Programme Area: Light Duty Vehicles

Project: Consumers and Vehicles

Title: Identification of Relevant Consumer Segments

Abstract:

This project was undertaken and delivered prior to 2012, the results of this project were correct at the time of publication and may contain, or be based on, information or assumptions which have subsequently changed. This report documents work carried out to identify consumer responses to plug-in vehicles, including battery electric vehicles and range extended/plug-in hybrid electric vehicles. Firstly, a systematic review of the existing literature was undertaken. Following this, qualitative interview data was collected from 11 long-term users of plug-in vehicles, 40 mainstream consumers (each of which were loaned a vehicle for around six days) and 20 fleet managers. These tasks informed a large-scale survey of mainstream consumers (2,729 responses) about their attitudes and opinions regarding plug-in vehicles. The resulting data was used to produce a segmentation of mainstream consumers, in terms of their likelihood of purchasing a plug-in vehicle and the various factors underlying this likelihood. Factors examined included demographics, attitudes towards perceived functional, instrumental, symbolic and affective characteristics of plug-in vehicles, personality variables, and reported responses to incentives. Alongside the survey of mainstream consumers, a choice experiment was implemented to test the complex trade-offs consumers make between factors (e.g. price, range, infrastructure availability, etc).

Context:

The Consumer and Vehicles project looked at the potential long-term performance and cost of plug-in vehicles. It examined consumer reactions and behaviours in buying and using them. It explored supporting infrastructure, and included in-depth surveys with 3,000 consumers and real-world testing with 40 drivers.

Consumer attitudes to electric vehicles

Final report

University of Aberdeen:
Jillian Anable
Geertje Schuitema

Shell Global Solutions:
Steve Skippon

University of Sussex:
Charles Abraham
Ella Graham-Rowe

TRL:
Emma Delmonte
Rebecca Hutchins
Neale Kinnear
Britta Lang
Jenny Stannard

RPN1768

Consumers and vehicles: Work package 1.3-6

PROJECT REPORT

No IP has been generated in the development of this deliverable

Transport Research Laboratory

PROJECT REPORT RPN1768

Consumer attitudes to electric vehicles

Final report

Prepared for: Project Record:	**Consumers and vehicles: Work package 1.3-6**
	Consumer attitudes to electric vehicles
Client:	**ETI**
	(Ranvir Ramewal)

This report has been prepared for ETI.

The views expressed are those of the author(s) and not necessarily those of ETI.

	Name	Date Approved
Project Manager	Jenny Stannard	21/04/2011
Technical Referee	Shaun Helman	21/04/2011

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Version	Date	Description	Editor	Technical Referee
1	21/04/2011	Draft report for customer approval	ED/NK	SH
2	21/07/2011	Report updated following customer feedback	NK	SH

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List of acronyms and abbreviations

AFV	Alternatively Fuelled Vehicle
BEV	Battery electric vehicle
CNG	Compressed Natural Gas
DC	Discrete choice
DSA	Driving Standards Agency
EHC	English House Conditions Survey
ETI	Energy Technologies Institute
EV	Electric vehicle (used as a generic term to refer to BEVs, PHEVs & REEVs)
HEV	Hybrid Electric Vehicle
HOV	High Occupancy Vehicle
GHG	Greenhouse gas
ICE	Internal combustion engine
LEV	Low Emission Vehicle
LTM	Long Term Memory
MNL	Multi-nominal logit
NAM	Norm Activation Model
NTS	National Travel Survey
NVP	Net Present Value
PHEV	Plug-in hybrid electric vehicle
REEV	Range Extended Electric vehicle
RP	Revealed Preference
SP	Stated Preference
SEM	Structural Equation Modelling
SMMT	Society of Motor Manufacturers and Traders
TGI	Target Group Index
VED	Vehicle Excise Duty
V2G	Vehicle to Grid

The term “Electric vehicle (EV)” is used generically and captures both BEVs and PHEVs, if making a distinction is not necessary.

Abstract

This report documents work carried out to identify consumer responses to plug-in battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). It forms part of the wider Plug-in Vehicle programme, commissioned and funded by the Energy Technologies Institute (ETI). Multiple methods were used to build an understanding of the likely consumer responses to EVs in the future.

Firstly, a systematic review of the existing literature was undertaken. Following this, qualitative interview data were collected from 11 long-term users of EVs, 40 mainstream consumers (each of whom was loaned a vehicle for around six days) and 20 fleet managers.

These tasks informed a large-scale survey of mainstream consumers (N=2,729) about their attitudes and opinions regarding EVs. The survey data were used to produce a segmentation of mainstream consumers, in terms of their likelihood of purchasing an EV and the various factors underlying this likelihood. Factors examined included demographics, attitudes towards perceived functional, instrumental, symbolic and affective characteristics of EVs, personality variables, and reported responses to incentives.

Finally, the segmentation resulting from the survey work was mapped geographically by linking post-code information from the sample with two existing geo-demographic databases (Experian 'Mosaic' and 'Rural/urban'). This geographical analysis along with the outputs from the other research tasks will enable modelling of likely consumer uptake of EVs.

Findings are summarised and recommendations made as to the next steps required to more fully understand the uptake of this important technology.

Executive summary

Background

This report documents work carried out on the identification of consumer responses to plug-in battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), as part of the wider Plug-in Vehicle programme, commissioned and funded by the Energy Technologies Institute (ETI).

Plug-in vehicles are novel technologies, and mainstream consumers lack experience of them. This presents a significant challenge to the investigation of the consumer response to such vehicles. To overcome this challenge, multiple methods were used.

Methods

Firstly, a systematic review of the international literature was undertaken, to provide a solid understanding of consumer behaviour relating to the uptake of cars in general and EVs (including fully electric, plug-in hybrid and range-extended electric vehicles) in particular.

Secondly, several pieces of qualitative research were undertaken. Interviews were held with three samples of people: long-term users of EVs; mainstream consumers (i.e. people with no previous EV experience) who were given an EV to use for a short period of time (around six days); and fleet managers.

Thirdly, the qualitative data and the outputs of the literature review fed into a large quantitative survey of mainstream consumers (N=2,729). The data from this survey were used to determine consumer segments in terms of their likelihood of purchasing an EV and the various factors underlying this. Factors examined included demographics, attitudes towards perceived functional, instrumental, symbolic and affective characteristics of EVs, personality variables, and reported responses to incentives.

Finally, the segmentation resulting from the survey work was mapped geographically by linking postccode information from the sample with two existing geo-demographic databases (Experian ‘Mosaic’ and ‘Rural/urban’). This geographical analysis along with the outputs from the other research tasks will enable modelling of likely consumer uptake of EVs.

Summary and Conclusions

Some of the more pertinent findings from the programme of research were:

Previous research

- Evidence to date has relied heavily on stated and revealed preference research that has determined a resistance to the cost of the technology. Price is often reported as the main barrier to adoption however consumer acceptance is unlikely to be solely determined by purchase price or cost-benefit analysis, but also emotional, symbolic, and functional factors.

Purchase decision making

- Results of the household trial suggest that potential consumers’ appraisals are not easily represented as a cost value and in some cases may not even be available to conscious reflection by the consumer (e.g. self-identity needs)
- Evidence suggests that it is not necessarily the cost of oil *per se* that impacts on consumer perception of cost but instead the rate of fuel price rises, or expected rises. This may impact on perceptions of potential savings for consumers considering the purchase of an EV. However, this may be tempered by perceptions of price rises, or expected rises, in electricity.

- The literature to date has focused almost exclusively on the private consumer and ignored the decision making processes of fleet purchasers who appraise the acquisition of new vehicles differently.
- Fleet managers interviewed in the study indicate that EVs have some distinct advantages over traditional vehicles for environmental, financial, and business reasons. EVs were seen to offer the potential to demonstrate the company's commitment to reducing CO_2 emissions, and were considered as new and innovative. However, barriers to the introduction of EVs to fleets were considered to be the lack of range afforded by an EV and the lack of available infrastructure.

Vehicle type

- Previous studies (mainly in the USA) suggest that PHEVs (and therefore probably REEVs) are more attractive to consumers than BEVs due to the blend of high fuel economy and extended range.

Incentives

- Possibly due to the nature of an immature market place, it is unclear from any studies what incentives are likely to have the largest impact in EV adoption.
- Increasing fuel prices appear to offer an incentive for EV adoption and participants in the qualitative household trial considered government-led financial incentives to be most attractive.
- The role of incentives, both fiscal and in the form of other inducements such as electricity tariff structures and parking or HOV (High Occupancy Vehicle) lane benefits, need detailed and thorough examination in the UK context.

EV use

- Some EV users reported altering their driving style (i.e. adopting an eco-driving style) to maximise the limitations range of their vehicle or to improve fuel consumption of their PHEV. In car feedback and ergonomics were considered vital to encouraging this type of behaviour change, improving the driving experience and reducing range anxiety.
- A range of experiences were reported from embarrassment and fear to happiness and a feel-good experience.
- Similar to previous studies, some participants did not use in-car functions to extend battery life. If consumers consider that they must limit their driving pleasure and comfort it is likely to influence their overall satisfaction and experience of EVs.

Infrastructure and charging behaviour

- Users appear to be overcautious when undertaking journeys and deciding when they need to charge, which is in line with findings from previous studies. Improvement in public infrastructure in one study appeared to increase users' confidence. An understanding of the symbolic and functional role of public charging infrastructure is required.
- Despite acknowledgement by consumers that their travel patterns do not necessarily require ranges longer than around 50 miles for most journeys, there remains a high premium placed on the option to drive longer distances.
- Participants' experiences of recharging in our trial were mixed. Most found the act of charging easy and preferable to refuelling at a service station. However, they had concerns relating to safety and the possibility of vandalism.

- Participants in our trial felt that there would be improvements in technology and infrastructure concurrent with a reduction in the purchase price of the vehicles hence they were unlikely to commit to purchasing an EV in the immediate future.

Consumer perceptions of EVs

- Research suggests that generally there are negative attitudes towards alternatively fuelled cars. However, there is evidence that EVs are symbolic and associated with desirable intentions such as lowering resource consumption, claiming independence from a reliance on oil, saving money, being technologically advanced and greenness.
- There was considerable individual variation in EV evaluation in our trial. EVs were viewed primarily as second cars for well-off environmentally-aware households due to their attributes of limited range, but practical for short, urban journeys on low-speed roads.
- Enhanced range, increased power as well as a better top speed were viewed as especially important attributes. Better ergonomic design, including personal space and clear instrumentation, was also highlighted.
- The EV and PHEV used in our trial were viewed as uninspiring and soulless which is important as there is a wealth of research that indicates cars can be seen as symbols of social status, power and identity, often based on their visual appeal, by some consumers.
- For some drivers, using EVs was a source of positive social identity and pride because it demonstrated a commitment to sustainable energy use and care for the environment. For others, the same identity connotations were negatively perceived. For example, BEV drivers were viewed disparagingly, because they were seen to irrationally compromise their personal mobility for the purpose of the environment.

Environmental considerations

- Some consumers seem prepared to pay more to drive lower emission vehicles, but this often relies on the assumption that alternative vehicles can match conventional vehicles for performance.
- There is some scepticism regarding whether EVs really represent a net CO_2 saving, when factoring in source CO_2 emissions (i.e. those from power stations).
- Pro-environmental behaviour, even in the absence of an explicit prioritisation by participants, can arise from other sources such as drivers changing their driving behaviour in PHEVs to ensure that they cut fuel bills by engaging the electric engine only; however it should be noted that negative ‘rebound’ environmental effects are also possible, for example when drivers drive more because they perceive that their cars are ‘eco-friendly’.
- Reduced noise pollution can be viewed as an advantage of EV use but it is also seen as a safety hazard because pedestrians used to responding to the sound of cars do not respond to the approach of an EV.

Consumer types

- It is likely that there is a great deal of heterogeneity in the early adopter and the early majority segments. Previous work has found that there are few consumers who make decisions purely on environmental grounds, and most can justify their purchases in economic terms including being less dependent on volatile oil prices, cash flow considerations rather than detailed payback calculations, and the high value placed on saving time refuelling and possibly parking or driving in HOV and bus lanes.

