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Market outlook to 2022 for battery electric vehicles and plug-in hybrid electric vehicles

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Executive Summary

Electric vehicles (EVs) have been around in various guises since the early 1900's and have found niche markets in low power, low range applications such as milt floats and golf buggies. However, despite previous failed attempts to launch the technology they have once again come to the fore as an option for more mainstream transportation. This is largely due to climate change's rapid rise up the political agenda. In particular policy makers have come to realise the difficulties in reducing greenhouse gas emissions (GHG) from the transport sector, particularly given the strong linkages between transport consumption and economic growth. It is widely accepted that as an economy expands consumers become more prosperous and look to travel further and more frequently. In turn this increases fuel consumption and hence GHG emissions.

The European Commission was determined to respond to this challenge. After voluntary agreements with automotive manufacturers failed to deliver sufficiently rapid reductions in CO_2 emissions the European Commission put in place average CO_2 emissions limits for new cars. The limits were set at an average of 130g/km and will be phased in between 2012 and 2015. The EC intends to tighten this limit to 95g/km by 2020.

From a climate change perspective, the key advantage of EVs and plug-in hybrid electric vehicles (PHEVs) is that they provide the opportunity to decarbonise the road transport sector to very significant extent. Of course this is dependent on grid electricity being decarbonised but policy frameworks are already in place in the UK to increase renewable generation capacity, replace nuclear capacity and trial carbon capture and storage technology.

A significant uptake of electric vehicles leads to several other very significant benefits. For example, it presents the opportunity to significantly reduce the usage of fossil fuels for meeting vehicle motive power requirements. This can have benefits for energy security (by diversifying the energy sources used in the transport sector), and reducing tailpipe emissions of air quality pollutants.

However, there is also a range of barriers to uptake of EVs and to a lesser extent PHEVs. Lithium-ion (li-ion) batteries are the technology of choice to store the electrical energy on board the vehicle. Unfortunately, they are very expensive. A sizeable reduction in range (to typically 60 to 100 miles) and a lack of charging infrastructure are also key barriers. That said, arguably the greatest barrier is public perception. Consumers need to be convinced that electric vehicles are a robust technology and that they can fulfil their requirements, particularly in light of the lack of infrastructure and the need to plug-in the vehicle.

The role of the Committee on Climate Change (CCC) is to review the level of the UK Government's climate change targets and advise on how they can be met. As part of the process of understanding the transport emissions reduction opportunities, an AEA-led consortium was commissioned by CCC in 2008 to compile a marginal abatement cost curve model for transport. This ranked the emissions savings opportunities according to cost effectiveness.

The 2008 MAC curve provided high-level estimates of the anticipated levels of uptake for EVs and PHEVs. However, as the interest in EVs and PHEVs grew it became clear they warranted more detailed analysis. Therefore, the CCC commissioned AEA to update the MAC curve with a particular focus on improving the EV and PHEV aspects of the model.

The first element of the project was to update the marginal capital cost and learning rate data entered into the MACC model. The second part of the project, which is referred to as 'The Market Outlook' seeks to build on that work by developing four MAC model scenarios specifically for EVs and PHEVs. This report describes the market outlook, which covers the period between 2009 and 2022 consists of the following sections:

1. Introduction
2. Automotive manufacturers' strategies and planned EV/PHEV developments

3. Examination of new business models to encourage the uptake
4. Upfront price support to encourage the uptake of EVs and PHEVs
5. Actions to create a favourable investment climate in EV and PHEV technologies
6. Scenarios for uptake of EVs and PHEVs
7. Key messages

Automotive manufacturer's strategies and planned EV developments

Before attempting to predict the likely uptake of EVs and PHEVs it was crucial to gain an insight into how and when the automotive manufacturers were planning to launch the technologies. The key messages from the review of automotive manufacturer's strategies were as follows:

- The EV and PHEV market is evolving rapidly with announcements on a very regular (almost daily basis)
- Many early EVs are likely to be small cars since their lower mass means smaller (and hence) cheaper batteries are required.
- There are currently no small PHEVs in development although it is thought such vehicles will be developed by 2022. The dual powertrain, which characterises PHEVs, is not currently commercially viable for small cars where price is a key differentiator.
- Aside from Ford, none of the mainstream manufacturers have announced that they are working on medium EVs. This could be due to battery cost concerns for what can be a very price sensitive segment, particularly for fleet vehicles. Manufacturers may also be waiting to test EVs on niche segments (e.g. small cars and sports cars) before choosing to develop EVs for their highest selling segment.
- Several companies are developing medium PHEVs, which are viewed as a more commercial proposition than EVs, pre-2022. Smaller batteries reduce the marginal capital cost and the range extending petrol or diesel engine negates the need for a widespread infrastructure.
- Most vehicles in the large car segment (which includes sports cars) are marketed at high earners and/or early adopters of technologies so in principle they are well suited for early EVs.
- A significant number of large electric cars are already available or will become available in the next couple of years. That said the absolute number of large EVs sold is likely to be relatively modest since they only made up 14% of new car sales in 2008.
- A number of large manufacturers have announced their intention to develop large PHEVs, which reflects the growing belief that PHEVs could act as a bridging technology between conventional power trains and EVs.
- There are several ranges of electric vans already available for purchase from specialist EV van manufacturers. Larger manufacturers such as Ford and Chrysler also recently announced planned models.
- Aside from niche low-range applications HGVs are not well suited to electric only operation. The size and cost of the battery packs and a lack of widespread charging infrastructure are key barriers. Consequently, the largest HGV available is 12tonne gross vehicle weight.

Advanced diesels

Over recent decades car manufacturers have developed diesel engines and improved their efficiency. In fact, advanced diesels will present strong competition for EVs and PHEVs over the coming years. All the major manufacturers are launching advanced diesel cars and vans based on engine downsizing and technologies such as sequential turbo charging and common rail diesel fuel injection.

The analysis of the market outlook for advanced diesel technologies provided the following conclusions:

- Diesel penetration is likely to grow over the coming years before peaking in the middle of the next decade. A key constraint will be a shortage of diesel refinery capacity – Europe is already a net importer. Increased competition from advanced petrol engines will also be a factor.
- Several manufacturers such as VW and SEAT currently brand small advanced diesel cars as 'eco-cars'. Over the next few years, it is anticipated that small diesel cars with CO_2 emissions performance below 100 g/km will become the norm, and potentially by 2022, average CO_2 emissions from small cars could drop below 80g/km.
- In a similar vein to small cars, medium advanced diesels currently occupy an eco-car niche. It is anticipated that many more medium cars will be able to attain a CO_2 emissions performance of lower than 120 g/km in the next couple of years. Based on aggressive annual CO_2 emissions improvement rates of 3.5%, medium advanced diesels should be able to get close to hitting the proposed 95g/km limit for new cars in 2020.
- There is a stark contrast between diesel penetrations within large car sub-segments. For instance, 78% of executive saloons and 83% of 4x4's purchased in 2008 were diesel powered. In contrast only 12% of new sport cars were diesels.
- The use of eco-branding is not nearly so prevalent in the large advanced diesel segment. That said it is anticipated that all the same advanced diesel technologies will still to be applied. Based on aggressive annual CO_2 emissions improvement rates of 3.5% an average new diesel large car would have emissions of 122 gCO_2/km in 2022

New business models to encourage the uptake of EVs and PHEVs

It was recognised at an early stage in the study that the high up front costs of EVs and PHEVs and the perceived technology risk would necessitate alternative business models if significant levels of uptake were to be achieved. The four main business models considered during the study can be summarised as follows:

- **Battery leasing.** By retaining liability for the battery the manufacturer is committed to replacing it if its performance is sub-optimal. This removes a significant element of the financial risk for consumers. It also solves the problem of how to value the residual life of the battery at resale given that most battery technologies' performance deteriorates with use. The monthly fee for leasing the batteries could simply switch from the original owner to the new owner. A further benefit to the consumer is that it allows the manufacturer to take advantage of any improvements in battery technology when the batteries are eventually replaced.
- **Mobile phone-style transportation contracts**. To cater for different customer segments, Better Place plans to offer a range of EV models via a series of subscription pricing packages that will provide access to the network of charging points and battery swap stations. The company plans to own the charging points and battery swap stations as well as the car batteries, which will be considered part of the Better Place Network. Both the mobile phone style contract and battery swap station elements of the business model introduce a great deal of flexibility for consumers, which is a weakness of many of the other business models.
- **Vehicle leasing**. The natural extension to battery leasing is to use a vehicle leasing business model to further reduce risk and minimise upfront costs. Vehicle leasing is currently being pursued by Mitsubishi as the initial business model for the i-MiEV electric small car, which is due to become available in the UK by the end of 2009.
- **Car-clubs**. In the short term the 'car club' business model could be a viable means of introducing the public to electric vehicle technology. In addition, it could provide added value in terms of promoting EVs and PHEVs. Indeed, it could be a means of allowing consumers to test EVs and PHEVs in real world conditions for a few weeks without the need to make a major financial commitment. Furthermore, the sight of EVs and PHEVs being driven around

would raise their profile, especially given that car club cars are utilised far more heavily on average than conventionally owned vehicles. That said, that apart from Th!nk, there does not seem to be an appetite amongst manufacturers to use the car club model as a way of encouraging the uptake of EVs or PHEVs.

Upfront price support to encourage the uptake of EVs and PHEVs

One of the key barriers to the uptake of EVs and PHEVs is the purchase cost of vehicles. The issue is the battery cost, which is the most significant influence on the overall vehicle price. Battery costs are currently high, and are largely determined by the cost of the electrode materials[1] with a contribution from development, production and shipping. The key findings from this part of the study were as follows:

- A number of national governments in Europe and both federal and state Governments in the USA have already introduced financial support packages to help stimulate the early uptake of EVs and PHEVs.
- In the April 2009 Budget, the UK Government has also announced that from 2011, financial incentives will be offered to people purchasing electric and plug-in hybrid electric vehicles in this country. These incentives will range from £2,000 to £5,000, but at this point in time no further details of how the scheme will operate are available. These amounts are broadly in line with the support being offered in the US and other European states.
- The view from the UK's Society of Motor Manufacturers and Traders (SMMT) and members is that up-front price support could be set at the level of support required to sell a certain number of units annually, or to sell a planned annual manufacturing capacity. They felt that although marginal cost is an indicator of what the potential price-support could be, the longer-term lower running costs implies that the up-front support required would be significantly less than this marginal cost over conventional vehicles.
- Unless marginal capital costs reduce significantly in the next couple of years many consumers and businesses may find it difficult to justify purchasing an EV or PHEV even taking account the Government's financial support.
- An alternative to the Government's upfront price support structure is proposed in Scenario 3:
  - £10k for the first 25,000 vehicles sold
  - £7.5k for the 25,000th to 50,000th vehicles sold
  - £5k for the 50,000 to 100,000 vehicles sold
  - £2.5k for the 100,000th to 150,000th vehicles sold

  This tapered structure would aim to get EVs to mass manufacture (assumed to 100,000) units as quickly as possible and provide limited ongoing financial support thereafter to prevent demand suddenly falling away. Whilst it would cost between £850m and £900m depending on the administration costs it ought to ensure the initial sales inertia is overcome. There is a risk that the £2k to £5k scheme proposed by Government will not be sufficient to allow EVs and PHEVs to gain a foothold in the market.

Actions to create a favourable investment climate in EV and PHEV technologies

Whilst upfront price support is clearly a key support mechanism, there are a number of other ways in which Government could create a favourable investment climate for EV and PHEV technologies:

- National Government policy statements;
- Regulatory pressures;

[1] Most current lithium-ion batteries use nickel cobalt aluminium cathodes, which are expensive, but offer good energy density performance. Forthcoming cathode materials such as lithium iron phosphate are cheaper and are likely to contribute to battery cost reductions.

- Government-backed R&D funding programmes;
- Government-backed demonstration and commercialisation programmes
- Softer measures such as reduced or free parking, use of bus lanes and exemption from congestion charges and tolls

The UK Government and/or the European Commission are taking action in all of these areas. Of particular interest is the New Automotive Innovation and Growth Team (NAIGT) set up by BERR. They recently made the following recommendations regarding low carbon vehicles, which is a consensus view of the automotive industry:

- Create a leadership team to develop future automotive strategy in the UK (Government/senior industry figures);
- Establish 'Test Bed UK' which is defined by the NAIGT as "a demonstrator to act as a powerful catalyst for change through demonstrating, experimenting and building the new low-carbon personal transportation system including its infrastructure[2]"
- Release and maintain roadmaps and research agendas to focus funding spend and collaboration;
- Establish Government funding mechanism to support product development and industrialisation phase of R&D;
- Evaluate new emissions test procedures based on well-to-wheels methodology, and energy focused rather than current tank-to-wheel approach to quantifying CO_2 emissions from vehicles[3].

Scenarios for uptake of EVs and PHEVs

The scenarios for uptake of EVs and PHEVs are set out in detail in Section 6 of the report but the key themes were as follows:

- Uptake of EVs and PHEVs will be very limited without upfront price support
- Uptake of PHEVs will occur faster than EVs due to their greater fuel flexibility and lower cost.
- Even under the more optimistic scenarios EVs and PHEVs are unlikely to reach mass production (defined at 100,000 units sold) until the early 2020's.
- Achieving high levels of EV and PHEV uptake will require a high degree of cooperation between local and national Government. Softer, local measures such as access to bus lanes, free parking and the provision of a widespread charging infrastructure will be need alongside central Government initiatives such as upfront price support.
- The launch of advanced diesels will affect the uptake of EVs and PHEVs in the short to medium term.
- However, advanced diesels will only be able to reduce GHG emissions so far. The deepest cut in transport GHG emissions can only be achieved by EVs.

[2] http://www.berr.gov.uk/files/file50539.pdf
[3] http://www.berr.gov.uk/files/file50300.pdf

Glossary

ACEA = European Automobile Manufacturers' Association

AFV = Alternative Fuel Vehicle Rebate Program

ARB = Californian Air Resources Board

BERR = Department for Business, Enterprise & Regulatory Reform

BEV = Battery Electric Vehicle

CAI = Controlled Auto-Ignition

CCC = Committee on Climate Change

Cenex = Centre of Excellence for Low Carbon and Fuel Cell Technologies

CEO = Chief Executive Officer

CNG = Compressed Natural Gas vehicles

DfT = Department for Transport

DoE = Department of Energy

EC = European Commission

EST = Energy Saving Trust

ETI = Energy Technologies Institute

EU = European Union

EV = Electric Vehicle

GDP = Gross Domestic Product

HCCI = Homogeneous Charge Compression Ignition

HEV = Hybrid Electric Vehicle

HGV = Heavy Goods Vehicle

IMF = International Monetary Fund

LCVIP = Low Carbon Vehicle Innovation Platform

MACC = Marginal Abatement Cost Curve

METI = Japanese Ministry for Economy, Trade and Industry

NAIGT = New Automotive Innovation and Growth Team

NIC = National Insurance Contribution

PAYE = Pay As You Earn

PHEV = Plug-in Hybrid Electric Vehicle

R&D = Research and Development

RD&D = Research, Design and Development

SME = Small and Medium Enterprises

SMMT = The Society of Motor Manufacturers and Traders Limited

SUV = Sport Utility Vehicle

TSB = Technology Strategy Board

UK = United Kingdom

USA = United States of America

VED = Vehicle Excise Duty

ZEV = Zero Emission Vehicles programme

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Appendices

1 Introduction

In 2008, the Committee on Climate Change (CCC) published its first report, “Building a Low Carbon Economy – the UK’s contribution to tackling climate change”. This document provided advice to the UK Government on the appropriate levels of reductions in emissions of greenhouse gases that need to be achieved by 2050 in order to avoid dangerous climate change. CCC’s recommendations were that emissions across the whole UK should be reduced by 80% against 1990 levels by 2050, and that an interim target of a 34% reduction should be set for 2020, increasing to a 42% reduction for the same year in the event that a global deal is agreed upon in December 2009.

In support of CCC’s work in 2008, an AEA-led consortium was commissioned by CCC to develop a CO_2 marginal abatement cost curve (MACC) model for the transport sector (hereafter referred to as the CCC transport MACC model), focusing on technology and efficiency options. This model was used to inform CCC’s recommendations on potential emissions abatement in the transport sector between 2009 and 2022. The model includes a detailed set of technology penetration scenarios that were developed by AEA and our consortium partners to describe different possible ways in which low carbon technologies and fuels could potentially be taken up in the road transport sector in the years to 2022. The model is a detailed, technology-rich, vehicle stock, activity and cost model that allows a wide variety of scenarios to be developed and analysed.

There is now a need to investigate in more detail than was possible in 2008, the potential for future emissions reductions that could be achieved through the application of electric vehicle (EV) and plug-in hybrid electric vehicle (PHEV) technology in the UK road transport sector. Consequently, AEA has been commissioned to develop a market outlook for EV and PHEV technologies covering the years 2009 to 2022. This market outlook has examined global developments in EV and PHEV technologies, likely future vehicle manufacturer model programmes, competition from advanced diesel technologies, and the potential need for market and R&D support to facilitate the uptake of electric and plug-in hybrid vehicles. The results of this work have been used to develop four revised technology scenarios that examine theoretical, but realistic scenarios for the potential future uptake of EV and PHEV technology in the UK road transport sector between 2009 and 2022. The findings from this research and the new technology scenarios will be used by CCC to develop further recommendations on the actions that may be needed to stimulate the uptake of EVs and PHEVs in the UK.

1.1 Definitions of electric and hybrid electric vehicles

To avoid confusion it is important to define the different sub-sets of electric and hybrid electric vehicles. Therefore, the following definitions will apply throughout this report:

- **Electric vehicle (EV)** – An electric vehicle that is powered solely by electricity stored in on-board batteries. A BEV does not feature an on-board engine and is charged by plugging into the National Grid or, on a limited number of models, swapping the battery.

- **Hybrid electric vehicle (HEV)** – A vehicle that is powered by an on-board engine supplemented by electricity that is recovered via regenerative braking. This is where braking energy that would otherwise be dissipated as heat is captured and stored in batteries. HEVs can have a ‘series’ configuration where the engine drives an electric motor that delivers power to the wheels or ‘parallel’ configuration where both an electric motor and the engine can provide power directly to the wheels. Most HEVs are ‘mild hybrids’ and cannot operate in electric only mode. However, some ‘strong’ or ‘full hybrids’ such as the Toyota Prius can operate in electric-only mode over a very short distance.

- **Plug-in hybrid electric vehicle (PHEV)** – A hybrid vehicle that features a larger battery than a HEV and is therefore able to be recharged via the National Grid and operate over a short distance in electric-only mode. However, the battery is smaller than a BEV so a conventional petrol engine and fuel tank is employed to extend the range.

1.2 Structure of the report

The remainder of this report contains the following sections:

- **Section 2** provides details of automotive manufacturers' strategies and planned EV/PHEV developments;
- **Section 3** provides details of the different business models that are being considered to encourage the uptake of EVs and PHEVs;
- **Section 4** discusses the need for upfront price support to encourage consumers and businesses to purchase EVs and PHEVs
- **Section 5** sets out the actions required to create a favourable investment environment for EV and PHEV technologies;
- **Section 6** describes the new EV and PHEV technology uptake scenarios developed for the CCC transport MACC model;
- **Section 7** sets out the summary and conclusions for the study.

2 Automotive manufacturers' strategies and planned EV/PHEV developments

2.1 Overview

This section of the report examines the strategies currently being pursued by automotive manufacturers to bring both EVs and PHEVs to the market. The objective of this analysis was to build up a comprehensive picture of current and future market developments in order to inform the development of new scenarios for the potential uptake of EV and PHEV technology in the road transport sector between now and 2022.

This research was based on examining the global automotive market from both a top-down and bottom-up perspective to understand the key influencing factors that have led vehicle manufacturers to start developing and deploying EVs and PHEVs, and to build up a comprehensive picture of the individual vehicle models in each vehicle/size category that are planned for market release in the coming years.

In carrying out this review, it is important to stress that market for EVs and PHEVs is evolving very rapidly, with announcements on planned vehicle model releases being issued by manufacturers on a very regular (almost daily) basis. With this in mind, it should be noted that some of the information provided in this report is likely to go out of date very quickly as new information on further planned new EVs and PHEVs will undoubtedly become available in the coming months. At the same time, the current global economic crisis has already had a profound effect on automotive manufacturers across the world, with many manufacturers experiencing severe reductions in consumer demand for new vehicles. For instance in the UK Car manufacture volumes fell by 55% in April 2009 compared to the previous year[4]. The impacts of the economic situation bring even greater levels of uncertainty with respect to planned future vehicle models, and this factor should be borne in mind with regard to the potential market release of EVs and PHEVs.

2.2 Rationale for EVs and PHEVs

The key advantages of EV and PHEV technology include the potential to significantly reduce the usage of fossil fuels for meeting vehicle motive power requirements. This can have benefits for energy security (by diversifying the energy sources used in the transport sector), reducing tailpipe emissions of air quality pollutants and, importantly, these technologies can also lead to significant reductions in life-cycle (well-to-wheels) emissions of CO_2.

EV and PHEV technologies are currently being developed globally by a wide variety of manufacturers in response to existing, proposed and potential future legislation in various countries around the world. They are viewed as a key step in decarbonising the transport sector and reducing its reliance on fossil fuels. A number of countries around the world including the US, Japan and Spain have set ambitious targets for the future uptake of EVs and PHEVs, with the main objective being to support national and international policies for tackling climate change. In support of these targets, some of these countries are providing financial support to stimulate both the development and market uptake of these types of vehicles.

There are several barriers to the extensive uptake of EV and PHEV technology that will need to be overcome before mass-market penetration can be achieved. These barriers include:

- Limited vehicle range, due to the current limitations of battery technology;
- High capital costs associated with vehicle batteries;
- Limited availability of recharging infrastructure.

[4] http://www.smmt.co.uk/articles/article.cfm?articleid=19591

Therefore, it should be noted that whilst EVs and PHEVs could contribute to reducing transport sector CO_2 emissions in the short and medium term, the main emissions reduction benefits of these technologies will be experienced in the long term (beyond 2020), when costs have been reduced and performance improved sufficiently to facilitate mass market uptake. In addition, to realise fully the lifecycle abatement potential from EVs and PHEVs, significant decarbonisation of the electricity generation sector will be required, and this is unlikely to happen in the UK until after 2020.

Taking into account all of the above factors, a broad range of vehicle manufacturers have now started to develop vehicles equipped with these technologies that will eventually be sold in the UK and across the world. Moreover, many activities are currently underway to aid the commercialisation of PHEVs and EVs, including a number of current and planned demonstration programmes in the UK and in other countries.

2.3 Approach used for reviewing manufacturers' strategies and plans

The following sections provide a review of the current and planned future activities of vehicle manufacturers around the world with regard to developing and commercialising PHEV and EVs. The approach that has been taken in this review is to collate information on planned and likely future PHEV and EV model releases for each manufacturer. Data has been obtained from a wide variety of news articles, press releases, and other sources of information.

Reliability of data

It should be stressed that the degree of confidence that can be attached to this information is variable, depending on whether the information has come directly from a vehicle manufacturer via official press releases, or if the information has been obtained from automotive magazines, business journals and news-wire articles that may include a degree of speculation and uncertainty with regard to the future plans of vehicle manufacturers. The degree of confidence that can be attached to each piece of information has been flagged using a "confidence" indicator ("high confidence", "medium confidence", and "low confidence").

"High confidence" indicates that there is a very strong likelihood that the information is correct and that the specified vehicle model is part of the particular manufacturer's confirmed future vehicle programme; specifically, this will mean that the manufacturer has issued a press release about the vehicle model, and information about retail price and dates for commercial availability may also have been made publicly available. It is possible that information about planned annual production volumes may also have been released, along with vehicle performance characteristics (e.g. energy consumption data, CO_2 emissions performance, power output, etc).

"Medium confidence" indicates that the information about the particular model is likely to be correct, but there may be a degree of uncertainty with respect to retail price, date of commercial availability, and other factors pertaining to the vehicle. It is possible that the manufacturer may have issued a press release, or a senior executive from the manufacturer may have provided some initial details about the model programme in an automotive journal/magazine interview, but the full details of the vehicle programme may not have been fully released.

"Low confidence" has been used for information about future vehicle models that has not been officially confirmed by the manufacturer. This means that no press releases have been issued and the information is based on unconfirmed and unauthorised "insider" information provided by employees of the vehicle manufacturer to the press, or is based on speculative assessments of future plans, made by industry journals and automotive sector magazine news articles. In this situation, data on the planned vehicle model may possibly be correct, but it is equally likely to be incorrect and/or out of date. Estimates of retail price and dates of commercial availability may have been provided in such articles, but again, there is a distinct possibility that such information may not be correct.

It should be noted that given the current financial problems afflicting the global automotive sector, there are likely to be instances of specific planned vehicle model releases that have been officially announced my manufacturers, but that may not in practice occur. In particular, a number of the major vehicle manufacturers have been experiencing severe financial problems that may lead to model programmes being cancelled, and in extreme cases, it is possible that some major companies may go out of business. Furthermore, some small volume manufacturers may have problems accessing the necessary financial capital to start producing new vehicle models that have already been developed.

Where possible, in identifying and reviewing data and articles on planned EV and PHEV model programmes, information has been collected on the likely regional markets that these vehicles will be made commercially available in. This is an important factor when attempting to develop new scenarios for the uptake of PHEVs and EVs in the UK, as not all planned models will be commercially available in all parts of the world. Specifically, there are a number of planned vehicle models that may only be made available in the USA or in Japan, whilst others will only be available in the EU, including the UK. Where such information is available, this has been provided.

Presentation of data

Information in the following sections is presented for each of the vehicle size/type categories included in the CCC's transport MACC model – namely:

- Small cars: (SMMT categories A and B)
- Medium cars: (SMMT categories C, D, and I)
- Large cars: (SMMT categories E, F, G, and H)

It should be noted that this vehicle categorisation was used in the model for pragmatic reasons. In particular, the time and resource limitations available for developing the model meant that it was not possible to include more than three different passenger car size/type categories within the model. However, it is recognised that the categories used in the model do not perfectly reflect real-world vehicle sizes and categorisations, and in particular it is acknowledged that the "large car" category used in the model actually consists of a combination of large conventional passenger cars (executive and luxury saloons), sport utility vehicles (4x4s), and sports cars. Whilst in practice these vehicles are quite diverse in nature and size, it was felt that given the small market share associated with new sales of vehicles in SMMT categories E, F, G, and H, it was not practical to separate these vehicles types any further. Data from the SMMT's latest CO_2 report (SMMT 2009[5]) indicates that each vehicle category accounted for the following percentage of sales in 2008:

[5] SMMT 2009, "New Car CO_2 report 2009 – Driving Down Emissions", Society of Motor Manufacturers and Traders

Table 2.1: SMMT market segments for passenger cars: 2008 market share and average new car CO_2 emissions performance

SMMT category	MACC model classification	Market share – new car sales in 2008	Average new car CO_2 emissions performance in 2008
Category A (mini-cars)	Small car	1.3%	123.9 gCO_2/km
Category B (superminis)	Small car	34.1%	137.7 gCO_2/km
Category C: (lower medium cars)	Medium car	28.4%	153.7 gCO_2/km
Category D: (upper medium cars)	Medium car	16.0%	161.0 gCO_2/km
Category E: (Executive cars)	Large car	4.6%	185.9 gCO_2/km
Category F: (Luxury cars)	Large car	0.5%	266.1 gCO_2/km
Category G: (Specialist sports)	Large car	2.4%	214.7 gCO_2/km
Category H: (Sport utility vehicles)	Large car	6.4%	219.1 gCO_2/km
Category I: (Multi-purpose vehicles)	Medium car	6.4%	175.4 gCO_2/km

As can be seen from the table above, the vehicle categories included in the large car classification in the model account for only 13.9% of passenger car sales in 2008, and the average CO_2 emissions performance of these vehicle types are all at the upper end of the range.

The following sections provide details of planned model releases and a general description of EV and PHEV market developments for each of the market segments.

2.4 Planned EV/PHEV vehicles releases

2.4.1 Small cars

Small cars (SMMT categories A and B) accounted for more than 35% of the new car market in 2008, equating to a total of 754,100 sales.

Battery electric vehicles

Many of the early passenger cars equipped with pure EV technology are likely to fall into the small car category. This is primarily because the lower mass associated with smaller vehicles means that the battery energy capacity requirements are smaller, thereby reducing overall vehicle cost and the size of the vehicle's battery pack. Whilst there are already a number of small electric vehicles available already on the UK market, it must be stressed that these vehicles are not officially classed as passenger cars under type approval regulations. Vehicles such as the Reva/Goin' Green G-Wiz and the NICE Mega City are all classed as quadricycles rather than full, type-approved passenger cars. Quadricycles have been excluded from this analysis for this reason, and because it is not thought likely that they will be taken up in any significant numbers across the UK.

A number of the major car manufacturers have started developing small battery electric cars with the aim of releasing these on the commercial market in the near future. Some of the key early models in this size category include the Mitsubishi i-MiEV, which should arrive on the UK market towards the end of 2009. The i-MiEV is an adaptation of the successful petrol-engine i-Car that has been sold in Japan since 2006 and in the UK since 2007. When it arrives, it will be the first mass-produced four-seater electric car available on the UK market. Interestingly, Peugeot has recently signed an agreement with Mitsubishi, whereby the latter will provide the former with versions of the i-MiEV electric car that will be rebranded for sale by Peugeot in a range of European markets (likely to include the UK).

Other major manufacturers also have well-advanced plans for this market segment, including Mercedes-Benz parent company, Daimler, which is already trialling 100 prototypes of its Smart ForTwo ED electric city car in the UK with a range of blue chip companies and public sector organisations, in advance of a planned market release in 2012. The Renault-Nissan alliance is also in the process of developing a range of electric cars, including supermini (SMMT category B) sized vehicles that are planned for release before 2012. The table overleaf provide full details of the latest (March 2009) information with respect to planned future electric vehicle model releases in the small car category.

Plug-in hybrid electric vehicles

At this point in time, no information has been identified that indicates that manufacturers are currently working on small plug-in hybrid electric vehicles. There are likely to be a number of reasons for this, including the potential vehicle packaging problems that would arise when trying to accommodate both an internal combustion engine and a relatively large battery pack into a small vehicle package. This is not to say that such vehicles will not be produced between now and 2022, but there is no current evidence to suggest that manufacturers are working on producing small passenger cars equipped with this technology.

