D52.1: Scenarios for green driving support systems

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Abstract	This work package developed a range of future scenarios with varying degrees of green driver support, considering technological, human and political perspectives. These scenarios will be used in the microsimulation (WP53) and the scaling-up (WP54). Focus groups and a survey were carried out, as well as aggregation to the vehicle market. In the focus group discussions, eco-driving systems were valued for heavy vehicle, fleet markets and individual drivers, with commercial buyers sensitive to costs and HMI, but private buyers concerned with engine type and fuel economy – both relating to costs. In the survey, purchasers indicated that they were willing to pay substantially more for a built in advice system as compared with a mobile phone app.

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Control sheet

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Table of contents

Index of figures

Index of tables

Glossary of terms

Term	Description
Eco-driving	Driving in a way that minimises fuel consumption, thus maximising efficiency and minimising Greenhouse gas emissions.
ecoDriver system	A device that supports eco-driving. This might be a mobile app, or system built into a vehicle including recording devices providing data for later analysis or real-time feedback to drivers.
Multinomial Logit Model	A method that generalises logistic regression to situations with more than two possible discrete outcomes, given a set of independent variables.
Stated Preference	SP experiments are a set of techniques "which use individual respondents' statements about their preferences in … [relation to a given] set of … options to estimate utility functions" (Kroes and Sheldon 1988).
Willingness to Pay	Willingness to pay (WTP) is the maximum amount an individual is willing to sacrifice to procure a good or avoid something undesirable.

Acronyms

Acronym	Description
AC	Air Conditioning
ACC	Acceleration
CBA	Cost-Benefit Analysis
CF	Challenging Future
CH	Charge Time
CT	Car Type
ED	ecoDriver system
ES	Engine Size
ET	Engine Type
FG/FGs	Focus Group(s)
FeDS	Full ecoDriver system
GF	Green Future
GX	Gearbox
HMIs	Human Machine Interfaces

Acronym	Description
ICE	Internal Combustion Engine
MNL	Multinomial Logit
PF	Policy Freeze
PHEV	Plug-in Hybrid Electric Vehicle
PR	Price
PW	Power
RA	Range
SP1	Sub Project 1
SP2	Sub Project 2
SP3	Sub Project 3
SP4	Sub Project 4
SP5	Sub Project 5
SP	Stated Preference
TR	Transmission
UK	United Kingdom
VMM	Vehicle Market Modelling
WP	Work Package
WTP	Willingness to Pay

1. Introduction

1.1 Objective, scope and structure of this report

The objective of this report is to report on the work of WP52. The purpose of WP52 is to develop a range of future scenarios with varying degrees of green driver support, considering:

- technological development
- drivers' acceptance and likely uptake of eco-driving systems
- potential political climates (DoW, WP52, p67).

These scenarios will be used in simulating the impacts of eco-driving in WP53 and scaling-up the results to the EU level in WP54.

In particular, the report covers the following elements of the research:

- Focus groups (FG/FGs) with key stakeholders to ascertain drivers' acceptance and likely uptake of eco-driving systems (Task 52.1; section 2 of this report)
- Stated preference (SP) work to ascertain the composition of the future vehicle stock (Task 52.3 element 2; section 3 of this report)
- Scenario development and description (Task 52.2; section 4 of this report).

Sections 1.2-1.4 set this work in the context of the ecoDriver project as a whole and sub-project 5 (SP5) in particular.

1.2 WP52 in context

The ecoDriver project addresses the need to consider the human element when encouraging "green" driving, since driver behaviour is a critical element in energy efficiency. The focus of the project is on technology working with the driver. The project aims to deliver the most effective feedback to drivers on green driving by optimising the driver-powertrain-environment feedback loop. It will carry out a substantial programme of work to investigate how best to win the support of the driver to obtain the most energy-efficient driving style for best energy use. The programme of work is arranged into five sub projects (SP1-5), each containing a number of work packages. WP52 on which the document reports is part of SP5 (Scaling up and future casting).

The feedback given by the system to the driver will include a preview of the upcoming situation, as well as post-drive feedback. The project will address a wide range of vehicle types — e.g. cars, light trucks and vans, medium and heavy trucks and buses — covering both individual and collective (passengers and freight) transport. The project will evaluate Human Machine Interfaces (HMIs) and feedback to drivers via both nomadic devices and built-in systems and compare the effectiveness of each. The built-in systems include those developed in collaboration with vehicle manufacturers and an additional Full ecoDriver System (FeDS) developed solely within the project. In each case a range of HMIs and feedback styles will be assessed. The project aims to examine driving not only with current and near-term powertrains but also with a full range of future vehicles, including various types of hybrid and plug-in electric vehicles. A comprehensive evaluation will be carried out both in the laboratory (a variety of driving simulators) and in real world driving in both the private and fleet contexts. Scenarios will be developed to assess the implications for the future effectiveness of green driving support. The target of ecoDriver is to deliver a 20% improvement in energy efficiency by autonomous means alone, which opens up the possibility of greater than 20% savings in combination with cooperative systems.

The aim of SP5 is to predict the environmental impact of a variety of systems and solutions in future scenarios, drawing on all the evaluations carried out in the project. The four major work items to be carried out in SP5 are:

- Development of scenarios (WP52)
- Traffic simulations (WP53)
- Scaling up (WP54, T54.1)
- Cost-benefit analysis (WP54, T54.2)

These four steps follow each other and make use of each other's output. Besides this, data from other parts of the project (i.e. from other SPs) and external data are needed. This is illustrated in Figure 1, where an overview of the work in SP5 and the data flows is given. The green blocks contain the work items of SP5 and the white blocks contain input data, from within the project (white blocks on the left) and external data (white blocks on the right).

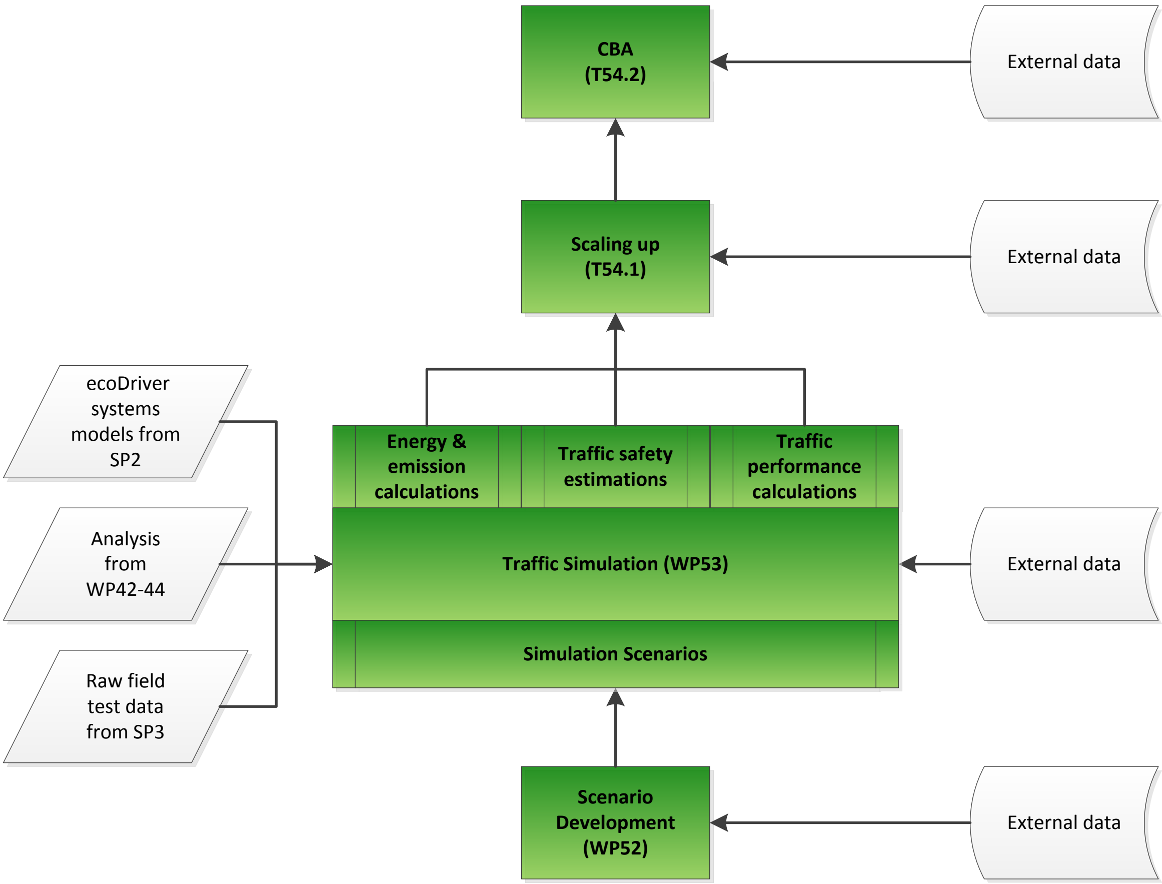

Figure 1: Overview SP5 and data flow

First, scenarios are developed in WP52. These scenarios describe the traffic of the future (20 years ahead) with respect to powertrain distributions, the distribution of private and public transport, etc. These scenarios are used as input for the simulations in WP53 – in which the scenarios are transformed into specifications for traffic simulation models. For the modelling of green driving support systems, results on driver behaviour from SP4 (WP42, WP43 and WP44) are needed. For the traffic simulations on micro level (on a small network) raw field test data from SP3 are needed to estimate and model drivers' compliance with the ecoDriver systems developed in SP2. The outputs of the traffic simulations (traffic efficiency impacts, energy usage and emissions impacts on a small scale) serve as input for the scaling up in T54.1. Here the results are translated to the whole of the European Union. This scaling up is done based on statistical data, for example vehicle kilometres by vehicle type. The last step in SP5 is the cost-benefit analysis (T54.2). In this task all costs and benefits for the EU on a societal level (as well as for some specific stakeholder perspectives) are determined.

Technical development encompasses the vehicle fleet of the future and traffic mix up to 20 years ahead – including powertrain distributions, fuel types, and the distribution of public and private transport. This has been addressed before in studies and official forecasts, so the challenge is to develop a set of scenarios appropriate to ecoDriver. Lifestyle and attitudes toward eco-driving by individual drivers are expected to play a key role in determining future acceptance and usage of a variety of green driving support systems. ecoDriver incorporates research looking specifically at take-up of eco-driving systems (T52.3), which will be used to refine the scenarios. Finally, political decisions with respect to eco-driving, including incentives implemented through taxes, standards, and supporting measures which encourage eco-driving, are a key part of the future environment.

The aim is not to provide an exhaustive list of possible combinations but to focus on a small set of conceivable but distinctive alternative futures. One of the main functions of these scenarios within the project will be to test the robustness of the ecoDriver solutions, faced with the uncertainties inherent in 20 year forecasts.

The following sections describe how these scenarios were developed. Firstly, qualitative research in the form of focus groups was carried out to explore key stakeholders' viewpoints of eco-driving (Section 2). Secondly, a survey is reported whereby drivers were asked to value certain features of vehicles, in an attempt to quantify the likelihood that they would be willing to buy an eco-driving system (Section 3). Finally, a number of scenarios are presented using the combined results of the focus groups and survey, supplemented by external data to scale up the results to the market as a whole (Section 4).

2. Focus Groups

2.1 Introduction

This section of the deliverable reports on the Focus Group (FG) work to ascertain drivers' acceptance and likely uptake of eco-driving systems as well as addressing some key externalities (Task 52.1). Focus groups were held with key stakeholders from a range of industry and related policy sectors and were arranged into the following themes (one FG per theme):

1. Passenger systems,
2. Freight systems,
3. Energy policy,
4. Technical feasibility,
5. Lease/fleet systems,
6. Vehicle and equipment manufacturers.

Focus groups were undertaken in the United Kingdom (UK; themes 1 and 2), Sweden (theme 3), Italy (theme 4) and the Netherlands (themes 5 and 6[1]) – see Annex A for the full schedule of focus groups and participants.

The six themes had been selected for investigation a priori based on the information requirements for building accurate future scenarios. The six themes reflected the different aspects of the transport system with an effect on and affected by eco-driving. The purpose of the FGs was to provide an understanding of the issues relating to eco-driving from the perspective of professionals in industry, academia and government sectors where relevant. With this focus on sector professionals and the presence of multi/transnational organisations in each sector, multiple FGs per sector were not deemed necessary due to the relatively small pool of potential participants. Thus, one focus group was run per sector. FGs were held in different European project partner countries to maximise potential attendance by experts based in different parts of Europe. Whilst this meant that attendees of the passenger systems FG (for example), which was held in the UK, were UK based, the wider perspective of participants beyond the UK meant that the actually location did not result in bias in the information collected. There was also sufficient overlap between themes, for example between technical feasibility and most other themes, to ensure that experts from around Europe could attend a FG.

The findings generated by the FGs were a key input into the scenarios developed in WP52. Inclusion of stakeholder opinion is essential to building credible future scenarios since stakeholders are able to provide insights into industry and policy sector reactions to technological development in eco-driving. The FGs were open-ended and provided an opportunity not just to obtain stakeholders opinions on future developments, but to sense check interpretation of data identified in WP51 for input into the scenarios.

[1] Focus group 6 was held in the Netherlands but the vehicle manufactures stakeholders were from several countries, see Annex A.

2.2 Method

2.2.1 Overview

Each focus group typically consisted of approximately four participants to facilitate a stimulating discussion without the group becoming unmanageable. Keeping the group small allows everybody the opportunity to make their contribution fully. Numbers may also limit themselves naturally, due to availability of senior professionals and careful selection of participants based on the fact that including too many potentially contrasting views in a group can inhibit discussion. Whilst the purpose of a focus group is to facilitate participants sharing and responding to each other's points of view, conflicting and strongly held views can have the reverse effect of inhibiting discussion.

Each group was run by an experienced moderator and assistant, following a pre-defined interview guide common to all focus groups (see the FG Protocol in Annex A). Whilst the interview guide was common to all focus groups to support comparison of results from each, scope to adapt questions or add questions that arise from the discussion was retained. Showcards were used to illustrate various concepts. Each group included a networking lunch with participants, and audio recordings were transcribed following the event. These transcripts were then analysed using content analysis (see Analysis Protocol in Annex A), usually by those who conducted each focus group.

2.2.2 Moderator's role

The moderator's role in the focus group discussion was to lead the session and facilitate a discussion among the participants. He or she ensured that all participants got the opportunity to speak and that the interview guide was followed. Besides that, the moderator took a neutral role and let the participants discuss the topics with each other.

The assistant's role was typically to take notes (as a backup to the recording), and assist with administration and running of the group as required. Moreover, he or she was responsible for the recording equipment and other material that was used in the focus group. However, the moderator-assistant relation was quite flexible, and agreed before each session began.

2.2.3 The interview protocol

The protocol was developed in collaboration with the other partners in this task and translated locally for use in the different countries. It was agreed that the moderator should ask all the questions in the focus group protocol (see Annex A) which should be covered in every focus group. Under each of these questions there are a set of cues, called moderator's cues. These were used by the moderator to inspire the participants and get the discussion going if needed. In other words, the moderator's cues were not a rigid set of questions that needed to be asked specifically, but rather were a set of prompts to guide the discussion. Note that some moderator's cues were more relevant than others depending on the theme of the focus group and the character of the participants.

2.2.4 Content analysis

Having been transcribed the focus group transcriptions were analysed using a content analysis approach. An Analysis protocol was provided for all moderators and other analysts to ensure a consistent approach to analysis across the different focus groups (see Annex A for a copy of the Analysis Protocol). Content analysis seeks to identify themes in a text or audio recording, and describe the key messages (Bryman, 2012). The analysis seeks to be objective, but also draw conclusions for the ecoDriver project, specifically the scenario development. In this case the focus group protocol was used as a guide to the concepts to be identified. For example, in the first section below, all potential gains and losses mentioned throughout the focus group were identified. The analysis of gains and losses then considered presence and absence – which issues are mentioned, which are not, which were expected, which were not (see moderator's cues for a guide) – and intensity, which issues are mentioned a lot/rarely, which are discussed forcefully (be that negatively or positively), which are discussed without conviction as if they hardly matter (regardless of what is actually said). Links between concepts were also identified and analysed, and a summary of what was said about the themes identified was provided. Concepts that we had not anticipated in the protocol were also included in the analysis, thus identification of concepts can be post-hoc as well as a-priori. Note that absence can be informative as well as presence: when issues that were anticipated, i.e. included in the protocol, were not discussed this was recorded; if the moderator later asked about the issue but participants still said little about it this was also recorded. In such cases an assessment was made as to whether an issue was not mentioned because it was not relevant to that group, e.g. 'not relevant to freight systems'. In other cases participants explicitly stated that an issue was not relevant/important. The record was used to draw inferences about importance, awareness and understanding.

Based on the content analysis of each FG, a set of findings was drawn up in discussion between the WP52 team in May 2013.

2.3 Results

These are the findings generated from the six stakeholder focus groups (one per theme) held between February and May 2013. The results are synthesised from the content analysis of all six focus group sessions. When quotations are used it is indicated from which focus group they come. The findings concentrate on the main themes emerging from the content analysis, namely: positive attitudes towards eco-driving systems, weak incentives for system uptake, HMIs, infrastructure integration, deployment rates and negative effects of deployment, organisational impacts and future uncertainty.

2.3.1 Positive attitudes towards eco-driving systems

A general finding from all focus groups was that eco-driving systems are seen as a support system having potential in contributing to reducing fuel consumption and emissions from vehicles. The participants agreed that the general trend is towards a more environmentally aware society, which creates effects on a wide range of areas. In the light of those effects, eco-driving systems have a natural raison d'être in the transport system.

The potential is very high, because our whole company is looking for green driving. All cars are going in this direction. This is the future. It's more gains than losses, because otherwise we wouldn't go in this direction. (Vehicle and Equipment Manufacturer)

However, it was considered unclear what the systems when deployed could contribute to in terms of reduced emissions. The current goal of achieving a 20% reduction of CO2 emissions was regarded too high, but much uncertainty of what level could be reached was expressed. This was considered depending on many factors, for example user motivation and acceptance, legislation and oil price. Moreover, the eco-driving support system was seen as one, but a relatively small part, in the hierarchy of many actions in making the transport system more green and energy efficient:

It's a pretty small part of the whole. It is our travel patterns that are crucial and our choice of fuels is crucial. A technical support system can never help us to make ourselves free of fossil fuels or fossil fuel independence. (Energy policy)

Hence, the eco-driving systems were not regarded as the final solution or utterly important in making the transport system green and energy efficient, but rather as one potential contributing piece in the overall process in that direction.

2.3.2 Weak current incentives to install, except in heavy vehicles

Except for heavy vehicles, mainly driven by professional drivers, a low demand of eco-driving systems is currently seen from the market. This can be understood as for heavy vehicles, the amount of fuel and money that can be saved is significant. It is mainly the economic aspects, rather than "green thinking", that drives that demand:

I think we see for the truck division it's clear that the focus is on the economical perspective. Fuel consumption, fuel cost that's the focus. (Vehicle and Equipment Manufacturer)

However, a sustainable green image is becoming more and more important for the companies to show. Installing eco-driving systems have a potential in contributing in that image-building process.

It can boost your company's image if you can prove that your company is dealing with CO2 reductions. It can even win you some points while engaging in a public tender. (Fleet owners)

For passenger cars the demand for eco-driving system from the market is near zero. Vehicle and equipment manufacturers experience a hard time selling the systems to the customers other than as a plus or presenting them as a marketing feature. Currently, the lack of legislation or certification gives insufficient bonus to the customer, and thus inadequate incentives to pay extra for obtaining the system. Contribution to meeting EU emission targets is recognised, but there is insufficient top down pressure to deviate from current industry/sector norms when they involve expenditure that increases costs in a context where future benefits and savings are felt to be uncertain. Therefore, from the vehicle and equipment manufacturer perspective, the necessary demand from customers is currently lacking:

I think for us it would be very useful to have a customer coming to our company saying; I want eco driver, so we can sell it. Today we can't sell it, because they don't want it. (Vehicle and Equipment Manufacturer)

The user knowledge of the system's potential is also rather unclear, and the acceptance and motivation to use it on a long term basis even when installed is relatively low. This can be partly understood as lack of knowledge on how much can be saved, but also that this may vary a lot between individuals given different driving styles:

> *I love to say from a marketing point of view, if you buy the eco-driving, it saves you 12 %. It's the easiest sales pitch that you can make. But you can't, because there's so many factors playing a role there. (Vehicle and Equipment Manufacturer)*

To sum up, if eco-driving systems are to become a success, especially in private cars, more incentives are needed and probably also some kind of legislation or certification for them. The biggest incentive seems to lie in the cost reduction potential, rather than a willingness to be more environmentally friendly and energy efficient. However, sustainable image-building is becoming more and more important for companies.

2.3.3 The HMI has to be attractive for the user

In order to achieve a large take-up of eco-driving systems it was pointed out through the group interviews that the application must be attractive in appearance and easy to use. At the same time they should not be distracting and provoking to the driver, but instead be rather hidden:

> *If we are good at developing an interaction mode so that all of these functions get surreptitiously into everyday life, people will use them and they will make a difference. (Technical feasibility)*

What should be avoided was to design an interface that is regarded intrusive and annoying by the user. Instead, the driver should be able to use the system more or less unconsciously and without any considerable cognitive load. Haptic, visual and acoustic feedback was regarded as fruitful and verbal messages should be avoided. It might also be fruitful to discriminate between HMIs for professional drivers and non-professional drivers.

Moreover, it was thought that a feeling competition would increase the motivation to drive in a more economical way:

> *You should make a game out of it so it could have that fun factor. (Fleet owners)*

That element was sometimes already practiced amongst professional drivers of heavy vehicles in the commercial sector.

Considering embedded versus smartphone apps, the general opinion was that higher usage potential could be obtained if the system was embedded in the vehicle compared to having a smartphone application. As the embedded system is already in place and does not require any extra effort in terms of setting up the smartphone in a holder and launch an application, it was considered advantageous over the smartphone. If however eco-driving advice could be integrated into smart phone navigation software it was thought to have higher usage potential.

2.3.4 Eco-driving – infrastructure integration possibilities

Today, the road transport system was regarded prioritized towards safety and comfort, rather than fuel efficient driving, but a change that also favours the latter was considered possible. Moreover, potentials were seen in integrating the eco-driving system with Intelligent Transport Systems (ITS) such as vehicle to vehicle communication (V2V) and infrastructure to vehicle communication (I2V).

2.3.5 Highest deployment rates to be expected in the heavy vehicle fleet

A broad consensus was expressed that the highest deployment rate (close to 100 %) would be observed among heavy vehicles, such as trucks, busses and possible lighter commercial vehicles. The rationale for this notion was that these vehicles consume lots of fuel and therefore the saving potential is big. Equally important is that these vehicles are used in the commercial paradigm where cost reduction is fundamental. In this sector, the motivation to use the systems was regarded highest, since it consists of mainly professional drivers:

> *As for trucks, ideally, you would go for a as a high percentage as possible, also because they are professional drivers and because of the nature of the work. They kind of have to, it's a cost element. So I think adaption can be very high. (Vehicle and Equipment Manufacturer)*

> *I see a big potential and a high market penetration for trucks. Nearly 100 %. (Vehicle and Equipment Manufacturer)*

Among personal car users more uncertainty existed but the deployment rate was thought to be lower than among heavy vehicles. However, as the vehicle fleet renews an increasing amount of systems are expected to be seen. As more and more support systems become standard equipment, the eco-driving systems will follow that trend and increase in share:

> */../ the market penetration [for eco-driving systems] will automatically increase as the vehicle fleet renews and it will also be regarded more natural with a bunch of different support systems in the car. (Energy policy)*

With regard to nomadic devices it was expressed that these would probably not be deployed to any large extent among private car user if people have to pay extra for them.

> *How many are willing to pay a penny? I think very few. In one way or another it will have to be included in something else. (Energy policy)*

Important factors thought to positively influence the ultimate penetration figure was certification or legislation mentioned above, high fuel prices and attractive HMI. Important factors that would contribute in the opposite direction was the lack of certification or legislation, high technical development of the engine and powertrain giving only a marginal saving potential, powertrains with the eco-driving principle "built in" and automated by default, and lower fuel prices.

2.3.6 Few negative effects expected by deploying eco-driving systems

Eco-driving systems were seen as something rather uncontroversial and positive in general. There are advantages in using them since they can contribute in saving fuel and money, and thereby help free up resources that can be invested elsewhere. However, some possible negative effects by deploying eco-driving systems were mentioned. There might be a rebound effect, where the saved fuel share will be taken out in more driving, and thus increasing the total traffic volume:

In other contexts you can talk about rebound effects that are if you improved the efficiency of something you can use it more as well. I do not know if it could have such an effect, but if people are driving and after a while note that they have saved 200 euros, then maybe it would feel less hassle to use the car one more time. (Energy policy)

Another negative effect that was considered was the possibility that the system could be regarded as a "big brother system" supervising and controlling driver behaviour, especially in circumstances where data is being stored and analysed by someone else. However, whether mentioned negative effects will exist in reality is unclear and further research is needed if answers are sought after.

2.3.7 Organisational impacts

Organisation energy efficiency goals and strategy, to which eco-driving systems could contribute.

Energy efficiency goals and strategies were not always explicitly identifiable. Some organisations, e.g., a local authority, had a travel plan with the aim of minimising the organisations carbon footprint at the same time as supporting activities of the organisation such as business travel. However, the focus of travel plans was more concerned with passenger travel (commuting and business trips) than logistics and associated fleets, e.g. waste truck fleets. Fleet management was beyond the scope of the travel plan, and where green vehicles are used that was more often at the instigation of the fleet manager and their team. Often such decisions arising from recognising cost benefits:

…from the operator's point of view, I think it's fair to say that the eco side of it is probably not at the forefront of their minds … when you start talking to them and saying that it's so closely linked to improved fuel consumption … that does get peoples' attention in the current world with the price of fuel. (Freight)

Where travel plans did not exist, energy efficiency goals and strategies were most often associated with desire to reduce fuel consumption to reduce costs. However, fleet operators are reluctant to adopt in-cab telematics despite high fuel prices and reductions on maintenance costs derived from vehicles being driven less harshly. Drivers can fear they are going to be spied upon and penalised in some way, creating a fear of change that some operators are hesitant to tackle head on.

Organisational and road transport system impacts of deployment of eco-driving systems.

Organisations could save a significant amount of money on fuel, and if the benefits were passed on, insurance premiums, since better driver management through in-cab telematics can result in fewer accidents. Thus there are a number of benefits for the road transport system – steadier driving could result in better traffic flow, and fewer accidents is obviously good for individuals, but again brings traffic flow benefits as well The nature of impacts identified went beyond straight forward fuel savings and accident benefits however:

Significant reduction in costs.

…the GPS location side of things … insurance companies now have the black box in vehicles … monitoring how you are driving [with insurance premium and safety impacts as well as] provid[ing] an actual individual perspective on how the individual is performing [in relation to emissions, as] test cycle [data] doesn't represent anything other than a measurement to show one vehicle against another in one very specific circumstance.

…in terms of fleet management … it would be a useful indicator for … drivers … [in need] of re-training…

Maintenance is almost certainly going to be a lot higher if it's driven a lot harder.

However, there could be issues with employer-staff relations, and maybe staff retention. Many operators are worried about how they will tell somebody who has been driving a truck for maybe 30 years, that they are not driving as well as they could be, and so are unwilling to embrace in-vehicle telematics. Whilst many of the very large fleet operators, e.g. a large bus company, are adopting systems and pushing the agenda forward, smaller organisations who do not have the ability to put in extensive support systems for implementation fear drivers may leave for operators of smaller vans and trucks that are considerably less regulated. The large operators are also able to absorb the not insignificant cost of implementation and potentially set it off against other activities, but smaller operators are not able to do this. The bus operators demonstrate that, if systems are embraced, overall staff resistance can diminish over time. It has been noted that staff whose initial training includes eco-driving systems see them as a normal part of the job, and there is much less resistance. Thus, staff turnover can actually support uptake.

Deployment timescales over the forthcoming 20 years, market penetration and factors key to system take-up.

Government subsidy would be helpful. We are where we are with reliance on diesel in the sector as a result of Government subsidy and taxation policies of the past pushing diesel. Alternative fuels are being looked at, but supply is more of a problem for a fleet of large vehicles due to the volume needed (despite creation of a supply network being potentially less problematic since it can utilise operators' depots). In the meantime in-cab telematics will be needed to reduce fuel consumption and achieve benefits for the road network that operators are reliant on. Increasing fuel costs will push operators into adopting.

It's going to come down to cost primarily. (Passenger)

Market awareness generally needs to change for large scale uptake. Currently there is a lack of awareness of the benefits, confusion between systems and perceptions that systems are still in the development phase, when in fact they are ready to buy off the shelf, and confusion with the Sat Nav function. Sat Nav's are not thought of as appropriate for trucks (they are considered not to identify low bridges and other unsuitable routes), so everything about a Sat Nav related system is perceived as unsuitable.

Current test cycles are also a barrier to uptake since they represent a narrow range of laboratory based emissions, rather than what happens on a real road. This means that vehicles are portrayed as more efficient than they actually are — owners and operators are unaware of how much more efficient their vehicles could be if driven differently.

Another area that needs to be resolved to facilitate uptake is how drivers receive feedback. In trucks for example, there are already systems that monitor drivers, but they don't necessarily see the output. Conversely, at least one bus operator has a system of in-cab lights to provide feedback real time. This also contrasts with one of the large coach operators who provide periodic summary feedback that is used as an input to ongoing driver training. Distraction or fear of distraction is a significant worry from a road safety perspective.

