Light Goods Vehicle – CO_2 Emissions Study:
Final report.

Summarising findings from all tasks

Framework Ref: PPRO 04/045/004 (Lot 2)

Contract undertaken by
AEA Technology
Gemini Building
Didcot, Oxfordshire, OX11 0QR

Research funded by The Department for Transport

Final report produced in February 2010

ED05896/TR
Issue Number 2

Title	Light Goods Vehicle – CO_2 Emissions Study: Final Report
Customer	Department for Transport
Customer reference	Framework Ref. PPRO 04/045/004 Lot 2
Confidentiality, copyright and reproduction	Copyright AEA Technology plc This report is submitted by AEA in response to the Terms of Reference issued by the Department for Transport dated 25th January 2008 against Framework Contract PPRO 04/045/004 Lot 2. It may not be used for any other purposes, reproduced in whole or in part, nor passed to any organisation or person without the specific permission in writing of the Commercial Manager, AEA.
File reference	M:\Projects\Policy_Group\Live_Projects\ED05896_DfT_Vans_CO2\Reports ED05896/ FR/Issue 2
Reference number	AEAT/ENV/R/2849/Issue 2

John Norris
AEA Energy & Environment
Gemini Building
Didcot
Oxfordshire
OX11 0QR

t: 0870 190 6439
f: 0870 190 6327

AEA is a business name of AEA Technology plc

AEA is certificated to ISO9001and ISO14001

Authors	Name	John Norris, Phil Stones and Pascal Reverault
Approved by	Name	Sujith Kollamthodi (AEA)
	Signature	
	Date	22nd March 2010

Table of contents

1 Introduction

Light goods vehicles (LGV) are defined as goods vehicles whose gross vehicle weight (GVW) does not exceed 3.5 tonnes, and are conveniently described as vans. Between 2004 and 2006 whilst the emissions of carbon dioxide (CO_2) from passenger cars declined by 3%, that from LGVs grew by 22%.

The main influence on global climate change is through the emissions of greenhouse gases (GHG), principally CO_2. This has led to international agreements to reduce GHG emissions, EU directives legislating to reduce CO_2 emissions from passenger cars, and the UK Government has set a target under the Climate Change Act (2008) to reduce the UK's greenhouse gas emissions by 34% by 2020 (against a 1990 baseline).

On 28 October 2009, the European Commission (EC) published a proposed regulation to reduce CO_2 emissions from LGVs. This aims to achieve an EU-wide reduction in average CO_2 emissions from new vans by setting individual targets for manufacturers. However, relative to passenger cars, CO_2 emissions from LGVs are much more poorly characterised. This project was commissioned by the UK Department for Transport (DfT) to undertake research into the CO_2 emissions from LGVs, with the project being managed on a day to day basis by the Low Carbon Vehicle Partnership (LowCVP).

The research specification from the DfT defined the four main objectives of the project as being:

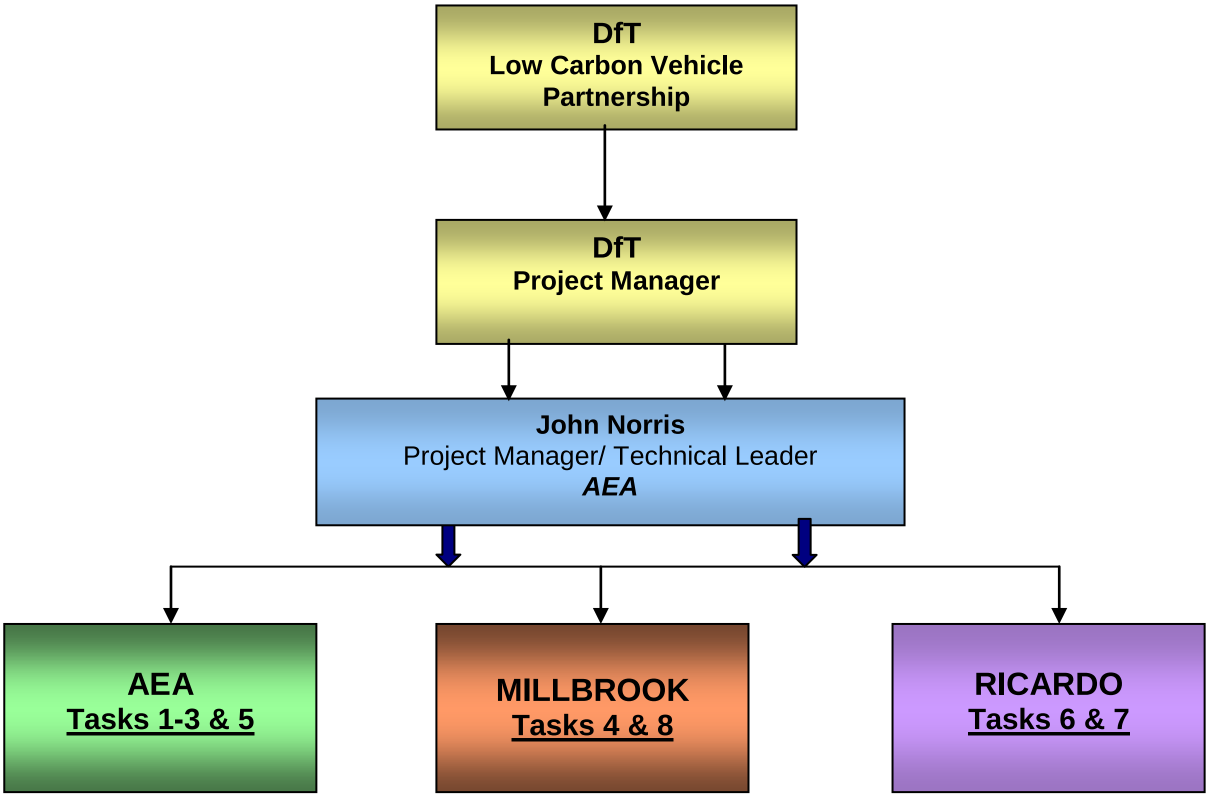
- The provision of evidence of the carbon dioxide outcomes from the current use of light goods vehicles, reflecting varying operational and technological factors, and the potential for future emissions reductions;
- The development of methodologies to measure carbon dioxide emissions for all types of light goods vehicle;
- The provision of evidence that can be used in the development of a policy position on the European Commission's proposal to impose carbon dioxide emissions targets for vans through legislation; and
- The provision of evidence which might enable a robust definition of a Low Carbon Van to be produced.

The research specification suggested a multi-task approach to satisfy these objectives, and the work programme agreed between the consortium, the DfT and LowCVP comprised 8 tasks, as follows:

- Task 1 – A review of the available data on lading factor and average load for vans in the United Kingdom.
- Task 2 – A review of the available data on the impact of tyre pressure monitoring systems and low rolling resistance tyres.
- Task 3 – A review of the available data on the CO_2 emissions of vans at Type Approval.
- Task 4 – An assessment of the impact of load state upon the CO_2 emissions of vans in the United Kingdom.
- Task 5 – Assessment of the potential for CO_2 emission reduction from vans in each of the Reference Mass categories in the short, medium, and longer term.
- Task 6 – The development and validation of a modelling method to correct CO_2 emissions measured on a chassis-cab vehicle to those which would be measured on the finished vehicle.
- Task 7 – The development and validation of a modelling method to correct CO_2 emissions measured on a regulatory drive cycle to those which would be produced on a real-world drive cycle at realistic load factors for the class and type of van being considered.
- Task 8 – A comparison of regulatory test cycles with the real-world operating conditions of vans in the United Kingdom, with particular reference to the accuracy of the regulatory cycles as predictors of real-world CO_2 emissions.

The project was undertaken by a consortium led by AEA Technology, who was supported by Millbrook (whose principal contribution was to undertake the vehicle testing tasks, 4 and 8) and Ricardo (whose principal contribution was to undertake the construction and validation of the model, tasks, 6 and 7). This is shown schematically in Figure 1.1.

Figure 1.1 Overview of project's structure



During the project the following reports have been issued:

- Task Report for Tasks 1, 2 and 3, "Light goods vehicle CO_2 emissions study: Task reports for Tasks 1, 2 and 3", Issue 3 circulated in January 2010
- Task Report for Task 5, "Assessment of the potential for CO_2 emissions reductions", Issue 3 circulated in January 2010,
- Task Report for Tasks 4 and 8, "An assessment of the impact of load state upon the CO_2 emissions of vans and a comparison of real and regulatory drive cycles and their influence on CO_2 emissions of vans", Report circulated in June 2009
- Task Report for Tasks 6 and 7, "Low carbon van simulation tool", Issue 1 circulated in June 2009,
- User Guide for model produced as part of Tasks 6 and 7, Issue 1 circulated in June 2009.

In addition, the van simulation model, a Microsoft Excel 2003 modelling tool, has been built and circulated.

This summary report provides a brief overview of all the projects activities and the findings and recommendations from the research. The order of the tasks reflects the order the reports were published, and describes the desk based (T1, 2, 3 & 5), practical measurements (T4 & 8) and modelling (T6 & 7) aspects of the projects.

2 Summary of individual tasks

2.1 Task 1: Review of lading factors and average load of vans in the UK

2.1.1 Objective

The objective of this task was to review currently available information to produce the best estimates of lading factor and absolute load. Both metrics were to be expressed as an absolute figure, and as a proportion of the maximum load.

2.1.2 Summary of research

The **lading factor** is the ratio of the actual tonne kilometres achieved by the vehicle to the maximum that could be achieved. It ranges from 0% for empty to 100% for fully laden. Despite extensive searching through the literature and public domain information, the first conclusion reached was that there are very few published data on lading factors.

