so that these figures and a range of other parameters can be varied by the user as appropriate.

This development of the model was based on the following key steps:

1. Determining baseline assumptions for current vehicle parc
2. Determining projections of vehicle numbers/mileage to 2020
3. Determining relevant economic/technical factors and parameters
4. Establishing carbon saving potential and cost of technology to be modelled (calculated from fuel saving data supplied from testing carried out by Millbrook/TRL in Project 3).
5. Establishing uptake scenarios (high/low)
6. Running the model to produce carbon saved and costs for each scenario
7. Illustrating output in £/tonne CO_2 saved

Steps 1-3 provided the necessary inputs and assumptions for the model itself. These are outlined in Appendix 3. Steps 4-7 and the results of running the model are covered in the rest of this section.

4.1 Technology Carbon Savings

Measurements of the savings which could potentially be achieved by the technologies in this study have been supplied to AEA by Millbrook Proving Ground. Table 12 gives details of the Four HGVs used in this testing.

Table 12: Vehicles Tested by Millbrook Proving Ground

Manufacturer:	Scania	Scania	Mercedes	DAF
Model:	P230	R420	Actros 2544 Blueline 5	CF85.430
Type:	Rigid	Articulated	Articulated	Articulated
GVW (kg):	18,000	23,800	25,000	18,000

This testing emulated four drive cycles which an HGV might be expected to cover in the course of operations.

Motorway driving was covered by testing on the Millbrook High Speed Circuit both in steady state (constant speed) and transient (accelerating and decelerating) conditions, the Hill Run course is assumed to be the equivalent of rural driving conditions and the City Run is comparable to urban driving conditions[10].

The DfT has published data on the proportion of vehicle-km driven by different categories of HGV[11]. This separates rigid HGVs into eight weight categories and articulated HGVs into five weight categories. These weight categories do not exactly match the categories under consideration in this study, however there is a clear demarcation in road usage between small and large rigid and small and large articulated HGVs, resulting in the breakdown shown in Table 13.

Table 13: Vehicle-km by HGV Category and by Road Type

Vehicle Category	Urban	Rural	Motorway
Rigid 7.5t - 17t	24%	49%	27%
Rigid >17t	23%	53%	24%
All Rigids	**24%**	**50%**	**26%**
Articulated <33t	9%	43%	48%
Articulated >33t	6%	38%	56%
All Artics	**6%**	**38%**	**55%**

The two different High Speed Circuit tests (transient and steady state) mean that the motorway vehicle-km must be split in two. No data could be found to quantify the proportion of motorway driving that is transient versus steady state so it was assumed that it is equally split.

These figures are used to weight the savings data supplied by Millbrook in order to arrive at a single estimate of an average annual saving for each vehicle category (Table 14).

Table 14: Weighted Fuel Saving by HGV Category

Measure	Small Rigid	Large Rigid	Small Artic	Large Artic
LRRT	-4.1%	-3.8%	-5.6%	-6.3%
Weight Reduction	-2.1%	-2.1%	-1.8%	-1.7%
Adjustable Cab Deflector	N/A	N/A	-4.8%	-5.1%

It should be noted that the tests were performed using a single example of the technology on one category of vehicle only but the results have been extrapolated to all categories of vehicle. This limitation should be taken into account when considering the following savings.

[10] An overview of the circuits can be found at http://www.millbrook.co.uk/Assets/1_1506_030609_millbrook_tracks_brochure.pdf
[11] http://www.dft.gov.uk/pgr/roads/environment/emissions/hgvfleet.xls

4.2 Cost-effectiveness results for the tested technologies

Low Rolling Resistance Tyres (LRRTs)

LRRTs are designed to have reduced rolling resistance compared with conventional tyres while maintaining the required grip characteristics for stopping and wet weather operations.

This lower rolling resistance is achieved by using a rubber compound which contains silicon however there is evidence to suggest that this compound wears more rapidly than conventional tyres and so requires more frequent replacements.

Conventional tyres typically last 50,000 – 60,000 miles (80,000 – 100,000 km) however very little quantitative evidence exists on LRRT lifetimes so a lifetime of 80% of a conventional tyre's lifetime has been assumed.

Following interviews with manufacturers and operators, a marginal cost for LRRTs over conventional tyres of 10% is used and the cost of a conventional tyre is around £100 (VAT deducted).

In order to align with the vehicle testing undertaken at Millbrook, it is assumed that all tyres are replaced with LRRTs.

Weighting the test data on the basis of vehicle-km driven, the average savings used in the model were as shown in Table 15 below.

Table 15: Weighted Saving from LRRTs

Small Rigid	Large Rigid	Small Artic	Large Artic
-4.1%	-3.9%	-5.6%	-6.3%

The following axle configurations were used to calculate the total cost of fitting conventional tyres and LRRTs to work out the annual marginal cost per vehicle:

Table 16: Number of LRRTs and Tyre Lifetime

Vehicle Type	Annual vkm	Axle Configuration	Axles	Wheels	LRRT Lifetime (Yrs)
Rigid 7.5t-17t	31,000	2	2	6	2.6
Rigid >17t	44,000	3	3	10	1.8
Artic <33t	71,000	2+3	5	18	1.1
Artic >33t	97,000	3+3	6	22	0.8

On the basis of the above data, Table 17 shows the marginal annual cost per vehicle of fitting LRRTs over conventional tyres to be:

Table 17: Calculated Marginal Cost Per Vehicle of LRRTs

Vehicle Type	Annual Marginal Cost
Rigid 7.5t-17t	£80
Rigid >17t	£190
Artic <33t	£540
Artic >33t	£900

This compares favourably with research undertaken by AEA in 2008 (Table 18) in developing the Committee on Climate Change's transport technologies marginal abatement cost curve (MACC) model which gave the following marginal costs for LRRT (presented in 2006 prices).

Table 18: Marginal Cost per Vehicle of LRRTs from MACC Study

Vehicle Type	Annual Marginal Cost
Rigid >7.5t	£161
Artic <33t	£409
Artic >33t	£614

Tyres are consumable items and therefore in the following cost-effectiveness calculations, capital costs are set to zero and the marginal tyre replacement costs are included under operating costs.

As the lifetime of LRRTs is short, the cost-effectiveness calculations given in Tables 19-22 are for the savings which accrue over the lifetime of the vehicle.

Table 19 Cost-effectiveness of utilising LRRTs on a small rigid vehicle (7.5t to 17t) over the vehicle's lifetime (10 years)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£0	£689	-£1,249	-£560	8.7	-£64
Operator	£0	£601	-£2,599	-£1,998	8.7	

Table 20 Cost-effectiveness of utilising LRRTs on a large rigid vehicle (>17t) over the vehicle's lifetime (10 years)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£0	£1,635	-£2,165	-£529	15.1	-£35
Operator	£0	£1,428	-£4,506	-£3,078	15.1	

Table 21 Cost-effectiveness of utilising LRRTs on a small articulated vehicle (<33t) over the vehicle's lifetime (7 years)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£0	£3,417	-£3,131	£287	21.8	£13
Operator	£0	£3,114	-£6,974	-£3,860	21.8	

Table 22 Cost-effectiveness of utilising LRRTs on a large articulated vehicle (>33t) over the vehicle's lifetime (7 years)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£0	£5,696	-£5,421	£274	37.8	£7
Operator	£0	£5,190	-£12,076	-£6,886	37.8	

Weight Reduction

The Millbrook testing compared the fuel consumption of a single rigid vehicle at a weight of 17.662t and a weight of 16.464t, a difference of 1.2t or 7% of vehicle weight.

Weight reduction only confers significant benefits on fuel consumption under transient conditions so savings from the Millbrook testing were only seen in the urban, rural and transient motorway phases of the testing.

Weighting the test data on the basis of vehicle-km driven gives the following average savings:

Table 23: Weighted Saving from Weight Reduction

Small Rigid	Large Rigid	Small Artic	Large Artic
-2.1%	-2.1%	-1.8%	-1.7%

The cost of reducing weight in new vehicles will vary considerably depending on the extent to which weight is reduced and the materials employed to achieve this weight reduction.

The savings above are equivalent to the savings given for 'medium' weight reduction in the work that AEA carried out to develop the marginal abatement cost curve model. This found that the marginal costs of weight reduction in new HGVs were[12]:

Table 24: MACC Costs for Weight Reduction

Vehicle Category	Mild	Medium	Strong
Rigid > 7.5t	£3,300	£6,500	£16,300
Articulated < 33t	£4,200	£8,500	£21,100
Articulated > 33t	£5,500	£11,000	£27,500

This previous MACC work does not specify what percentage weight reduction the terms 'mild', 'medium' and 'strong' refer to. The saving assumed in the MACC work for a 'medium' weight reduction is around 2% and so comparable to the savings derived from the Millbrook tests however as can be seen below, the cost effectiveness even at the lower cost is low.

As rigid vehicles are split into two weight categories in this study, it is assumed that the ratio in costs of weight reduction between small and large rigid HGV is the same as the ratio between small and large articulated HGVs (87% for small, 113% for large).

Basing the cost-effectiveness calculations on the costs of the 'mild' weight reduction leads to the results shown in Tables 25 – 28 below.