Opinions on fleet composition and fuel price projections and scenario assumptions.
Compressed Natural Gas is not seen as an option, instead there is a view that diesel will be with us for the foreseeable future. However, a Government decision on what alternative fuel to back is needed to support supply network development as well as actual fuel development. Similarly electric batteries are not seen as an option due to size, weight and range. Euro 6 already means there is no spare room in a vehicle, carrying a spare wheel is a challenge, fitting in all the necessary batteries isn't going to be possible. Bio-fuels are seen as an alternative for the aviation sector, since there cannot be sufficient supply for the road haulage and aviation sectors. Overall the internal combustion engine is seen as having a long future, even if the nature of the engine changes somewhat. Hybrid is one option – it's already being adopted by the bus industry, although with Euro 6 and onwards battery hybrids are unlikely in the truck sector. Similarly, there is a strong voice coming through that fuel costs will be high in the future.

> *I think that if you've got low economic growth it wouldn't be the user acceptance of the new vehicle technology, it would be the affordability of the technology. (Freight)*

2.3.8 Uncertainty about the future

A high degree of uncertainty was expressed by the participants about what will happen in the next 30 years in terms of changes in powertrain mix, technological development, economic climate and oil price. Lower oil prices were however not expected and were considered unrealistic by the participants:

> *In my opinion, low oil prices are not realistic. (Fleet owners)*

But on the other hand, the prices were not expected to rise dramatically. Instead, it was expressed that a constant to small increase was expected:

> *I think the oil price will be constant. Small increase. Small. (Vehicle and Equipment Manufacturer)*

In trucks and buses, diesel was thought to be the dominating fuel in the coming 30 years, especially in long haul operations. Hybrid and hydrogen vehicles could be anticipated depending on the battery and fuel cell development in the next decades. In the car market, plug-in hybrid powertrains were expected more and more in the coming 10 years. Large scale market penetration by electric cars was viewed as dependent on battery development.

Overall, the powertrain mix seen in the future will most likely be dependent on policy decisions (for example on carbon emissions targets), technological development and oil price. Different opinions existed on what drives users' willingness to change behaviour. However legislation and policy change were considered essential in the pursuit of a more sustainable transport system.

2.4 Summary

1. The experts consulted are positive about future demand for eco-driving systems – it is the task of the scenario development (WP52) to quantify this.

   Demand is expected to be strongest among heavy vehicles and intensively-used fleets, where fuel costs are a larger proportion of total costs, leading to higher market penetration over the 20 years from 2015.

2. To achieve high levels of market penetration, vehicle purchasers need to be better informed about the cost reduction potential of eco-driving systems – this is viewed as the strongest incentive to adoption, with only secondary motives being a willingness to be more environmentally friendly and energy efficient. One element of this could be a form of European-wide certification of eco-driving systems, although the market research in WP52 will have to find alternative ways of informing respondents about the ecoDriver system in the short term. It is important to be clear whether the stated fuel savings are in the official test cycle or in real world driving, as there is recognised to be a disparity between the two.

3. HMI design is believed to be a key in achieving acceptance: avoiding intrusive and annoying feedback; whilst making compliance as intuitive and easy as possible. Therefore in design of the WP52 choice experiment, steps must be taken to avoid respondents assuming feedback will be intrusive or annoying, and to give them confidence that – based on technological development work to date – significant fuel savings are achievable with a system whose interface with the driver is intuitive and easy.

4. The vehicle fleet and traffic mix can be expected to develop significantly over the 20 years from 2015. A high level of uncertainty exists, although some general trends and key dependencies have been identified. Take-up of hybrids is expected to grow in the car market. Plug-in hybrid and electric vehicle demand is seen as dependent on battery technology development. Similarly hydrogen vehicle demand is seen as dependent on fuel cell technology. Hybrid and electric vehicles are seen as having great potential for highly-utilised fleets such as taxis, buses and urban delivery vehicles. Long haul freight is expected to remain a niche for diesel vehicles. Policy – especially on carbon reduction targets – is seen as a key driver of the future fleet composition.

5. With regards to the proposed future scenarios, participants gave a range of responses. One common theme is that there is a great deal of uncertainty / it is difficult to be sure. This is recognised by the multiple scenario approach. For those who felt able to judge the proposed

scenarios, the range of expectations appeared similar to the range of scenarios presented, although it needs to be noted that: (i) hybrid demand is already exceeding the scenario projections in the present/short term, indicating that a revision to reflect recent data is needed; (ii) there was widespread scepticism about the 'low fuel price' trajectory, although this remains part of the forecasts from specialist energy agencies; (iii) some participants placed more credence in the 'Policy freeze' scenario whilst others' expectations were closer to the 'Green future'. Importantly, participants' responses indicated that a set of three future scenarios was more credible and understandable, in terms of the scenarios being sufficiently different, than the set of four presented.

3. Stated Preference Study

3.1 Introduction

This section of deliverable 52.1 reports on the Stated Preference (SP) analysis within Task 52.3: modelling take-up of eco-driving systems. Task 52.3 is comprised of three elements:

1. Consider the Vehicle Market Model (VMM) to ascertain the overall size of the vehicle stock: analysis of the net change in the vehicle stock arising from the uptake of alternative-fuel vehicles and any associated scrappage of older vehicles.
2. SP study to ascertain the composition of the vehicle stock: analysis of the purchase of new vehicles, focussing specially on the choice between alternative and conventional fuel vehicles, whilst accounting for ownership saturation.
3. Explore the VMM to ascertain the usage of the vehicle stock: analysis of the distance driven of both alternative and conventional fuel vehicles.

Elements one and three are based on national-level data on car-ownership and use and relate directly to the simulation of future traffic work in WP53 and scaling-up work in WP54. They are reported in the following chapter on Scenarios. Element two was based on a bespoke SP experiment undertaken with prospective vehicle purchasers. The SP work in ecoDriver was designed to cover four objectives:

- user acceptance of the ecoDriver system.
- consumer behaviour with respect to car choice. We place special emphasis on car attributes that have an impact on the car's fuel efficiency, such as an air-conditioning system, four-wheel drive or a certain engine type, as well as the fuel efficiency of the car.
- household decisions on the composition of their car fleet and the use of individual cars. This will allow us to explain the aggregate number of cars bought, the aggregate driving distance and the aggregate fuel demand. We also examine the impact of changes in household structure, increases in income and fuel prices on these values.
- the acceptance of new technologies and policies relating to the reduction of carbon dioxide emissions, such as a tax on fossil energy sources in general or on fossil fuels only.

In this chapter we describe the method (3.2), data (3.3) and results (3.4). Further technical details of the SP analysis are contained in Annex B.

3.2 Method

SP experiments are a set of techniques "which use individual respondents' statements about their preferences in … [relation to a given] set of … options to estimate utility functions" (Kroes and Sheldon 1988). These utility functions formalise and quantify individuals' preferences, in this case their preferences over a set of vehicle characteristics. Their great advantage in the context of ecoDriver is that they can be used to explore people's preferences over hypothetical options, which can include new and existing technologies, and different blends of technologies.

3.2.1 Questionnaire

A survey questionnaire was designed to meet the objectives set out above. The questionnaire included an SP exercise and collection of contextual data. This included household data on total income, household type, type of residential area, current vehicles owned and socio-demographic information. It also included the individual's attitudes towards policy measures and beliefs about the effectiveness of various technical aspects of cars related to fuel efficiency.

The first substantial part of the questionnaire is the SP exercise and involves respondents making a number of hypothetical choices between car options. Since these questions are rather demanding to answer we restrict our sample to people who have recently bought a car or are currently thinking of buying a new car. Initially, a choice of three cars is presented and we ask respondents to choose the most attractive one. We place special emphasis on car attributes that have an impact on the car's fuel efficiency, such as the inclusion/exclusion of an ecoDriver system, the efficiency of the engine, and other features such as an air-conditioning system or four-wheel drive. This is repeated several times with different combinations of attributes to generate the choice data. Then respondents are presented with two choice situations with six cars each, and are asked to state which of these cars they would buy and how much they would drive them, if they had to replace all their currently owned cars. We can, in principle, use this data to compute the households' demand for cars, driving distance and fuel by applying simple summary statistics or the Ordinary Least Square (OLS) method. Since we also want to model any changes in choices in the event that household income increases, fuel prices rise or prices or frequencies of the public transportation sector change, we ask them to repeat their choices given hypothetical changes in these variables.

In the second part of the questionnaire, the respondents are asked to enter data about their household. This data covers questions such as total income, household type, type of residential area, current vehicles owned and socio-demographic information. By use of that data we can identify if certain household segments have different Willingness To Pay (WTP) for car features or have different preferences with respect to car ownership and use.

In the third part of the questionnaire, respondents are asked to describe their attitudes towards policy measures and beliefs on the effectiveness of various technical aspects of cars related to fuel efficiency. This information can, in principle, be used to examine if these attitudes will actually have an impact on the WTP or the car ownership and use. Also, these responses provide information on which CO_2 reducing policies are deemed to be acceptable by car buyers.

In designing the experiment, particular attention was given to the following:

- the selection of car attributes and car types;
- the levels and combinations of levels of each attribute – both to make the exercise practical for the respondent and for statistical reasons (an 'efficient design');
- testing the experiment by simulation before piloting.

Further details can be found in Annex B, sections B.2 to B.6. Key extracts from the questionnaire (English version) are in Annex C.

The questionnaire was implemented online by UNIVLEEDS using php and html programming languages. The software covers a large number of functions, such as filtering respondents according to their socio-demographic characteristics and according to whether they have bought a car in the recent past. Additional functionality includes presenting choice selections that depend on previous choices, and presenting extra information as tooltips if asked for by the respondents. Also, in the three car choice experiment, the software randomises the ordering of the “air-conditioning”, ”ecoDriver system”, “transmission”, “fuel economy”, “acceleration” and “gearbox” attributes. We did this, since some respondents may assign more importance to attributes presented higher up the screen. The engine type and its characteristics were always displayed first, whilst price was always presented last.

The software recorded all of the data reported by the respondents, and adds a timestamp to each response so that the speed of response can be analysed. To ensure that only people who were invited by us have could access the questionnaire, we sent an 11-digit number to them. The software runs on a server at the university where the data are also stored.

3.2.2 Modelling

We used the data to compute the strength of preference for all car features, including the ecoDriver system, by means of a discrete choice model - in this case a multinomial logit (MNL) model (Annex B.2.1). This is a conventional model for this particular application. The results were computed using the software STATA. The parameters of the model reflect the utility (or strength of preference) of each attribute. A negative parameter indicates that – keeping everything else constant – the attribute is undesirable to consumers, and vice versa. By comparing the other parameters with the price parameter, we can in principle infer willingness-to-pay (WTP).

In order to forecast the aggregate fuel demand, the aggregate distance driven and the aggregate car demand of each vehicle type, we apply simple summary statistics and ordinary least square statistics to the data from the second set of SP questions, looking at household-level choice.

3.2.3 Piloting of the questionnaire

The questionnaire was tested in several stages:

- A ‘pre-pilot’ survey was conducted involving a small number of participants, covering both experts in the research area, as well as non-experts typical of the respondents we would recruit. As well as analysing the data from these respondents, we invited comments through ‘debrief’.
- Subsequently, we conducted three waves of ‘pilot’ survey. This involved opening the web-survey, and recruiting a pre-specified number of respondents (typically around 50) from an internet panel. The data from each wave was modelled and we conducted diagnostic testing of the data, so as to determine whether the survey was being completed in a robust fashion (e.g. looking at whether respondents were ‘clicking through’ the survey in an expedient fashion). The key outcome from this second stage of testing was to help inform the

specification of quality criteria, which were then implemented by Accent (e.g. respondents who completed the survey 'too quickly' were screened out and re-sampled).

3.2.4 Respondents and sample size

The SP work used a sample of respondents selected from an internet panel provided by a market research company. Respondents were recruited online and incentivised financially. Two filters were applied:

i. In order to mask the objective of our questionnaire – and thereby ameliorate bias – a filter question was asked at the recruitment stage about recent and planned purchasing activities (including car purchasing). Only those respondents who reported recent/planned car purchasing were retained.
ii. Further filtering was applied ex post to ensure data quality. Those who completed the questionnaire in less than 12.5 minutes were filtered out; we judged that these respondents failed to devote adequate attention to the questionnaire. We also filtered out those respondents who always chose the same SP option, and those who exhibited other fixed patterns of response; we judged that these respondents failed to engage in 'trade-off' behaviour.

This resulted in a sample of 876 individuals, roughly split between the three countries, Table 1.

Table 1: Sample size

	Number
UK	230
Germany	327
Spain	319
Total	876

3.3 Results

3.3.1 Attitudes to green technologies and policies

The findings in relation to the ecoDriver system are summarised in Table 2 and Table 3. Around 33% of respondents indicated that they either agreed or strongly agreed that an ecoDriver system would distract them from driving, although on average the mean score was neutral (M=2.94). Forty-four per-cent of respondents reported they would not be in favour of a device that influenced their driving behaviour directly, although again they were relatively neutral in this respect (M=3.17).

Table 2: Attitudes with respect to distraction

	I believe that the ecoDriver system would distract me from concentrating on my driving (% of sample)			
	UK	Germany	Spain	Mean
1 (strongly disagree)	15.8	18.4	13.4	15.87
2	18.3	17.7	15.2	17.07
3	37.6	30.9	31.8	33.43
4	21.3	25.5	26.9	24.57
5 (strongly agree)	6.9	7.5	12.7	9.03
Mean score	**2.85**	**2.86**	**3.10**	**2.94**

Table 3: Attitudes with respect to influencing behaviour

	I do not want any device that tries to influence my driving behaviour (% of sample)			
	UK	Germany	Spain	Mean
1 (strongly disagree)	10.4	5.8	8.1	8.10
2	16.8	9.9	14.1	13.60
3	34.7	37.8	30.4	34.30
4	21.8	25.9	33.9	27.20
5 (strongly agree)	16.3	20.8	13.4	16.83
Mean score	**3.17**	**3.46**	**3.30**	**3.17**

The results in Table 4 - Table 7 show that around half of respondents have some concerns over the risk of breakdown and maintenance issues with electric vehicles (which are implied not real scenarios). Their reservations are most accentuated in terms of lack of infrastructure (M= 4.2) and the risk that the battery could run flat whilst driving (M=4.12). These aspects may explain the magnitude of the negative coefficient attributed to the pure electric drive in the three car SP experiment (reported below). Concerns about the risk of the battery running flat whilst driving could explain why the magnitude of the negative coefficient attributed to the electric drive with range extender is much lower than that for the pure electric drive in the three car stated preference experiment.

Table 4: Attitudes with respect to electric vehicles – risk of a breakdown

I have some reservations about electric vehicles because...	**...there is a greater risk of a breakdown**			
	UK	Germany	Spain	Mean
1 (strongly disagree)	3.6	9.2	7.4	6.73
2	7.8	18.0	10.6	12.13
3	38.3	26.4	36.7	33.80
4	43.7	36.0	35.1	38.27
5 (strongly agree)	6.6	10.4	10.2	9.07
Mean score	3.42	3.20	3.30	3.31

Table 5: Attitudes with respect to electric vehicles –maintenance costs

I have some reservations about electric vehicles because...	**...there is a risk of higher maintenance costs**			
	UK	Germany	Spain	Mean
1 (strongly disagree)	3.0	8.0	5.7	5.57
2	6.6	12.8	8.6	9.33
3	29.3	29.6	29.0	29.30
4	45.5	33.6	35.9	38.33
5 (strongly agree)	15.6	16.0	20.8	17.47
Mean score	3.64	3.37	3.58	3.53

Table 6: Attitudes with respect to electric vehicles – charging stations

I have some reservations about electric vehicles because...	**..there is not enough infrastructure (charging stations) for electric vehicles**			
	UK	Germany	Spain	Mean
1 (strongly disagree)	2.4	1.2	1.2	1.60
2	3.6	5.6	2.0	3.73
3	13.2	13.2	19.2	15.20
4	33.5	31.6	30.6	31.90
5 (strongly agree)	47.3	48.4	46.9	47.53
Mean score	4.20	4.20	4.20	4.20

Table 7: Attitudes with respect to electric vehicles –range anxiety

I have some reservations about electric vehicles because...	**...there is a risk that the battery will run flat during a journey**			
	UK	Germany	Spain	Mean
1 (strongly disagree)	2.4	2.0	2.0	2.13
2	6.0	3.6	4.1	4.57
3	12.6	18.8	13.5	14.97
4	34.1	30.4	41.2	35.23
5 (strongly agree)	44.9	45.2	39.2	43.10
Mean score	4.13	4.13	4.11	4.12

A final set of attitudinal questions explored the participants' response to tax policies that would favour green driving and a shift towards active travel and public transport. The results are shown in Table 8 to Table 12. The results in Table 8 indicate that the respondents are on average neutral to slightly positive about increases in fossil fuel taxation. History suggests, however, that increases in fuel tax are very difficult to implement. Disputes about equity and the use of tax revenue are common. The most favoured tax scheme here would be to increase the price of fossil fuels[2] and use the revenue to reduce taxes on income (M=3.56). Less favourable opinions were found towards using the tax revenue to reduce government debts (M=2.99).

Table 8: Attitudes with respect to government policies –income tax

The government should increase taxes on petrol and diesel, and the entire tax revenue should be used for..	**...lowering income taxes**			
	UK	Germany	Spain	Mean
1 (strongly disagree)	9.6	16.3	2.0	9.30
2	11.5	15.8	4.4	10.57
3	26.3	24.2	14.5	21.67
4	30.1	25.0	38.7	31.27
5 (strongly agree)	22.4	18.8	40.3	27.17
Mean score	3.44	3.14	4.11	3.56

[2] e.g. perhaps by including them in the ETS without a fully offsetting tax reduction.

Table 9: Attitudes with respect to government policies –reimbursement

The government should increase taxes on petrol and diesel, and the entire tax revenue should be used for..	...reimbursing people with a fixed amount per capita[3]			
	UK	Germany	Spain	Mean
1 (strongly disagree)	16.0	15.4	8.5	13.30
2	13.5	12.9	7.7	11.37
3	34.0	18.8	23.4	25.40
4	26.9	33.3	38.3	32.83
5 (strongly agree)	9.6	19.6	22.2	17.13
Mean score	3.01	3.29	3.58	3.29

Table 10: Attitudes with respect to government policies –government debt

The government should increase taxes on petrol and diesel, and the entire tax revenue should be used for..	...reducing government debts			
	UK	Germany	Spain	Mean
1 (strongly disagree)	8.3	23.3	6.5	12.70
2	10.9	16.7	5.2	10.93
3	33.3	20.8	19.4	24.50
4	34.0	25.0	35.9	31.63
5 (strongly agree)	13.5	14.2	33.1	20.27
Mean score	3.33	2.90	3.84	3.36

[3] Everybody including children would get the same amount reimbursed.

Table 11: Attitudes with respect to government policies –government spending

The government should increase taxes on petrol and diesel, and the entire tax revenue should be used for..	**...general government spending**			
	UK	Germany	Spain	Mean
1 (strongly disagree)	10.9	36.3	17.7	21.63
2	16.7	14.2	10.9	13.93
3	26.9	22.5	19.8	23.07
4	35.9	20.4	24.6	26.97
5 (strongly agree)	9.6	6.7	27.0	14.43
Mean score	3.17	2.47	3.32	2.99

Table 12: Attitudes with respect to government policies –subsidise manufacturers

The government should increase taxes on petrol and diesel, and the entire tax revenue should be used for..	**...subsidising car manufacturers to produce more fuel efficient cars**			
	UK	Germany	Spain	Mean
1 (strongly disagree)	10.3	14.2	10.5	11.67
2	12.8	15.4	11.3	13.17
3	31.4	25.8	23.8	27.00
4	32.1	31.3	33.1	32.17
5 (strongly agree)	13.5	13.3	21.4	16.07
Mean score	3.26	3.14	3.44	3.28

3.3.2 Estimating preferences for the ecoDriver system

Table 13 shows the estimation results from the multinomial logit (MNL) model for the UK. Table 14 and Table 15 give the equivalent results for Germany and Spain. The estimated parameters indicate whether the attribute is liked (+) or disliked (-) on average across the population, keeping everything else constant. The standard deviation indicates how accurately the parameter could be estimated. The t-value expresses whether the estimated parameter can be considered different from zero: if the absolute value of the t-value is greater that two, then it can be considered very likely (~95% probable) that the estimated parameter has an impact on the utility level with the sign shown (marked *). Conversely the probability that the estimated parameter has no impact is less than 5%. Petrol, manual, front wheel drive, no air conditioning and no ecoDriver system are the 'base' in their respective categories, so their relative utility is zero and the utilities for the other levels is relative to the 'base'.

The base engine size, engine power, acceleration and fuel economy depend on the car type and engine type – see the table in Appendix B.4.3 for details.

Table 13: Estimation results from the three car stated preference experiment (UK)

Variable name		Estimated parameter	Standard deviation	t-value	Sig.
Engine type	Petrol	0	--	--	
	Diesel	-0.216	0.0912	-2.36	*
	Natural gas	-0.482	0.174	-2.76	*
	Hybrid	-0.452	0.117	-3.85	*
	Pure electric	-1.4	0.339	-4.14	*
	Electric with range extender	-0.681	0.187	-3.65	*
Engine size (cc)		-0.00031	0.000189	-1.64	
Engine Power (bhp)		0.000167	0.00187	0.09	
Acceleration (secs, 0-60mph)		-0.00345	0.0386	-0.09	
Fuel Economy (l/100km)		0.00862	0.00277	3.11	*
Gear Box	manual	0	--	--	
	automatic	-0.203	0.0857	-2.37	*
Transmission	Front wheel drive	0	--	--	
	Rear wheel drive	-0.0673	0.0741	-0.91	
	Four wheel drive	0.188	0.0873	2.16	*
Air-conditioning system	none	0	--	--	
	manual	-0.0062	0.0741	-0.08	
	automatic	-0.017	0.0813	-0.21	
ecoDriver system	None	0	--	--	
	Mobile phone app	0.114	0.0724	1.58	
	Built-in system	0.163	0.0671	2.42	*
Price (PR)		-0.0000451	0.0000233	-1.93	

Number of respondents = 230. Note: Price parameter in GBP. Fuel economy measured in miles per gallon.

Table 14: Estimation results from the three car stated preference experiment (Germany)

Variable name		Estimated parameter	Standard deviation	t-value	Sig.
Engine type	Petrol	0	--	--	
	Diesel	-0.238	0.0918	-2.59	*
	Natural gas	-0.612	0.164	-3.74	*
	Hybrid	-0.279	0.1	-2.78	*
	Pure electric	-1.01	0.155	-6.52	*
	Electric with range extender	-0.575	0.145	-3.98	*
Engine size (cc)		0.000160	0.000149	1.08	
Engine Power (bhp)		0.00339	0.00171	1.99	
Acceleration (secs, 0-60mph)		-0.0197	0.0323	-0.61	
Fuel Economy (l/100km)		-0.0999	0.0371 0.00253	-2.69	*
Gear Box	manual	0	--	--	
	automatic	0.0802	0.0772	1.04	
Transmission	Front wheel drive	0	--	--	
	Rear wheel drive	-0.111	0.0593	-1.87	
	Four wheel drive	0.0527	0.0733	0.72	
Air-conditioning system	none	0	--	--	
	manual	0.161	0.0636	2.53	*
	automatic	0.217	0.0620	3.50	*
ecoDriver system	None	0	--	--	
	Mobile phone app	-0.0542	0.0564	-0.96	
	Built-in system	0.0503	0.0524	0.96	
Price (PR)		-0.0000759	-0.0000225	-3.37	*

Number of respondents = 327.

Note: for comparability with Table 13, price parameter was converted to GBP for modelling (based on €1.25=£1) and is reported in GBP form here. Subsequently in this report, all willingness-to-pay results are expressed in €. Fuel economy in Germany was measured in l/100km.

Table 15: Estimation results from the three car stated preference experiment (Spain)

Variable name		Estimated parameter	Standard deviation	t-value	Sig.
Engine type	Petrol	0	--	--	
	Diesel	0.354	0.0877	4.04	*
	Natural gas	-0.433	0.158	-2.75	*
	Hybrid	0.436	0.102	4.26	*
	Pure electric	-0.0799	0.134	-0.59	
	Electric with range extender	0.0886	0.130	0.68	
Engine size		0.000151	0.000158	0.96	
Engine Power		0.00364	0.00171	2.12	*
Acceleration		-0.0469	0.0287	-1.64	
Fuel Economy		-0.123	0.0385 0.00253	-3.20	*
Gear Box	manual	0	--	--	
	automatic	-0.0407	0.0720	-0.57	
Transmission	Front wheel drive	0	--	--	
	Rear wheel drive	0.0695	0.0559	1.24	
	Four wheel drive	0.157	0.0753	2.09	*
Air-conditioning system	none	0	--	--	
	manual	0.0993	0.0666	1.49	
	automatic	0.189	0.0641	2.96	*
ecoDriver system	None	0	--	--	
	Mobile phone app	0.0546	0.0594	0.92	
	Built-in system	0.0855	0.0563	1.52	*
Price (PR)		-0.0000789	-0.0000216	-3.64	*

Number of respondents = 319

Note: for comparability with Table 13, price parameter was converted to GBP for modelling (based on €1.25=£1) and is reported in GBP form here. Subsequently in this report, all willingness-to-pay results are expressed in €. Fuel economy in Spain was measured in l/100km.

The results in Table 13 - Table 15 show that the respondents react quite strongly to the engine types. Compared to a standard petrol engine, they dislike diesel engines, natural gas and hybrid engines and in particular electric engines. They dislike the pure electric engine even more than the electric engine with a range extender, presumably due to issues they identified in the attitudinal questions (Table 4) including the limited range and the risk of an empty battery leaving them stranded. Furthermore, they might not like electric engines due to the additional effort of charging the car. The disutility for diesel engines could be due to the higher noise and vibration or to other negative perceptions about diesel cars.

The parameter accounting for an automatic gearbox shows a negative sign in the UK and Spain, indicating that on average this gearbox type is regarded as inferior to manual gearboxes in those countries. In Germany, this preference against automatics was not evident.

The parameters for air-conditioning systems are not significantly different to zero in the UK (perhaps demand is relatively weak in the UK due to climatic conditions), however in Germany and Spain there is positive utility for air-conditioning. The parameter for a four wheel drive is significant and positive in the UK and Spain which is intuitively correct, though compared to the disutility of a diesel engine, the level of utility from a four wheel drive is rather low. This could be a consequence of only a few respondents having a preference for four-wheel drives.

The parameters for the ecoDriver system are mostly positive, and the built-in system was always valued positively. This seems plausible since the built-in ecoDriver system was described as being more effective.

The parameter relating to fuel economy was as expected: positive for miles per gallon (UK) and negative for litres/100km (Germany and Spain). The remaining non-price parameters were not significant, including engine size, engine power and acceleration, except in Spain where there was a significant but small preference for engine power. The most plausible explanation for this is that the respondents tended to focus on qualitative attributes as they are easier to interpret than continuous variables such as engine power, engine size, acceleration and the price.

3.3.3 Implications for willingness-to-pay

Taking the parameters from Table 13-Table 15 at face value, and comparing the non-price parameters with the price parameter, would give the implied willingness-to-pay results in Table 16. For example, -(-0.216/-0.0000451)*1.25= - €5987. The 1.25 term is the exchange rate used (€1.25=£1). We would caution against applying these WTP numbers in further analysis, however. The key problem with the dataset is that the coefficient on the price variable is very low, which means the respondents are much less sensitive than expected to the car price. This leads to very high WTP values since this is the numeraire. For instance, these results imply that the disutility associated with a diesel engine versus a petrol engine (for an average respondent) is €5987 (UK), which appears high. When computing the price parameter for respondents who declared that the price played a key role when they bought a car, the price parameter is approximately 80% larger resulting in a disutility associated with a diesel engine relative to a petrol engine (for an average respondent) of €3269 which could be considered more realistic. Unfortunately the estimated WTP for the key attribute, the ecoDriver system, is particularly high compared with the expected fuel saving. Assuming a 10% fuel saving, a fuel price of €145/litre and a discount rate of 3.5%, the system would not achieve payback within the foreseeable lifespan of the car, which again means the WTP estimate is implausible.

Table 16: Implied WTP (subject to price parameter issue)

Variable name		**Willingness to pay €**		
		UK	Germany	Spain
Engine type	Petrol	Base		
	Diesel	-5987	-3920	5608
	Natural gas	-13359	-10079	-6860
	Hybrid	-12528	-4595	6907
	Pure electric	-38803	-16634	
	Electric with range extender	-18875	-9470	
Engine size				
Engine Power				58
Acceleration				
Fuel Economy, 1l/100km		-2287	-1645	-1949
Gear Box	manual	Base		
	automatic	-5626		
Transmission	Front wheel drive	Base		
	Rear wheel drive			
	Four wheel drive	5211		2487
Air-conditioning system	none	Base		
	manual		2652	
	automatic		3574	2994
ecoDriver system	None	Base		
	Mobile phone app	*3160*	*-893*	*865*
	Built-in system	4518	*828*	*1355*

Note: For ecoDriver units, all the results are shown, including those not significant at 95% confidence level (non-significant results are shown in *small italics*)

3.3.4 Forecasting the average fuel economy of the private car fleet

Since the WTP could not be computed with confidence, it was not possible to compute a forecast for the average fuel economy of the car fleet given changes relating to different technologies, for example, cost of hybrid engines compared to petrol engines. Nevertheless, given the parameter values we can conclude that the respondents have a positive WTP for built-in ecoDriver units. This would mean that if ecoDriver units are introduced to the market, some car buyers would buy them, though the exact proportion of car buyers who would buy such a system for a given price remains uncertain. In contrast, the parameters imply car buyers do have some reservations about technologies that might help to reduce carbon dioxide emissions. The respondents indicate that the disutility of a pure electric vehicle is between 4.2 and 6.5 times greater than the disutility of a diesel-engine vehicle, when compared with petrol as the 'most preferred' power source (for a given level of efficiency). The same ratio for an electric drive with a range extender is between 2.4 and 3.2. For natural gas powered vehicle the ratio is between 2.2 and 2.6. For hybrids, the ratio is most promising – between 1.2 and 2.1. This does not mean that the respondents do not have a preference for fuel savings in general – the model shows that the respondents have a positive preference for fuel efficiency – but they are reluctant to switch to alternative engine technologies in order to achieve greater fuel efficiency.