The conclusions from this task drew predominantly on the DfT survey of van activity 2004, reporting on a survey of company owned vans, and the DfT survey of privately owned vans Oct 2002 – 2003, undertaken by MORI and published in January 2004. Data on van numbers, ownership, and vehicle kilometres driven came from DfT's official Transport Statistics publications, whilst the data on maximum permissible payloads for vans, and their current sales figures came from a Society of Motor Manufacturers and Traders (SMMT) database.

From these sources the average loading factors and maximum permissible payload were found to be:

	Average loading factors (by volume)	Average maximum permissible payload[1]
Class I vans[2]	36.7%	625 kg
Class II vans	36.9%	1,035 kg
Class III vans	39.4%	1,214 kg
For all vans	38.2%	1,066 kg

It was also estimated that in terms of weights of goods carried the average over all vans was:

- 318 kg for company owned vans,
- 277 kg for privately owned vans,
- 305 kg for all vans.

It has not been possible to sub-divide the total weight of goods carried by vans among the three reference mass classes. However, an average lading of 28.6% for all vans could be calculated using the data above. This breaks down into 29.8% average lading for company owned vans and 25.9% average lading for privately owned vans.

It is noted that the lading factor for vans is likely to depend on the purpose for which the van is being used. For example, some vans are used as mobile workshops and are perpetually heavy laden. However, Figure 2.4 shows the relatively mild effect of lading on CO_2 emissions and consequently, variations and uncertainty in van lading have a significant, but not large, effect on van CO_2 emissions.

In terms of the robustness of the available data, the summary data above on loading and lading is founded on an extremely small set of available data, essentially two studies. Furthermore, only one of

---

[1] weighting undertaken on basis of numbers of the different types of vans registered, i.e. taking into account behavioural buying patters

[2] The current legislation defines Class 1 vans as commercial vehicles whose reference mass ≤ 1,305 kg, Class 2 vans as having 1305 kg ≤ reference mass ≤ 1,760 kg, and Class 3 vans as having a reference mass greater than 1,760 kg.

these contains any information on loading characteristics. Consequently the data must be treated with a degree of caution.

Regarding future research priorities within this area, the relative importance of knowledge of the loading/lading characteristics for specific categories of van users relative to that for all vans should be debated, particularly given the finding that van emissions are quite mildly affected by loading, at a rate of around 5 g/km for a 300 kg load (a result reported in Section 2.5). This should better define the optimum approach to gathering further loading and lading data. It is also recommended that passive measurement methods are considered, removing the need for van drivers to make judgements on load levels, and to keep records. However, if the approach is to gather information on different categories of van usage, then delivery drivers may already have information on what is delivered and at which point on the delivery round, which could be used.

2.2 Task 2: Review of data on tyre pressure monitoring systems and low rolling resistance tyres.

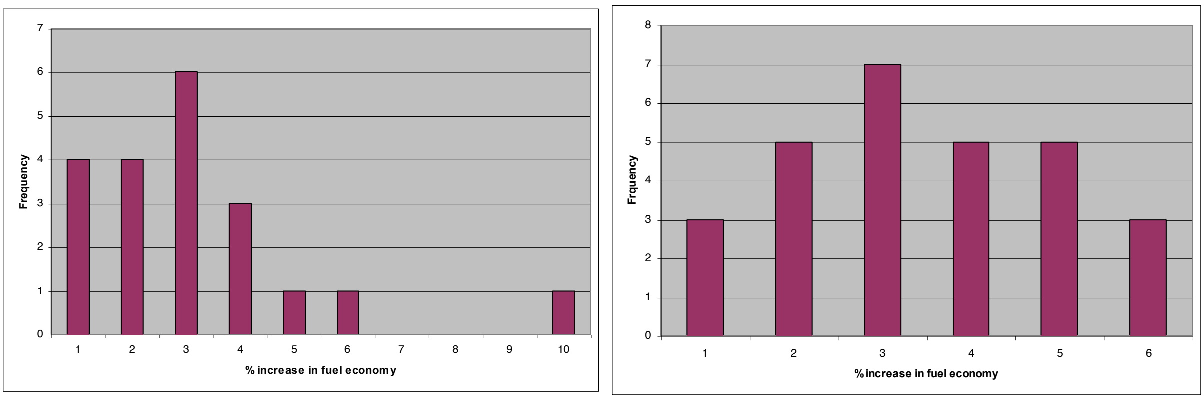
2.2.1 Objective

The objective of this task was to produce bounded figures for the likely impacts of tyre pressure monitoring systems (TPMS) and low rolling resistance tyres (LRRT) upon the average CO_2 emissions of vans operating in the real world.

2.2.2 Summary of research

Both these technical measures can reduce in-use CO_2 emissions when fitted to vans. Literature surveys were undertaken to collect available data, which was then collated. Much of the available data are based on passenger car studies, but it is anticipated that these data will apply similarly to light goods vans. For both technical measures, histograms are presented showing the frequency with which an “X%” decrease in CO_2 emissions (or “X%” increase in fuel economy) are quoted in the literature reviewed. These give indicative distributions of the extent to which different public domain documents quote that these technical measures **may** reduce CO_2 emissions.

Figure 2.1 Frequency with which % increase in fuel economy (reduction in vehicle CO_2 emissions) figures are quoted in report documents and manufacturer responses to enquiry



For tyre pressure monitoring systems

For low rolling resistance tyres

Analysis of these histograms gives:

for TPMS	average CO_2 emissions reduction	2.8% ± 1.4%
for LRRT	average CO_2 emissions reduction	3.5% ± 1.5%.

However, it should be noted that the likely impact on average CO_2 emissions, on the road is equal to the emissions reduction for each of the vehicles affected **multiplied by the number of affected vehicles**.

For TPMS, if this technology were fitted to all vehicles, the number of vehicles which are running with low tyre pressure, and consequently could benefit from the fitting of TPMS, is estimated to range from **10% (or lower) to 50%** of the van fleet, giving a total, fleet-wide CO_2 emissions reduction potential of 0.3 to 1.5%.

For LRRT potentially **all** vehicles could be fitted with these tyres, giving a CO_2 emissions reduction potential of around 3.5%.

It is noted that both TPMS and LRRT are aspects of vehicles that are included in the EC Regulation 661/2009 on “General safety requirements for vehicles”. In their impact assessment the EU estimate CO_2 reductions of around 2% and 4% for TPMS and LRRT, respectively[3].

In terms of robustness of the available data, and priorities for potential future areas, for both TPMS and LRRT the impact of the technology on CO_2 emissions reduction is adjudged to be sufficiently and accurately quantified at present, although additional data from light commercial vehicles, rather than passenger cars, would be of value. For TPMS the principal uncertainty arises from poor knowledge of the distribution of tyre pressures (as a percentage of the correct pressure) within the fleet. For LRRT the principal uncertainties are:

- Whether the observed reductions in CO_2 emissions apply equally to light commercial vehicles.
- The scope for further improvements (since it clearly gets harder to reduce the rolling resistance the lower it becomes).
- The manufacturing and production issues (e.g. can the production lines for LRRT be easily scaled up?)
- The economics of the cost benefit analysis of LRRT in the context of changing scales of production and outlay costs, and changing fuel prices.
- Are there any unintended negative implications associated with the widespread introduction of LRRT (e.g. durability, environmental impacts or regarding safety[4]).

If further research were to be commissioned in either area, it is recommended that reducing these uncertainties be the principal objectives of the study. Also, the influence of tyres on CO_2 emissions from vans should be placed in context with other savings to enable proportionate attention to be paid to these measures.

2.3 Task 3: Review of available data on CO_2 emissions of vans at type approval

2.3.1 Objective

The objective of this task was to produce a report on the mean, and the statistical distribution, of the CO_2 emissions of new vans in the UK market, both as a whole and within each of the van reference mass categories.

---

[3] This impact assessment is available from: http://ec.europa.eu/environment/air/transport/co2/pdf/sec_2007_1723.pdf

[4] By way of example, there is some evidence showing LRRT do not last as long as conventional tyres and therefore a full Life Cycle Analysis may show these unintended negative consequences reduce, or at worst lead to an increase, in tyre lifetime CO2 emissions.

2.3.2 Summary of research

The project specification and proposal for this research were both written before the announcement by the DfT and SMMT (representing the vehicle manufacturers) that a web-based database of CO_2 emissions from vans was to be created. This database was published in June 2009.

Notwithstanding, when this research was undertaken, in August 2008, the project's steering group felt it remained appropriate to review the available data on van CO_2 emissions. Three independent data sources were collected and analysed to obtain data on the mean and statistical distributions of the carbon dioxide emissions from new vans on sale within the UK. All three are incomplete, and generally are complementary rather than some being a sub-set of others. They originate from:

- the Motor Vehicle Registration Information System (MVRIS) which provides data on the registration of new vehicles in the UK in 2007, and is operated by SMMT,
- a search through the literature put into the public domain by manufacturers, and
- data put into the public domain by the German Federal Motor Transport Authority (KBA).

Augmenting the CO_2 data within the MVRIS database

Since the publication of the first version of the task reports for this project, a data matching exercise was commissioned by DfT, and in January 2010 the CO_2 data in the MVRIS database was augmented, using principally the VCA Van CO_2 database but also drawing on the Polk database for UK van sales. This matched **some** MVRIS entries lacking CO_2 data such that the augmented database contained CO_2 emissions data for 96.1% of all UK van sales (up from 4.7%) and 63.9% of the van variants listed (up from 22.3%).

In terms of the Task Reports, those for Tasks 1-3 and Task 5 and this Summary Final Report were revised to include the analysis of the expanded database. The captions of revised tables and figures use the phrase "augmented MVRIS database" to denote the revisions that have been made. (Also, in the revised reports the caveats warning against over interpretation of data, because it may be unrepresentative, have been removed and some commentary regarding the revised data is given as appropriate.)

Table 2.1 summarises the findings from these data sources.