- Mainstream consumers are likely to be less focused on running costs than on functional value of the technologies, and EVs will require continual improvements to remain attractive.
- Eight distinct segments have been discovered in the current research from a large sample of the UK new and nearly-new car buying population. Each of these represents a unique combination of self-reported likelihood to adopt a BEV or PHEV and differ in terms of perceptions, anxieties and symbolic motives. Profiling the segments on these variables has enabled a deeper understanding of the underlying belief structures and motivations of each group.
- Overall the analysis has identified more than one early adopter group distinguished by their level of enthusiasm towards different plug-in vehicles. While the **Plug-in Pioneers** are likely to lead the way, the **Zealous Optimists** are particularly enthusiastic about BEVs and the other, the **Willing Pragmatists**, are extremely negative about BEVs, but very keen on PHEVs. In addition, their motivations are different with the former attaching much importance to symbolic meanings such as environmental benefits and the potential to be less dependent on oil (as a society and as an individual), whereas the latter is more focused on fuel economy savings. A further group is perhaps somewhat surprisingly the **Company Car** owners who are highly innovative and informed about the vehicles and recognise many benefits in the technology.
- The results also suggest there may be more than one mainstream or laggard group, but with differing potential for uptake to be accelerated so that they become earlier adopters. For instance, the **Anxious Aspirers** have some real constraints and perceived constraints (e.g. parking and range respectively) on the suitability of plug-in technology for them. This group demonstrates archetypal concerns around range anxiety, reliability and performance of plug-in vehicles. Nevertheless, they remain positive about many aspects and, subject to affordability, may be a target for focused information and trials/demonstrators to directly address these concerns. In addition, perhaps somewhat counter-intuitively, another group appears to be more of a laggard *now* but has the potential to become an earlier adopter if concerns can be alleviated: the **Conventional Sceptics**. This group appears to be less motivated by image and identity than some other groups and this presents an opportunity to target them with information about functional attributes of EVs. However, environmental performance is not a motivator for this group and there are large obstacles such as their willingness to pay for fuel savings. However, despite their potential, both of these groups are likely to be very vulnerable to negative ‘press’ and continual improvements in the technology and charging infrastructure availability will be necessary for them to move from potential to actual adopters. The **Uninspired Followers** are likely to represent those influenced by general trends in the market and their likelihood to adopt will be influenced by the adoption rates of other consumer groups.
- The most negative group, the **Image-conscious Rejecters**, clearly present a challenge in this market place. They are resolutely negative about all aspects of the technology and this is coupled with a strong desire to project the ‘right image’, yet EVs are not deemed to fit in to this at all. For this group to become interested, their main opinion formers would have to become convinced of the positive aspects of EVs at which stage a ‘tipping point’ could occur.

Personality

- Driving an EV has been associated with high openness, high conscientiousness and high agreeableness. Our Plug-in pioneers segment had a distinct profile in this sense (and also high extraversion), although most other segments differed to only a modest extent on key personality domains.

Influences on uptake

- There are a number of influences on uptake including market penetration and associated changes to social norms and credibility, aesthetics, range anxiety, perceptions about performance and accommodations, recharging time, high initial purchase cost and lack of infrastructure.
- Consumers in our household trial value the convenience of home charging (as compared to using petrol stations); environmental benefits such as lower CO_2 emissions are less valued than the ability of EVs to meet users' mobility needs.
- The symbolic meaning of EVs are also important determinants of how likely people are to uptake the technology, including negative ones that put some segments off purchase (for example if they perceive that an EV does not project 'status').
- EVs are viewed as 'work in progress' by many consumers.

Recommendations

A number of recommendations are made regarding areas for further investigation:

- **Longitudinal research:** Since consumer preferences cannot be considered to be static (especially over the longer term) as the market develops, there is a need for longitudinal research to track changes in consumer responses (including differences between segments) to things such as higher market penetration of EVs, media messages, and changing social norms.
- **Replication of the segments and 'golden questions':** In order that the segmentation model be usable beyond the lifetime of the project, a replicable methodology and algorithm that assigns participants to unique segments on the basis of a set of 'golden questions' (those that best discriminate between the segments) needs to be developed.
- **Travel patterns, driving style and car ownership:** Work will be needed to understand the (likely interactive) relationship between EV ownership and changes in travel patterns and driving style that result. In addition, the changes people are willing to make to accommodate EV ownership will need to be understood.
- **Household decision making:** Research is needed to move beyond individual car buying decisions to include the role of household decisions in EV adoption.
- **Symbolism:** More work will be required to understand how symbolic meanings that are attached to EVs drive their uptake.
- **Affect:** Further research is required that investigates the emotional responses that consumers have after direct, hands-on experienced with driving EVs; positive messages about the driving 'experience' may be important for some segments to adopt EVs.
- **The impact of the media and marketing:** Work is needed to understand the media consumption patterns of the different segments, and the effect that the media might have on each of the segments.
- **Interpersonal and dynamic influences:** Further research is needed into how consumers respond to changes in the market and changes in the extent to which they peers and social groups have access to EVs.
- **Response to policy incentives:** The degree to which different policy incentives are likely to accelerate uptake of EVs as opposed to appealing to those segments who are already contemplating ownership requires further understanding. This

should include trying to gain a better understanding of consumer perceptions of electricity prices, including the opportunity for using ‘vehicle-to-grid’ technologies.

- **Expectations about charging needs:** This research found mixed results as to whether the issue of charging infrastructure availability was more or less important than range *per se*. This issue needs to be clarified if infrastructure provision is to match needs.
- **Current (H)EV owners:** It will be of value to study a larger sample of current H(EV) owners than was possible in the current study, to validate the suggestive finding that Plug-in Pioneers and Zealous Optimists were the most likely to own any AFV in the current sample. This would provide further data to validate the segmentation.
- **The difference between different plug-in vehicle technologies:** The reasons why BEVs and PHEVs seem to be perceived differently and seem likely to appeal to different people require further investigation.
- **Company car decision making processes and likely future uptake:** Work should be done to provide clearer information to the fleet industry regarding the attributes and charging routines of different EVs. This should be followed up with work to examine how informed fleet managers make decisions about which technologies to integrate into their fleet needs.
- **Geographical analysis:** Work to further understanding of the link between our segmentation and existing geo-demographic variables would aid the granularity at which it could inform modelling of likely uptake by geographical area, possible at the sub-postcode level.

Introduction

The direct use of fossil fuels to power most motorised transport results in the emission of carbon dioxide (CO_2), which has undesirable environmental consequences. National and international targets to reduce CO_2 emissions have led vehicle manufacturers to explore the development of vehicles that emit lower levels of CO_2. Meanwhile, consumers are being encouraged to drive these vehicles both directly via tax incentives, and indirectly via the price of petrol and diesel. One option for vehicle manufacturers and the consumer is the plug-in electric vehicle (EV).

EVs produce no CO_2 when driving on their electric motor and therefore offer a potential avenue to dramatically reduce CO_2 emissions. However, the market for EVs is in its infancy and many questions remain. For example it is unclear whether mass market consumers will buy EVs, how quickly EVs might take hold in the market, and what infrastructure is required to support EV uptake. Research that offers answers to these questions is imperative if manufacturers are to support consumers' needs and demands and if energy companies are to provide the infrastructure and supply necessary to support the development and use of EVs by the mass market.

This report reflects work undertaken as part of the wider Plug-in Vehicle programme, which was commissioned and funded by the Energy Technologies Institute. The ETI investment programme is investigating the business case for the mass market deployment of electric vehicles and plug-in hybrid electric vehicles in the UK and determining what energy infrastructure would be required. The particular aim of this part of the programme is to develop a model representing consumer attitudes to purchasing, and behaviours when using plug-in vehicles as a function of the key factors affecting the consumer response.

The research reported here was focused on the identification of consumer responses to plug-in battery electric vehicles (BEVs) and plug-in hybrid electic vehicles (PHEVs) only. It is acknowledged that alternative low carbon powertrains are being explored by some manufacturers and that there are variations of electric vehicle (e.g. standard hybrid or range-extended) and these were considered when searching for literature as information may have been indicative of BEV and PHEV purchase and use. Where the term EV is used in this report, it refers to BEV and PHEVs only and should not necessarily be applied to other forms of EV, unless stated.

Plug-in vehicles are novel technologies of which mainstream consumers have no experience. This presents a significant challenge to the investigation of the consumer response to such vehicles. The report includes a systematic review of the international literature to provide a solid understanding of consumer behaviour relating to the uptake of cars in general and EVs (including fully electric, plug-in hybrid and range-extended electric vehicles) in particular. This review underpins subsequent chapters that include qualitative research of a unique EV user trial and interviews with long-term EV users and fleet managers who might consider EVs in the future. Elements from both the literature review and the qualitative research fed into a large quantitative survey of mainstream automobile consumers. Responses from the survey were used to determine consumer segments underpinned by their likelihood to purchase an EV or PHEV in the near future. The specific elements of the Plug-in Vehicle programme were commissioned as individual work packages, as listed in Table 1. The final work package was the collation of this work as this final report.

Table 1: Overview of project

Work package	Task	Description
WP1.3-1	Literature review	A review of the main concepts in the fields of consumer choices and decision making. Also includes an overview of the literature on existing publications on consumer responses to all-electric or plug-in hybrid vehicles.
	Long term vehicle users study	A qualitative investigation into understanding long term users' views of EVs.
WP1.3-2	Development of tools and data collection for,the household study	This task describes how data collection methods were developed for the household trial and how the data collection was undertaken: • Interview guides were developed for pre- and post-exposure interviews. • A demographic questionnaire was administered after the pre-exposure interview (prior to vehicle exposure). • A questionnaire was administered after the post-exposure interview. • Travel diaries were collected; one for the week of exposure to the vehicle and one for a 'normal' week with participants' own vehicles.
WP1.3-3	Thematic and Grounded Theory analysis of household data	This task maps the factors shaping perceptions and motivations across different groups of potential consumers. The outcome provides the foundation for a sophisticated conceptual model of such facts.
	Development of quantitative survey	All of the previous project tasks fed into the development of a survey questionnaire to assess responses to all electric and plug-in hybrid vehicles with a sample of British new and nearly-new car consumers. A two-part questionnaire was developed to assess responses to battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).
WP1.3-4	The fleet perspective	It is likely that vehicle choices and purchase decisions made by fleet managers differ significantly from those of private users. This task presents information on the prioritisation of factors influencing the purchase and use of fleet vehicles in order to correctly represent the fleet consumer group in the modelling.
	Quantitative survey data collection and analysis	A market research company was used to undertake the data collection for this phase. Initial analysis of the data involved analysing demographic, descriptive and attitudinal constructs within the sample.
WP1.3-5	Consumer segmentation	The survey data was interrogated to segment the sample into consumer types influenced by consumer acceptance of PHEVs and BEVs.
WP1.3-6	Final report	The current report – all research stages combined into a single document.

LITERATURE REVIEW

1 Introduction to the literature review

1.1 Context

The literature review preceded the primary data collection and modelling. This informed the conceptual foundation for the empirical research and contributed to the design of survey instruments to identify the unique factors that are likely to impact the consumer response to plug-in vehicle technology.

1.2 Scope and objectives of the review

Plug-in vehicles are novel technologies of which mainstream consumers have no experience. This presents a significant challenge to the investigation of the consumer response to such vehicles. It also means that existing literature can essentially only contribute theoretical or experimental evidence given the lack of revealed preference data and empirical studies relating to these vehicles.

Nevertheless, the need to develop innovative survey techniques to overcome this challenge meant that it was necessary to inform the survey design with a solid understanding of consumer behaviour relating to existing car technologies including economic, functional, emotional and symbolic adoption factors at the individual level and peer effects and interactions at the interpersonal or societal level. As such, the empirical research outlined later in the report benefited from grounding in broader concepts in the fields of consumer choice and decision-making as well as any recent literature on consumer perceptions of or experience with hybrid or plug-in vehicle technology.

Examples of some of the questions we sought to answer in the literature review were as follows:

- What is the relative role of functional, affective and symbolic factors in car choice?
- What are people's expectations about the performance of these vehicles and how do these compare to their experiences? How do attitudes and preferences change after adoption?
- What are the expectations surrounding the availability of recharging facilities? What are the likely patterns of recharging behaviour?
- Do people's values and attitudes change as the number of people who adopt these vehicles increases? For example, can changes in values and attitudes towards EVs as a result of the diffusion of the technology (EVs) into the market be measured in a research design?
- To what extent are different people motivated by different factors? What can this tell us about those likely to be the earliest adopters and mainstream consumers of plug-in electric vehicles?
- Are people likely to use plug-in vehicles differently compared to their current travel patterns?
- Are there likely to be certain geographical hotspots from which a shift in consumer behaviour towards EVs will spread?
- How can Government incentives be used to encourage uptake and use of these vehicles?