Table 25 Cost-effectiveness of employing weight reduction on a small rigid vehicle (7.5t to 17t)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£2,870	£0	-£640	£2,230	4.5	£499
Operator	£2,870	£0	-£1,331	£1,539	4.5	

[12] http://hmccc.s3.amazonaws.com/CH6%20-%20AEA%20-%20Review%20of%20cost%20assumptions%20and%20technology%20uptake%20scenarios%20in%20the%20CCC%20transport%20MACC%20model.pdf

Table 26 Cost-effectiveness of employing weight reduction on a large rigid vehicle (>17t)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£3,730	£0	-£1,196	£2,534	8.4	£303
Operator	£3,730	£0	-£2,490	£1,240	8.4	

Table 27 Cost-effectiveness of employing weight reduction on a small articulated vehicle (<33t)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£4,200	£0	-£1,006	£3,194	7.0	£455
Operator	£4,200	£0	-£2,242	£1,958	7.0	

Table 28 Cost-effectiveness of employing weight reduction on a large articulated vehicle (>33t)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£5,500	£0	-£1,463	£4,037	10.2	£396
Operator	£5,500	£0	-£3,259	£2,241	10.2	

Adjustable Cab Deflectors

The Millbrook testing compared the saving which can be achieved between an articulated HGV without cab deflector to an articulated HGV with a correctly set adjustable cab deflector.

Most articulated HGVs already have a fixed cab deflector which will be doing a reasonable job of smoothing the airflow over the top of the trailer; however a fixed cab deflector will only perform at its best when the correct size of trailer is attached. At other times, a fixed deflector will be operating at sub optimal conditions and may even increase fuel consumption (for example when no trailer is attached).

Future testing to pin down the saving which can be gained by fitting an adjustable cab deflector versus a fixed cab deflector or the penalty which is incurred due to an incorrectly adjusted cab deflector would be useful.

Table 29: Weighted Saving for Adjustable Cab Deflector

Small Artic	Large Artic
-4.8%	-5.1%

Installed costs for adjustable cab deflectors are in the region of £1,500 and it is expected that ongoing maintenance costs would be negligible.

In view of the above, this leads to the following cost-effectiveness (compared with no cab deflector being fitted):

Table 30: Cost-effectiveness of employing a cab deflector on a small articulated vehicle (<33t)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£1,500	£0	-£2,665	-£1,165	18.6	-£63
Operator	£1,500	£0	-£5,935	-£4,435	18.6	

Table 31 Cost-effectiveness of employing a cab deflector on a large articulated vehicle (>33t)

Perspective	Capital Costs	Operating Costs	Present Value of Savings	Total Net Present Value	Lifetime Carbon Saving (tCO_2)	Cost Effectiveness (£/tCO_2)
Societal	£1,500	£0	-£4,393	-£2,893	30.6	-£94
Operator	£1,500	£0	-£9,784	-£8,284	30.6	

4.3 Cost-effectiveness analysis conclusions

As the above figures show, low rolling resistance tyres and adjustable cab deflectors are the most cost-effective of the three measures, with weight reduction much less cost-effective.

On the basis of these calculations it is surprising that uptake of this technology has not been more comprehensive. Perceived barriers such as reputed short tyre lifetimes may be impeding uptake however there is little independent test data available which quantifies the lifetime of low rolling resistance tyres in HGVs, an area which would be worth addressing.

Weight reduction is a high cost measure which provides comparatively modest savings and is therefore an expensive way of reducing CO_2 emissions. The best savings are to be found in vehicles with a larger proportion of the drive cycle spent in transient conditions. These conditions are mostly to be found in urban and rural situations and are less common on motorways and trunk roads. Therefore attention would best be focused on weight reduction in smaller rigid and articulated vehicles.

With costs as high as these, weight reduction does not pay back within the vehicle's lifetime. Furthermore a reduction in kerb (unloaded) weight would allow a greater payload to be carried which could reduce the saving per vehicle; however, this could also lead to a reduction in the number of vehicles on the road and therefore give a different CO_2 saving if calculated on a tonne/km basis.

The measure is most cost-effective in large rigid HGVs where the combination of a more transient drive cycle and reasonably high annual vehicle-km give the best saving.

The model shows that adjustable cab deflectors are very cost-effective, with payback being achieved within one to two years making them a desirable vehicle option to operators. Most operators already have some sort of cab deflector fitted to their vehicles, however there is still scope for increased uptake.

For a vehicle which already has a fixed cab deflector, the saving will be substantially lower and the payback time consequently longer. In order to achieve payback on a measure costing £1,500 within the vehicle's lifetime (seven years), the saving would have to be at least 1.2% for the small articulated HGV and at least 0.8% for the large articulated HGV. Anything lower than this and we would not expect payback within the vehicle's lifetime.

4.4 Cost-Benefit Analysis

For each technology considered in this study, two uptake scenarios (business as usual and high uptake) are applied out to 2020 in order to make an estimate of the carbon and financial savings which could be achieved if an incentive programme were introduced.

There is little data in existence quantifying the elasticity of demand for these technologies and the primary source used here comes from the CCC Marginal Abatement Cost Curve work undertaken by AEA in 2008.

Illustrative uptake of technologies

The MACC work considered potential uptake scenarios of both LRRTs and weight reduction.

Fitting low rolling resistance tyres can be treated as a retrofit measure so the following penetration rates can be applied to the whole HGV parc:

Table 32: Low Rolling Resistance Tyres Uptake Scenarios

Vehicle Category	Scenario	2010	2015	2020
Rigid >7.5t	Central	5%	25%	59%
	High	30%	84%	100%
Artic <33t	Central	5%	25%	59%
	High	30%	84%	100%
Artic >33t	Central	5%	25%	59%
	High	30%	84%	100%

Weight reduction is a measure which can be applied to new vehicles only:

Table 33: Weight Reduction Central Scenario

Vehicle Category	Scenario	2010	2015	2020
Rigid >7.5t	Central	0.8%	7.2%	22%
Artic <33t	Central	0.0%	6.8%	22%
Artic >33t	Central	0.0%	6.8%	22%

The MACC work does not have a high scenario for weight reduction so to illustrate potential carbon savings it is assumed that the penetration of weight reduction is doubled.

The MACC work also does not consider uptake of adjustable cab deflectors. The majority of articulated HGVs on the UK's roads already have some sort of cab deflector fitted so an estimate of the number of vehicles which do not have cab deflectors fitted was used and the high uptake scenario assumes that all remaining vehicles are fitted with cab deflectors.

Adjustable cab deflectors can be retrofitted to any existing HGV which has not been fitted with a cab deflector. As the majority of articulated HGVs already have a cab deflector, penetration of this technology is already high in 2010:

Table 34: Adjustable Cab Deflectors Central & High Scenarios

Vehicle Category	Scenario	2010	2015	2020
Artic <33t	Central	80%	85%	90%
	High	80%	90%	100%
Artic >33t	Central	80%	85%	90%
	High	80%	90%	100%

Carbon and Financial Savings from High Uptake Scenario

Tables 35 – 40 (below) illustrate the carbon saving potential and the costs and benefits associated with an increase in the uptake of these technologies between 2010 and 2020.

The Net Present Value gives the aggregated financial saving (or cost) and the CO_2 column gives the value of the CO_2 saved over the period. This is calculated by taking the total CO_2 saving which could be achieved by the scheme and multiplying them by the carbon prices set out in *Carbon valuation in UK policy appraisal: a revised approach*[13]

[13] http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/valuation/valuation.aspx

Low Rolling Resistance Tyres

Table 35: Additional Carbon Saving from LRRTs (ktCO2)

Vehicle Type	In 2015	In 2020	Cumulative 2010 to 2020
Rigid 7.5t-17t	18	12	124
Rigid >17t	147	108	1,046
Artic <33t	23	16	164
Artic >33t	352	252	2,504
Total	**540**	**388**	**3,843**

Table 36: Costs and Benefits from LRRTs (£m)

Vehicle Type	CAPEX	OPEX	Revenue	NPV	CO_2
Rigid 7.5t-17t	£0.0m	£8.5m	-£18.4m	-£9.9m	-£5.9m
Rigid >17t	£0.0m	£94.0m	-£149.5m	-£55.6m	-£47.4m
Artic <33t	£0.0m	£18.8m	-£23.4m	-£4.6m	-£7.4m
Artic >33t	£0.0m	£275.8m	-£357.9m	-£82.1m	-£113.5m
Total	**£0.0m**	**£397.1m**	**-£549.3m**	**-£152.2m**	**-£174.2m**

Weight Reduction

Table 37: Additional Carbon Saving from Weight Reduction (ktCO2)

Vehicle Type	In 2015	In 2020	Cumulative 2010 to 2020
Rigid 7.5t-17t	0	2	6
Rigid >17t	3	14	51
Artic <33t	0	2	6
Artic >33t	5	23	82
Total	**8**	**41**	**145**

Table 38: Costs and Benefits from Weight Reduction (£m)

Vehicle Type	CAPEX	OPEX	Revenue	NPV	CO_2
Rigid 7.5t-17t	£3.3m	£0.0m	-£0.8m	£2.5m	-£0.3m
Rigid >17t	£20.2m	£0.0m	-£7.2m	£13.0m	-£2.2m
Artic <33t	£3.3m	£0.0m	-£0.9m	£2.4m	-£0.3m
Artic >33t	£37.8m	£0.0m	-£11.7m	£26.2m	-£3.6m
Total	**£64.6m**	**£0.0m**	**-£20.6m**	**£44.0m**	**-£6.3m**

Adjustable Cab Deflectors

Table 39: Additional Carbon Saving from Adjustable Cab Deflectors (ktCO2)

Vehicle Type	In 2015	In 2020	Cumulative 2010 to 2020
Artic <33t	2	3	18
Artic >33t	24	50	269
Total	**26**	**53**	**287**

Table 40: Costs and Benefits from Adjustable Cab Deflectors (£m)

Vehicle Type	CAPEX	OPEX	Revenue	NPV	CO_2
Artic <33t	£1.6m	£0.0m	-£2.6m	-£1.0m	-£0.8m
Artic >33t	£13.9m	£0.0m	-£38.3m	-£24.3m	-£12.0m
Total	**£15.5m**	**£0.0m**	**-£40.9m**	**-£25.4m**	**-£12.8m**

4.5 Cost Benefit Analysis Conclusions

Due to the high costs of incorporating weight reducing technology into HGVs, this cost-benefit analysis suggests that there would be a significant cost to society through the implementation of this particular measure. Furthermore, weight reduction can only be incorporated into new vehicles and so the potential impact on HGV carbon emissions is comparatively modest.