Table 2.2: Detailed model plans for small battery-electric cars

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information	Regional availability	Other information	Information sources	Confidence level
Audi A2 (code name E1) (EV) **Range 50 miles unconfirmed**	2011 at the earliest	Unknown	Unknown	EU, USA.	Likely to be supermini-sized (SMMT category B), and will be available either as an electric car or as a conventional petrol/diesel car. Is being designed to accommodate an electric powertrain from the start. Vehicle range: 50 miles per charge	Comment from Audi board member Peter Schwarzenbauer at Paris 2008 Motor Show and interview Audi's head of R&D, Michael Dick, which appeared in "Autocar" magazine, 25th March 2009.	Medium
BMW Mini E (EV)	2009	500 (total)	Only available for one-year lease (US$850 per month) as part of demonstration/trial programme.	Only USA initially (New York, New Jersey, and Los Angeles). Limited numbers may be trialled in London and/or Berlin later.	Mini-E programme is a BMW-funded demonstration project to test and analyse how EVs perform under real-world conditions, prior to BMW commercialising the technology using a new vehicle platform (likely to be Project "i" – see below). Vehicle range: 150 miles per charge	Interview with Mini-E project director Peter Ratz, CAR Magazine, March 2009	Medium

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information	Regional availability	Other information	Information sources	Confidence level
					Recharging time: 2.5 hours using 240 volt supply Battery: Li-ion		
BMW Project "i" (EV)	2015	Unknown	Unknown	EU, USA	BMW has confirmed the existence of its Project "i" programme, which is aimed at developing new mobility concepts for the next decade. An electric small car is expected to be produced as part of this programme, but no details are available at this point in time. Vehicle range: unknown	BMW Press Conference: March 2008 – Announcement of Project "i" made by BMW chairman, Dr Norbert Reithofer	Medium
Chery S18 (EV)	Unknown	Unknown	Unknown	Unknown	In February 2009, Chery, one of China's largest motor manufacturers, provided details of the S18 EV. However, Chery has not yet	Reuters[6]	Medium

[6] Reuters, Feb 19 2009: http://www.reuters.com/article/rbssIndustryMaterialsUtilitiesNews/idUSSHA22946120090219

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information	Regional availability	Other information	Information sources	Confidence level
					confirmed whether this vehicle will go into full production. Should it go into production, it's not clear that the vehicle would be available in the UK. Vehicle range: 95 miles (150 km) per charge Recharging time: 4 to 6 hours Battery: Li-ion (Iron Phosphate)		
Daimler (Mercedes-Benz) **Smart ForTwo ED** (EV)	2010	Unknown	£20,000[7] (This is an unconfirmed price estimate if the car was available to buy. It is currently only available to lease to selected customers)	EU, USA	SMMT category A (mini-car). 100 vehicles currently on four-year market trial in the UK with fleet users, including the Metropolitan Police, Islington Borough Council, Coventry City	Smart website: www.smart.com	High

[7] http://www.channel4.com/4car/rt/smart/fortwo/25722/2

Vehicle manufacturer/model name	**Planned date available on the market**	**Planned production volume**	**Retail price information**	**Regional availability**	**Other information**	**Information sources**	**Confidence level**
					Council, Aston University, Foster & Partners, CarbonNeutral Company, EDF Energy and Amey. **Vehicle** range: 72 miles per charge Recharging time: 8 hours Battery: Sodium Nickel Chloride		
Ford (unnamed electric small car) (EV)	2011	Unknown	Unknown	Only USA confirmed so far	EV small car being developed in conjunction with automotive systems supplier Magna International. **Vehicle range: up to 100 miles (160 km) per charge**	Ford press release, January 11th 2009	High
Mitsubishi i-MiEV (EV)	2009 (Japan, UK); rest of EU (2010).	2,000 vehicles globally in 2009, rising	Will only be available for lease, but Mitsubishi has	UK, Japan, EU, possibly USA.	SMMT category A (mini-car) UK will be one of the	Mitsubishi press release: 2nd March 2009;	High

Vehicle manufacturer/model name	**Planned date available on the market**	**Planned production volume**	**Retail price information**	**Regional availability**	**Other information**	**Information sources**	**Confidence level**
		to 10,000 in 2010	quoted a current notional retail price of £35,000, dropping to below £20,000 by end of 2010.		lead markets for the i-MiEV, with 200 vehicles available for lease here in 2009. Mitsubishi has also announced a joint venture with Peugeot whereby the i-MiEV will be rebadged as a Peugeot for EU markets. Vehicle range: 100 miles per charge	Information also collated from various hands-on test drive reports in the UK motoring press.	
Nissan/**Renault (unnamed electric small car)** (EV)	2010 (fleet trial) 2012 (retail customers)	Unknown		USA, Japan, EU	SMMT category B (supermini) First production vehicles will be for selected regional areas such as California. Likely to be produced in conjunction with Nissan's parent company Renault. Vehicle range: unknown.	Autoweek/Automotive News, 3rd October 2008	High
Peugeot (unnamed	2011	10,000 in	Unknown, but	EU	SMMT category A	Mitsubishi press	High

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information	Regional availability	Other information	Information sources	Confidence level
electric small car) (EV)		2011 (estimate)	likely to be similar to Mitsubishi i-MiEV		(mini-car) Vehicle will be heavily based on Mitsubishi i-MiEV – Mitsubishi and Peugeot have signed a MoU Citroen (part of the same PSA group as Peugeot) are also offering electric conversions of the C1 in UK via its partner the electric car corporation. Vehicle range: unknown	release: 2nd March 2009	

2.4.2 Medium cars

Electric vehicles

As highlighted earlier in this report, the medium car segment (assumed to consist of SMMT categories C, D, and I) accounts for a very significant proportion of new car sales in the UK. However, at this point in time, very few manufacturers have openly announced that they are working on developing pure electric vehicles in this size category. Whilst at first sight, this may appear surprising given the size of this medium car market; in practice it is thought that there are a number of key reasons for this. Firstly, the larger size of medium cars compared to small cars means that significantly greater battery storage capacity is needed for this types of vehicles, which would lead to large increases in vehicle cost. As such vehicles are typically aimed at price-sensitive mass market private consumers and company fleet operators, much higher prices may deter a significant proportion of potential consumers, most of whom are unlikely to be early adopters of new technologies. Given the importance of vehicles in this size category to most of the major manufacturers operating in EU markets, it may be the case that manufacturers have made the decision to develop their initial pure electric vehicle offerings in other niche market segments, such as for the mini-car segment, the sports car segment, and the luxury car segment, before deciding whether to start developing such vehicles for the mass-market mainstream medium-size car market. However, it should be noted that is difficult to verify whether the above scenario is actually the case in practice, as the longer-term commercial strategies of the automotive manufacturers are obviously confidential.

At this point in time, two major manufacturers have announced that they are planning to release medium-sized EVs in the near future. At the beginning of 2009, Ford announced that an electric version of its next generation Focus model would be put into production for the US market. In May 2009, Ford also announced that in 2010 it would be setting up a demonstration project using electric demonstrator vehicles based on the current generation Ford Focus. The Technology Strategy Board will support the project, and Ford will be working with Strathclyde University and Scottish and Southern Energy to carry out the trial. The results will be used to help Ford evaluate the feasibility of introducing an electric version of the next generation Focus for the European market.

Renault is the other manufacturer that has made a firm commitment to producing pure electric medium-sized cars. Its first vehicle in this size category will be the new Renault Fluence saloon car, which will initially be released to the market in Israel in 2011 in conjunction with Better Place. The Fluence is also likely to be sold in Europe, although at this point in time it is not clear when it will be released on the EU market.

With the above factors in mind, and given the finding that only a very limited number of mainstream manufacturers have officially announced that they are currently developing medium-size electric cars for the European market, at this point in time it is not anticipated that many pure electric medium-sized cars will be launched on the EU or UK markets for several years. If the above assessment of manufacturer strategies is correct, and given the typical five year development cycle for a new vehicle model, if manufacturers started the process of developing such vehicles in 2010, the earliest they could realistically appear on the market is 2015. Beyond 2015 and through to 2022, it is thought possible that there could be significant numbers of medium-sized electric vehicles made available on the UK market, but this will be dependent on (a) the success of early electric vehicle models with consumers in other market segments, (b) the global economic situation over the next two to five years, and (c) developments in battery technologies/costs.

Plug-in hybrid electric vehicles

The situation concerning the development of medium-sized PHEVs is very different to that for pure electric vehicles. A number of major manufacturers have publicised plans to mass produce PHEVs, and these vehicles will be sold in a number of key global markets including the EU, Japan, and the USA. The most high profile planned vehicle releases are the Toyota Prius PHEV, the Chevrolet Volt (manufactured by General Motors), and the Volt's sister car, the mechanically identical Vauxhall/Opel

Ampera. All of these vehicles are planned for release on the UK market in 2012[8], but early uptake is likely to be very limited as the planned initial global production figures are very low; for example General Motors has indicated that between 10,000 and 30,000 Chevrolet Volts will be produced for sale globally in the first year of production, with production rising to 60,000 cars per year thereafter, depending on how consumers respond. It should be noted that the current ongoing financial problems at General Motors mean that it is possible the Chevrolet Volt and Opel/Vauxhall Ampera may not appear on the market. At the time of writing (April 2009), General Motors had already obtained more than US$13 billion in aid from the US Government was in the process of developing restructuring plans for its business operations, which could include closing down a number of operating divisions or selling off subsidiary companies including its Vauxhall/Opel European operations.

Beyond the Toyota and General Motors vehicles described above, a number of other manufacturers have indicated that they have plans to produce medium-sized PHEVs in future years, but none of these will arrive on the UK market before 2013 or 2014. Examples include models from the Volkswagen Group and Ford, amongst others. Beyond 2014, it is anticipated that many other manufacturers will start producing PHEVs for the medium-size car market, and as with pure electric vehicles, significant numbers of different model variants could be available by 2022. Given that PHEVs for this market segment are more developed as a commercial proposition than pure electric vehicles, it is expected that sales of PHEVs will be significantly greater than EVs for all years through to 2022.

[8] The Chevrolet Volt will initially be available in the USA from the end of 2010, and the Opel Ampera will be available in non-UK European markets from 2011.

Table 2.3: Detailed model plans for medium battery-electric cars

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information	Regional availability	Other information	Information sources	Confidence level
Ford Focus (EV)	2011 (US) Suitability for EU market to be evaluated	Unknown	Unknown	US and possibly EU	SMMT category C (lower medium) Production vehicle being developed in conjunction with Magna. Vehicle range: up to 100 miles (160 km) per charge	Ford press release, January 2009	High
Renault Fluence (EV)	2011 (Israel); EU release date unknown	20,000 to 40,000	Unknown	Israel, EU	SMMT category C/D (lower/upper medium) Vehicle range: Unknown	Autoblog Green, October 2008 (sourced from Automotive News)	High

Table 2.4: Detailed model plans for medium plug-in hybrid electric cars

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information	Regional availability	Other information	Information sources	Confidence level
Toyota Prius PHEV (PHEV)	2010 (initial release limited to selected fleet users)	Unknown	Unknown	EU, USA, Japan	SMMT category C/D (lower/upper medium) Electric-only range will be limited to a maximum of 12 miles, reflecting the small battery capacity that will be fitted to this vehicle. Currently undergoing trials in the UK in a partnership between Toyota and EDF Energy	Toyota press release	High
Chevrolet Volt / **Vauxhall-Opel Ampera (General Motors)** (PHEV)	2010 (US) 2011 (EU) 2012 (UK)	Initial production volumes range from 10,000 to 60,000 cars per year	US$40,000 (£28,000)	EU, USA, Australia, Japan	SMMT category C/D (lower/upper medium) Vehicle range: Electric-only range will be 40 miles. Will be fitted with 16 kWh lithium-ion batteries. Petrol engine capable of 4.7 litres/100 km. Combination of petrol engine and electric motor anticipated by General Motors to return 40	General Motors press releases, 2nd March 2009	Medium/High

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information	Regional availability	Other information	Information sources	Confidence level
					gCO_2/km. General Motors' current financial problems might have an impact on whether or not this vehicle can be brought to market.		
SEAT Leon Twin-Drive (PHEV)	2014	Unknown	Unknown	EU	SMMT category C (lower medium) SEAT, which is part of the Volkswagen Group, has presented a prototype version of a possible future PHEV version of the Leon lower medium family hatchback (SMMT category C). Prototype features a 1.9 litre diesel engine and a 35 kW electric motor. Seat's press release talks of an 'aspiration to develop a viable plug-in electric powered vehicle', hence it is not clear that a production version will definitely follow. Vehicle range: 31 miles on electric-only power (unconfirmed)	SEAT press release, 22nd January 2009	Medium

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information	Regional availability	Other information	Information sources	Confidence level
Volkswagen Golf Twin Drive (PHEV)	2015	Unknown	Unknown		SMMT category C (lower medium) VW has built 20 prototype diesel PHEV Golfs for evaluation. Can travel 30 miles on pure electric power at speeds of up to 31 mph. Fuel consumption for these prototypes is 113 miles per gallon (equivalent to 66 gCO_2/km). Vehicle range: 31 miles on electric-only power	Auto Express, August 2008 (test drive of prototype)	Medium

2.4.3 Large cars

Electric vehicles

As described earlier, the large car classification that has been used in the CCC MACC model includes sports cars, executive saloons, luxury cars and SUVs, most of which appeal to niche consumer market segments. The fact that most of the vehicles in this segment are expensive niche vehicles means that there is an opportunity for manufacturers to apply battery electric technologies to such vehicles in order to attract high-earning early adopter consumers that have a particular interest in new vehicle technologies. Previous research (Shell 2004) has shown that such consumers are insensitive to price and are in fact willing to pay a significant premium to be the first to have access to new low carbon vehicle technologies.

In practice, it can be seen that a significant number of the electric cars that are soon to be available on the market do indeed fall into the large car or sports car categories. High profile vehicles include the Tesla Roadster (a high performance sports car that is already available on the US market), the Tesla Model S luxury saloon (planned to be available in the USA from the end of 2011), the Liberty electric Range Rover conversion (available in the UK from the end of 2009), and a conversion of the Porsche 911 sports car produced by Ruf (also available in the UK from the end of 2009). It is anticipated that a number of other manufacturers are likely to start offering niche-market electric cars in the near future to capitalise on the growing interest in such vehicles. However, it must be stressed that in the short-to-medium term, such models are unlikely to have a significant impact on the overall UK, European, or even global uptake of electric vehicles. The vehicles that we have termed large cars make up only 14% of the new car market, and within this category, sports cars account for only 2.4% of new cars and luxury cars account for only 0.5% of sales. It is interesting to note that to date, none of the current or planned electric cars in this market segment are being produced by any of the major global manufacturers, but are instead either being produced by new companies (e.g. Tesla) or by small companies that are converting existing vehicles produced by the major manufacturers to use batteries. This may be another factor that may limit the uptake of these types of vehicles, at least in the short term, as previous research has shown that consumers place a high value on existing brand names when making new car purchasing decisions (Shell 2004[9], LowCVP 2006[10]).

In the years to 2022, it can be expected that there will be further new electric luxury cars and sports cars coming to the market. However, it is anticipated that the development of more mainstream large electric cars will be relatively limited, although some vehicles are likely to appear on the market. The most significant market segments in the large car category are the SUV segment (SMMT category H) and the executive car segment (SMMT category E), which together make up more than 10% of total new car sales. Many of the vehicles purchased in these segments are company cars that are high mileage vehicles. Due to the typical operating patterns of these vehicles (significant motorway mileage), current battery technology may not be able to provide the overall operating range that drivers of these types of vehicles may require at an economically viable price, at least not in the short term. However, improvements in battery technology may mean that this becomes more feasible by the end of the next decade.

Plug-in hybrid electric vehicles

At this point in time, only one manufacturer has released a PHEV large car; this vehicle, the Fisker Karma, is a niche-market luxury sports saloon that is currently only available in the USA. Again, many of the issues discussed above for large electric cars hold true in the case of the Fisker Karma; it is vehicles that is being aimed at high-earning, early adopter consumers, and is being produced by a new company with no previous track record in the automotive sector.

[9] Shell 2004, "Consumer acceptance of new fuels and vehicle technologies". Cambridge MBA students' study conducted on behalf of Shell). Presentation to the LowCVP, 2004.

[10] LowCVP 2006, "Car buyer research report – consumer attitudes to low carbon and fuel efficient passenger cars", report prepared by Ben Lane on behalf of the Low Carbon Vehicle Partnership

A number of major manufacturers have indicated that they have plans to produce large PHEVs in the near future. Ford has been conducting trials with a sport utility vehicle (SUV) equipped with PHEV technology, and selected motoring journalists have been allowed to road test prototypes of these vehicles. It is likely that Ford will start manufacturing a similar vehicle in the USA from 2012, but at this point in time it is unlikely that this vehicle will also be sold in the UK. PHEV technology is likely to be a very suitable technology for future large cars, as vehicles equipped with this technology would be capable of achieving significant improvements in tailpipe CO_2 emissions.

Table 2.5: Detailed model plans for large electric cars

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information (includes VAT for UK prices)	Regional availability	Other information	Information sources	Confidence level
Dodge Circuit (EV)	2011	Unknown	£50,000 to £55,000 (estimate)	US, possibly EU/UK	SMMT category G (specialist sports) Chrysler Group sports car based on Lotus Europa sports car, but fitted with battery electric powertrain instead of petrol engine. Vehicle range: 150-200 miles per charge Chrysler's current financial problems may prevent this car from being brought to market	Road test reports published in various motoring magazines, including Car Magazine, June 2009,	Low/medium
Liberty Range Rover (EV)	2009	1,000 per year	£95,000 to £125,000 depending on model and specification	UK	SMMT category H (dual purpose 4x4s/SUV) Battery electric conversion of the existing Range Rover model, which will be carried out by Liberty Electric Cars. No prototypes have yet been released for trial by		Medium

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information (includes VAT for UK prices)	Regional availability	Other information	Information sources	Confidence level
					the press, but the company states the vehicle will go into production in late 2009. Vehicle range: 150-200 miles per charge Recharging time: 4-6 hours		
Ruf e-Ruf Model A (conversion of Porsche 911) (EV)	2009	50 per year	£120,000	EU, UK	SMMT category G (specialist sports) Electric sports car conversion using Porsche 911 as the donor vehicle. Battery capacity: 51 kWh. Vehicle range: 150-200 miles per charge Recharging time: 10 hours	Ruf Automobile GmBh press release	Medium/High
Tesla Roadster (EV)	2008 in USA Autumn 2009 in UK	Unknown, but by the beginning of April 2009, 320 cars had been sold and	£87,000 to £94,000	US, EU, UK	SMMT category G (specialist sports) Electric sports car designed around the chassis layout of the petrol-engine Lotus Elise	Tesla Motors website	High

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information (includes VAT for UK prices)	Regional availability	Other information	Information sources	Confidence level
		delivered to customers			sports car. Battery capacity: 53 kWh. Vehicle range: up to 244 miles per charge Recharging time: 3.5 hours (240 Volts) Battery replacement cost: £9,000		
Tesla Model S (EV)	Late 2011 in USA	20,000 per year by end of first year of production	US$57,400	USA initially with EU and UK sales likely to follow later	SMMT category F (luxury car). Electric luxury car with space for seven occupants. Battery capacity: 42 kWh (up to 70 kWh available as an option). Vehicle range: 160 miles with 42 kWh battery pack; 300 miles with 70 kWh battery pack. Recharging time: 4 hours (220 Volt supply); Quick charge facility will enable charging in 45 minutes.	Tesla press release; Reuters news article, March 26 2009	Medium

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information (includes VAT for UK prices)	Regional availability	Other information	Information sources	Confidence level
					Production depends on Tesla securing a $350 million loan from the US Federal Government's Advanced Technology Vehicle Manufacturing Program. This loan would be used to construct a production facility for the Model S.		

Table 2.6: Table 2.7: Detailed model plans for large plug-in hybrid electric cars

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information (includes VAT for UK prices)	Regional availability	Other information	Information sources	Confidence level
Cadillac Converj (PHEV)	2012/13	Unknown	Unknown	US	SMMT category F (luxury car) Car presented at Detroit Motor Show in January 2009. Uses the same platform and technology as the Chevrolet Volt. Significant uncertainty around whether this vehicle will reach production Vehicle range: 40 miles on electric-only power	General Motors press release, January 2009	Low
Fisker Karma (PHEV)	2009	Unknown	US$87,900 (£63,000)	US	SMMT category F (luxury car) Battery capacity: 22.6 kWh Recharging time: 4-6 hours Vehicle range: 50 miles on electric-only power	Fisker	High
Ford Plug-in hybrid	2012	Unknown	Unknown	US,	US DoE awarded Ford	Ford press release	Medium

Vehicle manufacturer/model name	**Planned date available on the market**	**Planned production volume**	**Retail price information (includes VAT for UK prices)**	**Regional availability**	**Other information**	**Information sources**	**Confidence level**
car (PHEV)				possibly EU	$10 million grant to develop PHEVs in 2007 Vehicle range: 30 miles on electric-only power (unconfirmed)		

2.4.4 Vans and HGVs

Electric vehicles

There are already a number of electric light commercial vehicles on sale in the UK, with the key manufacturers being the UK companies Smith Electric Vehicles and Modec. Smith is the world's largest manufacturer of commercial electric vehicles, and the company currently manufactures five different models, including vans, a minibus, and heavy-duty trucks. Smith's model range is based on conventional diesel vehicle platforms, with a number of their vehicles being derived from Ford Transit vans. The company is unique in being able to offer a large (up to 12 tonne gross vehicle weight) heavy-duty rigid truck. Modec is a competitor to Smith and offers a range of electric vans and trucks based on their own bespoke chassis-cab design. Both Smith and Modec have managed to develop a broad customer base, without necessarily selling huge numbers of vehicles. For instance, Smith's customers include TNT (who recently ordered 150 vehicles), Royal Mail, BSkyB, DHL, Sainsbury's, Scottish and Southern Electricity, Openreach and Balfour Beatty.

A number of much smaller, niche-market electric vans are available on the UK market from companies such as Piaggio and Mega. These vans are much smaller than conventional vans (typically, they are the size of a mini-car (SMMT category A), and hence they are unlikely to be suitable for most businesses or individuals.

In recent months, a number of the major global automotive manufacturers have announced that they are planning to bring electric vans to the market. In January, Ford announced a partnership with Smith Electric Vehicles to bring an electric version of the Transit Connect model to market (Smith already produces an electric version of this vehicle), and in April 2009, Chrysler announced plans to produce electric vans for the US Postal Service, although this will be dependent on receiving grants from the US Federal Government. Furthermore, the company has been very heavily affected by the global economic crisis, and the availability of these vans will also depend on the company's ability to improve its current financial situation.

With respect to heavy goods vehicles, although Smith Electric Vehicles already have their Newton 12 tonne truck on the market, it is not envisaged that there will be many other such vehicles released between now and 2022. In general terms, large trucks are not currently the most suitable candidates for electrification; they have high energy requirements, necessitating the use of large, and very expensive battery packs, and a significant proportion of these vehicles are used for long-distance freight operations (travelling hundreds or even thousands of miles), both nationally and internationally. Without a well-developed recharging infrastructure, and significant improvements in battery technology, it is unlikely that there will be any major new models released between now and 2022.

Table 2.8: Detailed model plans for electric vans

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information (includes VAT for UK prices)	Regional availability	Other information	Information sources	Confidence level
Chrysler Town and Country Van (EV)	Unknown	Unknown	Unknown	US	Being developed for US postal service. Production is dependent on Chrysler's financial status improving and on being awarded a development grant from the US Government Vehicle range: 40 miles per charge (unconfirmed)	Chrysler press release, 22nd April 2009	Low
Ford Transit Connect electric (EV)	2010	Unknown	Unknown	US	This vehicle will be a Ford-branded version of the Smith Ampere electric van (already available on the market – see below), which is itself based on the bodyshell of the petrol/diesel Ford Transit Connect. Vehicle range: close to 100 miles per charge	Ford press release, 11th January 2009	High

Vehicle manufacturer/model name	Planned date available on the market	Planned production volume	Retail price information (includes VAT for UK prices)	Regional availability	Other information	Information sources	Confidence level
Modec (EV)	Available now	450 vehicles in 2009	£55,000 (£35,000 +£400/month if battery pack leased)	UK	Vehicle range: 50 miles per charge Recharging time: 4-6 hours Payload: 2 tonnes	Interview with Modec sales director published in What Van magazine (21st October 2008)	High
Smith Electric Vehicles (Ampere, Edison, and Newton) (EV)	Available now	Unknown	£32,000 to £100,000 depending on model	UK, EU, US	Smith has a full range of electric vans and trucks already available on the UK market, including car-derived vans, panel vans, chassis cab vans, and a full-size rigid truck. Most vehicles are based on conventional Ford vans. Ampere vehicle range: 100 miles per charge Edison vehicle range: 100 miles per charge Newton vehicle range: 150 miles per charge	Smith Electric Vehicles	High

2.5 Advanced diesel vehicles

2.5.1 Overview

The foregoing sections have discussed current and likely market developments with respect to electric and plug-in hybrid vehicles over the next 15 years. However, whilst these technologies offer the potential for significant reductions in greenhouse gas emissions, there are still a number of limitations associated with these options that may limit uptake over the next few years. In particular, the high costs and limited range associated with electric vehicle technologies may lead to consumer resistance. With this in mind, in addition to starting to develop EVs and PHEVs, most of the major European car manufacturers are already developing improvements to existing internal combustion engines that will significantly improve fuel efficiency and reduce CO_2 emissions. Much of this activity is driven by the forthcoming EU legislative requirements for fleet-weighted average new car CO_2 emissions of 130 g/km, with further reductions planned for later years. Given the uncertainty around the uptake of electric vehicle technologies, efficiency improvements for conventional petrol and diesel engines will be necessary in order that manufacturers are able to meet these near-term targets.

2.5.2 Introduction to advanced diesel technologies

AEA's previous research for CCC to develop a marginal abatement cost curve model included characterisation of a range of CO_2 abatement technologies that can be applied to new cars to improve fuel efficiency and thereby reduce CO_2 emissions. These technologies included a range of powertrain options that can be applied to both petrol and diesel engines, including stop/start technology, micro-hybrid technology, mild hybrid technology, and full hybrid technology. Furthermore, a number of technologies that are being applied to petrol engines have also been included in the model, and these have been grouped together under the names first generation advanced petrol technologies (direct injection, variable valve actuation) and second generation advanced petrol technologies (first generation technologies plus engine downsizing and boosting technologies such as supercharging and turbocharging). The model also includes data on the likely abatement potential of controlled auto-ignition (CAI) technology for petrol engines and homogeneous charge compression ignition (HCCI) technology for diesel engines. In addition to powertrain technologies, the model also allows a wide range of non-powertrain abatement options to be analysed. These include, low-rolling resistance tyres, weight reduction options, and improved aerodynamics amongst others.

Whilst the above-listed technologies cover the majority of technological developments that are likely to be applied to conventional petrol and diesel vehicles over the next fifteen years, there is a need to examine in further detail the scope for applying new technologies to diesel engines in order to reduce CO_2 emissions and improve fuel efficiency. Diesel engines are already significantly more efficient than petrol engines with an equivalent power output, and technological advances over the next decade could mean that improved diesel powered vehicles are likely to compete strongly with emerging electrically powered vehicles. Forthcoming developments in diesel engine technology, when coupled with various powertrain and non-powertrain technologies could mean that the emissions performance of typical medium sized cars drops dramatically between now and 2020. Improvements in diesel engines will be achieved by combining a number of different technologies to improve efficiency and reduce emissions. These technologies include the following:

- Engine downsizing
- Sequential twin-turbocharger systems
- Improved fuel injection systems

A key element in the strategy for diesel technology is engine downsizing, which is also being applied to petrol engines. Smaller capacity engines provide many potential benefits including reductions in weight and engine internal friction, which lead to improvements in fuel efficiency. Smaller engines are also easier to package and there may also be some cost reductions. However, without taking appropriate compensatory measures, smaller engines are also less powerful (which may not be acceptable to consumers used to more powerful engines) and hence it is necessary to combine engine downsizing with technologies that allow smaller, more efficient engines to achieve the same overall performance as conventional larger engines. Most, if not all, current diesel engines use turbocharging to provide the performance necessary to meet the demand of modern vehicles, conventional turbocharging strategies may not provide sufficient low-speed torque and the rapid response required to overcome the performance deficiencies of a downsized engine. Hence, manufacturers are starting to deploy novel turbocharging systems for diesel engines that allow downsized engines to return improved fuel efficiency and similar (or better) performance than a conventional larger engine. A good example of such a system is the twin sequential turbocharging system that is being used by a number of different major car manufacturers. The system consists of two differently sized turbochargers that operate at different engine speeds that enhance fuel efficiency by improving the generation of lean fuel/air mixtures in the engine, as well as improving vehicle driveability.

In addition to new types of turbocharging systems, advanced diesel engines are also being equipped with improved fuel injection systems that aid fuel efficiency. Over the last few years, there has been a shift towards using so-called “common-rail” diesel injection systems that allow the diesel fuel to be injected into the combustion chamber at much higher pressures, enabling better atomisation of the fuel (i.e. it can be injected as an extremely fine spray). The benefits of better atomisation are that there is better mixing of the fuel with air in the combustion chamber, allowing more complete combustion and better overall fuel efficiency. Common rail diesel engines also include highly accurate electronic control of the fuel injection process, as opposed to the mechanically controlled systems used on older diesel engines. Electronic control allows very precise amounts of fuel to be injected into the combustion chamber, again aiding overall fuel efficiency. The fuel injection systems used in common rail diesel engines have improved significantly over the last few years, with the latest systems using hundreds of piezo crystal wafers for the fuel injector actuators. Piezo crystals expand very rapidly when an electric charge is applied to them, which allows the time intervals between consecutive fuel injections to be reduced. This allows the engine to operate more quietly and more efficiently than is possible with previous actuator designs. In particular, the level of fuel atomisation that can be achieved piezo crystal actuators is even greater than is possible with the previous types of actuators used in first and second-generation common rail diesel engines.

In combination, engine downsizing with advanced common rail and fuel injection systems can give very significant improvements in fuel consumption, and there are likely to be significant further developments in these areas over the next few years.

2.5.3 Market outlook for advanced diesel technologies

In the European market, the pressure to reduce passenger car CO_2 emissions due to the proposed European Commission regulations means that there will be a rapid and significant shift to downsized petrol and diesel engines. This has already started to happen for petrol engines, but these developments will continue further and will also be applied to diesel engines, using many of the technologies described above. The following sections provide an overview of current and likely future market developments for each vehicle size/type category. Details of current average and best-in-class emissions performance for each size category have been provided, using data collated by the SMMT. Additionally, estimates of the projected future average and best-in-class CO_2 emissions performance for each vehicle size category have been developed using assumptions for the possible annual improvements in new diesel vehicle fuel efficiency that could be seen between now and 2022.

It should be noted that across all passenger car market segments, there have been significant increases in diesel penetration between 1997 and 2008. The significant recent improvements in diesel technology have dramatically improved the performance, refinement, and fuel efficiency of diesel vehicles, making this option much more attractive to consumers. Whilst there are likely to be further increases in diesel penetration in future years, the rate of increase is likely to slow significantly, and possibly will peak in the middle of the next decade. Bosch, one of the major manufacturers of diesel fuel injection systems, has developed a set of projections for diesel penetration in light-duty vehicles (Bosch 2009[11]). These projections estimate that in Western Europe, diesel penetration will continue to

[11] Bosch 2009, Diesel market share worldwide – market potential, sales by powertrain http://rb-k.bosch.de/en/powerconsumptionemissions/dieselsysteme/latest/dieselworldwide.html (accessed, 23rd April 2009)

increase until 2016, at which point overall penetration will peak with 61% of new vehicles being equipped with diesel engines. Diesel penetration is likely to peak for a number of reasons; firstly, global crude oil refinery capacity is limited and the EU is currently a net importer of diesel (a significant proportion is imported from the USA). As diesel penetration increases in the USA, then there are likely to be constraints on global supply, which may push fuel prices upwards. Additionally, diesel technology faces strong competition from advanced petrol engine technologies, including petrol-electric hybrids. These factors may conspire to restrict further increases in diesel penetration.

With respect to light commercial vehicles (vans), the vast majority of vehicles are equipped with diesel engines (more than 98% of new vans are fitted with diesel engines), and hence there is very limited scope for any further shift away from petrol towards diesel; almost all heavy-duty vehicles are equipped with diesel engines. The emission reduction technologies described above for passenger car engines are also applicable to light duty commercial vehicles and heavy-duty vehicles. However, at this point in time the levels of technology penetration are lower than for vans and trucks than they are for cars, primarily due to the fact that EU legislation for reducing emissions from vans is still in the process of being developed, and initial research on policy options for reducing emissions from heavy duty vehicles is currently being carried out. With this in mind, it is thought likely that uptake of advanced diesel technologies in the light commercial vehicle sector and in the heavy duty vehicle sector will be lower than in the passenger car sector for all years between 2009 and 2022.

The following sections provide a theoretical assessment of how average CO_2 emissions from new diesel passenger cars could change between 2008 and 2022, taking into account the uptake of the advanced diesel technologies described above. This assessment has been carried out for small cars, medium cars and large cars separately, using recent trends in average new car CO_2 emissions as a guide to how emissions performance could decrease over time under a “minimum improvement” scenario. Professional judgment has also been used in order to develop more aggressive estimates for emissions improvements, given that proposed future European Union legislation could lead to the introduction of significantly more stringent targets for new car CO_2 performance.

Within the resources available for carrying out this study, it has not been possible to perform similar analyses for vans and heavy duty vehicles, as detailed data on annual changes in the average CO_2 emissions performance these types of vehicles is not currently available.

2.5.4 Small cars

The UK market for small cars is currently dominated by petrol engine technology; based on SMMT sales data (SMMT 2009), only 16% of new cars in SMMT categories A and B cars (mini-cars and superminis) were equipped with diesel engines in 2008. However, it should be noted that this is an increase over previous years; in 2007, 13% of new small cars were equipped with diesel engines, whilst in 2006, only 11% of new small cars were fitted with diesel engines. It is anticipated that between now and 2022, the proportion of new small cars powered by diesel engines may increase further, but it is unlikely that there will be a step change to diesel technology for small cars due to the price differential between petrol and diesel engines (the small car market is very price sensitive) and the fact that small petrol-engined cars are already relatively fuel efficient. Additionally, further diesel penetration is likely to be limited by global crude oil refinery capacity.

Even though diesel technology is unlikely to be the primary type of powertrain technology used in small cars in the near future, there are a number of developments that will lead to some adoption of high efficiency diesel powertrains in this market sector. A number of highly efficient small diesel-powered cars have already been released on the EU and UK markets that combine advanced diesel powertrains with stop-start or micro-hybrid technology, improved aerodynamics, low rolling resistance tyres, and weight-reduction strategies. At the moment, these vehicles are very much niche-models that do not form the bulk of a manufacturer’s model range, and they tend to be marketed as specific “eco” models. Many of these existing vehicles are capable of achieving CO_2 emissions performance of just less than 100 gCO_2/km. It is likely that this trend will continue and that further improvements will be achieved in the coming years through the more widespread adoption of these technology packages. Near-market examples include the 2010 Volkswagen Polo that will be capable of achieving 87 gCO_2/km, a 9% improvement over the 2009 model (Volkswagen 2009); this performance will be achieved partially through the use of a downsized diesel engine (this new model will use a 1.2 litre diesel engine compared to the 1.6 diesel that will be fitted to the 2009 model). It is likely that in order to effectively compete in this market, other manufacturers will also soon introduce competitor vehicles with similar emissions performance to the new Polo.