3.3.5 Forecast fleet size, fleet composition and car use

In order to help forecast fleet size, fleet composition and car use, we used the model to investigate how key indicators would change in response to fuel prices, income and certain transport market assumptions. The following measures were computed: the average distance driven per household; the average fuel economy of the car fleet (each car with weight one as it is used by the European Commission for computing the car fleet fuel economy); the average fuel economy (each car weighted with the driving distance), the average number of cars per household and the average sum of the price of the new cars the respondents would choose. Table 17 shows the changes in the aggregate numbers relative to the baseline scenario where "everything is like today".

Table 17: Changes in aggregate numbers given different fuel prices, income and transport market assumptions

Change in assumptions	**Fuel consumption**	**Total price of cars (GBP)**	**Number of cars**	**Distance driven (miles)**	**Fuel economy (mpg), weight miles**	**Fuel efficiency (mpg), weight one**
Baseline	0	0	0	0	0	0
Fuel price +50%	-13.7%	-7.5%	-3.3%	-8.1%	6.5%	6.2%
Income +20%	-1.4%	0.1%	-2.2%	-2.7%	-1.4%	-1.5%
Public transportation, price -50%	-8.4%	-1.8%	-2.4%	-8.0%	0.4%	0.5%

Change in assumptions	Fuel consumption	Total price of cars (GBP)	Number of cars	Distance driven (miles)	Fuel economy (mpg), weight miles	Fuel efficiency (mpg), weight one
Public transportation, frequency +100%	-6.9%	-0.9%	-2.6%	-6.3%	0.7%	0.3%
Car sharing (car park)	-10.1%	-1.9%	-3.7%	-9.8%	0.3%	0.8%

Table 17 shows some plausible results for the assumption “fuel price +50%”. Unfortunately, the results for the assumption “income +20%” are not plausible. The increase in mileage should be at least 10% bearing in mind the results of previous studies, if people earn 20% more. Further, the average total price of the car fleet does not increase in this scenario, and the number of cars drops. Note however that these results have to be taken with caution, since self-reported mileage in the surveys could inevitably include some inaccuracy.

3.4 Summary

The Stated Preference surveys and analysis produced a range of outputs which will be applied in the scenario development, as well as some findings (particularly on WTP) which raised further research questions.

1. The built-in ecoDriver system was valued positively by respondents. The results suggested the mobile phone app was less valuable (though its parameter was not significant at the 95% level so it is impossible to be certain). This is plausible since the built-in system was described as being more effective and it can be assumed also that the respondents appreciated a built-in system from an aesthetic and convenience point of view.
2. Due to the price parameter being lower than expected, it is not possible to accurately translate the utility parameters for the ecoDriver units into WTP, and as a result, it is not possible to use this information to forecast the potential market uptake for a given price. The reason for the low price parameter could not be ascertained for certain - one possible explanation identified was the complexity of the questionnaire which required respondents to consider a large number of choices and attributes. The questionnaire was considerably simplified following feedback during the early stages of testing, but the low price parameter still emerged. This issue could be investigated further, for example by a comparative study using different questionnaire designs.
3. Other car attributes valued positively by respondents were: fuel economy; air-conditioning (except in the UK); and four wheel drive (except in Germany).
4. Using the SP results, we were able to compute the relative preferences for different engine types. The petrol engine was the most preferred engine type. The second most preferred engine

type was the diesel engine. The results indicate that the disutility of the other engine types versus a petrol engine , expressed as a factor, was as follows:

- diesel = 1 ;
- hybrid = 1.2 – 2.1 ;
- natural gas 2.2 – 2.6 ;
- electric with range extender 2.4 – 3.2 ;
- pure electric 4.2 – 6.5.

  Therefore whilst respondents have a preference for fuel economy, the model shows they are also reluctant to switch to alternative engine technologies, especially electric vehicles.

5. Using the results of the SP model, a set of aggregate indicators was computed. This gave plausible results for an increase in fuel prices (by 50%), however the results for "income +20%" are not plausible and hence the results should be applied with caution.
6. The attitudinal data showed that approximately 28% thought that an ecoDriver system would distract them from concentrating on driving. 38% of the respondents reported they would not like to use any device that would influence their driving behaviour.
7. A majority of respondents have concerns about multiple aspects of owning and using an electric vehicle. Their reservations are most accentuated in terms of lack of infrastructure (81% feel concerned) and the risk that the battery could run flat whilst driving (79% feel concerned). They are also concerned about the risk of a breakdown (50% feel concerned) and the risk of higher maintenance costs (61% feel concerned). These concerns help to explain the disutility parameters for electric vehicles found by the SP modelling.
8. Another set of attitudinal questions explored the respondents' response to tax policies that would favour green driving and a shift towards active travel and public transport. The results indicate that the respondents are on average neutral to slightly positive about increases in fossil fuel taxation. History suggests, however, that increases in fuel tax are very difficult to implement. The most favoured tax scheme here would be to use increase the price of fossil fuels and use the revenue to reduce taxes on income. For this tax scheme, a majority of 52% would agree or strongly agree. By comparison, 45.5% would agree or strongly agree with an increase in fuel tax in order to fund a government subsidy to more fuel-efficient cars.

4. Scenarios

4.1 Introduction

This section of the report presents the scenarios developed from the work of WP52. The scenarios are based on the data collection, focus group outputs, SP research and aggregation to the market as a whole.

Three overarching scenarios are presented: ‘Green Future’ (GF), ‘Policy Freeze’ (PF) and ‘Challenging Future’ (CF). These cover a range of assumptions about the level of support for green driving, given: technological development; drivers’ acceptance and likely uptake of systems; and wider policy and economic contexts. ‘Policy Freeze’ is the closest to a ‘Business-as-Usual’ scenario, whilst ‘Green Future’ and ‘Challenging Future’ present alternatives on either side of this, in terms of the factors cited above. Textual descriptions of the scenarios are set out below in section 4.2: these are based on the research team’s synthesis of the evidence emerging from the data collection, focus groups and original SP analysis. Subsequently we present the results of quantification of these scenarios in section 4.3: this provides a set of essential inputs for the simulation modelling work in WP53, and will be subject to further generalisation to the EU28 as part of WP54 Scaling-Up and Cost-Benefit Analysis.

4.2 Scenario descriptions

4.2.1 Scenario set

Our scenarios (Figure 2) are characterised by:

- contextual assumptions that can be described as: Green Future (GF), Policy Freeze (PF) or Challenging Future (CF). For example these sets of assumptions differ in terms of: the outlook for fuel prices over the next 20 years; how public attitudes and policy are evolving in relation to lower-carbon driving; and what is the pace of technological development in vehicle efficiency;
- the presence or absence of ecoDriver systems – this is the standard do-something/do-nothing comparison for cost-benefit analysis; and
- projections over 20 years, at 5 yearly intervals.

Contextual scenarios

	Fuel price outlook	Supportive attitudes and policy	Technology development
A. 'Green future'	High	Yes	Faster
B. 'Policy freeze'	Central	No	Slower
C. 'Challenging future'	Low	No	Slower

× *With/Without ecoDriver system*

Analysis for: 2015, 2020, 2025, 2030

Figure 2: Characterisation of scenarios

Combining the contextual scenarios with the presence/absence of ecoDriver systems, we have six scenarios in total, and will quantify these at five year intervals. The following numbering system will be used for the scenarios and the future years: Scenario Name – with ecoDriver (Yes=Y or No=N) – Year (Figure 3). In 2015, it is assumed that the scenario is common – the current situation. A subscript combining the three elements above will be used to indicate the future values of variables, e.g. $FP_{GF\text{-}Y\text{-}2020}$ to indicate fuel price in contextual scenario GF 'Green Future', with ecoDriver systems in place, in the year 2020.

N-2015	GF-Y-2020	GF-Y-2025	GF-Y-2030
N-2015	GF-N-2020	GF-N-2025	GF-N-2030
N-2015	PF-Y-2020	PF-Y-2025	PF-Y-2030
N-2015	PF-N-2020	PF-N-2025	PF-N-2030
N-2015	CF-Y-2020	CF-Y-2025	CF-Y-2030
N-2015	CF-N-2020	CF-N-2025	CF-N-2030

Figure 3: Scenario and year numbering

4.2.2 Oil prices

Underlying the traffic projections are oil price projections, which influence the attractiveness of driving and of different powertrains & fuel types. Figure 4 summarises the range of oil price projections we have considered, based on our assessment of forecasts by the IEA, the US EIA, the IMF and the UK Department of Energy and Climate Change (DECC, 2014).

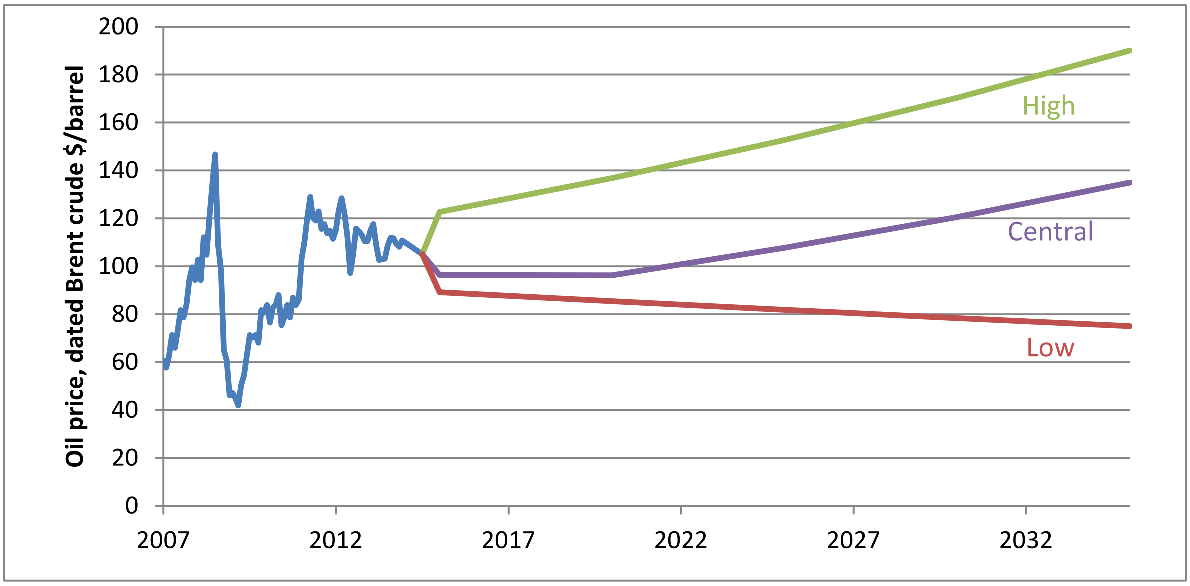

Figure 4: Oil price trajectories, 2014 $ prices
(Historic data: EC Energy Statistics and Market Observatory (2014). Forecasts: DECC (2014))

The fuel price outlook incorporated in the 'Policy Freeze' scenario is represented by the 'Central' trace in Figure 4, reaching ~$135 by 2035 (in 2014 dollars). A high fuel price outlook, which is built into the 'Green Future' scenario would be better represented by the upper ('High') trace, while the low fuel price outlook which is part of the 'Challenging Future' scenario can be represented by the 'Low' trace in Figure 4. We have worked through the consequences of this during Task 52.3 and incorporated these projections into the final scenarios.

4.2.3 Other scenario assumptions

Alongside the oil price assumptions, we also assume the following, broadly consistent with the EC Transport White Paper (2011) updated for trends since 2011:

- Population: EU-28 expected to grow by 0.2% p.a. to 2035 then decline slightly thereafter, remaining fairly stable at around 500 million in the next 40 years; individual countries' populations may differ substantially from this trend;
- GDP growth: EU-28 1.2% p.a. 2000-2010 (past), projected rate 2010-2020 assumed to recover to 2.2% (similar to 1990-2000 average) due to higher productivity growth rate in the new Member States. Projected to fall to 1.6% again 2020-2050 mainly due to demographics – an ageing population implies a reduction in the population of working age and a drag on growth; the 'Challenging Future' scenario will look to the lower end of the range for GDP growth projections; again there will be latitude for variations at country level based on specific data & forecasts.
- Public transport prices: country-specific data and forecasts are used to drive bus demand and car ownership responses.

4.2.4 Description of the Contextual Scenarios

Green Future (GF)

In the Green Future scenario, it is assumed that the following influences come together to achieve ambitious carbon reductions from the road transport sector. Crude oil prices take the high trend projected by the main international organisations, to an average of around $190/barrel by 2035 (in 2014 prices). There is also an increase in production of renewable energy. Public attitudes swing in favour of carbon reduction and people have in general more pro-green environmental attitudes. Policymakers respond by continuing to develop and enact legislation in support of ambitious long term carbon targets such as those set out by the European Commission – i.e. an overall 80% reduction in emissions by 2050 relative to 1990 levels, a 60% reduction from transport over the same period, and by 2030 capping the growth in CO2 emissions within the range -9% to +20% compared with 1990.

In the vehicle market, consumers are highly accepting of the need for lower-carbon and fuel-saving vehicles and focus on the technologies best able to deliver these improvements, giving the automotive sector the strongest incentives to develop greener technologies. In addition, governments provide specific incentives in the form of financial and legislative support for technology shifts such as electric vehicle charging infrastructure, and disincentives for purchase of carbon-intensive vehicles, for example through differentiated vehicle and fuel taxation, road user charges, subsidies for installing electric charge poles at workplaces and low emissions zones. As a consequence, electric vehicles achieve about 10% of the new car market by 2035, and another 50% of that market is filled by hybrids and plug-in hybrids. New buses are ~15% electric and ~50% hybrid. Car renewal rates will be high especially for electric, hybrid and plug-in hybrid vehicles.

The trend will be towards partial automation of some of the driving tasks, e.g. systems as traffic jam assist. At the later years there will be some fully automated vehicles for low speed conditions in urban areas. The trend will also be that eco-driving systems will go from informing the driver on how to drive towards automation of the fuel minimisation task, at least at the end of the study period. Deployment of automated eco-driving systems will be high for trucks and commercial vehicles and somewhat less for cars. There will be a high rate of innovation related to vehicles, infrastructure and traffic control in general.

Forecasts indicate that real income will rise over the period rather than stay static. An OECD report (http://www.oecd.org/eco/growth/Growth-prospects-and-fiscal-requirements-over-the-long-term.pdf) states that between now and 2060, GDP per capita is seen to increase more than eightfold in India and sixfold in Indonesia and China, whereas GDP per capita in the highest-income OECD countries may only roughly double over this period. Households will spend more of their income on green and environmentally friendly goods and services. The number of vehicles per household will decrease compared with other scenarios (however, given the forecast growth in the EU as a whole up to 2035, it will take some time for the number of vehicles per household to decline). There will be more shared vehicles and an increase in public transport, cycling and walking trips. Economic performance – GDP and unemployment – will broadly follow current forecasts.

There will be an increase in transport demand including an increase in demand of transport of goods by road. However, this might not lead to an increase in the number of vehicle km driven by trucks due to a trend towards better coordination of transports and logistics.

Whilst this scenario is most favourable to low-emissions vehicles, its impact on eco-driving systems is somewhat open, since the future level of emissions of a vehicle without eco-driving systems will be reduced. However, the positive environmental attitudes of the public and enhancements of the eco-driving systems will result in an increase in both usage and compliance of the eco-driving systems. The deployment of the Full ecoDriver System (FeDS) will get close to 100% in 2030 (especially in trucks). Vehicles not equipped with a FeDS will have a nomadic ecoDriver system and the share of vehicles without any ecoDriver system will decrease towards zero over the study period.

Policy Freeze (PF)

In the Policy Freeze scenario, fuel prices take the 'Central' path towards a value of $135/barrel by 2035 (in 2014 prices). The current policy ambitions at EU and national levels are not brought to fruition. Instead, policy is frozen in its current legislative position, without further progress on issues such as emissions targets for road vehicles beyond 2020, or heavy goods vehicles. The European economy is assumed to slowly resume growth, with transport activity resuming its long term growth trends: passenger activity rising by ~50% and freight by ~82% by 2050. Economic performance – GDP and unemployment – will broadly follow current forecasts. The higher fuel price will result in slightly lower household purchasing power. There will continue to be a similar distribution of environmental attitudes as today: some consumers will be highly accepting of the need for lower carbon and fuel saving vehicles while some will not place much or any importance on those attributes.

The automotive industry will continue the development of cleaner vehicles. However, the pace of electrification in the transport sector will be similar to today, and market penetration of electric cars remains at similar levels as today throughout our scenario period (2015-2034). The deployment rate of rate of hybrids and plug-in hybrids cars will increase over the study period. Buses and goods vehicles remain predominantly (>95%) powered by diesel internal combustion engines. Vehicle renewal rates will stay at similar levels to today.

Charging infrastructure for charging electric vehicles will continue to be limited (e.g. only available in some local communities or commercial areas but not wide spread). Development and deployment of automated driver support systems will be slow and will be limited to high-end cars and rich and eco-friendly vehicle buyers. Automation of eco-driving systems will mainly appear for trucks and usage and compliance levels of eco-driving systems for cars will stay at similar levels as today. Deployment rates of the FeDS will be low for cars and higher for trucks whilst the deployment rates of the nomadic system will be higher.

Challenging Future (CF)

In this scenario, oil prices are assumed to follow a lower trajectory, towards $75/barrel by 2035 (in 2014 prices), consistent with the lower predictions of the main international organisations. This reduces the market incentive for vehicle manufacturers to develop fuel-saving vehicles. It is also assumed in this scenario that public attitudes are hostile to public carbon reduction targets, in part because global economic growth remains subdued (one of the causes of the lower oil price trajectory). In the vehicle market, the consequences are broadly stasis at around today's fleet mix and traffic mix in terms of different powertrains and fuel types.

In this scenario, there are fewer environmentally-supportive policies and regulations, e.g. lower fuel taxes and CO_2 prices, less financial support to public transport which is left increasingly to the market, and cycling and walking infrastructure is limited and not well maintained. Household income will be low for a large part of the population. The number of vehicles per household will be similar to today but the renewal rates will be lower.

There will be less renewable energy than today. The number of electric vehicles will decrease and the deployment of hybrids and plug in hybrids will slow down. The number of vehicle km driven on electricity will be low. There are few incentives for the vehicle manufacturers to develop greener cars and the development of vehicle efficiency technologies will be slow. The public will have limited interest in buying such new technologies, partly because low production rates will keep the unit costs of installation high, whilst the need to save fuel will be low for a large part of the population.

There will be only a gradual increase in demand for road freight driven by subdued economic growth, and continued low coordination of transportation and city logistics. Travel demand by car will increase modestly due to cheap oil and economic growth and a lack of focus on public transport systems.

The deployment of the ecoDriver systems will be low due to limited public interest and economic incentives, and high purchase cost in combination with low household income. Usage of and compliance with the ecoDriver systems will vary across market segments: broadly high in freight transport where the potential savings are largest per vehicle; and high amongst cost-conscious and environmentally sensitive car drivers; but for other segments broadly as today.

4.2.5 With/Without ecoDriver

These two situations will be defined as follows:

- 'With ecoDriver' (Y): eco-driving systems exist and market penetration follows a path projected by the work in WP52. In broad terms, we expect:
    - Market penetration among buses, commercial vehicles and fleet cars to approach 100% over time, driven by cost-saving motives;
    - Market penetration among personal car users will grow more slowly, still approaching 100% but at a later date, as the fleet is gradually replaced.
- 'Without ecoDriver' (N): assume zero market penetration, for the purposes of isolating the benefit due to eco-driving systems by comparison with the (Y) situation.

4.3 Quantification

4.3.1 Introduction

The Simulation of Future Traffic (WP53) and the Scaling-Up and CBA (WP54) both require quantitative descriptions of the scenarios. For the traffic simulations, which are the first user of the ecoDriver scenarios, the key data requirement is the future traffic mix, by road type, vehicle type and powertrain/fuel type. For the CBA, it is also important to have predictions of the take-up of ecoDriver systems, in order to compare the 'with ecoDriver' and 'without ecoDriver' scenarios.

The method and results are given in this chapter: section 4.3.2 describes the method; section 4.3.2 gives the results for traffic mix; 4.3.2 gives the results for ecoDriver takeup; and 4.3.2 gives the remaining results. For clarity, we show a summary of the results tables here in the main text, and the rest are set out in Annex E.

4.3.2 Method

The principal steps involved in quantifying the scenarios were the following.

1. Identifying the output requirements
2. Collating background data that was gathered in WP52 and any essential additional data, such as:
   - up-to-date forecasts of real GDP/capita;
   - population forecasts;
   - the most recent fuel price data and forecasts (EC Energy Statistics and Market Observatory, 2014; DECC, 2014); and
   - vehicle fleets and traffic data that provide the baseline.
3. Development of a projection of the vehicle fleet, across all cars, vans, trucks and buses, from 2015 to 2035.
4. Based on the fleet projection and vehicle usage (km per annum), projections of traffic mix from 2015 to 2035.
5. An assessment of future market take-up of the ecoDriver systems – both the FeDS and the mobile app – taking into account the SP results and other evidence.
6. Discussion of the results by the project team, identification of improvements and preparation of quantified scenarios for reporting.

The main *output requirements* for the quantified scenarios were the following,

a. The traffic mix, by
   - Road type (urban, rural and motorway)

     ×
   - Vehicle type

     ×
   - Powertrain/fuel type

     ×
   - Scenario (PF,GF,CF with and without ecoDriver systems)

     ×
   - Year (2015/20/25/30/35)

b. Take-up of eco-driving systems – specifically the FeDs and the mobile app – from 2015 to 2035;
c. The growth in traffic over time (2015-2035), so the simulations can analyse increasing demand conditions on the network; and
d. The vehicle fleet mix from 2015-2035 – mainly as an intermediate result, the traffic mix being the more important final output.

Previous vehicle fleet scenario studies, e.g. SULTAN (Hill and Morris, 2012), and TOSCA (Kok, Laparidou and Rahman, 2011) are now becoming out-of-date and have been overtaken by changes in the vehicle fleet, and the trajectories of economic variables following the crisis of 2008. Hence a fresh set of projections was required. Moreover, in order to develop a set of quantified future scenarios at the level of detail indicated above, a suitable base dataset was needed, comprising detailed vehicle fleet data and traffic not just at the aggregate level but broken down by road type, vehicle type and fuel/powertrain type. It is also invaluable to have a set of forecasts for the key economic indicators underlying the projections, and where possible an existing vehicle market forecast around which ecoDriver can pivot, varying the key assumptions and drivers of future vehicle demand. For these reasons, we chose to use data for the UK which gives the scope and quality of data available. The UK can be regarded as broadly representative in EU terms, in its take-up of cleaner and more efficient vehicles and its vehicle market in general. The comparison between the UK, the EU-28 and selected other EU countries is shown in Table 18, which indicates that the UK's diesel, hybrid and electric shares are close to the EU-28 average. In 2013, the UK's EV+PHEV share was slightly below the EU-28 average at 0.16%, however by 2014, SMMT data indicate that it had increased to 0.59%, reflecting annual volatility. In recent years, some other countries, particularly the Netherlands in 2013, have experienced rapid increases in electric and hybrid ownership. This has been partly due to the incentives offered by government, and could be repeated in other countries where the government was willing to incentivise purchased of low carbon vehicles in the same ways. We use the three main scenarios – the Green Future, Policy Freeze and Challenging Future, to present different take-up trajectories, and the Green Future mirrors most closely the recent experience in the Netherlands (up to 2013) and in Norway (outside the EU).

Table 18: EU-28 vehicle market comparison, % of new car purchases, 2013

Countries	Diesel	Hybrid	EV/PHEV
EU-28	53%	1.4%	0.42%
Germany	48%	0.8%	0.25%
UK	50%	1.3%	0.16%
France	66%	2.6%	0.52%
Spain	67%	1.4%	0.12%
Netherlands	25%	5.7%	5.43%

Source: ICCT (2014)

A wide range of *background data* was gathered, including:

- real GDP per capita – historic data plus projections from 2015-2035 sourced from OBR (2014);
- population – historic data plus projections to 2035 from ONS (2013);
- oil and fuel prices and forecasts from EC Energy Statistics and Market Observatory (2014) and DECC (2014);
- long-term trends in public transport prices from published statistics (House of Commons, 2013);
- historic vehicle fleet mix (DfT, 2014; SMMT, 2014);
- historic traffic mix by road type and vehicle type (DfT, 2014) and forecast traffic to 2035, based on the central projections of GDP, population and fuel prices (DfT, 2013);
- forecast fuel type mix in traffic to 2035 (NAEI, 2014).

Where background data was available at five year intervals, linear interpolation was used to complete all years.

Vehicle fleet projections

The first step in the analysis was to develop a breakdown of the *vehicle fleet*, across all cars, vans, trucks and buses. This was done with aid of detailed historic official statistics (DfT, 2014). Having established a baseline in 2013 we projected the series forward to 2015, 2020, 2025, 2030 and 2035 using the following approach. Transportation elasticities from the literature (Annex D) were used to identify how the desired vehicle stock would evolve over time, driven by real GDP, population and fuel prices, and constrained by the capacity of the network through increasing travel time and delay. Evidence of vehicle lifetimes and scrappage rates from official statistics (DfT, 2014) were used to predict what % of the fleet would be scrapped each year. The gap between the desired fleet and fleet carried over from the previous year after scrappage was assumed to be made up by new vehicle purchases, and these were allocated between fuel types based on assumptions about the relative attractiveness of petrol, diesel, hybrid and electric vehicles, in view of the evidence emerging from the Focus Groups and the SP survey. Those assumptions are recorded in the descriptive scenarios. For example:

- In the Policy Freeze scenario, market penetration of electric cars remains at similar levels as today (which we apply to EV and PHEV), while buses and goods vehicles remain predominantly (>95%) powered by diesel ICEs. The deployment rates of hybrids will increase.
- In the Green Future scenario, electric cars achieve about 10% of the new car market by 2035, and another 50% of that market is filled by Hybrids and PHEVs. In the Van market, we assume a steady rate of growth to a 5% market share each for EV/PHEVs and hybrids by 2035, and in the Truck market a 2.5% market share each for EV/PHEVs and hybrids by 2035. New buses are assumed to be ~15% electric and ~50% Hybrid.
- In the Challenging Future scenario, there is broadly stasis around today's fleet mix.

In all the scenarios, the relative shares of diesel and petrol cars were projected as flat (constant) over the period, after taking account of variations in hybrid, EV and PHEV shares. This reflected a judgement that the mix of factors affecting future petrol vs diesel demand were complex, and did not point clearly in favour of each fuel type over the period concerned. For example, petrol engines are typically superior in terms of urban emissions whilst diesels are typically superior in terms of CO2 emissions. Whilst diesels have seen a recent surge in new purchase market share, this may be tempered in the medium term by tighter regulation based on their local emissions, whilst petrol engine technology is currently advancing in terms of fuel economy.

The scrappage rates differ between vehicle types reflecting the available data, i.e. cars have 14 year mean life in the PF scenario, vans 14.4 years, trucks 13.6 years and buses 17.7 years (DfT, 2014). The project team also assumed that scrappage rates would respond to the different scenarios: in particular, the mean life of a car is assumed to reduce to 12 years in the Green Future, since high fuel prices would incentivise drivers to acquire cleaner and more efficient vehicles more quickly, whilst in the Challenging Future, with lower fuel prices, the mean life of a car is assumed to extend to 16 years.

Traffic mix

The second step was to examine the *traffic mix* on the network, which is specific to road types that link to the simulations in WP53, i.e. an urban network, a rural route and a motorway. In order to obtain the traffic mix, vehicle usage rates in km per annum – by road type – were applied to the fleet projections. Vehicle use for the base year (2013) was obtained from the latest traffic and vehicle stock data (DfT, 2014). The NAEI (2014) data was used to break traffic down also by fuel type, although the data did not identify hybrids separately, and the hybrid share was inferred from other sources (e.g. the SULTAN model). For future years the rate of use was varied to reflect the development of expected key drivers including GDP, population density and fuel prices, again based on elasticity evidence (Annex D). For buses, the key driver is the mode shift effect from the car segment of the market, as fuel prices evolve in each of the three scenarios. For all vehicle types, the projected vehicle use was applied to the absolute quantity of traffic in billions of vehicle km (by road, vehicle and fuel type).

Given the way the traffic mix was calculated, it was relatively straightforward to derive *traffic growth* over time, from the results. In principle this needed to take into account any network capacity expansion, however relatively little was planned – approximately a 0.2% expansion, over the first 7 years of the period studied, with no fixed plans thereafter. Indeed, in some urban areas there is a trend towards car capacity reduction in favour of public transport and active modes. Therefore for WP53, an approximation to traffic growth is derived directly from the traffic mix calculations.