On the other hand, low rolling resistance tyres and, to a lesser extent, adjustable cab deflectors are highly cost-effective and both technologies can be retrofitted to an existing vehicle. These technologies therefore show a substantial societal benefit, along with significant carbon savings.

5 Cost-Benefit Analysis - Incentive Schemes

In order to illustrate what the total costs and benefits of a potential incentive scheme could be, a cost-benefit analysis was conducted over the period 2010 to 2020. This analysis quantifies the capital and operating costs of adopting carbon reducing technologies across the HGV parc along with the financial savings through reduced fuel consumption and CO_2 savings are also estimated and monetised. Other benefits (such as reduced air quality emissions were not included in the scope of this project and have not been quantified).

Any capital costs incurred in setting up an incentive scheme plus ongoing scheme operating costs have also been factored in to the cost-benefit analysis section of the model. All of the parameters can be adjusted by the user, enabling the addition of new technologies to the cost-benefit analysis, the modification of savings or uptake scenarios as improved data comes to light.

5.1 Cost-benefit analysis using an example incentive scheme

An incentive which could encourage operators to invest the additional sums necessary to reduce CO_2 emissions from HGVs is a variation of the Enhanced Capital Allowances scheme[14]. As explained in section 3, this enables a business to claim 100% first-year capital allowances on spending on qualifying technologies which have been proven to make a significant reduction in carbon emissions.

Businesses can write off the whole of the capital cost of their investment in these technologies against their taxable profits of the period during which they make the investment. Capital purchases which do not fall under an ECA scheme are treated as Capital Allowances. Under Capital Allowances, 20% of the capital cost can be offset against their taxable profits in the first year and in subsequent years for the lifetime of the investment, 20% of the balance can be offset.

The ECA therefore primarily acts as a short term cash-flow boost, however there are also overall savings to be had.

For example if a company which makes more than £300,000 per year profit (and therefore paying corporation tax at 28%) purchased a qualifying HGV that employed a lower weight design with a marginal cost of £3,300 over a £30,000 conventional vehicle, the tax savings would work as follows:

[14] http://www.eca.gov.uk

Year	Capital Costs		Capital Allowances			Enhanced Capital Allowances		
	Conventional	Improved	Balance	Reduction in Taxable Amount	Reduction in Tax Bill	Reduction in Taxable Amount	Reduction in Tax Bill	
1	£30,000	£33,300	£30,000	£6,000	£1,680	£33,300	£9,324	
2			£24,000	£4,800	£1,344			
3			£19,200	£3,840	£1,075			
4			£15,360	£3,072	£860			
5			£12,288	£2,458	£688			
6			£9,830	£1,966	£551			
7			£7,864	£1,573	£440			
8			£6,291	£1,258	£352			
9			£5,033	£1,007	£282			
10			£4,027	£805	£225			**Difference**
				Total Saving:	**£7,498**	**Total Saving:**	**£9,324**	**£1,826**

While the benefit to the operating company is clear, the figures given above show that there will be an overall loss in tax revenue to the Treasury over the lifetime of the vehicle and a substantial reduction in tax revenue in the first year in particular.

With this in mind, the ECA scheme was subjected to a basic cost benefit calculation, which in addition to giving an initial understanding of the business case for such a scheme in the UK, also led to the development of a basic framework through which other schemes could be assessed.

AEA has experience of running ECA schemes and currently manages both the Water Technology List[15] and the Energy Technology List[16]. The budget for the Water Technology List, which includes scheme marketing costs, is around £170,000 per annum. The water technology list (WTL) has different technology categories (taps, showers etc) with criteria for inclusion on the list that AEA devised along with industry experts. Review of the criteria to assess products is carried out annually.

5.2 Cost Benefit Result - ECA

For this we have used the costs and carbon benefits of weight reduction and adjustable cab deflectors, along with the cost of administering the scheme to 2020 (estimated at approximately £170,000 per annum or £1.6 million (present value) over the period 2010 to 2020). As low rolling resistance tyres are considered a consumable item, they may not be eligible for inclusion in an Enhance Capital Allowance scheme.

The spreadsheet model permits the user to include these costs in order to arrive at a final cost-benefit estimate once a more fully developed range of technologies is decided on.

15 http://www.businesslink.gov.uk/bdotg/action/layer?topicId=1084216413

16 http://www.eca.gov.uk/etl

The results of using the ECA example are shown in Table 41 below.

Table 41: Example ECA Scheme Costs and Benefits (£m)

CAPEX	OPEX	Revenue	NPV	CO_2
£80.1m	**£1.6m**	**-£61.5m**	**£20.2m**	**-£19.1m**

It is worth emphasising that the costs of an incentive scheme such as Enhanced Capital Allowances would ultimately be likely to be spread over a much wider range of technologies than those listed here and would be expected to be small in comparison to the measure costs and savings generated through the uptake of measures across the HGV parc.

6 Conclusions

This study has provided a useful indication of the current market situation for low carbon vehicle technologies – from a demand side perspective. It did not set out to appreciate supply-side issues, so has not assessed considerations such as high manufacturing costs (e.g. battery technology), or relative progress in commercialising new R & D.

It has shown that demand is there from operators for low-carbon HGV technologies – but for small and medium sized fleets this is in the context of saving fuel in the short term rather than any long term carbon reduction aspirations (as can sometimes be the case with larger operators). Their own continued attempts to increase the efficiency of their operations means that they have good awareness of the kinds of measures available to them. The difficulty they experience is in identifying those measures that can genuinely and credibly show a return within an acceptable period. For most smaller operators this would need to be anywhere from a few months to a couple of years; so while there are still good fuel/carbon savings to be gained over the life of a vehicle where paybacks are longer than this, it is unlikely that the majority of small and medium sized operators would be willing/able to make the investment.

There is good evidence in support of a means of independently verifying technologies, providing a level of accreditation beyond that offered by manufacturers' marketing claims. Our cost effectiveness calculations show that for some technologies (e.g. Low Rolling Resistance Tyres), there appears to be a strong case for operators to make the additional investment – fuel and carbon savings look to be available within a short payback period. The indications are that this is the kind of measure operators could invest in without any subsidisation – but there is clearly a need to overcome the barrier of a lack of faith in manufacturers' claims, and provide operators with the level of assurance they need. This would be helped significantly if there were a trusted means of accreditation, easily recognisable to operators.

Where technologies have a longer payback period, perhaps even with a greater fuel/carbon saving over its lifetime than the shorter payback measures, most operators would need financial incentives before they could consider them. However it is important to consider whether the costs of the technology will drop to a sufficiently low level in the future so that uptake can continue unsupported at the end of the incentivisation programme. Our review of incentive schemes has shown a large number financial support schemes around the world that incentivise the uptake of such vehicles.

Our basic cost benefit calculations for an example of such a scheme (ECA), adapted for HGVs could deliver significant societal benefits. This scheme in particular would serve to provide both an accredited list of suitable technologies that would act as a reference point for operators, with an upfront boost to the payback of a technology investment through reduced taxation in year 1. A further model which combines the need for accreditation, with financial support, which might be considered in the UK, is that of the Environmental Protection Agency (EPA) in the United States. The 'EPA Smartway' scheme includes an accreditation scheme for truck and trailers, and provides loans to help operators make the investment.

In both of these cases, it would be possible to overcome the two main barriers to uptake (belief in payback and level of investment), without needing to directly provide significant amounts of public funding on purely a grant basis. It is therefore concluded that to achieve increased uptake of Low Carbon HGV technologies that two key actions are required, both of which are unlikely to happen without some kind of Government intervention:

1. The introduction of an independent certification scheme to provide operators with a reliable and trusted means by which they will have confidence in the performance of the technology in

terms of fuel savings and payback. This is important for those technologies which could payback in a relatively short period (i.e. <2 years).

2. The provision of financial incentives to increase uptake of technologies where payback/Return on Investment is weaker (i.e. >2 years).

This suggests a clear role for Government in order to support the introduction of these measures, which are unlikely to happen if left to the market alone. Some evidence was found to suggest that in some cases non-financial interventions (e.g. provision of advice/information; demonstration of benefits through Government-backed trials) might help, but the study did not specifically set out to assess this type of policy intervention, so would require further analysis to explore their potential efficacy further.