Over the next few years, it is anticipated that small diesel cars with CO_2 emissions performance below 100 g/km will become the norm, and potentially by 2022, average CO_2 emissions from small cars could drop below 80g/km.

In order to estimate the possible future performance of diesel small cars, data on actual improvements in average CO_2 emissions over the last ten years has been obtained from the SMMT and Energy Saving Trust. These data track the changes in average new car CO_2 emissions between 1997 and 2008. Due to the limited number of diesel mini-cars (SMMT category A), accurate data are only available for superminis (category B). The data show that over the time period 1997 to 2008, average CO_2 emissions factors for diesel superminis declined from 153.4 g/km in 1997 to 118.9 g/km in 2008, an average improvement of 2.3% per year. If it is assumed that this level of annual improvement continues to be achieved between 2008 and 2022, then an average new diesel small car could have emissions of around 86 gCO2/km by 2022. The same methodology can also be used to estimate future best-in-class emissions performance. Using the same annual improvement factor, and projecting from the 2010 best-in-class figure of 87 gCO_2/km, it can be estimated that by 2022, best-in-class diesel emissions performance could reach 66 gCO_2/km. It should be noted that best-in-class performance would only be achieved through the combined application of advanced diesel technology, micro-hybrid systems, weight reduction, and improved aerodynamics.

These estimates are predicated on assuming that future annual improvements occur at the same rate as recent historic annual improvements. However, improvements since 1997 have largely occurred in response to the car manufacturers' voluntary agreement on CO_2 emissions, whereas future improvements are likely to occur in response to the proposed EC legislation in this area. It is possible that given the likely legislative requirements to reduce emissions (and the related financial penalties for non-compliance), the rate at which emissions improvements occur in future years could increase. With this in mind, a second set of calculations have been carried out to estimate the possible impacts of increasing the rate at which advanced diesel technologies filter through to new small cars. In this scenario, the average rate of improvement in emissions has been assumed to be 3.5% per year; using this figure, by 2022, average new diesel superminis would be capable of approximately 73 gCO_2/km, whilst the best-in-class diesel supermini would be 57 gCO_2/km.

Table 2.9: Projected possible future CO_2 emissions performance of small cars equipped with advanced diesel engines

	Projected diesel emissions performance based on annual improvement of 2.25%		**Projected diesel emissions performance based on annual improvement of 3.5%**	
	New car fleet average	**Best-in-class**	**New car fleet average**	**Best-in-class**
2008 (actual)	118 gCO_2/km	98 gCO_2/km	118 gCO_2/km	98 gCO_2/km
2010 (projection)	114 gCO_2/km	87 gCO_2/km*	111 gCO_2/km	87 gCO_2/km*
2014 (projection)	104 gCO_2/km	79 gCO_2/km	96 gCO_2/km	75 gCO_2/km
2018 (projection)	95 gCO_2/km	73 gCO_2/km	83 gCO_2/km	65 gCO_2/km
2022 (projection)	86 gCO_2/km	66 gCO_2/km	73 gCO_2/km	57 gCO_2/km

* Figure based on information released by Volkswagen Group in March 2009 for 2010 VW Polo Bluemotion

It is worth noting that even as long ago as 1999, limited examples of very high efficiency diesel small cars were commercially available on the EU (but not UK) market, with CO_2 emissions significantly better than today's best-in-class vehicles. These vehicles were the Volkswagen Lupo 3L (SMMT category A) and the Audi A2 3L (SMMT category B), both of which were capable of fuel consumption figures of three litres per 100 km (81 gCO_2/km). The very high fuel efficiency figures exhibited by these vehicles were achieved by combining advanced (by 1999 standards) diesel engines, with stop-start technology, improved aerodynamics and strong weight reduction (both vehicles made extensive use of aluminium and magnesium in their bodyshells, with the Audi vehicle's main body structures being constructed entirely from aluminium). Due to the high retail prices for these vehicle models, neither car was particularly successful on the market, and consequently neither of these cars is available today (both were discontinued in 2005). No current diesel cars on the UK or wider EU market are able to match the emissions performance of these vehicles.

2.5.5 Medium cars

SMMT data (SMMT 2009) indicates that in 2008, 56% of new medium cars were equipped with diesel engines. Diesel penetration has significantly increased in recent years (in 1997, only 20% of new medium cars had diesel engines), and whilst there may be further increases in penetration over the next few years, it is thought likely that these increases will be much smaller. In particular, the level of further diesel penetration is likely to be limited by the global refinery capacity issues discussed in the previous section, and by strong competition from vehicles equipped with advanced petrol engines and petrol-hybrid-electric cars. With this in mind, maximum diesel penetration levels for medium cars may peak at between 60% and 65%[4].

There are already a number of diesel powered medium cars with emissions performance below 120 g/km – the Vehicle Certification Agency's CO_2 database identifies more than fifteen cars that fall into this category. As with small cars, many of these vehicles are niche-market "eco" branded variants that feature weight reduction, improved aerodynamics, and higher gearing to reduce fuel consumption. It is anticipated that many more medium cars will be able to attain a CO_2 emissions performance of lower than 120 g/km in the next couple of years. It is important to note that none of the vehicles available on the market today in this market segment are able to emit less than 110 g/km (the current best-in-class performance is exhibited by the Ford Focus which emits 114 g/km). Later in 2009, Volkswagen will release to the market an updated version of its Golf Bluemotion model which will be capable of 99 gCO_2/km; this performance will be achieved through a combination of advanced diesel technology, weight reduction, changes to gear ratios, improved aerodynamics, and the use if low rolling resistance tyres. As with the small car market, it is anticipated that other manufacturers will soon be offering medium-sized diesel vehicles that are capable of providing the same or better emissions performance, using a similar combination of technologies.

Average emissions performance data for the new diesel medium car segment have been collated from SMMT. These data indicate that average CO_2 emissions for new medium-sized diesel cars dropped from 172 g/km in 1997 to just under 150 g/km in 2008; these figures equate to an annual improvement of approximately 1.3% per year. These recent improvements are very modest, and reflect the fact that although diesel engine efficiency has improved significantly, average medium cars have significantly increased in weight and overall size over the last ten to fifteen years. If annual improvements in average emissions continued at a rate of 1.3% per year between now and 2022, an average medium-sized diesel car would emit 125 gCO_2/km in that year. However, as noted earlier, annual average improvements in new car emissions of 1.3% are very low, and given the need to meet the proposed EC new car fleet-weighted emissions limits of 130 gCO_2/km for 2012/2015, and possible future limits of 95 gCO_2/km for 2020, annual improvement rates for both diesel and petrol cars will need to be significantly higher in order to meet these limit values. For medium cars, there is likely to be more scope for reducing emissions than for small cars; in particular, there are greater opportunities for engine downsizing and weight reduction, and it is easier to improve the aerodynamic performance of a medium car than it is for a smaller car. With these factors in mind, projected future emissions performance for average new medium diesel cars and the best-in class car have also been estimated using a more aggressive improvement rate of 3.5% per year.

Table 2.10: Projected possible future CO_2 emissions performance of medium cars equipped with advanced diesel engines

	Projected diesel emissions performance based on annual improvement of 1.3%		**Projected diesel emissions performance based on annual improvement of 3.5%**	
	New car fleet average	**Best-in-class**	**New car fleet average**	**Best-in-class**
2008 (actual)	150 gCO_2/km	114 gCO_2/km	150 gCO_2/km	114 gCO_2/km
2010 (projection)	146 gCO_2/km	98 gCO_2/km	139 gCO_2/km	98 gCO2/km
2014 (projection)	139 gCO_2/km	93 gCO_2/km	121 gCO_2/km	83 gCO_2/km
2018 (projection)	132 gCO_2/km	88 gCO_2/km	105 gCO_2/km	72 gCO_2/km
2022 (projection)	125 gCO_2/km	84 gCO_2/km	91 gCO_2/km	62 gCO_2/km

2.5.6 Large cars

Since 1997, the large car category (encompassing luxury saloons, executive cars, sports cars and 4x4s) has seen the most dramatic shift in diesel penetration of any of the passenger car market segments. In 1997, less than 19% of new large cars were equipped with diesel engines; by 2008, this proportion had increased to 68%. Much of this shift is due to the reforms in the UK company car tax regime that occurred at the beginning of the decade. Within this segment, there are significant variations in the levels of diesel penetration. The SMMT's vehicle registration data for 2008 shows that in the executive saloon category, 78% of new cars were equipped with diesel engines, whilst the figure for dual-purpose 4x4s was even higher at 83% (10% and 50% respectively in 2007). In 2008, 54% of new luxury saloons and 12% of new specialist sports cars were equipped with diesel engines; by contrast, in 1997, none of the vehicles sold in either of these market segments used diesel engines. As with the other market segments, for the large car segment it is anticipated that there may be further increases in diesel penetration in future years, but these increases are likely to occur at a slower rate due to limitations in global refinery capacity, and competition from petrol-electric hybrid vehicles. A number of major manufacturers, including Mercedes-Benz, BMW, and Jaguar Land Rover (amongst others) are planning to release petrol-electric hybrid luxury saloons and 4x4s in the next few years (the first of which will arrive on the market this year), and these vehicles are likely to offer similar levels of CO_2 emissions to equivalent diesel vehicles.

Data on the current best-in-class vehicles has been identified for each of the sub-segments included in the large car category, taking data from the Government's "Act on CO_2" website. The best performing vehicles are as follows: BMW 520d (executive car, 136 gCO2/km), BMW 120d coupe (specialist sports, 128 gCO_2/km), Hyundai Santa Fe diesel (dual purpose 4x4, 190 gCO_2/km), and BMW 730 d (luxury saloon, 192 gCO_2/km). Unlike the small and medium car market segments, the use of eco-branding has not (yet) been widely applied to the types of cars included in the large car category, and there are only limited examples of specific vehicles models that have been designed or modified to optimise CO_2 emissions performance. The exception to this is the strategy that has been pursued by the BMW Group. Most BMW cars (both petrol and diesel) across the full range are now equipped with what BMW refers to as its "Efficient Dynamics" package. This includes micro-hybrid technology and a "smart" battery/alternator system to enable regenerative braking. The benefits of this system can be seen in the emissions performance figures for BMW vehicles. In the large car segment, for three of the market sub-segments, BMW vehicles currently have the lowest CO_2 emissions.

SMMT data has been analysed to identify trends in large car diesel emissions performance since 1997. Across all of the individual market segments that have been grouped into the large car category, average new diesel car emissions performance has improved from 258 gCO_2/km in 1997 to

202 gCO_2/km in 2008. This equates to a 28% reduction over this time period, or an average improvement rate of 2.2% per year. If this rate of improvement was assumed to continue between now and 2022, an average new diesel car in the large car category would have emissions of 148 gCO_2/km. Depending on the mass of the large cars, 148g/km may actually fall beneath the ‘limit value curve’ in the 130g/km legislation. If a car manufacturer’s average emissions per km fall above the limit value curve they will incur fines of 20Euro per tonne in 2012 rising to 90Euro per tonnes in 2015. The limit curve is shaped such that heavier cars are allowed to emit slightly higher levels of CO_2/km than lighter car without incurring fines. If it were assumed that average annual improvements in CO_2 emissions of 3.5% occur, then an average new diesel large car would have emissions of 122 gCO_2/km in 2022.

Table 2.11: Projected possible future CO_2 emissions performance of large cars equipped with advanced diesel engines

	Projected diesel emissions performance based on annual improvement of 2.2%	**Projected diesel emissions performance based on annual improvement of 3.5%**
	New car fleet average	**New car fleet average**
2008 (actual)	202 gCO_2/km	202 gCO_2/km
2010 (projection)	194 gCO_2/km	189 gCO_2/km
2014 (projection)	177 gCO_2/km	163 gCO_2/km
2018 (projection)	162 gCO_2/km	142 gCO_2/km
2022 (projection)	148 gCO_2/km	123 gCO_2/km

3 Examination of new business models to encourage the uptake of EVs and PHEVs

This section of the market outlook will investigate the new business models being implemented to encourage use of EVs and PHEVs. The rationale for companies looking to introduce innovative business models, not based on straightforward ownership, is clear: High upfront costs compared to other similar vehicles and risks associated with the new technology provide a significant barrier to ownership of EVs and PHEVs. The major technological risk associated with EVs and PHEVs is owning the battery:

- Firstly, the batteries are expensive to replace (they are largely responsible for the price premium over conventional vehicles) so if they failed prematurely yet outside the vehicle warranty the owner could be left with a sizeable bill.
- Secondly, there is an issue regarding the value of the battery upon re-sale of the vehicle. Given that it will represent a large proportion of the value of the vehicle would the battery may need to be inspected prior to re-sale. It is also not clear how the residual value of the battery would be priced, given that battery performance (with most battery chemistries) degrades with use.
- Thirdly, lithium-ion battery technology, which is likely to be the battery technology of choice for many EVs and PHEVs, is still relatively new to market, particularly in an automotive application. Consequently, this will exacerbate the fears amongst some consumers of a potentially costly battery failure.

The various business models discussed below look at different ways to overcome these barriers.

This section will be presented as a series of four case studies of business models that are being used (or in one case could be used) to support the penetration of EVs and PHEVs. In particular, the section reviews the following business models:

- Battery leasing model
- Mobile phone style subscription service covering the car and battery (Better Place)
- Vehicle leasing model
- Car clubs where vehicles are effectively leased by the hour or day

Each case study will consider the following elements of each business model:

- The cost to the consumer, where data was available;
- The benefit to the consumer versus a conventional business model;
- The scalability – is there anything that might prevent the business model being rolled out more widely?
- Assessment of the likely market impact including timescales for widespread adoption.

This section will then conclude with an analysis of the overarching impact of these business models, which will feed into the development of the scenarios for EV and PHEV uptake in Section 6 of this report.

3.1 Battery leasing business model

One of the most significant contributors to the current high capital costs associated with electric and plug-in hybrid vehicles is the cost of battery packs. These costs can mean that an electric vehicle, including its batteries, is currently sold at between two and three times the price of an equivalent conventional petrol or diesel vehicle. Furthermore, battery technology for electric vehicles is not yet mature and there are potential durability and reliability issues that potential purchasers may view as an unacceptable risk.

By leasing the battery pack to vehicle owners, the upfront costs associated with electric vehicles can be reduced substantially and the risks associated with the technology can be minimised for vehicle users. A number of electric vehicle manufacturers are pursuing a strategy based around battery leasing. This section describes the battery leasing business model proposed by the manufacturer electric car manufacturer Th!nk, although it should be noted that other companies are also following this route, including Modec, the UK-based manufacturer of electric vans.

Th!nk is a Norwegian electric vehicle manufacturer that has been developing EVs since early 1990s. Until their recent difficulties they had the fifth generation of their urban two-seat vehicle, the Th!nk City, in production and another vehicle platform, the five-seat Th!nk Ox, at the conceptual stages of development. The Th!nk City has a maximum range of 180km and a top speed of 100km/h[12]. To date "a few thousand" have been sold[13]. Th!nk was owned by Ford between 1999 and 2003 and they invested $150million in the development of the Th!nk City model[14]. However, Th!nk was divested from the Ford group when the Zero Emissions Vehicles (ZEV) regulations implemented in California were not as demanding as had been anticipated and emphasis shifted on to fuel cell vehicles[14].

In December 2008 Th!nk halted production and reported that it was in "urgent financial distress" due to difficulties obtaining working capital in the wake of the credit crunch and the fact that suppliers were offering tougher terms to provide parts[14]. However, in January 2009 Th!nk was rescued by a consortium that included Ener1 group (who supply Li-ion batteries to Th!nk)[15]. The consortium provided $5.7million of interim funding, which allowed Think to put in place a three-step plan to re-start manufacture[15]. The first step in that process has been implemented, which has entailed recalling 44 key personnel[15]. However, efforts are continuing to attract longer term funding that would secure the future of the company.

Th!nk's financial difficulties illustrate an underlying issue with the business models for electric vehicle manufacture. In common with the development of any vehicle, they require enormous investment to get a product to market. For instance, in 2008 a Th!nk executive estimated that it will take a further US$200 million to finish developing the Th!nk Ox concept and bring it to market[14]. In the current financial climate when credit is extremely difficult to obtain this poses a major challenge to small manufacturers. Even once a vehicle is on the market significant numbers must be sold to break even and begin generating a return for investors. In that sense the business model for small manufacturers of EV or PHEV is precarious, relying on many factors, some of which may be outside of their control.

The basic premise of Th!nk's business model is to sell the car to the consumer and lease the battery. Prior to their financial difficulties in 2008 Th!nk quoted a figure of £14,000 for the car and "just over £100 per month" to lease the battery[14]. In a recent press conference the CEO of Th!nk stated that the price of the US version (equipped with a larger motor to extend the top speed to 72mph from 62mph on the European version) will be US$20,000 + US$80-90 per month to lease the battery[16]. The monthly fee to rent the batteries covers maintenance, insurance and replacement of the battery. Th!nk describe this as moving from purchasing a vehicle to paying for a 'mobility concept'.

This business model has several benefits for the consumer. Firstly, by retaining liability for the battery Th!nk are committed to replacing it if its performance is sub-optimal. This removes a significant element of the financial risk for consumers. It also solves the problem of how to value the residual life

[12] http://www.reuters.com/article/rbssConsumerGoodsAndRetailNews/idUSLF23844320081215?pageNumber=1&virtualBrandChannel=10276
[13] http://www.autobloggreen.com/2009/03/12/think-city-coming-to-the-u-s-info-overload/
[14] http://www.businessgreen.com/business-green/analysis/2212579/interview-think-bring-electric
[15] http://www.roadtransport.com/Articles/2009/01/07/132633/fedex-orders-modecs-with-batteries-included.html
[16] http://www.autobloggreen.com/2009/03/12/think-city-coming-to-the-u-s-info-overload/

of the battery at resale given that most battery technologies' performance deteriorates with use. The monthly fee for leasing the batteries simply switches from the original owner to the new owner. A further benefit to the consumer is that it allows Th!nk to take advantage of any improvements in battery technology when the batteries are eventually replaced. Typically, an EV or PHEV will require one new set of batteries during its lifetime after approximately five or six years of operation. Therefore, when this renewal is due Th!nk will be able to replace the batteries with the latest battery technology, which may have improved performance and range.

This kind of hybrid business model where the consumer purchases the car yet leases the battery is likely to appeal to UK and European residents. Given that EV and PHEV will already necessitate a significant shift in behaviour in terms of refuelling of the vehicle, an ownership model that bears some similarities to conventional vehicles may provide welcome reassurance to consumers. Conversely, attempts to initiate a widespread shift to 100% leasing of vehicles could be perceived as a step too far by consumers who would already need to adjust to plugging in the vehicle than refuelling with a pump.

A battery leasing business model also leaves the door ajar for a 'battery swap' business model, whereby spent batteries are swapped for fully charged batteries at battery stations. The current design of the Th!nk City does not suit that business model since it takes around an hour to swap the battery[12]. However, Renault's forthcoming electric vehicles will have a rapid battery swap capability so it could be an option in the future if leasing the battery proves popular with consumers.

The scalability of Th!nk's business model will depend on a number of factors but most crucially its ability to obtain finance to secure its long-term future. To that end, in March 2009 it announced that it will be applying to the US Department of Energy's Advanced Technology Vehicle Manufacturing program for a loan to fund a manufacturing facility in the USA. The Advanced Technology Vehicle Manufacturing program was created in 2007 to help develop US production capabilities for the highly fuel-efficient vehicles needed to meet long-range energy security and environmental challenges. Th!nk is currently in discussions with eight states, including Michigan, hoping to host the facility, which would initially employ about 300 workers with a starting production capacity of 16,000 cars per year[17]. Th!nk currently has capacity to manufacture 5,000 vehicles per shift at its manufacturing facility in Norway[17].

In principle, Th!nk's business model of leasing the battery and selling the car would be feasible to operate on a larger scale by a large number of vehicle manufacturers. Indeed, other manufacturers (such the electric van manufacturer Modec) offer customers the option of leasing battery packs rather than purchasing them, as it is widely recognised that the high costs associated with batteries may act as a significant deterrent to potential customers.

However, even assuming the deal in the US materialise the prospects for scalability will depend on battery production being ramped up, the development of a reliable supply chain on favourable terms, sufficient re-charging infrastructure being in place and Government support to subsidise the price premium. For these reasons, which are certainly not unique to this business model it seems unlikely that Th!nk's approach will have a significant impact in the short to medium term.

3.2 "Better Place" business model

Better Place is a venture capital supported company based in California that has the aim of developing new infrastructure to support electric vehicles in order to reduce global dependence on oil. It was founded in October 2007 by entrepreneur Shai Agassi and has so far raised over $200million of financing[18]. It has recently partnered with Australia's Macquarie Bank to raise an additional $1 billion Australian dollars[19]. Better Place does not make vehicles, but is planning to partner with a number of major automotive manufacturers in order to offer consumers access to electric vehicles from well-known brands that consumers are already familiar with. The Renault-Nissan alliance is currently the key vehicle manufacturer working with Better Place. Better Place has also formed a range of partnerships with governments in individual countries/states, including Israel, Denmark, Australia,

[17] http://www.think.no/think/content/view/full/873
[18] http://www.betterplace.com/our-bold-plan/global-progress/
[19] http://www.canadianbusiness.com/managing/strategy/article.jsp?content=20090316_10003_10003&page=2

California, Hawaii and Canada who have committed to deploying the world's first electric car networks[18].

The business model for Better Place is sophisticated and innovative. It is based around developing a new business model for transportation services based on mobile phone-style contracts. To cater for different customer segments, Better Place plans to offer a range of EV models and subscription pricing packages that will subsidise the car as part of this package[18]. The company plans to own the network that charges the cars as well as the car batteries, which will be considered part of the Better Place Network. The consumer gains use of the car via a contract that allows them access to the network of charging points and battery stations. The consumer will also pay for the electricity used to charge the battery, which should be a fraction of the cost of petrol or diesel barring a total collapse in the price of crude oil. In a similar vein to mobile phone contracts, it is hoped this will allow consumers to 'own' an electric vehicle for a fraction of the true upfront cost[18]. Depending on the nature of the subscription this may pave the way for 'free' electric vehicles. Quoting from the Better Place website, the business model is planned to work as follows:

- *"Drivers pay to access a network of charging spots and conveniently located battery exchange stations powered by renewable energy.*
- *Drivers pay for the miles they drive*
- *Cars are made much more affordable - even free in some markets - by the business model's financial and environmental incentives to add drivers into the network*
- *Better Place operates the electric recharge grid that brings it all together". No information is currently available to suggest whether Better Place will buy the electricity and sell it on or whether they will simply charge consumers for using their network and allow users to pay for the electricity separately.*

Better Place describes this system as "transportation as a sustainable service, with drivers as subscribers". Under this model, Better Place describes itself as a "mobility operator".

Better Place and their EV partners Renault-Nissan are unique in their decision to pursue battery swapping as a key feature of the business model. Other manufacturers have not designed their EVs to accommodate rapid battery swapping capability. There are a range of challenges that would need to be overcome before battery swapping became a more mainstream part of EVs:

- Standardisation of batteries or the battery packs that make up 'the battery'
- The need to hold sufficient stock at battery swap stations
- Funding another layer of charging infrastructure in addition to charging posts

That said, the batteries on other models tend to still be relatively accessible (indeed most EVs will require at least one new set of batteries over their lifetime) but not in a rapid automated fashion as is planned by Better Place. Assuming they can recoup their investment in the battery swap stations this difference could represent a key competitive advantage for the Renault-Nissan models since it will allow the range of EVs to be extended indefinitely, assuming a network of battery stations is in place. Better Place claims that the battery swap will take around the same time as refuelling a conventional petrol or diesel vehicle, although it will need to be undertaken more often than conventional refuelling given that the maximum vehicle range will initially be around 100 miles.

In terms of benefits to consumers the unique features of the Better Place business model are the planned range of ownership packages and the battery swapping capability. Both these facets of the business model introduce a great deal of flexibility for consumers, which is a weakness of many of the other business models described in this section. Perhaps more importantly, the extended range provided by the battery stations will mean EVs 'feel' like conventional vehicles. Concerns regarding running out of power should no longer be so much of an issue providing sufficient geographical coverage is achieved.

Participants in the Better Place project will also benefit from Better Place retaining the liability for the battery and the advantages this brings in terms of reduced financial risk and negotiating the resale price of the vehicle.

The Better Place business model is certainly scalable in theory. Once the battery charging/swapping technology has been proven it could be rolled out globally wherever there is a reliable electricity supply. However, the major barrier is the cost of doing so. Whilst Better Place as shown itself to be adept at raising capital even under highly challenging economic circumstances, the scale of the investment required will be extremely high. Better Place may chose to be very strategic in where it locates its networks, although even this approach will require a sizeable investment to create a local network with sufficient geographical coverage.

That said, Shai Agassi has very ambitious plans to roll out the network in Israel. In a recent press release Better Place stated that "The company started the network deployment pilot in Israel with several municipalities including Tel Aviv, Haifa, Kefar Sava, Holon, and Jerusalem, and it plans to continue to deploy the network in public places in these cities.…the company has signed an agreement with "Ahuzat Hof's" parking lots while it also simultaneously finished infrastructure deployment in other areas including the Bazel parking lot, Europe house, Axelrod and the IBM corporate campus."

In 2007 he targeted 100,000 electric vehicles in Israel by 2010[20]. That timeframe no longer seems likely given that the network of charging points and battery stations will only come into operation in 2010[18]. No new timetable has been announced so it remains to be seen how quickly Better Place can reach a critical mass of subscribers in Israel. One constraint will be production of the EVs. Renault-Nissan are only planning to sell 20,000 to 40,000 EVs worldwide in 2011 - the year that their four planned EV models are likely to reach the market. This will ramp up to 100,000 between 2012 and 2015. It is unclear how many of these vehicles will go to Better Place. In summary, it seems unlikely that Better Place will make a significant impact in terms of cars on the road for at least five years.

3.3 Vehicle leasing

Section 3.1 describes battery leasing business models that could be used more widely to reduce upfront costs and risks to consumers associated with electric vehicles. The natural extension to battery leasing is to use a vehicle leasing business model to further reduce risk and minimise upfront costs. Vehicle leasing is currently being pursued by Mitsubishi as the initial business model for the i-MiEV electric small car, which is due to become available in the UK by the end of 2009.

During 2009, Mitsubushi plans to build up to 2,000 i-MiEVs which it will make available to businesses and consumers in selected countries around the world, including Japan and the UK. Mitsubishi has estimated that if it were to put the i-MiEV on sale this year, the notional price of the vehicle would be £35,000, a figure that does not compare favourably with the current retail price of the equivalent petrol version of this vehicle, the i-Car. This latter vehicle is currently priced at £9,140 on the UK market. Mitsubishi accepts that buyers are unlikely to be willing to purchase a new electric car priced at a significant premium to conventional vehicles. Instead, it hopes to attract early adopters by offering the cars for lease at a price of around £750 a month.[21]

Following the take up of the first 2,000 vehicles this year, manufacturing volumes should increase and the price of the vehicle should reduce significantly. Through a joint venture with Yuasa batteries Mitsubishi plans to produce 10,000 i-MiEVs in 2010 and possibly double that again in the following years. By 2011 it is hoped the price will have fallen to below £20,000[22].

Recharging the i-MiEV takes around 7 hours via the mains[22]. However, Mitsubishi have developed a three-phase system capable of recharging the i-MiEV's battery to 80% of capacity in just 20 minutes. Mitsubishi is planning to import and lease these devices, which are about the size of a vending machine, alongside the cars. However, in view of the charger's size, owners will need to find significant secure space, such as a garage to store the device.

[20] http://www.autobloggreen.com/2007/08/27/israel-corp-to-invest-100m-in-new-electric-car/
[21] http://www.whatcar.com/news-article.aspx?NA=237190
[22] http://www.verdictoncars.com/jsp/vocmain.jsp?lnk=211&featureid=990&pageid=-1

In terms of scalability it remains to be seen whether consumers have an appetite for leasing the whole vehicle and a charger, particularly given the proposed monthly leasing cost, which is very expensive for a small car. However, it should be noted that given that the majority of private new car purchases are already made either using hire purchase plans or personal contract plans, both of which entail monthly payments, a vehicle leasing business model may not appear that different to many consumers, especially to those used to personal contract plans where the customer pays a monthly fee over a set time period (e.g. two, three, or four years, etc), and at the end of this period can then choose whether to pay a pre-determined lump sum to purchase the vehicle outright, return the vehicle to the retailer without paying any further charges, or return the vehicles and switch to a new personal contract plan.

Given all of the above, vehicle leasing may be attractive to consumers who want to remove as much risk as possible by leasing rather than owning the vehicle. Furthermore, whilst a monthly fee of £750 for the Mitsubishi i-MiEV is high compared to the leasing costs associated with equivalent conventional petrol and diesel cars, it is likely to be more palatable than the notional £35,000 purchase price that Mitsubishi has quoted for the first production vehicles that will be released this year. Leasing the vehicle also implicitly means that the vehicle battery packs will be provided to consumers on a leased basis. This should again reduce the risks to customers, as the vehicle manufacturer will retain ownership of the battery packs.

3.4 Car clubs

The previous sub-sections have described business models that are being pursued by vehicle manufacturers and infrastructure developers to help increase the penetration of electric vehicles. However, it is also worth examining other business models that may help to increase awareness of electric vehicles and, in the long term, support deployment. This sub-section discusses the potential use of car clubs to support electric vehicle deployment. It should be noted that apart from Th!nk, there does not seem to be an appetite amongst manufacturers to use the car club model as a way of encouraging the uptake of EVs or PHEVs. In May 2009 a Norwegian company call 'Move About' purchased 13 Th!nk City's and set up a car club in down town Oslo[23]. Move About plan to have 75 Th!nk City vehicles available to rent around Oslo within a year[23].

Car club schemes have been set up in a number of cities to provide people that do not usually need to use a car with short-term access to a vehicle for specific journeys that they are unable to make using other forms of transport. Consumers can pay to rent a car on an hourly, daily or weekly basis as and when they need it. Cars are reserved in advance and collected from a local parking space. Several commercial car clubs have sprung up such as City Car Club and Street Car. Their prices are given in the table below.

Table 3.1: Fees for commercial car clubs

Payment scheme	City Car Club	Street Car
Annual membership	£30 - £50	£59.50
Hourly rental charge	£4.95 to £5.95	£3.95 to £8.95
Daily rental charge	£49.50 to £59.50	£39.50 to £69.50
Mileage charge	50 miles free per 24hr period, 24p per mile thereafter	30 miles for free each day followed by 23p per mile thereafter

To date, the car club business model has not been applied to electric vehicles, but in Summer 2008, the Paris city authorities announced that they are planning to introduce an "Autolib" electric car hire scheme, similar in principle to the city's successful Velib cycle hire scheme, which itself operates in a similar manner to car club schemes. Users of the proposed Autolib would be able to pick up an electric car from a wide variety of locations across Paris and then drop them off at another location

[23] http://blog.norway.com/tag/move-about/

once they have finished using the car. By the end of 2009, it is planned that 4,000 electric vehicles will be placed within the city and on its outskirts, with a total of 700 vehicle pick-up points planned for the scheme. Payment procedures are also planned to operate in a similar manner to the Velib cycle scheme, with users subscribing or paying electronically at the point of use. The Mayor of London has announced that he has set up a working group to look at electric vehicles, and that this group would consider whether a London equivalent to the proposed Paris Autolib scheme should be introduced.

The car club business model could be used to roll out EVs and PHEVs to occasional drivers. A significant uptake by car clubs could help push EVs and PHEVs towards volume manufacture, which would help bring the price down – a kind of positive feedback mechanism.

The car club business model is particularly suited to EV and PHEV for the following reasons:

- The average journey length for a car club journey is 30 – 50 miles[24] which brings it within the range of an EV
- A buffer at the end of the booking slot could be included automatically to recharge the vehicle (fast charge technology can recharge vehicles to 80% charged in minutes).

In principle, scalability is a very real possibility for the car club business model as has already been demonstrated by City Car Club and Street Car. However, there is clearly a critical mass of drivers needed in any one area before the car club business model becomes viable. This would apply to the EV or PHEV variant of a car club – enough users would need to be signed up either in advance or fairly rapidly following the launch. Assuming this potential barrier is overcome, the main stumbling blocks would be availability of vehicles and their upfront costs in the medium term until manufacture volumes grow.