Table 2.1 Summary of all reported CO_2 data and its context

	Augmented MVRIS	Manufacturers	KBA
Total number of van variants identified	3,141	829	29
Number of van variants for which CO_2 data is reported	2,007	224	29
Class I vans – Mean CO_2 emissions (g/km)	147.7		154
Class I vans – size of sample	47		13
Class II vans – Mean CO_2 emissions (g/km)	207.9		159
Class II vans – size of sample	365		5
Class III vans – Mean CO_2 emissions (g/km)	236.8		236
Class III vans – size of sample	1,595		11
All vans – Mean CO_2 emissions (g/km)	229.5	222.0	186
All vans – size of sample	2,007	223	29
Median CO_2 emissions (g/km)	230	232	

Two conclusions are:

- The average of the “all classes” mean values, from the three databases, is 212.5 ± 23.3 g/km based on equal weight for each entry within each database.
- However, the EC analysis for vans considered each separate model using sales weighted data. This is only available from the augmented MVRIS van database, and is 207.6 g/km, considerably lower than the mean calculated treating each model variant as being equivalent (229.4 g/km for all vans).

Headline average van CO_2 emissions

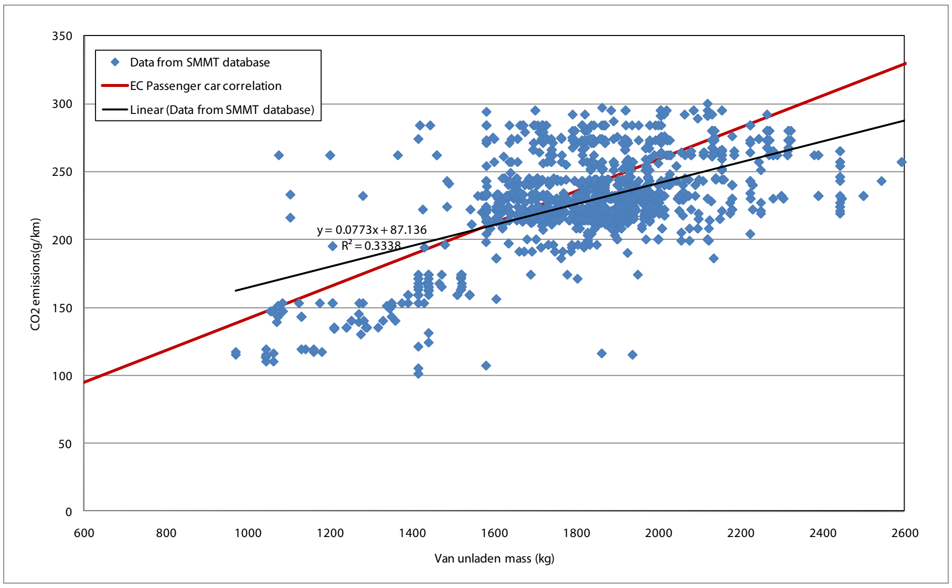
From the augmented MVRIS database the headline average van CO_2 emissions for the UK (based on 2007 sales data) are

207.6 g/km.

Under EC proposed regulation of van CO_2 emission this would be reduced to 175 g/km by 2016 and 135 g/km by 2020[5].

Distribution profiles were generated from the augmented MVRIS database for each class of van and for the whole population. Also, these emissions were plotted against the vans’ reference masses, see Figure 2.2 for the graph including all vans for which there was CO_2 data.

Figure 2.2 **Correlation diagram of CO_2 emissions against van unladen mass for all vans (from the augmented MVRIS database)**



This correlation diagrams show:

- For the vans the range of kerb masses is quite small, generally 1,250 kg < M < 2,500 kg, whilst the range of CO_2 emission values is quite large.
- The linear regression of the CO_2 emissions against vehicle mass is poor. Consequently, the analysis should be treated circumspectly, and should not be over emphasised.
- The EC-derived line relating CO_2 emissions to vehicle mass for passenger cars does go through the van data, close to its middle as judged by eye.

In terms of the robustness of the available data, it has been noted that the MVRIS dataset is significantly larger than the other two datasets. However, in terms of CO_2 emissions, closer examination did reveal some anomalous data that were addressed in Task 5. The details of the analysis undertaken in this task formed a starting point for a more detailed analysis undertaken in Task 5.

---

[5] The actual average value is 175 g/km based on the EU-27 mean van reference mass figure. The value for the UK will differ slightly from this (being slightly larger) because the UK mean van reference mass differs slightly from that within the EU-27.

2.4 Task 5: Assessment of the potential for CO_2 emissions reductions

2.4.1 Objectives

There were five objectives for this task, namely:

a) Consideration of technologies that could be applied to LGVs to reduce their emissions;

b) The potential emissions reduction that could be achieved;

c) Quantification of the potential for accelerated emissions reductions from light goods vehicles by shifting vehicle purchasing behaviour; and

d) Quantification of the extent to which vehicle pricing influences purchasing decisions.

e) Provision of information to assist the specification for the procurement of lower carbon vans;

2.4.2 Summary of research

Technologies that could be applied to reduce emissions and the potential emissions reductions

18 different emerging technologies were considered (8 affecting vehicles' power train, 6 being non-power train technologies and 4 which are anticipated to increase CO_2 emissions). They span a range of CO_2 emissions savings potentials. The levels of risk adjudged to be associated with each of the technologies, caused by both technology maturity and the infrastructure requirements were assessed using a 1 (little risk) to 5 (high risk) scoring scheme. The data were derived from recent, authoritative detailed reviews[6].

The data summarised in these reviews has been compared and found to be, on the whole, consistent. Additional new material is constantly becoming available, e.g. via news media motoring correspondents, SMMT technical circulars and press releases from companies. Consequently, it is believed that the data reported is current and robust. However, an important conclusion from the study is that because many of the technologies are relatively immature with respect to their application to light goods vehicles, the data on potential CO_2 savings, or on the rate of technology penetration in the future, may require updating as further experience based information becomes available.

The consensus view from the different authoritative sources reviewed is that generally these emerging technologies are starting from a very low degree of penetration, and that it will take time for them to influence the fleet. Levels of technology penetration that could technically be achieved with concerted efforts on behalf of industry and the Government by 2009, 2013, 2018 and 2022 were presented together with the potential CO_2 savings for each technology. These penetration rates assume there will be some moderate pressure to encourage the uptake of low carbon technologies. The cumulative effect of all technologies on the CO_2 emissions relative to a static baseline from the 2008 new van sales (excluding the impact of the four measures that will increase CO_2 emissions) was estimated to give savings of around 11.7% by 2016 and 24.8% by 2020. Further CO_2 savings could be achieved if the penetration rates of technologies were accelerated by regulatory pressures or other externalities.

The savings for plug in hybrids and battery electric vans, where external electric power sources augment, or totally replace, the liquid fuel, were calculated using well to wheels data, and the current electricity supply industry generating mix. For consistency, these calculations used the same data

---

[6] Data sources were
- "Making cars more fuel efficient", a report from the International Energy Agency, IEA (2005)
- 'The King Review of low carbon cars, King (2008),
- 'Measuring and preparing reduction measures for CO_2 emissions from N1 vehicles' report produced by TNO automotive, TNO (2004), and
- "UK marginal abatement cost curve model for the transport sector: Part 1 – technology and efficiency" study undertaken by AEA, AEA (2008b).

sources that were used by AEA in 2008 to develop a transport sector CO_2 marginal abatement cost curve (MACC) model for the Committee on Climate Change.

As these technologies are still developing there may be a number of potential issues to be understood. For plug-in hybrid electric vehicles these include their uptake, and potential usage pattern which could vary from never drawing power from the electricity mains to being used exclusively as electric vehicles.

Overall, a key message from this analysis is that the potential CO_2 emissions reductions from these technologies within the next five years is judged to be quite low (around a 6% improvement), although in the longer term, i.e. between now and 2020, the potential CO_2 emissions reductions is much larger (up to 30% on a well to wheels basis).

Quantification of the potential for accelerated emissions reductions from light goods vehicles by shifting vehicle purchasing behaviour.

This sub-task involved further detailed analysis of the augmented MVRIS database to quantify the accelerated emissions reductions that could be achieved by either encouraging those who purchase LGVs to buy vehicles with the “best in class” CO_2 emissions, or through the accelerated penetration of new technologies into the market place. However, at the beginning of the study it was found that there were some errors in the MVRIS database. This led to a revision of the database, and a re-examination of the optimum definition of van categories.

These activities concluded that the project would continue to use the amended, more robust, MVRIS database because it was the best database currently available, and the project would continue to use the reference weight boundaries between the categories defined by the EU for pollutant emission standards, i.e. Classes I, II and III, because these are well aligned with van users perceptions.

In addition, as noted in the box in Section 2.3.2, the MVRIS database was then augmented to cover more than 96% of van sales, drawing on the CO_2 emissions data published in the VCA Van CO_2 database. The results reported here are from the analysis of this augmented (and amended) MVRIS database.

With regard to encouraging the purchase of “best in class” the analysis concluded that when payload weights and volumes were taken into account, the categorisation of vans should be divided into three main groups (Classes I, II and III as defined by EU directives) with Classes I and II further sub-divided into two sub-classes for the smaller and larger sub-sets. This categorisation is summarised in Table 2.2.

Table 2.2 Possible categorisation of vans

Name	Reference mass	Class, as defined for EU emissions standards	Payload mass	Payload volume
Small car derived vans	≤1,305 kg	Class I	≤ 600 kg	≤ 1.5 m^3
Larger car derived vans	≤1,305 kg	Class I	> 600 kg	> 1.5 m^3
Smaller Class II vans	1,305 – 1,740 kg	Class II	≤ 1,000 kg	≤ 3 m^3
Larger Class II vans	1,305 – 1,740 kg	Class II	> 1,000 kg	> 3 m^3
Large vans	> 1,740 kg	Class III	Any	Any

Using these five groups a methodology to define the “best in class” was developed based on analysing CO_2 emissions for ten equal groups of van types of each class (arranged in order of increasing CO_2 emissions), and taking the average CO_2 emissions from each decile. (A consequence of this approach is that the “best in class” groups are not dominated by any single manufacturer, or any specific vehicle’s emissions.) Table 2.3 summarises the results of this analysis.