Take-up of ecoDriver systems

Finally, the take-up of ecoDriver systems is assumed to be conditioned by their availability on one hand and the demand for them on the other. Key aspects of equipment availability are: the ownership of smartphones, which enables use of the mobile app; the presence of the full ecoDriver system (FeDS) pre-fitted to vehicles; and the prices associated with each option. We assume that the FeDS is not available for retrofit to existing vehicles: this was considered and rejected as a possibility within reasonable cost limits. We also assume that the ecoDriver mobile app is itself essentially free of charge – Focus Groups found that this was expected by the market, and take-up would be deterred otherwise. There is a small additional cost to the user (€15) for the phone holder, which is taken into account.

Equipment availability

To use the mobile app, the main equipment needed is a smartphone. Evidence is that smartphone take-up is near saturation: this will be reached at 92% ownership by 2018 (Kantar Comtech/Guardian, 2014). In the car market, we assume that drivers who don't have a smartphone are not part of the market for ecoDriver systems and exclude them from further analysis. In the market for goods vehicles and buses, we make a slightly different assumption: that all operators are potentially users of smartphones, and those that do not do so are either users of the FeDS or are part of the small group who would not use an ecoDriver system if available (assumed to be 5% in GF, 10% in PF and 20% in CF).

To use the FeDS, the system must be pre-fitted to the vehicle. Availability is limited by fleet turnover, and we use the fleet turnover analysis from the previous section to implement this. Ultimate levels of market penetration in the fleet by the FeDS system are based on the team's judgement, in view of Focus Group discussions and the SP survey (see the highlighted figures in the final column of Figure 8).

Demand

We use two main approaches. The first takes the attitudinal data from the SP survey on who would use an ecoDriver system if fitted, and extrapolates it to other scenarios and shifts in attitudes over time. In 2016, in the PF and CF scenarios, we assume – based on the survey responses – that 38% of car drivers will not use an ecoDriver system if fitted. In the same year we assume that in the Green Future scenario there is an immediate attitude shift so that only 20% of car drivers will not use an ecoDriver system if fitted. In GF and PF we allow usage to increase slightly over time as familiarity with such systems increases and attitudes shift. In the CF, we assume attitudes remain fixed. The team has discussed and agreed these numbers.

The second considers WTP for the ecoDriver systems. Here the main finding is that WTP exceeds the expected cost saving for most drivers in most scenarios, however we take a cautious and systematic approach. First we note that usage is constrained by the spread of FeDS in the fleet and by the assumed logistic curve ('product take-off curve') over the first 5 years for the mobile app. Second we analyse for whom the FeDS is a worthwhile purchase over and above the mobile app (incremental analysis). For this we examine the distribution of annual mileages, and hence cost savings, in the fleet (for car). We find that for a majority (in most cases), the FeDS is a worthwhile incremental purchase, though the size of that majority varies. We feed this information back into the projected market shares of the mobile app, the FeDS, and 'no ecoDriver system used'.

Goods vehicles and buses tend to be more highly utilised, and for these classes of vehicles the FeDS is very widely justified as an incremental investment. The cases where the FeDS is least valuable are the Challenging Future scenario with low fuel prices, and even here the smartphone app turns out to be useful for 26% of drivers, versus 54% for the FeDS and still only 20% without ecoDriver systems by 2035.

Outputs

Hence the main results are the % of drivers using each ecoDriver system, and the % of vehicles fitted with the FeDS. Note that most but not all FeDS systems are used, because some are packaged with other features and trim levels, leading to the vehicle being purchased by someone who does not wish to use the FeDS; we assume that it can be switched off.

All the above calculations were carried out in an Excel workbook. Discussion of the preliminary scenario results amongst the project team in February 2015 led to further refinements, and a number of corrections to the analysis. The final results after incorporating these changes are shown in the following 3 sections.

4.3.3 Traffic mix

The urban traffic mix in the three main scenarios is shown in Figure 5 - Figure 7. The results for rural roads and motorways are given in Annex E.

Urban (non-motorway)							
		Year					
Vehicle type	Fuel type	2013	2015	2020	2025	2030	2035
Car	Petrol	58.0%	55.1%	50.3%	47.0%	44.8%	43.0%
	Diesel	41.3%	44.0%	48.2%	50.6%	51.9%	52.2%
	Hybrid	0.5%	0.7%	1.2%	1.8%	2.6%	3.8%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.0%	0.1%	0.2%	0.2%	0.2%	0.3%
	PHEV	0.0%	0.1%	0.2%	0.3%	0.5%	0.7%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.9%	2.6%	2.0%	1.6%	1.4%	1.3%
	Diesel	96.7%	97.1%	97.7%	98.1%	98.4%	98.5%
	Gas	0.2%	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
	Hybrid+Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Bus	Diesel	99.8%	99.7%	99.6%	99.4%	99.4%	99.3%
	Hybrid	0.2%	0.2%	0.4%	0.4%	0.5%	0.6%
	Gas	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%
	EV	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 5: Projected traffic shares by road type and vehicle type, 2015-2035, 'Policy Freeze' scenario, Urban (non-motorway) roads, % of vehicle km

Urban (non-motorway)						
		Year				
Vehicle type	Fuel type	2015	2020	2025	2030	2035
Car	Petrol	55.3%	49.6%	45.4%	41.1%	34.3%
	Diesel	43.7%	48.4%	50.0%	48.6%	42.0%
	Hybrid	0.7%	1.5%	3.4%	7.8%	18.2%
	Gas	0.1%	0.1%	0.0%	0.0%	0.0%
	EV	0.1%	0.3%	0.8%	1.9%	4.1%
	PHEV	0.0%	0.1%	0.3%	0.6%	1.4%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.7%	2.1%	1.7%	1.5%	1.3%
	Diesel	97.0%	97.5%	97.7%	97.2%	95.4%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.1%	0.2%	0.4%	0.9%	2.2%
	Hybrid+Ot	0.0%	0.0%	0.1%	0.4%	1.1%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	99.9%	99.7%	99.2%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	4.4%	9.1%	13.5%	18.8%	25.7%
	SUBTOTAL	104.4%	109.1%	113.4%	118.5%	124.9%
Bus	Diesel	99.7%	99.4%	98.7%	97.0%	92.7%
	Hybrid	0.2%	0.5%	1.1%	2.6%	6.3%
	Gas	0.0%	0.1%	0.1%	0.1%	0.1%
	EV	0.0%	0.0%	0.1%	0.3%	0.9%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 6: Projected traffic shares by road type and vehicle type, 2015-2035, ‘Green Future’ scenario, Urban (non-motorway) roads, % of vehicle km

Urban (non-motorway)						
		Year				
Vehicle type	Fuel type	2015	2020	2025	2030	2035
Car	Petrol	55.2%	50.5%	47.6%	45.8%	44.6%
	Diesel	43.8%	48.2%	51.0%	52.8%	53.9%
	Hybrid	0.7%	0.9%	1.1%	1.2%	1.3%
	Gas	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.0%	0.1%	0.1%	0.1%	0.0%
	PHEV	0.1%	0.2%	0.2%	0.1%	0.1%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.6%	2.0%	1.7%	1.4%	1.3%
	Diesel	97.1%	97.7%	98.1%	98.4%	98.6%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.1%	0.1%	0.1%	0.1%	0.1%
	Hybrid+Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Bus	Diesel	99.7%	99.6%	99.6%	99.6%	99.6%
	Hybrid	0.2%	0.3%	0.3%	0.3%	0.2%
	Gas	0.0%	0.1%	0.1%	0.1%	0.1%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 7: Projected traffic shares by road type and vehicle type, 2015-2035, ‘Challenging Future’ scenario, Urban (non-motorway) roads, % of vehicle km

These results highlight the potential differences in the mix of ICE, hybrid and EV/PHEV vehicles on the network in future years up to 2035, given different trajectories for key variables such as fuel prices, income growth and government support for green technologies in the vehicle market. For example, the hybrid share in car traffic could be as high as 18% by 2035, or as low as 1.3%, depending on the scenario being adopted. Note also that an 18% share in car traffic corresponds to a 48% share in new car purchases in 2035, as the fleet gradually turns over and older vehicles are withdrawn.

4.3.4 Take-up of ecoDriver systems

The results for the take-up of ecoDriver systems are shown in Figure 8, and the market penetration of the Mobile app and the FeDS in the two contrasting scenarios – Green Future and Challenging Future – are shown in Figure 9 and Figure 10. In the early years, Mobile app take-up is strongest, because the main user requirement is simply ownership of a smartphone, whereas the FeDS takes longer to integrate into the vehicle fleet. However, the FeDS offers an advantage in fuel savings, which is attractive to most users – except those who drive a low mileage or have attitudes that are resistant to the use of in-vehicle technologies to improve driving efficiency. Consequently over time the FeDS becomes dominant in the Green Future. In the Challenging Future, the FeDS share is smaller, since private car drivers are assumed to maintain their current attitudes (found in the SP survey) such that 38% will not use an ecoDriver system if fitted, and these drivers are treated as choosing 'None' in the table below. For goods vehicles and buses, ecoDriver systems are assumed to be purchased purely on cost saving grounds. These vehicles also have high annual mileages. This leads to higher market penetration for these vehicle types. Take-up is not instantaneous for the Mobil app or the FeDS: instead there is assumed to be an S-shaped product take-off curve in the first 5-9 years starting from 2015. Combined with the Mobile app's early years advantage, this results in an n-shaped profile of market share for the Mobile app, rising initially and then falling as the FeDS replaces it in the fleet.

Vehicle type	Scenario	Share (use)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Car	GF	Mobile app	0%	7%	21%	50%	64%	60%	54%	49%	43%	38%	32%	27%	21%	18%	18%	18%	19%	19%	19%	19%	19%
		FeDS	0%	0%	1%	3%	6%	12%	18%	24%	30%	36%	42%	48%	54%	57%	57%	58%	58%	59%	59%	60%	60%
		None	100%	93%	78%	48%	30%	28%	28%	27%	27%	26%	26%	25%	25%	25%	24%	24%	23%	23%	22%	22%	21%
	PF	Mobile app	0%	5%	15%	36%	47%	47%	45%	43%	41%	39%	37%	34%	32%	30%	28%	26%	24%	23%	22%	22%	22%
		FeDS	0%	0%	1%	2%	3%	5%	8%	10%	13%	15%	18%	20%	23%	26%	28%	30%	32%	34%	35%	36%	36%
		None	100%	95%	84%	62%	50%	47%	47%	47%	46%	46%	46%	45%	45%	44%	44%	44%	43%	43%	43%	42%	42%
	CF	Mobile app	0%	4%	13%	32%	41%	43%	42%	41%	39%	38%	37%	35%	34%	32%	31%	30%	28%	27%	26%	25%	25%
		FeDS	0%	0%	1%	1%	2%	3%	4%	5%	6%	8%	9%	10%	12%	13%	15%	16%	17%	19%	20%	21%	20%
		None	100%	95%	86%	67%	57%	54%	54%	54%	54%	54%	54%	54%	54%	54%	54%	54%	54%	54%	54%	54%	54%
Goods, bus	GF	Mobile app	0%	9%	26%	61%	76%	80%	75%	69%	64%	59%	53%	48%	42%	37%	31%	26%	21%	16%	12%	9%	10%
		FeDS	0%	0%	1%	2%	6%	11%	17%	22%	28%	33%	39%	45%	50%	56%	62%	68%	73%	79%	83%	85%	86%
		None	100%	91%	73%	37%	18%	9%	9%	8%	8%	8%	8%	7%	7%	7%	7%	6%	6%	6%	6%	5%	5%
	PF	Mobile app	0%	8%	25%	58%	73%	79%	75%	71%	67%	62%	58%	53%	49%	44%	40%	35%	31%	27%	23%	20%	18%
		FeDS	0%	0%	1%	2%	4%	7%	11%	16%	20%	25%	30%	34%	39%	44%	49%	54%	58%	63%	67%	70%	72%
		None	100%	92%	74%	40%	23%	14%	14%	13%	13%	13%	13%	12%	12%	12%	12%	11%	11%	11%	11%	10%	10%
	CF	Mobile app	0%	8%	23%	54%	69%	75%	73%	70%	66%	63%	59%	55%	51%	48%	44%	40%	37%	33%	30%	28%	26%
		FeDS	0%	0%	1%	2%	3%	5%	7%	10%	14%	17%	21%	25%	29%	32%	36%	40%	43%	47%	50%	52%	54%
		None	100%	92%	76%	44%	28%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%

Figure 8: Projected take-up of ecoDriver systems, 2015-2035, ‘Green Future’/‘Policy Freeze’/‘Challenging Future’ scenarios, % of drivers

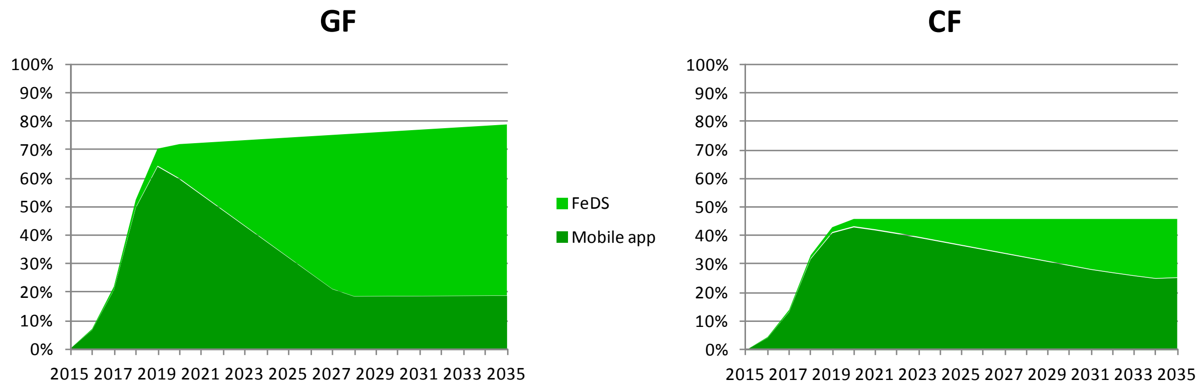

Figure 9: Projected market penetration of ecoDriver systems, Green Future and Challenging Future scenarios, use by car drivers, 2035

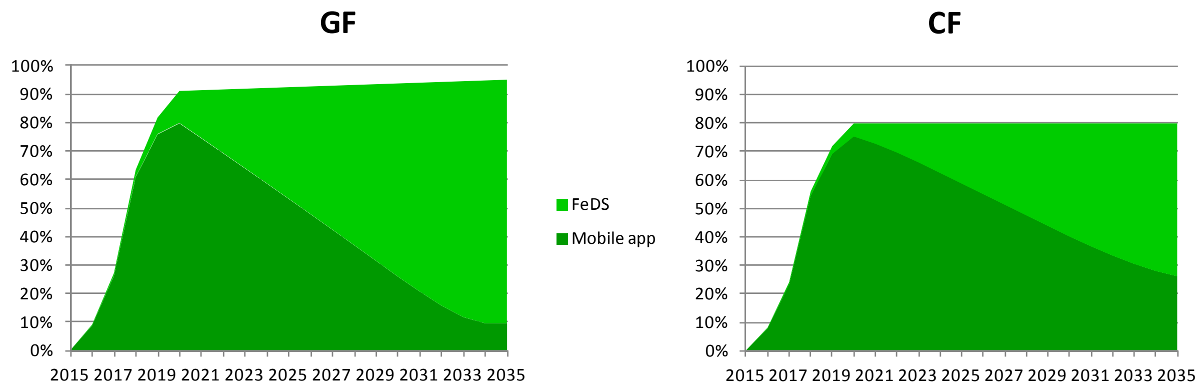

Figure 10: Projected market penetration of ecoDriver systems, Green Future and Challenging Future scenarios, use by goods and bus drivers, 2035

4.3.5 Other outputs

Other outputs include projections of the vehicle stock and traffic growth on each of the key network types. These are described in the figures and tables below.

Table 19 shows the fuel type shares of the car stock in 2035, to illustrate the effect of the different scenarios by the end of the study period.

Since it takes a long time for the fleet to be replaced (e.g. 14 years is the mean life of a car), the share of electric and hybrid vehicles in new car purchases tends to outstrip their share of the car stock. So for example by 2035, the share of hybrids in new car purchases is 48% in the Green Future (see Figure 11), versus only 19% of the car stock. Among the key drivers of this traffic growth, the most powerful is real GDP growth, however also very important in differentiating the three scenarios from each other is the fuel price variable, which contributes a 16% difference in traffic between the Green Future and the Challenging Future scenarios.

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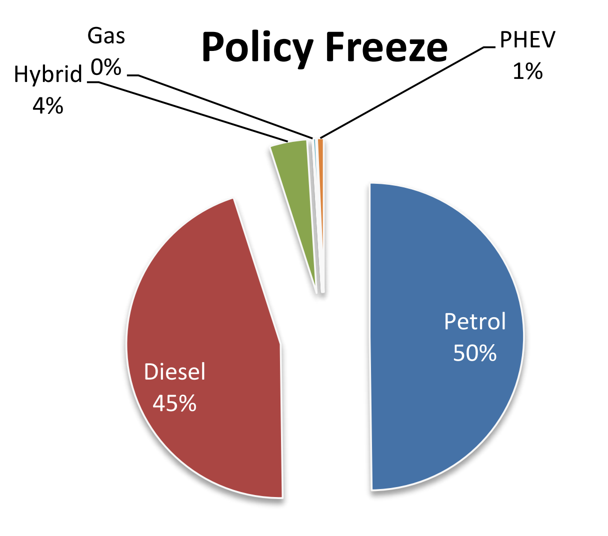
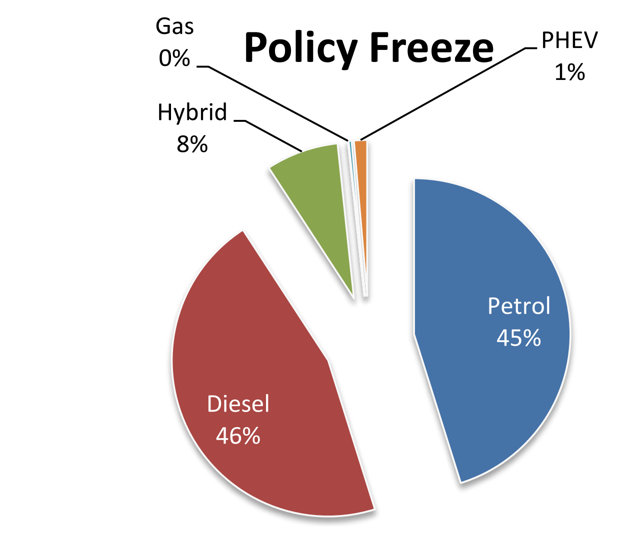
<tr><th>Projected car stock in 2035</th><th>Projected new car purchases in 2035</th></tr>
<tr><td>
</td><td>
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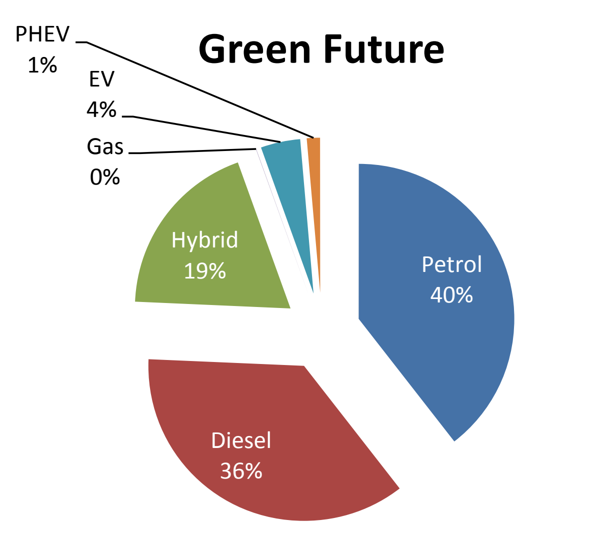
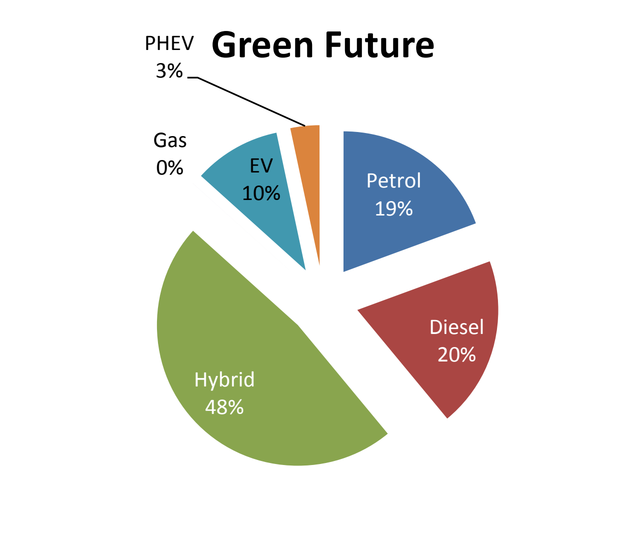
<tr><td>
</td><td>
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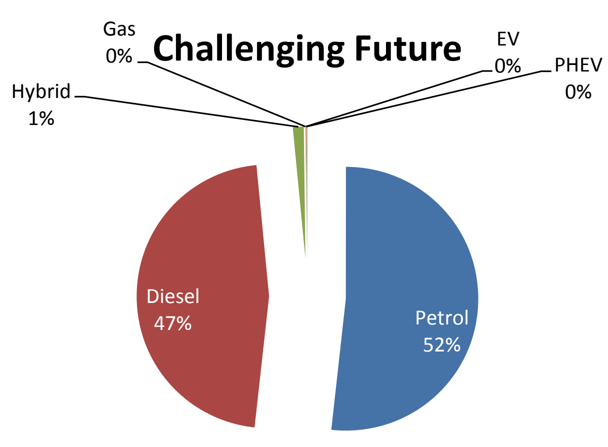
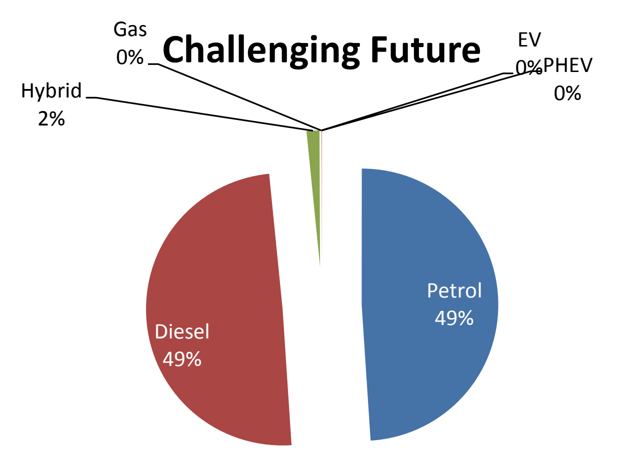
<tr><td>
</td><td>
</td></tr>
</table>

Table 19: Projected car stock and new car purchases by fuel type, all scenarios, 2035

Traffic growth index, 2015=100						
		2015	2020	2025	2030	2035
Urban (non-motorway)	Policy Freeze	100.0	113.6	126.2	138.2	149.9
	Green Future	100.0	110.6	121.2	132.1	143.2
	Challenging Future	100.0	122.3	143.2	166.7	183.8
Rural (non-motorway)	Policy Freeze	100.0	114.2	127.2	139.5	151.5
	Green Future	100.0	111.0	121.4	131.2	138.9
	Challenging Future	100.0	122.9	144.4	168.6	186.3
Motorways	Policy Freeze	100.0	115.6	129.8	143.2	156.1
	Green Future	100.0	112.7	124.3	134.9	143.1
	Challenging Future	100.0	124.7	147.7	173.3	192.1

Figure 11: Projected traffic by road type, 2015-2035, all scenarios (based on UK data)

4.4 Conclusions

Traffic mix, demand levels and vehicle fleet projections have been derived as required by WP53. In fact the simulations will not cover the same range of vehicle and fuel types as the scenarios – they are more limited (Table 20). For other vehicle and fuel types, e.g. diesel bus, WP53's results will be derived by extrapolation from the types modelled. The wider set of projections in this deliverable will be used in WP54 'Scaling-up and Cost-Benefit Analysis', where they will play a key role in generalising the findings from the field trials and simulation.

Table 20: Vehicle and fuel types to be simulated in WP53

Vehicle type	Fuel type
Car	Petrol
	Diesel
	EV
Van	Diesel
Truck	Diesel

An important footnote to the above numbers is that in due course compliance results will become available from SP4, and will allow us to refine our modelling of the fuel savings achieved. For the moment, the analysis in this section has been based on the achievable fuel savings and a simplifying assumption that those who choose to use an ecoDriver system will comply with it. The issue of compliance with pre-fitted systems not chosen by the driver will be revisited following the SP4 results.

As a reflection on the methodology used in section 4.3, the results are dependent on a mix of data, evidence from the focus groups and SP survey, and assumptions made by the project team. They are not purely model-driven: instead they are the project team's best attempt to represent the three descriptive scenarios in quantitative terms.

5. Overall conclusions

Three separate strands of research were carried out with the end goal to establish an agreed set of scenarios on which to base the remainder of the work in SP5, namely the microsimulation and scaling up. The focus groups were carried out to tease out the opinions of a key set of stakeholders; car drivers were then interrogated to establish their willingness to pay for a range of eco-driving systems; and using both sets of results a scenario building exercise was undertaken. The findings can be summarised as follows:

1. Key stakeholders believe there will be demand for eco-driving technologies, particularly for heavy vehicles and amongst fleets.
2. High levels of market penetration will only be achieved if users clearly understand the financial benefits.
3. Design aspects of the systems are very important - the interface should be intuitive and easy.
4. The vehicle fleet and traffic mix will evolve organically, with hybrids becoming more popular and electric vehicle demand dependent on battery technology development.

5. The built-in ecoDriver system was valued more positively by respondents.
6. Willingness to pay could not be used to forecast the potential market uptake for a given price.
7. Petrol engines were the most preferred engine type and respondents showed a reluctance to switch to alternative engine technologies, despite being sensitive to fuel economy .
8. Electric vehicles in particular evoked concerns about lack of infrastructure and battery range.
9. Around a quarter of respondents thought that an eco-driving support system would distract them from concentrating on driving and 40% would not like to use any device that would influence their driving behaviour.

10. Three overarching scenarios are presented: ‘Green Future’ (GF), ‘Policy Freeze’ (PF) and ‘Challenging Future’ (CF).
11. They are not purely model-driven: instead they are the project team’s best attempt to represent the three descriptive scenarios in quantitative terms.
12. The stakeholders in the focus groups reported they rated them as being realistic and sufficiently different from each other

The three strands of work are complimentary and were not intended as comparator pieces of research. Each provided food for thought in proceeding into the next stages of ecoDriver, as detailed in the next chapter.

6. Implications for the ecoDriver project

The work described here has provided a set of major building blocks for the subsequent work of SP5. Specifically, in WP53, the impacts of the ecoDriver systems when deployed more widely in the vehicle fleet are being investigated using microsimulation models. The traffic mix in different future years over the period 2015-2035 is a key input to this modelling. Moreover, the extent of differences in the traffic mix between scenarios (GF/PF/CF) and years, has allowed WP53 to identify a set of priority 'simulation cases' to run first, in order to explore the envelope of possible situations on the network.

In WP54, the results of WP52 are being used to scale-up the impacts of ecoDriver systems, specifically by providing a forecast of ecoDriver market penetration as well as input data that enables WP53 to provide fuel consumption and emissions outputs, travel time and safety outputs. WP54 is building these outputs into a stakeholder-by-stakeholder CBA of the ecoDriver systems at the EU level.

The conclusions from Section 5 will now be addressed in turn, in relation to the remainder of the ecoDriver project.

1. ***Key stakeholders believe there will be demand for eco-driving technologies, particularly for heavy vehicles and amongst fleets.*** The ecoDriver project involves the participation of fleets (TomTom) and Heavy Goods Vehicles (Daimler). Both will be collecting data in SP3.
2. ***High levels of market penetration will only be achieved if users clearly understand the financial benefits.*** The SP survey took this recommendation on board and presented information in terms of the amount of fuel saved.
3. ***Design aspects of the systems are very important - the interface should be intuitive and easy.*** The HMI taskforce in SP3 addressed this issue. The HMI designs were evaluated via the European Statement of Principles (see D33.1 and D34.1), which allows assessment of possible effects of distraction due to clutter, placement etc. This was done prior to the field trials in SP3 being carried out. In addition, the participants were asked to provide feedback on the interfaces after using them in the on-road trials - this was reported in D42.2 and the comments used in the updating of the systems for the final applications, see D14.2.
4. ***The vehicle fleet and traffic mix will evolve organically, with hybrids becoming more popular and electric vehicle demand dependent on battery technology development.*** Electric vehicles will feature in the SP3 trials, alongside hybrid buses. Qualitative comments re: the former will be collected from participants, however there is already plenty of research on range anxiety (e.g. Franke et. al 2011).
5. ***The built-in ecoDriver system was valued more positively by respondents.*** Both subjective comments (WP42.1) and objective data from SP3 will ascertain the certainty of this. In particular the data analysed in SP4 will ascertain the effectiveness of embedded systems over nomadic in terms of energy savings and driver behaviour.
6. ***Willingness to pay could not be used to forecast the potential market uptake for a given price.*** A simple method of eliciting willingness to pay will be used in the field trials, after participants have had the opportunity of using the systems. This will provide a comparator.