In the short term the car club business model could be a viable means of introducing the public to electric vehicle technology. In addition, it could provide added value in terms of promoting EVs and PHEVs. This could have a high impact since it would expose a significant number of users to EVs and PHEVs in a relatively short space of time – between 6 and 20 cars are taken off the road for each car club car added to a fleet[24]. Indeed, it could be promoted as a means of allowing consumers to test EVs and PHEVs in real world conditions for a few weeks without the need to make a major financial commitment. Furthermore, the sight of EVs and PHEVs being driven around would raise their profile, especially given that car club cars are utilised far more heavily on average than conventionally owned vehicles.

3.5 The overarching impact of new business models

Alternative business models will be necessary to mitigate the risks associated with owning EVs, and to a lesser extent PHEVs. These risks particularly apply to the EV and PHEV batteries:

- The batteries are very expensive and may need to be replaced at least once during the lifetime of the vehicle.
- It will be difficult to place a value on the residual life of the battery, which will create difficulties when trying to sell the vehicle on the second hand market.

At current prices it is possible that consumers will not purchase EVs or PHEVs in significant numbers without alternative business models, at least during the next few years. However, whilst a number of manufacturers are pursuing alternative business models, it should be noted that others, such as Tesla Motors, Smith Electric Vehicles, and Fisker, are operating a more traditional business model, where the vehicles (including the battery packs) are sold to customers outright. It may be the case that the conventional business model is more suitable for the Tesla and Fisker vehicles as they are niche-market products aimed at wealthy individuals who are likely to have access to the significant financial resources necessary to purchase these vehicles. For electric vehicles aimed at mass-market

[24] http://www.carplus.org.uk/carclubs/car_clubs_carbon_savings.htm

consumers, it is likely that there will be more need for the use of alternative business models. Private consumers in particular are very sensitive to the up-front capital costs associated with purchasing a new vehicle, and given that electric and plug-in hybrid vehicles are currently significantly more expensive to buy than conventional petrol or diesel vehicles, it may be difficult to persuade people to switch to this new technology. However, it should be noted that as the technology becomes more mature and prices decrease, the need for alternative business models might decline. If and when battery technology progresses to the stage that consumers have confidence in the reliability and durability of vehicle batteries, and the purchase costs associated with batteries and electric vehicles are close to the purchase costs of conventional petrol and diesel vehicles, then there may no longer be a need for alternative business models.

In the short term it is likely that both vehicle leasing and battery leasing business models will play a significant role in increasing the uptake of EVs and PHEVs. Both of these models significantly reduce the upfront costs to consumers and businesses associated with EVs and PHEVs, and also reduce the risk of exposing customers to the high costs associated with battery failure. Furthermore, vehicle leasing business models are already widely used across the motor industry; in 2008 more than 16% of new cars were made available to customers under contract hire car leasing schemes (SMMT 2009), and hence it is thought unlikely that there are significant barriers to using such a business model for electric vehicles.

The car club model is unlikely to play a significant role in accelerating the uptake of electric vehicles in the UK. Car clubs are typically targeted at people who previously owned a car, but who no longer need a car to meet the majority of their usual travel needs. Car club users typically reduce their annual car mileage by approximately 50% when shifting from car ownership to car club use, and hence this model would not aid the process of electrifying as many car miles travelled as possible. Furthermore, there are currently very limited numbers of car club cars across the UK – currently there is a total of 1,500 car club cars used by a total of around 50,000 car club members (CarPlus, 2009). Most members are based in London, where around 70% of the car club cars are based. Hence, electric car club cars would probably only be suitable for London, and would more likely to used to raise awareness of electric vehicles amongst members of the public, rather than being used as a business model to encourage the adoption of these types of vehicles.

In summary, alternative business models such as vehicle leasing, battery leasing, and subscription-based mobility services are likely to play a role in encouraging the early uptake of EVs and PHEVs; in particular, such business models will help to minimise upfront costs to consumers and reduce the perceived risks associated with adopting a new technology. The vehicle leasing model is very similar to the business models currently used by consumers and businesses to acquire new vehicles – contract hire and personal contract plans are widely understood and used by businesses and consumers and hence leasing an electric vehicle would not be a significantly different proposition for many drivers. However, as indicated by the leasing cost data for the Mitsubishi -MiEV, the likely monthly leasing costs associated with electric vehicles are likely to be significantly higher than the leasing costs associated with an equivalent conventional petrol or diesel vehicle. This is because as long as the overall capital costs of EVs and PHEVs are higher than for conventional vehicles, manufacturers/vehicle retailers will need to charge customers a higher monthly rate in order to avoid losing money on the transaction. Similar problems are likely to occur where only the battery is leased; the overall cost of buying the vehicle and leasing the battery is likely to initially be higher than the overall cost of buying or leasing a conventional petrol or diesel car. Hence, whilst alternative business models can, to a certain extent, help to reduce consumer exposure to high upfront vehicle/battery costs, and reduce their exposure to the risk of battery failure, these models are unlikely to be competitive with the costs associated with leasing or purchasing conventional petrol or diesel vehicles. For this reason, financial incentives are likely to be necessary in order to encourage consumers and businesses to purchase and/or lease EVs and PHEVs. This topic is discussed in detail in the following section of this report.

4 Upfront price support to encourage the uptake of EVs and PHEVs

The need for up-front price support for electric and plug-in vehicles is an area that has received much attention over the last year. In particular, a number of national governments in Europe and both federal and state Governments in the USA have already introduced financial support packages to help stimulate the early uptake of these types of vehicles. More recently, in the April 2009 Budget, the UK Government has also announced that from 2011, financial incentives will be offered to people purchasing electric and plug-in hybrid electric vehicles in this country. These incentives will range from £2,000 to £5,000, but at this point in time no further details of how the scheme will operate are available. A total of £250 million has been allocated to this support programme, the bulk of which will be used to provide direct financial support to consumers and businesses purchasing electric and plug-in hybrid vehicles.

This section of the report reviews the evidence on upfront price support that have been made available in other countries around the world to support the uptake of plug-in hybrid and electric vehicles. It should be noted that at this point in time, it is not possible to evaluate the effectiveness of these support schemes, as in most cases, the financial support packages have not been in place long enough to assess the impact on vehicle sales.

4.1 Rationale for upfront price support

One of the key barriers to the uptake of EVs and PHEVs is the purchase cost of vehicles. Whilst the running costs of electric vehicles are currently lower than conventional petrol and diesel vehicles, the main issue is the battery cost, which is the most significant influence on the overall vehicle price. Battery costs are currently high, and are largely determined by the cost of the electrode materials[25] with a contribution from development, production and shipping. Most current lithium-ion batteries use nickel cobalt aluminium cathodes, which are expensive, but offer good energy density performance. Forthcoming cathode materials such as lithium iron phosphate are cheaper and are likely to contribute to battery cost reductions. Furthermore, recent research carried out for DfT and BERR (Arup/CENEX 2008) indicates that there is considerable scope for cost reduction through improvements in battery manufacturing processes. Currently, the manufacture of battery systems requires a significant amount of manual handling, with associated labour costs. Once production volumes increase, it is likely to be economically viable to invest in automated production processes that would help reduce the unit costs of manufacturing batteries. Hence, battery prices may come down in the future as new electrode materials are developed and production processes are improved. At the moment, current battery costs could result in forecourt electric vehicle prices twice or even three times that of conventional vehicles.

In order to address the price differential that currently exists between electric vehicles and standard petrol or diesel vehicles, financial incentives or support can be provided consumers in order to reduce the additional upfront costs associated with these vehicles. Upfront price support therefore aims to increase the affordability of electric vehicles by reducing the marginal capital cost, which is one of the key barriers to their uptake. This may be a necessary step in increasing the attractiveness of electric vehicles, if significant uptake is to be achieved in the medium term.

4.2 Review of overseas price support packages

This section considers a variety of examples of price support packages for electric vehicles from overseas. A review of these examples ensured that best practice was considered when

[25] Most current lithium-ion batteries use nickel cobalt aluminium cathodes, which are expensive, but offer good energy density performance. Forthcoming cathode materials such as lithium iron phosphate are cheaper and are likely to contribute to battery cost reductions.

recommending a level of price support. The review has also helped to inform the development of the new vehicle technology uptake scenarios.

4.2.1 USA

There are different types of tax credits and incentives for the purchase of new vehicles in the United States. Under the *National Energy Policy Act 1992*, purchasers of new electric vehicles were entitled up to 10% federal tax credit ($4,000). The credit was reduced to $1,000 in 2006, and expired thereafter.

In late 2008, a credit for the purchase of plug-in electric drive vehicles was included in the *Emergency Economic Stabilization Act of 2008* (which also supports investment in fuel cells, electric recharging property, smart meters and grid modernisation). The energy package established a credit for purchase of plug-in electric drive vehicles, which will help consumers and manufacturers to grow the marketplace for clean, efficient cars and trucks. Measures included:

- Plug-in electric drive vehicles with batteries of at least 4 kWh qualifying for a $2,500 credit;
- An additional $417 is provided for each additional kWh, up to $7,500 for vehicles up to 10, 000 lbs gross vehicle weight (4,540 kg);
- Vehicles with gross vehicle weight up to 14,000 lbs (6,356 kg) qualifying for a $10,000 credit.
- Vehicles with gross vehicle weight between 14,000 and 26,000 lbs (6,356 kg to 11,804 kg) qualifying for a $12,500 credit.
- Vehicles with gross vehicle weight over 26,000 lbs (11,804 kg) qualifying for a $15,000 credit.

The credit will begin to be phased out after 250,000 qualifying vehicles are sold in the U.S, and will expire at the end of 2014. The credit is available against the alternative minimum tax[26][27]. It should be noted that no passenger cars weigh more than 10,000 lbs, and hence the maximum credit available for passenger cars is $7,500.

California is well known for its efforts in terms of the promotion and uptake of electric vehicles. It currently has the highest number of laws and incentives aimed at the use of electricity as an alternative fuel. In order to reduce the harmful emissions of the transport sector, the Californian Air Resources Board (ARB) introduced the Zero Emission Vehicles (ZEV) programme in 1990[28]. There is a package of supporting measures under the ZEV programme, which comprise the following:

- Mandates: originally there was an obligation for the largest vehicle manufacturers to sell a minimum number of ZEVs (2% of their new vehicle fleets from 1998 to 2000, 5% in 2002/3, 10% from 2003). However, the original targets were relaxed in 1996 and 1998, because the level of battery technology was not sufficient to warrant widespread introduction of EVs. The 10% mandate was allowed to include partial credits for other clean vehicles.
- Voluntary agreements between the ARB and the largest auto manufacturers.
- Awareness and information activities.
- A 'try before you buy' scheme: short-term leasing programme for public fleets.
- Vehicle purchase subsidies.
- Tax incentives: reduced license fees.
- Infrastructure subsidies: up to 90% of the installation charges for EV chargers.
- Green fleet initiatives to influence public and private purchasing.
- Setting standards: standardisation of the EV recharging equipment.

[26] http://www.electricdrive.org/index.php?ht=redisplay/1/printerfriendly/1
[27] http://visforvoltage.org/forum/4990-bailout-plan-includes-plugin-vehicle-tax-credits
[28] http://www.arb.ca.gov/msprog/zevprog/zevprog.htm

Further examples of upfront purchase incentive schemes in operation in California are summarised below:

- An *Alternative Fuel Vehicle (AFV) Rebate Program* is in operation whereby grants of up to $5,000 are provided to consumers who purchase/lease eligible zero-emission vehicles, plug-in hybrid electric vehicles, and AFVs between 24th May 2007 and 31st March 2009.
- In San Joaquin Valley there are a range of low-emission incentives. The REMOVE II Program provides incentives for the purchase of low-emission passenger vehicles, light-duty trucks, small buses, and trucks with gross vehicle weight Ratings of 14,000 pounds (6,356 kg) or less. The program offers between $1,000 and $3,000 per vehicle, depending on the emission certification level and size of the vehicle. Eligible vehicles must be powered by alternative fuel, electric, or hybrid electric engines/motors.
- Alternative fuel and advanced technology vehicle and infrastructure incentives are on offer in the City of Vacaville, in Solano County. This includes incentives for the purchase or lease of new battery-electric vehicles, dedicated compressed natural gas (CNG) vehicles, plug-in hybrid electric vehicles (up to $6,000)[29].

4.2.2 Canada

Between 20th March 2007 and 31st December 2008, the Canadian Government offered purchasers of eligible new 2006-2008 model year vehicles a rebate of between CAD$1,000-CAD$2,000 under its ecoAUTO scheme. The scheme is aimed at encouraging Canadians to purchase new fuel-efficient vehicles. Hybrid electric and highly energy efficient vehicles are included on the list of eligible vehicles.

In addition, consumers may also be eligible for similar rebates for advanced technology and fuel-efficient vehicles from five of the Canadian provinces, bringing the total of the potential rebate from the federal and province governments up to a maximum of $5,000[30]. These incentives are summarised below:

- *Prince Edward Island:* CAD$3,000 rebate on hybrid vehicles purchased/leased since 30th March 2004.
- *Quebec:* Up to CAD$2,000 (between 23rd March 2006 and 1st January 2009) for eligible new hybrid vehicles.
- *Ontario:* Up to CAD$2,000 (between 9th May 2001 and 1st April 2012) for eligible new hybrid electric vehicles.
- *Manitoba:* CAD$2,000 (between 1st March 2007 and 15th November 2008) for eligible new hybrid electric vehicles.
- *British Columbia:* Up to CAD$2,000 (between 16th February 2005 to 31st March 2011) for eligible new hybrid electric vehicles.

Gulati et al (2008[31]) undertook an evaluation of the effectiveness of government incentives on the purchase of hybrid vehicles in Canada (federal rebates and the five provincial rebates, similar to those outlined above). The study also included data on sales of cars other than hybrids to estimate both the increase in hybrid vehicle sales from the tax incentive, and the effects of these incentives on the sales of other cars. Results from the study indicated that a 1% share (proportion of sales price) increase in the tax rebate increases the share of hybrid vehicles in the market by 4.5%, although it remains to be seen whether this would apply to EVs given the greater barriers to uptake. The share of hybrid vehicles in total light vehicle sales in Canada was 0.35% in 2005. The study found that whilst purchasing more hybrid vehicles, consumers were largely shifting from purchasing similarly priced relatively fuel-efficient vehicles (compact, intermediate and compact SUVs). The study also found that there was not a statistically significant reduction in sales of heavier and less fuel-efficient vehicles as a

[29] http://www.cityofvacaville.com/departments/public_works/evprogram.php
[30] http://www.tc.gc.ca/programs/environment/ecotransport/ecoautoinformation.htm
[31] http://www.econ.ucsb.edu/~grainger/gulati.pdf

result of the implementation of these policies. Therefore, the results suggest that hybrid tax incentives may not be the most effective way to encourage people to switch from fuel inefficient vehicles. The authors suggest that more aggressive fuel taxes may be required to further skew the relative price between fuel-efficient and fuel inefficient cars.

4.2.3 Japan

The Japanese government set a target in 1998 for the diffusion of clean energy vehicles by 2010, in light of the targeted reduction of CO_2 emissions based on the Kyoto protocol. The Japanese Ministry for Economy, Trade and Industry (METI) and the Ministry for Land, Infrastructure and Transport managed the programme. A target for clean energy vehicles was set to achieve 3.65 million units in the overall vehicle fleet in operation by 2010 (including about 100,000 electric vehicles and 2 million hybrid vehicles). A budget of about US$100 million per year was invested in this programme. Incentives have been introduced to help ensure that these targets are reached. These include:

- Electric and hybrid electric vehicles can receive a purchase subsidy of up to 50% of the incremental cost of a vehicle;
- Subsidy for the establishment of clean energy vehicle refueling facilities;
- Funding demonstration for low-pollution vehicles including car-sharing and station car;
- Discount on the automobile tax;
- Business tax credit – purchase of clean energy vehicles for business use and establishment of fuelling facilities for CNG and methanol vehicles[32].

It has been reported that the Japanese Government offers incentives of up to 1,390,000 Yen or $16,000 off the retail price of electric vehicles, and reductions in road tax and registration fees[33] [34]. Table 4.1 provides an overview of the upper limits of purchase subsidy offered for a range of electric and hybrid vehicles (2003).

[32] http://www.evaap.org/pdf/incentive.pdf
http://209.85.229.132/search?q=cache:Vs5W72IcJbgJ:www.evaap.org/pdf/incentive.pdf+Upper+limits+of+purchase+subsidy+(2003)+-+Japan&cd=2&hl=en&ct=clnk&gl=uk

[33] http://www.hybridcars.com/electric-cars/miitsubishi-all-electric-car-2010-imiev.html

[34] http://jalopnik.com/5280147/production-all+electric-mitsubishi-i+miev-gets-eye+popping-47k-price

Table 4.1: Upper limits of purchase subsidy (2003) - Japan[35]

Vehicles*	Price of Vehicle (Japanese Yen, ¥)	Price Difference between this vehicle and equivalent conventional vehicle (Japanese Yen, ¥)	Amount of subsidy (Japanese Yen, ¥)
ELECTRIC VEHICLES			
Mitsuoka CONVOY88	888,000	452,000	210,000
Araco Everyday Coms	685,000	300,000	140,000
CQ QUNO	1,290,000	428,000	200,000
Zero Sports Elexceed RS	1,980,000	975,000	380,000
Nissan Hypermini	3,500,000	2,556,000	940,000
Daihatsu Hijet van EV	2,900,000	2,092,000	800,000
HYBRID VEHICLES			
Toyota Prius	2,150,000	444,000	210,000
Toyota Estima Hybrid	3,350,000	500,000	240,000
Honda Insight	2,180,000	487,400	230,000
Honda Civic Hybrid	2,090,000	482,000	230,000
Suzuki Twin Hybrid	1,290,000	545,000	240,000
Toyota Coaster Hybrid	14,550,000	9,360,000	4,510,000

*** Vehicles to be subsidized**

- EVs and HEVs newly purchased and registered by local governments, corporation, and the other users who use the vehicles for business including commute.
- Excluding the following vehicles: taxies, motor cycles, industrial vehicles, and vehicles acquired by their manufacturers or sales affiliates.

4.2.4 France

Financial incentives to purchase ‘green’ vehicles are also being implemented in France. The government has pledged $1.3 billon to subsidise the purchase of new vehicles. Consumers are entitled to €1,000 credit when purchasing new vehicles with CO_2 emissions less than 160g/km[36].

A ‘feebate’ system was introduced in France in early 2008 (‘Eco-Pastille’). The system has been designed to encourage car buyers to make ‘greener’ purchase choices. Purchasers of new passenger cars under 130 g CO_2/km are awarded a bonus, with the highest bonus going to the purchase of electric vehicles (€5,000). However, those purchasing vehicles new vehicles that emit more than 160 g CO_2/km will have to pay a penalty (up to €2,600). It is intended that the threshold points will advance by 5g CO_2/km every two years to encourage ongoing development. The ‘sliding scale’ of payments and penalties under the scheme are set out in Table 4.2.

[35] http://www.evaap.org/pdf/incentive.pdf
[36] http://www.thegreencarwebsite.co.uk/blog/index.php/2008/12/06/green-car-incentives-in-france/

Table 4.2 - France's feebate payments and thresholds

Class	Emission CO_2 (g/km)	Bonus (-) / Penalty (+) (€)	Examples	% Market share of class in 2006
A+	Under 60	- 5,000	Electric vehicles	0%
A	Under 100	-2,000	Smart ForTwo; VW Polo Bluemotion	0%
B	100-120	-700	Citroën C1, C2 and C3; Renault Clio; Peugeot 107 and 207; Fiat Punto	18.1%
C+	121-130	-200	Citroën C4, Renault Mégane, VW Polo, Dacia Logan	12.8%
C-	131-140	0	Citroën Xsara Picasso, Peugeot 307 and 407; Seat Ibiza	15.8%
D	141-160	0	Citroën C5, Mercedes A Class, Ford Focus	28%
E+	161-165	+200	Peugeot 607, Opel Zafira	4%
E-	166-200	+750	Mégane II break, BMW 3 Series, Toyota Rav 4	14.5%
F	201-250	+1,600	Mercedes E Class, Nissan X-Trail, Renault Vel Satis	5.4%
G	>250	+2,600	VW Touareg, Citroën C6	1.4%

In the eight months following introduction of the scheme, official figures have shown a 45% increase in sales of vehicles consuming less than 130 gCO_2/km (the average CO_2 emissions from new cars sold fell by 9% in the same time period). However, in the time between the feebate scheme was announced and its introduction, there was a reported surge in purchases of 4x4s. The cost of the scheme to the French Government is estimated to be approximately €140 million, largely due to the greater than expected success of the scheme[37][38].

France's feebate system is supported by a scrappage initiative, announced at the end of 2008. The scrappage scheme offers bonuses of €1,000 for those who scrap older cars or vans and purchase a new fuel-efficient vehicle. It is reported that the scrappage scheme will cost the French Government €220m in 2009[39].

4.2.5 Spain

In Spain, the Government has set a target of achieving 1 million electric cars on the roads by 2014. It is part of a plan to cut energy consumption and dependence on expensive imports. The plan is expected to cost US$381m and contains 31 measures. For an electric car bought in Spain, €6,000 or 15% of the price of the vehicle will be returned to the customer.

4.2.6 Summary of price support measures

Table 4.3 provides an overview of the up-front price support measures for electric vehicles available in various countries.

[37] http://www.lowcvp.org.uk/news/985/french-government-declares-car-feebates-system-a-success/
[38] http://www.lefigaro.fr/economie/2007/12/05/04001-20071205ARTFIG00283-eco-pastille-les-nouvelles-regles-du-jeu.php
[39] http://www.lowcvp.org.uk/news/1070/archive/france-announces-car-scrappage-incentives-as-part-of-economic-stimulus-package/

Table 4.3: Overview of up-front price support measures

Country	Up Front Price Support/Financial Incentives
USA	Up to US$7,500 tax rebate for purchasers of plug-in hybrid and electric passenger cars. Up to US$15,000 is available for purchasers of plug-in hybrid and electric heavy-duty trucks.
Canada	A range of incentives from federal and provincial governments, of up to CAN$5,000 rebate for new hybrid electric vehicles.
Japan	Incentives of up to $16,000 off the retail price of electric vehicles, and reductions in road tax and registration fees.
France	A French initiative named Eco-pastille, which began on January 1st 2008, sees that people who buy electric cars receive €5,000 back.
Spain	For an electric car bought in Spain €6,000 or 15% of the price of the vehicle will be returned to the customer.
Norway	Electric cars exempt from car registration tax. For a B class car the registration tax is around €7,500. VAT (25%) does not apply to electric cars.
Denmark	Electric cars do not pay registration tax.
Sweden	Low or zero carbon emission vehicles get a subsidy of 10,000 SEK, after owning the vehicle for 6 months. The Government has allocated SEK 250m for the rebate (50m in 207, 100m in 2008 and 100m in 2009).[40]
Ireland	Hybrid and flexible fuel vehicles are allowed a maximum remission of €2,500 on cars registered between 1st July 2008 and 31st December 2010. EVs are exempt from vehicle registration tax until December 31st 2015.
Netherlands	Electric cars in the Netherlands are exempted from car registration tax.
Switzerland	Individual cantons (sub-divisions of the country) provide their own EV incentives.
Greece	No road tax or car registration fees for electric cars.

Figure 1 is a graphical shows the maximum level of upfront price support that is available for electric or plug-in hybrid cars in various countries. In contrast, Table 4.4 illustrates the upfront price support offered for selected electric, plug-in hybrid electric and hybrid electric vehicles. This is worth noting because the largest incentive available in Japan (4,510,00 Yen) is for the Toyota Coaster which is a HEV, rather than a PHEV or EV.

[40] http://www.vv.se/templates/page3____21927.aspx

Figure 1: Maximum up-front price support offered for cars (£, approximate value)

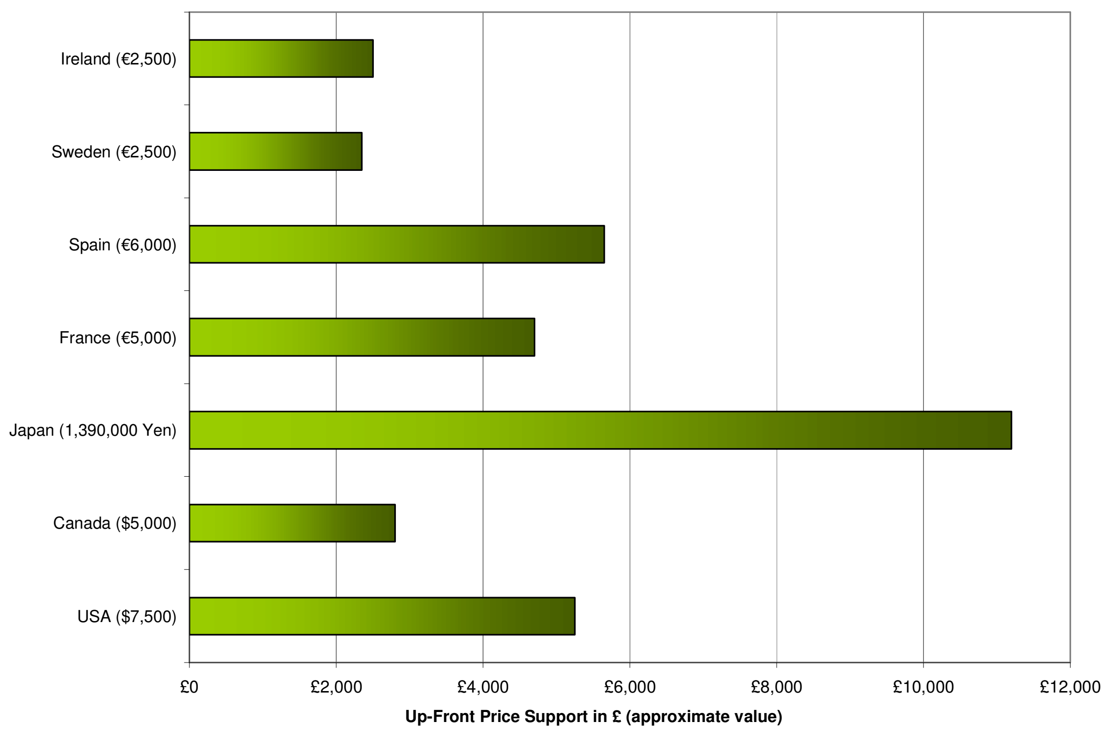

Table 4.4: Up-front price support offered (currency of origin/£, approximate value)

Country/Vehicle Details	Value of support in currency of origin	Value of support in £ (approximate)	Value of support as a % of total vehicle price
Canada: (Federal rebates for vehicles 5.5l/km, e.g. Toyota Prius 1.5 l, Honda Civic Hybrid, 1.3l and additional provincial rebates for plug in electric and hybrid vehicles)	$2,000 / $3,000 (CAD)	£1,115 / £1,675	
Belgium: (vehicles with emissions up to 105 g CO_2/km)	€ 4,350	£4,000	20% to 40%
Ireland: (Hybrid and Flexi-Fuel - first registration)	€ 2,500	£2,300	Up to 15%
Sweden: (Hybrids with emissions less than 120g CO_2/km, electric cars - less than 37 kWh)	10,000 SEK	£850	Up to 5%
France: (Class A, vehicles under 100g CO_2/km)	€ 2,000	£1,850	Up to 15%
France: (Class A+, vehicles under 60g CO_2/km)	€ 5,000	£4,700	Up to 25%
USA: (Plug-in electric, batteries of at least 4kWh)	$2500	£1,700	Up to 8%
USA: (Plug-in electric, gross vehicle weight up to 10,000 lbs)	$7,500	£5,250	Up to 20%
USA: (Plug-in electric, gross vehicle weight up to 14,000 lbs)	$10,000	£6,800	
USA: (Plug-in electric, gross vehicle weight between 14,000 lbs and 26,000 lbs)	$12,500	£8,500	
USA: (Plug-in electric, gross vehicle weight up to 26,000 lbs)	$15,000	£10,160	
Japan: (Nissan Hypermini - electric car)	940,000 JPY	£5,040	27%
Japan: (Mitsuoka CONVOY88 - electric car)	210,000 JPY	£1,125	24%
Japan: (Zero Sports Elexceed RS - Hybrid)	380,000 JPY	£2,040	19%
Japan: (Toyota Prius – hybrid)	210,000 JPY	£1,125	10%
Japan: (Honda Civic Hybrid)	230,000 JPY	£1,240	11%

Error! Reference source not found. ***- Overview of other incentives that aimed at owners/drivers of electric vehicles.***

Country	Other Incentives
Norway	Electric cars are not subject to the annual car tax of €345. EVs do not have to pay road tolls in Oslo. EVs qualify for free parking which can provide annual savings of around €2,000-€4,000. EVs are permitted to use bus lanes.
Denmark	Electric cars are exempt from annual car tax and qualify for free parking. It is thought that further incentives will be put in place to encourage the use of EVs to coincide with the introduction of Project Better Place in 2011.
Germany	Germany is currently considering inner circle parking and congestion charge incentives for EVs similar to those in London.
France	Free parking spaces for EVs (equipped with charging apparatus) are also being reviewed.
Greece	Electric cars are also free to drive in Athens when parts of it are restricted to other vehicles to reduce traffic congestion. There is also free charging on the street of some cities.
Italy	Certain cities in Italy have restricted driving within the city to EVs only. Some cities also allow free parking and charging for EVs.
Israel	The Israeli government is providing tax incentives to help Project Better Place achieve its goals. A 72% sales tax on gasoline-powered vehicles has been instituted, while electric cars are only taxed at 10%[41].

4.3 Factors to consider when offering upfront price support

There are a number of factors that may affect Governments' decisions to offer upfront price support as an incentive for the purchase of new EVs or PHEVs, and the level at which financial support is set. These factors are discussed in more detail below.

4.3.1 How much price support is required to incentivise the uptake of EVs and PHEVs?

A key consideration in offering upfront price support is the level at which the subsidy should be set. Section 4.2 showed a variety of levels of support that are currently offered in different countries, although at this point in time it is not possible to assess how successful these upfront incentives have been, primarily because the schemes have not yet been in place long enough, or suitable vehicles are not yet available. Whilst the range constraints would still exist, by covering the whole of the price differential, there would obviously be a large incentive to select EV and PHEV models over conventional passenger car models, particularly in view of the reduced fuel costs. However, this would be at a high cost to the Government as it may be more than is necessary to achieve an increase in the penetration of these technologies. Industry opinion is that the upfront price of vehicles is likely to be one of the foremost considerations of the private consumer, rather than, perhaps, the longer term running costs of a vehicle. Previous research carried commissioned by the Low Carbon Vehicle Partnership (LowCVP, 2006) has also highlighted the fact that when making vehicle purchasing decisions, private consumers place a much larger emphasis on upfront vehicle purchase price than they do on running costs. Furthermore, whilst business and fleet buyers tend to take a broader perspective on vehicle ownership costs, and will examine factors such as purchase price, running costs, and CO_2 emissions performance (primarily due to the nature of the UK's company car tax regime), they will still be looking minimise their exposure to risk. Hence, business/fleet buyers are also likely to need some form of upfront price support to encourage them to purchase EVs and PHEVs. Given the above factors, the higher the levels of up-front price support, the more likely it will

[41] http://climateintel.com/2008/08/27/israeli-government-provides-tax-incentives-to-electric-car-initiative/

be that consumers and businesses will choose to purchase EVs and PHEVs. However, based on early experience in other countries, and the likely overall cost to Government, it may be difficult to present a compelling case UK Government support to cover the whole of the price differential between the purchase price of an EV or PHEV and an equivalent conventional vehicle. Experience from other countries shows that the level of support for pure battery electric cars is typically around 20% to 27% of the total retail price of the vehicle.

4.3.2 Should the price support fall over time as price differential reduces?

There is a question over whether the level of Government price support should remain static over time, or whether it should fall over time as the price differential between plug-in electric vehicles and conventional vehicles reduces due to learning effects as production volumes increase. Therefore, in principle, the level of price support could also reduce without affecting its effectiveness. If the Government chooses to reduce the level of financial support available over time, it will need to consider, when and at what rate the subsidies should be reduced, and importantly, provide clear information to the public, to businesses, and to vehicle manufacturers on when the levels of financial support will decrease or disappear.

Interestingly, the US has chosen to reduce the subsidy once claimants rise above 250,000 as described in Section 4.2.1. One of the benefits of structuring the incentive in this manner is that it allows the cost of the incentive to be estimated more readily than if an open ended commitment was made. Potentially, a similar structure could be implemented in the UK, with the levels of financial support to consumers and businesses declining once penetration reaches a certain level within the UK car fleet. If such a system were to be used, it is likely that maximum effectiveness would be achieved by setting the level of financial support relatively high during the early stages of uptake, and then gradually decreasing the level of support as uptake across the vehicle fleet begins to occur. Such a scheme would probably be more complex to design than a simple “flat rate” support scheme, but is likely to be more effective in encouraging early uptake of EVs and PHEVs.