Table 2.3 Analysis of van emissions, defining best in each class and savings possible

	Weighted by number of new registrations in augmented MVRIS database		**Weighted by number of vehicle type entries in augmented MVRIS database**	
Van group	**Emissions for best decile** (g/km)	**Emissions for whole group** (g/km)	**Emissions for best decile** (g/km)	**Emissions for whole group** (g/km)
Smaller Class I	110.5	114.7 (2.3%)*	112.4	115.7 (0.7%)
Larger Class I	135.0	139.4 **(7.1%)	135.6	146.0 **(1.6%)
Smaller Class II	141.5	150.6 (19.9%)	139.6	156.4 (5.4%)
Larger Class II	195.8	215.5 (9.4%)	203.2	229.8 (12.8%)
Class III	207.2	234.0 (61.2%)	204.6	236.8 (79.5%)
	Savings if all vehicles in each class were the "best in class"			
Class 1 small vans	3.7%		2.9%	
Class 1 large vans	3.2% **		7.1% **	
Class 1	**3.3%** **		**5.7%** **	
Class 2 small vans	6.0%		10.8%	
Class 2 large vans	9.1%		11.6%	
Class 2	**7.0%**		**11.0%**	
Class 3	**11.5%**		**13.6%**	

* The figure in brackets in the "Emissions for the whole group" columns is the fraction of the whole fleet that comprise this group
** The highest emitting decile of Class I vans was excluded from this analysis

When the CO_2 savings for each class are weighted by the fraction of the overall LGV registrations then the savings for the whole van fleet that would occur if **all those who purchase light goods vehicles were to buy the vehicles with the "best in class" CO_2 emissions** can be found. This is a reduction of 9.4%.

It is also noted that in 2007 the number of new registrations was close to 10% of the total LCV population, indicating that the average van is used for 10 years. This means that the overall van fleet emissions contains contributions from vans which are 10 years old, i.e. it takes 10 years for the benefits of vans with lower emissions to percolate through the fleet. However, by that time the "new" van will have evolved and have even lower CO_2 emissions.

With regard to encouraging the uptake of new technologies, the analysis concluded that if there were an accelerated take up of the technologies as they mature, then by 2016 around 50% of the fleet could have at least medium light weighting, 42% could be micro-hybrids, and 8.6% could be battery-electric vehicles. When the emissions savings for each of the three technologies are taken into account, the total savings are around 22% as calculated by tank to wheels CO_2 savings (with 4.7% coming from the battery-electric vehicles).

With the predicted rate of uptake of technology, the total savings are expected to be around 6% by 2016. (This figure is around half the savings that are predicted to be achievable with the concerted efforts of industry and government, 11.7% by 2016.)

Consequently, it appears that the current immaturity of the low carbon van technologies means that their likely impact in the next 5 years on the LGV fleet emissions remains low.

Quantification of the extent to which vehicle pricing influences purchasing decisions of this kind behaviour.

A literature survey, backed up by anecdotal evidence, highlighted differences between the purchasing behaviour of car buyers and van buyers, and of company and private buyers.

A key difference found is the importance of economic considerations for company purchases. Businesses rank the importance of economic considerations when making vehicle purchasing decisions in first place rather than the tenth place which is the ranking given by private car purchasers. This influences fleet composition, and hence its CO_2 emissions, particularly given DfT data that quantifies company vans as driving two thirds of the total van km. Its importance is that **if low carbon**

van technology is cost effective then it would be a strong factor in company purchasing decisions. This is further emphasised by the different discount rates that are relevant to the private and company purchasers. It is additionally important because whilst the company vans account for two thirds of the van km driven, the proportion of new vans that are bought by companies is even higher, with private buyers dominating the second hand market. Hence, if company purchasers can see the financial benefit of buying low carbon vans, through lower whole-life vehicle ownership costs, these vans would find their way into private ownership in time.

However it was found that the lack of published information by manufacturers on emission figures of their vehicles threatens to undermine the opportunity that exists. Fleet managers are confused when making procurement choices because although they would like to go green they are not convinced by manufacturers' claims unless there is clear independent evidence supporting those claims. These concerns should be addressed by the recent publication by the VCA of the van CO_2 emissions database, although there remains the challenge of effectively communicating the database's contents to those involved in purchasing vans.

A further challenge for company van owners is knowledge of how varying loads will affect fuel efficiency, and therefore running costs. Tasks 6 and 7 of this project addressed this question.

In terms of the robustness of the analysis, it is appreciated that there is a relatively high degree of subjective judgement involved. Further, whilst the factors that influence purchasing decisions are well characterised, e.g. whole-life vehicle ownership costs, the quantification of the cost effectiveness of low carbon van technologies does vary with external factors. These include:

- The discount rate used when calculating the cost effectiveness of options (the discount rate converts all costs to "present values" so that they can be compared. Different discount rates are used to represent different time preferences for goods and services);
- The cost of fuel;

In addition to the factors above, there are subjective influences that affect purchasing decisions including the economic circumstances of the potential buyer and the overall economic environment. The last 12 months have highlighted how each of these factors can change both markedly and swiftly.

Overall, despite the current external economic climate, the findings from this review are encouraging. The message is that if low carbon vehicles can be manufactured sufficiently cheaply so that there is a net saving over an appropriate period of ownership, then company van owners are more likely to purchase these vans than private owners. Also, there is potentially a receptive audience for the recently published CO_2 emissions database, when appropriately presented, because of the purchasing behaviour of van buyers and their interest in seeing independent sources of emissions information to support manufacturer's claims.

Information to assist the specification for the procurement of lower carbon vans.

A draft specification for low carbon light goods vehicles was developed as part of this research project. In a number of respects this is based on the specification Ricardo developed for the low carbon vehicle procurement programme, and that was reported to DfT in 2008. However, on the key aspect of CO_2 emissions an independent assessment has been undertaken in this study. This concluded:

- It is possible/desirable to have a low carbon specification for the whole range of light goods vehicles;
- LGVs are best categorised in three classes with two of these classes being split into larger and smaller variants, i.e. a total of five sub-categories, see Table 2.2.
- The low carbon specification could be expressed as a continuous function dependent on vans' kerb or gross vehicle weight.

Consideration of the data available has concluded that the specification should:

- As a minimum be based on the average CO_2 emissions for the EU regulatory New European Driving Cycle (NEDC);
- Ideally also be based on the urban and suburban components of the NEDC if they are available; and
- Be based on the EU regulatory test procedure (unladen weight +100 kg, dynamometer settings as per regulations etc).

It is appreciated that the above are a compromise and do not necessarily reflect emissions for loaded vans, or the effect of the vans' bodywork on emissions. However, it is thought unrealistic to require real coast down data and emissions data for unladen, fully laden and possibly an intermediate lading value.

Within these assumptions draft low carbon LGV threshold CO_2 emissions data were derived for the five van sub-categories from the analysis of the augmented MVRIS database, as given in Table 2.4.

Table 2.4 Draft CO_2 emission targets for "Low Carbon Vans" for 2009

Type of van	Recommended Low C Van threshold for 2009
Smaller Class I	110 g/km
Larger Class I	135 g/km
Smaller Class II	142 g/km
Larger Class II	196 g/km
Class III	207 g/km

The data in Table 2.4, when plotted against the gross vehicle weight, or the kerb weight, for the five van sub-categories, is shown in Figure 2.3. The fit to a linear function is moderate, and consequently the specification of a low carbon van could be expressed as a continuous function, rather than the five discrete sub-categories given in Table 2.4.

Figure 2.3 CO_2 emissions against kerb weight and GVW for the 5 categories of vans.

It is appreciated that this is the first occasion where a draft specification for low carbon vans has been proposed across the whole range of light goods vehicles. It is recommended that, subject to DfT's and LowCVP's judgement, this is discussed more widely:

- In the context of the specification for other low carbon vehicles; and
- With stakeholders.

2.5 Tasks 4 and 8: An assessment of the impact of load state, and of real and regulatory drive cycles, on CO_2 emissions of vans

Because these two tasks share the common needs of test vehicles and test facilities, they were undertaken together by Millbrook using their specialist test facilities.

2.5.1 Objective

The objectives of the two tasks associated with the practical testing of vehicles were:

- to collect data on the relationship between vehicle load state and CO_2 emissions,
- to collect data on the dependence of the above on the vans' drive trains and body types,
- to collect data on the relationship between CO_2 emissions for real and regulatory drive cycles, and
- to collect data on the relationship between load state and CO_2 emissions for real and regulatory drive cycles.

2.5.2 Methodology

The methodology was to define an appropriate set of vehicles, drive cycles, load states and test conditions, and to devise a test matrix that investigates each parameter in a controlled manner, but within the resources available to the project.

Vehicles:

Three vehicles were selected, in consultation with the project's Steering Committee, namely:

Peugeot Partner	a small Class II car derived van, whose GVW was 1,960 kg
Ford Transit	a small Class III van, whose GVW was 2,600 kg
Mercedes Sprinter	a large Class III van, whose GVW was 3,500 kg.

These three high volume sales vans covered three different manufacturers and sizes, and were agreed to be representative of the UK van fleet as a whole. They also complemented some additional data that Millbrook had from a previous study undertaken with the LowCVP Van Working Group, data from a VW Caddy and a Vauxhall Vivaro van.