7. ***Petrol engines were the most preferred engine type and respondents showed a reluctance to switch to alternative engine technologies, despite being sensitive to fuel economy.*** This reluctance to switch to alternatives will be reflected in the realistic modelling of the vehicle fleet in future work in SP5, but in addition a more utopian approach will of course be modelled in the Green future scenario.
8. ***Electric vehicles in particular evoked concerns about lack of infrastructure and battery range.*** See point (4) above.
9. ***Around a quarter of respondents thought that an eco-driving support system would distract them from concentrating on driving and 40% would not like to use any device that would influence their driving behaviour.*** The amount of distraction is highly depend on how the information and advice is presented to the driver. Both subjective and objective data pertaining to distraction will be collected and analysed in SP3 and SP4 respectively.
10. ***Three overarching scenarios are presented: 'Green Future' (GF), 'Policy Freeze' (PF) and 'Challenging Future' (CF).*** These scenarios will be carried forward into the next stages of ecoDriver, with particular reference to the scaling up activities in WP54.
11. ***They are not purely model-driven: instead they are the project team's best attempt to represent the three descriptive scenarios in quantitative terms. Such expert judgement is necessary in the absence of alternative hard and fast data.*** These scenarios have been presented publicly (e.g. at the ITS Congress, Bordeaux, 2015) and have been attributed as being realistic.
12. ***The stakeholders in the focus groups reported they rated them as being realistic and sufficiently different from each other.*** The acid test of the distinction between the scenarios will be in the scaling up exercise (WP54).

7. Lessons Learned

This WP took a qualitative and quantitative approach to developing the likely scenarios for green driving support systems. A multi-method approach such as this enabled the partners to gain a clearer understanding of the viewpoints of a range of stakeholders. Whereas the focus groups are based upon expert stakeholders, the willingness-to-pay surveys are based upon potential purchasers of environmentally-friendly cars and ecodriving devices. Such a mixed methods approach has been used successfully in other fields, such as healthcare (e.g. Plano Clark, 2010). The ecoDriver project also adopted this approach in other WPs, such as that which developed the HMI design. The initial focus groups allowed an interactive exploration of a range of pre-defined issues, but also initiated discussions that were unforeseen. This shows the value that consultation can have, rather than relying on the opinions of the consortium. They helped to shape the likely future scenarios and provide additional data where it was lacking.

On the whole, the experts consulted were positive about future demand for eco-driving systems and strongly hinted that the most promising way of ensuring high levels of market penetration would be to ensure that vehicle purchasers are fully informed of the potential monetary savings they could make. This was useful information to take forward into the stated preference exercise, and care was taken to present this in as clear and concise manner as possible.

One slight weakness of using the mixed methods approach is that the various modules are not as integrated as they might have been. For example, the outcomes of the focus groups could have been exploited more fully to inform the design of, and corroborate findings from, the willingness-to-pay surveys. In a similar vein, the scaling-up module synthesises findings from the preceding modules, but the discrete nature of the various modules renders this a challenging exercise.

It is apparent that particular challenges were encountered in undertaking the willingness-to-pay surveys, and the research team have reflected upon the scoping of this, and whether it was overly ambitious. There are so many possible predictive variables, that sometimes it is difficult to tease out the important ones, in order to make a survey respondent's task as simple as possible. The main issue with the SP was that the price parameter was lower than expected and it was therefore not possible to translate this into willingness to pay. This made forecasting the potential market uptake for a given price. One possible explanation for this price parameter being low was identified as the complexity of the questionnaire which required respondents to consider a large number of choices and attributes. As well as some ambiguities on the willingness-to-pay values themselves, limited insight has been gleaned on how these values might vary across individuals with different incomes and different propensities to engage in 'green' behaviour. That said, the research team invested substantial time and effort in seeking to overcome these challenges.

One thing that can be said for sure, and confirmed by the stakeholders, is that uncertainty about the future affects the response to eco-driving systems, and it is perhaps this ambiguity that made the willingness-to-pay exercise so challenging. However, when presented with the three scenarios developed internally by the project team, the range of expectations about the future among stakeholders appeared similar to the range of scenarios presented. The set of three future scenarios was found to be sufficiently credible and understandable. It could be valuable in future to focus on the presentation of scenario-type uncertainty in WTP surveys.

References

Balcombe et al (2004), *The Demand for Public Transport*, TRL Report 593. Crowthorne: TRL.

Booz Allen Hamilton (2003), *ACT Transport Demand Elasticities Study,* Canberra Department of Urban Services.

Bryman, A. (2012), *Social Research Methods.* London: Routledge.

Dargay J. and Hanly M. (1999), *Bus Fare Elasticities*, Report to the UK Department of the Environment, Transport and the Regions (DETR). London: ESRC Transport Studies Unit, UCL.

DECC (2014), *DECC Fossil Fuel Price Projections, September 2014*. London: Department of Energy and Climate Change.

De Jong G. and Gunn H. (2001), 'Recent Evidence on Car Cost and Time Elasticities of Travel Demand in Europe', *Journal of Transport Economics and Policy*, 35(2), pp. 137-160.

Department for Transport (2013), *Road Traffic Forecasts 2013, Results from the Department for Transport's National Transport Model.* London: DfT.

Department for Transport (2014), *Transport Statistics.* London: DfT. Online at: https://www.gov.uk/government/organisations/department-for-transport/about/statistics

EC Energy Statistics and Market Observatory (2014), *History of Dated Brent Price (per bbl).* https://ec.europa.eu/energy/sites/ener/files/documents/Dated_Brent_0.pdf

Franke, T., Neumann, I., F. Bühler, Cocron P. and Krems, J. (2011). Experiencing Range in an Electric Vehicle: Understanding Psychological Barriers. Applied Psychology: An International Review . Volume 61, Issue 3, pages 368–391.

Goodwin P., Dargay J. and Hanly M. (2003), *Elasticities Of Road Traffic And Fuel Consumption With Respect To Price And Income: A Review*, Report to DETR. London: ESRC Transport Studies Unit, UCL.

Goodwin P., Dargay J. and Hanly M. (2004), 'Elasticities of Road Traffic and Fuel Consumption With Respect to Price and Income: A Review', *Transport Reviews,* 24(3), pp. 275-292.

Hill N. and Morris M. (2012), *Further development of the SULTAN tool and scenarios for EU transport sector GHG reduction pathways to 2050.* Task 6 paper produced as part of a contract between European Commission Directorate-General Climate Action and AEA Technology plc. www.eutransportghg2050.eu

House of Commons (2013) *Railways: fare statistics, Standard Note:*

SN/SG/6384. London: House of Commons Library.

ICCT (2014), *European Vehicle Market Statistics Pocketbook*. ICCT: Berlin.

Johansson O. and Schipper L. (1997), 'Measuring the Long-Run Fuel Demand for Cars', *Journal of Transport Economics and Policy*, 31(3), pp. 277-292.

Kantar Comtech/Guardian (2014), 'The death of the featurephone in the UK – and what's next', *The Guardian*, 30.4.2014. http://www.theguardian.com/technology/2014/apr/30/featurephone-smartphone-uk-

Kroes E.P. and Sheldon R.J. (1988), 'Stated Preference Methods', *Journal of Transport Economics and Policy,* 22(1), (pp. 11- 25).

Litman T. (2013), *Transport Elasticities: Impacts on Travel Behaviour*. Bonn: GIZ.

NAEI (2014), *Vehicle fleet composition projections.*

Plano Clark, V. (2010). The adoption and practice of mixed methods: U.S. trends in federally funded health related research. Qualitative Inquiry, 16(6), 428-440.

SMMT (2014), Year 2014 Hybrid and EV Registrations data. http://www.smmt.co.uk/smmt-membership/member-services/market-intelligence/vehicle-data/monthly-automotive-data/

Annex A: Focus Group Protocol, Showcards and Analysis Protocol

Table 21: Focus Group Themes, Participants, Locations and Dates

	Themes	Participants	Country held (lead partner)	Date
1	Passenger systems	First Group, City of York Council, Post Graduate researcher in low carbon technologies.	UK (LEEDS)	30/04/2013
2	Freight systems	Institute of Mechanical Engineers, Road Haulage Association, Post Graduate researcher in vehicle emission modelling, Society of Motor Manufacturers and Traders.	UK(LEEDS)	16/04/2013
3	Energy policy	Swedish Transport Administration, Swedish Energy Agency, Vinnova (Sweden's Innovation Agency), Stockholm Municipality, Linköping Municipality.	SE (VTI)	14/05/2013
4	Technical feasibility	Magneti Marelli (automobile parts manufacturer: http://www.magnetimarelli.com/company), 5T (Intelligent Transport Systems and Infomobility company) http://www.5t.torino.it/5t/en/docs/sistema5t.jspf), SATIF (Italian Highways (Torino-Frejus)), University of Turin Politecnico.	IT (CRF)	08/04/2013
5	Lease/fleet systems	Alphabet Carlease, Wagenborg Shipping, Ministry of Interior and Kingdom Relations, Athlon Carlease.	NL (TNO)	12/03/2013
6	Vehicle and equipment manufacturers	BMW, CRF, Daimler, TomTom.	NL (VTI)	20/02/2013

Task 52.1 Focus group protocol	
Version number:	final (n06)
Date:	23/01/13
Changes made by:	John Nellthorp
Authors:	Jonas Ihlström, Johan Olstam, Ann Jopson, John Nellthorp, Katja Kircher, Andreas Tapani

Suggested duration 2 ½ hours including ½ hr networking lunch.
Allow plenty of time for open discussion in each section of the focus group outlined below.

1. *Introduction and interests (15 mins)*

Welcome, thanks for coming, emergency exits, toilets, structure of focus group, end time, everybody ok with this, permission to record and sign consent forms.
Outline ecoDriver systems and project. Looking to understand their interests, needs, potential gains and losses. Identify any issues, barriers to deployment, help us to model potential take-up... (i.e. be open about purpose of focus group).
Ask each attendee to introduce themselves (name, organisation), and indicate their awareness, experiences and general thoughts on any ED sytems.
What energy efficiency goals and strategy does your organisation have which eco-driving systems could contribute to?
Moderator's cues
Anything specific to:
- vehicle energy efficiency?
- fuel efficiency?
- CO_2 efficiency?

2. *Potential gains and losses (15 mins; running total 30)*

(O1) How do you think organisations of your kind would be affected by deployment of eco-driving systems?
(O2) How do you think the road transport system would be affected by the deployment of eco-driving systems?
Moderator's cues
- change in purchasing and use of vehicles?
- potential gain in revenue?
- potential loss of revenue (e.g. fuel tax)
- increased/reduced costs (e.g. vehicles, equipment)
- changes in traffic
- changes in environmental quality
- changes in safety
- any impact on other organisational goals?

3. *Deployment and take-up (15 mins; 45mins)*

Before we get into a more in-depth discussion regarding potential barriers after lunch, we would like your immediate thoughts on three questions. The first one:
If we're looking at the forthcoming 20 years, when do you think it is feasible these systems can be deployed?

Moderator's cues

- is there any uncertainty? – what are the upper and lower estimates on the pace of deployment?

By:
- car fleet?
- bus/coach fleet?
- goods vehicle fleet: heavy good vehicles and light commercial vehicles?

What is the ultimate market penetration?

Moderator's cues

- will market penetration be 100%, if no, what will it be?

What does take-up depend on?

Moderator's cues

- How much does market take-up depend on price?
- In your view, is an incentive needed either for the nomadic or embedded devices?
- Who (which characteristics) do you think will be early adopters?
- Who will lag?
- fuel price (high, mid point, low)?
- fleet composition (rapid, moderate or slow turn over and filtering down of embedded systems (initially in high end vehicles) and how does this influence purchase of nomadic devices)?

Networking LUNCH (30 mins)

Welcome back, I hope you enjoyed your lunch … can I just check whether there is anything else you discussed or thought of over lunch that we should take on board. (10 mins; 55 mins (excluding lunch))

4. *Barriers to deployment (30 mins; 1hr25 mins)*

What are the main issues and barriers you face in implementation of ED systems?

Moderator's cues

- Are you currently implementing any ED systems (if answer to this hasn't already been offered above). If no, why? If yes, what benefits are you expecting to see?
- IF you are implementing, what are the main methods of implementation you are currently pursuing? Any of the following?

- *Incentives for vehicle ownership and use (efficient vehicles/driving styles...)*
- *Marketing*
- *technology development / R&D*

- What do you think are the main issues from a technology point of view (if applicable)?
- Conflicts with other support systems
- Will it be a problem that eco-driving principles and recommendations may vary between powertrains?

- How well are roads designed from a eco-driving perspectives? Are the general location of speed limit signs, traffic signal controlling, variable speed limit systems, etc. good from an eco-driving point of view?
- To what extent will it be possible to design/redesign roads to encourage and help eco-driving?
- What role will vehicle to vehicle, vehicle to infrastructure and infrastructure to vehicle communication play in the development and effect of eco-driving support systems?

5. Fleet composition and fuel prices (20mins; 1hr45)

This section is purely about gauging focus group participants' reactions to projections and scenarios that may feed into the modelling work that follows these focus groups. Any discussion of powertrain and fuel price projections and scenarios for use in the modelling should be left until this section to avoid duplication and ensure all participants' opinions are heard.
[Note: provide a showcard containing the powertrain mix, fuel price projections and descriptive scenarios [showcards are included below]. Substitute van and HGV data for car data in the Freight Systems focus group].

A key part of modelling the take-up of eco-driving systems is assumptions on: future vehicle fleet – in particular the powertrain mix; future fuel prices; and different policy scenarios and levels of user acceptance. Projections from the most recent research were given in the background paper and are available on the showcard. What are your thoughts on these projections and scenario assumptions?

Moderator's cues
- which of the two scenarios seems more realistic
- which elements of these seem plausible and which – if any – raise concerns?
- which of the scenarios seems most in tune with other evidence you have seen, and your judgement?
- which of the policy scenarios do you think we should focus on?

6. Open Discussion (15mins; 2hrs)

Finally, before we finish, are there any other issues raised by eco-driving systems that we have not covered? Is there anything else we should take into consideration that we have not discussed (e.g. unwanted side-effects you can forsee)?

Thank you, what happens next, goodbye.

Task 52.1 Showcards	
Version number:	final
Date:	23/01/13
Changes made by:	John Nellthorp
Authors:	John Nellthorp

Oil prices, vehicle fleets and scenarios were shown as three separate showcards.

Oil prices

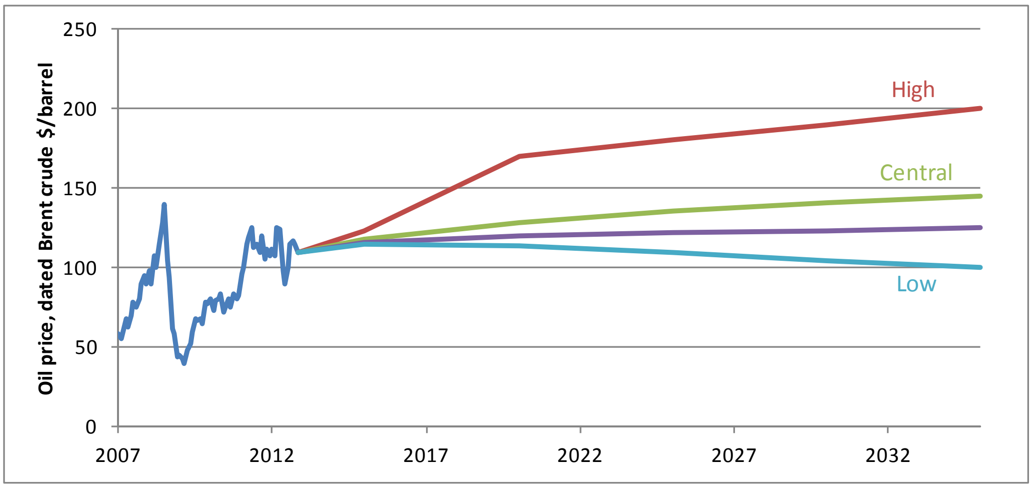
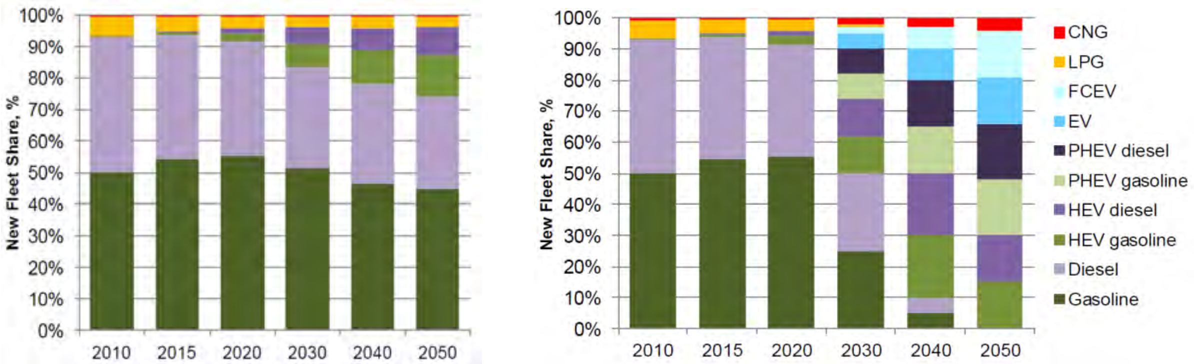


Figure 12: Oil price trajectories (2011 US dollars) (Sources: OECD/IEA, 2012; Benes et al, 2012)

Vehicle fleets



Business as Usual 60% carbon reduction by 2050 (without ecoDriver)

Figure 13: New car fleet share by powertrain (Source: AEA et al, 2012)

(Abbreviations: CNG=Compressed Natural Gas; LPG=Liquefied Petroleum Gas; FCEV=Fuel Cell Electric Vehicle; EV=Electric Vehicle – battery; PHEV diesel=Plugin Hybrid Electric/Diesel Vehicle; HEV diesel=Hybrid Electric/Diesel Vehicle).

Scenarios

Scenario 1: Central Estimate of the Future*.* Central oil price and growth forecasts; climate and transport policy at a midpoint between Business as Usual (only current legislative commitments) and the full package needed to secure 60% CO_2 reduction by 2050; and a realistic trajectory for consumer acceptance of new vehicle technologies (emerging from this project).

Scenario 2: Green Future*.* High oil price trajectory; high economic growth; effective climate and transport policies – the full package needed to secure 60% CO_2 reduction by 2050, with strong incentives; upper bound user acceptance.

Scenario 3: Dark Future. Low oil price trajectory; low economic growth; high pollution; policy failure; weak incentives; lower bound user acceptance of new vehicle technologies.

Scenario 4: 'We can afford to be green'. Low oil price trajectory; but an affluent society with high economic growth – able to focus on quality of life and therefore able to make green choices in consumption and politics; hence high acceptance and supportive policy.

Task 52.1 Focus group content analysis framework	
Version number:	02
Date:	26/03/13
Changes made by:	Ann Jopson
Authors:	Ann Jopson, Jonas Ihlström, Johan Olstam, John Nellthorp, Katja Kircher, Andreas Tapani

Instructions

The focus groups should be analysed using a content analysis approach. Content analysis seeks to identify themes in a text or audio recording, and describe the key messages. The analysis should seek to be objective, but also draw conclusions for the Ecodriver project, specifically the scenario development. Advice on conceptual content analysis can be found at http://writing.colostate.edu/guides/page.cfm?pageid=1310 as recommended by Bryman: Social Research Methods: 4e http://global.oup.com/uk/orc/sociology/brymansrm4e/01student/weblinks/ch13/ (accessed 26/03/13)). In this case the focus group protocol should be used as a guide to the concepts to be identified. For example, in the first section below, all potential gains and losses mentioned throughout the focus group should be identifed. The analysis of gains and loses should then consider presence and absence – which issues are mentioned, which are not, which were expected, which were not (see moderator's cues for a guide) – and intensity, which issues are mentioned a lot/rarely, which are discussed forcefully (be that negatively or positively), which are discussed without conviction as if they hardly matter (regardless of what is actually said). Links between concepts should also be identified and analysed, and a summary of what was said about the themes identified should be provided. Concepts that we had not anticipated in the protocol should also be included in the analysis, so in this case, identification of concepts to be analysed can be post-hoc as well as a-priori. The focus group analysis should be written up using the form below.

A further note on presence and absence: it is important throughout to identify when issues we anticipated, i.e., included in the protocol were and were not discussed. Absence can be as informative as presence. If when you asked the initial open questions in the protocol (without reference to the moderators cues) an issue included in the prompts was not initial mentioned by participants, please say so (as well as telling us what was said) as this tells us something about the importance of the issue. If you later asked about the issue but participants still said little about it, say so as this again tells us something about importance and possibly awareness and understanding. If the discussion developed such that you did not have the opportunity to ask about an issue identified in the moderators cues, this is not a problem, cues are there for use if needed, and you should focus on what was said. If in your professional opinion an issue was not mentioned because it was not relevant to the group you were talking to, e.g., X was not relevant to lease/systems professionals, then please say so. Similarly, if participants explicitly stated that an issue was not relevant/important make this clear.

Focus group context
Focus group theme (e.g., freight): **Where did the focus group take place:** **What language did the focus group use:** **Date of focus group:** **Who moderated the focus group:** **Focus group particpants roles, years experience in sector, approximate age group and gender:**

Introduction: what energy efficiency goals and strategy does your organisation have which eco-driving systems could contribute to? *(Moderator's cues: Anything specific to vehicle energy efficiency, fuel efficiency, CO_2 efficiency.)*

Potential gains and losses: (O1) How do you think organisations of your kind would be affected by deployment of eco-driving systems? (O2) How do you think the road transport system would be affected by the deployment of eco-driving systems? (*Moderator's cues: change in purchasing and use of vehicles, potential gain in revenue, potential loss of revenue (e.g. fuel tax), increased/reduced costs (e.g. vehicles, equipment), changes in traffic, changes in environmental quality, changes in safety, any impact on other organisational goals.)*

Deployment and take-up: If we're looking at the forthcoming 20 years, when do you think it is feasible these systems can be deployed (by car fleet, bus/coach fleet, goods vehicle fleet: heavy good vehicles and light commercial vehicles? (*Moderator's cues: is there any uncertainty, what are the upper and lower estimates on the pace of deployment?)* **What is the ultimate market penetration?** (*Moderator's cues: will market penetration be 100%, if no, what will it be?)* **What does take-up depend on?** (*Moderator's cues: How much does market take-up depend on price?, In your view, is an incentive needed either for the nomadic or embedded devices?, Who (which characteristics) do you think will be early adopters?, Who will lag?, fuel price (high, mid point, low)?, fleet composition (rapid, moderate or slow turn over and filtering down of embedded systems (initially in high end vehicles) and how does this influence purchase of nomadic devices)?*

Barriers to deployment: What are the main issues and barriers you face in implementation of ED systems? (*Moderator's cues: Are you currently implementing any ED systems (if answer to this hasn't already been offered above). If no, why? If yes, what benefits are you expecting to see?, IF you are implementing, what are the main methods of implementation you are currently pursuing? Any of the following: Incentives for vehicle ownership and use (efficient vehicles/driving styles...), Marketing, technology development / R&D? What do you think are the main issues from a technology point of view (if applicable)?, Conflicts with other support systems, Will it be a problem that eco-driving principles and recommendations may vary between powertrains?, How well are roads designed from a eco-driving perspectives?, Are the general location of speed limit signs, traffic signal controlling, variable speed limit systems, etc. good from an eco-driving point of view?, To what extent will it be possible to design/redesign roads to encourage and help eco-driving?, What role will vehicle to vehicle, vehicle to infrastructure and infrastructure to vehicle communication play in the development and effect of eco-driving support systems?*

Focus group context
Fleet composition and fuel prices: A key part of modelling the take-up of eco-driving systems is assumptions on: future vehicle fleet – in particular the powertrain mix; future fuel prices; and different policy scenarios and levels of user acceptance. Projections from the most recent research were given in the background paper and are available on the showcard. What are your thoughts on these projections and scenario assumptions? *Moderator's cues: which of the two scenarios seems more realistic, which elements of these seem plausible and which – if any – raise concerns?, which of the scenarios seems most in tune with other evidence you have seen, and your judgement?, which of the policy scenarios do you think we should focus on?*

Open Discussion: Finally, before we finish, are there any other issues raised by eco-driving systems that we have not covered? Is there anything else we should take into consideration that we have not discussed (e.g. unwanted side-effects you can forsee)?

Conclusions for the Ecodriver project.

This section should summarise the key take home messages for the development of the scenarios arising from your focus group(s).

In this section please ensure you address the following questions and comment throughout on the importance of issues discussed for the scenario development:

- **What energy efficiency goals and strategy should the scenarios encompass, drawing on the energy efficiency goals and strategies participants said eco-driving systems could contribute to?**
- **What potential gains and losses should steer the development of the scenarios?**
- **What deployment and take-up rates should the scenarios be based on?**
- **What barriers to deployment should the scenaios incorporate?**
- **What fleet composition and fuel price projections should the scenarios incorporate?**
- **What other issues should the scenarios include/exclude?**
- **If not covered in responses to the individual questions above, what in your professional opinion are the most important conclusions that should be taken forward in the scenario development, and what turned out to be unimportant after all/was there anything respondents explicitly said was not relevant?**

If there is little to say in answer to one or more of these questions then please simply say something along the lines of, "the lease/fleet systems focus group did not discuss this issue because it was not relevant to this group/because the group had little to say about it even when questioned".

Beyond this, do focus on what was said. The final "other issues" question should capture key messages not included under the other questions, but if you feel it would be clearer to create a sub-section to cover an important theme or message for the scenario development please do so.

Annex B: Stated Preference Study – Detail of Method

B.1 Modelling technique

Five specific tasks were undertaken:

Task A: Estimate willingness to pay (WTP) for the ecoDriver system

The WTP for the ecoDriver system can be used to compute the demand for such a system at a certain price and to determine the proportion of car drivers who would use the ecoDriver system. It can also be used to examine which segments of the population are more inclined to buy such a system, for example high-income households that also support policies aimed at reducing greenhouse gas emissions, as well as segments which are less inclined to buy such a system. Furthermore, it should also be possible to find out for each of the car types investigated whether or not car buyers would like to purchase an ecoDriver system. This information is useful in that the effect of using an ecoDriver system is higher in a large car than in a small car since large cars are driven greater distances on average and are less fuel-efficient.

Task B: Forecast the average fuel economy of the private car fleet

In order to forecast the fuel economy of vehicles, we need to understand how many people will purchase an ecoDriver system and how many will buy cars with features that have an impact on fuel consumption. Prominent examples of such features are fuel-saving engines, larger car sizes, four-wheel drive transmissions and air-conditioning systems. Thus, we need to compute consumers' WTP for all these features. We could then compute the demand for these features at market prices assumed for the future. We also examine whether the WTP increases in line with income. Since we expect the WTP for four-wheel drive transmissions, larger car sizes and air-conditioning systems to increase in line with income and since we also expect the cost of producing these features to decrease over time, we expect an increasing demand for these features over time. Thus, this may reduce the positive effect of the demand for fuel-saving engine types and ecoDriver units.

In order to be able to complete this forecast, the following sub-tasks are specified:

- Estimate WTP for car attributes with an impact on fuel consumption.
- Examination of whether WTP for car attributes with an impact on fuel consumption and the WTP for the ecoDriver system change if a household's income changes.
- Examination of whether WTP for car attributes with an impact on fuel consumption and the WTP for the ecoDriver system change if fuel prices change.

Task C: Forecast fleet size, fleet composition and car use

We also want to forecast the average fuel demand, the average mileage driven and the average car demand for each vehicle type. Knowledge about allocating mileages to different car types within a household is crucial since the car type defines fuel economy and thus has a major impact on the demand for different fuels. This is an important element in forecasting the CO_2 emissions from car use.

Task D: Predict acceptance of new technologies

We also examine the acceptance of new technologies such as hybrid engines, natural gas engines, electric cars and ecoDriver units. In this way, we are able to identify which household types have reservations against new technologies that may help to reduce CO_2 emissions.

Task E: Predict acceptance of policies aimed at greenhouse gas reductions

We also examine the acceptance of new technologies such as hybrid engines, natural gas engines, electric cars and ecoDriver systems. In this way, we are able to identify which household segments have reservations against new technologies that may help to reduce CO_2 emissions.

The first model we used is the MNL model, which is used to compute the WTP for the ecoDriver system and other car features. The car features included in the model as explanatory variables are listed in Table 22. These variables are used to estimate the average fuel economy of the private car fleet.

Table 22: List of explanatory variables in the car choice experiment

Explanatory Variable
Car type (CT)
Engine type (ET)
Engine size (ES)
Power (PW)
Gearbox (GX)
Transmission (TR)
Acceleration (ACC)
Fuel economy (FE)
Air conditioning (AC)
ecoDriver system (ED)
Price (PR)
Range (RA)
Charge time (CH)

Stated Preference data are collected by presenting a number of hypothetical choice situations to respondents. In this case, we presented three cars similar to the car the respondent has bought recently or similar to the car which they are currently thinking of buying. All these cars differ with regards to their attributes (Table B1). The respondent then indicates which car they would choose from these three cars. In order to collect more data, a number of such choice situations are presented to each respondent. From this information, we can learn consumers' preferences, enabling us to compute the WTP for each car attribute. In order to compute the WTP we will apply the MNL model. The MNL is based on the assumption that respondents will always choose the option that offers them maximum utility. We assume that utility offered to a consumer depends on the level of car attributes. For instance, we assume that consumer utility depends positively on the engine power and negatively on the price of the vehicle. In this case, we assume that the impact of all attribute levels on utility is linear.

B.1.1 The basic MNL model

The basic form of this model is as follows:

$$U_{ijn} = \beta \cdot x_i + \varepsilon_{ijn}, \qquad (1)$$

$$U_{\bar{i}jn} \geq U_{ijn} \quad \forall i = 1..J \qquad (1a)$$

where i denotes the index for an alternative car presented, j is the index of the question put to the respondent ($j = 1..J$), n is the index for the household ($n = 1..N$). Utility level U_{ijn} denotes the utility respondent n would get from choosing alternative i in the j:th question. Vector x_{ijn} contains all attributes of alternative i presented to respondent n in its j:th question.