In light of these research questions, two issues regarding the scope of the review need to be highlighted. Firstly, the review has not been restricted to literature relating exclusively to plug-in electric cars; this is primarily because studies on consumer preferences for such technology are still limited in line with its limited commercial availability and because there is insight to be gained from studies on other vehicle technologies. Secondly, as discussed in Section 2.1, at least half of all new cars in the UK are first registered by fleet or business consumers. A large proportion of these vehicles are likely to be adopted as the result of private individuals exerting a great deal of influence over the decision process. The literature on fleet car adoption is much smaller than for private consumers and as such this review has concentrated on private car choices.

1.3 Structure of the literature review

The literature review is divided into three remaining sections. Section 1.4 outlines the approach used to search, select and synthesise the literature used in this review. Section 2 presents the evidence review, divided into subsections with emphasis on what we know about the importance that consumers attach to the functional and psychological attributes of cars. The final section reflects on the evidence in order to inform the design of the empirical work on private consumers being undertaken in the remainder of the Consumers and Vehicles project.

1.4 Method

The review used a search strategy designed to capture aspects of consumer demand for EVs relating to the following issues, also used to screen the literature:

- the current uk car market and what is known about new car adopters;
- models of purchase behaviour in relation to car choice;
- the car purchasing process including the relative importance of functional, symbolic and individual factors;
- policy incentives likely to impact on the adoption of EVs;
- specific issues impacting on consumer acceptance of plug-in vehicle technology;
- segmentation of car owners/adopters;
- the likely impact of plug-in EV use on attitudes, recharging behaviour and travel patterns; and
- potential dynamic effects which may impact on the rate of uptake of plug-in EV technology.

The methodology adopted for this review aimed to meet, as closely as time and resources allowed, the standards of a systematic review (Petticrew & Roberts, 2006). These standards include focusing on answering specific questions, using protocols to guide the review process, seeking to identify as much of the relevant research as possible, appraising the quality of the research, synthesising the research findings and updating in order to remain relevant. The latter stage was particularly important in this review as much of the literature on EVs is very recent and could not be found using traditional literature searches.

1.5 Search strategy

The search for relevant literature started with identifying relevant search terms. Deriving the search terms involved reading key papers and consulting among the wider project team.

Table 2 shows the search keywords that were identified. First order search terms were related to energy efficient cars using as many specific terms relating to plug-in electric technology as was feasible. In all cases, terms related to cars were combined with terms related to purchasing/motivation/refuelling behaviour. In order to construct a logical relationship among these research terms and to avoid running searches unnecessarily with overlapping search terms, Boolean search terms ('and', 'or', 'not') were used.

Table 2: Main keywords used in the literature searches

STEP 1: terms related to energy efficient/plug-in electric cars:

- low emission *and* car *or* vehicle *or* automobile
- low carbon *and* car *or* vehicle *or* automobile
- energy efficient *and* car *or* vehicle *or* automobile
- electric *and* car *or* vehicle *or* automobile
- battery *and* car *or* vehicle *or* automobile
- plug-in *and* car *or* vehicle *or* automobile
- hybrid *and* car *or* vehicle *or* automobile
- limited range *and* car *or* vehicle *or* automobile
- alternative *and* car *or* vehicle *or* automobile

STEP 2: terms related to purchasing/recharging behaviour and motivations:

• purchase	• choice	• refuel*
• buying	• preference	• recharg*
• adoption	• perception	• range anxiety
• uptake	• attitud*	• early adopters
• consum*	• motivation	• segment*

These keywords were used to search five databases. These were ScienceDirect, Scopus, Google Scholar, PsychInfo and the Transport Research Laboratory Knowledge Base[1]. Studies could be qualitative, quantitative, theoretical, or review articles. They could also be peer reviewed academic sources as well as published or unpublished reports. To find 'grey' literature, members of the team were also asked to nominate additional studies (particularly unpublished or recently published 'in press' studies) and reference lists were also consulted ('snowballing').

1.6 Study selection and inclusion criteria

The search process generated approximately 160 pieces of literature. In order to prioritise this list for review, a three-stage process was undertaken.

1. The first stage noted the basic information about each document, e.g. title, where it was published, authors and context, and assessed the document

[1] The TRL Knowledge Base comprises a number of databases, including the Transport Research Abstracting and Cataloguing System (TRACS). This is the main catalogue of transport research publications held both in the TRL library and elsewhere. It contains bibliographic references and abstracts of English and foreign language articles from journals, books and research reports. It is the English language version of the worldwide ITRD (International Transport Research Documentation database) and contains abstracts from publications in the USA, Australia, Scandinavia, the Netherlands and Canada, in addition to UK material. The database has been updated daily since 1972 and comprises over 260,000 items.

against the eight screening issues (listed above) to determine its relevance for the study. If it was considered to be relevant, it was then assessed further in a second stage. For each piece of literature reviewed, its relevance to the issues was documented in an Excel spreadsheet, reproduced here as Table 3.

2. Where a piece of literature did not offer relevant material in any of the categories, it was rejected for further review. Where it did offer relevant material it was read in detail and notes were taken under each relevant issue.
3. As the review got underway, gaps in some topic areas became evident. These included, for example, literature on the symbolic motives applicable to car preference. In order to fill the gap, titles and abstracts of accumulated literature were scanned in order to prioritise these references.

It became evident early on that the search strategy had resulted in more references than could be included given the resources available. Consequently, a decision was made to reject publications if either of the following were true:

- the main focus was an assessment of the merits of different methods and techniques applied to car choice modelling; or
- the main focus was the knowledge and information sources (such as advertising, eco-labelling) relevant to car choice, these were deemed as not immediately relevant to the core project aims and out of scope.

In addition, studies undertaken since 2000 and studies undertaken in the UK context were prioritised.

This process was led by one member of the study team and cross-checked by the second reviewer, particularly all undecided cases. It led to 88 references being taken forward for detailed review.

1.7 State of the evidence

The literature fell into four broad categories:

1. Revealed and stated preference surveys of consumer behaviour regarding a variety of vehicle powertrains.
2. Qualitative and conventional questionnaire surveys eliciting consumer attitudes and perceptions of vehicle attributes, alternatively fuelled vehicles and policy incentives.
3. Evidence of consumer responses to EVs before and after small-scale vehicle trials.
4. Theoretical texts relating to socio-technical transitions, symbolic behaviour and consumer segmentation.

By far the greatest proportion of literature is in the form of stated and revealed preference surveys (category 1). The following key observations can be made about the state of the evidence on consumer adoption of EVs:

- The dominance of stated preference (SP) surveys is due to the attempt, since the early 1980s, to overcome the challenge of asking consumers to predict their interest in a radically new product that does not yet exist in the marketplace. However, much of this literature is US-dominated and often based on a limited number of attributes and powertrains. Consequently, apart from offering insight into vehicle attribute measurement, the specific modelling results provide little useful prediction of likely UK consumer response to EV products and incentives.
- Many relevant attributes such as size, performance, range and refuelling/recharging time have been poorly measured in both SP and more

standard qualitative and quantitative survey techniques. Consequently we have a very poor understanding of the role that these instrumental factors may play in EV uptake.

- Private consumers have difficulty in providing answers to willingness to pay questions in surveys as very few currently know their fuel consumption and calculate their vehicle running costs.
- Value placed on fuel economy and different vehicle technologies is influenced by symbolic, affective and instrumental factors. These include anticipated driving affect (i.e. the emotional pleasure derived from driving), expression of the person's position or social status, and the expression of personal identity and values, including environmental values. We have some understanding of the importance of these factors, but there is little indication that symbolic and instrumental factors have been considered in parallel or that attempts have been made to incorporate this understanding into predictive modelling of EV uptake.
- Evidence on the role of policy incentives is fragmented and largely US focused.
- Recent work originating from EV trials in the UK and elsewhere has provided invaluable evidence on recharging patterns and expectations, driving behaviour and some attitudinal data. However the evidence base does not help us to predict the likely impact of EV uptake on travel patterns or car ownership.
- Attempts to segment consumers with respect to EV uptake have largely been restricted to the crude early adopter/early majority model rather than a finer grained classification based on an understanding of motivations and preferences.
- There is a lack of application of social and behavioural psychology to understand impulsive individual processes and social dynamic effects. The lack of evidence is most apparent in relation to the processes thought to take place at the interpersonal, community or societal level as opposed to the individual level. Sociological theories that stress the interpersonal environment offer key insights of the attitude-behaviour link and account for the role of social factors, peer effects, social networks, imitative and learned behaviours.
- Likewise, there is an almost complete absence of qualitative data to gain insight into the psychological processes guiding the formation of beliefs and preferences with regard to EVs.
- There is very little evidence relating to the decision-making processes underpinning the adoption of EVs into public and private sector vehicle fleets.

1.8 Summary table

Table 3 provides a conceptual 'map' of the literature included in this review. It uses headings which approximate to the sections of this report to indicate main areas of focus for each study included. This resource is a main point of reference throughout the remainder of this report as findings are synthesised under each of these sections.

Table 3: Overview of the reviewed literature

(Note, light grey ticks denote a lower level of attention to this area in the relevant publication)
DC = discrete choice; MNL = Multi-nomial logit; RP = Revealed preference; SP = Stated preference; SEM = Structural Equation Modelling

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Adler, T., Wargelin, L., Kostyniuk, L., Kavelac, C. & Occhuizzo, G. (2003).					✓				✓	✓								Telephone, mailback and www, SP, 2002, California, N=2,200, nested MNL	✓	
Ahn, J., Jeong, G. & Kim, Y. (2008).				✓														SP, Face to face, N=280, Age 20-59 with a car. Seoul, July 2005. Discrete Choice model	✓	
Allen, M. W. & Ng, S. H. (1999).			✓			✓												Mail survey, N=270, New Zealand. Tested value and attitude scales. Factor analysis, ANOVA		
Alvarez-Daziono, R. & Bolduc, D. (2009).							✓		✓									Hybrid choice model/SP, N=866, Canada. Bayesian method and classical estimation method	✓	
Anable, J., Lane, B. & Banks, N. (2009).				✓		✓		✓										Semi structured interviews		
Angle, H. et al. (2007).				✓		✓				✓		✓	✓					Survey, N=1,151, UK, 2007, drivers aged 17+		

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Axsen, J. & Kurani, K.S. (2008)		✓			✓						✓							On-line SP + RP survey, N=535, Canada; Hybrid Choice model; 3 penetration scenarios; hypothetical information about the technology from 3 different sources (newspaper, brochure and personal testimonial)	✓	
Axsen, J. & Kurani, K. S. (2010).					✓						✓		✓					Three part on-line survey collected from new vehicle buyers, N=877, California, 1 day travel diary, design games		
Axsen, J., Kurani, K. & Burke, A. (2010).					✓													Design games		
Axsen, J., Mountain, D. C. & Jaccard, M. (2009).									✓					✓				On-line SP + RP, N=943, Canada and California, owners of new vehicles, March 2006, aged 19+, drove 3+ times per week, lived in an urban area; HEV owners purposively sampled	✓	
Batley, R.P. & Toner, J.P. (2003).																		SP, UK, summer 2002, N=331, MNLM	✓	

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Beggs, S., Cardell, S. & Hausman, J. (1981).					✓													Ordered logit model, N=~200, 9 cities in USA, principal drivers of a compact or sub-compact car, all commuters with daily round trips <50 miles		
Beresteanu, A. & Li, S. (2009).									✓									Data set of vehicle registrations in 22 Metropolitan areas 1999-2006, market equilibrium model		
Bollinger, B. & Gillingham, K. (2010).			✓			✓												Diffusion of PV panels using data on installations in California		
Brownstone, D., Bunch, D.S. & Train, K. (2000).					✓				✓									SP + RP, multi-wave panel survey, N=2,857, California, June 1993, Mixed logit	✓	
CABLED (2010).											✓	✓						GIS data loggers on 22 Mitsubishi iMiEVs		✓
Cambridge Econometrics (2008).				✓						✓			✓					Telephone survey, N=900, recently purchased a new or nearly-new vehicle; some SP (to changes in different costs of motoring); RP analysis to estimate own and cross elasticities of past behaviour of households; WTP for fuel efficiency;	✓	