Drive cycles and test conditions:

It was not appropriate to devise any new drive cycles as part of this research. Consequently, the drive cycles chosen were from the pre-existing pool of cycles. Those selected, in consultation with the project's Steering Committee, were:

NEDC[7]	Av speed 33.5 km/h	idle time 24.9% (294 s)	max speed 120 km/h
FIGE Vehicle cycle[8]	Av speed 59.0 km/h	idle time 3.8% (68 s)	max speed 91.1 km/h
Artemis 130[9]	Av speed 96.9 km/h	idle time 1.5% (16 s)	max speed 131.8 km/h
Urban Delivery DC[10]	Av speed 12.9 km/h	idle time 50.3% (1604 s)	max speed 93.0 km/h.

The load states at which the vehicles were tested were their reference mass (as for the regulatory test); with 50% load; and with 100% load (i.e. at their GVW).

---

[7] NEDC selected because it is the regulatory test cycle
[8] FIGE vehicle cycle selected because the engine form is the regulatory cycle for goods vehicles >3.5 tonnes GVW
[9] Artemis130 cycle selected because some vans spend the majority of their time on motorways
[10] Urban delivery drive cycle selected because it is derived from the behaviour of delivery vans in urban areas.

2.5.3 Summary of results

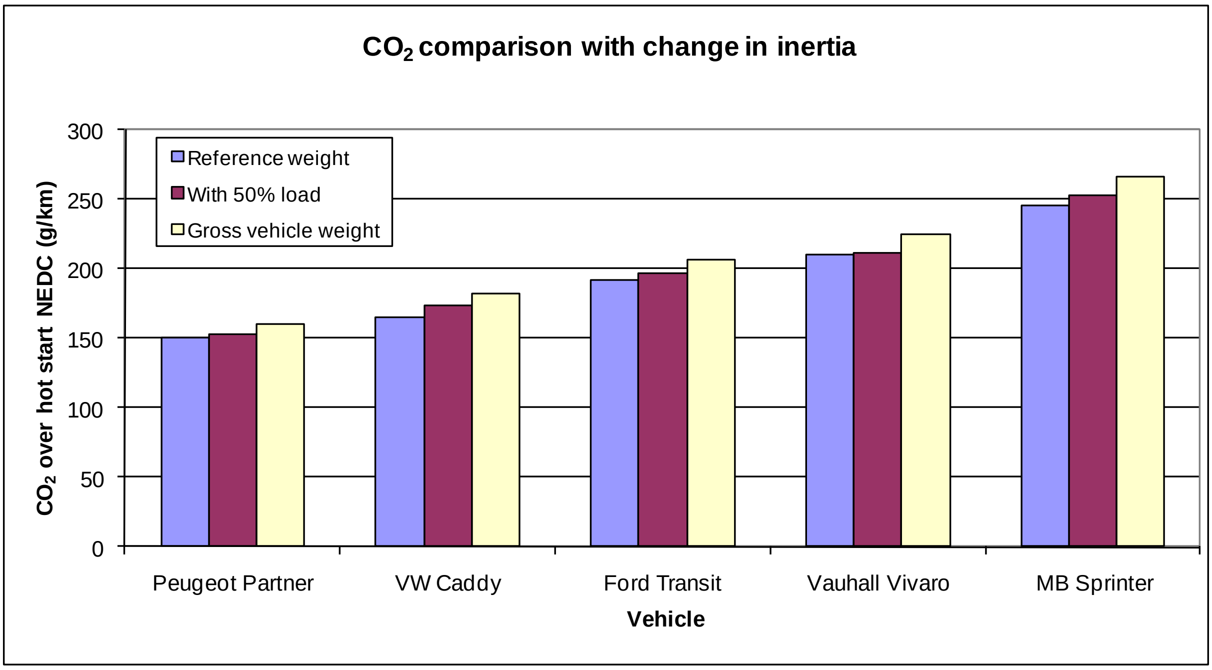
Effect of inertia and payload on CO_2 emissions:

Figure 2.4 shows how the CO_2 emissions vary for all 5 vehicles for the regulatory (NEDC) cycle, in order of their weight at 50% load. The numerical data are given in Table 2.5.

Table 2.5 CO_2 emissions for the vans (g CO_2/km) as a function of payload

	Peugeot Partner	VW Caddy	Ford transit	Vauxhall Vivaro	MB Sprinter
Emissions at reference weight (g CO_2/km)	151.0	164.9	192.3	210.6	245.6
Emissions with 50% load (g CO_2/km)	153.0	173.5	197.1	211.0	252.6
Emissions at gross vehicle weight (g CO_2/km)	160.0	182.3	206.1	225.0	265.9
Difference between Reference weight and GVW (kg)	490	798	628	890	1230
Emissions per 1,000 kg load (g/tonne km)	326.5	228.4	328.2	252.8	216.2
Change in emissions per 100 kg load (g/km)	1.84	2.18	2.20	1.62	1.65

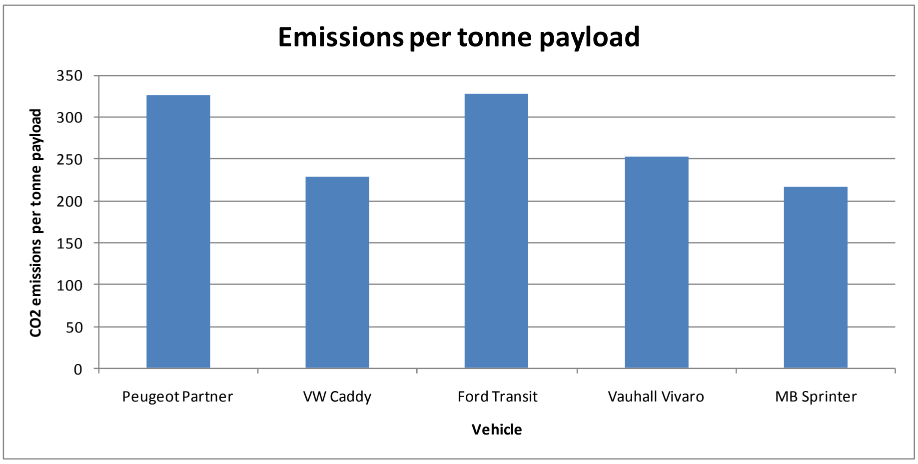
Figure 2.4 Measured variations in CO_2 emissions with payload



As expected, heavier vehicles emit more CO_2 per kilometre. But the average change in CO_2 emissions on going from unladen to fully laden is 7.8% ± 1.8%. This is markedly less than the average increase in the vehicles' weights on going from their reference mass to fully laden, which is around 50%. However, it is likely that this relatively low sensitivity to the degree of loading is, in part, caused by the relatively smooth style of the NEDC. This can be evaluated using the vehicle simulation tool (see Section 2.6).

The CO_2 emissions expressed in g per vehicle kilometre do not convey all key information when considering either the weight or the volume of goods that need to be transported. The data in Table 2.5 is used to provide the CO_2 emissions per tonne of payload for the fully laden vans. These data are shown in Figure 2.5, and show, broadly, a reversal of the pattern shown in Figure 2.4. Consequently, if several tonnes of goods had to be transported it is more efficient to use a smaller number of Sprinter vans than a larger fleet of smaller vans.

Figure 2.5 Measured variations in CO_2 emissions with payload



An alternative metric is the change in CO_2 emissions per 100 kg load added. These data are also included in Table 2.5, and the average of this for the five vans studied is 1.7 ± 0.30 g/km per 100 kg load.

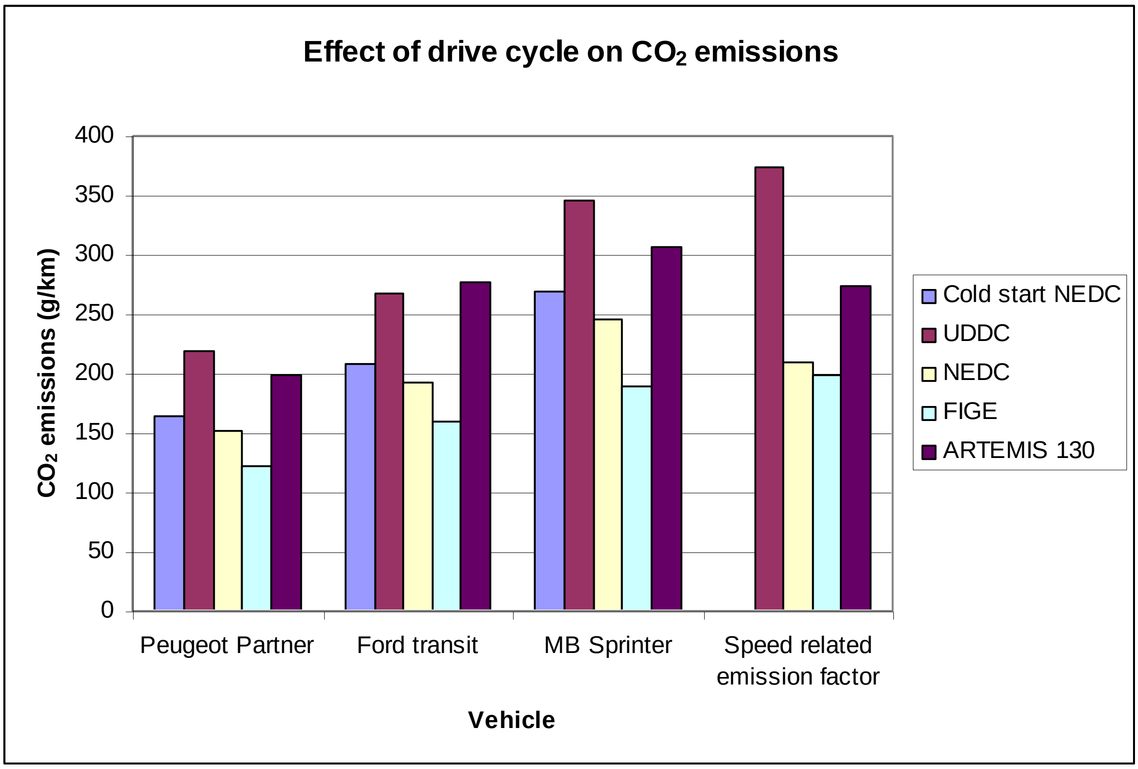
Effect of drive cycle and dynamometer settings on CO_2 emissions:

Figure 2.6 shows the influence of drive cycle on the average CO_2 emissions for the three vehicles tested in this project. The cycles are ordered as follows: cold start NEDC first, and then in order of their average speed (UDDC, NEDC, FIGE, Artemis 130). The general pattern of CO_2 emissions is similar for the three vans. This pattern also follows that predicted from the recently released (revised) speed-related emission functions (used to calculate the CO_2 emissions for emissions inventories). The group of four columns on the right of the figure are the CO_2 emission factors for Euro 4, Class III diesel N1 vans.