Expression (1a) denotes that, in each choice situation, respondents always choose the alternative that offers them maximum utility. Each component of the parameter vector β denotes the extent to which an increase in value of the corresponding attribute x_{ijn} contributes to utility. The random variable ε_{ijn} vector accounts for households' unobserved preferences. If we use MNL then these random variables ε_{ijn} are independently and identically standard Gumbel distributed[4]. This accounts mainly for the fact that each household may valuate each alternative slightly differently to as stated in (1). It also accounts for the fact that respondents may not choose the option that actually provides the greatest utility. This could be because respondents put insufficient effort into evaluating all of the alternatives properly in this hypothetical decision situation or because errors occur, since the alternatives are presented in a rather abstract way. In contrast, term $\beta \cdot x_{ijn}$ accounts for the deterministic component of utility. The aim of the researcher is to estimate β and expressed in general terms, to explain respondents' choices as accurately as possible. Note that if ε_n is very small, then the model could forecast exactly which alternative the respondent would choose. In reality, the model can only forecast the probability of a respondent choosing a certain alternative. The estimation method for determining parameter values β is the maximum likelihood estimation (MLE) method. Here, the MLE method adapts the models' parameters such that the probability of observing all choices of alternatives by all respondents is maximised, given explanatory variables x_i.

4 The standard Gumbel distribution is defined by the following probability density function: $z = e^{-x} \cdot \exp\left(-e^{-x}\right)$, see Train, Kenneth, 2003, "Discrete Choice Methods with Simulation," Online economics textbooks, SUNY-Oswego, Department of Economics, number emetr2, Spring on page 34. Note that the standard deviation of this distribution is $\pi/\sqrt{6} = 1.2825$

B.1.2 Computing the WTP

In our case, we want to compute the WTP. The concept behind this can be illustrated by the following example where we want to compute the WTP for one additional horsepower for the engine. Assume that parameter β relating to the price is -0.001. Assume further that the parameter relating to engine power is 0.02. The concept of the WTP is now as follows: "If the engine power increases by a unit: how much must the price rise GBP in order to keep the utility level of that car constant?" Alternatively, if you were a car manufacturer, you would ask "By how much can I increase the price of the car such that its remains equally attractive to consumers if I offer an engine with one additional horsepower". This price mark-up will be exactly the value at which the consumer is indifferent about purchasing the original car or the car with one additional horsepower. This price mark-up is thus the consumer's maximum WTP for one additional horsepower: if the price mark-up offered by the car manufacturer is thus below his WTP, then he would opt for the car with more horsepower, and vice versa. In this example, the WTP for one additional horsepower would be GBP 20. Expressed in general terms, the WTP for each attribute can be computed as follows:

$$WTP_k = -\frac{\beta_k}{\beta_p} \quad (2)$$

Index k denotes the attribute for which we want to compute the WTP, e.g. engine power; index p denotes the price. Note that, due to the existence of the random term ε_{ijn}, parameters β cannot be estimated accurately. Thus, the parameter vector β is a random vector. The distribution of β is asymptotically normal. The distribution of the WTP (2) can be best approximated by applying the delta method[5].

B.1.3 The MNL model with socio-demographic attributes

Since we expect the WTP may differ in different consumer segments, we must use an MNL model that captures socio-demographic variables. Examples of such variables are household income, type of household and type of residential area. For example, we expect young single households to have a higher WTP for engine power. Thus, we modify model (1) as follows:

$$U_{ijn} = \beta \cdot x_i + \gamma \cdot s_n \cdot x_i + \varepsilon_{ijn} \quad (3)$$

Note that matrix s contains the socio-demographic variables and vector $s \cdot x_{ijn}$ denotes interaction terms. Parameter γ relates to these interaction terms. An illustration of this is as follows: the type of households is differentiated between young single households and any other households. If now the dummy variable "non-single household" is interacted with engine power, the corresponding parameter γpw,ys expresses the additional preference for engine power (pw) of young single households (ys). In this example, two WTP for engine power can be computed:

[5] Daly, Andrew, Stephane Hess and Gerard de Jong (2012), "Calculating errors for measures derived from choice modelling estimates", Transportation Research Part B: Methodological, Volume 46 (2012), Issue 2, p. 333-341

$$WTP_{pw,non-ys} = -\frac{\beta_{pw}}{\beta_p} \text{ and} \quad (4a)$$

$$WTP_{pw,ys} = -\frac{\beta_{pw} + \gamma_{ys}}{\beta_p} . \quad (4b)$$

We expect that the WTP of “young single households” to be higher than that of “non-young single households”. Therefore, a supplier may choose a price increase for a car with a more powerful engine so that only “young single households” would buy the upgraded car.

B.1.4 Scenario analysis using an MNL model

We also want to find out consumer change with respect to car choice if incomes increase or fuel prices increase. Thus, we ask respondents to repeat their choices given fictitious situations in which their income increases by 10% or fuel prices increase by 20%. We then compute the parameters of model (3) or apply model (4), where we use interactions terms by adding indicators in s that account for the different choice situations. We do this in order to see whether there are any differences in the WTP between the scenarios. We would expect the WTP for features such as “air conditioning” to increase in line with income. We also expect the WTP for more fuel-efficient engines to increase when fuel prices go up.

B.2 Car fleet choice and car use

In order to forecast the aggregate fuel demand, the aggregate mileage driven and the aggregate car demand of each vehicle type, we apply just basic summary and ordinary least square statistics. The reason for this is that there is no well-established discrete-continuous choice model in the literature that meets our needs. The key to our method is thus to collect data that will meet our needs and to use it to compute our results by applying only simple summary statistics. We will present six cars of various sizes to respondents. They then decide which of these cars they would buy if they had to swap them with all their existing cars. They must also disclose how many miles they would drive annually using each car that they would buy. The features listed in Table 23 characterise all these cars.

Table 23: List of explanatory variables for car fleet choice and car use

Explanatory Variable
Car type (CT)
Engine type (ET)
Engine size (ES)
Power (PW)
Gearbox (GX)
Transmission (TR)

Explanatory Variable
Acceleration (ACC)
Fuel economy (FE)
Price (PR)
Range (RA)
Charge time (CH)
Car type (CT)
Engine type (ET)

Since respondents take decisions with the knowledge of fuel economy, we can compute the annual fuel demand of each household from the annual mileage. Respondents must make this car choice and perform the car use task for six different scenarios, Table 24.

Table 24: List of scenarios for car fleet choice and car use

Scenarios
Status quo: situation as it is today
Fuel prices would increase by 50%
Income would increase by 20% now and in future due to a tax cut
All public transportation (PT) fares would for the household would be halved
The operating frequency of all public transportation (PT) would double
There would be a rental car parked in the vicinity of the household

For each situation, we compute the aggregate mileage driven and the aggregate car demand of each vehicle type and the aggregate fuel demand. By relating these results to changes in fuel prices, changes in income and other changes, we compute the corresponding elasticities. Since we are also interested in whether specific household segments behave differently, e.g. to what extent families with children tend to buy larger vehicles or whether they react more sensitively to changes in fuel prices, we apply this procedure to different subsets of households. In order to produce a more detailed segmentation, we use the ordinary least square method (OLS) for capturing more household features to explain the aggregate mileage driven and the aggregate car demand of each vehicle type and the aggregate fuel demand. We are aware that the results of the OLS method must be treated with caution because some assumptions of the model’s error term are violated, but the results will provide useful insight nevertheless.

B.2.1 Evaluation of attitudinal questions

The attitudinal questions concerning fuel-saving technologies, political concerns and policy measures with regard to reducing CO2 emissions are all evaluated by simple summary statistics (mean and quantiles) and graphical representations such as histograms or by ordered logit models. Ordered logit models will be used when we want to explain which types of households tend to agree with a statement and which do not.

$$U_n = \delta \cdot s_n + \varepsilon_n \, , \qquad (5)$$

$$y = \begin{cases} 0 & if\ U_{in} \le \mu_1, \\ 1 & if\ \mu_1 < U_{in} \le \mu_2, \\ 2 & if\ \mu_2 < U_{in} \le \mu_3, \\ \vdots & \quad \vdots \\ K & if\ \mu_K < U_{in}. \end{cases} \qquad (5a)$$

In the ordered logit model as stated above, parameters δ denote by which magnitude the values of socio-demographic variables contribute to the latent variable U_n. Again, random variable ε_n maps the unobserved impacts, in this case the unobserved impacts on U_n. In addition to in (1), the random variable is distributed logistically. Parameters µk define the bins. Each bin corresponds to a level that a respondent can select in the questionnaire. Note that if ε_n is very small, then the model can forecast exactly which level the respondent would choose. In reality, the model can only forecast the probability with which respondents would choose a specific level. The final outcome of this model is to determine the probability that a respondent will choose a certain level. The estimation method for determining parameter values δ and μ_1, μ_2, μ_k, μ_K is the MLE method. Here, the MLE method adapts the models' parameters such that the probability of observing all respondents' choices of the level is maximised, given explanatory variables x_i.

In addition, some of these responses will be used for testing whether they explain some WTP. For instance, it could be tested whether respondents who report a high level of concern for environmental problems have a higher WTP for fuel-efficient engines.

B.3 Creation of car attributes for the three car choice experiments

B.3.1 Introduction

Creating car attributes for the three car choice experiment involves deciding which levels of attributes should be presented to the respondents. The aim is to present data such that the computed WTP of interest are unbiased and as accurate as possible, given the number of respondents. In this chapter, we describe how we computed our attribute levels for the three car choice experiment.

B.4.2 Criteria

In this section we list the criteria used to create the attribute levels for our three car choice experiment.

Orthogonality

The orthogonality of the attribute data means that the levels vary independently from one another. The reason why this is important can be illustrated by looking at the effect of the opposite case, namely the effect of perfect correlation. Imagine that for all cars presented, the engine power is perfectly correlated with the engine size, e.g. if the engine size increases by 100 cc, then the engine power will increase by 7 bhp. Imagine now that a respondent has a preference for larger engines as well as for more engine power. He would then always tend to choose the car with a larger engine and greater engine power. However, since these value always differ in the same way, we would be unable to identify his preference for engine size and engine power, since we cannot find out whether he reacted to the change in engine size or the change in engine power. If we are interested in finding out about both effects, we must present attribute data such that the variation of the engine size differs slightly from the variation of the engine power. In the best case, the variation of engine size will be independent from the variation of engine power — this would correspond to orthogonality between engine size and engine power. In reality, optimal designs — so-called “efficient designs” — are generally not orthogonal. Also, some attributes are correlated by a number of restrictions. For instance, if the engine of car one is much less powerful than that of car two, it is infeasible to present a lower acceleration time for car one than for car two. In our case, we only use small changes in engine power and acceleration so that it remains feasible to keep the variation of these attributes uncorrelated.

Avoiding irrelevant alternatives

Irrelevant alternatives are alternatives that are clearly worse that the other alternatives presented. In this case, a car equipped similarly to those presented but which costs much more would be an irrelevant alternative. Adding irrelevant alternatives does not provide extra information to the researcher. The intuitive explanation for this is that we already know that respondents would not choose the more expensive option and therefore we would not gain any knowledge by including it in the study. Also, presenting irrelevant alternatives could reduce respondents’ motivation because it could cause them to wonder whether the aim of the survey was simply to test whether or not they are reading the questions properly.

A general concept for avoiding the presentation of irrelevant alternatives is to compute the utility level we expect a certain car would provide to a respondent. Thus, we need to define a prior belief about the WTP for each feature. Given these priors, the V level of each alternative is computed by applying (1), from which the choice probability of each alternative is then yielded. The attributes of each alternative are then chosen such that the choice probability of each alternative is not too small, e.g. above 10% in most cases. Table 25 lists all attributes and the corresponding WTP we believe are realistic priors of the WTP.

Table 25: List of attributes and their assumed WTP parameters

Variable name	Assumed WTP	
Car type (CT)	8000 / 8000 / 9000	Small car (hatchback/saloon/estate)
	13000 / 13000 / 14000	Low to mid-size car (hatchback/saloon/estate)

Variable name	Assumed WTP	
	17500 / 17500 / 19000	Mid-size car (hatchback/saloon/estate)
	24500 / 24500 / 28500	Upper-to mid-size car (hatchback/saloon/estate)
	20500	Small SUV
	53500	Large SUV
	22000	Compact van
	29860	Van
	58000	Luxury car
	39500	Sports car
Engine type (ET)	0	Petrol
	-1000	Diesel
	-1500	Natural gas
	1500	Hybrid
	-1500	Pure electric
	2500	Electric with range extender
Engine size (ES)	2	-200, 0, 200
Power (PW)	20	-20, 0, 20
Gearbox (GX)	0	5 gear, manual
	1000	6 gear, manual
	1200	5 gear, continuous
	1400	6 gear, continuous
	1600	7 gear, continuous
	1800	8 gear, continuous
	2000	Automatic, continuous
Transmission (TR)	0	Front wheel drive
	0	Rear wheel drive
	1000	Four wheel drive
Acceleration (ACC)	-667	-1, 0, 1
Fuel economy (FE)	-936	-1, 0, 1
Air conditioning (AC)	0	None
	300	Manual
	500	Automatic

Variable name	Assumed WTP	
ecoDriver system (ED)	0	None
	50	Mobile phone app
	100	Built-in system
Price (PR)	-1	-4000, -3000, -2000, -1000, 0, 1000, 2000, 3000, 4000
Range (RA)	(*) -4500, (**) -1000	(*) 100, (**) 400
Charge time (CH)		(*) 4h, (**) 2h

Avoiding dominated alternatives

Dominated alternatives are alternatives for which each attribute provides less utility compared to the attributes on at least one other alternative. Let us imagine two cars. Car one has more horsepower and is cheaper that car two. Providing all other attributes are equal, then car two will be dominated by car one. Even if the difference in V values between the two cars were low, since the differences in the attribute level may be only 10 bhp and £500, respectively, no respondent would choose car two. Dominated alternatives should be avoided because they lead to biased parameters or may reduce respondents' motivation to complete the survey, since they would question its seriousness.

Choosing the number of attributes

We chose a rather large number of attributes, namely thirteen. The reason for this is that we do not want to present the ecoDriver system against just a few much more relevant attributes. There are four reasons for this: first, it could direct too much of respondents' attention to this feature, which would result in too high WTP. Second, it could make respondents realise that we are mainly interested in the ecoDriver system. This could lead to strategic responses. Third, providing a sufficient number of attributes reduces the problem of estimating biased parameters. It reduces the so-called "omitted variable bias". Fourth, if only a few much more relevant attributes were presented in addition to the ecoDriver system, then respondents' motivation to participate could be reduced, because they might cast doubts on the quality of the survey.

Presenting cars which are familiar to the respondent

Car choice is not a trivial decision due to the vast number of attributes each car has. Since in the case of our survey respondents do not usually like to take more than half a minute to make a decision, it is important that they are already familiar with cars. For this reason, we only recruit respondents who have purchased a car within the last 11 month or who are currently thinking about buying a car. In addition, we only present cars that are familiar to them. To this aim, we ask them to state which car they purchased recently or which car they are currently thinking about buying. We then present cars that are similar to these ones.

Blocking the data

We will present the same type of choice sets to respondents six times, each time different. Six choice sets are grouped into a block. A method of improving the efficiency of the attribute data is selecting the attributes of each column of the block such that these are the average correlation between the blocking column and that all other design columns are minimal.

Efficient designs

The term "efficient designs" refers to a criterion. There are different criterions. Most relate to the aim that the standard deviation of the estimated parameters should be minimal. Since there are a couple of parameters to optimise, a measure that is to be minimised must be defined. We choose the so-called "D_p error". The D_p error is equal to the determinant of the asymptotic variance-covariance matrix of the estimated parameter values. The routine for finding an efficient design can be outlined as follows:

1. Choose all attribute levels for all choice situations of each respondent. This defines a "design".
2. Compute the variance covariance matrix of the estimated parameters values given this data.
3. Compute the determinant of this covariance matrix of the estimated parameters.
4. Choose a new attribute levels for all choice situations of each respondent.
5. Repeat steps 1., 2. and 3. and check to see whether the determinant of this covariance matrix of the estimated parameters has decreased. If this is the case, take the new design as the benchmark; it this is not the case, keep the old design.
6. Keep this routine running until you are satisfied with the d-value found.

The following example may provide information about the D_p error criterion: imagine the estimated parameters are all uncorrelated and, thus, the asymptotic variance-covariance matrix of the estimated parameters would be diagonal. In this case, the D_p error would be equal to the product of the variances of the estimated parameters. Then, minimising the D_p error would be equal to minimising the product of the variances of the estimated parameters, minimising the product of the standard deviations of the estimated parameters, or minimising the sum of the logarithms of the standard deviations of the estimated parameters.

B.3.3 Creating attribute data

We use the software "NGENE" to create the attribute data. The advantage of this software is that it conducts all the steps stated above and uses an algorithm to help find new trials in step 4 above. Note that we have a large number of attributes. Thus, the number of combinations that can be presented is too large to try all of them out. Moreover, NGENE enables the criteria to be incorporated "avoiding irrelevant alternatives", "dominated alternatives" and "blocking". In order to identify the optimal design, we instruct NGENE to use the D_p error criterion.

Since we want to adapt the attribute data to the car that respondents are familiar with, we defined eighteen different car types. For all these car types, we defined so-called benchmark values for the attributes engine size, engine power, acceleration, fuel economy and price, Table 26.

Table 26: Car types and WTP assumptions

Car types	Car models	Engine size (cc)	Engine power (bhp)	Fuel efficiency (l/100km)	Accele-ration (0-60mph)	Price (£)
Small car, hatchback	Audi A1, VW Polo, Ford Fiesta	1200	80	5.0	12.0	8000
Small car, saloon	Audi A1, VW Polo, Ford Fiesta	1200	80	5.0	12.0	8000
Small car, estate	Audi A1, VW Polo, Ford Fiesta	1200	80	5.0	13.0	9000
Low- mid-size car, hatchback	Audi A3, VW Golf, Ford Focus, Merc. A	1600	110	6.0	11.5	13000
Low to mid-size car, saloon	Audi A4, VW Golf, Ford Focus, Merc. A	1600	110	6.0	11.5	13000
Low to mid-size car, estate	Audi A5, VW Golf, Ford Focus, Merc. A	1600	110	6.0	12.5	14000
Mid-size car, hatchback	Audi A4, VW Passat, Ford Mondeo, Merc. C	1800	130	6.5	12.0	17500
Mid-size car, saloon	Audi A4, VW Passat, Ford Mondeo, Merc. C	1800	130	6.5	12.0	17500
Mid-size car, estate	Audi A4, VW Passat, Ford Mondeo, Merc. C	1800	130	7.0	12.5	19000
Upper to mid-size car, hatchback	Audi A6, Merc. E	2400	170	8.5	10.5	24500
Upper to mid-size car, saloon	Audi A6, Merc. E	2400	170	8.5	10.5	24500
Upper to mid-size car, estate	Audi A6, Merc. E	2400	170	9.0	11.0	28500
Small SUV	Audi Q3, VW Tiguan, Ford Kuga	2000	140	8.0	12.5	20500
Large SUV	Audi Q7, VW Tuareg, Range Rover BMW X5	3200	220	14.5	10.5	53500
Compact MPV	VW Touran, Ford B-MAX	1800	130	7.5	12.0	15500
MPV	VW Sharan, Ford Galaxy	2400	170	10.0	10.5	22000
Luxury car	Audi A8, VW Phaeton, Merc. S	3600	250	12.0	8.0	58000
Sports car	Audi TT, Merc. SLK	3200	220	11.5	7.0	39500

NGENE will pivot the attribute levels around these levels (Table 25). Note that in the case of small cars, prices pivot only with deltas of -3000, -2000, -1000, 0, 1000, 2000, 3000 and for engine power deltas of -10, 0, 10. We chose this restriction for small cars because keeping the initial ranges would have led to implausible attribute levels, such as a car price of only £4000. The WTP is listed for each level. These levels will be used to compute utility levels *V* of each alternative, see (1). Note that we should not directly enter the WTP in (1). If we did, then the model would become almost completely deterministic, as the variance added by the error term εijn – note the standard deviation of ε_{ijn} of about 1.28 – is negligible. We choose to scale down the WTP by a factor of 0.001.

It is important to note that the frequency with which each attribute level is presented depends on the car type. For instance, we defined that the level "automatic" is presented in 80% of cases of the attribute "air-conditioning system" for luxury cars because it is rare for a luxury car to be sold without an air-conditioning system. Note that in the case of pure electric vehicles and electric vehicles with a range extender, only two combinations of ranges and charge time indicated by (*) and (**) are presented.

B.3.4 Testing the attribute data

It is crucial to test whether estimates based on responses resulting from the attributes will yield parameter estimates that are unbiased and with low standard errors. The following example illustrates why "bad" attribute data could lead to biased estimates. Let us imagine that we only wanted to find out about the WTP of an air automatic conditioning system versus none. We would then present cars with or without an automatic conditioning system to respondents, with all other attributes apart from the price being constant. We would choose a price that is between £50 and £100 higher if the car has an automatic air-conditioning system. We would present ten such choice situations to a respondent in order to find out about his WTP for an automatic air-conditioning system. Let us assume that his WTP for such a system is £300. Thus, he would always opt for the car with an air-conditioning system. However, given the data we presented, we would compute a WTP in the range of £50 and £100. This would be clearly too low – the computed WTP is biased. The reason why this problem arose here is that the researcher had wrong assumptions about the respondent's WTP.

Testing by simulation

Biases caused by a wrong assumption about respondents' WTP can also arise in the case of model with more attributes. Thus, we need to check whether our attribute data could cause biases if our assumptions were inaccurate. In order to check for this, we applied the following procedure:

1. We decided that 800 respondents would answer each of these six repeated questions, thus we have 4800 responses. For each such response we draw the three corresponding random variables ε_{1jn}, ε_{2jn}, ε_{3jn}.
2. We chose a set of parameters that differ slightly from the assumptions used to create the data (see Table 25). We choose most of the parameters to vary randomly and uniformly,

independent of previous draws and draws of other parameters within a range of +/- 20% within their true values.

3. We computed which alternatives respondents would choose given the attribute data of each choice set and given random variables ε_{1jn}, ε_{2jn}, ε_{3jn}. To this end, we compute (1) using these values and check which is the largest V_{1jn}, V_{2jn}, V_{3jn} for each choice set. We then set indicator y_{1jn} to the corresponding value.

4. We applied the MLE method to estimate the parameters using the attribute data and indicators y_{1jn}. We store the results in βm, *var*(βm) and t-values βm

5. We repeated steps 2. .. 4. one hundred times, m = 1..100.

6. We analysed the distribution of βm, *var*(βm) and t-values βm and $wtps_m$. We are particularly interested in whether $wtps_m$ deviate from their true values.

The outcome of this analysis was that the deviations of the WTP were rather small, all below 10% in 90% of the cases simulated. Only the attributes "engine type pure electric", "engine type electric with range extender" and the ecoDriver systems suffered from higher biases. The reason for the first attribute could be that electric engines are options that are presented only rarely. The reason for the bias of the ecoDriver system is that its WTP – £50 for the mobile phone app and £200 for the built-in-screen version – are rather low. Nevertheless, we decided to proceed with this design in order to obtain a rough idea of the WTP in reality in a pilot study and then to decide whether to change the design based on new insight.

Testing by creating real data

Another way to test a choice experiment is to fill in the questionnaire a number of times. Since we are conducting the survey by means of an online questionnaire, this is also good way for testing whether the data recording of the software program works perfectly. We filled in the questionnaire twenty times, generating 120 responses. Using these results, we estimated parameters β. The results were satisfying, not only in terms of the estimated values, which were all in the range we expected, but also in terms of the t-values. Of course, due to the small sample size, the t-values corresponding to engine types and ecoDriver systems and a number of other dummy variables were rather low.

B.4 Creation of car attributes for the car fleet and car use experiment

B.4.1 Introduction

We presented six different cars for the car fleet choice and car use experiment. Each car is from a different car type. We were not only interested in respondents' choices about car type, but also about their mileage and the fuel economy of the cars. Thus, we wanted to present fuel economy as a feature. In order not to ensure respondents paid no greater attention to this feature than in reality, we also presented a number of other features listed in Table 25. Among these, we also presented some with an engine type that is purely electric or electric with a range extender in order to see whether such cars could perhaps be chosen as supplements, e.g. for commuting to work if the distance is limited, if we offer them within a price range that is typical for the specific car type.

B.4.2 Creation of data

First, we chose the type of vehicles we want to present. Since six cars are a very restricted number of cars for the question “Imagine only these cars existed: Which of these would you choose if you had to replace all the cars you currently own?”, we presented cars that cover a wide range of needs. We ensured that we always presented at least two cars belonging to the group of "cheap", "average" and "spacious" cars, and at least one belonging to the "exclusive" and "luxury" groups, Table 27.

Table 27: Car type categories and their car types

	"Cheap"	"Average"	"Spacious"	"Exclusive"	"Luxury"
Small car, hbk	3				
Small car, sln	3				
Small car, est	3				
Lo. mid., hbk	3				
Lo. mid., sln	3				
Lo. mid., est	3		3		
Mid-size, hbk		3			
Mid-size, sln		3			
Mid-size, est		3	3		
Up. mid., hbk		3	3		
Up. mid., sln		3	3		
Up. mid., est		3	3		
Small SUV		3	3		
Large SUV				3	3
Compact van		3			
Van					
Luxury car				3	3
Sports car				3	

Second, we defined the car attributes by choosing randomly attributed data from the corresponding three car choice table.

Third, we checked manually whether certain car features are over-represented. In particular, we ensured that there were not too many cars in one choice set that have non-conventional engine types, i.e. “natural gas”, “hybrid”, “pure electric” or “electric with range extender”. If this was the case, we changed the engine type to "petrol" or "diesel". The reason for this was that some respondents may have strong reservations against such engine types and could thus exclude the choice of cars with such engine types. Since we were primarily interested in whether they would choose larger vehicle types if their income increased or if they opt for less fuel-efficient cars if fuel prices go up, we did not want the choice of different car types for some respondents to be restricted even more than it already is by the design itself.

B.5 The questionnaire

B.5.1 Introduction

The questionnaire was designed such that the data can be used to cover a wide range of analyses later on. Thus, it not only covers the collection of the stated preference data from the choice experiments and socio-demographics; it is also about understanding households' current situations related to having to drive and finding out about household attitudes to fuel-saving technologies and policy measures.

B.5.2 Questionnaire parts

In the following table we present the parts of the questionnaire and explain the purpose of each part. The online questionnaire is structured in the same order as in Table 28.

Table 28: Overview of the SP questionnaire

Questionnaire section	Objective	Model used
Filtering respondents (income, gender, household type, type of residential area)	Ensure representativeness of sample	-
Declaration of the type of car recently bought or that they are thinking of buying	The ability to present "similar" cars in the car choice sets (CS), 3 alternatives	-
SP questionnaire, car choice sets, 3 alternatives	Forecast the willingness to pay (WTP) for ecoDriver systems and other car features, especially those relevant for fuel consumption (all-wheel drive and air conditioning)	MNL
SP questionnaire, car choice sets, 3 alternatives, repetition of choices given different changes (income, fuel prices, public transportation, …)	Forecast car choice with a special focus on fuel-saving technologies (engine type) given the scenarios (income and fuel prices)	MNL
SP questionnaire, car choice sets, fleet decisions, 6 alternatives asking for car type choice and annual mileages.	Explain fleet size, demand for new cars, driving demand and fuel demand given household attributes, in particular household income, household type and type of residential area. Forecast aggregate driving distance and CO2 emissions given various scenarios (income, fuel prices, public transport, …)	Summary stats, OLS

Questionnaire section	Objective	Model used
SP questionnaire, car choice sets, 6 alternatives, repetition of questions given different changes (income, fuel prices, public transport, …).	Forecast fleet size, demand for new cars, driving demand and fuel demand given the scenarios (changes in income, fuel prices and public transport)	Summary stats, OLS
SP questionnaire, attitudes, policy priorities, general	Policy acceptance of different segments of the population	Summary stats, ordered Logit

B.5.3 Implementation of the questionnaire

The questionnaire was tested in several stages. First, there was a 'pre-pilot' survey. This involved of a small number of participants, covering both experts in the research area, as well as non-experts typical of the respondents that we would in due course seek to recruit. As well as analysing the data from these respondents, we invited comments through 'debrief'. Informed by this pre-pilot survey, we edited/or and removed some questions, but it did not give us cause to change the substance of the questionnaire. Second, we conducted three waves of 'pilot' survey. This involved opening the web-survey, and recruiting a pre-specified number of respondents (typically around 50) from Accent's internet panel. The data from each wave was modelled so as to derive tentative estimates of WTP, and we also conducted diagnostic testing of the data so as to determine whether the survey was being completed in a robust fashion (e.g. looking at whether respondents were 'clicking through' the survey in an expedient fashion). The key outcome from this second stage of testing was to help inform the specification of quality criteria, which were then implemented by Accent (e.g. respondents who completed the survey 'too quickly' were screened out and re-sampled).

The questionnaire was implemented by UNIVLEEDS using the php and html programming languages. The software covers a large number of functions, such as filtering respondents according to their socio-demographic characteristics and according to whether they have bought a car in the recent past. Additional functionality includes presenting choice selections that depend on previous choices, and presenting extra information as tooltips if asked for by the respondents. Also, in the three car choice experiment, the software randomises the ordering of the "air-conditioning", "ecoDriver system", "transmission", "fuel economy", "acceleration" and "gearbox" attributes. We did this, since some respondents may assign more importance to attributes presented higher up the screen. The engine type and its characteristics were always displayed first, whilst price was always presented last.