4.3.3 Should the price support be offered to all low carbon modes of road transport?

Government may decide to treat all low carbon road transport technologies in a consistent manner when it comes to financial support. Alternatively, they may wish to create a hierarchy or ‘pick winners’ in terms of the level of price support provided. In the recent past, the UK Government has predominantly adopted “technology neutral” policies and strategies with regard to encouraging the uptake of low carbon technologies and products. Good examples of such policies in the transport sector including the current company car taxation system and vehicle excise duty (VED), both of which provide financial benefits to cars with lower levels of tailpipe CO_2 emissions, and penalise cars with higher levels of emissions.

Whilst a technology-neutral stance has benefits in terms of not favouring particularly technologies, and allowing a market to evolve, in the context of achieving the UK’s 2050 target of reducing CO_2 emissions by 80% against 1990 levels, it may be necessary to review whether technology-neutral policies are likely to be most effective over the long term. In particular, technology-neutral policies and strategies may mean that there is a risk that the market will favour the lowest cost solution to meet the near-term emissions targets, which may be advanced diesel vehicles rather than EVs and PHEVs. Whilst significant emissions reductions could be achieved through increased uptake of advanced diesel vehicles, over the longer term, PHEVs and particularly EVs offer the opportunity to dramatically reduce transport sector emissions to levels that are unlikely to be achieved with conventional internal combustion engines.

In that sense the upfront price support could be seen as a means of correcting a so-called market failure. In other words, the failure to account for the need to make deep cuts in carbon emissions. Proponents of market-based instruments might argue this failing could be addressed by setting longer-term limits on average CO_2 emissions. At the moment the 130g/km target is set to be phased in between 2012 and 2015, which is a relatively short-term timescale. If the proposed 95g/km limit for

2020 (and perhaps an even more aggressive limit) were enshrined in law this might encourage car manufacturers to develop EVs more quickly than would otherwise be the case.

Feedback from SMMT and ACEA is that they would be keen for government to adopt an all-inclusive and 'technology neutral' approach, rather than focusing specifically on EVs and PHEVs to the exclusion of others. No details were provided with regard to how such a technology neutral approach could be introduced.

4.4 Views on the proposed level of upfront price support in the UK

This section discusses public statements made by a range of vehicle manufacturers with regard to the their thoughts on the level of price support they think is necessary.
In 2007, General Motors publicly stated that they thought that approximately US$10,000 of up-front price support would be needed to ensure that their Chevrolet Volt plug-in hybrid vehicle is successful in the US when it reaches the market at the end of 2010. In practice, the level of support that will be available for this vehicle in the USA will be US$7,500.

In the course of this study, we consulted both ACEA and SMMT to gain their views and feedback on the issues surrounding up-front price support for EVs and PHEVs.

The view from SMMT and members is that up-front price support could be the level of support required to sell a certain number of units annually, or to sell a planned annual manufacturing capacity. They felt that although marginal cost is an indicator of what the potential price-support could be, the longer-term lower running costs implies that the up-front support required would be significantly less than this marginal cost over conventional vehicles. A range of examples of existing schemes is provided above, but any scheme introduced in the UK should be limited to fully agreed vehicles only. SMMT also noted their view that incentive schemes need to be designed to avoid unintended consequences such as delaying vehicle orders from potential customers waiting for grants to be available before placing orders (e.g. Low Carbon Van Procurement Programme).

As part of an informal consultation to inform this study SMMT have set out a list of possible incentives for consumers:

1. Buyer incentives for low carbon vehicles: (Note that ultra low carbon is defined in the EU New Car CO_2 Regulation as <50g CO_2/km).
2. Green public procurement: lead by example and with possible championing role of Office of Government Commerce.
3. Fleet incentives: such as capital car allowances - Capital allowances set the value of depreciation which companies are able to subtract from their taxable profits, and hence the benefit is to the company purchasing the vehicles. For ultra low carbon vehicles the capital allowance should be 100% - the full value of the cars could then be subtracted from the taxable profits of the company.
4. Vehicle Excise Duty (VED) and congestion charge exempt.
5. Free city parking.
6. Recharging available in public parking spaces, on street and available in car parks, shopping centres etc.
7. Incentives to install recharging plugs at home - up to around £100 to cover the cost for installation equipment. Also, should cover the cost of an electrician to ensure that the house is fit for car recharging.
8. Utility company reduced electricity rate - similar to off peak charging but available all day. (Note: there would need to be some mechanisms of identifying the electricity used for recharging car batteries as opposed to electricity used for other purposes).

9. Dealer incentives to cover education, retooling of dealership to cope with new technology etc
10. Support PR and communication activity on electric vehicles - consumer education programme, consumers need to be aware of the cost savings of charging their vehicle against the running costs of a conventional car.

ACEA also provided views on up-front price support and the uptake of electric vehicles. In their opinion, due to the competitive market, manufacturers are unable to provide details on the marginal cost differences for electric vehicles or suggest an appropriate amount for the level of price support. ACEA stated that the automotive industry backs a 'technology neutral' approach. The view from their members is that although operating costs of EVs and PHEVs are lower than conventional vehicles, the consumer does not take this into account. However, those consumers who purchase new vehicles are likely to do so every three to five years. Therefore, in ACEA's view this is the timescale against which comparisons should be made when considering the reduced operating costs.

4.5 Potential impacts of the proposed UK market support scheme for EVs and PHEVs

The foregoing discussion has provided details of current market support provided by Government in a number of countries around the world, and has also provided some views on how a financial support scheme for EVs and PHEVs could be designed. Over the time period in which this report was prepared, the UK Government has announced that starting in 2011, it plans to offer financial support to purchasers of EVs and PHEVs, with support ranging from £2,000 to £5,000 per vehicle. This support is part of a package of measures aimed at increasing the penetration of EVs and PHEVs worth £250 million in total. At this point in time, it is not clear how the scheme will operate, and no details have been provided on the types of vehicles that would be eligible for the maximum £5,000 support. However, the range of values for financial support available for individual vehicles closely matches the market support available in other countries. Based on the review set out in Section 4.2.6, support levels for EVs and PHEV passenger cars range from £1,125 per vehicle to £5,250 per vehicle. In the USA, higher levels of support are available for heavy-duty vehicles.

Whilst the headline figures for the levels of market support that will be available in the UK are similar to current international practice, the effectiveness of this support will critically depend on the criteria used for determining a vehicle's eligibility for the different levels of funding that will be available. This can be illustrated by using two example scenarios.

Example 1: Small electric car

As discussed earlier in this report, the Mitsubishi i-MiEV is likely to be one of the first fully type approved four-door electric vehicles equipped with modern lithium-ion batteries available on the UK market. Mitsubishi has estimated that by late 2010/early 2011, the retail price of this vehicle could drop from the current notional £35,000 (the vehicle will only be available for lease initially, hence the retail price is notional), to approximately £20,000. The electric i-MiEV is based on the conventional Mitsubishi i-Car that is equipped with a petrol engine and has a retail price in the UK of £9,140. Hence, in 2011, the marginal price of the electric i-MiEV compared to the petrol i-Car is likely to be £10,000. Hence, £5,000 support would be cover 50% of the marginal cost to consumers/businesses (25% of the total vehicle price), whilst £2,000 support would cover 20% of the marginal cost (10% of the total vehicle price). If the maximum £5,000 in financial support is available to consumers and businesses that buy the i-MiEV, it is possible that there could be a significant increase in levels of uptake, although it should still be borne in mind that the total cost to consumers of £15,000 would enable them to buy a bigger and relatively efficient diesel car (e.g. the Volkswagen Polo Bluemotion (99 gCO_2/km) and Ford Fiesta Econetic (98 gCO_2/km) are both significantly larger than the i-MiEV and cost substantially less than £15,000). If the level of financial support available for purchasers of the Mitsubishi i-MiEV was only £2,000, then the total purchase cost to consumers and businesses in 2011 is likely to be £18,000. Under this scenario, uptake of this vehicle is likely to be more limited, particularly as consumers and businesses would be able to purchase a car from two classes above for the same money (e.g. Ford Focus, Ford Mondeo, VW Golf).

Example 2: Medium-sized PHEV

The Vauxhall Ampera is likely to be one of the first plug-in hybrid electric vehicles available in the UK; General Motors plans to release this vehicle in the UK by 2012. No UK price information has yet been made publicly available, but General Motors has indicated the US version of the same car, the Chevrolet Volt, will have a retail price of US$40,000 (approximately £28,000). For this example, it has been assumed the UK price will match the US price, although it should be stressed that in practice there are likely to be differences in prices in different markets due to exchange rate fluctuations, differences in vehicle specifications in individual markets, and tax rates. The Vauxhall Ampera will fall into SMMT size category C, and the best-selling vehicle in this category is the Ford Focus. The current price of the lowest emitting variant of the Focus is £17,795, or just over £10,000 less than the possible retail price of the Vauxhall Ampera. Hence, as with the previous example, £5,000 in support would cover approximately 50% of the marginal cost (18% of the total vehicle price), whilst £2,000 in support would cover 20% of the marginal cost (7% of the total vehicle price). By covering 50% of the marginal cost in this example, the market support would match the level of support that will be available in the USA to support the uptake of the almost identical Chevrolet Volt. This level of support is thought likely to be sufficient to start stimulating demand for the vehicle, although as before, it should be noted that the total cost to consumers and businesses (in this case £23,000) would enable the purchase of a substantially larger or more luxurious vehicle. If the level of support for PHEVs such as the Ampera were set to £2,000, the total cost to consumers and businesses would drop from an estimated £28,000 to approximately £26,000. Many consumers and businesses may find it difficult to justify purchasing a vehicle that is £8,000 more expensive than an equivalent diesel car, even after accounting for the Government's financial support.

The above examples illustrate the possible impacts of the proposed UK Government-backed market support scheme for EVs and PHEVs. It is difficult at this point in time to draw any firm conclusions on the likely effectiveness of the proposed scheme as the full details of how the scheme will operate have not yet been made available. However, based on the international review of current practice with respect to market support schemes for EVs and PHEVs, and the illustrative examples presented above, it is recommended that in order to be effective in stimulating demand for EVs and PHEVs in the UK from 2011 onwards, the financial support scheme should be designed to provide 50% of the marginal cost to those vehicles that are likely to play an important role in electrifying the road transport sector in the UK. This will not only include pure battery electric vehicles, but also some forms of extended range plug-in hybrid electric vehicles. This point is important, as it is likely that PHEVs will play an important role in the electrification of road transport in the UK. However, there are likely to be many different types of PHEVs in future years, with significant differences in battery capacity, and consequently, in their ability to travel on pure battery electric power. For example, whilst the Chevrolet Volt/Vauxhall Ampera is being designed to travel distance of up to 40 miles on battery power alone, other similarly-sized PHEVs in development will have a much more limited range (e.g. electric range of only 12 miles). Hence, it will be important to take a number of different performance characteristics into account when deciding on the level of support available to different types of vehicle. A relatively simple method of deciding on the level of support available for different vehicles could be to base this decision on tailpipe CO_2 emissions performance. For example, the scheme could be designed so that all vehicles capable of tailpipe emissions at or below 50 gCO_2/km could be eligible for the maximum £5,000 support. This would mean that all pure electric cars would be eligible as well as the best-performing PHEVs. The specific design of the scheme is beyond the remit of this study, but the above information provides some specific points of interest that may be useful to take into account when developing the market support scheme in detail.

5 Actions to create a favourable investment climate in EV and PHEV technology

In addition to the potential need for up-front price support to encourage the uptake of electric vehicle technologies, there may also be a need for other actions that enable or encourage investments to be made in these technologies. This may be particularly important in the current economic climate, where access to credit is severely restricted due to the global financial crisis. Consequently, investors are likely to be looking for increased levels of confidence with respect to large-scale investment decisions. Therefore, the purpose of this section is to qualitatively analyse potential actions that could be undertaken to create a favourable investment climate for electric vehicle technology and identify those that are the most effective.

There are a number of ways in which favourable investment climates could be achieved, and these include (amongst others):

- National Government policy statements;
- Regulatory pressures;
- Government-backed R&D funding programmes;
- Government-backed demonstration and commercialisation programmes.
- ‘Utility’ measures

To a certain extent, all of the above activities have occurred in different parts of the world (including the UK) with the aim of stimulating the uptake of electric/plug-in vehicles and/or low carbon vehicles more generally.

These approaches are described in more detail below.

5.1 National Government policy statements

A national government policy statement may vary in its format, but is likely to include the setting of targets for the uptake of EV/PHEV, or its intention to support research and development, which may in turn stimulate action from manufacturers or consumers.

One such example is that of Spain. On 1st August 2008, Spain’s Government set out its intention to cut the country’s oil consumption by 10% between 2008 and 2011, and to have one million electric cars on the road by 2014. The plan is expected to cost the Spanish Government €245 million and consists of 31 measures. In addition to electric vehicles, the measures include lowering speed limits by 20% on major roads into and within big cities, encouraging the use of bicycles and extending the opening hours of subway systems. Government officials will be required to use low-energy cars for official use and public transport vehicles will have to run on at least 20% biofuel starting in 2009. It is anticipated that the plan will save between 5.8 and 6.4 million tonnes of oil through initiating its electric car infrastructure until 2011[42].

In April 2009 the UK Government set out a high level strategy on low carbon vehicles with the publication of the report *Ultra-low Carbon Vehicles in the UK*. This does not include uptake targets but rather set out five key areas for government intervention:

- **Investments & skills**: Supporting the automotive industry through the downturn;
- **R&D**: Making the UK a world leader in research, development and demonstration of ultra-low carbon vehicles;

[42] http://www.iht.com/articles/2008/08/01/business/energy.php

- **Infrastructure**: Creating a viable environment to support the adoption of alternatively fuelled ultra-low carbon vehicles in lead cities and regions;
- **Finance:** Making ultra-low carbon vehicles competitive for consumers (including via the upfront support discussed in Section 4 above);
- **Leadership**: Clear and strategic leadership and coordination across Government and beyond Whitehall (including through the publication of R&D maps).

5.2 Regulatory pressures

Regulations can be introduced to stimulate changes or developments in vehicle R&D, the resultant technology, and the subsequent uptake of vehicles equipped with new technologies by consumers. These regulations may include the provision of information at point of sale of vehicles (e.g. emissions information) or emission standards that are to be met by auto manufacturers.

For example, a new set of car CO_2 emissions limits for 2012 to 2015, backed up by a system of fine for car manufacturers who fail to comply, were agreed in 2008 Providing the new limits are met the average CO_2 emissions for new passenger cars should be 130g/km by 2015, and potentially 95g/km by 2020 (to be determined in 2013). Such stringent targets may potentially stimulate investment in plug-in and electric vehicle technologies. However, in the current economic climate government-backed R&D may be required to ensure that manufacturers are able to meet these targets.

5.3 Government-backed R&D funding programme

Government-backed research and development (R&D) programmes may be necessary in terms of overcoming known barriers to the uptake of electric vehicles and plug-in hybrid electric vehicles. However, it should be noted that the majority of cars sold in the UK are not manufactured in the UK, and this issue needs to be taken into account when providing any R&D support funding. Barriers that may be addressed by such programmes may include:

- Battery, volume, cost, reliability and safety;
- Lack of domestic sources for batteries;
- Consumer behaviour and expectations; and/or
- Robust operation in a range of environmental conditions.

In October 2008, the UK Government announced it was investing £100million in the Low Carbon Vehicle Integrated Delivery Programme[43]. The aim of the programme will be to co-ordinate the UK's low carbon vehicle activity from initial strategic research, through to R&D and vehicle demonstration. The programme will be managed by the Technology Strategy Board via its Low Carbon Innovation Platform. The initiatives that make up the Low Carbon Vehicle Integrated Delivery Programme will include:

- Up to £10m for business collaborative R&D to support projects in all areas relevant to the development of enabling system and sub-system technologies to deliver more cost effective and higher performing all-electric and hybrid vehicles for mass market applications.
- £5m to £10m for wider collaborative projects covering all vehicle technologies capable of delivering large-scale carbon reductions in the coming decades.
- £3m of academic research on lower carbon vehicle technology. This will support research relevant to lower carbon vehicles, which could potentially be taken forward into collaborative research and development activity in the future[44].

[43] http://www.greencarcongress.com/2008/10/uk-government-i.html
[44] http://www.dft.gov.uk/press/speechesstatements/speeches/spchelectricvehicles

In January 2009, the Government announced further funds aimed at stimulating the uptake of low-emission cars, in the form of £250m committed for consumer incentives and infrastructure development, which supports the existing Low Carbon Vehicle Integrated Delivery Programme for research, development and demonstration (part of which is described above). It remains to be seen how much of these funds is taken up by the upfront price support of between £2k to £5k announced by the Government in the 2009 budget.

In the same month, the UK Government also announced plans to provide loan guarantees to Britain's auto manufacturers and large suppliers. This plan includes £1.3 billion from the European Investment Bank, and a further £1 billion lending/loans from the UK for the Automotive Assistance Programme (AAP)[45]. To date, in the UK, Jaguar Land Rover and Nissan have both received approval for loans from the European Investment Bank scheme. Whilst not a pre-requisite of either loans or loan guarantees, the UK Government is encouraging projects that are "consistent with its objectives" in terms of "reducing fuel consumption, reducing CO_2 emissions and achieving higher environmental protection standards".

5.4 Government-backed demonstration and commercialisation programmes

Government-backed demonstration and commercialisation programmes are important in terms of creating pilots for certain vehicles/technologies, gaining knowledge and experience in the use of both vehicles and the supporting infrastructure, raising the profile of such vehicles amongst potential consumers, and raising the profile of the UK in terms of attracting investment to undertake further R&D activities related to the electrification of passenger cars. There are currently a range of sources of existing/potential funding in the UK for R&D and demonstration of low carbon technologies in the UK.

For instance, an ultra low carbon vehicle demonstration competition was announced as part of the package introduced by the Technology Strategy Board's Low Carbon Vehicle Innovation Platform (LCVIP), which also includes the more R&D focused activities mentioned above. The aim of the competition is to see up to 200 new innovative cars on the road in several locations around the UK by the end of 2009, with up to £10m of funding available and will provide a portion of the costs for business-led demonstration projects of vehicles with tailpipe emissions of 50g CO_2/km or less and a significant electric only range. The Energy Technologies Institute (ETI) is currently working in collaboration with the Technology Strategy Board (TSB), LowCVP and DfT as part of the UK's strategy for the electrification of light vehicles. The ETI are exploring opportunities for a large-scale demonstration project for the infrastructure to support the electrification of light vehicles, potentially including a significant number of vehicle users representatives who make up a broad cross section of the consumer market[46]. The Energy Technologies Institute's objectives are to:

- Increase the level of funding devoted to R&D in low-carbon (non-nuclear) energy technologies to meet UK's energy policy goals, both domestically and internationally;
- Deliver R&D that facilitates the rapid commercial deployment of cost effective, low carbon technologies;
- Provide better strategic focus for commercially applicable energy related R&D in the UK;
- Connect and manage networks of the best scientists and engineers both within the UK and overseas to deliver focussed R&D projects to accelerate eventual deployment; and
- Build R&D capacity in the UK in the relevant technical disciplines to deliver the UK's energy policy goals.

[45] http://www.berr.gov.uk/whatwedo/sectors/automotive/supportmeasures/page49874.html
[46] http://www.energytechnologies.co.uk/Home/Technology-Programmes/Transport.aspx

DfT will contribute £5m per annum from 2008 onwards to ETI expenditure on lower carbon transport technologies. DfT will also work to ensure ETI funding fits with national low carbon transport policy directions and is appropriately co-ordinated with other Government and industry research activities.

In particular, DfT's participation in the ETI and the Innovation Platform seeks to:

- Encourage the merging and simplification of funding streams where appropriate – the decision to bring together future DfT and DTI support for UK low carbon vehicle R&D through the Innovation Platform is quoted by DfT as an example of this approach in practice
- Encourage the use of joint calls and wider co-ordination of funding approaches – potentially bringing funding from a range of partners together to allow larger projects or calls to be supported
- Ensure that the balance of, and priorities for, funding, continue to match Government's transport and energy policies in this area over time – while maintaining support for a diversity of technology options
- Ensure detailed technology research priorities and project proposals are reviewed and assessed by relevant industry and academic experts
- Share and publish regularly up-dated information on RD&D funding programmes, open calls and other relevant developments.
- Engage directly with industry and other key stakeholder groups in this area such as the Low Carbon Vehicles Partnership, the National Non-Food Crops Centre and Cenex – the UK centre of excellence for low carbon and fuel cell technologies – in particular to identify areas where research, development and demonstration activities can be most effectively deployed in the UK[47].

In May 2007 the Government also announced £20million of funding for the Low Carbon Vehicle Procurement Programme. Cenex (the Centre of Excellence for Low Carbon and Fuel Cell Technologies) runs the programme on behalf of the Department for Transport. The aim of the programme is accelerate the introduction of low carbon technologies into the UK vehicle fleet. The first phase of the programme will focus on vans but it could be rolled out to all vehicles if it proves to be a success.

The first phase of the programme will fund van manufacturers to trial or demonstrate their technologies with public sector organisations. It is hoped that exploiting the buying power of the UK 's public sector will help to accelerate the introduction of low carbon vehicles. The LowCVP Programme will purchase or lease the vehicles in question following a competitive tender process.

5.5 Utility measures

Intuitively it might seem logical that consumers think long and hard before they purchase a car, weighing up the pros and cons of different models and perhaps considering the running costs. However, during a stakeholder event to present the interim findings from the project, car manufacturers emphasised that the very opposite is frequently the case. In other words, car purchases are often not rational decisions. For instance, consumers heavily discount fuel savings from more efficient vehicles and place a great deal of value on relatively minor benefits that would never accrue the same level of financial savings.

Extending this argument, there was a strong consensus from car manufacturers that a range of 'softer' benefits could significantly increase the attractiveness of purchasing an EV or PHEV. In turn, this would increase the likelihood of car manufacturers investing in bringing EVs and PHEVs to the UK market. The types of measures they had in mind were as follows:

[47] http://www.dft.gov.uk/pgr/scienceresearch/technology/lctis/lowcarbontis?page=11

- Reduced or free parking
- Use of bus lanes
- Exemption from congestion charging

Whilst these measures might result in a local loss of revenue they would not require significant capital investment. Consequently, if the manufacturers are correct and the softer measures encourage potential users to purchase EVs or PHEVs there is a good chance they could exhibit high benefit to cost ratios and modest barriers to implementation.

5.6 Summary of proposed mix of most favourable options

The Department for Business, Enterprise and Regulatory Reform (BERR) has set up a number of Innovation and Growth Teams as a mechanism to facilitate the creation of a strategic view collectively from industry on innovation and growth challenges for future competitiveness. One of these is the New Automotive Innovation and Growth Team (NAIGT). NAIGT are currently considering issues arising from market risks associated with technological change required to address reduction in energy consumption and carbon emissions. They are also considering how the automotive industry may adapt and what partnerships may emerge as a result of future challenges and opportunities that may arise related to the electrification of transport. NAIGT recently made the following recommendations regarding low carbon vehicles, which is a consensus view of the automotive industry:

- Create a leadership team to develop future automotive strategy in the UK (Government/senior industry figures);
- Establish 'Test Bed UK' which is defined by the NAIGT as "a demonstrator to act as a powerful catalyst for change through demonstrating, experimenting and building the new low-carbon personal transportation system including its infrastructure[48]"
- Release and maintain roadmaps and research agendas to focus funding spend and collaboration;
- Establish Government funding mechanism to support product development and industrialisation phase of R&D;
- Evaluate new emissions test procedures based on well-to-wheels methodology, and energy focused rather than current tank-to-wheel approach to quantifying CO_2 emissions from vehicles[49].

SMMT and members have provided feedback on the conditions required to create a favourable investment environment in EV technology. Their views are set out in more detail in Box 1 below.

[48] http://www.berr.gov.uk/files/file50539.pdf
[49] http://www.berr.gov.uk/files/file50300.pdf

Box 1: SMMT's views on the conditions required to create a favourable investment environment in plug-in electric vehicle technology

SMMT and members see NAIGT as a very important contribution to Government strategy, as the consensus view of the auto industry. They are keen that the CCC's recommendations align with the outcome of the NAIGT, both in terms of the roadmap and the schedule. SMMT believes there is a need for consistency and durability in aligning all policies on consumer incentives to buy low carbon products. The same applies with respect to support for investment in RD&D in the UK. A key concern of NAIGT is to avoid diluting their impact through fragmentation, dispersal and a lack of materiality in the whole enabling and support framework. It is also important that the policies avoid contradicting each other. For instance, supporting UK RD&D and production of a given product and then the VED or other consumer signals giving a contradictory message further down the chain.

SMMT and its members view R&D Tax Credits as a valued support mechanism for research and innovation in firms in the automotive sector. They enable more costs to be offset against taxable profits. An enhancement of the basic rate would be the most effective change in the sector. However, the current system of offsetting the tax credit against corporation tax for large automotive manufacturing firms does not always provide a consistent incentive for creating more R&D. Under existing scheme rules the largest firms are excluded from receiving an immediately payable credit whilst small or medium companies not in profit can surrender the tax relief to claim payable tax credits in cash. In SMMT's view this restriction should be removed.

The ability to realise immediate cash savings where there is no or insufficient profit would be welcomed by the auto industry. Large companies who have insufficient profits could benefit as per the SME regime of offsetting credits against PAYE & NIC liabilities. This would be especially valuable and appropriate to cyclical industries such as the automotive sector, which are prone to unprofitable periods and where it is essential to maintain R&D levels during these periods. This is to ensure sufficient R&D on new products can help to achieve a return to profitability. It will also assist to maintain the credit incentive to the main element of R&D costs - employment costs.

Alternatively the value of the credit payment to each firm could be limited and any balance carried forward reverting to an offset to future taxable profits. SMMT recommend this as a highly effective, targeted and temporary aid to ease an exceptional squeeze on cash flow now. However, it could be adapted, further targeted or focused on larger firms to secure more high value manufacturing, engineering and scientific activity in the UK.

Whilst the manufacturers suggest a revised system of tax credits would be the best means of creating a favourable investment climate, a more rounded portfolio of measures may be preferable. By designing a suite of policies that features policy statements and emissions limits as well as grants or tax-breaks for R&D, the Government would be able to ensure the investment is being channelled in the right direction. In particular, it is important to ensure that the additional RD&D funding is used to develop low carbon vehicles that are consistent with the Government's, short, medium and long-term aims with respect to reducing greenhouse gas emissions.

6 Scenarios for uptake of EVs and PHEVs

6.1 Introduction to the scenarios

This section presents four draft scenarios for the uptake of car and van EVs and PHEVs between 2009 and 2022:

- Scenario 1: Severe Protracted Recession
- Scenario 2: Green Recovery
- Scenario 3: Green Recovery + Upfront Price Support
- Scenario 4: Green Recovery + Upfront Price Support + Strong Competition from Advanced Diesel

Each scenario follows a common format. It begins with an overview of the car scenario, which is followed by a list of assumptions for cars covering small EVs, medium EVs, large EVs, medium PHEVs and large PHEVs. Next the van scenario and assumptions are listed. These assumptions for cars and vans include penetration rates for 2014, 2018 and 2022 as well as the reduction in car / van sales. To avoid confusion it is important to note that a negative percentage for the 'fall' in car sales indicates a rise in sales. It is important to stress that none of these scenarios are predictions for what will happen over the period between 2009 and 2022; rather they are storylines that have been used to described what could happen to UK new vehicle sales under certain assumptions. These scenarios can be used in the CCC's transport MACC model to assess the possible impacts of these assumptions on transport sector CO_2 emissions and the costs to the economy associated with these assumptions. During the process of developing the scenarios, the study team has worked closely with CCC and has used input from expert peer reviewers appointed by CCC in order to ensure that the assumptions included in each scenario have been consulted upon, validated and where necessary refined to ensure that they are as robust as possible.

In each scenario, the penetration rates for the years between 2014, 2018 and 2022 are linearly extrapolated. The extrapolated penetration rates have not been included in this section to avoid giving the impression that they are more accurate than is actually the case. However, they can be found in Appendix 1, which presents the full scenarios including penetration rates for every technology included in the MACC model.

HGVs have not been covered in the scenarios at the current time. The project team are of the opinion that uptake will be negligible for the foreseeable future due to the prohibitively expensive battery packs that would be required and the practical issues associated with recharging regularly.

6.2 Methodology for compiling the scenarios

The first step in the process of developing the scenarios was to agree the broad thrust of each scenario with CCC. This entailed agreeing some of the main themes and assumptions. For instance, the type of Government intervention for each scenario and the hierarchy of scenarios were agreed at this stage.

The project team then began to develop the detailed scenarios around this framework. The first suite of detailed assumptions to be made was around the duration of the recession and when growth would return to the economy. These assumptions were the building blocks for the rest of the scenario since they gave a strong signal in terms of how car manufacturers would be affected. News articles in the media, particularly in terms of companies that were likely to collapse, also informed the impact on manufacturers. To that end we monitored a range of news websites and automotive blogs on a daily basis:

- Autoblog

- Autoblog green
- Automotive world
- The Guardian website
- The Times website
- The New York Times website

The project team took care to place greater weight on press releases than unattributed quotes from ‘sources’ within the industry.

The next step was to consider whether the impact of the recession might cause the EC to delay the introduction of the 130g/km emissions limit or the proposed 95g/km limit. Given that the 130g/km limit can be met with existing technologies it was felt this would remain in place even in the most pessimistic scenario. However, the proposed 95g/km limit was pushed back 3 years in the first ‘Severe Protracted Recession’ scenario.

Once these decisions had been made the project team began drafting percentage penetrations for each scenario in 2014, 2018 and 2022. There was a high degree of confidence in the 2014 estimates since they were very well informed by the daily review of news websites. A car typically takes around 5 years to develop from the start of the design process to appearing on showroom forecourts. Therefore, it was fair to assume than any models not in development would not show significant sales in 2014.

To a certain extent the uptake in 2018 could also be extrapolated forward from current development activities. In the automotive sector new technologies are often produced in small quantities initially so as to gauge consumer interest. Therefore, production volumes are slow to ramp up, so a new EV model launched in 2014, at an initial worldwide production volume of say a few thousand, may still only be at a production volume of say 10,000 in 2016. However, the project team were careful not to make this assumption without validating it against manufacturer announcements. For instance, the Chevrolet Volt is a good example of where a manufacturer is planning to veer away from the norm and hope to ramp up production volumes more rapidly.

The uptake in 2022 was more reliant on the project team’s professional judgement. However, this was informed by experience of the pace at which new infrastructure (i.e. charging infrastructure in this case) could be rolled out and the rate at which consumers will be willing to shift to a totally different means of recharging the vehicle. The views of the manufacturers were also taken into account by reviewing technology roadmaps (e.g. the recently published NAIGT report) and consulting SMMT and ACEA. However, the project team were careful to ensure their opinions were not excessively influenced by the automotive sector. Some critics of the automotive sector claim they do not always promote new technologies as fast as they could do, so as to ensure they maximise the profit from investments in existing technologies.

Whilst drafting the percentage uptakes for each scenario the project team started with the most optimistic scenario (number 3) and worked backwards. This ensured a sensible ceiling was placed on penetration rates and prevented the percentage uptakes from running out of control. Otherwise, there is a temptation to continually push the upper limit upwards.

Compiling the scenarios was very much an iterative process. A great deal of effort was put into ‘sense’ checking the scenarios and ensuring they were consistent with each other. They were reviewed internally at AEA by the Project Director and externally by experts retained by CCC.

6.3 Scenario 1: Severe Protracted Recession

6.3.1 Cars

Overview of Scenario 1

- During the course of 2009, the UK economy remains in recession (negative growth).
- The recession continues until 2011 in advanced economies including the UK. A full recovery in economic growth to 2007 levels is not complete by 2014 globally and may take a few more years in the UK. This scenario may be assumed to be consistent with the downside medium-term scenario in the latest IMF World Economic Outlook or the low end of independent forecasts for the medium-term as surveyed by the UK Treasury in May 2009. With the respect to the UK economy, the latter forecast assumes that the economy will contract by 4.5% in 2009, with a further 1% contraction in 2010. In 2011, the economy begins to grow again but rather slowly (1 % growth in 2011, 1.2% growth in 2012, and 1.4% growth in 2013).
- As a result of the recession there is a significant scaling back in manufacturers' activities regarding the development of PHEVs and EVs from mid-2009 to the end of 2011.
- Some models are cancelled as one major manufacturer collapses, and many other manufacturers delay the development and launch of vehicles.
- EV and PHEV development begins again from 2012 onwards.
- The new car CO_2 limits were agreed by the European Parliament in December 2008 but are now ratified by the European Commission (130g/km for 65% of new cars in 2012, 75% in 2013, 80% in 2014 and 100% in 2015) and remain in place since this can be met with existing technologies.
- A new car 95g/km CO_2 limit proposed by the European Commission for 2020 is delayed until 2023 in light of the slow recovery.
- New car sales fall 28% in 2009 compared to 2008 (based on February 2009 SMMT year to date figures); a further 10% fall is experienced in 2010 followed by a 20% upsurge in 2011.
- With the exception of EVs, PHEVs and HEVs this scenario is based on the 'ELECTRIC - HIGH UPTAKE' scenarios from the original transport MACC model developed by AEA for CCC. The increased penetration of EVs and PHEVs in the original scenario has been removed for this new scenario.
- All PHEV %'s penetrations are split evenly between petrol and diesel PHEVs.