Finally, for one van, the Ford Transit, its CO_2 emissions were compared for when the dynamometer resistance was set up according to the industry standard coefficients reference data, and by matching the dynamometer to the vehicle's coast down data, measured by the Millbrook team. This study was to investigate the influence of test variables on CO_2 emissions in the context that the vast majority of van data are collected using these reference datasets. It was found that the coast down (van specific) settings led to higher CO_2 emissions for three of the four drive cycles with the average increase being 2.7%, but the spread of the change being high (around 3% for the range of drive cycles used).

All the results presented here are average CO_2 emissions over whole drive cycles. In addition, CO_2 emissions were measured on a second by second basis. These provided a myriad of data points as inputs to the vehicle simulation model, discussed in the next section.

Figure 2.6 Measured variations in CO_2 emissions for different drive cycles



2.6 Tasks 6 and 7: Development and validation of modelling methods to correct CO_2 emissions measured on a chassis cab, and over the regulatory drive cycles to real-world drive cycles

These two tasks share the common needs of a model platform, and consequently they were undertaken together by Ricardo.

2.6.1 Objective

The objectives of tasks 6 and 7 were to build a vehicle simulation model for the prediction of vehicle fuel consumption, and hence CO_2 emissions, to allow the user to run sensitivity studies. The model was constructed to allow the influence of the following parameters on emissions to be investigated:

- vehicle shape (chassis cabs to box van) i.e. modelling the effects of aerodynamics,
- vehicle mass, i.e. for different body types, and different levels of loading,
- drive cycles, from regulatory to a variety of real world cycles, and
- tyre rolling resistance.

2.6.2 Summary of research

The construction of the vehicle simulation model was undertaken by Ricardo, and complements the research into existing knowledge on LGV CO_2 emissions and the vehicle testing programme by providing a validated simulation tool able to predict the effect of the four parameters listed above on CO_2 emissions. The simulation tool reduces the need for more extensive vehicle testing and can be exploited beyond the end of this study for further work and future studies.

At the beginning of the project, it was decided that the simulation tool would be built in Microsoft Excel[11] for the following reasons:

- Ease of dissemination within DfT,
- No software licensing issues
- Ease of use for non vehicle simulation experts.

The model comprises:

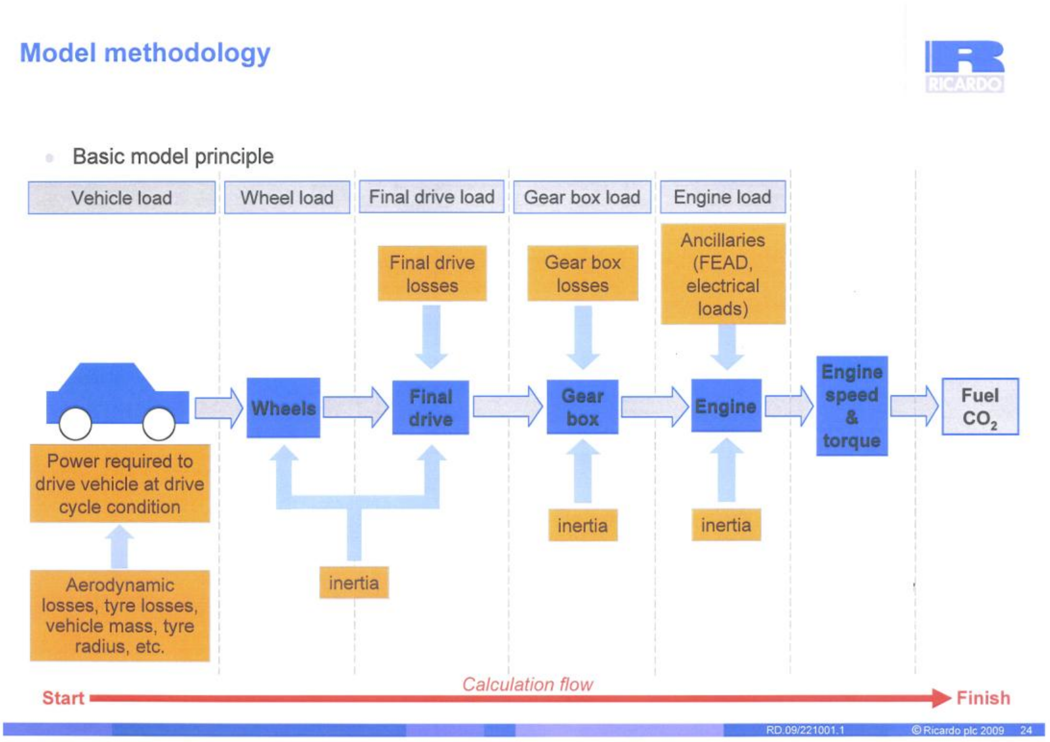
- a graphical user interface (GUI)
- the calculations at the heart of the vehicle simulation, and
- numerical and graphical results.

Ricardo provided a user guide. This describes the processes required to install, setup and run the model and the results produced. Its contents comprise:

1. Introduction
2. Getting started
3. Setting up the model
4. Running the model
5. Results
6. Model methodology.

The model is a “backward facing” calculation tool. The calculation flow is shown in Figure 2.7.

Figure 2.7 Model methodology – schematic of the calculation flow



---

[11] The simulation tool was developed for use in Microsoft Excel 2003

A crucial part of the model development was its validation against the data collected by Millbrook on the three vans, the Peugeot Partner, the Ford Transit and the Mercedes Sprinter at different loads. Care was taken to ensure that the actual forces modelled on the vans were identical to those experienced during testing by transferring the dynamometer settings to the model. The task report provides extensive data on the validation for the regulatory cycle, the cold start NEDC, for the NEDC with a hot start, and for the "real world cycles" the FIGE, Artemis 130 and UDDC.

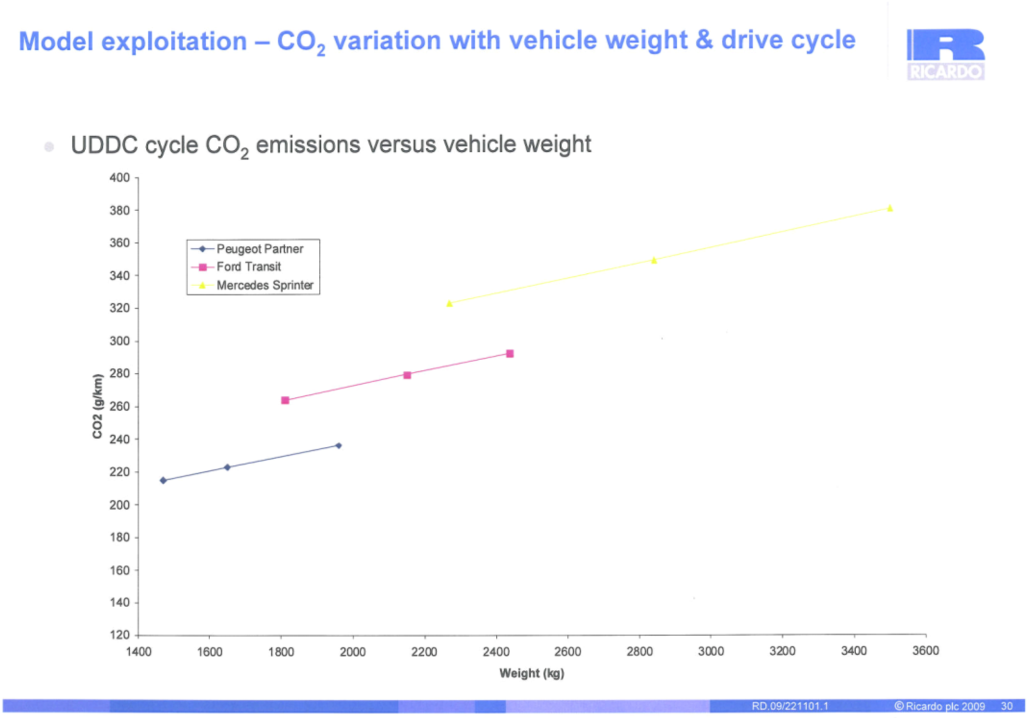
Having built and validated the model, Ricardo used it to model the following scenarios:

- variations in CO_2 emissions with vehicle weight;
- variations in CO_2 emissions with drive cycle; and
- variations in CO_2 emissions with aerodynamic drag.

The first two of these studies contain the reference conditions for which experimental data were obtained. However, the model can predict the CO_2 emissions for vehicles with intermediate weights, and over new drive cycles.

Figure 2.8 is illustrative of the graphical data that can be produced by the van simulation model, showing the variations in CO_2 emissions for all 3 vans with vehicle weight over the urban delivery drive cycle (UDDC).