The software recorded all of the data reported by the respondents, and adds a timestamp to each response so that the speed of response can be analysed. To ensure that only people who were invited by us have can access the questionnaire, we send an 11-digit number to them. The software is run on a server at the university where the data are also stored.

B.6 Respondents

The SP work used a sample of respondents provided by Accent (a market research agency) via their sub-contractors Survey Sampling. Respondents were recruited online and incentivised, for example through retail discounts, or panel (loyalty) points. Since the respondents had a financial incentive to fill in the questionnaire, the supplier implemented a filter that asked about a number of purchasing and other activities over the past twelve months or planned for the next six months.

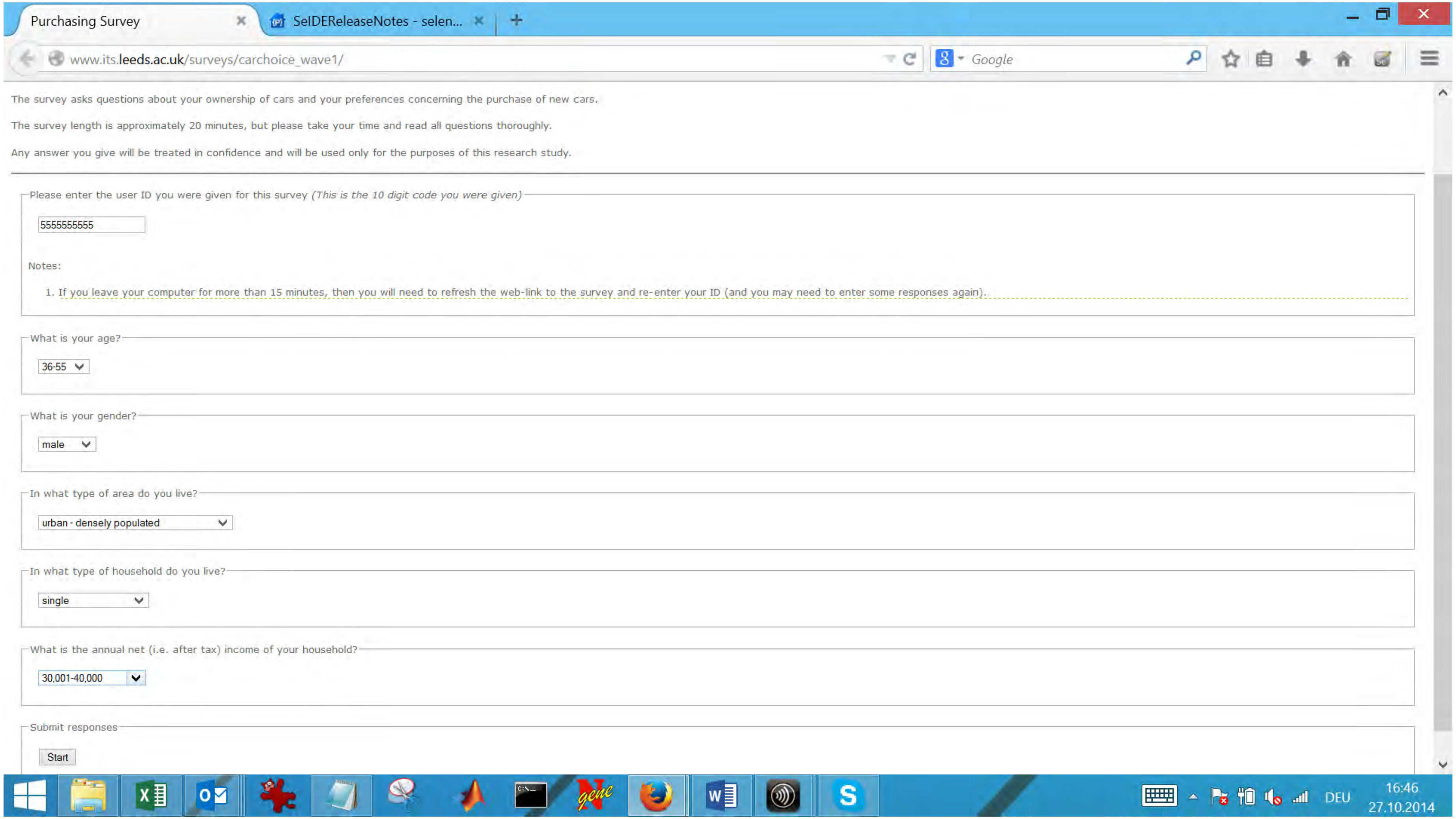
Asking about multiple purchases identified those genuinely engaged with purchasing a car. Respondents were asked about purchasing a car, purchasing a home, purchasing a new bike or learning a new language. Only those actively engaged in buying a car and thus familiar with the process and decision making were eligible since the questionnaire was demanding in terms of respondents needing to thinking about multiple car choice criteria. Respondents with little knowledge of car buying would be likely to provide inaccurate or biased answers. To ensure respondents to the SP survey met the desired criteria of being approximately representative of the population being surveyed, in terms of income, household type, area type (urban versus rural) and age, a further filter was used.

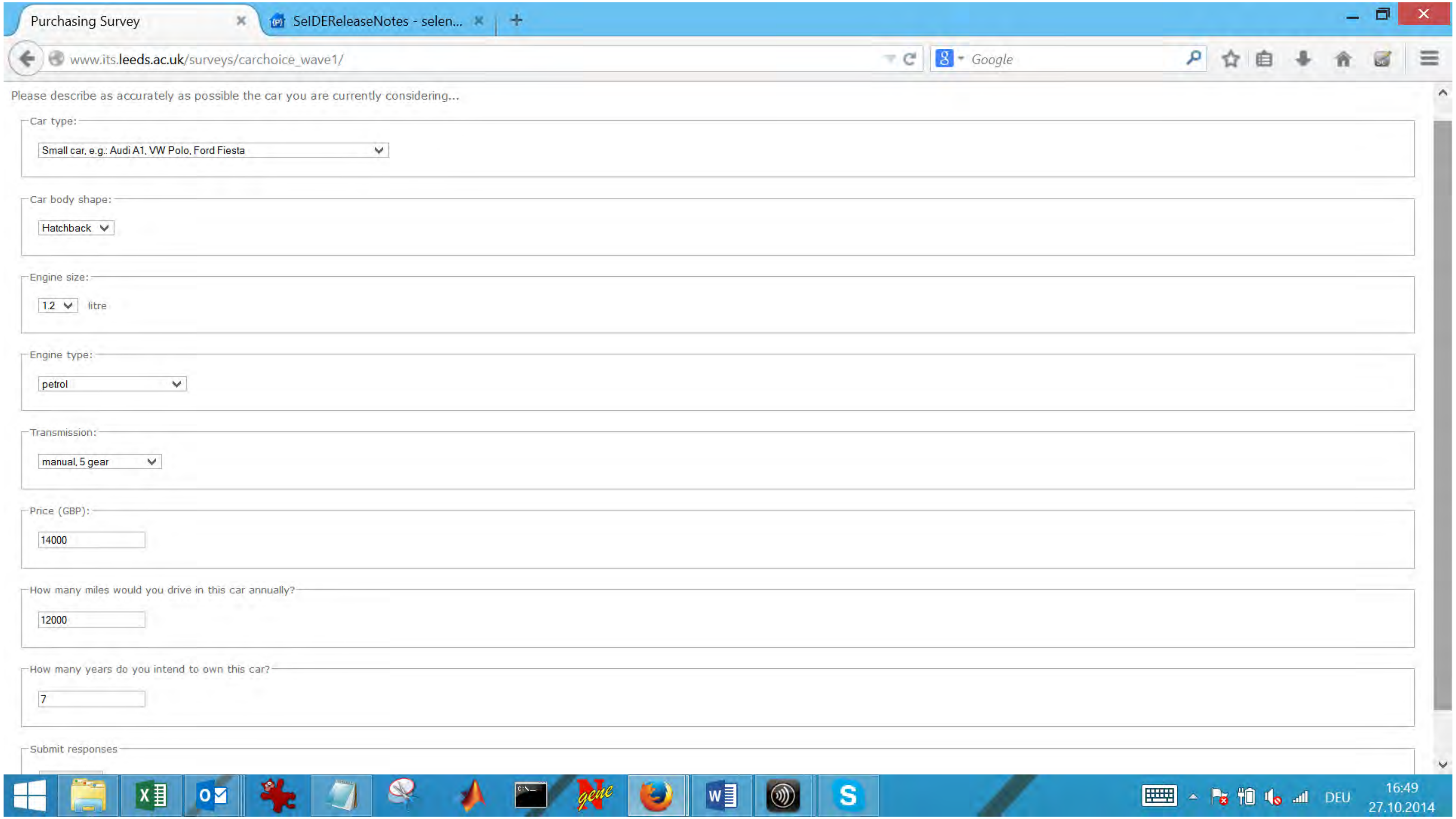
Thus two filters were used:

iii. A priori filtering: Accent recruited respondents via their internet panel. In order to mask the objective of our questionnaire – and thereby ameliorate bias – a filter question was implemented at the recruitment stage which asked respondents about recent and planned purchasing activities (including car purchasing). In order to ensure that respondents were familiar with the subject of the questionnaire, only those respondents who reported recent/planned car purchasing were retained.

iv. Ex post filtering: Having recruited respondents on the basis described above, and administered the questionnaire to these respondents, further filtering was applied ex post so as to ensure data quality. Those who completed the questionnaire in less than 12.5 minutes were filtered out; we judged that these respondents failed to devote adequate attention to the questionnaire. We also filtered out those respondents who always chose the same SP option, and those who exhibited other fixed patterns of response; we judged that these respondents failed to engage in 'trade-off' behaviour.

Annex C: Example Pages From Stated Preference Questionnaire




Purchasing Survey
SelDEReleaseNotes - selen...
www.its.leeds.ac.uk/surveys/carchoice_wave1/
Google
Please describe as accurately as possible the car you are currently considering...
Car type:
Small car, e.g.: Audi A1, VW Polo, Ford Fiesta
Car body shape:
Hatchback
Engine size:
1.2
litre
Engine type:
petrol
Transmission:
manual, 5 gear
Price (GBP):
14000
How many miles would you drive in this car annually?
12000
How many years do you intend to own this car?
7
Submit responses
DEU
16:49
27.10.2014

Purchasing Survey

www.its.leeds.ac.uk/surveys/carchoice_wave1/

Purchasing Survey

Choosing a new car

On the following screens, we will offer you a choice between 3 alternative cars.

Each car is described in terms of 9 features; you should assume that the 3 cars are identical in terms of brand and any other features not explicitly stated.

Please recall the situation for the new car you are considering.

If only these 3 alternative cars were available, we are interested to know which car you would choose.

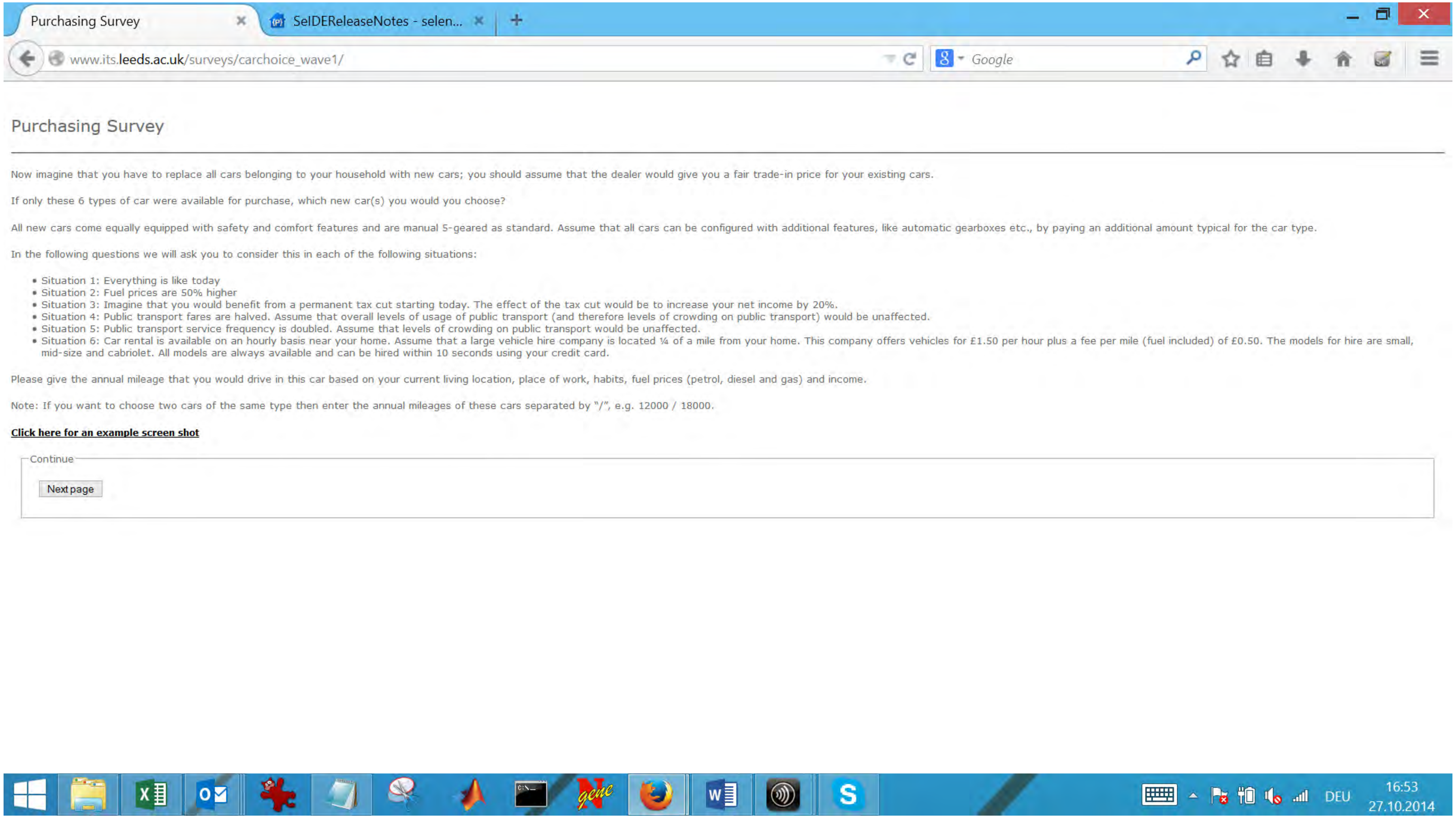
Game 1

Feature	Car 1	Car 2	Car 3
Car type	Small car, hatchback	Small car, hatchback	Small car, hatchback
Engine type	electric with range extender (90.0 bhp) 400 miles range 2 hours charge time	1.2 litre diesel (80.0 bhp)	pure electric (70.0 bhp) 100 miles range 4 hours charge time
Fuel/energy economy and emissions	10.0 kWh/100km + 3.0 litres/100km 70.4 equivalent mpg 135.5 g per km co2 emissions	56.5 mpg 132.5 g per km co2 emissions	12.0 kWh/100km 233.1 equivalent mpg 77.7 g per km co2 emissions
Ecodrive-system	mobile phone app	none	built in, screen
Transmission	front-wheel drive	front-wheel drive	rear-wheel drive
Gearbox	automatic, continuous	automatic, 7 gear	automatic, continuous
Acceleration (0-60mph)	12.0 secs	12.0 secs	12.0 secs
Air conditioning	none	auto	auto
Price	9000 GBP	9000 GBP	5000 GBP
Your choice(s):	(●) 1	( ) 2	( ) 3

Submit responses

Next

16:50 27.10.2014



Purchasing Survey

Now imagine that you have to replace all cars belonging to your household with new cars; you should assume that the dealer would give you a fair trade-in price for your existing cars.

If only these 6 types of car were available for purchase, which new car(s) you would you choose?

All new cars come equally equipped with safety and comfort features and are manual 5-geared as standard. Assume that all cars can be configured with additional features, like automatic gearboxes etc., by paying an additional amount typical for the car type.

In the following questions we will ask you to consider this in each of the following situations:

- Situation 1: Everything is like today
- Situation 2: Fuel prices are 50% higher
- Situation 3: Imagine that you would benefit from a permanent tax cut starting today. The effect of the tax cut would be to increase your net income by 20%.
- Situation 4: Public transport fares are halved. Assume that overall levels of usage of public transport (and therefore levels of crowding on public transport) would be unaffected.
- Situation 5: Public transport service frequency is doubled. Assume that levels of crowding on public transport would be unaffected.
- Situation 6: Car rental is available on an hourly basis near your home. Assume that a large vehicle hire company is located ¼ of a mile from your home. This company offers vehicles for £1.50 per hour plus a fee per mile (fuel included) of £0.50. The models for hire are small, mid-size and cabriolet. All models are always available and can be hired within 10 seconds using your credit card.

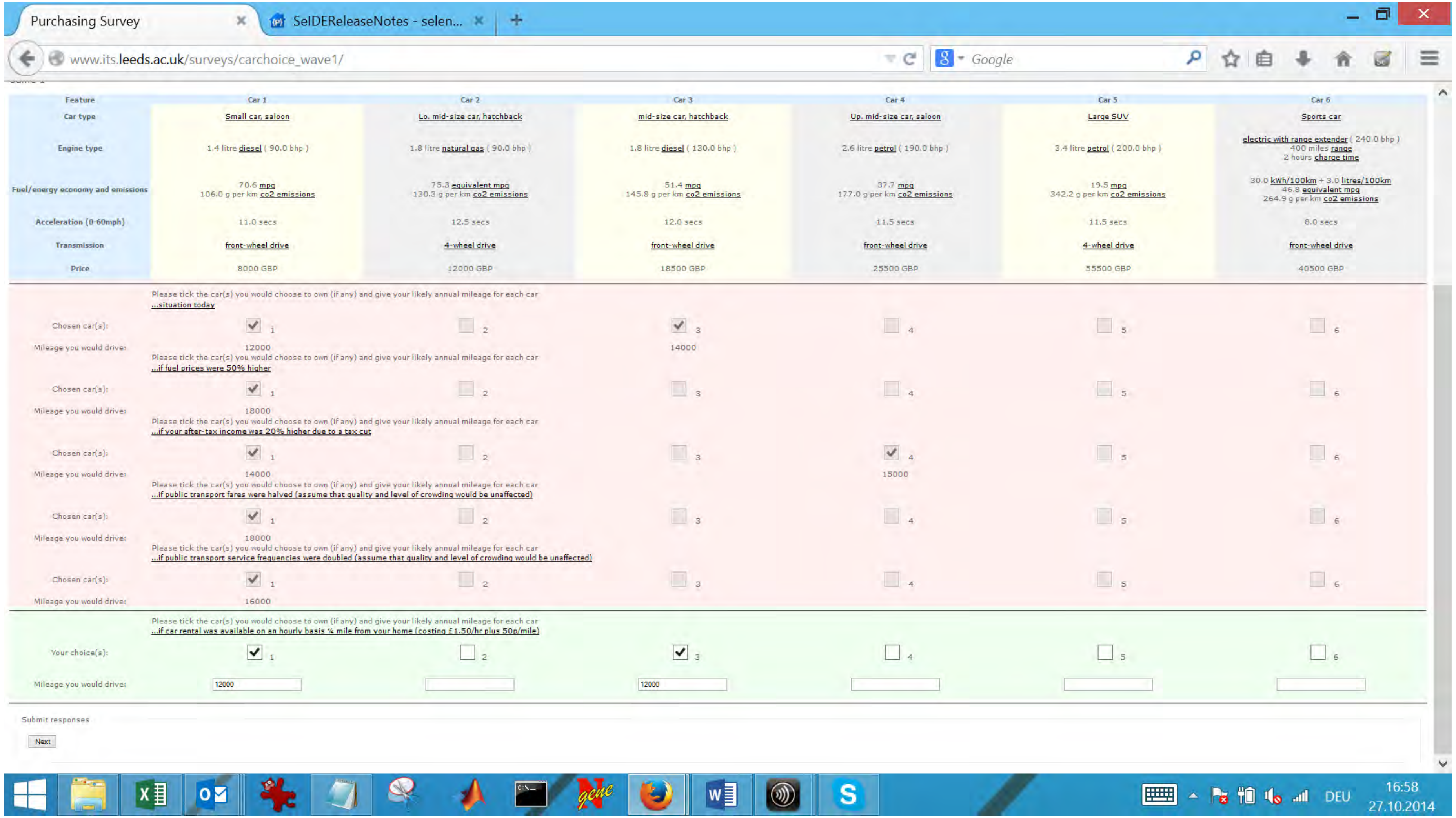
Please give the annual mileage that you would drive in this car based on your current living location, place of work, habits, fuel prices (petrol, diesel and gas) and income.

Note: If you want to choose two cars of the same type then enter the annual mileages of these cars separated by "/", e.g. 12000 / 18000.

Click here for an example screen shot

Continue

Next page



Purchasing Survey

www.its.leeds.ac.uk/surveys/carchoice_wave1/

Feature	Car 1	Car 2	Car 3	Car 4	Car 5	Car 6
Car type	Small car, saloon	Lo. mid-size car, hatchback	mid-size car, hatchback	Up. mid-size car, saloon	Large SUV	Sports car
Engine type	1.4 litre diesel (90.0 bhp)	1.8 litre natural gas (90.0 bhp)	1.8 litre diesel (130.0 bhp)	2.6 litre petrol (190.0 bhp)	3.4 litre petrol (200.0 bhp)	electric with range extender (240.0 bhp) 400 miles range 2 hours charge time
Fuel/energy economy and emissions	70.6 mpg 106.0 g per km co2 emissions	75.3 equivalent mpg 130.3 g per km co2 emissions	51.4 mpg 145.8 g per km co2 emissions	37.7 mpg 177.0 g per km co2 emissions	19.5 mpg 342.2 g per km co2 emissions	30.0 kWh/100km + 3.0 litres/100km 46.8 equivalent mpg 264.9 g per km co2 emissions
Acceleration (0-60mph)	11.0 secs	12.5 secs	12.0 secs	11.5 secs	11.5 secs	8.0 secs
Transmission	front-wheel drive	4-wheel drive	front-wheel drive	front-wheel drive	4-wheel drive	front-wheel drive
Price	8000 GBP	12000 GBP	18500 GBP	25500 GBP	55500 GBP	40500 GBP

Please tick the car(s) you would choose to own (if any) and give your likely annual mileage for each car ...situation today

	1	2	3	4	5	6
Chosen car(s):	✓		✓			
Mileage you would drive:	12000		14000			

Please tick the car(s) you would choose to own (if any) and give your likely annual mileage for each car ...if fuel prices were 50% higher

	1	2	3	4	5	6
Chosen car(s):	✓					
Mileage you would drive:	18000					

Please tick the car(s) you would choose to own (if any) and give your likely annual mileage for each car ...if your after-tax income was 20% higher due to a tax cut

	1	2	3	4	5	6
Chosen car(s):	✓			✓		
Mileage you would drive:	14000			15000		

Please tick the car(s) you would choose to own (if any) and give your likely annual mileage for each car ...if public transport fares were halved (assume that quality and level of crowding would be unaffected)

	1	2	3	4	5	6
Chosen car(s):	✓					
Mileage you would drive:	18000					

Please tick the car(s) you would choose to own (if any) and give your likely annual mileage for each car ...if public transport service frequencies were doubled (assume that quality and level of crowding would be unaffected)

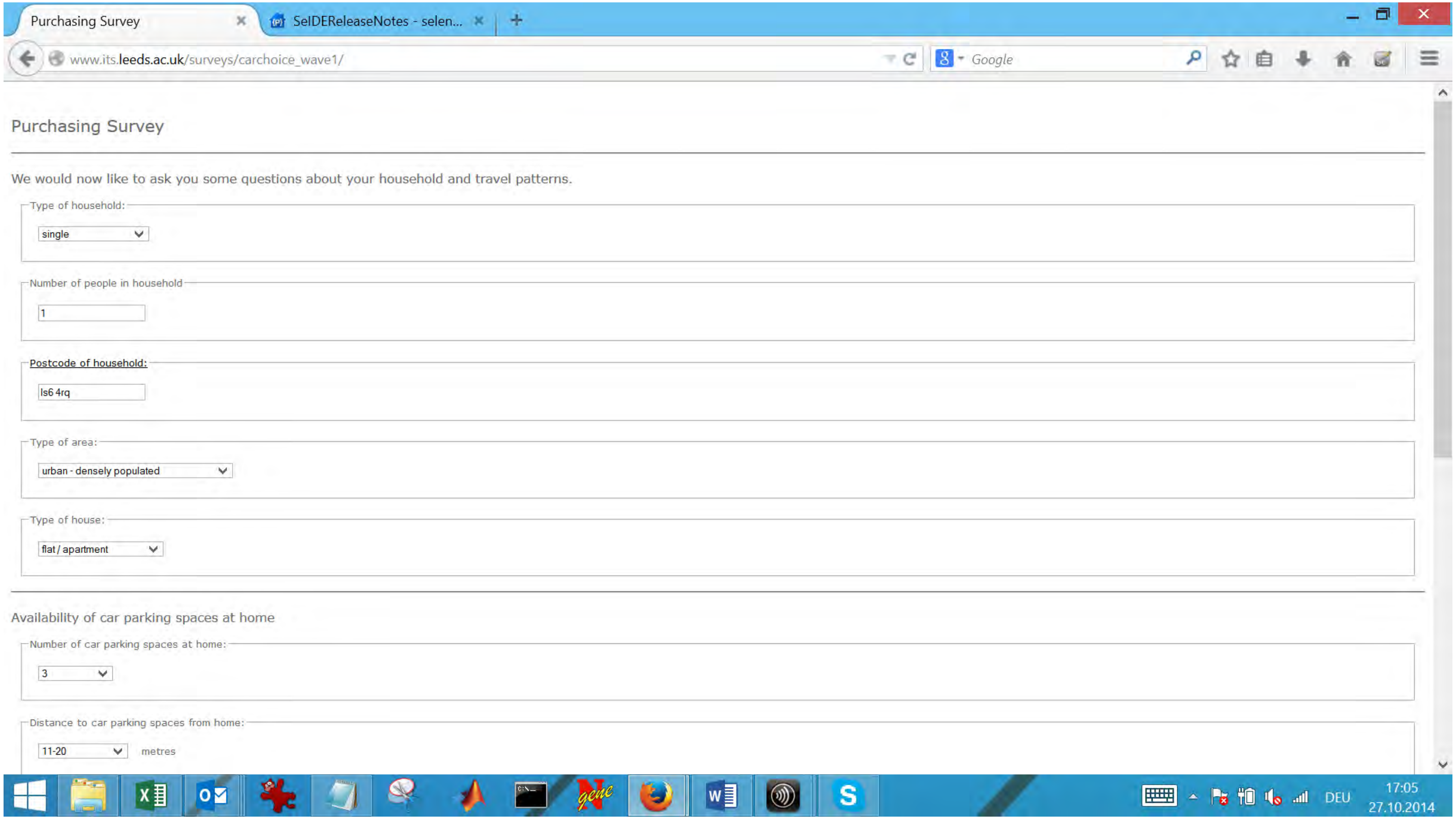
	1	2	3	4	5	6
Chosen car(s):	✓					
Mileage you would drive:	16000					

Please tick the car(s) you would choose to own (if any) and give your likely annual mileage for each car ...if car rental was available on an hourly basis ¼ mile from your home (costing £1.50/hr plus 50p/mile)

	1	2	3	4	5	6
Your choice(s):	✓		✓			
Mileage you would drive:	12000		12000			

Submit responses

Next



Purchasing Survey

We would now like to ask you some questions about your household and travel patterns.

Type of household:
single

Number of people in household
1

Postcode of household:
ls6 4rq

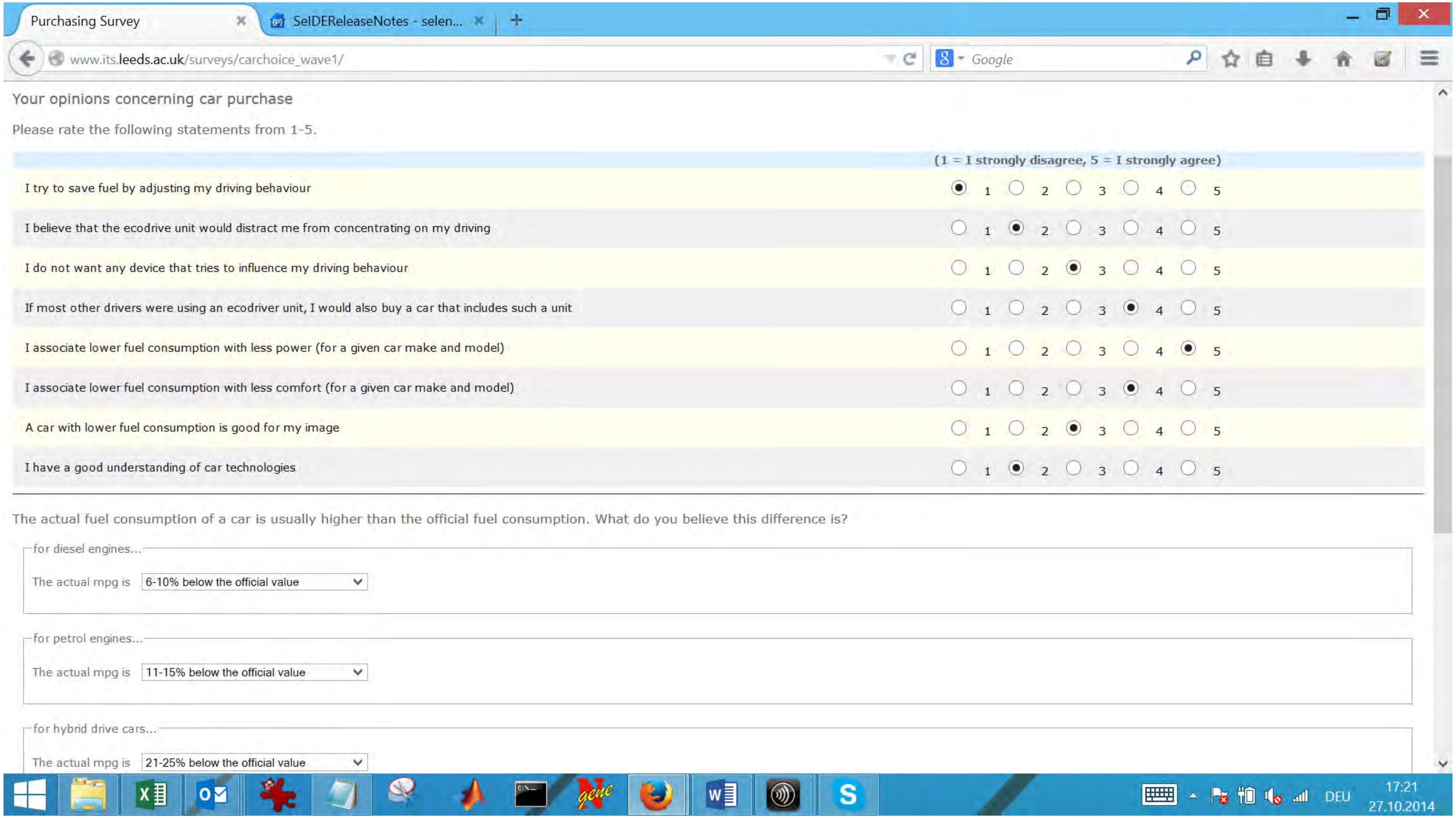
Type of area:
urban - densely populated

Type of house:
flat / apartment

Availability of car parking spaces at home

Number of car parking spaces at home:
3

Distance to car parking spaces from home:
11-20 metres



Purchasing Survey

www.its.leeds.ac.uk/surveys/carchoice_wave1/

Your opinions concerning car purchase

Please rate the following statements from 1-5.