Table 6.1: Projected change in car sales volumes in Scenario 1

% Fall in car sales in 2009 vs. 2008 SMMT figures	28%
% Fall in car sales in 2010 vs 2009	10%
% Fall in car sales in 2011 vs 2010	-20%

Assumptions in Scenario 1
Small EVs

- 2009 to 2014: 0% penetration (in practice, more than zero, but numbers so small that would be rounded to zero) as uptake lower than anticipated due to economic downturn, limited availability of EVs and limited infrastructure
- 2015 to 2018: Penetration reaches 0.5% of small cars by 2018 as growth returns to the economy and availability of cars and charging infrastructure improves
- 2019 to 2022: Penetration increase post- 2018 (assumes economy now well out of recession), reaching 10% of small cars by 2022. In the absence of upfront price support the price premium vs conventional cars constrains uptake.

Medium EVs

- 2009 to 2014: RD&D delayed so the first volume manufactured medium EV models not launched until 2014
- 2015 to 2018: Penetration slow to ramp up due to limited availability of medium EVs and absence of upfront price support. Medium EVs are lagging small EVs by at least 5 years.
- 2019 to 2022: Uptake grows slowly post-2018 (assumes economy now well out of recession), as penetration reaches 1% of new car sales by 2022

Large EVs

- 2009 to 2014: 0% uptake - with the exception of niche sports cars, no volume manufactured large EVs put on the market until 2018
- 2015 to 2018: limited 0.5% uptake achieved in first year on sale
- 2019 to 2022: 2% penetration by 2022 (assumes economy now well out of recession)

Small PHEVs

- No small PHEVs under development due to the cost of providing 2 power trains in the most price sensitive market segment so zero uptake through to 2018. Small PHEVs then begin to become available in relatively small numbers in the early 2020's.

Medium PHEVs

- 2009 to 2014: Some models cancelled and the others are delayed so 0% uptake (in practice, more than zero, but numbers so small that would be rounded to zero)
- 2015 to 2018: Uptake begins to grow after 2014 (assumes economy now well out of recession), as manufacturers launch delayed PHEVs. Penetration reaches 2% but constrained by limited manufacturing capacity.
- 2019 to 2022: Penetration grows rapidly, reaching 10% of medium cars by 2022

Large PHEVs

- 2009 to 2014: Many new large car models cancelled and the others are delayed so 0% uptake (in practice, more than zero, but numbers so small that would be rounded to zero)
- 2015 to 2018: Uptake begins to grow (assumes economy now well out of recession), as manufacturers launch large PHEVs. Penetration reaches 1% but constrained by lack of manufacturing capacity.
- 2019 to 2022: Penetration ramps up more quickly after 2018, reaching 7% of medium cars by 2022. For large cars, PHEVs are preferred to EVs due to dual power source and therefore less need to refuel regularly.

Summary of Car Penetration Rates in Scenario 1

Table 6.2: Car Penetration Rates in Scenario 1

Technology	2014	2018	2022
Small EVs	0.0%	0.5%	2.0%
Medium EVs	0.0%	0.0%	1.0%
Large EVs	0.0%	0.5%	2.0%
Small PHEVs	0.0%	0.0%	0.0%
Medium PHEVs	0.0%	1.0%	3.0%
Large PHEVs	0.0%	0.5%	2.0%

Full car penetration rates are detailed in Appendix 1.

6.3.2 Vans

Overview of Scenario 1

- During the course of 2009, the UK economy remains in recession (negative growth).
- The recession continues until 2011 in advanced economies including the UK. A full recovery in economic growth to 2007 levels is not complete until 2014 globally and possibly later in the UK. This scenario may be assumed to be consistent with the low end of the range of the latest IMF global growth forecasts and with the lowest of independent forecasts for the medium-term as surveyed by the UK Treasury in February 2009. With the respect to the UK economy, the latter forecast assumes that the economy will contract by 3.6% in 2009, with a further 1.2% contraction in 2010. In 2011, the economy begins to grow again (0.7% growth in 2011, 1.5% growth in 2012, and 1.9% growth in 2013).
- As a result there is a significant scaling back in manufacturers' activities re PHEVs and EVs from mid-2009 to the end of 2011.
- Some models are cancelled as one major manufacturer collapses, and many other manufacturers delay the development and launch of vehicles.
- EV and PHEV development begins again from 2012 onwards.
- Once launched, PHEV vans grow more quickly than EV vans since they are more affordable and practical for 'green' consumers.
- Van uptake is slightly ahead of large cars due to companies purchasing vans being more inclined to take account of full lifecycle costs and keener to demonstrate their green credentials.
- Lack of upfront price support limits uptake.
- It is assumed that no petrol PHEV vans are developed - petrol vans currently account for less than 2% of the new van market. On average commercial vehicle mileage is significantly higher than car mileage so it is more cost effective to purchase diesel vehicles (which are more fuel efficient) despite their small price premium.
- New van sales fall 50% in 2009 compared to 2008 (based on Feb 09 SMMT year to date figures), further 20% fall in 2010 and 10% upsurge in 2011 before returning to MACC projections thereafter

Table 6.3: Projected fall in van sales volumes in Scenario 1

% Fall in van sales in 2009 vs 2008 SMMT figures	50%
% Fall in van sales in 2010 vs 2009	20%
% Fall in van sales in 2011 vs 2010	-10%

Assumptions in Scenario 1

Electric vans

- 2009 to 2014: Models available at significant price premium to conventional vans since no upfront price support. Therefore penetration negligible by 2014.
- 2015 to 2018: Uptake reaches 0.5% of new vans by 2018 as growth returns to the economy. Lack of upfront price support limits uptake.
- 2019 to 2022: Penetration ramps up slightly more quickly than cars post-2018 (assumes economy now well out of recession), reaching 3% of new vans by 2022. Lack of upfront price support limits uptake.

Plug-in hybrid vans

- 2009 to 2014: 0% penetration since no PHEV vans launched by manufacturers

- 2015 to 2018: PHEV vans launched post 2014 (assumes economy now well out of recession). Penetration reaches 1% but constrained by limited manufacturing capacity and lack of upfront price support.
- 2019 to 2022: Penetration continues to grow, reaching 4%. Lack of upfront price support limits uptake.

Summary of Van Penetration Rates in Scenario 1

Table 6.4: Van penetration rates in Scenario 1

Technology	2014	2018	2022
Electric Vans	0.0%	0.5%	3.0%
Plug-in Hybrid Vans	0.0%	1.0%	4.0%

Full van penetration rates are detailed in Appendix 1.

6.4 Scenario 2: Green Recovery

6.4.1 Cars

Overview of Scenario 2

- During the course of 2009, the UK economy remains in recession (negative growth).
- Helped by efforts to tackle credit strains and by expansionary fiscal and monetary policies, the global economy experiences a gradual recovery in 2010. UK growth also turns positive during the course of 2010. The Green Recovery scenario assumes that Governments across the world provide co-ordinated fiscal stimulus packages with a significant element of investment in R&D for low carbon technologies across all sectors of the economy. Fiscal stimulus in the UK is assumed to be 4% of GDP, with 20% of this package focused on stimulus for low carbon technologies (across all sectors). These assumptions are in line with those proposed by the Grantham Research Institute and the Centre for Climate Change Economics and Policy in February 2009 (Bowen et al, 2009).
- The fiscal stimulus packages introduced by several advanced economies (including the UK) see the introduction of significant grants and loans (of the order of several billion pounds Sterling) to vehicle manufacturers to support medium term research to further develop EVs and PHEVs that will have an impact in the UK (the loans and grants will not be limited to UK companies).
- No upfront price support for consumers.
- All planned models are developed (I.e. no manufacturers go bust).
- The new car CO_2 limits were agreed by the European Parliament in December 2008 but are now ratified by the European Commission (130g/km for 65% of new cars in 2012, 75% in 2013, 80% in 2014 and 100% in 2015) and remain in place since this can be met with existing technologies.
- The European Parliament and European Commission agree to tighten the CO_2 limits for new passenger cars to 95g/km in 2020 and propose an even tougher limit of 60g/km for 2025.
- For EV this results in a time lag before uptake accelerates. This is because EVs remain too expensive for mainstream consumption until the fruits of research (e.g. cheaper batteries) reduce the price.
- PHEV uptake grows more quickly than EV uptake since they are more affordable and practical for 'green' consumers.
- With the exception of EVs, PHEVs and HEVs this scenario is based on the 'ELECTRIC - HIGH UPTAKE' scenarios from the original transport MACC model developed by AEA for CCC.
- All PHEV percentage penetrations are split evenly between petrol and diesel PHEVs

Table 6.5: Projected change in car sales volumes in Scenario 2

% Fall in car sales in 2009 vs 2008 SMMT figures	28.00%
% Fall in car sales in 2010 vs 2009 car sales	-10.00%
% Fall in car sales in 2011 vs 2010 car sales	-30.00%

Assumptions in Scenario 2

Small EVs

- 2009 to 2014: Models launched at significant price premium to conventional cars since no upfront price support. Therefore penetration negligible by 2014.

- 2015 to 2018: Uptake begins to become noticeable as fruits of research spend come to fruition and price begins to fall. Penetration reaches 1% by 2018.

- 2019 to 2022: Penetration accelerates post-2018 as forthcoming increasingly stringent emissions limits incentivise car companies to promote EVs ahead of advanced diesels or PHEVs. Penetration reaches 4% of small cars by 2022. Uptake is constrained by price premium and lack of upfront price support.

Medium EVs

- 2009 to 2014: Time lag before launch of medium EVs (compared to small EVs). Models launched towards the end of the period at significant price premium to conventional cars since no upfront price support. Therefore negligible penetration by 2014.

- 2015 to 2018: Uptake becomes noticeable as fruits of research spend come to fruition and prices begin to fall. Penetration reaches 0.5% by 2018 – there is still a lag in uptake compared to small EVs and still constrained by lack of price support and low manufacturing volumes.

- 2019 to 2022: Penetration accelerates after 2018 as tougher emissions limits incentive car companies to promote EVs heavily. Penetration reaches 2% of new medium cars by 2022 due to limited demand from consumers, which is driven by the price premium and lack of upfront price support.

Large EVs

- 2009 to 2014: Very limited penetration since high cost of batteries means manufacturers only launch high priced sports cars and luxury saloon cars in this segment. 0% penetration (in practice, more than zero, but numbers so small that would be rounded to zero).

- 2015 to 2018: Uptake begins to accelerate as impacts of research spend come to fruition as the price of batteries, rapid recharge kit and battery swap technology begins to fall and car manufacturers launch large EVs. Low manufacture volumes constrain penetration to 0.5% by 2018.

- 2019 to 2022: Penetration ramps up after 2018 as tougher emissions limit incentive car companies to promote EVs heavily. Penetration reaches 2% of large cars by 2022 but price premium still a major issue particularly with the larger battery packs required for large vehicles.

Small PHEVs

- No small PHEVs under development due to the cost of providing 2 power trains in the most price sensitive market segment so zero uptake through to 2018. Small PHEVs then begin to become available in relatively small numbers in the early 2020's.

Medium PHEVs

- 2009 to 2014: Models launched towards the end of the period at price premium to conventional cars since no upfront price support. However, price premium is lower than EV and greater flexibility in terms of fuels encourages early adopters to purchase medium PHEVs. However, this comes too late to have a noticeable impact on sales volumes in this period.

- 2015 to 2018: Uptake accelerates as fruits of research spend come to fruition, price of batteries begins to fall and manufacture volumes rise. Penetration reaches 2% by 2018.

- 2019 to 2022: Penetration grows to 5% by 2022 as further cost reductions mean the technology moves into the mainstream

Large PHEVs

- 2009 to 2014: Very limited uptake due to lack of large mainstream PHEVs on the market - only sports cars and luxury saloon cars available. 0% penetration (in practice, more than zero, but numbers so small that would be rounded to zero)
- 2015 to 2018: Uptake begins to accelerate as large PHEVs are launched. Penetration reaches 1% by 2018.
- 2019 to 2022: Penetration ramps up post-2018 as tougher emissions limit incentive car companies to promote PHEVs for large cars. Large EVs are still perceived as too expensive due to the size of battery packs required. Penetration reaches 4% of new large car sales by 2022.

Summary of Car Penetration Rates in Scenario 2

Table 6.6: Car Penetration Rates in Scenario 2

Technology	2014	2018	2022
Small EVs	0.0%	1.0%	4.0%
Medium EVs	0.0%	0.5%	2.0%
Large EVs	0.0%	0.5%	2.0%
Small PHEVs	0.0%	0.0%	0.5%
Medium PHEVs	0.0%	2.0%	5.0%
Large PHEVs	0.0%	1.0%	4.0%

Full car penetration rates are detailed in Appendix 1.

6.4.2 Vans

Overview of Scenario 2

- During the course of 2009, the UK economy remains in recession (negative growth).
- Helped by efforts to tackle credit strains and by expansionary fiscal and monetary policies, the global economy experiences a gradual recovery in 2010. UK growth also turns positive during the course of 2010. The Green Recovery scenario assumes that Governments across the world provide co-ordinated fiscal stimulus packages with a significant element of investment in R&D for low carbon technologies across all sectors of the economy. Fiscal stimulus in the UK is assumed to be 4% of GDP, with 20% of this package focused on stimulus for low carbon technologies (across all sectors). These assumptions are in line with those proposed by the Grantham Research Institute and the Centre for Climate Change Economics and Policy in February 2009 (Bowen et al, 2009).
- The fiscal stimulus packages introduced by several advanced economies (including the UK) see the introduction of significant grants and loans (of the order of several billion pounds Sterling) to vehicle manufacturers to support medium term research to further develop EVs and PHEVs that will have an impact in the UK (the loans and grants will not be limited to UK companies). No upfront price support for consumers.
- All planned models are developed (I.e. no manufacturers go bust).
- Once launched, PHEV vans grow more quickly than electric vans since they are more affordable and practical for 'green' consumers.

- Van uptake is slightly ahead of large cars due to companies purchasing vans being more inclined to take account of full life-cycle costs and keener to demonstrate their green credentials.
- It is assumed that no petrol PHEV vans are developed - petrol vans currently account for less than 2% of the new van market. On average commercial vehicle mileage is significantly higher than car mileage so it is more cost effective to purchase diesel vehicles (which are more fuel efficient) despite their small price premium.
- New van sales fall 50% in 2009 compared to 2008 (based on Feb 2009 SMMT year-to-date figures), a further 10% fall in 2010, followed by a 25% increase in 2011 before gradually returning to previous projections in the transport MACC model by 2014.

Table 6.7: Projected change in van sales volumes in Scenario 2

% Fall in van sales in 2009 vs 2008 SMMT figures	50%
% Fall in van sales in 2010 vs 2009	10%
% Fall in van sales in 2011 vs 2010	-25%

Assumptions in Scenario 2

Small electric vans

- 2009 to 2014: Models available at significant price premium to conventional vans since no upfront price support. Therefore penetration negligible by 2014.
- 2015 to 2018: Uptake grows as fruits of research spend come to fruition and price begins to fall. Penetration reaches 3% by 2018.
- 2019 to 2022: Penetration after 2018 peaks at 10%. This is because electric vans are a relatively niche product - some vans are used for lots of short journeys (e.g. Royal Mail vans collecting the post from post boxes) but many others would need to recharge regularly or battery swap due to greater journey lengths.

Plug-in hybrid vans

- 2009 to 2014: Virtually 0% penetration since very few if any PHEV vans launched by manufacturers (A PHEV version of the Mercedes Sprinter and the 'IDEA' van by the 'Bright' company are the only PHEV vans in development - neither has a fixed launch date).
- 2015 to 2018: Models launched at price premium to conventional vans since no upfront price support. However, price premium is lower than EV and greater flexibility in terms of power source encourages early adopters to purchase PHEV vans. Consequently penetration reaches 2% relatively quickly.
- 2019 to 2022: Penetration ramps up to 7% post-2018. Once again, this is due to lower battery cost and dual power source providing the necessary flexibility vs electric vans.

Summary of Penetration Rates in Scenario 2

Table 6.8: Van penetration rates in Scenario 2

Technology	2014	2018	2022
Electric Vans	0.0%	1.0%	5.0%
Plug-in Hybrid Vans	0.0%	2.0%	7.0%

Full van penetration rates are detailed in Appendix 1.

6.5 Scenario 3: Green Recovery + Upfront Price Support

6.5.1 Cars

Overview of Scenario 3

- During the course of 2009, the UK economy remains in recession (negative growth).
- Helped by efforts to tackle credit strains and by expansionary fiscal and monetary policies, the global economy experiences a gradual recovery in 2010. UK growth also turns positive during the course of 2010. The Green Recovery scenario assumes that Governments across the world provide co-ordinated fiscal stimulus packages with a significant element of investment in R&D for low carbon technologies across all sectors of the economy. Fiscal stimulus in the UK is assumed to be 4% of GDP, with 20% of this package focused on stimulus for low carbon technologies (across all sectors). These assumptions are in line with those proposed by the Grantham Research Institute and the Centre for Climate Change Economics and Policy in February 2009 (Bowen et al, 2009).
- The fiscal stimulus packages introduced by several advanced economies (including the UK) see the introduction of significant grants and loans (of the order of several billion pounds Sterling) to vehicle manufacturers to support medium term research to further develop EVs and PHEVs that will have an impact in the UK (the loans and grants will not be limited to UK companies).
- In addition to providing grants and loans to vehicle manufacturers, upfront price support is provided to consumers and businesses that purchase EVs and PHEVs. For EVs this up front price support is assumed to take the form of a grant of up to £10k for the first 25,000 vehicles sold. It has been assumed that most of the early EVs that appear on the market will be in the small car category, with limited numbers of niche-market large cars (sports cars and luxury cars) and no medium cars appearing until 2015. Most of the initial uptake is therefore likely to be dominated by small EVs.
- Assuming 25,000 EVs are sold as a result of this measure and the central learning rate for small electric cars holds true (see Section 3.4 of Task 1 and 2 report) the price ought to have fallen to around £23-£24k, making the price with the grant around £13k-£14k which is a much more palatable price premium (around £4k to £5k) vs a conventional small car with a typical price of around £9,000-£10,000. The grant could then reduce to £7.5k for the next 25,000 vehicles (the 25,000th to 50,000th) before falling again to £5k for 50,000th to 100,000th vehicles sold to maintain this £4k to £5k price premium. Finally, the grant would fall to £2,500 for the 100,000th to 150,000th vehicle sold. In total this package would cost £812.5 million in grants, which would probably rise to £850 - £900 million when the administration of the scheme is included.
- This tapered structure would aim to get EVs to mass manufacture (assumed to 100,000) units as quickly as possible and provide limited support thereafter to prevent demand suddenly falling away.
- The proportion of total EV production sold in the UK will remain fixed at 2015 levels.
- For PHEVs the up front price support could take the form of £5k grant for the first 25,000 vehicles sold and £2,500 for the next 25,000 vehicles sold (the 25,000th to the 50,000th) assuming the central learning rate for the Chevrolet Volt holds true. However, this would necessitate defining a PHEV (as opposed to an EV) and having separate upfront price support schemes for either technology. If the Government preferred to have a single scheme they could set the grant levels according to CO_2 tailpipe emissions and/or battery size. This approach would structure the incentives so that PHEVs undertaking a higher proportion of all-electric miles would be encouraged. In total this package would cost £187.5 million in grants, which would probably rise to around £200 - £210 million including administration of the scheme.
- The price support is not sufficient to cover the whole marginal cost of EV and PHEV technology. It had been assumed that the Government takes the view that the marginal cost should be shared with the consumer, particularly given the fuel cost savings.

- Up front price support encourages car manufacturers to increase production capacity faster than would otherwise be the case in the Green Recovery scenario (Scenario 2).
- The new car CO_2 limits agreed by the European Parliament in December 2008 are ratified by the European Commission (130g/km for 65% of new cars in 2012, 75% in 2013, 80% in 2014 and 100% in 2015).
- The European Parliament and European Commission agree to tighten the CO_2 limits to 95g/km in 2020 and propose an even tougher limit of 60g/km for 2025.
- Both PHEV and BEV grow rapidly. PHEV grow faster initially until coverage of charging infrastructure improves.
- With the exception of penetration rates for EVs, PHEVs and HEVs this scenario is based on the 'ELECTRIC - HIGH UPTAKE' scenarios from the original MACC model.
- All PHEV percentage penetrations are split evenly between petrol and diesel PHEVs

Table 6.9: Projected fall in car sales volumes in Scenario 3

% Fall in car sales in 2009 vs 2008 SMMT figures	28.00%
% Fall in car sales in 2010 vs 2009 car sales	-10.00%
% Fall in car sales in 2011 vs 2010 car sales	-30.00%

Assumptions in Scenario 3

Small EVs

- 2009 to 2014: Models launched at significant price premium to conventional cars. However, upfront price support means EVs are much more affordable. Penetration limited to 0.5% by 2014 due to low production volumes and lack of infrastructure coverage.
- 2015 to 2018: Uptake begins to accelerate as production volumes increase, infrastructure improves and the price of EVs begins to fall. Penetration reaches 2% by 2018.
- 2019 to 2022: Penetration ramps up quickly after 2018 as infrastructure now has national coverage, marginal cost has reduced further and tougher emissions limits incentivises car companies to promote EVs. Penetration reaches 10% of small cars by 2022

Medium EVs

- 2009 to 2014: Time lag before launch of medium EVs compared to small EVs. First launches occur in 2013 or 2014. Therefore negligible penetration by 2014.
- 2015 to 2018: Uptake begins to pick up as manufacture volumes rise, fruits of research spend help to reduce the price and upfront price support reduces marginal cost further. Penetration reaches 1% by 2018 - Still a lag compared to small EVs.
- 2019 to 2022: Penetration accelerates after 2018 as infrastructure now has national coverage, marginal cost has reduced further and tougher emissions limit incentivises car companies to promote EVs ahead of advanced diesels or PHEVs. Penetration reaches 5% of medium cars by 2022

Large EVs

- 2009 to 2014: Very limited penetration initially since despite upfront price support few large EVs are released to market due to high cost of batteries. Furthermore, most initial vehicles are niche-market sports cars or luxury saloons that will appeal to a very limited proportion of car buyers. 0% penetration (in practice, more than zero, but numbers so small that would be rounded to zero)

- 2015 to 2018: Upfront price support and fruits of research (which reduce price of batteries, rapid charge and battery swap technology) prompts car manufacturers launch large EVs. Low production volumes constrain penetration to 1% by 2018.

- 2019 to 2022: Production volumes increase but uptake lags behind small or medium EVs since consumers prefer PHEVs for this segment where longer journeys are more common and hence dual power source saves times. Penetration reaches 3% of large cars by 2022.

Small PHEVs

- No small PHEVs under development due to the cost of providing 2 power trains in the most price sensitive market segment so zero uptake through to 2018. Small PHEVs then begin to become available in relatively small numbers in the early 2020's.

Medium PHEVs

- 2009 to 2014: Very limited penetration initially since few medium EVs will have been launched by 2014.

- 2015 to 2018: Uptake accelerates rapidly as production volumes are ramped up dramatically to cope with demand. Upfront price support reduces marginal cost to a manageable amount and means consumers can recoup the price premium over several years. Dual power source encourages early adopters to purchase medium PHEVs since limited recharging infrastructure less of an issue for these vehicles. Penetration reaches 4% by 2018.

- 2019 to 2022: Penetration ramps up to 15% of new cars by 2022 as production volumes rise and the technology becomes increasingly mainstream. Dual fuel source continues to prove popular due to the flexibility it provides for the users.

Large PHEVs

- 2009 to 2014: Very limited uptake due to lack of large mainstream PHEVs on the market - only sports cars and luxury cars available. 0% penetration (in practice, more than zero, but numbers so small that would be rounded to zero).

- 2015 to 2018: Uptake begins to accelerate as large PHEVs are launched. Large PHEVs are viewed by consumers as much more practical than large EVs due to the longer journeys that are more often undertaken by vehicles in this segment. Penetration reaches 3% by 2018.

- 2019 to 2022: Penetration ramps up quickly after 2018 as tougher emissions limit (95gCO_2/km by 2020) incentivise car companies to promote PHEVs for large cars. Large EVs are still perceived as too expensive due to the size of battery packs and lacking convenience due to need to regularly recharge or swap battery. Penetration reaches 12% of large cars by 2022.

Technology	2014	2018	2022
Small EVs	0.5%	2.0%	10.0%
Medium EVs	0.0%	1.0%	5.0%
Large EVs	0.0%	1.0%	3.0%
Small PHEVs	0.0%	0.0%	1.0%
Medium PHEVs	0.0%	4.0%	15.0%
Large PHEVs	0.0%	3.0%	12.0%

Table 6.10: Car penetration rates in Scenario 3

Full car penetration rates are detailed in Appendix 1.

6.5.2 Vans

Overview of Scenario 3

- During the course of 2009, the UK economy remains in recession (negative growth).
- Helped by efforts to tackle credit strains and by expansionary fiscal and monetary policies, the global economy experiences a gradual recovery in 2010. UK growth also turns positive during the course of 2010. The Green Recovery scenario assumes that Governments across the world provide co-ordinated fiscal stimulus packages with a significant element of investment in R&D for low carbon technologies across all sectors of the economy. Fiscal stimulus in the UK is assumed to be 4% of GDP, with 20% of this package focused on stimulus for low carbon technologies (across all sectors). These assumptions are in line with those proposed by the Grantham Research Institute and the Centre for Climate Change Economics and Policy in February 2009 (Bowen et al, 2009).
- The fiscal stimulus packages introduced by several advanced economies (including the UK) see the introduction of significant grants and loans (of the order of several billion pounds Sterling) to vehicle manufacturers to support medium term research to further develop EVs and PHEVs that will have an impact in the UK (the loans and grants will not be limited to UK companies).
- In addition to providing grants and loans to vehicle manufacturers, upfront price support is provided to consumers and businesses that purchase EVs and PHEVs. The price support is not sufficient to cover the whole marginal cost - Government take the view that the marginal cost should be shared with the consumer, particularly given the fuel cost savings.
- This encourages van manufacturers to increase production capacity faster than would otherwise be the case in the basic Green Recovery scenario (Scenario 2).
- Once launched, sales of PHEV vans grow more quickly than EV vans since they are more affordable and practical for 'green' consumers.
- Van uptake is slightly ahead of large cars due to companies purchasing vans being more inclined to take account of full lifecycle costs and keener to demonstrate their green credentials.
- In the longer term (by 2022), penetration of EVs begins to plateau as they reach saturation in their niche 'short trip' market. Penetration of PHEVs increases due to lower battery cost and the flexibility of a dual fuel source.
- It is assumed that no petrol PHEV vans are developed - petrol vans currently account for less than 2% of the new van market. On average commercial vehicle mileage is significantly higher than car mileage so it is more cost effective to purchase diesel vehicles (which are more fuel efficient) despite their small price premium.
- New van sales fall 50% in 2009 compared to 2008 (based on Feb 09 SMMT year to date figures), a further 10% fall in 2010 and 25% increase in 2011 before gradually returning to previous projections in the transport MACC model by 2014.

Table 6.11: Projected fall in van sales volumes in Scenario 3

% Fall in van sales in 2009 vs 2008 SMMT figures	50%
% Fall in van sales in 2010 vs 2009	10%
% Fall in van sales in 2011 vs 2010	-25%

Assumptions in Scenario 3
Electric vans

- 2009 to 2014: Models available at significant price premium to conventional vans. Upfront price support means EVs are much more affordable. Penetration limited to 1% by 2014 due to low manufacture volumes and lack of infrastructure coverage.

- 2015 to 2018: Uptake begins to accelerate as manufacture volumes increase, infrastructure improves and price of EVs begins to fall. Penetration reaches 3% by 2018.

- 2019 to 2022: Penetration ramps up quickly after 2018 as infrastructure now has national coverage and electric vans continue to become cheaper. However, niche market begins to constrain penetration as it reaches 12%.

Plug-in hybrid vans

- 2009 to 2014: Virtually 0% penetration since very few if any PHEV vans launched by manufacturers (A PHEV version of the Mercedes Sprinter and the 'IDEA' van by the 'Bright' company are the only PHEV vans in development - neither has a fixed launch date).

- 2015 to 2018: Models launched at significant price premium to conventional vans but upfront price support reduces this to a manageable level. Greater flexibility in terms of power sources encourages early adopters to purchase PHEV vans. Consequently penetration reaches 2% relatively quickly.

- 2019 to 2022: Penetration ramps up to 15% post-2018. Once again, this is due to lower battery cost and dual power source providing the necessary flexibility vs electric vans.

Summary of Penetration Rates in Scenario 3

Table 6.12: Van penetration rates in Scenario 3

Technology	2014	2018	2022
Electric Vans	1.0%	3.0%	12.0%
Plug-in Hybrid Vans	0.0%	2.0%	15.0%

Full van penetration rates are detailed in Appendix 1.

6.6 Scenario 4: Green Recovery + Upfront Price Support + Strong Competition from Advanced Diesel

6.6.1 Cars

Overview of Scenario 4

- During the course of 2009, the UK economy remains in recession (negative growth).
- Helped by efforts to tackle credit strains and by expansionary fiscal and monetary policies, the global economy experiences a gradual recovery in 2010. UK growth also turns positive during the course of 2010. The Green Recovery scenario assumes that Governments across the world provide co-ordinated fiscal stimulus packages with a significant element of investment in R&D for low carbon technologies across all sectors of the economy. Fiscal stimulus in the UK is assumed to be 4% of GDP, with 20% of this package focused on stimulus for low carbon technologies (across all sectors). These assumptions are in line with those proposed by the Grantham Research Institute and the Centre for Climate Change Economics and Policy in February 2009 (Bowen et al, 2009).
- The fiscal stimulus packages introduced by several advanced economies (including the UK) see the introduction of significant grants and loans (of the order of several billion pounds Sterling) to vehicle manufacturers to support medium term research to further develop EVs and PHEVs that will have an impact in the UK (the loans and grants will not be limited to UK companies).
- In addition to the Green recovery package of measures, the UK Government provides upfront price support to consumers who purchase EVs and PHEVs as detailed in Scenario 3.
- The upfront price support is not sufficient to cover the whole marginal cost. The Government takes the view that the marginal cost should be shared with the consumer, particularly given the fuel cost savings.
- The new car CO_2 limits agreed by the European Parliament in December 2008 are ratified by the European Commission (130g/km for 65% of new cars in 2012, 75% in 2013, 80% in 2014 and 100% in 2015).
- Advanced diesel vehicles are promoted heavily by some car manufacturers who view them as a cost effective way of reducing emissions from road vehicles in both the short term (to 2015) and in the medium term (to 2020/2025).
- This has a negative impact on EV and PHEV penetration compared to the penetration rates set out for Scenario 3 (Green Recovery + Upfront price support) until more stringent emissions limits (95g/km by 2020 and a proposed limit of 60g/km by the mid-2020's) force manufacturers to shift their focus to EVs/PHEVs.
- The uptake of PHEVs is particularly affected by strong competition from diesel technology; as manufacturers promote advanced diesel vehicles dominate the market for cars that are a 'lighter shade of green'. Medium PHEVs bear the brunt since large PHEVs are not available on the market in significant numbers.
- Even with upfront price support PHEVs remain more expensive than advanced diesels and achieve limited CO_2 reductions for market segments that regularly travel distances beyond the electric-only range.
- This scenario is based on the 'ELECTRIC - HIGH UPTAKE' scenarios from the original transport MACC model developed by AEA for CCC in 2008.
- All PHEV percentage penetrations are split evenly between petrol and diesel PHEVs

Table 6.13: Projected change in car sales volumes in Scenario 4

% Fall in car sales in 2009 vs 2008 SMMT figures	28.00%
% Fall in car sales in 2010 vs 2009 car sales	-10.00%
% Fall in car sales in 2011 vs 2010 car sales	-30.00%

Assumptions in Scenario 4

Small EVs

- 2009 to 2014: Models launched at significant price premium to conventional cars. However, upfront price support means EVs are much more affordable. Penetration limited to 0.5% by 2014 due to low manufacture volumes and lack of infrastructure coverage. No significant impact from advanced diesels initially (advanced diesel technology is less likely to be taken up in the small car market, which is dominated by vehicles equipped with petrol engines).