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
																		Discrete choice (mix)		
Cao, X. & Mokhtarian, P. (2003).					✓													Literature review		
Carroll, S. & Walsh, C. (2010).		✓			✓					✓	✓	✓		✓			✓	Trials and before and after questionnaires		✓
Chéron, E. & Zins, M. (1997).							✓				✓							Short SP of focus group participants (N=37) using linear regression		
Choo, S. & Mokhtarian, P. L. (2006).				✓		✓				✓			✓					Mail survey, N=1,904, San Francisco, 1998,many attitudinal variables (ANOVA, Chi sq) + MNL	✓	
Coad, A., de Haan, P. & Woersdorfer, J. S. (2009).			✓					✓						✓				Secondary analysis of Swiss household data to understand link between policy support and behaviour		
Competition Commission (2000).	✓																	Analysis of UK car market		
Curtin, R., Shrago, Y. & Mikkelsen, J. (2009).		✓																Interviews with 2,523 adults		

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Dagsvik, J.K., Wennemo, T., Wetterwald, D.G. & Aaberge, R. (2002).					✓													SP, random sample, Norway, N=662	✓	
De Haan, P., Mueller, M. G. & Peters, A. (2006b).						✓							✓		✓			Survey of Hybrid owners, N=367, Switzerland		
De Haan, P., Peters, A. & Mueller, M.G. (2006a).				✓	✓	✓	✓											Survey of Hybrid owners, N=367, Switzerland		
De Haan, P., Peters, A. & Scholz, R. W. (2007).								✓							✓			Survey of Hybrid owners, N=367 Switzerland		
DfT (2009a).	✓																	UK National Travel statistics		
DfT (2009b).	✓																	UK National vehicle registrations		
Diamond, D. (2008).									✓									Secondary data analysis of impact of HOV lanes in Virginia		
Diamond, D. (2009).									✓									Cross sectional analysis of Hybrid registration data to investigate impact of incentives		

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Eftec (2008).	✓			✓														Aggregate discrete choice modelling using RP	✓	
Element Energy (2009).	✓				✓				✓	✓	✓	✓					✓	Review of literature; analysis of NTS and EHC survey; Survey of Private + Fleet EV owners (N=36 + 11) and EV considers (N=215+16)		
EST (2007).	✓			✓				✓					✓					MNL based on historic data and detailed consumer survey	✓	
Ewing, G.O. & Sarigöllü, E. (1998).					✓				✓									Montreal, N=881, post-war suburbs, drivers to work or school,	✓	
Experian (2009).	✓																	UK Market Research Data		
Gallagher, K.S. & Muehlegger, E.J. (2007).									✓									Consumer data 2000-2006 on sales of hybrids coupled with data on US Government incentives		
Garcia, R. (undated).														✓				Agent based modelling		
Gärling, A. & Johansson, J. (1999).		✓			✓				✓		✓							3 month EV trials+ before/after in depth interviews		✓
Gärling, A. & Thøgersen, J. (2001).			✓										✓					Review		

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Gärling, A. (2001).		✓	✓		✓		✓											Questionnaires (N=1,349+569); internet marketing tool (N=30); showroom visits and test-drives (N=30); free 3 month trials (N=42 families)		✓
Garwood, M. & Skippon, S. (2010).		✓	✓		✓		✓			✓	✓							EV trials (N=92), post-experience questionnaire		✓
GfK Automotive (2006).				✓														Web based research using GfK's NOPs e-panel; 1,468 respondents, April - July 2006 new car owners		
GfK Automotive (2009).				✓		✓												Web based research using GfK's NOPs e-panel; 2,000 respondents, April - May 2009 new and used car buyers; private motorists and company car drivers		
Girard (undated)													✓			✓		Analysis of hybrid owners in London + Mosaic data to identify 'Hotspots'		
GLA (2009)					✓													Web based research using GfK's NOPs e-panel, N=1,468, April - July 2006 new car owners	✓	

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Golob, T. F. & Gould, J. (1998).		✓			✓						✓	✓						Two week trials, travel diary, California 1995-96, N=69, pre & post surveys		✓
Golob et al. (1993)					✓												✓	Three phase SP survey, MNL, N~900, California, 1991	✓	
Greene, D.L., Duleep, K.G. & McManus, W. (2004).		✓			✓													Nested MNL calibrated to 2002 model year sales, 8 scenarios tested	✓	
Heffner, R. (2007).		✓					✓											Household interviews		
Heffner, R. R., Kurani, K. S. & Turrentine, T. S. (2007).							✓											Ethnographic interviews with hybrid vehicle owners, California + semiotic theory		
Heffner, R., Kurani, K. & Turrentine, T. (2006).							✓											Review of semiotics		
Heutel, G. & Muehlegger, E. (2009).									✓					✓				Reanalysis of dataset in Gallagher and Muehlegger based on consumer purchases of new vehicles		
Hodson, N. & Newman, J. (2009).												✓						Analysis of US car driving patterns		

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Huetink, F.J., Van der Vooren, A. & Alkemade, F. (2005).			✓						✓					✓				Agent based simulation model in Dutch context for hydrogen		
Jansson, J. (2009).			✓							✓				✓				Two postal surveys N=1,904 + N=1,691, Sweden, car owners with a boost of AFV owners, 2006 and 2008		
Kahn, M.E. (2006).							✓							✓				Uses Census track panel data for Los Angeles County over 3 years to track diffusion of Hybrid Vehicles		
Klein, J. (2007).					✓		✓		✓				✓					Online + telephone survey (N=118)		
Kurani, K. & Turrentine, T. (2004)		✓	✓		✓		✓											57 households who purchased new or used (8 HEVs), semi structured interviews		
Kurani, K. S., Turrentine, T. & Sperling, D. (1996).			✓		✓		✓					✓		✓				Experiment-oriented interviews + four stage mail survey (N=454) with some SP		
Kurani, K., Heffner, R. & Turrentine, T. (2007).		✓			✓		✓				✓		✓	✓				Semi structured interviews + 23 converted Prius's		✓

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Lane, B. & Albery, T. (2009).							✓											Focus groups and telephone surveys, Camden UK, May-July 2009		
Lane, B. (2005).	✓	✓	✓	✓		✓		✓		✓			✓				✓	Desk based review		
Lane, N. & Banks, N. (2010).	✓			✓		✓		✓		✓								Focus groups + web based survey (N=~1,000) of new and nearly-new (up to two years old) UK car buyers		
Larrick, R.P. & Soll, J.B. (2008).				✓														Short questionnaires to elicit knowledge about fuel consumption		
Martin, E. et al. (2009).		✓																Ride and drive clinics with pre and post surveys (N=182)		✓
Mau, P. et al. (2008).														✓				Two SP surveys (N=916 + 1,019), Canada, www, survey for different technology and treatment groups with different market shares, DC model (capital vintage model)	✓	
Mintel (2009).	✓																	1,000 Internet users aged 16+ who own a car		
Mueller, M. G. & De Haan, P. (2009).			✓				✓		✓				✓					Agent based microsimulation using Swiss Data		

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
Peters, A., de Haan, P. & Scholz, R.W. (unpublished).				✓			✓											Two wave survey, June 2005, N=1,150		
Peters, A., Scholz, R.W. & Gutscher, H. (2011).				✓			✓											Survey of 302 Swiss new car purchasers, SEM		
PLANYC (2010).		✓			✓		✓		✓		✓		✓					Semi structured interviews, focus groups + full length survey (N=1,384)		
Potoglou, D. & Kanaroglou, P. S. (2007).									✓	✓						✓		Internet, Canada (urban Hamilton), 2005, N=482, NMNL	✓	
Roche, M.Y. et al. (2010).		✓	✓			✓											✓	Literature review		
Sangkapichai, M. & Saphores, J.D. (2009).					✓				✓									Telephone survey, California, July 2004, ordered choice model, N=2,505, perceptions of environmental policies		
Santini, D.J. & Vyas, A.D. (2005).			✓				✓		✓				✓	✓				SP + RP; logit model but develops coefficients for early group and majority buyers	✓	
Skerlos, S. J. & Winebrake, J. J. (2010).									✓									Review article		
Skinner, I. et al. (2006).	✓			✓		✓		✓		✓						✓	✓	Review article		

Author(s)	Current UK car market	Public perception of AFVs	Theories/ Approaches	Functional + cost attributes		Emotional/ psychological factors		Policy attributes/ incentives		Socio-economic characteristics	Recharging behaviour	Travel behaviour	Segmentation	Dynamic effects	Rebound	Land use planning	Fleet	Approach		
				ICE	(H)EV	ICE	(H)EV	ICE	(H)EV									Method	SP/RP	Trials
SMMT (2010a).	✓																	Market data		
SMMT (2010b).									✓									Market data		
Sovacool, B. K. & Hirsh, R. F. (2009).		✓	✓											✓				Review article/Thinkpiece		
Thatchenkery, S.M. (2008).																		Cross-sectional data on vehicle registrations (2006) + other datasets + MNL modelling		
Thøgersen, J. & Gärling, A. (2001).			✓					✓					✓					Current car owners in Gothenburg, Sweden. Mail back questionnaires, Sept 1998, N=165+782; SEM		
Turrentine, T. S. & Kurani, K. S. (2007).			✓		✓	✓												Semi structured interviews		
Whelan, G. (2007).	✓									✓								RP (data from FES and NTS, discrete choice (binary dogit)	✓	
Ziegler, A. (2010).					✓		✓			✓								SP CAPI Survey in car dealerships (N=598, Germany 2007-2008; those intending to buy a vehicle in near future); multi-nomial probit	✓	

2 Review synthesis

2.1 The current UK car market

In order to set the Consumers and Vehicles study in context and assist with survey design, this literature review sought to collate information on the broad composition of the UK car market including the main consumer segments, demographics of new and used car 'adopters' and recent trends in the uptake of low emission, hybrid and EVs. The intention was to inform the sampling frame to be applied in the main quantitative survey.

Disaggregated information on the consumer side of the UK automotive market is not easily available. Statistical data on new registrations are taken from a number of sources including the Society of Motor Manufacturers and Traders (SMMT) and the Driving Standards Agency (DSA) (SMMT, 2010a; DfT, 2009b). In addition, the UK National Travel Survey (DfT, 2009a) offers an insight into the proportion of households with cars and some insight into the broad geographic distribution of ownership. However, information on the demographic composition of consumers in terms of who tends to purchase brand-new or used vehicles is contained in a limited number of available consumer insight reports (Mintel, 2009; Experian, 2009).

2.1.1 Level of car ownership

At the end of 2008, there were just over 27 million cars licensed in the UK (DfT, 2009a). Over the past two decades, the proportion of households with more than one vehicle has almost doubled with 44% of households in the UK having one car and 32% more than one car in 2008. Over the same period, the proportion with no car at all has fallen by 15 percentage points (to 24%). The number of cars per household has risen steadily over the 20 years, as has the number of vehicles per adult, which now exceeds six cars for every ten people aged 17 and above compared with four in 1985/86.

Factors behind this growth include higher levels of affluence leading to ownership of second cars, increased numbers of women in the workforce, and an increased tendency for older age groups to drive (Whelan, 2007; Mintel, 2009).

2.1.2 UK car sales

Figures for car sales in the UK show that, in 2009, about 2 million cars were registered as new and 7 million were sold. Thus, used car sales accounted for 77% of all cars sold (SMMT, 2010a).

New car sales can be divided into a number of possible customer categories, although only three tend to be used. These are private, business and fleet.

Table 4 shows that in 2009, non-private registrations (business and fleet) accounted for 49% of all new cars registered.

Table 4: New and used cars sales in the UK (2005-2009)

	2005	2006	2007	2008	2009
Total New	2,439,717	2,344,864	2,404,007	2,131,795	1,994,999
% Fleet	49%	49%	50%	52%	44%
% Business	7%	7%	7%	6%	5%
% Private	44%	44%	44%	42%	51%
Total Used	7,576,724	7,584,466	7,487,544	7,186,286	6,798,864
Total All	10,016,441	9,929,330	9,891,551	9,318,081	8,793,863
% New	24%	24%	24%	23%	23%
% Used	76%	76%	76%	77%	77%

Source: SMMT 2010a

From these figures it is clear that any investigation of consumers' car purchasing preferences needs to consider both the private and non-private customer segments. However, with respect to understanding the decision-making processes which impact on the adoption of new cars, it is important to understand the degree of autonomy which private individuals within the non-private sector are likely to be able to exert over their choice of car.