7 Appendices

Appendix 1. Interview Script

Appendix 2. Long-list of incentive schemes identified

Appendix 3. Modelling assumptions

Appendix 1: Semi Structured Interview Questions

1	Business Details	a. Contact name
		b. Contact role
		c. Business name
		d. Business type
		e. No of vehicles in fleet
		f. Vehicle types
2	What, in your view represents low carbon HGV technology? (The respondent may give a list of technology types in response to this question – or may simply mention associated emissions reduction of technologies – the type of response will influence the approach to later questions).	
3	Have you used any of the technologies you have mentioned? (*the response to this question will determine the interviewers approach to questions 4 to 9 in order to avoid repetition)*	
	a. If **Yes**	i. What (e.g. retrofitted devices, low carbon vehicle trial etc)?
		ii. When?
		iii. Where?
		iv. Why?
		v. How?
		vi. Was it cost effective? How was cost effectiveness assessed - what did the operator use to make the decision about the value of the investment?
	b. If **No**	i.Do you intend to trial or invest in any low carbon technologies in the future?
		ii. Have you investigated low carbon technologies – what has been the stalling point if this is the case (e.g. cost/ availability/ suitability for their business operations etc)?
		iii. Perhaps they have not had a real opportunity to investigate using low carbon technologies in their fleet – if this is the case, what information would they have looked for first, and where would they have looked for the information?
	c. Would you choose to use low carbon technology if it was readily available to you?	i. If **no,** the interviewer should question further to find out what dissuades the respondent from answering, yes?
		ii.If **yes;**
		Technology Type
		Aerodynamic kits for HGVs such as aerodynamic fairings, and adjustable cab deflectors
		Low rolling resistance tyres
		Aerodynamic trailer design (e.g. Teardrop/ Cheetah/ Aeroliner)
		Lightweight bodies
		Electric/ hybrid (powertrain)

4	Do you think this technology costs more than standard equipment (this question may be influenced by responses to questions 3a and 3b. If the respondent has already given an opinion about the cost of low carbon technology compared to standard, instead, the interviewer should ensure they have a clear understanding of what the respondent bases their opinion on – e.g. in-house trials, industry press, manufacturers press)?
	a. If Y**es,** do you know how much more than traditional technologies?
	b. If so, how long would it take for you to gain a return on investment? Also find out what the organisation would consider to be a reasonable ROI or payback period for an investment?
	c. If **No,** have you used the technology (this may have been addressed following the response to question 3 a.
5	What would prevent you from investing in new low carbon HGV technologies (barriers – such as legislative barriers resulting from operations/ uncertainty about the future of technologies etc)?
6	What could help you to overcome these issues?
7	What would encourage you to try or invest in new low carbon technologies? Where an example is asked for, select from; a. Financial measures b. Reduction in the cost of equipment c. More readily available information about scientific / practical technology trials on carbon reductions/ payback d. The environmental benefits of reduced emissions e. Nothing – it is a gradual process that occurs with fleet renewal cycles f. The marketable competitive benefits to using the technology g. Other (please note)
8	What would enable you to start using low carbon HGV technologies?
9	Would you like to see more information about low carbon HGV technologies more readily available for operators?
	a. If **yes,** what would you like to see information focussing on (e.g. ROI)?
10	Where do you usually look for information about vehicle fleet technologies, incentive schemes or on HGVs in general?

APPENDIX 2 – Long-list of global incentive schemes

Incentive schemes in the EU

Incentive	Member State	Description
Low Emission Zones	EU	**Low Emission Zones** Several countries in Europe will be restricting the access of older Euro rated vehicles in 2010. The list below is purely a guide, but does highlight which countries could cause issues with road haulage fleets. **Austria** - A12 Tyrol - From 1.11.09 only trucks with a Euro 2 or better rating will be allowed on much of this road. Also until Oct 2010, vehicles of Euro 5 will be exempt from the night driving ban on this section as well. **Denmark** - From July 2010 only Euro 4 (or 3 with particulate traps and documentary evidence) or better will be allowed in Copenhagen, Frederksberk & Aalborg **Germany** - From Jan 2010 the major cities will all restrict vehicles to Euro 4 (Euro 3 with particulate traps and paperwork) or better - these include Frankfurt, Berlin, Cologne & Hannover. **Italy** - Milan is the only city at present which has an LEZ, vehicles are charged relating to their age. Euro 3 or better are free. Some Northern regions of Italy have zones, but they are not chargeable at present. **Netherlands** - In the cities affected, from Jan 2010, vehicles should be no older than 8 years from registration and Euro 3 with particulate trap, but this is only until 2013, from Jan 2013 all vehicles must be full Euro 4 standard **Sweden** - Stockholm, Lund, Gotenburg & Malmo Euro 4 have free entry until 2016, Euro 5 allowed free entry until 2020. Vehicles of Euro 2 or 3 are only allowed into the cities up to 8 years after their first date of registration, which means anything that was registered in 2001 is now no longer able to enter these cities.
Eco fee for heavy transport	France	Taxation of heavy transport based on mileage. The Grenelle environment forum has adopted the principle for introducing an eco-fee on heavy goods vehicles weighing over 3.5 tonnes on the national toll-free road network. This use-based charge, which will come into force in 2011, will make it possible to generate new resources which will be allocated to the AFITF (Agency for financing transport infrastructures in France).
The Joint Ministerial Decision 90364. Incentives for the replacement of old middle weight and heavy vehicles	Greece	Since January 2002, The Joint Ministerial Decision 90364 concerning the introduction of fuel consumption and CO2 emissions label for new cars, implements the EU Council Directive 1999/94/EC in Greece. Incentives for the replacement of old middle weight and heavy vehicles, of passenger cars and promotion of energy efficient vehicles (natural gas, biofuels, hybrid cars) are under planning phase. Since 1999, Law 2682 promotes the purchase of low polluting vehicles with incentives such as tax reductions for electric, alternative and hybrid vehicles satisfying the specifications of the EC Directive 94/12 or more recent Directives. Addition-ally these vehicles are exempted from traffic restrictions e.g. access in the Athens city centre.
National Electric Vehicle	UK	EVs in the UK benefit from a range of national incentives, managed by OLEV (Office of Low Emission Vehicles), including: • Vehicle Excise Duty exemption

incentives		• Enhanced Capital Allowance
Congestion Charge exemption in London	UK	Only alternative fuel cars vehicles are exempt from the £8 a day charge. This means London commuters driving in and out of the city centre can save over £1,600 in Congestion Charges. Cars exempt from the Charge include: • Electric Cars - including the G-Wiz and NICE Mega City • Hybrid Cars – including Toyota Prius, Honda Civic hybrid and Lexus Hybrids models • Alternative Fuel Cars – including Saab 9-5, Volvo CNG V70 & S60 and Ford FFV • LPG Converted Cars
Free/reduced price parking in the City of Westminster, London	UK	Zero emission vehicles may park in one Westminster City Council car park for a £361 annual administration fee (excluding Cramer Street and St. John's Wood). Application forms and availability advice are available through Westminster Council. To qualify, the vehicle must be 100% electric. – (The vehicle must be powered solely by electricity when in normal use and produce nil emissions) Electric Vehicle season tickets are not available to electric motorcycles, LPG, concept (such as Hydrogen) dual fuel vehicles or any others that may fall into this category.
OLEV Plug-in Car Grant	UK	A grant to reduce the cost of eligible electric, Plug-in hybrid and hydrogen cars by 25% (to a maximum of £5,000) will be available to consumers and business buyers from January 2011 and will run until 2014. (subject to notifying the technical requirements of the scheme to and getting state aid approval from the European Commission). The grant will be available at the point of purchase directly from the dealership or manufacturer, so consumers will not be out of pocket or have to go through a separate application process. It will work in a similar way to the Government Scrappage scheme; except that you will not have to scrap your old car. Government has defined performance criteria which cars will need to meet, assessed by an expert panel. Once approved, the details of the eligible cars will be listed on this website with a link to the manufacturers' own website, where consumers can find out more.
Logistics Carbon Reduction Scheme	UK	Freight Transport Association (FTA)'s Logistics Carbon Reduction Scheme is an industry-led approach to reducing carbon emissions from road freight. Both FTA members and non members are invited to join the scheme which will record and report reductions in carbon dioxide emissions from freight transport and logistics operations. The Logistics Carbon Reduction Scheme is based on measurement of fuel usage in each business that is converted into carbon dioxide emissions using Government-approved conversion factors. FTA will aggregate the fuel usage figures from scheme members and will report totals periodically and track improvements in carbon emissions and fuel efficiency over time
Freight Facilities Grant (FFG)	UK	Freight facilities grants (FFGs) offer cash incentives for businesses to take freight off congested roads and move it on to rail or water. In its February 2009 allocation round for mode shift grant, the Department for Transport awarded £1.02 million over the next 2 years as part of the Rail Environmental benefits Procurement Scheme (REPS). This funding, for carrying freight by rail and water that would otherwise be carried by roads, will help remove over 48,000 lorry journeys from the UK road network. This includes provision for a potential Waterborne Freight Grant for traffic between Liverpool and Greater Manchester.
Rail Environmental	UK	Rail Environmental Benefit Procurement Scheme (REPS): assists companies with the operating costs associated with running rail freight transport instead of road