- 2015 to 2018: Uptake begins to accelerate as manufacture volumes increase, infrastructure improves and price of EVs begins to fall. Penetration reaches 2% by 2018. Impact from advanced diesel still negligible since 'green' early adopters favour EVs over diesel cars.

- 2019 to 2022: Penetration ramps up quickly after 2018 as EV infrastructure now has national coverage, the marginal cost has reduced further, and tougher emissions limits incentivise car companies to promote EVs. Penetration reaches 8% of small cars by 2022. Impact of advanced diesel cars begins to be felt as EVs enter the mainstream and are no longer solely the preserve of early adopters. Up front price support ends as Government judges EVs to be in mass manufacture and hence advanced diesels are cheaper. However, many car manufacturers continue to promote EVs heavily to ensure they meet the aggressive emissions reduction targets.

Medium EVs

- 2009 to 2014: Time lag before launch of medium EVs compared to small EVs. First launches occur in 2013 or 2014. Therefore negligible penetration of EVs by 2014. Advanced diesel technologies appear on the market during this time period and make a significant impact in terms of penetration.

- 2015 to 2018: Uptake begins to pick up as manufacture volumes rise, fruits of research spend help to reduce the price and upfront price support reduces marginal cost further. Penetration reaches 1% by 2018 - still lagging compared to small EVs. The majority of new medium cars are now equipped with advanced diesel technology (more than 60%) – diesel car penetration peaks in 2016, but drops only slightly after this.

- 2019 to 2022: Penetration of EVs accelerates gently after 2018 as infrastructure now has national coverage, marginal cost has reduced further and tougher emissions limit incentivises car companies to promote EVs ahead of advanced diesels or PHEVs. Penetration of EVs reaches 3% of medium cars by 2022. Impact of advanced diesel technology is felt strongly as up front price support ends and hence advanced diesels are cheaper. However, many car manufacturers continue to promote EVs heavily to ensure they meet the aggressive future emissions reduction targets.

Large EVs

- 2009 to 2014: Very limited penetration initially since despite upfront price support few large EVs have been launched due to high cost of batteries, and the high mileage associated with vehicles in this segment, which necessitates either rapid recharge or battery swap. 0% penetration (in practice, more than zero, but numbers so small that would be rounded to zero). Advanced diesel technologies appear on the market during this time period and make a significant impact in terms of penetration.

- 2015 to 2018: Upfront price support and fruits of research (which reduce price of batteries, rapid charge and battery swap technology) prompts car manufacturers launch large EVs. Low production volumes and preference for advanced diesels or PHEVs for this segment constrain penetration of EVs to 0.5%. The majority of new large cars (more than 75%) are now equipped with advanced diesel technology – diesel car penetration peaks in 2016, but drops only slightly after this.

- 2019 to 2022: EV production volumes increase but uptake still lags well behind small or medium EVs since consumers prefer advanced diesels where longer journeys are more common and hence less frequent refuelling saves times. EV penetration reaches 2% of large cars by 2022. Advanced diesel penetration assumed to be approximately 70% by 2022.

Small PHEVs

- No small PHEVs under development due to the cost of providing 2 power trains in the most price sensitive market segment so zero uptake through to 2018. Small PHEVs then begin to become available in relatively small numbers in the early 2020's.

Medium PHEVs

- 2009 to 2014: Very limited penetration initially since few medium EVs will have been launched by 2014. Advanced diesel technologies appear on the market during this time period and make a significant impact in terms of penetration.

- 2015 to 2018: Upfront price support reduces marginal cost to a manageable level and means consumers can recoup the price premium after a few years. Dual power source encourages early adopters to purchase medium PHEVs since patchy charging infrastructure not an issue. However, penetration constrained to 3% by limited manufacture volumes and strong competition from advanced diesels vehicles that are being promoted heavily by some manufacturers. The majority of new medium cars are now equipped with advanced diesel technology (more than 60%) – diesel car penetration peaks in 2016, but drops only slightly after this.

- 2019 to 2022: Uptake continues to grow and reaches 10% of new vehicles by 2022. However, penetration constrained by advanced diesels, which are perceived as a more reliable and trusted technology by some consumers. Impact of advanced diesel cars is felt strongly as up front price support ends and hence advanced diesels are significantly cheaper. However, many car manufacturers continue to promote EVs heavily to ensure they meet the aggressive future emissions reduction targets.

Large PHEVs

- 2009 to 2014: Very limited uptake due to lack of large mainstream PHEVs on the market - only sports cars and luxury cars available. 0% penetration (in practice, more than zero, but numbers so small that would be rounded to zero). Advanced diesel technologies appear on the market during this time period and make a significant impact in terms of penetration.

- 2015 to 2018: Uptake increases as more large PHEVs are launched. However, strong competition from advanced diesels erodes the natural niche for large PHEVs. Penetration limited to 2%. The majority of new large cars (more than 75%) are now equipped with advanced diesel technology – diesel car penetration peaks in 2016, but drops only slightly after this.

- 2019 to 2022: Penetration continues to ramp up post-2018 as tougher emissions limit incentivises car companies to promote PHEVs rather than advanced diesels for large cars. Large EVs are still perceived as too expensive due to the size of battery packs and lacking convenience due to need to regularly recharge or swap battery. PHEV penetration reaches 8% of large cars. Advanced diesel penetration assumed to be approximately 70% by 2022.

Summary of Penetration Rates in Scenario 4

Table 6.14: Car penetration rates in Scenario 4

Technology	2014	2018	2022
Small EVs	0.5%	2.0%	7.0%
Medium EVs	0.0%	1.0%	3.0%
Large EVs	0.0%	0.5%	2.0%
Small PHEVs	0.0%	0.0%	0.5%
Medium PHEVs	0.0%	3.0%	10.0%
Large PHEVs	0.0%	2.0%	8.0%

Full car penetration rates are detailed in Appendix 1.

6.6.2 Vans

Overview of Scenario 4

- During the course of 2009, the UK economy remains in recession (negative growth).
- Helped by efforts to tackle credit strains and by expansionary fiscal and monetary policies, the global economy experiences a gradual recovery in 2010. UK growth also turns positive during the course of 2010. The Green Recovery scenario assumes that Governments across the world provide co-ordinated fiscal stimulus packages with a significant element of investment in R&D for low carbon technologies across all sectors of the economy. Fiscal stimulus in the UK is assumed to be 4% of GDP, with 20% of this package focused on stimulus for low carbon technologies (across all sectors). These assumptions are in line with those proposed by the Grantham Research Institute and the Centre for Climate Change Economics and Policy in February 2009 (Bowen et al, 2009).
- The fiscal stimulus packages introduced by several advanced economies (including the UK) see the introduction of significant grants and loans (of the order of several billion pounds Sterling) to vehicle manufacturers to support medium term research to further develop EVs and PHEVs that will have an impact in the UK (the loans and grants will not be limited to UK companies).
- In addition to the Green recovery package of measures, the UK Government provides upfront price support to consumers who purchase EVs and PHEVs as detailed in Scenario 3.
- The upfront price support is not sufficient to cover the whole marginal cost. Government take the view that the marginal cost should be shared with the consumer, particularly given the fuel cost savings.
- Once launched, sales of PHEVs grow more quickly than EVs since they are more affordable and practical for 'green' businesses and consumers.
- Advanced diesel vehicles are promoted heavily by most van manufacturers who view them as a cheaper way of reducing CO_2 emissions.
- This has a significant impact on EV and PHEV sales as many van buyers prefer to stick with a derivative of a tried and tested technology.
- Sales of PHEVs are particularly affected as advanced diesels dominate the market for low CO_2 vans.
- Uptake of PHEVs and EVs in the vans segment is slightly ahead of large cars due to companies purchasing vans being more inclined to take account of the full life-cycle costs.
- It is assumed that no petrol PHEV vans are developed - petrol vans currently account for less than 2% of the new van market. On average commercial vehicle mileage is significantly higher than car mileage so it is more cost effective to purchase diesel vehicles (which are more fuel efficient) despite their small price premium.
- New van sales fall 50% in 2009 compared to 2008 (based on February 2009 SMMT year-to-date figures), a further 10% fall in 2010 and 25% increase in 2011 before gradually returning to previous projections in the transport MACC model by 2014.

Table 6.15: Projected change in van sales in Scenario 4

% Fall in van sales in 2009 vs 2008 SMMT figures	50%
% Fall in van sales in 2010 vs 2009	10%
% Fall in van sales in 2011 vs 2010	-25%

Assumptions in Scenario 4
Electric vans

- 2009 to 2014: Models priced at significant premium to conventional vans. However, upfront price support means EVs are much more affordable. Penetration limited to 1% by 2014 due to low production volumes and lack of charging infrastructure coverage. Advanced diesel technologies appear on the market during this time period, but do not make a significant impact due to the lack of European regulations to control van CO_2 emissions (conventional 'common rail' diesel engines continue to be used for the majority of vans).

- 2015 to 2018: Uptake begins to accelerate as manufacture volumes increase and charging infrastructure improves. Penetration reaches 3% as competition from advanced diesel still not significant. Electric vans and advanced diesel vans sit in slightly different segments - EVs will not be suitable for long journeys for the foreseeable future but could work well in niche markets such as vehicles that undertake regular short journeys e.g. postal delivery vans.

- 2019 to 2022: Penetration ramps up after 2018 as infrastructure now has national coverage and marginal cost has reduced further. The size of the niche market for regular short journeys begins to constrain growth, as does increased competition from advanced diesel technology. Penetration reaches 10%.

Plug-in hybrid vans

- 2009 to 2014: Virtually 0% penetration since very few if any PHEV vans launched by manufacturers (A PHEV version of the Mercedes Sprinter and the 'IDEA' van by the 'Bright' company are the only PHEV vans in development - neither has a fixed launch date). Advanced diesel technologies appear on the market during this time period, but do not make a significant impact due to the lack of European regulations to control van CO_2 emissions.

- 2015 to 2018: Upfront price support reduces marginal cost to a manageable amount and means consumers can recoup the price premium after a few years. Dual power source encourages early adopters to purchase PHEV vans since patchy charging infrastructure not an issue. However, penetration constrained to 2% by limited manufacture volumes and strong competition from advanced diesels that are being promoted heavily by some manufacturers and viewer as a more reliable technology by some consumers.

- 2019 to 2022: Despite competition from advanced diesels penetration continues to rise, all be it at a slower rate than GR + UPS, and reaches 8% of vans by 2022.

Table 6.16: Van Penetration Rates in Scenario 4

Technology	2014	2018	2022
Electric Vans	1.0%	3.0%	10.0%
Plug-in Hybrid Vans	0.0%	2.0%	8.0%

Full van penetration rates are detailed in Appendix 1.

6.7 Overall penetration rates for EVs, PHEVs and vans

This sub-section presents the overall penetration rates for each of the four scenarios described earlier in this section. Values are presented in absolute numbers as well as the overall percentage of new cars or vans purchased in the year in question.

It is important to note that the absolute number of vehicles is based on assumed new car and van sales of 2 million and 250,000 per year respectively. These figures will clearly change during the period in question and are not intended to be precise estimates. They merely serve to provide the reader with a feel for the scale of the number of vehicles in question and the relative changes in numbers of EVs and PHEVs as uptake increases. Finally, it is also important to bear in mind that the numbers presented in this section are annual rather than cumulative sales figures.

Table 6.17: Overall penetration rates for Scenario 1 – Severe Prolonged Recession

Technology	2014	2018	2022
Number of small EVs	0	3,276	13,103
Number of medium EVs	0	0	10,719
Number of large EVs	0	1,365	5,459
TOTAL EV sales	**0**	**4,641**	**29,281**
% of Total car sales	**0.0%**	**0.2%**	**1.5%**
Number of small PHEVs	0	0	0
Number of medium PHEVs	0	10,719	32,157
Number of large PHEVs	0	1,365	5,459
TOTAL PHEV sales	**0**	**12,084**	**37,616**
% of Total car sales	**0.0%**	**0.6%**	**1.9%**
TOTAL EV van sales	**0**	**1,250**	**7,500**
% of Total van sales	**0.0%**	**0.5%**	**3.0%**
TOTAL PHEV vans sales	**0**	**2,500**	**10,000**
% of Total van sales	**0.0%**	**1.0%**	**4.0%**
Assumed TOTAL new car sales per year	**2,000,000**	**2,000,000**	**2,000,000**
Assumed TOTAL new van sales per year	**250,000**	**250,000**	**250,000**

Table 6.18: Overall penetration rates for Scenario 2 – Green Recovery

Technology	2014	2018	2022
Number of small EVs	0	6,552	26,207
Number of medium EVs	0	5,359	21,438
Number of large EVs	0	1,365	5,459
TOTAL EV CARS	**0**	**13,276**	**53,103**
% of Total car sales	**0.0%**	**0.7%**	**2.7%**
Number of small PHEVs	0	0	3,276
Number of medium PHEVs	0	21,438	53,595
Number of large PHEVs	0	2,729	10,917
TOTAL PHEV CARS	**0**	**24,167**	**67,788**
% of Total car sales	**0.0%**	**1.2%**	**3.4%**
TOTAL EV VANS	**0**	**2,500**	**12,500**
% of Total van sales	**0.0%**	**1.0%**	**5.0%**
TOTAL PHEV VANS	**0**	**5,000**	**17,500**
% of Total van sales	**0.0%**	**2.0%**	**7.0%**
Assumed TOTAL new car sales per year	**2,000,000**	**2,000,000**	**2,000,000**
Assumed TOTAL new van sales per year	**250,000**	**250,000**	**250,000**

Table 6.19: Overall penetration rates for Scenario 3 – Green Recovery + Upfront Price Support

Technology	2014	2018	2022
Number of small EVs	3,276	13,103	65,516
Number of medium EVs	0	10,719	53,595
Number of large EVs	0	2,729	8,188
TOTAL EV CARS	**3,276**	**26,552**	**127,299**
% of Total car sales	**0.2%**	**1.3%**	**6.4%**
Number of small PHEVs	0	0	6,552
Number of medium PHEVs	0	42,876	160,785
Number of large PHEVs	0	8,188	32,752
TOTAL PHEV CARS	**0**	**51,064**	**200,089**
% of Total car sales	**0.0%**	**2.6%**	**10.0%**
TOTAL EV VANS	**2,500**	**7,500**	**30,000**
% of Total van sales	**1.0%**	**3.0%**	**12.0%**
TOTAL PHEV VANS	**0**	**5,000**	**37,500**
% of Total van sales	**0.0%**	**2.0%**	**15.0%**
Assumed TOTAL new car sales per year	**2,000,000**	**2,000,000**	**2,000,000**
Assumed TOTAL new van sales per year	**250,000**	**250,000**	**250,000**

Table 6.20: Overall penetration rates for Scenario 4 – Green Recovery + Upfront Price Support + Increased Competition from Advanced Diesel

Technology	2014	2018	2022
Number of small EVs	3,276	13,103	45,861
Number of medium EVs	0	10,719	32,157
Number of large EVs	0	1,365	5,459
TOTAL EV CARS	**3,276**	**25,187**	**83,477**
% of Total car sales	**0.2%**	**1.3%**	**4.2%**
Number of small PHEVs	0	0	3,276
Number of medium PHEVs	0	32,157	107,190
Number of large PHEVs	0	5,459	21,835
TOTAL PHEV CARS	**0**	**37,616**	**132,301**
% of Total car sales	**0.0%**	**1.9%**	**6.6%**
TOTAL EV VANS	**2,500**	**7,500**	**25,000**
% of Total van sales	**1.0%**	**3.0%**	**10.0%**
TOTAL PHEV VANS	**0**	**5,000**	**20,000**
% of Total van sales	**0.0%**	**2.0%**	**8.0%**
Assumed TOTAL new car sales per year	**2,000,000**	**2,000,000**	**2,000,000**
Assumed TOTAL new van sales per year	**250,000**	**250,000**	**250,000**

6.8 Comparison of CCC 2008 scenarios and AEA scenarios

This section will compare the ‘ambition’, ‘extended ambition’ and ‘stretch’ scenarios presented in CCC’s 2008 ‘Building a low carbon economy’ report to Government. These scenarios are defined as follows in the Building a low carbon economy report (the definition applying to all sectors of the economy as opposed to specifically to the transport sector):

- ***The Current Ambition scenario*** *includes identified measures which would cost less per tonne than our forecast carbon price12, and/or which are covered by policies already in place; the scenario includes cautious estimates of emission reductions from these measures. It also includes significant progress towards low-carbon electricity generation and some progress on improving fuel efficiency in new cars.*

- ***The Extended Ambition scenario*** *incorporates more ambitious but still reasonable assumptions on the penetration of energy efficiency improvements and a number of measures which would cost appreciably more per tonne of carbon abated than our forecast carbon price, but which are important stepping stones on the path to 2050. It is broadly in line with policies to which the government is committed in principle, but where precise definition and implementation of policy is still required. It includes, for instance, a significant penetration of renewable heat, more ambitious energy efficiency improvement in cars, and some lifestyle changes in home and transport.*

- ***The Stretch Ambition*** *scenario adds further feasible abatement opportunities for which at the moment no policy commitment is in place, including more radical new technology deployment and more significant lifestyle adjustments.*

A summary of these scenarios in terms of penetration rates for EVs and PHEVs can be found the following tables, along with comparison tables for the four new scenarios developed during this study.

6.8.1 Comparison of CCC 2008 and AEA scenarios for small cars

Table 6.21: CCC small car penetration rates for EVs and PHEVs

CCC Scenario	Vehicle type	2014	2018	2022
Current ambition	EV	0.00%	0.00%	0.00%
	PHEV	0.00%	0.00%	0.00%
Extended ambition	EV	6.00%	15.60%	30.00%
	PHEV	0.00%	0.00%	0.00%
Stretch	EV	6.00%	15.60%	30.00%
	PHEV	0.00%	0.00%	0.00%

Table 6.22: Small car penetration rates for EVs and PHEVs in the four new scenarios

CCC Scenario	Vehicle type	2014	2018	2022
Scenario 1 - Severe protracted recession	EV	0.00%	0.50%	2.00%
	PHEV	0.00%	0.00%	0.00%
Scenario 2 - Green recovery	EV	0.00%	1.00%	4.00%
	PHEV	0.00%	0.00%	0.00%
Scenario 3 - Green recovery + upfront price support	EV	0.50%	2.00%	10.00%
	PHEV	0.00%	0.00%	0.00%
Scenario 4 - Green recovery + upfront price support + competition from advanced diesel technology	EV	0.50%	2.00%	7.00%
	PHEV	0.00%	0.00%	0.00%

6.8.2 Comparison of CCC 2008 and AEA scenarios for medium cars

Table 6.23: CCC Penetration rates for Medium Cars

CCC Scenario	Vehicle type	2014	2018	2022
Current ambition	EV	0.00%	0.00%	0.00%
	PHEV	0.00%	0.00%	0.00%
Extended ambition	EV	1.20%	4.40%	10.00%
	PHEV	1.96%	7.20%	20.00%
Stretch	EV	1.20%	4.40%	10.00%
	PHEV	1.96%	7.20%	20.00%

Table 6.17: Medium car penetration rates for EVs and PHEVs in the four new scenarios

CCC Scenario	Vehicle type	2014	2018	2022
Scenario 1 - Severe protracted recession	EV	0.00%	0.00%	1.00%
	PHEV	0.00%	1.00%	3.00%
Scenario 2 - Green recovery	EV	0.00%	0.50%	2.00%
	PHEV	0.00%	2.00%	5.00%
Scenario 3 - Green recovery + upfront price support	EV	0.00%	1.00%	5.00%
	PHEV	0.00%	4.00%	15.00%
Scenario 4 - Green recovery + upfront price support + competition from advanced diesel technology	EV	0.00%	1.00%	3.00%
	PHEV	0.00%	3.00%	10.00%

6.8.3 Comparison of CCC 2008 and AEA scenarios for large cars

Table 6.18: CCC Penetration rates for Large Cars

CCC Scenario	Vehicle type	2014	2018	2022
Current ambition	EV	0.00%	0.00%	0.00%
	PHEV	0.00%	0.00%	0.00%
Extended ambition	EV	0.20%	2.00%	8.00%
	PHEV	1.60%	6.40%	16.00%
Stretch	EV	0.20%	2.00%	8.00%
	PHEV	1.60%	6.40%	16.00%

Table 6.19: Large car penetration rates for EVs and PHEVs in the four new scenarios

CCC Scenario	Vehicle type	2014	2018	2022
Scenario 1 - Severe protracted recession	EV	0.00%	0.50%	2.00%
	PHEV	0.00%	0.50%	2.00%
Scenario 2 - Green recovery	EV	0.00%	0.50%	2.00%
	PHEV	0.00%	1.00%	4.00%
Scenario 3 - Green recovery + upfront price support	EV	0.00%	1.00%	3.00%
	PHEV	0.00%	3.00%	12.00%
Scenario 4 - Green recovery + upfront price support + competition from advanced diesel technology	EV	0.00%	0.50%	2.00%
	PHEV	0.00%	2.00%	8.00%

6.8.4 Comparison of CCC 2008 and AEA scenarios for vans

Table 6.20: CCC Penetration rates for Vans

CCC Scenario	Vehicle type	2014	2018	2022
Current ambition	EV	0.00%	0.00%	0.00%
	PHEV	0.00%	0.00%	0.00%
Extended ambition	EV	0.00%	0.00%	0.00%
	PHEV	0.00%	0.00%	0.00%
Stretch	EV	5.80%	12.00%	20.00%
	PHEV	0.86%	3.20%	8.00%

Table 6.21: Van penetration rates for EVs and PHEVs in the four new scenarios

CCC Scenario	Vehicle type	2014	2018	2022
Scenario 1 - Severe protracted recession	EV	0.00%	0.50%	3.00%
	PHEV	0.00%	1.00%	4.00%
Scenario 2 - Green recovery	EV	0.00%	1.00%	5.00%
	PHEV	0.00%	2.00%	7.00%
Scenario 3 - Green recovery + upfront price support	EV	1.00%	3.00%	12.00%
	PHEV	0.00%	2.00%	15.00%
Scenario 4 - Green recovery + upfront price support + competition from advanced diesel technology	EV	1.00%	3.00%	10.00%
	PHEV	0.00%	2.00%	8.00%

In terms of EVs and PHEVs the CCC's 2008 'Current Ambition' scenario corresponds to AEA's business as usual scenario from the original MACC model (compiled by AEA on behalf of CCC) in that there is no uptake of either technology in any year between 2009 and 2022. The rationale for this is that there will be no significant uptake of EVs or PHEVs over this time period unless there is an aggressive policy framework in place to specifically support their uptake. Whilst the 130g/km CO_2 emissions limit for cars and proposed 95g/km CO_2 limit will undoubtedly reduce the carbon intensity of road transport (assuming the targets are met or progress is made towards them) they will not be sufficient on their own to stimulate significant uptake of EVs and PHEVs. This is because both these emissions limits can be met with advanced gasoline and diesel technologies, which will be significantly cheaper than EVs and PHEVs. Furthermore, putting in place recharging infrastructure with sufficient geographical coverage, which is widely seen as a pre-requisite for significant uptake, will need support and leadership from Government. However, it should be noted that none of the four new scenarios presented in this section share this conservative view; they all assume additional policy interventions will be put in place and hence some level of uptake of EVs and PHEVs by 2022.

On the other hand the CCC's 2008 'Extended Ambition' and 'Stretch' scenarios (which are one and the same for cars and were therefore intended as an upper bound of what could be feasibly achieved) are very likely to be too ambitious for passenger car EVs in the short term. Even the most optimistic of the four new scenarios (Scenario 3: Green Recovery + Upfront Price Support) assumes very little uptake between 2009 and 2014. This is driven by the fact that very few manufacturers will have passenger car EVs in large-scale volume production during this period. The Mitsubishi i-MiEV, which will probably be the first mass market EV to be sold in the UK, should reach global manufacture volumes of 10,000 by 2011 if everything proceeds as planned. Assuming the UK continues to get 10% of global production this would be a mere 1,000 vehicles or around 0.05% of new car sales (assuming annual car sales of 2 million). Other manufacturers will have EVs on the market by 2012, but annual sales volumes of each model in the UK before 2014 are likely to be very low indeed, in the order of a few hundred.

Passenger car EV penetration rates in the 'Extended Ambition' and 'Stretch' scenarios also appear to be too optimistic for the 2015 to 2018 and 2019 to 2022 periods. The difference between the two sets of scenarios is particularly stark for small cars. The CCC 2008 Extended Ambition and Stretch scenarios anticipate that EVs will make up 15.6% of new cars in 2018 and 30% in 2022. In contrast, AEA's most optimistic scenario estimates 2% and 10% respectively. It is highly unlikely that car manufacturers would be sufficiently down the development lifecycle to scale-up production to that extent by 2018 and 2022. For example, if it were assumed that 2 million new cars would be sold in 2018 (a conservative estimate) then 15.6% of small cars would equate to around 102,000 vehicles. According to the definition employed in this study and others studies by TNO, electric vehicles would therefore be in mass production. AEA's scenarios for EVs are broadly consistent with the recently publish NAIGT roadmap, which anticipates that EVs could become a mass-market technology by the 2020's.

Whilst there is a significant discrepancy between the two sets of scenarios for EV cars, there is a closer level of correlation for PHEVs. The CCC 2008 scenarios are still more aggressive than AEA's scenarios but the gap is more modest. For instance, for medium cars in 2014, 2018 and 2022 the CCC's Extended Ambition and Stretch scenarios anticipate an uptake of 1.96%, 7.2% and 20% respectively compared to AEA's estimates of 0%, 4% and 15%. There is a similar trend for large PHEV cars.

The CCC 2008 scenarios and the four new scenarios are all in agreement that there will be no small car PHEVs on the market for the foreseeable future and hence penetration will be negligible right up to 2022. The small car market is highly price competitive so the additional cost of providing dual powertrains is not viable. In contrast, there is more scope to absorb these additional costs in larger cars. However, it should be noted that it is possible that in the next five to ten years, technological developments or an alternative policy framework may mean that small PHEV cars become economically viable.

There is some correlation between the CCC's 2008 Stretch scenario and AEA's most ambitious scenario (scenario 3). Both scenarios agree that there will be negligible uptake in 2014. However, they take different opinions for the growth between 2014 and 2018. Whilst AEA's scenario 3 takes a conservative view, anticipating that 2% of new vans will be PHEVs by 2018, the CCC Stretch scenario assume a far higher 12% of new vans being plug-in hybrids. The gaps narrows by 2022 with the AEA and CCC scenarios estimating uptake of PHEVs to be 15% and 20% of new vans respectively. Once again the CCC Stretch seems rather ambitious as it would require production to jump from virtually zero in 2014 to 15% of new vans in 2018 (37,500 vehicles per year). Furthermore, persuading the market to purchase that many vehicles will also prove very challenging. That said, the barriers to purchasing a PHEV are lower due to fuel-flexibility. Consequently, the lack of a widespread charging infrastructure ceases to be an issue since a PHEV would be able to re-charge where facilities allow and behave like a normal van on other occasions.

In summary, the CCC's 2008 Extended ambition and Stretch scenarios are much more ambitious than AEA's most optimistic scenario. These scenarios were intended to provide an upper bound of possible take-up, but unless there is a radical change to the policy framework supporting the introduction of EVs/PHEVs to persuade carmakers to ramp up production dramatically, it seems highly unlikely that they will be met. On the other hand the CCC 2008 Current ambitious scenario look rather conservative in assuming no penetration of either EVs or PHEVs by 2020. All the AEA scenarios assume additional policy interventions will be put in place and hence some level of uptake of EVs and PHEVs by 2022.

6.9 Constraints on early uptake of EVs and PHEVs

Much of the analysis undertaken to compile the scenarios focussed on the availability of EVs and PHEVs and the impact this would have on penetration rates pre-2014. However, it is important to note that there are a variety of other factors that will influence the short-term uptake of EVs and PHEVs. Element Energy, who were commissioned by CCC to undertake a separate EV study (focussing more on charging infrastructure, charging regimes and impact on the Grid) and one of the external experts retained by CCC both agreed that a lack of charging infrastructure would be a key barrier in the short term. In their view the absence of either a widespread public charging infrastructure or a charging infrastructure at workplaces would limit uptake to urban commuters with off-street parking who could plug in at home and perhaps light duty delivery vehicles. This clearly has implications for the overall penetration rates outlined in the scenarios.

That said, the scenarios would appear to be consistent with theses conclusions. Even the most optimistic scenario in 2014 and 2018 only assumes 0.2% and 1.3% uptake of EVs across all car sizes. The outlook for PHEVs is similarly conservative at 0% (rounded to 0% - in practice there will be a small number on the road) and 2.6% in 2014 and 2018 respectively. It is only post-2018 that penetration rates are expected to ramp up more steeply.

7 Key Messages

This section presents the key messages from each of the main sections of the report.

7.1 Automotive manufacturer's strategies and planned EV developments

- The EV and PHEV market is evolving rapidly with announcements on a very regular (almost daily basis)
- Many early EVs are likely to be small cars since their lower mass means smaller (and hence) cheaper batteries are required.
- There are currently no small PHEVs in development although it is thought such vehicles will be developed by 2022. The dual powertrain, which characterises PHEVs, is not currently commercially viable for small cars where price is a key differentiator.
- Aside from Ford, none of the mainstream manufacturers have announced that they are working on medium EVs. This could be due to battery cost concerns for what can be a very price sensitive segment, particularly for fleet vehicles. Manufacturers may also be waiting to test EVs on niche segments (e.g. small cars and sports cars) before choosing to develop EVs for their highest selling segment.
- Several companies are developing medium PHEVs, which are viewed as a more commercial proposition than EVs, pre-2022. Smaller batteries reduce the marginal capital cost and the range extending petrol or diesel engine negates the need for a widespread infrastructure.
- Most vehicles in the large car segment (which includes sports cars) are marketed at high earners and/or early adopters of technologies so in principle they are well suited for early EVs.
- A significant number of large electric cars are already available or will become available in the next couple of years. That said, the absolute number of large EVs sold is likely to be relatively modest since they only make up 14% of new car sales.
- A number of large manufacturers have announced their intention to develop large PHEVs, which reflects the growing belief that PHEVs will act as a bridging technology between conventional power trains and EVs. That said, some manufacturers (such as Toyota) argue that PHEVs are a significant technology in their own right and should not be viewed as a stepping-stone.
- There are several ranges of electric vans already available for purchase from specialist EV van manufacturers. Larger manufacturers such as Ford and Chrysler also recently announced new models.
- Aside from niche low-range applications HGVs are not well suited to electric only operation. The size and cost of the battery packs and a lack of widespread charging infrastructure are key barriers. Consequently, the largest HGV available is 12tonne gross vehicle weight.

7.2 Advanced diesels

- Advanced diesels will present strong competition for EVs and PHEVs over the coming years. All the major manufacturers are launching more efficient diesel cars and vans based on engine downsizing and technologies such as sequential turbocharging and common rail diesel fuel injection.
- That said, whilst diesel penetration is likely to grow over the coming years before peaking in the middle of the next decade. A key constraint will be a shortage of diesel refinery capacity –

Europe is already a net importer. Increased competition from advanced petrol engines will also be a factor.