There exists a wide variety of fleet customers including companies that buy thousands of new cars each year and companies that buy only a small number. Some fleet customers buy large numbers of similar cars for their employees' use on the company's business; others allow their employees to choose their own model variants, normally subject to some restrictions. Table 5 attempts to define each of the three categories and offers a picture of the degree of autonomy over vehicle choice that may exist.

It is important to note that a high proportion of cars registered as 'non-private' will not be used and taxed as a 'company car.' This is clearly the case for rental cars, and many dealer/manufacturer cars have simply been pre-registered but will be used and taxed as private vehicles. This may be why Lane (2005) categorised the market into business fleets, individual consumers, and contract hire/leasing companies. In addition, there are some doubts expressed over the accuracy of the allocation of registration data. These data are derived from information recorded by the dealer when the car is sold, the accuracy of which is not checked and can be influenced by other factors (e.g. sales targets to a particular type of customer) (Skinner et al. 2006).

Evidence suggests that 'non-private' cars generally have more than twice the annual mileage of private cars, have larger engines, are more likely to be diesel, and are heavier than private cars (DfT, 2009; Skinner et al., 2006). It is also worth noting that households with a company car are more likely to own a second car than comparable households whose first car is privately purchased (Whelan, 2007).

Table 5: Definition of the main car customer segments in the UK

Segment	%	Definition	Degree of private individual autonomy
Fleet	44%	A vehicle that is registered to a fleet of 25 or more cars, or a fleet of 25 or more commercial vehicles. Also included: cars pre-registered by supplier or dealers daily rental car companies Motability[2] cars leased vehicles	On average, fleets are made up of about 8–10 cars in companies with no written policy about which cars should be adopted. The car adopters can be classified as follows: <u>Zero choice</u>: e.g. all sales engineers are given a specific make/model but they are free to be used privately <u>Restricted choice</u>: companies which source from certain car manufacturers only and, depending on the grade of the employee, can choose the appropriate sized car <u>User-chooser</u>: employees get to choose any car within a price band and, increasingly, below a certain level of emissions (e.g. 160 g CO_2/km)
Business	5%	These cars are part of fleets of less than 25 cars, with a very high proportion in single 'fleets'.	Assume high proportion of 'user choosers'.
Private	51%	Cars for the personal use of a private individual.	Total autonomy

Source: compiled from SMMT (2010a), Competition Commission (2000) and personal communication with Nigel Underdown (Energy Savings Trust)

2.1.3 Recent trends in UK car sales

As Table 4 indicates, there has been a drop in both new and used car sales in the UK. Prior to the collapse in sales in 2008 and 2009 as the recession took hold, sales of new cars had been falling in the UK since 2004. Indeed, consumer insight research from Mintel concludes that the UK car market suffers from a "significant underlying structural weakness" in that it is largely a "mature replacement market" and the frequency with which car owners replace cars is falling (Mintel, 2009). Mintel claim this is partly because cars have become more reliable and durable and there is less risk of higher repair costs if cars are owned for longer. Also, high rates of depreciation on cars results in a large funding gap between the resale value of a currently owned car and its new or younger used replacement.

This trend has been exacerbated by the recession but has been temporarily relieved by the introduction of a car scrappage scheme in mid 2009 which gave owners of older cars a £2,000 discount off a new small car. The incentive

[2] Motability is a Government-run charitable scheme to provide cars at low prices to people receiving the higher rate of mobility allowance and is the biggest single source of fleet cars in Europe. Using the SMMT data for 1998, the Motability scheme accounted for 7 per cent of all new cars registered and 15 per cent of all fleet registrations (Competition Commission, 2000). This is potentially a very interesting 'segment' as individuals get an allowance to purchase a car but have many characteristics which would otherwise suit EVs: they are car dependent and 'home centric', tending to make short car journeys with dedicated parking spaces. In addition, EV vehicles do not have gears which are important for certain types of disability.

stemmed the collapse in new car sales (funding 300,000 new car purchases) but had the opposite effect on used car sales which fell sharply in 2009. The scrappage scheme has therefore been successful in bringing a different type of buyer into the new car market by converting formerly used car buyers into buying brand new cars.

In contrast to the overall drop in car sales, sales of alternatively fuelled vehicles (AFVs) including hybrid and fully electric cars have risen during all but the most recent year since 2005. Sales of AFVs still only account for less than 1% of new sales, with around 15,000 units sold in 2009 in the UK, 98% of which were petrol/electric hybrid vehicles. Only 55 all-electric units were sold in that year (SMMT 2010a). More generally, the average engine size of licensed cars is stabilising, with an established market shift towards smaller vehicles, particularly minis and superminis.

2.1.4 How are cars financed?

Mintel (2009) suggests that nearly three-quarters of new cars are likely to be bought for more than £10,000. In a recent survey in the UK of purchasers of new and nearly-new cars (N=1,000, Feb–April 2010), one study found a slightly smaller proportion (around 60%) had paid more than £10,000 (Lane & Banks, 2010). The modal car price paid by participants who had recently bought a new or nearly-new car was £11–15k.

Lane and Banks also found that the majority of participants had acquired their current car through an outright purchase (61%), with hire purchase (11%) and personal loans (12%) also proving popular, corroborating evidence from Mintel which suggests 38% of (new and used) car sales were on finance in 2008.

Interestingly, Mintel believes it has identified a general societal trend in the UK of people becoming less motivated by ‘owning stuff’ and ‘are more concerned with expressing fashion and glorifying transience by renting’ (Mintel, 2009). As a consequence it believes there may be a greater trend away from outright ownership of cars towards renting or leasing programmes, particularly if the car industry develops a new form of revolving credit where the car ‘buyer’ pays an initial deposit and then a fixed monthly fee which carries on indefinitely.

2.1.5 Who buys new and used cars?

A new car is purchased by around 5% of households a year according to the Target Group Index (TGI), a syndicated survey of 25,000 households representative of the population of Great Britain, conducted annually by BMRB (Cambridge Econometrics, 2008).

It is, however, difficult to find detailed information on who buys new cars. Mintel market intelligence informs us that the AB (Managerial and Professional) segment[3] is fundamental to the retail car market as it accounts for just over 40% of new cars currently owned and for 40% of new car purchases (Mintel, 2009). However, it also suggests that C1s (Supervisory and Clerical) are a potential growth market for new cars during periods of economic growth.

Data on the car purchasing intentions of current car owners show that almost a third of those stating they intend to buy a brand new car over the following 12 months are existing owners of a car bought second-hand. Linked to this, it is also clear from the data that older people tend to own a greater proportion of cars owned from new.

[3] AB Managerial and Professional; C1 Supervisory and Clerical, C2 Skilled Manual, DE Unskilled Manual and Unemployed

From this information, there are four important issues which impact on the design of a survey of potential adopters of EVs:

- Given that only 5% of households per annum acquire a new car, it would be very difficult to conduct a survey of new car users using a random probability method (Cambridge Econometrics 2008).
- Given that a third of people who currently own a second-hand car say they intend to buy a new car next time around, it may not be necessary to concentrate on people who have only purchased a brand new car in the past.
- New car purchases are more frequent in the older age groups. However, given that the younger people of today are likely to be the new car purchasers of tomorrow, it might also be worth surveying some younger, potential new car purchasers. However, this is difficult as their preferences and attitudes are likely to change as they get older and have different needs.
- For the purposes of researching car consumers, it would also be worth knowing the proportion of people who purchase ‘nearly-new’ vehicles. However, this information was not found.

A discussion of the recent evidence on who has tended to adopt hybrid and EV cars in the UK and elsewhere is included in Section 2.7.

2.2 Approaches to the study of vehicle adoption

As the search results for this review demonstrated, there is a very large body of literature addressing consumer demand for cars, albeit dominated by studies of conventional vehicle technology as opposed to attempts to predict the uptake of alternatively fuelled and, more specifically, plug-in EVs. Studies are largely dominated by rational, economic modelling approaches using national data at the aggregate level or individual level. However, sections of the literature reject such approaches or at least supplement them with insights from theories from environmental or social psychology, marketing, or models of transitions or social learning.

It is beyond the scope of this review to document comprehensively the large body of research that has been applied to understanding the factors at play in the vehicle market and consumer attitudes and preferences for vehicle technology. Here we describe briefly the main theoretical backdrops revealed in this literature review. In subsequent sections we develop insights from these theoretical approaches by examining in more detail the factors that have been found to influence consumer choice with respect to conventional, hybrid and electric vehicles.

Table 6 offers a categorisation and brief overview of the dominant theoretical backdrops found. The categorisation follows a trajectory from (i) individual conscious and rational processes which shape decisions and actions, to (ii) emotional, impulsive and non-rational individual processes, to (iii) interpersonal or societal level dynamic processes of change.

Table 6: Summary of main theoretical 'backdrops' to the literature

(i) INDIVIDUAL CONSCIOUS AND RATIONAL APPROACHES			
Approach / methodology	**Underlying assumptions [original references]**	**Application to vehicle choice**	**References (applied to vehicle choice)**
Rational decision making	Automobiles are thought of as bundles of attributes desired by consumers, such as fuel economy, durability, style, performance, safety, and brand. Different makes and models are distinguished by the various attributes they offer. Consumers (i) make rational cost-benefit analyses and (ii) choose the option that maximises their benefits and minimises their costs subject to their preferences, knowledge, alternatives and budget.	Preferences for environmental goods and services which are not usually traded within the market mechanism can be inferred by revealed preference and stated preference techniques: • Revealed preference: is a method that assumes that consumer behaviour can be predicted on the basis of their current (revealed) behaviour. • Stated preference: the assumption is that consumers have well defined preferences, and is used to analyse the trade-off that individuals would be willing to make between the good in question and some other good (usually money). Some studies combine revealed and stated preference data. The application of discrete choice models or energy-economy models derives coefficients to predict an implied monetary value per unit of change of a vehicle attribute. These estimated parameters can be used for the derivation of potential policy incentives.	Alvarez-Daziono & Bolduc (2009); Dagsvik et al. (2002); Ewing & Sarigöllü (1998); Golob & Gould (1998); Greene et al. (2004); Mau et al. (2008); Potoglou & Kanagoglou (2007); Ziegler (2010) Brownstone et al. (2000); Axsen & Kurani (2008); Axsen et al., (2009); Cambridge Econometrics (2008); Santini & Vyas (2005)
Theory of Planned Behaviour	Behaviour is determined by behavioural intention and that intention is determined by (i) attitudes to the behavior, (ii) social norms about the behaviour and (iii) perceived behavioural control (i.e. the extent to which people think it is easy or difficult to engage in that specific behaviour). [Ajzen (1991)]	In this context, an individual's acceptance of a technology, although not strictly a psycho-sociological term, can be regarded as an intention to adopt or use the technology, or to consent or actively support its development.	Roche et al. (2010); Lane & Potter (2007)

(ii) INDIVIDUAL UNCONSCIOUS AND EMOTIONAL APPROACHES			
Approach / methodology	**Underlying assumptions [original references]**	**Application to vehicle choice**	**References (applied to vehicle choice)**
Norm Activation Model / Value Beliefs Norm Theory	Consumer behaviour is determined by values, personal norms, problem awareness and perceived responsibility [Schwartz (1977); Dietz & Stern (1994); Stern (2000)]	At the general level, these models suggest that human values influence general constructs such as attitudes, attributes, consequences, or consumption values that in turn influence product choice. At the specific level, these models represent how certain human values influence certain product choice through particular association networks. First, values can direct consumers' attention to products with similar meanings to the human values, and second, the effect of the human value could be transferred to the evaluation of the product meaning. For instance, an individual's preference for the human value `prestige' would direct his or her attention to products that have meanings similar to prestige, such as a Mercedes-Benz, and would contribute favourably to his or her positive evaluation of the automobile.	Roche et al. (2010); Allen & Ng (1999); Jansson (2009)
Symbolism	Consumers base their behaviour on the symbolic meaning that they attach to a product. [Dittmar (1992)]	The assumption is that consumers attach an affective and symbolic meaning to certain objects such as cars, which is reflected in the identity of a person. Distinctions can be made between (1) the instrumental and functional use of objects, (2) their emotional dimension, related to pleasure and relaxation, and (3) their symbolic meaning, as a symbol of identity. The symbolic function can, in turn, be subdivided into two components: the person's position or social status and the expression of personal identity and values. Therefore, consumers can use an object as a means to express themselves or their social position.	Heffner, Kurani & Turrentine (2006, 2007)
Risk perception	Consumers base their behaviour on the extent to which they believe engaging in this behaviour is a risk to society, to them personally, or financially. [Slovic (1987)]	The premise of this approach is that whilst experts rely on complex risk assessments for their decisions, the general public makes judgements based on individual characteristics, such as risk awareness, perceived control over a situation and experience with risks.	Roche et al. (2010); Coad et al. (2009)