Statement	(1 = I strongly disagree, 5 = I strongly agree)
I try to save fuel by adjusting my driving behaviour	1
I believe that the ecodrive unit would distract me from concentrating on my driving	2
I do not want any device that tries to influence my driving behaviour	3
If most other drivers were using an ecodriver unit, I would also buy a car that includes such a unit	4
I associate lower fuel consumption with less power (for a given car make and model)	5
I associate lower fuel consumption with less comfort (for a given car make and model)	4
A car with lower fuel consumption is good for my image	3
I have a good understanding of car technologies	2

The actual fuel consumption of a car is usually higher than the official fuel consumption. What do you believe this difference is?

for diesel engines...

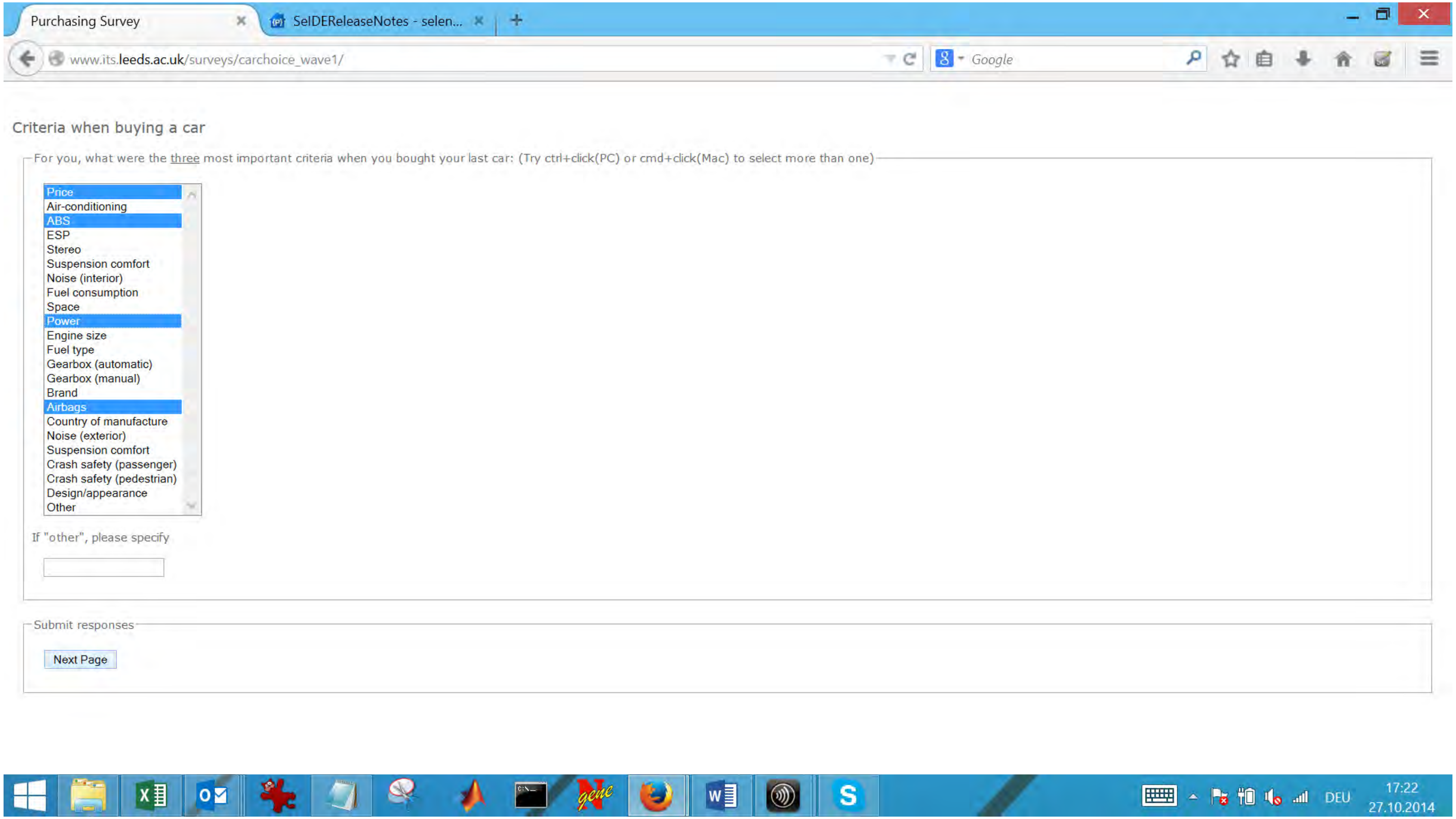
The actual mpg is 6-10% below the official value

for petrol engines...

The actual mpg is 11-15% below the official value

for hybrid drive cars...

The actual mpg is 21-25% below the official value


Purchasing Survey
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www.its.leeds.ac.uk/surveys/carchoice_wave1/
Google
Criteria when buying a car
For you, what were the three most important criteria when you bought your last car: (Try ctrl+click(PC) or cmd+click(Mac) to select more than one)
Price
Air-conditioning
ABS
ESP
Stereo
Suspension comfort
Noise (interior)
Fuel consumption
Space
Power
Engine size
Fuel type
Gearbox (automatic)
Gearbox (manual)
Brand
Airbags
Country of manufacture
Noise (exterior)
Suspension comfort
Crash safety (passenger)
Crash safety (pedestrian)
Design/appearance
Other
If "other", please specify
Submit responses
Next Page
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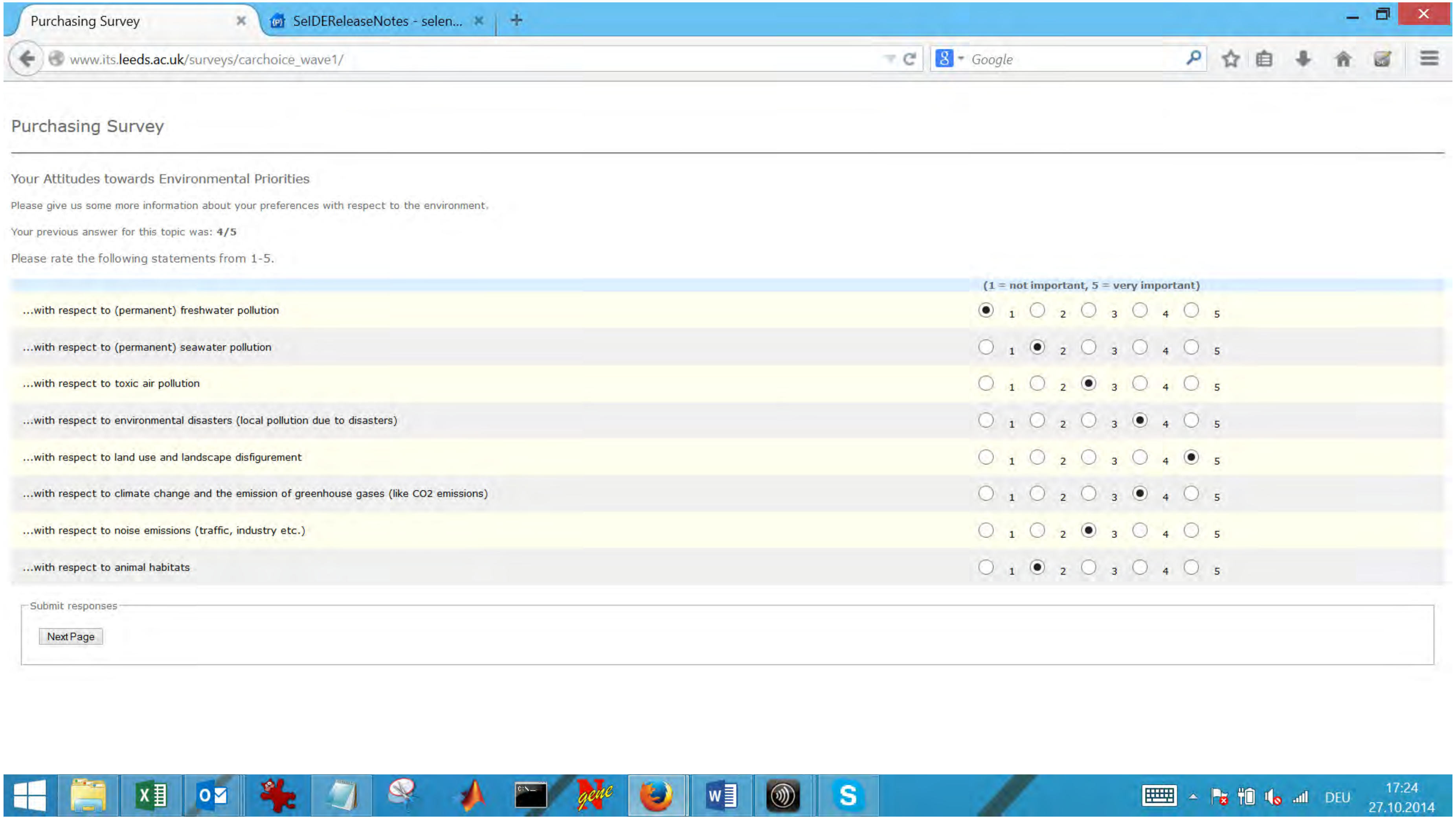
27.10.2014



Purchasing Survey

www.its.leeds.ac.uk/surveys/carchoice_wave1/

Purchasing Survey

Your Attitudes towards Environmental Priorities

Please give us some more information about your preferences with respect to the environment.

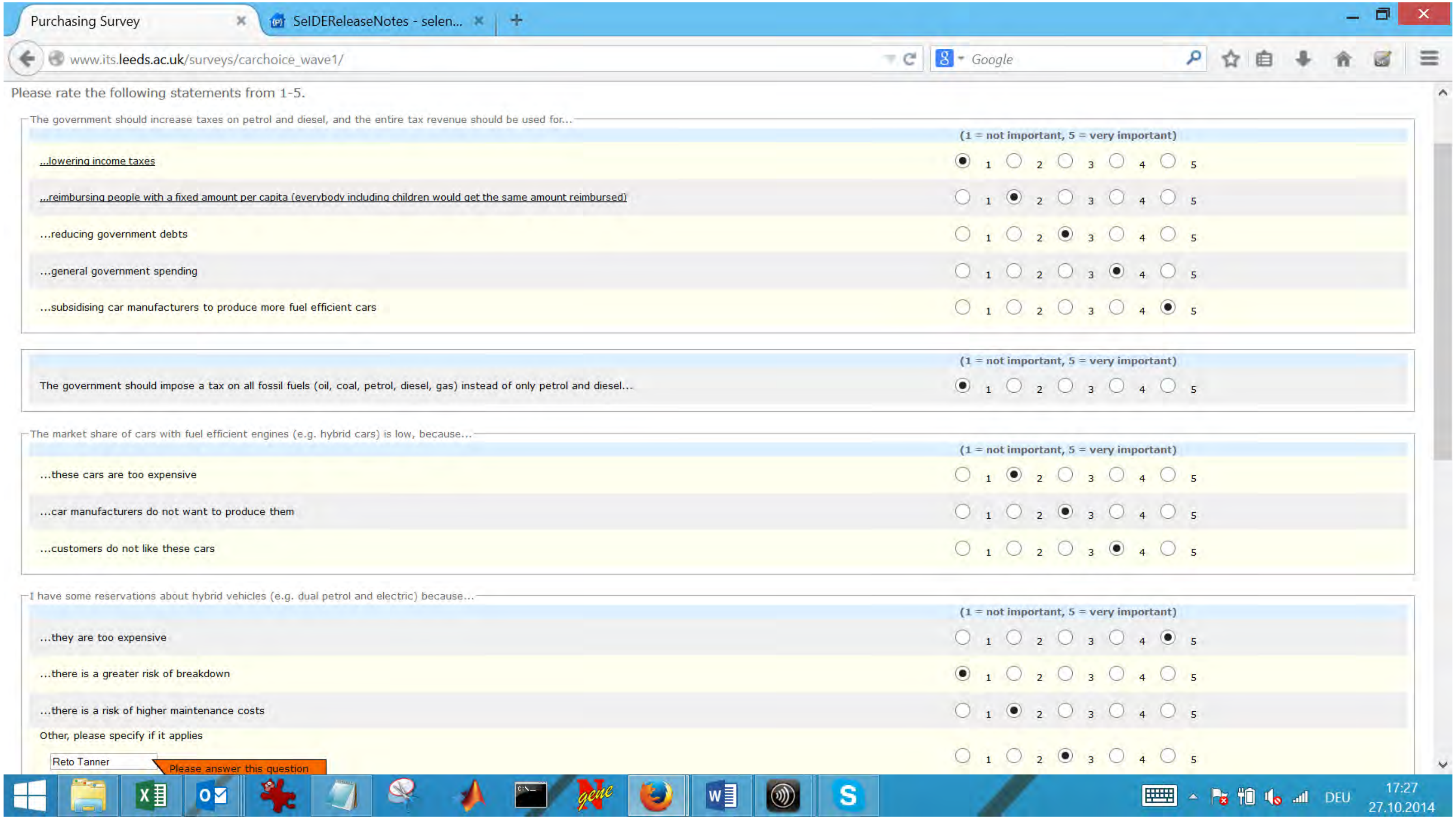
Your previous answer for this topic was: **4/5**

Please rate the following statements from 1-5.

	(1 = not important, 5 = very important)				
	1	2	3	4	5
...with respect to (permanent) freshwater pollution	●	○	○	○	○
...with respect to (permanent) seawater pollution	○	●	○	○	○
...with respect to toxic air pollution	○	○	●	○	○
...with respect to environmental disasters (local pollution due to disasters)	○	○	○	●	○
...with respect to land use and landscape disfigurement	○	○	○	○	●
...with respect to climate change and the emission of greenhouse gases (like CO2 emissions)	○	○	○	●	○
...with respect to noise emissions (traffic, industry etc.)	○	○	●	○	○
...with respect to animal habitats	○	●	○	○	○

Submit responses

Next Page



Purchasing Survey | SelDEReleaseNotes - selen...

www.its.leeds.ac.uk/surveys/carchoice_wave1/

Please rate the following statements from 1-5.

The government should increase taxes on petrol and diesel, and the entire tax revenue should be used for...

	(1 = not important, 5 = very important)
...lowering income taxes	(●) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5
...reimbursing people with a fixed amount per capita (everybody including children would get the same amount reimbursed)	( ) 1 (●) 2 ( ) 3 ( ) 4 ( ) 5
...reducing government debts	( ) 1 ( ) 2 (●) 3 ( ) 4 ( ) 5
...general government spending	( ) 1 ( ) 2 ( ) 3 (●) 4 ( ) 5
...subsidising car manufacturers to produce more fuel efficient cars	( ) 1 ( ) 2 ( ) 3 ( ) 4 (●) 5

	(1 = not important, 5 = very important)
The government should impose a tax on all fossil fuels (oil, coal, petrol, diesel, gas) instead of only petrol and diesel...	(●) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

The market share of cars with fuel efficient engines (e.g. hybrid cars) is low, because...

	(1 = not important, 5 = very important)
...these cars are too expensive	( ) 1 (●) 2 ( ) 3 ( ) 4 ( ) 5
...car manufacturers do not want to produce them	( ) 1 ( ) 2 (●) 3 ( ) 4 ( ) 5
...customers do not like these cars	( ) 1 ( ) 2 ( ) 3 (●) 4 ( ) 5

I have some reservations about hybrid vehicles (e.g. dual petrol and electric) because...

	(1 = not important, 5 = very important)
...they are too expensive	( ) 1 ( ) 2 ( ) 3 ( ) 4 (●) 5
...there is a greater risk of breakdown	(●) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5
...there is a risk of higher maintenance costs	( ) 1 (●) 2 ( ) 3 ( ) 4 ( ) 5
Other, please specify if it applies: Reto Tanner — Please answer this question	( ) 1 ( ) 2 (●) 3 ( ) 4 ( ) 5

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Annex D: Elasticities

The table below shows the demand elasticities assumed in the scenario analysis.

Table 29: Demand elasticities

Elasticity	Value	Sources
Car stock elasticity to GDP per capita	0.9	Johansson and Schipper, 1997: 1.0; assume effect moderated slightly since UK is above-average income country, where we expect to see elasticities decline slightly.
Car stock elasticity to Population	0.55	Assume 0.95 (versus typical 1.0). Apply -0.4 (Johansson and Schipper, 1997) for population density, assuming fixed land area. Net 0.55
Car stock elasticity to Fuel Price	-0.25	Goodwin Dargay, and Hanly 2003/4 (fuel ~ 25% of total vehicle costs).
Car stock elasticity to Journey Times	-0.3	Approximation based on various evidence including de Jong and Gunn (2001), p137.
Car stock elasticity to Public Transport Fares	0.01	Approximate average value based on a wide range of literature, e.g. Litman (2013), p27.
Bus stock elasticity to GDP/capita	-0.33	Balcombe et al (2004), Table 10.11.
Bus stock elasticity to Population	1.0	Assuming constant bus trip rate per head population. Literature is open on this.
Bus stock elasticity to Public Transport Fares	-0.6	Dargay and Hanly 1999, urban long run maximum (below rural).
Car travel elasticity (vehicle km) to Fuel Price	-0.3	Goodwin Dargay, and Hanly (2003/4)
Bus travel elasticity to Bus Fares	-0.5 urban -1.0 non-urban	Dargay and Hanly (1999)
Car travel (vehicle km) to Public Transport Fares	0.01	Booz, Allen and Hamilton (2003)
Car travel (vehicle km) to GDP per capita	-0.28	DfT (2013)
Bus travel elasticity to fuel prices	0.15	Balcombe et al (2004); Litman (2013)

Annex E: Quantitative scenarios results tables

Table 30: Projected traffic shares by road type and vehicle type, 2015-2035, 'Policy Freeze' scenario, Rural (non-motorway) roads, % of vehicle km

		Year					
Vehicle type	Fuel type	2013	2015	2020	2025	2030	2035
Car	Petrol	54.8%	51.9%	47.1%	44.0%	41.9%	40.3%
	Diesel	44.6%	47.3%	51.6%	54.1%	55.4%	55.8%
	Hybrid	0.5%	0.7%	1.1%	1.7%	2.6%	3.8%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	PHEV	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.9%	2.6%	2.0%	1.7%	1.4%	1.3%
	Diesel	96.8%	97.2%	97.9%	98.3%	98.5%	98.7%
	Gas	0.2%	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Hybrid+Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Bus	Diesel	99.5%	99.3%	99.0%	98.7%	98.6%	98.4%
	Hybrid	0.5%	0.6%	0.9%	1.1%	1.3%	1.4%
	Gas	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%
	EV	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 31: Projected traffic shares by road type and vehicle type, 2015-2035, 'Policy Freeze' scenario, Motorways, % of vehicle km

		Year					
Vehicle type	Fuel type	2013	2015	2020	2025	2030	2035
Car	Petrol	45.3%	42.4%	37.9%	35.0%	33.1%	31.7%
	Diesel	54.0%	56.7%	60.8%	63.1%	64.2%	64.5%
	Hybrid	0.5%	0.7%	1.1%	1.7%	2.5%	3.6%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
	PHEV	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.9%	2.6%	2.0%	1.7%	1.4%	1.3%
	Diesel	96.8%	97.2%	97.9%	98.3%	98.5%	98.7%
	Gas	0.2%	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Hybrid+Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Bus	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Gas	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 32: Projected traffic shares by road type and vehicle type, 2015-2035, 'Green Future' scenario, Rural (non-motorway) roads, % of vehicle km

		Year				
Vehicle type	Fuel type	2015	2020	2025	2030	2035
Car	Petrol	52.2%	46.6%	42.7%	39.1%	33.5%
	Diesel	47.0%	51.8%	53.7%	52.7%	46.9%
	Hybrid	0.7%	1.5%	3.4%	7.9%	18.9%
	Gas	0.1%	0.1%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.1%	0.2%	0.5%
	PHEV	0.0%	0.0%	0.0%	0.1%	0.2%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.7%	2.1%	1.7%	1.5%	1.3%
	Diesel	97.1%	97.7%	98.0%	98.1%	97.5%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	Hybrid+Ot	0.0%	0.0%	0.1%	0.4%	1.1%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	99.9%	99.7%	99.2%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.1%	0.3%	0.8%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Bus	Diesel	99.3%	98.6%	97.0%	93.3%	84.4%
	Hybrid	0.6%	1.3%	2.8%	6.3%	14.7%
	Gas	0.0%	0.1%	0.1%	0.1%	0.1%
	EV	0.0%	0.0%	0.1%	0.3%	0.8%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table 33: Projected traffic shares by road type and vehicle type, 2015-2035, 'Green Future' scenario, Motorways, % of vehicle km

		Year				
Vehicle type	Fuel type	2015	2020	2025	2030	2035
Car	Petrol	42.7%	37.4%	33.9%	30.8%	26.4%
	Diesel	56.5%	61.0%	62.6%	61.0%	54.2%
	Hybrid	0.7%	1.4%	3.2%	7.5%	18.0%
	Gas	0.1%	0.1%	0.0%	0.0%	0.0%
	EV	0.0%	0.1%	0.2%	0.4%	1.0%
	PHEV	0.0%	0.0%	0.1%	0.1%	0.3%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.7%	2.1%	1.7%	1.5%	1.3%
	Diesel	97.1%	97.7%	98.0%	98.1%	97.5%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	Hybrid+Ot	0.0%	0.0%	0.1%	0.4%	1.1%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Bus	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	Gas	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table 34: Projected traffic shares by road type and vehicle type, 2015-2035, 'Challenging Future' scenario, Rural (non-motorway) roads, % of vehicle km

		Year				
Vehicle type	Fuel type	2015	2020	2025	2030	2035
Car	Petrol	52.0%	47.4%	44.5%	42.6%	41.5%
	Diesel	47.1%	51.6%	54.3%	56.1%	57.2%
	Hybrid	0.7%	0.9%	1.1%	1.2%	1.3%
	Gas	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	PHEV	0.0%	0.0%	0.0%	0.0%	0.0%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.6%	2.0%	1.7%	1.4%	1.3%
	Diesel	97.2%	97.9%	98.2%	98.5%	98.7%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	Hybrid+Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Bus	Diesel	99.3%	99.1%	99.1%	99.2%	99.3%
	Hybrid	0.6%	0.8%	0.8%	0.7%	0.6%
	Gas	0.0%	0.1%	0.1%	0.1%	0.1%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table 35: Projected traffic shares by road type and vehicle type, 2015-2035, ‘Challenging Future’ scenario, Motorways, % of vehicle km

		Year				
Vehicle type	Fuel type	2015	2020	2025	2030	2035
Car	Petrol	42.6%	38.1%	35.4%	33.7%	32.7%
	Diesel	56.6%	60.9%	63.4%	65.1%	66.1%
	Hybrid	0.7%	0.9%	1.1%	1.1%	1.2%
	Gas	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	PHEV	0.0%	0.0%	0.0%	0.0%	0.0%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Van	Petrol	2.6%	2.0%	1.7%	1.4%	1.3%
	Diesel	97.2%	97.9%	98.2%	98.5%	98.7%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	Hybrid+Other	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Truck	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Bus	Diesel	100.0%	100.0%	100.0%	100.0%	100.0%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	Gas	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.0%	0.0%	0.0%	0.0%	0.0%
	SUBTOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table 36: Projected vehicle stock by vehicle type and fuel type, % of vehicle stock by type, 2015-2035, all scenarios

SCENARIO: POLICY FREEZE							
		Year					
Vehicle type	Fuel type	2013	2015	2020	2025	2030	2035
Car	Petrol	64.8%	62.0%	57.3%	54.1%	51.7%	49.8%
	Diesel	34.5%	37.0%	41.1%	43.5%	44.8%	45.3%
	Hybrid	0.5%	0.7%	1.2%	1.8%	2.7%	4.0%
	Gas	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.011%	0.06%	0.15%	0.21%	0.24%	0.27%
	PHEV	0.011%	0.06%	0.17%	0.30%	0.46%	0.70%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Van	Petrol	4.2%	3.7%	2.9%	2.4%	2.1%	1.9%
	Diesel	95.4%	95.9%	96.8%	97.4%	97.7%	98.0%
	Gas	0.3%	0.3%	0.2%	0.1%	0.1%	0.1%
	EV	0.108%	0.108%	0.109%	0.109%	0.110%	0.110%
	Hybrid+Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Truck	Diesel	100.0%	99.99%	99.98%	99.98%	99.97%	99.97%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.00%	0.01%	0.02%	0.02%	0.03%	0.03%
Bus	Diesel	99.4%	99.2%	98.9%	98.6%	98.4%	98.2%
	Hybrid	0.5%	0.6%	0.8%	1.0%	1.2%	1.3%
	Gas	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%
	EV	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%

SCENARIO: GREEN FUTURE						
		Year				
Vehicle type	Fuel type	2015	2020	2025	2030	2035
Car	Petrol	62.3%	56.6%	52.3%	47.5%	39.5%
	Diesel	36.8%	41.3%	43.1%	42.0%	36.2%
	Hybrid	0.7%	1.5%	3.5%	8.1%	18.8%
	Gas	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.07%	0.33%	0.83%	1.9%	4.1%
	PHEV	0.04%	0.12%	0.28%	0.6%	1.4%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%
Van	Petrol	3.9%	3.0%	2.5%	2.1%	1.9%
	Diesel	95.7%	96.6%	96.9%	96.6%	94.9%
	Gas	0.3%	0.2%	0.1%	0.1%	0.1%
	EV	0.1%	0.1%	0.3%	0.7%	1.6%
	Hybrid+Other	0.0%	0.1%	0.2%	0.6%	1.5%
Truck	Diesel	99.99%	99.95%	99.82%	99.46%	98.43%
	Hybrid	0.00%	0.02%	0.09%	0.26%	0.78%
	EV	0.01%	0.03%	0.09%	0.27%	0.79%
Bus	Diesel	99.2%	98.5%	96.7%	92.6%	82.9%
	Hybrid	0.6%	1.1%	2.5%	5.7%	13.2%
	Gas	0.1%	0.1%	0.2%	0.2%	0.3%
	EV	0.1%	0.2%	0.6%	1.4%	3.7%

SCENARIO: CHALLENGING FUTURE						
		Year				
Vehicle type	Fuel type	2015	2020	2025	2030	2035
Car	Petrol	62.2%	57.6%	54.8%	52.9%	51.7%
	Diesel	36.9%	41.1%	43.8%	45.6%	46.7%
	Hybrid	0.7%	1.0%	1.1%	1.3%	1.3%
	Gas	0.1%	0.1%	0.1%	0.0%	0.0%
	EV	0.05%	0.07%	0.07%	0.06%	0.05%
	PHEV	0.07%	0.15%	0.16%	0.15%	0.12%
	Other	0.0%	0.0%	0.0%	0.0%	0.0%
Van	Petrol	3.7%	2.9%	2.4%	2.1%	1.9%
	Diesel	95.9%	96.8%	97.4%	97.8%	98.0%
	Gas	0.3%	0.2%	0.1%	0.1%	0.1%
	EV	0.1%	0.1%	0.1%	0.1%	0.0%
	Hybrid+Other	0.0%	0.0%	0.0%	0.0%	0.0%
Truck	Diesel	99.99%	99.98%	99.98%	99.99%	99.99%
	Hybrid	0.0%	0.0%	0.0%	0.0%	0.0%
	EV	0.01%	0.02%	0.02%	0.01%	0.01%
Bus	Diesel	99.2%	99.0%	98.9%	99.0%	99.1%
	Hybrid	0.6%	0.7%	0.7%	0.7%	0.6%
	Gas	0.1%	0.1%	0.2%	0.2%	0.3%
	EV	0.1%	0.1%	0.1%	0.1%	0.1%

For more information about ecoDriver

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