Figure 2.8 Variation in CO_2 emissions with vehicle weight over the UDDC



Model exploitation – CO_2 variation with vehicle weight & drive cycle

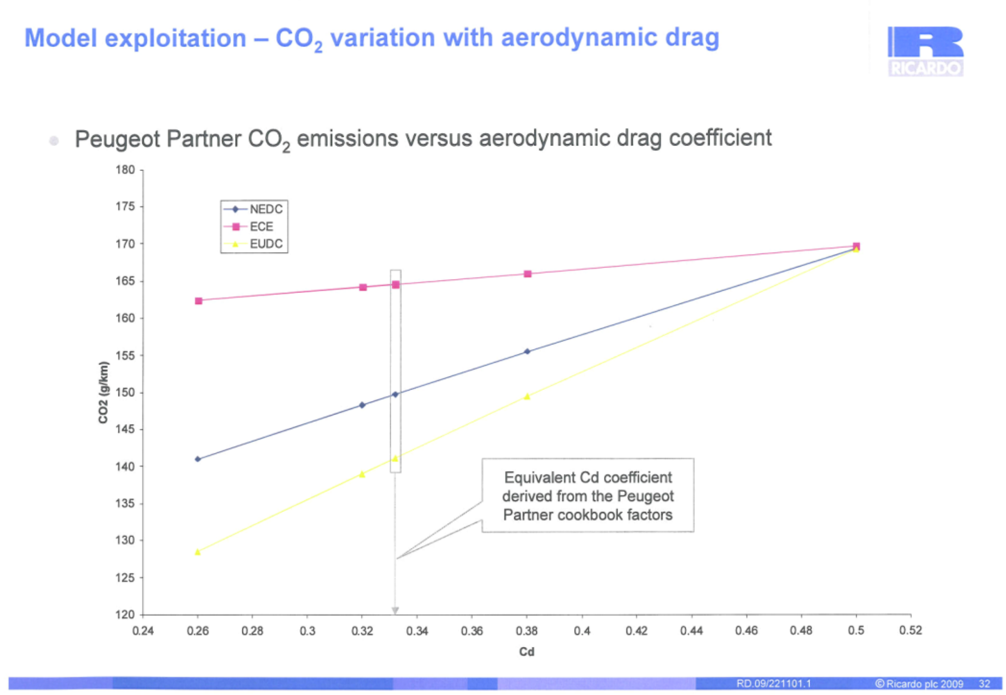
- UDDC cycle CO_2 emissions versus vehicle weight

RD.09/221101.1 ©Ricardo plc 2009 30

To illustrate how the CO_2 emissions vary with aerodynamic drag, Ricardo carried out a study where each of the three vans were simulated over the NEDC (regulatory cycle) using five different values of drag coefficient (C_d) ranging from 0.26 (low) to 0.50 (very high). This range extends above and below the drag coefficient for the standard panel van models and results for the Peugeot Partner are shown in Figure 2.9.

The figure clearly shows the relatively low sensitivity of the CO_2 emissions for the low average speed ECE portion of the regulatory drive cycle to C_d (the red line), and, in contrast, the much higher sensitivity of the CO_2 emissions for the EUDC portion of the regulatory drive cycle (where speeds reach 120 km/h) to C_d (the yellow line). This is both intuitively logical (aerodynamics are more important at higher speeds) but also quantifies how poor aerodynamic modification, increasing the drag factor from 0.33 to 0.50, would lead to around a 21% increase in CO_2 emissions for a Peugeot Partner whose principal role is to travel at higher speeds, but only around a 3% increase in CO_2 emissions for vans undertaking urban deliveries.

Figure 2.9 Variation in CO_2 emissions with drag coefficient over the NEDC



Model exploitation – CO_2 variation with aerodynamic drag

- Peugeot Partner CO_2 emissions versus aerodynamic drag coefficient

Equivalent Cd coefficient derived from the Peugeot Partner cookbook factors

RD.09/221101.1 ©Ricardo plc 2009 32

3 Conclusions and recommendations

The preceding chapter has summarised the research undertaken, and the findings, for each of the project's component tasks. These demonstrate the successful completion of all tasks.

The review of lading factors and the average loads found that only limited data are available. The average lading factor was found to be around 38%, for all vans, corresponding to carrying around 300kg, although the evidence base for this is only moderately strong. However, later tasks showed that carrying 300 kg only leads to around a 5 g/km increase in CO_2 emissions, relative to the emissions measured at a van's reference mass (reference mass emissions are 150 g/km for the Peugeot Partner, and 250 g/km for the Mercedes Sprinter). Hence one conclusion from the project is that lading factor is not one of the more sensitive parameters affecting van CO_2 emissions.

RECOMMENDATION 1

The relative importance of knowledge on the loading/lading characteristics should be re-evaluated and debated in the context of this study's findings that it has a relatively minor importance in determining van CO_2 emissions.

The review of tyre pressure monitoring systems (TPMS) and low rolling resistance tyres (LRRT) concluded that these technical measures do reduce in-use CO_2 emissions when fitted to vans. The CO_2 emissions reduction potentials are 0.3 – 1.5% (for TPMS) and 3.5% ± 1.5% for LRRT. The large uncertainty quoted for TPMS arises because of the very poor data on the percentage of vans that have under-inflated tyres, not because of a lack of accuracy regarding the savings that correctly inflated tyres generate relative to under inflated ones.

A review of the available data on CO_2 emissions from vans tested using type approval conditions concluded that the SMMT Motor Vehicle Registration Information System (MVRIS) database was the best of three potential databases available at the time of the original study. The original analysis used the "as provided" database which only had CO_2 data for around 22% of data entries, and for around 5% of van sales. Subsequently, this database was augmented, principally by adding CO_2 emissions data from the VCA Van CO_2 database (published in June 2009). The augmented MVRIS database contained CO_2 emissions data for just over 96% of van sales in the UK in 2007.

RECOMMENDATION 2

From the augmented MVRIS database the headline average van CO_2 emissions for the UK are

207.6 g/km.

for all vans. This is the starting figure, based on **2007** UK van sales, which should be considered alongside the EU Van CO_2 proposal of 175 g/km in 2016[12].

This mean van CO_2 emissions figure is similar to the figure of 203 g/km for the whole of Europe, reported in a study for the EU[13] based on analysis of the JATO database, and is very similar to the figure of 206.2 g/km for the UK only reported in a study for the DfT[14] based on analysis of the 2008 Polk database.

The more detailed analysis of the emerging technologies that might lead to reductions in CO_2 emissions concluded that there were a considerable number of them, fourteen of which were reviewed in this study. A further four measures examined lead to increases in CO_2 emissions. However, an

---

[12] The actual average value is 175 g/km based on the EU-27 mean van reference mass figure. The value for the UK will differ slightly from this (being slightly larger) because the UK mean van reference mass differs slightly from that within the EU-27.

[13] "Assessment of options for CO_2 legislation for light commercial vehicles", AEA, TNO, December 2008, AEA report AEA/ED05315010/Issue 1

[14] "Van CO_2 database matching project", AEA, July 2009, AEA report AEA/ED46928/R01/Issue 1

important conclusion from the study is that generally the emerging technologies are relatively immature with regard to their application to light goods vehicles. The consensus view from the different authoritative sources reviewed is that the technologies are starting from a very low degree of penetration, and that it will take time for them to influence the fleet. The research estimated the levels of penetration that could be achieved with concerted efforts on behalf of industry and the Government, and combined this with the potential CO_2 savings for each technology. The projected cumulative effect of all technologies on the CO_2 emissions relative to a business as usual baseline was predicted to give savings of around 11.7% by 2016 and 24.8% by 2020. Though, further CO_2 savings could be achieved if the penetration rates of technologies were accelerated by regulatory pressures or other externalities.

It is noted that, unlike for passenger cars, increased penetration of diesel-engined vans is not going to lead to reductions in van CO_2 emissions because over 99% of new vans registered are already diesel fuelled (from analysis of the MVRIS database).

RECOMMENDATION 3

The motor industry and UK Government should continue to use their concerted efforts to encourage the development and uptake of low carbon van technologies to accelerate the reduction in van CO_2 emissions relative to a “business as usual” scenario. However, operational factors need to be included in the defining of the “most environmentally friendly van”, because vans with the lowest CO_2 emissions might not be able to carry the volume of weight that needs to be moved.

More positively with regard to van CO_2 emissions reduction, this study showed that vehicle pricing and running costs influence the purchasing decisions for vans to a much larger extent than for passenger cars, with price and running costs being ranked first in terms of importance for the purchase of company vans, whereas for private passenger cars it is ranked around tenth. Company vans are responsible for around two thirds of all van kilometres, and an even higher proportion of new van purchases, whereas private users tend to buy second hand vehicles.

Therefore, despite the current external economic climate, the findings from this review are encouraging with the message that if low carbon vehicles can be manufactured sufficiently cheaply so that there is a net saving over an appropriate period of ownership, then company van owners are more likely to purchase these vans than private owners.

There is also potentially a receptive audience for the recently published CO_2 emissions database. The challenge associated with this database is the effective communication of the databases contents to those involved in purchasing vans.

RECOMMENDATION 4

The previous studies into the communication of benefits, and purchasing behaviour (especially those funded by DfT, LowCVP and Act on CO_2 Campaign) should be built upon to publicise the contents of the recently published VCA Van CO_2 emissions database, and to emphasise the benefits of selecting the best van for the role required.
(This may involve expressing relative CO_2 emissions, currently in g/km, as fuel costs, e.g. £ fuel costs per 100 miles, and imaginative labelling[15].)

However, operational factors need to be included in the defining of the “most environmentally friendly van”, because vans with the lowest CO_2 emissions might not be able to carry the volume of weight that needs to be moved.