Benefit Scheme (REPS)		(where rail is more expensive than road). The scheme is a direct replacement for the Track Access Grant (TAG) and Company Neutral Revenue Support (CNRS) schemes in Great Britain. REPS operates in two parts: • REPS (Intermodal) for the purchase of intermodal container movements by rail (replaces CNRS). • REPS (Bulk) for the purchase of other freight traffic movements by rail (replaces TAG).
Waterborne Freight Grant Scheme	UK	Waterborne Freight Grant scheme (WFG): assists companies with the operating costs, for up to three years, associated with running water freight transport instead of road (where water is more expensive than road).
Tax incentive for electric vehicles	Austria	A fuel consumption tax (Normverbrauchsabsage or NoVA) is levied upon the first registration of a passenger car. It is calculated as follows: - Petrol cars: 2% of the purchase price x (fuel consumption in litres – 3 litres) - Diesel cars: 2% of the purchase price x (fuel consumption in litres – 2 litres) Under a bonus-malus system, cars emitting less than 120g/km receive a maximum bonus of €300. Alternative fuel vehicles including hybrid electric vehicles attract an additional bonus of maximum €500. This bonus regime is valid from 1 July 2008 until 31 August 2012. Electric vehicles are exempt from the fuel consumption tax and from the monthly vehicle tax. The Austrian automobile club ÖAMTC publishes the incentives granted by local authorities on its website (www.oeamtc.at/elektrofahrzeuge).
Tax incentive for electric vehicles	Belgium	Purchasers of electric cars receive a personal income tax reduction of 30% of the purchase price (with a maximum of €9,000).
Tax incentive for electric vehicles	Cyprus	A premium of €700 is granted for the purchase of an electric car (maximum 7 cars per company/person).
Tax incentive for electric vehicles	Czech Republic	Electric, hybrid and other alternative fuel vehicles are exempt from the road tax (this tax applies to cars used for business purposes only).
Tax incentive for electric vehicles	Denmark	Electric vehicles weighing less than 2,000 kg are exempt from the registration tax. This exemption does not apply to hybrid vehicles. The registration tax is based on the price of the vehicle. It is calculated as follows: (105% x vehicle price up to DKK 79,000) + (180% x vehicle price above DKK 79,000).
Tax incentive for electric vehicles	Germany	Electric vehicles are exempt from the annual circulation tax for a period of five years from the date of their first registration. Subsequently, they will pay a tax amounting to €11.25 (up to 2,000 kg), €12.02 (up to 3,000 kg) or €12.78 (up to 3,500 kg) per 200 kg of weight or part thereof.
Tax incentive for electric vehicles	Spain	Various regional governments grant tax incentives for the purchase of alternative fuel vehicles including electric and hybrid vehicles: - Aragon, Asturias, Baleares, Madrid, Navarra, Valencia, Castilla la Mancha, Murcia, Castilla y Léon: €2,000 for hybrids, €6,000 for electric vehicles - Andalucia: up to 70% of the investment
Tax incentive for electric vehicles	France	Under a bonus-malus system, a premium is granted for the purchase of a new car when its CO2 emissions are 125 g/km or less. The maximum premium is €5,000 for vehicles emitting 60 g/km or less. This incentive will remain in place until 2012. For such vehicles, the amount of the incentive cannot exceed 20% of the vehicle purchase price including VAT, increased with the cost of the battery if this is

		rented. Hybrid vehicles emitting 135 g/km or less receive an incentive of €2,000.
Tax incentive for electric vehicles	Greece	Electric and hybrid vehicles are exempt from the registration tax. If their engine capacity is 1929 cc or less, they are also totally exempt from the annual circulation tax. Above 1929 cc, the exemption is limited to 50%.
Tax incentive for electric vehicles	Ireland	Electric and hybrid vehicles benefit from a reduction of maximum €2,500 of the registration tax. This benefit is valid from 1 July 2008 until 31 December 2010.
Tax incentive for electric vehicles	The Netherlands	Hybrid vehicles with an energy efficiency label A benefit from a maximum reduction of €6,400 of the registration tax. For hybrid vehicles with a B label, the maximum bonus is €3,200. These incentives will remain in place until 1 July 2010. The registration tax is based on price and CO2 emissions.
Tax incentive for electric vehicles	Portugal	Electric vehicles are totally exempt from the registration tax. Hybrid vehicles benefit from a 50% reduction of the registration tax. This registration tax is based on engine capacity and CO2 emissions.
Tax incentive for electric vehicles	Romania	Electric and hybrid cars are exempt from the special pollution tax (registration tax). This tax is based on CO2 emissions, cylinder capacity and compliance with Euro emission standards.
Tax incentive for electric vehicles	Sweden	Hybrid vehicles with CO 2 emissions of 120 g/km or less and electric cars with an energy consumption of 37 kwh per 100 km or less are exempt from the annual circulation tax for a period of five years from the date of their first registration. For electric and hybrid vehicles, the taxable value of the car for the purposes of company car taxation is reduced by 40% compared with the corresponding or comparable petrol or diesel car. The maximum reduction of the taxable value is SEK 16,000 per year.
Tax incentive for electric vehicles	UK	Electric vehicles are exempt from the annual circulation tax. This tax is based on CO2 emissions and all vehicles with emissions below 100 g/km are exempt from it. As from 1 April 2010, electric cars receive a five-year exemption from company car tax and electric vans a five-year exemption from the van benefit charge (£ 3,000). As from 2011, purchasers of electric vehicles (including plug-in hybrids) will receive a discount of 25% of the vehicle's list price up to a maximum of £ 5,000. The government has set aside £ 230m for this incentive programme.
EU Energy Star	EU	The EU Energy Star scheme involves the labelling of energy efficient office equipment. It features a recognisable logo available for any product tested and verified as meeting certain minimum energy efficiency requirements and products can also be located using an online database. The scheme is EU-wide and applicable in USA. Labelling is then available to demonstrate energy efficiency credentials of the product.
Market Transformation Programme	UK	A Defra funded programme, the MTP is a coordinated approach to supporting the uptake of sustainable products. It incentivises manufacturers and end-users. Incentives can be financial schemes such as grant and subsidy provision, setting minimum standards, labelling (both voluntary and mandatory) and ECA (Enhanced Capital Allowance scheme) which is outlined in more detail below. MTP reduces the environmental impact of products across the product life cycle by: •Collecting information. Stock, sales, usage and resource consumption data is gathered on household and industrial products, such as televisions, fridges and electrical motors. •Building evidence. The information gathered is used to model how products will evolve in the market place and to estimate future environmental impacts. •Working with industry and other stakeholders. A common understanding is reached on how these impacts can be mitigated; action plans are agreed and the measures implemented.

Enhanced Capital Allowance	UK	ECA includes schemes such as the water and energy technology lists (WTL and ETL) and works on the principle that businesses can claim 100% first-year capital allowances on their spending on qualifying plant and machinery. Plant and machinery qualify after assessment by a technical expert, in some cases accredited testing by a third party and can even be self-certified by an ISO 9001 certified organisation. Once verified, a uniquely identifiable label (the label certification number is unique to each for specific product) is made available for manufacturers and suppliers who market the products.

Figure 1 Incentive schemes in countries outside the EU

Incentive	Country	Description / GHG Impact (if known)
Hong Kong - Tax Incentives for Environmentally Friendly Commercial Vehicles	China (Hong Kong)	As of 1 April 2008, Hong Kong's Environmental Protection Department (EPD) has implemented an incentive scheme to encourage investment in environmentally friendly commercial vehicles meeting Euro V emission standards for heavy-duty and light-duty diesel vehicles. Owners of such vehicles are offered a reduction in their First Registration Tax (FRT) and vehicles include taxis, light-, medium- and heavy-goods vehicles, public and private light buses, public and private non-franchised buses and special purposes vehicles.
New Taxation Regulations and Incentive Scheme for Purchasing Environmental Friendly Cars	Japan	Information on the new scheme in Japan and commentary on the strength and weakensses is outlined in Holger, B (2010) "On the Way to a Low-carbon Society? Japan's Automobile Market and Industry in the Aftermath of the Financial Crisis" Available from: http://kgsaint.kwansei.ac.jp/sanron37/37-9.pdf
Top Runner Programme: Fuel efficiency standards for Heavy duty vehicles	Japan	Japan introduced the fuel-efficiency target standard values for heavy duty vehicles in 2006 as a part of measures to reduce fuel consumption and to address global warming. Discussions on establishing new Top Runner standards for heavy duty vehicles began in September 2004, at a joint meeting between the Ministries of Economy, Trade and Industry (METI) and Land, Infrastructure and Transport (MLIT), based on the Energy Conservation Law. Based on the "Top Runner Programme" (that requires current best in class performance to become the average performance level by a target date), manufacturers are required to improve the fuel economy of heavy duty vehicles until the target year 2015. Failure to achieve the target results in a succession of sanctions starting with 'advice' from METI to the company at fault, followed by public naming and shaming and finally a ministerial order to comply with a fine levied for non-compliance. Japan also introduced tax incentives for vehicles that meet both fuel economy and low emission standards. It is possible to have 1-2 percent reduction in the acquisition tax of new vehicles if the standards have been met. Based on the early results, 13 percent of different types of trucks and more than 25 percent of types of buses have met the new fuel standards.
Green Taxation and Subsidies for Automobiles	Japan	The Japanese government introduced in April 2001 a broad taxation scheme which reduces the automobile acquisition tax, the tax on low-polluting vehicles (methanol, hybrid, compressed natural gas, and electric, including fuel cells) and on certain fuel-efficient and low-emissions vehicles. It also increases the tax on old polluting vehicles to promote the development and social acceptance of environmentally sound vehicles. In 2003, the taxation was revised to focus on