Heuristics	Consumers engage in limited economic rationality as they have limited cognitive capacity and therefore rely on 'short cuts' to make decisions. [Kahneman, Tversky & Slovic (1982); Berretty, Todd & Martignon (1999)]	People have limited cognitive capacity and therefore rely on simplifying assumptions and quick decision tools. Hence, it may be that such heuristics are used when distilling information on new car attributes so that only a limited set of characteristics are used to make a decision. Likewise, when eliciting information through surveys such as 'how much would you pay for better fuel economy', respondents may answer with an accessible rather than an accurate number. This simplifying effect can be exacerbated with the absence of direct experience when consumers attempt to answer preference questions.	Turrentine & Kurani (2007); Mueller & de Haan (2009); Garwood & Skippon (2010)
Prospect theory	This tries to model real life choices rather than optimal decisions. When consumers decide between alternatives involving risk, they evaluate potential losses and gains. They decide which outcomes they see as identical and set a reference point: lower outcomes are seen as losses and higher as gains. [Kahneman & Tversky (1979)]	Financial incentives for EVs should be designed so that consumers perceive them separately from the purchase price. Consumers can be expected to be more sensitive to fees than to rebates of the same magnitude.	Mueller & de Haan (2009); Axsen et al. (2009)
Personality and self identity	Five factor model of personality (openness, conscientiousness, agreeableness, extraversion, neuroticism). [Goldberg, (1992), (1993)] Narcissistic Personality Inventory (authority, entitlement, exhibition-ism, exploitation, self-sufficiency, superiority and vanity). [Raskin and Hall (1981)]	This approach is based on the theory that the symbolic meanings of consumer products represent conscious or non-conscious signals to others about the user's personality traits. A number of studies have striven to uncover personality traits associated with how early an individual adopts an innovation ('innate innovativeness'). Narcissism is hypothesised to be associated with greater interest in the symbolic rather than the functional value of products. Choo & Mokhtarian (2006) investigated 'adventure seeker', organiser, loner and calm personalities with respect to vehicle choice modelling and concluded that personalities spread somewhat more evenly across vehicle types than do attitudes, but that adventure seeking tendencies can be predictive of car choice behaviour.	Choo & Mokhtarian (2006); Garwood & Skippon (2010); Gärling & Thøgersen (2001)

(iii) INTERPERSONAL OR SOCIETAL LEVEL DYNAMIC PROCESSES			
Approach / methodology	**Underlying assumptions [original references]**	**Application to vehicle choice**	**References (applied to vehicle choice)**
Diffusion of innovations / Innovation theory	Innovations can be classified along five dimensions; the likelihood and rate of adoption of an innovation is determined by consumers' perception of the innovation on these dimensions. [Rogers (1962)] Although innovativeness is conceptualised as a personality trait measureable in, for instance, individual favourable attitude, perceived benefits, willingness to sacrifice and latent need, this relative-time-of- adoption definition focuses more on the dynamics of the diffusion process at the interpersonal or societal level than on (more static) individual predispositions.	Five dimensions to classify innovations: (i) relative advantage (over the entity it supersedes), (ii) value compatibility (with the adopter's values, needs and experiences), (iii) complexity (how difficult it is to understand and use), (iv) trialability (can it be tested without or with limited costs) and (v) observability (influences the likelihood that *others* will adopt). Five types of adopters can be distinguished: Innovators: first individuals to adopt an innovation; willing to take risks, youngest in age; highest social class; great financial lucidity; very social and have closest contact to scientific sources and interaction with other innovators; Early adopters: second fastest category of individuals who adopt an innovation; typically younger in age; have a higher social status; have more financial lucidity; advanced education; and are more socially forward than late adopters; Early majority: tend to be slower in the adoption process; above average social status; contact with early adopters; Late majority: adopt an innovation after the average member of society; typically sceptical about an innovation; below average social status; very little financial lucidity; in contact with others in late majority and early majority; Laggards: last to adopt an innovation; typically focused on "traditions"; lowest social status; lowest financial fluidity; oldest of all other adopters; in contact with only family and close friends. Many believe the classification by Rogers (1962) offers the most promising starting point for segmenting the potential EV market.	Gärling & Thøgersen (2001); Gärling 2001; Lane (2005); GfK Automotive (2006); Huétink (2005); Heutel & Muehlegger (2009).

Social learning theory	Consumers acquire new information, attitudes and behaviour by observing others in their social network. [Bandura (1977); Hirschman (1973)]	Social interaction determines consumers' behaviour to some extent. It is assumed that particularly early adopters seek new information and experiences through social interaction and advertising. Moreover, early adopters are likely to have more contact with other early adopters who can serve as a role model and sparring partners.	Bollinger & Gillingham (2010); Huétink (2005)

Whilst Table 6 demonstrates the potential breadth of approaches that could be applied to an investigation of consumers and vehicles, it belies the imbalance within the literature and the overwhelming domination of the rational economic approach. Moreover, even where environmental psychology is applied to the study of the relationship between attitudes and intended car purchase behaviour, it still tends to be a utility maximising approach. The most commonly applied theory is the Theory of Planned Behaviour which suggests that behaviour is the outcome of a reasoned set of planned decisions.

Yet, models of car choice are likely to be inadequate without a proper consideration of impulsive or non-conscious regulatory processes including the role of affect (or emotion), identity/symbolism and personality in car preference. A fundamentally different approach to understanding behaviour towards the environment is that of symbolism, widely used in consumer research. Heffner et al. (2006, 2007) have recently taken up the seminal literature and lessons of recent studies exploring the symbolic meanings of cars, and have produced empirical results regarding the purchase of hybrid cars (see Section 2.4). These studies are based on the assumption that vehicles symbolise ideas related to self-identity and that the choice of a vehicle is used to communicate interests, beliefs, values, and social status. Studies of symbols rely usually on ethnographic interviews. A possible caveat in the use of this approach for the study of new technologies such as plug-in vehicles is that new symbolic meanings take time to appear and be communicated among consumers.

Alternative models have also been used in the environmental psychology field and have been more accurate in explaining how people make complex decisions, especially when lacking complete information. However, they have only been mentioned ‘in passing’ in the literature on car consumers. A consistent finding is that pre-purchase research activity is limited, even though the car is a major durable good (Mueller & de Haan 2009).

Even where the consumer decision-making process may be a result of conscious choices among an array of alternatives, these choices are systematically related to psychological processes (i.e. perception, attitudes, beliefs formation) and any models need to make salient the role that human values play in consumer behaviour. Allen & Ng (1999) suggested that basic human values have a direct influence on consumer choice when individuals evaluate the symbolic meaning of a product and thus make an affective judgment about it. For instance, strong symbolic motives to express one’s personality and social status with one’s own car may inhibit the activation of a personal ecological norm to purchase a more fuel economical vehicle (Peters et al. (in press)).

The Norm Activation Model (NAM) gives prominence to values, but in reality all of the approaches in Table 6 are linked in some way. For instance, the potential of values-based measures to explain behaviour is enhanced when personality traits are included to capture awareness of consequences of behaviour and denial of responsibility (Choo & Mokhtarian, 2006). Likewise, a number of studies have found that potential adopters’ perceptions of an innovation on the dimensions outlined by Rogers (1962) are better predictors of vehicle adoption than personality and demographic characteristics (Gärling & Thøgersen, 2001). Still, personality, values and socio-demographics may offer valuable supplementary segmentation criteria.

The greatest dearth of evidence exists in relation to the dynamic processes thought to take place at the interpersonal, community or societal level. Sociological theories that stress the interpersonal environment offer key insights of the attitude-behaviour link and account for the role of social factors, peer effects, social networks, imitative and learned behaviours.

We will return to the individual and interpersonal level concepts including segmentation and the characterisation of early adopter segments in sections 2.6 and 2.7 by reviewing their specific application to the adoption of EVs.

2.3 Cost and functional vehicle attributes

There are a number of different types of factors, economic and non-economic, that influence how and why cars are purchased. Many of these are common to all powertrains, but some, such as availability of charging infrastructure, are specific to EVs. This section summarises the literature on functional attributes. Functional attributes are the instrumental-reasoned motives which relate to the economic or general practical attributes of a vehicle. Whilst the term 'functional' implies objectivity, there is still the potential for these to be conceptualised differently by different consumers and, where the evidence sheds light on this, these differences are discussed.

2.3.1 Attributes measured in revealed and stated preference studies

Modern welfare economics assumes consumers are rational decision makers with well defined preferences. Associated models stipulate that individuals will choose options that maximize utility (i.e. satisfaction or pleasure) subject to their preferences, knowledge of alternatives and budget.

Models used to capture these preferences can be classified as aggregate or disaggregate. Aggregate models are used to forecast regional or national demand or car ownership levels (e.g. Eftec 2008), whereas disaggregate models[4] generally consider the household as the unit of analysis and apply random utility theory to predict household vehicle choice. A 'coefficient', through a set of equations and specified relationships, predicts an implied (or buyer-perceived) monetary value per unit of change of a vehicle or policy attribute.

Some features of these models are outlined below:

- The models tend to concentrate on cost and physical attributes associated with cars, household and driver characteristics and brand loyalty.
- More recently, models used to predict the uptake of AFVs also include some variables which are not applicable to conventional vehicle technology but which are likely to greatly affect uptake such as availability of fuel stations/charging points, refuelling/recharging time and maintenance cost (Alvarez-Daziono & Bolduc, 2009; Dagsvik et al., 2002; Element Energy, 2009; EST, 2007; Ewing & Sarigöllü, 1998; Golob & Gould, 1998; Greene et al., 2004; Mau et al., 2008; Santini & Vyas, 2005; Ziegler, 2010).
- Some models include policy attributes such as subsidies, excise duties, preferential parking and high occupancy vehicle lanes, which may influence consumer preferences for new technology (Adler et al., 2003; Alvarez-Daziono & Bolduc, 2009; Cambridge Econometrics, 2008; Ewing & Sarigöllü, 1998; Potoglou & Kanagoglou, 2007; Santini & Vyas, 2005).
- Vehicle and household characteristics are mainly considered as explanatory variables in the models.
- The models do not usually consider consumers' travel attitudes, personality, lifestyle, and mobility as factors that may affect the vehicle type choice (Choo & Mokhtarian, 2006).

[4] These can be further divided into (i) vehicle purchasing models and (ii) vehicle-holding models, depending on whether the model looks at the most recently purchased vehicle or any owned vehicles respectively (Choo & Mokhtarian, 2006).

We reviewed 21 studies spanning at least two decades involving conventional choice models. All but one of these studies use disaggregate discrete choice models for the vehicle type choice. Most are based on data from stated preference (SP) surveys that look at intended behaviour in hypothetical or constructed markets since alternative energy sources and plug-in EVs are still in limited supply or do not exist in the market place (e.g. Ewing & Sarigöllü, 1998; Dagsvik et al., 2002; Potoglou & Kanaroglou, 2006; Ahn et al., 2008). Other studies (e.g. Brownstone et al., 2000; Axsen et al., 2009) combine SP and revealed preference (RP) data. These techniques analyse the trade-off that individuals would be willing to make between the good in question and some other good (usually money). The inferred economic preferences can be used for estimating the monetary values of environmental goods, and examining the response of the model to different policy scenarios can provide insight to the future market viability of lower carbon vehicle technologies (EST, 2007).