A quantification of the potential for generating more rapid CO_2 emissions reductions through encouraging a shift in vehicle purchasing behaviour was undertaken using the augmented MVRIS

---

[15] Imaginative labelling should include indication of the emissions per tonne of payload or per cubic metre of goods moved.

database. This sorted van model variants into ten groups, based on their CO_2 emissions, for each N1 class. It then considered the emissions of each decile thereby defining the “best group”. (The use of deciles, means that no group is dominated by a specific vehicle’s emissions or by a single manufacturer. This is especially important regarding the “best in class” group.) On this basis, if all new van purchases were from the best deciles, the savings that would occur, weighted by the numbers of new registrations, was calculated to be 9.4%.

The final activity, within the desk based review and data analysis activities, was the provision of data to assist the specification of the procurement of lower carbon vans. This built on the analysis of the augmented MVRIS database to define “best in class” van CO_2 emissions, and produced draft CO_2 emission targets for currently available low carbon vans as measured using the regulatory NEDC procedure (vans currently have to be tested in this manner to demonstrate compliance with the regulated pollutant emission standards). The discrete targets are summarised below in Table 3.1.

Table 3.1 Possible categorisation of vans and draft CO_2 emission targets for “Low Carbon Vans” for 2009

Type of van	Reference mass	Class, as defined for EU emissions standards	Payload mass	Payload volume	Recommended Low Carbon Van threshold for 2009
Small car derived vans	≤ 1,305 kg	Class I	≤ 600 kg	≤ 1.5 m^3	110 g/km
Larger car derived vans	≤ 1,305 kg	Class I	> 600 kg	> 1.5 m^3	135 g/km
Smaller Class II vans	1,305 – 1,740 kg	Class II	≤ 1,000 kg	≤ 3 m^3	142 g/km
Larger Class II vans	1,305 – 1,740 kg	Class II	> 1,000 kg	> 3 m^3	196 g/km
Large vans	> 1,740 kg	Class III	Any	Any	207 g/km

The data in Table 3.1, when plotted against the gross vehicle weight, or the kerb weight, for the five van sub-categories, is shown in Figure 3.1. The fit to a linear function is moderate, and consequently the specification of a low carbon van could be expressed as a continuous function, rather than the five discrete sub-categories given in Table 3.1.

Figure 3.1 CO_2 emissions against kerb weight and GVW for the 5 categories of vans.

It is appreciated that this is the first occasion where a draft specification for low carbon vans has been proposed across the whole range of light goods vehicles.

RECOMMENDATION 5

It is recommended that, subject to DfT's and LowCVP's judgement, the possible categorisation of vans and draft CO_2 emission targets for "Low Carbon Vans" is discussed more widely:

- In the context of the specification for other low carbon vehicles; and
- With stakeholders.

In addition to reviewing existing knowledge, statistics and data, the project contained major tasks of an experimental van measurement programme, and the building and validation of a van simulation model. These two tasks, together, have markedly added to the knowledge base of van CO_2 emissions during "normal" driving.

The van measurement programme studied the effect of loading and drive cycles on CO_2 emissions for a small, medium and large van. The emissions from different drive cycles did follow the pattern expected from the drive cycles' average speed, and the knowledge within the recently published speed related CO_2 emission factors. However, the effect of load was smaller than might have been expected. It was found that on average a fully loaded van will weigh 50% more than an empty van, however its CO_2 emissions would only increase by 7.8 +/- 1.8%.

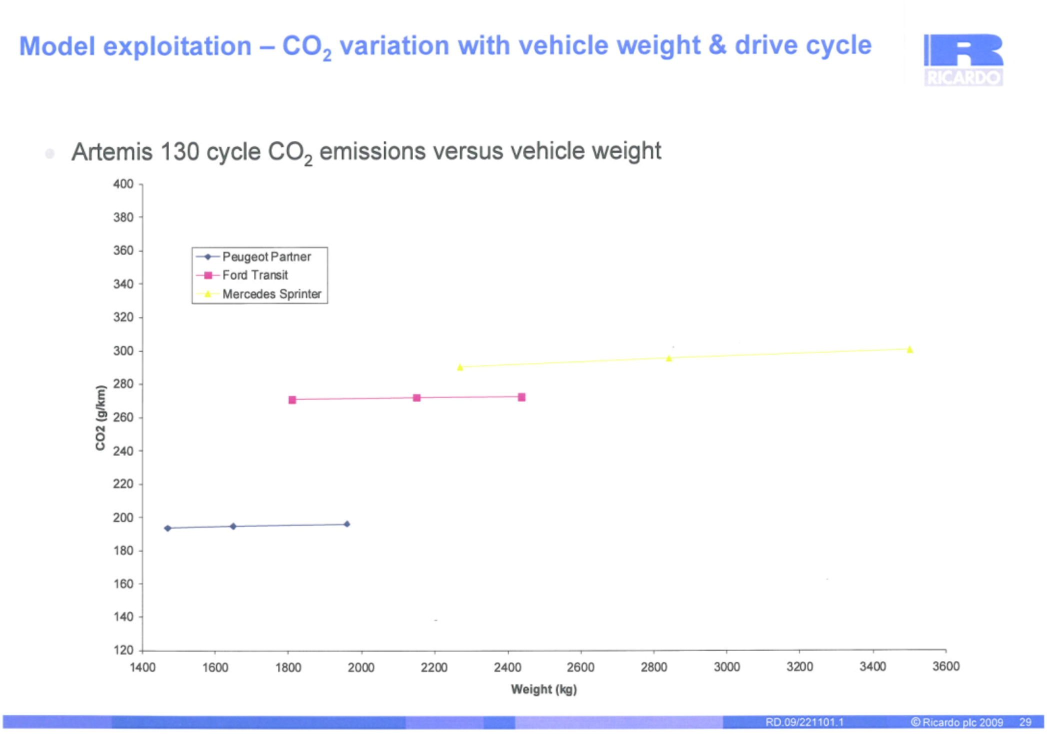
In addition to generating new data, the van measurement programme also generated second by second CO_2 emissions data for the three vans over a range of different drive driving cycles. This formed input data for the validation of the vehicle simulation model. The model was then used to investigate the influence of parameters, such as aerodynamic drag and weight, on the CO_2 emissions for cycles and ladings not evaluated experimentally. Figure 3.2 shows the CO_2 emissions calculated for the three vans for different ladings for the Artemis 130 drive cycle. This graph is included because it illustrates the power of the research in providing guidelines for reducing van CO_2 emissions.

Over the regulatory NEDC the three vans tested had CO_2 emissions of approximately 150, 190 and 245 g/km. This simulation shows that for motorway driving the CO_2 emissions are virtually load independent (because it is the aerodynamics of the van that dominate CO_2 emissions rather than overcoming inertia, as during stop/start driving). Furthermore, the simulation shows the implications of the choice of van. For a delivery involving motorway driving, the simulation shows that the penalty of using the medium sized van, rather than the smaller van, is approximately a 40% increase in CO_2 emissions, and thence fuel costs. For the urban delivery cycle, see Figure 2.8 in Section 2.6, the increase in CO_2 emissions is around 22%.

The example cited is the effect of van choice for predominantly motorway usage. Other scenarios that could be modelled may include the effect of fitting 70 mph speed limiters to Class II and III LGVs to obtain both CO_2 emissions reductions and safety improvements.

Consequently, the experimental programme, combined with the vehicle simulation tool, enables vehicle fuel consumption and CO_2 emissions to be investigated over a wide range of potential operational parameters. This capability should be built upon.

Figure 3.2 Variation in CO_2 emissions with vehicle weight over the Artemis 130 drive cycle



Model exploitation – CO_2 variation with vehicle weight & drive cycle

- Artemis 130 cycle CO_2 emissions versus vehicle weight

RECOMMENDATION 6

Use the project's van simulation model to further investigate the effects of van shape, load and drive cycle to further characterise the sensitivity of these parameters for different van application sectors, and define/prioritise those circumstances where there is a large difference in CO_2 emissions for different choices of vans. This quantification of benefit can then be used in the development of policy and incentives.

Finally, the results from this study are part of a much wider portfolio of DfT, and other UK Government, funded activities aimed at reducing CO_2 emissions. The results from this project should feed into these. Recommendation 7 is merely one example as to how this might occur.

RECOMMENDATION 7[16]

DfT funds the Van Best Practice (VBP) programme, whose twin objectives are to reduce the environmental impacts, and to improve the safety, of van users in England. The findings from this research project and the vehicle simulation tool should be used within the VBP programme to provide identification of the vehicle operating envelops that generate high CO_2 emissions, and the subsequent quantification of the savings that could be generated by alternative operational practices.

---

[16] This recommendation was updated in Jan 2010 to reflect the awarding of the VBP programme to AEA.

Glossary

CCC	UK Committee on Climate Change
C_d	Drag coefficient
CO_2	Carbon dioxide
DfT	Department for transport
ECE	First part of the NEDC regulatory test cycle, simulating urban driving
EU	European Union
EUDC	Second part of the NEDC regulatory test cycle, simulating suburban driving
FIGE	Regulatory test cycle for heavy-duty vehicles
GHG	Greenhouse gases
GUI	Graphical user interface
GVW	Gross vehicle weight
KBA	German Federal Motor Transport Authority (KBA)
LGV	Light goods vehicles
LowCVP	Low Carbon Vehicle Partnership
LRRT	Low rolling resistance tyres
MACC	Marginal abatement cost curve
MVRIS	Motor Vehicle Registration Information System
NEDC	Regulatory test cycle for light-duty vehicles (new European drive cycle)
SMMT	Society of Motor Manufacturers and Traders
TPMS	tyre pressure monitoring systems
UDDC	Urban delivery drive cycle
VCA	Vehicle Certification Agency (a DfT executive agency)

AEA group
329 Harwell
Didcot
Oxfordshire
OX11 0QJ

Tel: 0870 190 xxxx
Fax: 0870 190 xxxx