		more fuel-efficient and lower-emission vehicles and to cover LPG cars in addition to existing targets. For low gas emission diesel-powered trucks and buses that are more than 3.5 tons in the gross vehicle weight and meet the fuel efficiency standard of the year 2005 for heavyweight vehicles, the preferential measures were formulated as follows: -The automobiles that achieved the fuel efficiency standard for heavyweight vehicles, and automobiles (heavyweight vehicles) that achieved nitrogen oxide (NOx) or particulate matters (PM) reduction by 10% from the automobile emission standard value of the year 2005: Reduction by 2%. -The automobiles that achieved the fuel efficiency standard for heavyweight vehicles, and the automobile emission standard value of the year 2005: Reduction by 1%.
Heavy Vehicles Fee	Switzerland	The heavy-duty (> 3.5 tonnes) vehicle fee (HVF) was introduced in 2001. Its prime goal is to internalise external road transport costs. The HVF is calculated on distance, weight and emissions standards, replacing a previous flat fee. This gradual approach gave hauliers time to improve productivity, which partly offset the cost of the HVF.
Technology Strategy Board, California	US	Incentives for all clean technology vehicles in California are listed below. Rebates: •Employee Corporate Incentives •South Coast AQMD CNG Home Refueler Incentive •San Joaquin Valley Light/Medium Duty Vehicle Emission Reduction Incentive •Clean Vehicle Rebate Project •City of Riverside Employee Vehicle Purchase Incentives Discounts: •City of Vacaville Alternative Fuel Vehicle Incentive Program •LA Department of Water and Power Incentives for EVs •Southern California Edison Discount Rate for EVs •Pacific Gas and Electric E9 Discount Rate for EVs •SMUD Discount Rate for EVs •Farmers Insurance Discounts •San Diego Gas and Electric Clean Transportation Program •AAA Insurance Discount for Hybrid and Alternative Fuel Vehicles Tax: •Plug in Electric Drive Vehicle Tax Credit •Fuel Cell Motor Vehicle Tax Credit •Plug-In Electric Vehicle Tax Credit - Low Speed/ 2-3 wheeled •Plug-in Electric Drive Conversion Kit Tax Credit •Hybrid Tax Credits •Diesel Tax Credits •Alternative Fuel Vehicle Tax Credits Carpool lane: •High Occupancy Vehicle (HOV) Lane Exemption Parking: •Free EV Parking - Los Angeles International Airport (LAX) •Free EV Parking - City of Sacramento Parking Lots •Free Metered Parking - Santa Monica •Free Metered Parking - San Jose •Electric Vehicle Parking Decal •Free Metered Parking - Hermosa Beach
Employee Corporate	California, US	Across the country private companies are helping employees to purchase hybrid or alternative fuel vehicles. Some include California hotels, Bank Of America,

Incentives		Google, Integrated Archive Systems, Clif Bar & Co., Timberland, Patagonia, and many more. Incentives range from $1000 - $5000.
South Coast AQMD CNG Home Refueler Incentive	California, US	The South Coast Air Quality Management District (SCAQMD) Governing Board approved an incentive program which matches the Mobile Source Air Pollution Reduction Review Committee (MSRC) buy down program for the purchase of a compressed natural gas (CNG) home refueling appliance (HRA) manufactured by Fuelmaker. The SCAQMD incentive program matches a $1000 buy-down by the MSRC for a total of $2000 buy-down for consumers who reside in the SCAQMD jurisdictional boundaries. Specifically the incentive buy-down program will apply to the purchase of up to 100 units through Fuelmaker and the lease of up to 300 units through Honda.
San Joaquin Valley Light/Medium Duty Vehicle Emission Reduction Incentive	California, US	The REMOVE II program provides incentives for the purchase of low-emission passenger vehicles light trucks small buses and trucks under 14000 pounds Gross Vehicle Weight Rating. The purpose of this program is to encourage the early introduction of low-emission vehicles in the San Joaquin Valley. The program pays between $1000 and $3000 per vehicle depending on the emission certification level and size of the vehicle. Vehicles must be powered by alternative fuel electric or hybrid electric engines/motors.
Clean Vehicle Rebate Project (California Air Resources Board)	California, US	California's new Zero-Emission and Plug-in Hybrid Electric Vehicle (Clean Vehicle) Rebate Project was officially launched on March 15, 2010. Only qualifying vehicles purchased on or after this date will be eligible for rebates. The Clean Vehicle Rebate Project is funded by the California Environmental Protection Agency's Air Resources Board (ARB) and administered statewide by the California Center for Sustainable Energy. A total of $5 million was appropriated from the ARB's Air Quality Improvement Program for the project to promote the use and production of alternative fuel vehicles. The program was created by Assembly Bill 118 that was signed by Governor Schwarzenegger in October 2007 and that funds air quality improvement projects through 2015. Rebates of up to $5,000 per vehicle are available for individuals and business owners who purchase or lease new eligible zero-emission or plug-in light-duty vehicles until the funding runs out. Certain zero-emission commercial vehicles are also eligible for rebates up to $20,000. General Eligibility: •Zero-emission and plug-in hybrid vehicles •Cars, trucks, commercial medium- and heavy-duty vehicles, motorcycles, neighborhood electric vehicles •Must be new •Must meet certain qualifying requirements
City of Riverside Employee Vehicle Purchase Incentives	California, US	City of Riverside employees are eligible to receive a rebate toward the purchase of qualified natural gas or hybrid electric Advanced Technology Partial Zero Emission Vehicles that are purchased from a City of Riverside automobile dealership. New qualified vehicles can receive up to $2,000 and used qualified vehicles can receive up to $1,000.
City of Vacaville Alternative Fuel Vehicle Incentive Program	California, US	The city offers a $1000 incentive towards a new dedicated CNG vehicle. The City of Vacaville also offers a $2000 incentive on the purchase and installation of the Phill Home Refueling Appliance (HRA). The EV program grants up to $6000 available per new EV purchased or leased. Hybrids are not covered currently under this program because the incentive targets alternative engine technologies. Contact the City of Vacaville prior to purchasing a qualified vehicle to confirm eligibility for the incentive program.

LA Department of Water and Power Incentives for EVs	California, US	LADWP offers an EV discount of $0.025/kWh for electricity. The discount is available for a maximum of 500 kWh/month limited to the base-period rate (off-peak hours). LADWP has proposed additional incentives for installing EV-charging equipment. LADWP also provides EV-infrastructure services to help customers determine applications for EVs in fleet operations EV maintenance services and training.
Southern California Edison Discount Rate for EVs	California, US	Southern California Edison offers a discount rate of $0.07825 per kWh for electricity used to recharge EVs during off-peak time periods.
Pacific Gas and Electric E9 Discount Rate for EVs	California, US	Pacific Gas and Electric offers a discount rate for electricity used to charge battery electric vehicles, plug-in hybrid electric vehicles, and natural gas vehicle home fueling appliances during off-peak time periods. This schedule applies everywhere PG&E provides electric service.
SMUD Discount Rate for EVs	California, US	Sacramento Municipal Utility District (SMUD) offers a discount rate of $0.04187/kWh for electricity used to recharge EVs during off-peak time periods.
Farmers Insurance Discounts	California, US	Farmers Insurance offers 10% discount on all major coverages for those who drive hybrids and other alternative fuel vehicles. Gas-electric hybrids, electric vehicles, and dedicated compressed natural gas, ethanol, methanol or propane vehicles qualify. A complete VIN (Vehicle Identification Number) is required to validate vehicle eligibility.
San Diego Gas and Electric Clean Transportatio n Program	California, US	San Diego Gas and Electric has three time-of-use (TOU) discount rates available for electric vehicle charging and the operation of residential compressed natural gas refueling (CNG) facilities in single family dwellings flats and apartments.
AAA Insurance Discount for Hybrid and Alternative Fuel Vehicles	California, US	AAA offers up to a 5% discount on auto insurance policies for drivers of factory-built hybrid and electric vehicles, as well as automobiles that use ethanol (E85), natural gas or propane.
Plug in Electric Drive Vehicle Tax Credit	California, US	Plug-in hybrid-electric vehicles (PHEVs) purchased in or after 2010 may be eligible for a federal income tax credit of up to $7,500. The credit amount will vary based on the capacity of the battery used to fuel the vehicle.
Fuel Cell Motor Vehicle Tax Credit	California, US	A tax credit of up to $8,000 is available for the purchase of qualified light-duty fuel cell vehicles. After December 31, 2009, the credit is reduced to $4,000. Tax credits are also available for medium- and heavy-duty fuel cell vehicles; credit amounts are based on vehicle weight.
Plug-In Electric Vehicle Tax Credit - Low Speed/ 2-3 wheeled	California, US	The new law also creates a special tax credit for two types of plug-in vehicles: certain low-speed electric vehicles and two- or three-wheeled vehicles. The amount of the credit is 10 percent of the cost of the vehicle, up to a maximum credit of $2,500 for purchases made after Feb. 17, 2009, and before Jan. 1, 2012. To qualify, a vehicle must be either a low speed vehicle propelled by an electric motor that draws electricity from a battery with a capacity of 4 kilowatt hours or more or be a two- or three-wheeled vehicle propelled by an electric motor that draws electricity from a battery with the capacity of 2.5 kilowatt hours. A