- Several manufacturers such as VW and SEAT currently brand small advanced diesel cars as 'eco-cars'. Over the next few years, it is anticipated that small diesel cars with CO_2 emissions performance below 100 g/km will become the norm, and potentially by 2022, average CO_2 emissions from small cars could drop below 80g/km.
- In a similar vein to small cars, medium advanced diesels currently occupy an eco-car niche. It is anticipated that many more medium cars will be able to attain a CO_2 emissions performance of lower than 120 g/km in the next couple of years. Based on aggressive annual CO_2 emissions improvement rates of 3.5%, medium advanced diesels should be able to get close to hitting the proposed 95g/km limit for new cars in 2020.
- There is a stark contrast between diesel penetrations within large car sub-segments. For instance, 78% of executive saloons and 83% of 4x4's purchased in 2008 were diesel powered. In contrast only 12% of new sport cars were diesels.
- The use of eco-branding is not nearly so prevalent in the large advanced diesel segment. That said, it is anticipated that all the same advanced diesel technologies will still to be applied. Based on aggressive annual CO_2 emissions improvement rates of 3.5% an average new diesel large car would have emissions of 122 gCO_2/km in 2022

7.3 New business models to encourage the uptake of EVs and PHEVs

- Due to the high up front costs of electric vehicles and the perceived technology risk, alternative business models are likely to be required to encourage their uptake. Both these issues arise from the use of costly and unproven (in a vehicle context) li-ion batteries in the next generation of EVs.
- A number of electric vehicle manufacturers (e.g. Th!nk) are pursuing a strategy based around battery leasing. By retaining liability for the battery the manufacturer are committed to replacing it if its performance is sub-optimal. This removes a significant element of the financial risk for consumers. It also solves the problem of how to value the residual life of the battery at resale given that most battery technologies' performance deteriorates with use. The monthly fee for leasing the batteries could simply switch from the original owner to the new owner. A further benefit to the consumer is that it allows the manufacturer to take advantage of any improvements in battery technology when the batteries are eventually replaced.
- The business model for Better Place is based around offering mobile phone-style transportation contracts. To cater for different customer segments, Better Place plans to offer a range of EV models via a subscription pricing packages that will provide access to the network of charging points and battery swap stations. The company plans to own the charging points and battery swap stations as well as the car batteries, which will be considered part of the Better Place Network. Both the mobile phone style contract and battery swap station elements of the business model introduce a great deal of flexibility for consumers, which is a weakness of many of the other business models.
- The natural extension to battery leasing is to use a vehicle leasing business model to further reduce risk and minimise upfront costs. Vehicle leasing is currently being pursued by Mitsubishi as the initial business model for the i-MiEV electric small car, which is due to become available in the UK by the end of 2009.
- In the short term the car club business model could be a viable means of introducing the public to electric vehicle technology. In addition, it could provide added value in terms of promoting EVs and PHEVs. Indeed, it could be a means of allowing consumers to test EVs and PHEVs in real world conditions for a few weeks without the need to make a major financial commitment. Furthermore, the sight of EVs and PHEVs being driven around would raise their profile, especially given that car club cars are utilised far more heavily on average

than conventionally owned vehicles. That said, that apart from Th!nk, there does not seem to be an appetite amongst manufacturers to use the car club model as a way of encouraging the uptake of EVs or PHEVs.

7.4 Upfront price support to encourage the uptake of EVs and PHEVs

- One of the key barriers to the uptake of EVs and PHEVs is the purchase cost of vehicles. The issue is the battery cost, which is the most significant influence on the overall vehicle price. Battery costs are currently high, and are largely determined by the cost of the electrode materials50 with a contribution from development, production and shipping.
- A number of national governments in Europe and both federal and state Governments in the USA have already introduced financial support packages to help stimulate the early uptake of EVs and PHEVs.
- In the April 2009 Budget, the UK Government has also announced that from 2011, financial incentives will be offered to people purchasing electric and plug-in hybrid electric vehicles in this country. These incentives will range from £2,000 to £5,000, but at this point in time no further details of how the scheme will operate are available. These amounts are broadly in line with the support being offered in the US and other European states.
- The view from SMMT and its members is that up-front price support could be the level of support required to sell a certain number of units annually, or to sell a planned annual manufacturing capacity. They felt that although marginal cost is an indicator of what the potential price-support could be, the longer-term lower running costs implies that the up-front support required would be significantly less than this marginal cost over conventional vehicles.
- Unless marginal capital costs reduce significantly in the next couple of years many consumers and businesses may find it difficult to justify purchasing an EV or PHEV even taking account the Government's financial support.
- An alternative structure for upfront price support is proposed in Scenario 3:
    - £10k for the first 25,000 vehicles sold
    - £7.5k for the 25,000th to 50,000th vehicles sold
    - £5k for the 50,000 to 100,000 vehicles sold
    - £2.5k for the 100,000th to 150,000th vehicles sold

  This tapered structure would aim to get EVs to mass manufacture (assumed to 100,000) units as quickly as possible and provide limited support thereafter to prevent demand suddenly falling away. Whilst it would cost between £850m and £900m depending on the administration costs it ought to ensure the initial 'sales inertia' is overcome. There is a risk associated with the £2k to £5k scheme proposed by Government that EVs and PHEVs may never gain a foothold in the market.

7.5 Actions to create a favourable investment climate in EV and PHEV technologies

- There are a number of ways in which Government could create a favourable investment climate for EV and PHEV technologies:
    - National Government policy statements;

[50] Most current lithium-ion batteries use nickel cobalt aluminium cathodes, which are expensive, but offer good energy density performance. Forthcoming cathode materials such as lithium iron phosphate are cheaper and are likely to contribute to battery cost reductions.

- Regulatory pressures;
- Government-backed R&D funding programmes;
- Government-backed demonstration and commercialisation programmes.

- The UK Government and/or the European Commission are taking action in all of these areas. Of particular interest is the New Automotive Innovation and Growth Team (NAIGT) set up by BERR. They recently made the following recommendations regarding low carbon vehicles, which is a consensus view of the automotive industry:
  - Create a leadership team to develop future automotive strategy in the UK (Government/senior industry figures);
  - Establish 'Test Bed UK' which is defined by the NAIGT as "a demonstrator to act as a powerful catalyst for change through demonstrating, experimenting and building the new low-carbon personal transportation system including its infrastructure[51]"
  - Release and maintain roadmaps and research agendas to focus funding spend and collaboration;
  - Establish Government funding mechanism to support product development and industrialisation phase of R&D;
  - Evaluate new emissions test procedures based on well-to-wheels methodology, and energy focused rather than current tank-to-wheel approach to quantifying CO_2 emissions from vehicles[52].

7.6 Scenarios for uptake of EVs and PHEVs

The scenarios are set out in detail in Section 6 of the report so there is little value in repeating them here. However, certain key themes can be taken from scenarios:

- Uptake of EVs and PHEVs will be very limited without upfront price support
- Uptake of PHEVs will occur faster than EVs due to their greater fuel flexibility and lower cost.
- Even under the more optimistic scenarios EVs and PHEVs are unlikely to reach mass production (defined at 100,000 units sold) until the early 2020's.
- Achieving high levels of EV and PHEV uptake will require a high degree of cooperation between local and national Government. Softer, local measures such as access to bus lanes, free parking and the provision of a widespread charging infrastructure will be need alongside central Government initiatives such as upfront price support.
- The launch of advanced diesels will affect the uptake of EVs and PHEVs in the short to medium term.
- However, advanced diesels will only be able to reduce GHG emissions so far. The deepest cut in transport GHG emissions can only be achieved by EVs.

[51] http://www.berr.gov.uk/files/file50539.pdf
[52] http://www.berr.gov.uk/files/file50300.pdf

Appendices

Appendix 1: Scenarios 1 to 4 – Full Uptake Rates

Appendix 1

Scenarios 1 to 4 – Full annual uptake rates (as a percentage of new car sales in that year) for each technology considered by the transport MACC

Scenario 1 – Severe Protracted Recession
Small Cars
Medium Cars
Large Cars
Vans

Scenario 2 – Green Recovery
Small Cars
Medium Cars
Large Cars
Vans

Scenario 3 – Green Recovery + Upfront Price Support
Small Cars
Medium Cars
Large Cars
Vans

Scenario 4 – Green Recovery + Upfront Support + Strong Competition from Advanced Diesel
Small Cars
Medium Cars
Large Cars
Vans

Scenario 1 – Severe Protracted Recession (Small Cars)

SMALL CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	59.0%	59.0%	55.3%	51.6%	47.9%	44.2%	35.5%	26.8%	18.0%	9.2%	0.4%	0.5%	0.4%	0.3%	0.1%	0.0%
1st gen advanced petrol engine	24.6%	24.6%	24.6%	24.6%	24.6%	24.6%	19.7%	14.8%	9.8%	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.8%	0.6%	0.4%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.2%	0.2%	3.9%	7.6%	11.3%	15.0%	29.0%	43.0%	56.9%	70.9%	84.9%	85.4%	85.9%	86.4%	86.9%	87.4%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	14.6%	14.6%	13.3%	11.9%	10.6%	9.2%	7.4%	5.5%	3.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	1.4%	2.7%	4.1%	5.4%	7.2%	9.0%	10.8%	12.6%	14.4%	13.6%	12.9%	12.1%	11.4%	10.6%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.9%	1.3%	1.6%	2.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 1 – Severe Protracted Recession (Medium Cars)

MEDIUM CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	35.0%	35.0%	30.9%	26.7%	22.6%	18.3%	15.6%	13.0%	10.1%	7.2%	4.3%	3.8%	2.9%	1.9%	0.9%	0.0%
1st gen advanced petrol engine	15.0%	15.0%	13.8%	12.5%	11.3%	10.0%	8.0%	6.0%	4.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	2.9%	2.9%	3.4%	3.9%	4.5%	5.0%	4.0%	3.0%	2.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	13.3%	16.6%	19.9%	23.2%	26.5%	21.2%	15.9%	10.6%	5.3%	0.0%
Mild Hybrid - petrol engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%	10.6%	11.2%	11.8%	12.4%	13.0%
Full hybrid - petrol engine	0.4%	0.4%	1.5%	2.7%	3.8%	5.0%	7.0%	9.0%	11.0%	13.0%	15.0%	18.8%	22.6%	26.4%	30.2%	34.0%
Plug-in hybrid - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.8%	1.0%	1.3%	1.5%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	46.7%	46.7%	44.1%	41.5%	38.9%	36.3%	29.0%	21.8%	14.5%	7.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	13.3%	16.6%	19.9%	23.2%	26.5%	21.2%	15.9%	10.6%	5.3%	0.0%
Mild Hybrid - diesel engine	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	1.6%	2.9%	4.3%	5.6%	7.0%	8.6%	10.2%	11.8%	13.4%	15.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	2.2%	4.1%	6.1%	8.0%	10.0%	14.8%	19.6%	24.4%	29.2%	34.0%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.8%	1.0%	1.3%	1.5%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 1 – Severe Protracted Recession (Large Cars)

LARGE CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	19.0%	19.0%	16.0%	13.0%	10.0%	7.0%	6.5%	6.0%	5.2%	4.5%	3.7%	3.4%	2.5%	1.7%	0.9%	0.0%
1st gen advanced petrol engine	15.0%	15.0%	13.8%	12.5%	11.3%	10.0%	8.0%	6.0%	4.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	4.8%	4.8%	7.3%	9.9%	12.4%	15.0%	12.0%	9.0%	6.0%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	2.2%	2.4%	2.6%	2.8%	3.0%	2.4%	1.8%	1.2%	0.6%	0.0%
Mild Hybrid - petrol engine	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	3.8%	6.6%	9.4%	12.2%	15.0%	13.4%	11.8%	10.2%	8.6%	7.0%
Full hybrid - petrol engine	1.2%	1.2%	2.1%	3.1%	4.0%	5.0%	8.0%	11.0%	14.0%	17.0%	20.0%	23.4%	26.8%	30.2%	33.6%	37.0%
Plug-in hybrid - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.6%	0.8%	1.0%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	60.1%	60.1%	59.4%	58.8%	58.2%	57.6%	50.0%	42.4%	34.8%	27.2%	19.6%	15.6%	11.7%	7.8%	3.9%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	2.2%	2.4%	2.6%	2.8%	3.0%	2.4%	1.8%	1.2%	0.6%	0.0%
Mild Hybrid - diesel engine	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	3.4%	6.3%	9.2%	12.1%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	8.0%	12.0%	16.0%	20.0%	23.4%	26.8%	30.2%	33.6%	37.1%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.6%	0.8%	1.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.9%	1.3%	1.6%	2.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 1 – Severe Protracted Recession (Vans)

VANS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
1st gen advanced petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	97.6%	97.6%	96.4%	95.1%	93.8%	92.5%	87.9%	83.4%	78.4%	73.5%	68.5%	50.1%	36.0%	21.9%	7.7%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	9.0%	13.0%	17.0%	21.0%	25.0%	41.3%	51.5%	61.6%	71.8%	75.9%
Mild Hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	0.6%	0.8%	1.0%	1.6%	2.2%	2.8%	3.4%	4.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.5%	0.9%	1.2%	1.6%	2.0%	3.2%	4.4%	5.6%	6.8%	8.0%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	2.5%	4.0%	5.5%	7.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	1.1%	1.8%	2.4%	3.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.3%**
Percentage petrol	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*	*2.4%*
Percentage diesel	*97.6%*	*97.6%*	*97.6%*	*97.6%*	*97.6%*	*97.6%*	*97.6%*	*97.6%*	*97.5%*	*97.4%*	*97.3%*	*97.1%*	*96.5%*	*95.9%*	*95.3%*	*94.9%*
Percentage electric	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.1%*	*0.3%*	*0.4%*	*0.5%*	*1.1%*	*1.8%*	*2.4%*	*3.0%*
Additive technologies																
Improved aerodynamics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low rolling resistance tyres	0.0%	0.0%	3.8%	7.5%	11.3%	15.0%	22.0%	29.0%	36.0%	43.0%	50.0%	55.0%	60.0%	65.0%	70.0%	75.0%
Gearshift indicators	0.0%	0.0%	2.0%	4.0%	6.0%	8.0%	14.4%	20.8%	27.2%	33.6%	40.0%	44.0%	48.0%	52.0%	56.0%	60.0%

Scenario 2 – Green Recovery (Small Cars)

SMALL CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	59.0%	59.0%	55.3%	51.6%	47.9%	44.2%	35.5%	26.8%	17.9%	8.9%	0.0%	0.4%	0.3%	0.2%	0.1%	0.0%
1st gen advanced petrol engine	24.6%	24.6%	24.6%	24.6%	24.6%	24.6%	19.7%	14.8%	9.8%	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.8%	0.6%	0.4%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.2%	0.2%	4.2%	8.1%	11.6%	15.0%	29.0%	43.0%	56.9%	70.9%	84.9%	85.0%	85.1%	85.2%	85.3%	85.4%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	14.6%	14.6%	13.3%	11.9%	10.6%	9.2%	7.4%	5.5%	3.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	1.4%	2.7%	4.1%	5.4%	7.2%	9.0%	10.8%	12.6%	14.4%	13.6%	12.9%	12.1%	11.4%	10.6%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	1.8%	2.5%	3.3%	4.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.3%**	**100.5%**	**100.3%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 2 – Green Recovery (Medium Cars)

MEDIUM CARS	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Conventional petrol engine	35.0%	35.0%	30.9%	26.7%	22.6%	18.3%	16.2%	14.2%	11.5%	7.8%	6.1%	5.5%	4.4%	3.3%	2.1%	1.0%
1st gen advanced petrol engine	15.0%	15.0%	13.8%	12.5%	11.3%	10.0%	8.0%	6.0%	4.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	2.9%	2.9%	3.4%	3.9%	4.5%	5.0%	4.0%	3.0%	2.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	13.0%	16.0%	19.0%	22.0%	25.0%	20.0%	15.0%	10.0%	5.0%	0.0%
Mild Hybrid - petrol engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%	10.6%	11.2%	11.8%	12.4%	13.0%
Full hybrid - petrol engine	0.4%	0.4%	1.5%	2.7%	3.8%	5.0%	7.0%	9.0%	11.0%	13.0%	15.0%	18.5%	22.0%	25.5%	29.0%	32.5%
Plug-in hybrid - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	1.4%	1.8%	2.1%	2.5%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	46.7%	46.7%	44.1%	41.5%	38.9%	36.3%	29.0%	21.8%	14.5%	7.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	13.0%	16.0%	19.0%	23.0%	25.0%	20.0%	15.0%	10.0%	5.0%	0.0%
Mild Hybrid - diesel engine	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	1.6%	2.9%	4.3%	5.6%	7.0%	8.1%	9.2%	10.3%	11.4%	12.5%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	2.2%	4.1%	6.1%	8.0%	10.0%	14.8%	19.6%	24.4%	29.2%	34.0%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	1.4%	1.8%	2.1%	2.5%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.9%	1.3%	1.6%	2.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 2 – Green Recovery (Large Cars)

LARGE CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	19.0%	19.0%	18.9%	18.7%	18.6%	18.3%	15.5%	12.8%	9.6%	6.5%	3.4%	3.3%	2.5%	1.6%	0.8%	0.0%
1st gen advanced petrol engine	15.0%	15.0%	13.8%	12.5%	11.3%	10.0%	8.0%	6.0%	4.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	4.8%	4.8%	4.8%	4.9%	4.9%	5.0%	4.0%	3.0%	2.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	8.6%	7.2%	5.8%	4.4%	3.0%	2.4%	1.8%	1.2%	0.6%	0.0%
Mild Hybrid - petrol engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	7.0%	9.0%	11.0%	13.0%	15.0%	13.4%	11.8%	10.2%	8.6%	7.0%
Full hybrid - petrol engine	1.2%	1.2%	2.1%	3.1%	4.0%	5.0%	8.0%	11.0%	14.0%	17.0%	20.0%	23.2%	26.4%	29.6%	32.8%	36.0%
Plug-in hybrid - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.9%	1.3%	1.6%	2.0%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	60.1%	60.1%	54.1%	48.2%	42.2%	36.3%	33.0%	29.6%	26.3%	22.9%	19.6%	15.6%	11.7%	7.8%	3.9%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	8.6%	7.2%	5.8%	4.4%	3.0%	2.4%	1.8%	1.2%	0.6%	0.0%
Mild Hybrid - diesel engine	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	3.2%	6.1%	9.1%	12.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	4.2%	8.1%	12.1%	16.0%	20.0%	23.2%	26.4%	29.7%	32.9%	36.1%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.9%	1.3%	1.6%	2.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.9%	1.3%	1.6%	2.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 2 – Green Recovery (Vans)

VANS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	2.1%	2.1%	2.3%	2.2%	2.2%	2.1%	2.5%	2.8%	2.6%	2.3%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
1st gen advanced petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engin	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	97.6%	97.6%	96.4%	95.2%	94.0%	92.8%	87.8%	82.9%	78.0%	73.0%	68.1%	54.5%	40.9%	27.2%	13.6%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	9.0%	13.0%	17.0%	21.0%	25.0%	43.0%	52.7%	62.6%	72.3%	73.9%
Mild Hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	0.6%	0.8%	1.0%	1.6%	2.2%	2.8%	3.4%	4.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.5%	0.9%	1.2%	1.6%	2.0%	3.2%	4.4%	5.6%	6.8%	8.0%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.8%	1.2%	2.0%	3.3%	4.5%	5.8%	7.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%	0.6%	1.0%	2.0%	3.0%	4.0%	5.0%
TOTAL	**99.8%**	**99.8%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**107.4%**	**107.5%**	**107.8%**	**108.0%**	**100.0%**
Percentage petrol	*2.1%*	*2.1%*	*2.3%*	*2.2%*	*2.2%*	*2.1%*	*2.5%*	*2.8%*	*2.6%*	*2.3%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*
Percentage diesel	*97.6%*	*97.6%*	*97.7%*	*97.8%*	*97.8%*	*97.9%*	*97.5%*	*97.2%*	*97.2%*	*97.3%*	*97.3%*	*104.3%*	*103.4%*	*102.7%*	*101.9%*	*92.9%*
Percentage electric	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.2%*	*0.4%*	*0.6%*	*1.0%*	*2.0%*	*3.0%*	*4.0%*	*5.0%*
Additive technologies																
Improved aerodynamics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low rolling resistance tyres	0.0%	0.0%	3.8%	7.5%	11.3%	15.0%	22.0%	29.0%	36.0%	43.0%	50.0%	55.0%	60.0%	65.0%	70.0%	75.0%
Gearshift indicators	0.0%	0.0%	2.0%	4.0%	6.0%	8.0%	14.4%	20.8%	27.2%	33.6%	40.0%	44.0%	48.0%	52.0%	56.0%	60.0%

Scenario 3 – Green Recovery + Upfront Price Support (Small Cars)

SMALL CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	59.0%	59.0%	55.3%	51.6%	47.8%	44.1%	35.9%	27.5%	19.1%	10.6%	2.1%	3.0%	2.3%	1.5%	0.8%	0.0%
1st gen advanced petrol engine	24.6%	24.6%	24.6%	24.6%	24.6%	24.6%	19.7%	14.8%	9.8%	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.8%	0.6%	0.4%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engin	0.2%	0.2%	4.2%	8.1%	11.6%	15.0%	28.4%	41.8%	55.1%	68.5%	81.9%	81.4%	80.9%	80.4%	79.9%	79.4%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	14.6%	14.6%	13.3%	11.9%	10.6%	9.2%	7.4%	5.5%	3.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	1.4%	2.7%	4.1%	5.4%	7.2%	9.0%	10.8%	12.6%	14.4%	13.6%	12.9%	12.1%	11.4%	10.6%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.5%	0.9%	1.3%	1.6%	2.0%	4.0%	6.0%	8.0%	10.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100.0%	**100.0%**	**100.2%**	**100.5%**	**100.2%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 3 – Green Recovery + Upfront Price Support (Medium Cars)

MEDIUM CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	35.0%	35.0%	30.9%	26.7%	22.6%	18.3%	17.0%	15.8%	13.3%	10.8%	8.3%	8.6%	6.5%	4.3%	2.1%	0.0%
1st gen advanced petrol engine	15.0%	15.0%	13.8%	12.5%	11.3%	10.0%	8.0%	6.0%	4.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	2.9%	2.9%	3.4%	3.9%	4.5%	5.0%	4.0%	3.0%	2.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engin	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	12.6%	15.2%	17.8%	20.4%	23.0%	18.4%	13.8%	9.2%	4.6%	0.0%
Mild Hybrid - petrol engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Full hybrid - petrol engine	0.4%	0.4%	1.5%	2.7%	3.8%	5.0%	7.0%	9.0%	11.0%	13.0%	15.0%	18.0%	21.0%	24.0%	27.0%	30.0%
Plug-in hybrid - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	3.4%	4.8%	6.1%	7.5%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	46.7%	46.7%	44.1%	41.5%	38.9%	36.3%	29.0%	21.8%	14.5%	7.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	12.6%	15.2%	17.8%	20.4%	23.0%	18.4%	13.8%	9.2%	4.6%	0.0%
Mild Hybrid - diesel engine	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	1.6%	2.9%	4.3%	5.6%	7.0%	7.6%	8.2%	8.8%	9.4%	10.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	2.2%	4.1%	6.1%	8.0%	10.0%	14.0%	18.0%	22.0%	26.0%	30.0%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	3.4%	4.8%	6.1%	7.5%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	2.0%	3.0%	4.0%	5.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 3 – Green Recovery + Upfront Price Support (Large Cars)

LARGE CARS	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Conventional petrol engine	19.0%	19.0%	16.0%	13.0%	10.0%	7.0%	6.5%	6.0%	4.5%	3.0%	1.5%	2.6%	2.0%	1.3%	0.7%	0.0%
1st gen advanced petrol engine	15.0%	15.0%	13.8%	12.5%	11.3%	10.0%	8.0%	6.0%	4.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	4.8%	4.8%	7.3%	9.9%	12.4%	15.0%	12.0%	9.0%	6.0%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	2.2%	2.4%	2.6%	2.8%	3.0%	2.4%	1.8%	1.2%	0.6%	0.0%
Mild Hybrid - petrol engine	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	3.8%	6.6%	9.4%	12.2%	15.0%	13.4%	11.8%	10.2%	8.6%	7.0%
Full hybrid - petrol engine	1.2%	1.2%	2.1%	3.1%	4.0%	5.0%	8.0%	11.0%	14.0%	17.0%	20.0%	22.3%	24.6%	26.9%	29.2%	31.5%
Plug-in hybrid - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.8%	1.1%	1.5%	2.6%	3.8%	4.9%	6.0%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	60.1%	60.1%	59.4%	58.8%	58.2%	57.6%	50.0%	42.4%	34.8%	27.2%	19.6%	15.6%	11.7%	7.8%	3.9%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	2.2%	2.4%	2.6%	2.8%	3.0%	2.4%	1.8%	1.2%	0.6%	0.0%
Mild Hybrid - diesel engine	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	3.4%	6.3%	9.2%	12.1%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	8.0%	12.0%	16.0%	20.0%	22.3%	24.6%	26.9%	29.2%	31.5%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.8%	1.1%	1.5%	2.6%	3.8%	4.9%	6.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	1.5%	2.0%	2.5%	3.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 3 – Green Recovery + Upfront Price Support (Vans)

VANS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
1st gen advanced petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engin	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	97.9%	97.9%	96.6%	95.3%	94.0%	92.5%	87.7%	82.6%	77.0%	71.5%	65.9%	58.8%	44.7%	30.6%	16.6%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	9.0%	13.0%	17.0%	21.0%	25.0%	28.0%	33.5%	39.0%	44.4%	52.4%
Mild Hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	0.6%	0.8%	1.0%	1.6%	2.2%	2.8%	3.4%	4.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.5%	0.9%	1.2%	1.6%	2.0%	4.5%	7.0%	9.5%	12.0%	14.5%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	5.3%	8.5%	11.8%	15.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	5.3%	7.5%	9.8%	12.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Percentage petrol	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*	*2.1%*
Percentage diesel	*97.9%*	*97.9%*	*97.9%*	*97.9%*	*97.9%*	*97.6%*	*97.4%*	*96.9%*	*96.4%*	*95.9%*	*95.4%*	*94.9%*	*92.6%*	*90.4%*	*88.1%*	*85.9%*
Percentage electric	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.3%*	*0.5%*	*1.0%*	*1.5%*	*2.0%*	*2.5%*	*3.0%*	*5.3%*	*7.5%*	*9.8%*	*12.0%*
Additive technologies																
Improved aerodynamics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low rolling resistance tyres	0.0%	0.0%	3.8%	7.5%	11.3%	15.0%	22.0%	29.0%	36.0%	43.0%	50.0%	55.0%	60.0%	65.0%	70.0%	75.0%
Gearshift indicators	0.0%	0.0%	2.0%	4.0%	6.0%	8.0%	14.4%	20.8%	27.2%	33.6%	40.0%	44.0%	48.0%	52.0%	56.0%	60.0%

Scenario 4 – Green Recovery + Upfront Support + Strong Competition from Advanced Diesel (Small Cars)

SMALL CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	59.0%	59.0%	55.3%	51.6%	47.9%	44.2%	35.7%	27.1%	18.5%	9.8%	1.1%	1.6%	1.2%	0.8%	0.4%	0.0%
1st gen advanced petrol engine	24.6%	24.6%	24.6%	24.6%	24.6%	24.6%	19.7%	14.8%	9.8%	4.9%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.8%	0.6%	0.4%	0.2%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.0%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.2%	0.2%	3.9%	7.6%	11.3%	15.0%	28.6%	42.2%	55.7%	69.3%	82.90%	82.8%	82.7%	82.6%	82.5%	82.4%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	14.6%	14.6%	13.3%	11.9%	10.6%	9.2%	7.4%	5.5%	3.7%	1.8%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	1.4%	2.7%	4.1%	5.4%	7.2%	9.0%	10.8%	12.6%	14.35%	13.6%	12.9%	12.1%	11.4%	10.6%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.9%	1.3%	1.6%	2.0%	3.3%	4.5%	5.8%	7.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 4 – Green Recovery + Upfront Support + Strong Competition from Advanced Diesel (Medium Cars)

MEDIUM CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	35.0%	35.0%	30.9%	26.7%	22.6%	18.3%	16.4%	14.6%	11.7%	8.9%	6.0%	5.8%	4.3%	2.9%	1.4%	0.0%
1st gen advanced petrol engine	15.0%	15.0%	13.8%	12.5%	11.3%	10.0%	8.0%	6.0%	4.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	2.9%	2.9%	3.4%	3.9%	4.5%	5.0%	4.0%	3.0%	2.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	12.9%	15.8%	18.7%	21.6%	24.5%	19.6%	14.7%	9.8%	4.9%	0.0%
Mild Hybrid - petrol engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Full hybrid - petrol engine	0.4%	0.4%	1.5%	2.7%	3.8%	5.0%	7.0%	9.0%	11.0%	13.0%	15.0%	18.5%	22.0%	25.5%	29.0%	32.5%
Plug-in hybrid - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.8%	1.1%	1.5%	2.4%	3.3%	4.1%	5.0%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	46.7%	46.7%	44.1%	41.5%	38.9%	36.3%	29.0%	21.8%	14.5%	7.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	12.9%	15.8%	18.7%	21.6%	24.5%	19.6%	14.7%	9.8%	4.9%	0.0%
Mild Hybrid - diesel engine	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	1.6%	2.9%	4.3%	5.6%	7.0%	7.7%	8.4%	9.1%	9.8%	10.5%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	2.2%	4.1%	6.1%	8.0%	10.0%	14.8%	19.6%	24.4%	29.2%	34.0%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.8%	1.1%	1.5%	2.4%	3.3%	4.1%	5.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	1.5%	2.0%	2.5%	3.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 4 – Green Recovery + Upfront Support + Strong Competition from Advanced Diesel (Large Cars)

LARGE CARS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	19.0%	19.0%	16.0%	13.0%	10.0%	7.0%	6.5%	6.0%	4.9%	3.7%	2.6%	3.1%	2.3%	1.6%	0.8%	0.0%
1st gen advanced petrol engine	15.0%	15.0%	13.8%	12.5%	11.3%	10.0%	8.0%	6.0%	4.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2nd gen advanced petrol engine	4.8%	4.8%	7.3%	9.9%	12.4%	15.0%	12.0%	9.0%	6.0%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 2nd gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 2nd gen petrol engine	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	2.2%	2.4%	2.6%	2.8%	3.0%	2.4%	1.8%	1.2%	0.6%	0.0%
Mild Hybrid - petrol engine	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	3.8%	6.6%	9.4%	12.2%	15.0%	13.4%	11.8%	10.2%	8.6%	7.0%
Full hybrid - petrol engine	1.2%	1.2%	2.1%	3.1%	4.0%	5.0%	8.0%	11.0%	14.0%	17.0%	20.0%	22.8%	25.6%	28.4%	31.2%	34.0%
Plug-in hybrid - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	1.8%	2.5%	3.3%	4.0%
CAI - petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	60.1%	60.1%	59.4%	58.8%	58.2%	57.6%	50.0%	42.4%	34.8%	27.2%	19.6%	15.6%	11.7%	7.8%	3.9%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	0.5%	1.0%	1.5%	2.0%	2.2%	2.4%	2.6%	2.8%	3.0%	2.4%	1.8%	1.2%	0.6%	0.0%
Mild Hybrid - diesel engine	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	3.4%	6.3%	9.2%	12.1%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	8.0%	12.0%	16.0%	20.0%	22.8%	25.6%	28.4%	31.2%	34.1%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	0.8%	1.0%	1.8%	2.5%	3.3%	4.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.9%	1.3%	1.6%	2.0%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Additive technologies																
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	50.0%	58.0%	66.0%	74.0%	82.0%	90.0%
Low rolling resistance tyres	0.0%	0.0%	15.0%	30.0%	45.0%	60.0%	66.0%	72.0%	78.0%	84.0%	90.0%	92.0%	94.0%	96.0%	98.0%	100.0%
Gearshift indicators	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	26.0%	32.0%	38.0%	44.0%	50.0%	52.0%	54.0%	56.0%	58.0%	60.0%

Scenario 4 – Green Recovery + Upfront Support + Strong Competition from Advanced Diesel (Vans)

VANS																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Conventional petrol engine	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
1st gen advanced petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Stop/start - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - 1st gen petrol engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conventional diesel engine	97.9%	97.9%	96.6%	95.3%	94.0%	92.5%	87.7%	82.6%	77.2%	71.9%	66.5%	51.0%	37.3%	24.1%	10.1%	0.0%
Stop/start - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Micro-hybrid - diesel engine	0.0%	0.0%	1.3%	2.5%	3.8%	5.0%	9.0%	13.0%	17.0%	21.0%	25.0%	37.1%	45.7%	53.9%	62.8%	67.9%
Mild Hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	0.6%	0.8%	1.0%	1.6%	2.2%	2.8%	3.4%	4.0%
Full hybrid - diesel engine	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.5%	0.9%	1.2%	1.6%	2.0%	3.2%	4.4%	5.6%	6.8%	8.0%
Plug-in hybrid - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.8%	1.2%	2.0%	3.5%	5.0%	6.5%	8.0%
HCCI - diesel engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electric	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.5%	1.0%	1.4%	1.8%	2.2%	3.0%	4.8%	6.5%	8.3%	10.0%
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Percentage petrol	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*	*2.11%*
Percentage diesel	*97.89%*	*97.89%*	*97.89%*	*97.89%*	*97.89%*	*97.64%*	*97.39%*	*96.89%*	*96.49%*	*96.09%*	*95.69%*	*94.89%*	*93.14%*	*91.39%*	*89.64%*	*87.90%*
Percentage electric	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.25%*	*0.50%*	*1.00%*	*1.40%*	*1.80%*	*2.20%*	*3.00%*	*4.75%*	*6.50%*	*8.25%*	*10.00%*
Additive technologies																
Improved aerodynamics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mild weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Strong weight reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low rolling resistance tyres	0.0%	0.0%	3.8%	7.5%	11.3%	15.0%	22.0%	29.0%	36.0%	43.0%	50.0%	55.0%	60.0%	65.0%	70.0%	75.0%
Gearshift indicators	0.0%	0.0%	2.0%	4.0%	6.0%	8.0%	14.4%	20.8%	27.2%	33.6%	40.0%	44.0%	48.0%	52.0%	56.0%	60.0%

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