Again, it is beyond the scope of this review to detail the modelling and analysis approaches and the resulting attribute coefficients. In any case, most published studies are US or Canadian based and therefore are likely to have been calibrated to these markets. Exceptions to this include EST (2007), Cambridge Econometrics (2008) and Batley and Toner (2003) in the UK, Ziegler (2010) in Germany and Dagsvik et al. (2002) in Denmark. In addition, it can be difficult to make general conclusions on the dominant factors influencing vehicle choice from these models as different vehicle categories were chosen, and different attribute measures and trade-offs were examined.

Nevertheless, the overview suggests that first, higher purchase price tends to be negatively associated with the probability of choosing a vehicle, as does operating cost. Brand loyalty is often significant, as is the number of seats, luggage space, engine size and horsepower. Similar to conventional vehicles, purchase price or operating cost are also significant in most models which include AFVs. However, specific to AFVs, various performance variables, especially driving range, fuel availability and fuel flexibility appear as significant factors (Dagsvik et al., 2002, Brownstone et al., 2000; Ewing & Sarigöllü, 1998). In their own review of this literature, Cao and Moktarian (2003) point out that a lower emissions rate also increases an individual's probability of choosing AFVs, "*…suggesting that the innovative attribute of AFVs is well accepted by at least a niche market [of] environmentalists*" (p17).

Of direct interest to the wider ETI study is an understanding of *which* vehicle attributes have been measured in previous studies. Within SP surveys, the most important attributes (apart from cost of vehicle purchase and operation) that distinguish EVs from conventional vehicles have been found to be: range between refuelling, availability of fuel, multiple fuel capacity, incentives and, less importantly, reduction in emissions. Other attributes such as vehicle size, performance (mainly maximum speed), dual fuel capacity and market penetration, have also been explored. Table 7 itemises the studies included in this review and documents the main vehicle attributes measured. These attributes will be discussed in more detail in the remainder of this section.

Table 7: Summary of the attributes measured in SP/RP surveys

Author(s)	Method	Powertrains	Purchase price		Fuel cost		Other costs			Fuel availability/ recharging				Performance/ driveability				Safety	Size	Emissions	Incentives/privileges	Penetration	Mileage	Make/model/style	Other
			Purchase price	Purchase subsidy	Fuel efficiency/consumption	Fuel cost	Service & maintenance (incl battery replacement)	Depreciation	Other	Fuel availability	Multi-fuel capability	Range	Time to refuel/recharge	Horsepower/performance	Acceleration	Comfort/ride quality	Top speed								
Adler et al. (2003)	Telephone, mailback & www, SP, California, 2002, N=2200, nested MNL	Petrol/ diesel, fuel efficient, BEV	✓	No vehicle sales tax on purch-ase		£/yr	✓							✓	0-60				Sub-compact, mini etc		Free parking at public meter, use of HOV lane			✓	
Ahn et al. (2008)	SP, face to face, N=280, age 20-59 with a car, Seoul, July 2005. DC model	Petrol/ diesel, CNG, LPG, HEV	All cars consi-dered to have same PP		Km/ litre	£/ litre	Tax & maint-enance per 6 mths							✓										General passenger vs RV or SUV	
Alvarez-Daziono & Bolduc (2009)	Hybrid choice model, SP, N=866, Canada. Bayesian & classical estimation methods	Petrol, natural gas, HEV, HFC	✓			✓				% of stations selling the fuel				Power relative to user						Relat-ive to a stan-dard gas-oline vehicle	HOV lane access				

			Purchase price		Fuel cost		Other costs			Fuel availability/ recharging				Performance/ driveability											
Author(s)	Method	Powertrains	Purchase price	Purchase subsidy	Fuel efficiency/consumption	Fuel cost	Service & maintenance (incl battery replacement)	Depreciation	Other	Fuel availability	Multi-fuel capability	Range	Time to refuel/recharge	Horsepower/performance	Acceleration	Comfort/ride quality	Top speed	Safety	Size	Emissions	Incentives/privileges	Penetration	Mileage	Make/model/style	Other
Axsen & Kurani (2008)	Online SP & RP survey (N=535, Canada); hybrid choice model; 3 penetration scenarios, hypothetical info about the technology from 3 different sources (newspaper, brochure, personal testimonial)		% of user	Tax rebate (% HEV capital cost)		£/week based on mpg								% change relat-ive to user						Relat-ive to current vehicle		Mark-et share ratios			
Axsen et al. (2009)	Online SP & RP, N=943, Canada & California, new vehicle owners, Mar 2006, age 19+, drive 3+ times per week, lived in urban area, HEV owners purposively sampled	HEV, petrol	% of user	Tax rebate (% HEV capital cost)		£/week								HP relat-ive to user						Rela-tive to current vehicle		3 pene-tration scen-arios			

Author(s)	Method	Powertrains	Purchase price		Fuel cost		Other costs			Fuel availability/ recharging				Performance/ driveability				Safety	Size	Emissions	Incentives/privileges	Penetration	Mileage	Make/model/style	Other
			Purchase price	Purchase subsidy	Fuel efficiency/consumption	Fuel cost	Service & maintenance (incl battery replacement)	Depreciation	Other	Fuel availability	Multi-fuel capability	Range	Time to refuel/recharge	Horsepower/performance	Acceleration	Comfort/ride quality	Top speed								
Batley & Toner (2003)	SP, UK, summer 2002, N=331, MNLM	Petrol/ diesel, near term AFV, compromise option	On the road price or credit price			Running costs incl. depreciation & maintenance	✓	Retained value after 3 yrs/ 36,000 miles				Range on full recharge or refuel	Time for a full refuel or recharge		0-60		✓			% of a year 2000 petrol car					
Beggs et al. (1981)	Ordered logit model, N=~200, 9 USA cities, principal drivers of compact/ sub-compact car, commuters with <50 miles daily	Petrol, BEV	✓			£/ 10,000 miles						Range before refuelling/ recharge			✓		✓		Seating capacity						Warranty, air con
Brownstone et al. (2000)	SP & RP, multi-wave panel survey, California, June 1993, N=2,857, mixed logit	BEV, natural gas, methanol	Price divided by natural log of household income			Home & service station £/ mile				Availability per 10 gas stations		Miles between recharging/ refueling	At home & at a service station		0-30		✓		Size relative to compact car & luggage space relative to 1995 new gasoline vehicle	Relative to 1995 new gasoline vehicle				Luxury vs import/ car, truck or van	

Author(s)	Method	Powertrains	Purchase price		Fuel cost		Other costs			Fuel availability/ recharging				Performance/ driveability				Safety	Size	Emissions	Incentives/privileges	Penetration	Mileage	Make/model/style	Other
			Purchase price	Purchase subsidy	Fuel efficiency/consumption	Fuel cost	Service & maintenance (incl battery replacement)	Depreciation	Other	Fuel availability	Multi-fuel capability	Range	Time to refuel/recharge	Horsepower/performance	Acceleration	Comfort/ride quality	Top speed								
Cambridge Econometrics (2008)	Telephone survey, N=900, recently purchase new/nearly-new vehicle, some SP (to changes in different motoring costs), RP analysis to estimate own & cross elasticities of household behaviour, WTP for fuel efficiency, discrete choice	Diesel/ petrol, or 'anything else'	Base price		ℓ/ 100km	£/100km			Insurance, VED					Engine size, max HP, power: weight ratio	✓	✓	✓	Breaking distance, no. air-bags	Seating capacity, length, width, wheelbase, weight, boot volume, no. doors	CO_2 g/km			Household av. mileage	Manufacturer, make, model	Mechanical reliability, warranty, security, transmission, amenities
Cambridge Econometrics (2008)	Short SP of focus group participants (N=37), linear regression	BEVs										✓	✓				✓								Cost & delay of a dead battery
Dagsvik et al. (2002)	SP, random sample, Norway, N=662	LPG, BEV, dual fuel	✓		ℓ/ 10km						✓	✓					✓								

Author(s)	Method	Powertrains	Purchase price		Fuel cost		Other costs			Fuel availability/ recharging				Performance/ driveability				Safety	Size	Emissions	Incentives/privileges	Penetration	Mileage	Make/model/style	Other
			Purchase price	Purchase subsidy	Fuel efficiency/consumption	Fuel cost	Service & maintenance (incl battery replacement)	Depreciation	Other	Fuel availability	Multi-fuel capability	Range	Time to refuel/recharge	Horsepower/performance	Acceleration	Comfort/ride quality	Top speed								
Element Energy (2009)	Lit review, analysis of NTS & EHC survey, survey of private & fleet owners (N=36+11) & EV considerers (N=215+16)	BEV, PHEV	✓							✓		✓	✓	✓								✓	✓		Unfamiliarity with technology
Eftec (2008)	Aggregate DC modelling using RP	6 categories	✓			£/ 100km		Re-sale price	Fixed annual cost-ing VED & insurance prmeiums					Engine size	Secs to 100 km /hr, no. gears			No. of air-bags, ABS	Length x width, no. doors	CO_2 g/km				13 body types	Trans-mission, air con, alloy wheels
EST (2007)	MNLI based on historic data & detailed consumer survey	12 categories	✓			£/yr or 16,000km	✓	✓	Insurance, VED	Availability of infrast-ructure		Distance on full tank			✓	Torque curve/ gear shift; refine-ment (NVH & ride/ hand-ling)	✓	Perce-ived safety	Load capacity, no. pass-engers	CO_2 g/km		Avail-ability to purch-ase			Reliab-ility

Author(s)	Method	Powertrains	Purchase price		Fuel cost		Other costs			Fuel availability/ recharging				Performance/ driveability				Safety	Size	Emissions	Incentives/privileges	Penetration	Mileage	Make/model/style	Other
			Purchase price	Purchase subsidy	Fuel efficiency/consumption	Fuel cost	Service & maintenance (incl battery replacement)	Depreciation	Other	Fuel availability	Multi-fuel capability	Range	Time to refuel/recharge	Horsepower/performance	Acceleration	Comfort/ride quality	Top speed								
Ewing & Sarigöllü (1998)	Montreal, N=881, postwar suburbs, drive to work/school	Petrol/ diesel, fuel efficient, BEV	✓				✓					✓	Time spent refuel-ing		0-60 comp-ared to user					✓	Time & cost of com-muting (week-ly cost for fuel & parking)				
Golob et al. (1993)	Three phase SP survey, MNL (N=~900), California, 1991	Petrol, LPG, CNG (dual fuel), BEV (hig & low perform-ance)	✓			✓				% of stations selling the fuel, home & work recharge	✓	✓		✓						Perce-ived % of gas-oline cars					
Greene et al. (2004)	NMNL calibrated to 2002 model year sales, 8 scenarios tested	Diesel, HEV	✓		MPG & real-world pena-lty	£/mile				% of stations selling the fuel		✓	Value of time saved not refuel-ing	HP/ torque									Decre-asing with age of vehicle		

Author(s)	Method	Powertrains	Purchase price		Fuel cost		Other costs			Fuel availability/ recharging				Performance/ driveability				Safety	Size	Emissions	Incentives/privileges	Penetration	Mileage	Make/model/style	Other
			Purchase price	Purchase subsidy	Fuel efficiency/consumption	Fuel cost	Service & maintenance (incl battery replacement)	Depreciation	Other	Fuel availability	Multi-fuel capability	Range	Time to refuel/recharge	Horsepower/performance	Acceleration	Comfort/ride quality	Top speed								
Mau et al. (2008)	Two SP surveys (N=916+1,019), Canada, www, survey for different technology & treatment groups with different market shares, DC model (capital vintage model)	Petrol/ diesel, HEV (gas-electric), HFC	% of user	% of capital cost		% current car				% of stations selling the fuel		Distance between refueling										Market share ratios			Warranty
Potoglou & Kanaroglou (2007)	Internet, Canada, 2005, N=482, NMNL	Petrol/ diesel, HEV, AFV	Relative to base	Purchase tax		£/year (% of gasoline car)	Annual cost relative to base			% of stations selling the fuel					0-60				Class/ size	% of a present day average car	HOV lanes, parking fees				Urban form
Santini & Vyas (2005)	SP & RRP, logit model but develops coefficients for early group & majority buyers	Petrol/ diesel, HEV				£ mile						Range			0-60				Luggage space % of base trunk		HOV lane access				Potential to provide back-up power to a house

			Purchase price		Fuel cost		Other costs			Fuel availability/ recharging				Performance/ driveability											
Author(s)	Method	Powertrains	Purchase price	Purchase subsidy	Fuel efficiency/consumption	Fuel cost	Service & maintenance (incl battery replacement)	Depreciation	Other	Fuel availability	Multi-fuel capability	Range	Time to refuel/recharge	Horsepower/performance	Acceleration	Comfort/ride quality	Top speed	Safety	Size	Emissions	Incentives/privileges	Penetration	Mileage	Make/model/style	Other
Ziegler (2010)	SP CAPI survey in car dealerships (N=598, Germany, 2007-2008, those intending to buy a vehicle in near future), MNL probit	Petrol/ diesel, HEV, gas, biofuel, HFC, BEV	% of user			Euro/ 100km				% of stations selling the fuel		Km per tank capacity		✓					Small vs large	CO_2 g/km			Km/ year		Company car

2.3.2 The relative ranking of cost and functional attributes

Designing a discrete choice experiment entails three initial decisions: identifying relevant attributes to include, deciding the number and values of the discrete levels of each attribute, and deciding how many alternatives to include in a choice set. This process itself is reliant on previous studies and prior empirical work to elicit the attributes and attribute levels.