		taxpayer may not claim this credit if the plug-in electric drive vehicle credit is allowable.
Plug-in Electric Drive Conversion Kit Tax Credit	California, US	The American Recovery and Reinvestment Act of 2009 (ARRA) provides energy incentives for both individuals and businesses. The new law provided a tax credit for plug-in electric drive conversion kits. The credit is equal to 10% of the cost of converting a vehicle to a qualified plug-in electric drive motor vehicle and placed in service after February 17, 2009. The maximum amount of the credit is $4,000. The credit does not apply to conversions made after December 31, 2011. A taxpayer may claim this credit even if the taxpayer claimed a hybrid vehicle credit for the same vehicle in an earlier year.
Hybrid Tax Credits	California, US	Hybrids purchased or placed into service after December 31, 2005 may be eligible for a federal income tax credit of up to $3,400. Credit amounts begin to phase out for a given manufacturer once it has sold over 60,000 eligible vehicles. (Note: The following requirements must be met to claim the credit: • The original use of the vehicle commences with the taxpayer. • The vehicle is acquired for use or lease by the taxpayer, and not for resale. (The credit is only available to the original purchaser of a new, qualifying vehicle. If a qualifying vehicle is leased to a consumer, the leasing company may claim the credit.) • The vehicle is used mostly in the United States. • The vehicle must be placed in service by the taxpayer after December 31, 2005 and must be purchased on or before December 31, 2010.
Diesel Tax Credits	California, US	Some diesels purchased or placed into service after December 31, 2005 may be eligible for a federal income tax credit of up to $3,400. (No eligible vehicles were manufactured for sale until 2008.) Credit amounts begin to phase out for a given manufacturer once it has sold over 60,000 eligible hybrid and diesel vehicles.
Alternative Fuel Vehicle Tax Credits	California, US	Qualifying alternative fuel vehicles (AFVs) purchased or placed into service between January 1, 2005 and December 31, 2010 may be eligible for a federal income tax credit of up to $4,000. Vehicles placed into service before January 1, 2005 may be eligible for a $2,000 clean-fuel vehicle tax deduction.
High Occupancy Vehicle (HOV) Lane Exemption	California, US	California law allows single-occupant use of High Occupancy Vehicle (HOVs) lanes by certain clean alternative fuel and full-electric vehicles. Use of these lanes with only one occupant requires an identification sticker issued by the California Department of Motor Vehicles. These stickers will be valid until January 1, 2011 at which time this access program expires.
Free EV Parking - Los Angeles International Airport (LAX)	California, US	Free parking is available for electric vehicles only at charging stations.
Free EV Parking	California, US	Sacramento - offers free parking to individuals or small businesses certified by the city's Office of Small Business Development that own or lease EVs with an EV parking pass. Santa Monica - 100% electric 100% CNG or hybrid vehicles carrying the Clean Air Decal may park at any meter in the City of Santa Monica for free. San Jose - Free parking at Downtown San Jose public parking facilities and on-

		street meters throughout the City for Clean-Fuel Vehicles with the Clean Air Decal in the City of San Jose. Hermosa Beach - Free metered parking at silver poled meters for vehicles with the Clean Air Decal in downtown Hermosa Beach. California - Electric Vehicle Parking Decal. This parking decal allows Battery Electric Vehicles (BEVs) to park in designated charging spots throughout California.
Incentives Outside California	California, US	Many US and Canadian states offer programs similar to those found in California including the following incentive schemes. http://www.hybridcars.com/local-incentives.html UNITED STATES Arizona Hybrid Incentive Colorado Hybrid, Plug-in Hybrid and Electric Car Tax Credit & Rebates Connecticut Sales Tax Exemption Delaware Energy Credits District of Columbia Hybrid Incentives Florida Hybrid and Plug-in Hybrid Incentives Georgia Hybrid And EV Incentive Illinois Hybrid Tax Rebate Louisiana Tax Credit Maine Hybrid Tax Reduction Maryland Hybrid and EV Discounts Massachusetts Hybrid Tax Cut Michigan Hybrid Parking Perk Montana tax credit of $500 is available for an electric car conversion. Nevada Hybrid Emissions Exemption New Mexico Hybrid Sales Tax Exemption & Parking Perk New Jersey Hybrid HOV Use--and EV Incentives New York Hybrid HOV Use Oklahoma Income Tax Credit Oregon Tax Credit Pennsylvania Hybrid Tax Rebate South Carolina Sales Tax Credit Tennessee Hybrid Sales Tax Cut Texas Clean Car Parking Incentive Utah Clean Fuel Tax Credits and Use of Carpool Lanes Salt Lake City grants free metered parking to vehicles powered solely by an alternative fuel Virginia Clean Fuel Express Lanes Washington High-MPG Sales Tax Exemption West Virginia Alternative Fuel Tax Credit

Main references and Sources for information on incentive schemes

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Europe

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International Federation of Freight Forwarders Association (FIATA) http://www.fiata.com/
IGD http://www.igd.org.uk/index.asp?id=0
Food Storage and Distribution Federation (FSDF) http://www.fsdf.org.uk/index.php?p=21/0/0
Technology Strategy Board (US)
http://www.driveclean.ca.gov/incentives.php?tech=All&incentive_type=All&city=&city_zip=1&zipcode=&x=45&y=7
World Energy Outlook (2009) http://www.iea.org/Textbase/pm/?mode=weo
JAMA (Japan Automobile Manufacturers Association) http://www.jama.org/
Energy Intelligence for Europe http://www.aid-ee.org/documents/018TopRunner-Japan.PDF

2. Energy

Europe
European Commission, Directorate General Energy and Transport:
http://ec.europa.eu/dgs/energy_transport/index_en.htmv
Intelligent Energy Europe Programme covering many projects on appliances:
http://ec.europa.eu/energy/intelligent/projects/index_en.htm
Eceee – European Council for an Energy Efficient Economy: www.eceee.org
European Commission, Joint Research Centre, Institute for Energy: http://re.jrc.ec.europa.eu/energyefficiency
IEA - International Energy Agency: www.iea.org

Denmark
Elsparefonden, Denmark (Electricity Saving Trust): http://www.savingtrust.dk/
Elsparefonden Purchasing Guidelines for public authorities
http://www.savingtrust.dk/publications/guidelines/purchasing-guidelines-2009
The Danish Energy Agency: http://www.ens.dk/
The association of utilities, Danish Energy Association: www.danishenergyassociation.com

France
ADEME's website: www.ademe.fr
Result of measuring campaigns in homes: www.enertech.fr/Nouveautes.html
GIFAM, manufacturers' union: www.gifam.fr

Germany
The German Energy Agency: www.dena.de
Stiftung Warentest: www.test.de/spargeraete
Consumer Centres: www.verbraucherzentrale.de

Italy
Italian National Agency for New Technologies, Energy and the Environment (ENEA):
http://efficienzaenergetica.acs.enea.it
Regulatory Authority for Electricity and Gas: http://www.autorita.energia.it/index.htm

University Politecnico di Milano, participant in the European REMODECE project: http://www.eerg.polimi.it/remodece.php

Netherlands
Agency of the Dutch Ministry of Economic Affairs: http://www.senternovem.nl/english/
Hier, climate programme: www.hier.nu
BCC, retailer: www.bcc.nl

Poland
Polish national energy conservation agency, KAPE: www.kape.gov.pl
CECED Polska, gathering manufacturers: www.cecedpolska.pl/?m=docs&i=56_55

Portugal
Website from the Ministry of Economy, General direction for energy and geology: www.dgge.pt/default.aspx?cn=63636448AAAAAAAAAAAAAAAA
REMODECE project website: www.isr.uc.pt/~remodece
Energy regulator ERSE: www.erse.pt/ven/entrada

Switzerland
The Swiss Agency for Energy Efficiency (S.A.F.E.): www.energy-efficiency.ch
The Swiss Federal Office Energy (SFOE): www.swissenergy.ch.

UK
Market Transformation Programme: Global Carbon Impacts of Energy Using Products Defra and the Market Transformation Programme: www.mtprog.com
www.defra.gov.uk/environment/consumerprod/mtp/index.htm
Energy Saving Trust, Energy Saving Recommended www.energysavingtrust.org.uk/Energy-saving-products/Home-appliances

APPPENDIX 3 – Modelling assumptions

General Model Parameters

The model has a range of parameters which are common across all technologies and which can be customised by the user. Note that while example figures given below are for the years 2010, 2015 and 2020 only, the model has values for every year.

Discount Rates and Cost of Capital

Both social and private discount rates and costs of capital can be set by the user. Initial values used in this analysis are:

Social Discount Rate	3.5%
Social Cost of Capital	3.5%
Private Discount Rate	7.0%
Private Cost of Capital	7.0%

Fuel Prices

The central scenario from DECC's *Valuation of energy use and greenhouse gas emissions for appraisal and evaluation*[17] has been used as the basis for the fuel price estimates to 2020. The user can then select a retail fuel price scenario (Central or High). Fuel prices are currently over £1.20 per litre and so are more aligned with the High scenario:

	2010	2015	2020
Central	£1.16	£1.25	£1.27
High	£1.24	£1.39	£1.49

The prices given above are retail prices and HGV operators purchase fuel at a discounted rate. A retail to bulk price conversion factor has been incorporated into the model to account for this.
Duty rates set out by the Treasury[18] to 2014 and then flat thereafter.

Carbon Prices

The central scenario, non-traded carbon prices from DECC's revised carbon valuation approach[19] are used in this analysis. These have been inflated to 2010 values using Treasury GDP deflator projection for 2009-10[20]:

	2010	2015	2020
Low	£26	£28	£31
Central	£53	£57	£61
High	£79	£85	£92

Fuel Energy Content and Carbon Factors

17 http://www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx
18 http://www.hmrc.gov.uk/budget2010/bn58.pdf
19 http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/valuation/valuation.aspx
20 http://www.hm-treasury.gov.uk/d/gdp_deflators.xls

The basis for estimating CO_2 savings from the measures can be selected by the user. There are two fuel options (pure mineral diesel or mineral diesel / biodiesel blend) and for each the user can choose either tailpipe emissions (tank to wheel) or tailpipe plus upstream emissions (well or field to wheel).

The figures used to estimate the carbon emissions from different biofuel feedstocks come from the work which AEA did to derive the transport supply side marginal abatement cost curve[21] for the Committee on Climate Change.

The biofuel concentrations to 2020 were provided by the Department for Transport and come from the central Renewable Energy Strategy[22] scenario of 10% biofuels by energy in transport fuel in 2020:

	2010	2015	2020
Biodiesel Content By Energy	4.1%	7.7%	10.0%

The projected concentrations are then used to calculate the energy content of the fuel and from this, the fuel carbon factors ($kgCO_2$/litre) can also be derived:

		2010	2015	2020
100% Mineral Diesel	Tank to Wheel	2.63	2.63	2.63
100% Mineral Diesel	Well to Wheel	3.17	3.17	3.17
Diesel / Biodiesel Blend	Tank to Wheel	2.52	2.42	2.36
Diesel / Biodiesel Blend	Well / Field to Wheel	2.53	2.44	2.39

Vehicle Categories

Four HGV categories have been chosen for this model. They are:

HGV Category	Gross Vehicle Weight
Small Rigid	7.5t – 17t
Large Rigid	>17t
Small Artic	<33t
Large Artic	>33t

Originally, all rigid vehicles were to be considered as one group, however it was noted that the small rigid HGV category had significantly lower annual mileage than the large rigid HGV category (28,000km per year compared with 43,000km per year), which would impact on the measure cost effectiveness and may make certain measures impractical.

Vehicle Lifetime

Average vehicle lifetimes are derived from work undertaken for the marginal abatement cost curve study. This looked at the proportion of vehicles remaining on the road by age of vehicle:

[21] http://www.theccc.org.uk/other_docs/Tech%20paper%20supply%20side%20FINAL.pdf
[22] http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

Age	Rigid	Artic
0	99.0%	99.0%
1	98.8%	98.9%
2	96.6%	97.1%
3	92.2%	84.3%
4	87.9%	74.5%
5	81.1%	62.4%
6	75.1%	52.0%
7	68.9%	40.9%
8	61.6%	29.2%
9	59.0%	24.3%
10	49.5%	17.1%
11	42.2%	12.5%
12	37.5%	9.2%
13	29.0%	6.3%
14	23.9%	3.2%
15	18.7%	2.1%
16	14.4%	2.1%
17	11.1%	1.4%
18	8.7%	1.0%
19-25	2.8%	0.3%

Based on this data, the average lifetime of rigid HGVs is 10 years and the lifetime of articulated HGVs is 7 years.

Vehicle Activity

Section 1 (*The domestic activity of GB-registered goods vehicles*) of RFS2008 breaks down goods vehicles into different weight categories to Section 4 (*Goods vehicle licensing and economic activity*) and, to a lesser extent, Section 5 (*Environment and safety*) making it challenging to match up vehicle km, number of vehicles licensed and fuel consumption. The tables in section 1 of RFS2008 align with the gross vehicle weights chosen for this study and so this is the data which has been used for the model's baseline activity in 2010.

Table 1.19c: Average annual vehicle kilometres by vehicle type: 1998 – 2008

Vehicle Type	GVW	2008
Rigid	Over 3.5 to 7.5	24,000
	Over 7.5 to 17	31,000
	Over 17 to 25	45,000
	Over 25	44,000
	All Rigid	34,000
Articulated	Over 3.5 to 33	71,000
	Over 33	97,000
	All Articulated	94,000

Table 1.12: Vehicle kilometres by vehicle type: 1998 - 2008 (Billion kilometres)

Vehicle Type	GVW	2008
Rigid	Over 3.5 to 7.5	3.5
	Over 7.5 to 17	1.1
	Over 17 to 25	2.5
	Over 25	3.2
	All Rigid	10.3
Articulated	Over 3.5 to 33	0.9
	Over 33	9.9
	All Articulated	10.8

From these tables, an estimate of the number of vehicles in these weight categories can be derived:

Vehicle Type	GVW	2008
Rigid	Over 3.5 to 7.5	152,000
	Over 7.5 to 17	39,000
	Over 17 to 25	57,000
	Over 25	74,000
	All Rigid	322,000
Articulated	Over 3.5 to 33	14,000
	Over 33	106,000
	All Articulated	120,000

The actual total number of licensed vehicles at the end of 2008 is given in RFS2008 Table 4.2 and amounts to 316,800 rigid HGVs and 119,500 articulated HGVs, so these figures compare favourably.

The outputs of the model focus at the savings to 2020, however the workings of the model stretch out to 2030 in order to account for measures that have lifetimes longer than 10 years. It is therefore necessary to project vehicle activity out to 2020 and the source for this is the National Transport Model[23] (NTM), which looks at projected growth in vehicle-km driven by HGVs in England and Wales out to 2035.

An analysis of the detailed figures[24], which break HGV vehicle-km down into rigid and articulated vehicles gives the following growth:

[23] http://www.dft.gov.uk/pgr/economics/ntm/forecasts2009
[24] http://www.dft.gov.uk/pgr/economics/ntm/forecasts2009/xls/forecasts.xls

Forecast Traffic by Vehicle Type and Area Type (% change from 2003)							
Year	**Vehicle Type**	**London**	**Large Urban**	**Other Urban**	**Rural**	**All Areas**	**Inter Urban**
2015	Rigid	+6%	+10%	+9%	+21%	+16%	+22%
	Artic	+6%	-5%	+2%	-5%	-4%	-5%
2025	Rigid	+10%	+16%	+15%	+27%	+22%	+28%
	Artic	+20%	+5%	+13%	+6%	+7%	+6%
2035	Rigid	+14%	+21%	+20%	+33%	+28%	+35%
	Artic	+34%	+15%	+25%	+18%	+18%	+18%

Forecast Traffic by Vehicle Type and Road Type (% change from 2003)						
Year	**Vehicle Type**	**Motorway**	**Trunk**	**Principal**	**Minor**	**All Roads**
2015	Rigid	+24%	+17%	+12%	+11%	+16%
	Artic	-6%	-4%	0%	-3%	-4%
2025	Rigid	+31%	+23%	+18%	+16%	+22%
	Artic	+5%	+8%	+11%	+6%	+7%
2035	Rigid	+38%	+29%	+23%	+22%	+28%
	Artic	+17%	+20%	+21%	+15%	+18%

In both HGV categories, only the larger rigids and artics have seen an increase in vehicle-km travelled over the past decade. All future growth has therefore been attributed to these larger vehicles, while the total vehicle-km from the smaller vehicle categories are kept flat or reduced.

Fuel Consumption

Data on fuel consumption of HGVs in 2007 (the most recent year for which data is available) is given in RFS2008 Table 5.1:

Vehicle Type	Gross Vehicle Weight	Fuel Cons (mpg)
Rigid	Over 3.5t to 7.5t	13.7
	Over 7.5t to 14t	11.4
	Over 14t to 17t	9.1
	Over 17t to 25t	9.5
	Over 25	6.7
	All Rigid	9.4
Articulated	Over 3.5t to 33t	8.9
	Over 33	7.9
	All Articulated	8.0

A weighted average fuel consumption (based on the number of vehicles given above) is calculated for rigid vehicles greater than 17t GVW. For rigid vehicles with a gross vehicle weight of 7.5t to 17t, a straight average has been used as the number of rigid vehicles in the 7.5t to 14t and 14t to 17t categories are not known. The number of these smaller rigid vehicles and their annual activity is low compared to other vehicle types so their impact on the model results will be limited.

The above fuel consumption figures in miles per gallon are converted into MJ per vehicle-km for use in the calculating fuel consumption and CO_2 savings.

The NTM assumes that fuel consumption of the HGV parc reduces by an average of 0.3% per year out to 2035[25] and this has been incorporated into the model.

Model Functions

Individual Vehicles

The first part of the model looks at the lifetime cost effectiveness (both social and private) of a measure applied to an individual vehicle in 2010. This is calculated over the entire lifetime of the measure so if the measure lifetime exceeds 10 years, it will incorporate savings accrued after 2020 as well as those accrued before 2020.

Capital costs are annualised over the lifetime of the measure, while maintenance costs are attributed to the year in which the maintenance expense falls.

Financial savings used in the private cost effectiveness calculation are based on the bulk fuel price less VAT, while financial savings used in the social cost effectiveness calculation are based on the bulk fuel price less VAT and duty.

The cost effectiveness of the measure is calculated on a present value basis and is expressed in £/tCO_2 saved, with negative values indicating an overall financial saving and positive values indicating an overall cost.

The model also calculates an estimate of the profit / loss that the operator would see if the measure is adopted, along with the internal rate of return.

HGV Parc

The second part of the model looks at the HGV parc as a whole and the total financial and carbon savings that would be expected following the uptake of these measures on a wide scale.

Two uptake scenario cases are considered: business as usual and high. The market penetration of the technologies in any year can be customised but initial figures are based on work undertaken for the marginal abatement cost curve study.

The technologies can either be applied to new vehicles only or can be retrofitted to existing vehicles as well as new vehicles. If the "New" option is selected, the model estimates the total number of new vehicles entering the parc by taking the total parc and dividing by the average lifetime. The technology uptake rate is then applied to this figure. If the "Retrofit" option is selected, the model applies the uptake rate to the total number of vehicles in that category.

For each year the total financial costs and savings in that year for each vehicle category are calculated and the net present value is presented.

So if 1,000 vehicles are fitted with the measure in 2015, the capital costs for those vehicles are calculated. Maintenance costs in that year are calculated based on all vehicles which have had the measure fitted prior to 2015 and whose maintenance cycle falls in 2015.

Fuel cost and CO_2 savings in 2015 are calculated by taking the cumulative number of vehicles with the measure and multiplying it by the average saving per vehicle. The value of the carbon saved across the parc is also calculated.

[25] http://www.dft.gov.uk/pgr/economics/ntm/forecasts2009/pdf/forecasts2009.pdf

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