The majority of SP studies conclude that purchase price is the most influential factor. However, this is not necessarily borne out by other types of study which have elicited attitudes using a more simple ranking exercise (see Table 8). These studies often have the advantage of including a number of variables which cannot be easily measured in discrete choice models such as attributes relating to quality, comfort and perceptions of reliability and image/status.

Table 8 shows the results of five recent studies undertaken in the UK which have measured the importance attached to various attributes by those involved in the car purchasing process. These have been ordered in the table according to the importance attached to purchase factors found in the most recent UK study (Lane & Banks, 2010). This study also has the advantage of having elicited these ranked attributes using open-ended questions so as not to pre-empt attribute choice[5].

[5] Participants were allowed to offer up to ten responses, which they then scored on a four-point Likert scale ranging from 'Not important' (0) to 'Overwhelmingly important' (3). Responses were allocated to key categories by the survey team and the rankings reflect the weighting given to each factor.

Table 8: Comparison of ranks of importance given to attributes that influence the car purchase decision from five recent UK studies.

(NB Top five attributes in red/orange**)**

Car attribute	Lane & Banks 2010 ~	GFK 2009 ^	Mintel 2009 #	Cambridge Econometrics 2008 *	Angle et al. 2007 +
Fuel consumption/ running cost	1	4	3	4	3
Size/Practicality	2	1			
Purchase price	3	2	1	5	2
Style/Appearance	4	6	5	8	8
Reliability	5	3	2	1	1
Comfort	6	5	6	2	5
Safety	7		4	3	7
Brand/ image/reputation	8	10	9	12	4
Emissions	9		10	11	10
Performance/Power	10	8	11		
Fuel type	11				
Personal experience	12			9	9
Engine Size	13			14	6
Road tax	14	7			
Features/Gadgets	15				
Maintenance	16		13	10	9
Transmission	17				
Quality	18		7		
Insurance cost	19	9	8	13	9
Recommendation					12
Dealer				15	
Warranty period			12	6	
Security				7	11
Resale value			14	16	
Credit facilities			15	17	
Company car tax		11			

Sources:
~ Lane & Banks, 2010: Internet survey, Feb-March 2010, N=1,000 people who had either recently bought a brand new or nearly-new car or were planning to make a purchase in the next 12 months (unprompted)
^ GfK, 2009: Internet survey, April/May 2009, N=2,000, new and used car purchasers/intenders (rankings for new cars used here) (prompted)
# Mintel, 2009: Internet survey, Dec 2008, N=1,000 aged 16+ who own a car (rankings for new cars used here) (prompted)
* Cambridge Econometrics, 2008: Face to face (CAPI), May 2007, N= 900 people who had bought a brand new car, or a car that was less than 12 months old, in the past 12 months (prompted)
+ Angle et al., 2007: N=1,020, all drivers involved in the car purchase decision, new and used cars (prompted)

From this it is clear that respondents assign approximately equal importance to a number of non-cost attributes of the vehicle such as size, style, reliability and comfort in addition to fixed and variable cost attributes, such as purchase price, fuel consumption/running cost. According to these studies, of less importance are attributes such as impact on the environment, warranty periods and resale value. Moreover, to the extent that comparisons can legitimately be made between these studies, consumer focus does not seem to have shifted in favour of environmental issues over time, although there is some suggestion from these results that fuel consumption has recently become a higher priority.

It should also be noted that studies have found differences between new and used car buyers. Used car purchasers pay more attention to price, reliability and fuel consumption and new car buyers place more emphasis on safety, style, design, comfort and quality

(Mintel, 2009). This is also reflected in the table in the study by Angle et al. (2007), in which both new and used car purchasers were studied.

It is also important to note that none of these studies specifically set out to examine vehicle attributes in the context of AFVs. The question is whether attributes that on the face of it are independent of the EV option (e.g. size) are in fact treated differently due to a new set of values and scrutiny employed by purchasers in a diversifying market. This question will be addressed in the following sections.

2.3.3 Purchase price

Two issues are important in the consideration of the role of purchase price/capital cost[6]. First is the extent to which it is a determining factor in the choice of a vehicle and second is the premium consumers are willing to pay for a variety of vehicle attributes.

Modelling evidence based on SP surveys suggests that purchase price has the greatest influence on car choice. However, in the five ranking exercises considered above, purchase price ranked between first and fifth in importance among other cost and non-cost attributes. Any discrepancy is likely to be explained by the 'funnelling' process employed during purchasing in which people work within certain budgetary constraints (Lane, 2005; Skinner et al., 2006). This places purchasing cost as one of the most important adoption factors but it can mean that 'lesser' factors may end up having a greater than expected role in the latter stages of purchase in influencing competing makes/models within the same price bracket. This can have implications for research on this topic as consumers often downgrade the importance attached to purchase price as they assume it is a given. In a recent focus group exercise for example, it was noted that purchase price was hardly mentioned as a factor by people as the 'downstream' factors were freshest in their mind (Lane & Banks, 2010).

Many of these studies have not had an explicit focus on EVs. Element Energy, on the other hand, undertook a web based survey of private and commercial current EV owners and 'EV considerers' and asked people to rate the relative disutilities of EV ownership (Element Energy, 2009). They found that both private EV owners and EV considerers consistently state that high price is the greatest challenge to ownership. It is also an important challenge for fleet users, but other factors (such as range, time to charge) were equally as important in their case.

Many studies have attempted to calculate the premium car buyers would be prepared to pay for a plug-in hybrid EV (PHEV) or battery EV (BEV). The findings are related to the trade offs which are found to take place between purchase price and other attributes such as fuel economy, image and performance (examined below). It is difficult to summarise these studies as they have each used such diverse methods of elicitation. Nevertheless, there appear to be some common conclusions:

- Studies have found a good deal of interest among consumers for EVs, particularly PHEVs, as well as a good deal of resistance based on the estimated cost of this new technology (Curtin et al., 2009; Element Energy, 2009).
- However, consumer responses to increasing price premiums of plug-in vehicles in terms of purchase probabilities is generally greater than can be justified based on purely economic rationales. This means that consumer acceptance is not solely determined by costs as environmental and other non-economic factors influence the likelihood of future purchases (Curtin et al., 2009).
- The role of purchase price is discussed in all of the literature attempting to define the early adopter market for LEVs and (P)HEVs and BEVs. The possible characteristics of the early adopter segment will be discussed further in section 2.6. Suffice to say here, it is likely that early adopters of EVs will be willing to pay more for their purchase and many may not even compare the price difference with conventional

[6] Used interchangeably from this point onwards.

vehicles (Element Energy, 2010; Kurani et al., 2007; Heffner et al., 2007; PlaNYC, 2010).

On the latter point Kurani, Heffner and Turrentine (2007) suggest that if PHEV buyers behave in the same way as the early market for HEVs, "*data on consumers' willingness-to-pay for PHEV technology derived from the assumption that people are simply comparing powertrains in otherwise identical vehicles may not be useful in predicting demand"* (p5). However, this does not assist our understanding of the likely behavioural response to price by the 'early majority' segment.

2.3.4 Fuel economy

A review of the vehicle choice literature highlights inconsistency observed within and between studies on the importance of fuel efficiency as a factor in the purchasing behaviours of consumers. Some studies found that consumers are not primarily concerned about fuel efficiency (Kurani et al., 2007; Turrentine & Kurani, 2007; Santini & Vyas, 2005; Sovocool & Hirsh, 2009) whereas other studies found a positive correlation between fuel efficiency and purchase decisions (Cambridge Econometrics, 2008; Popp et al., 2008). Others highlight the 'mpg paradox': that although 'mpg' is reported by car buyers as a key decision factor, little effort is actually made to compare fuel consumption data during the decision-making process (Lane, 2005; Anable & Lane, 2008; Sovocool & Hirsh, 2009; Skinner et al., 2006).

The ranking exercises outlined in Table 8 suggest that fuel efficiency is indeed the cost factor that respondents often consider most important. It is possible that the importance attached to this has risen recently given high oil prices and recessionary pressures (Banks & Lane, 2010; Anable & Lane, 2008; Sovocool & Hirsh, 2009). This has been reflected in recent car purchase trends in the UK towards smaller vehicles (SMMT, 2010a). However, despite recent trends, there is debate as to the degree to which the stated importance attached to fuel economy translates into vehicle preference at the individual level.

A common assumption is that consumers will pay more for technologies that increase fuel economy only if the initial cost of these technologies is offset by the cost savings during a specified period of time, known as the 'payback period'. Consumers are assumed to consider the cost of fuel and fuel economy both in their travel and vehicle choices, and to consider such costs over time.

Many stated choice experiments are designed with this assumption in mind and set out to understand the fundamental trade-off between vehicle price and fuel cost (Beggs et al., 1981; Cambridge Econometrics, 2008; Curtin et al., 2009; Eftec, 2008; EST, 2007; Garwood & Skippon, 2010; Santini & Vyas, 2005). Discount rates are used widely when assessing a consumer's awareness of lifetime cost savings and therefore predicting market uptake of new energy saving products ranging between 0 and 41% (EST, 2007; Sovocool & Hirsh, 2009; Beggs et al., 1981). The higher the discount rate, the less consumers take account of lifetime costs.

Based on consumers' actual expenditure on fuel with their current vehicles, in the US context Curtin et al. (2009) found the average payback period for the added premium to be offset by fuel savings ranged from 2.0 to 8.5 years at an inflation-adjusted discount rate of 3%. In the UK, Cambridge Econometrics (2008) found that households are willing to pay £510 in extra purchase price to reduce fuel costs by £1 per 100 km, implying a discount rate of 6–19%, a rate comparable to the findings of other studies. Garwood and Skippon (2010) conclude that consumers will be willing to pay purchase premiums of up to four times the perceived annual running cost savings.

EST questioned the relatively high valuation their UK-wide consumer survey inferred for fuel consumption. The valuations implied the average consumer would capitalise up to 20 years of fuel costs at the point of purchase (at 2007 fuel price). EST make the observation that, in addition to the effect of "'*expectation bias' whereby survey* *respondents tend to overestimate the factors the survey is supposed to be investigating"* (p35), the discrepancy may reflect consumers' difficulty in converting from fuel consumption (expressed in litres/100km and miles per gallon (MPG)) into an effective yearly cost.

This concurs with several studies showing that the majority of consumers do not have even the fundamental building blocks to be able to make detailed payback calculations. Three separate studies in California with conventional vehicles, HEVs and PHEVs found that few consumers of any vehicle type actually perform payback computations when purchasing any type of vehicle (Heffner et al., 2007; Kurani et al., 2007; Turrentine & Kurani, 2007). The latter study included eight hybrid owners and the authors emphasise "*no hybrid owner we interviewed was solely or even importantly interested in saving money on gasoline. They did know a lot more about the vehicle and the environmental issues it addresses than they did about their own gasoline cost"* (Turrentine & Kurani, 2007, p1221).

These studies found that many did not know the mpg of their vehicles, much less what they spent cumulatively on fuel in a month or a year. Therefore, the authors suggest such consumers will have no way of knowing how much they might save in a 'fuel economic' vehicle.

Similarly, two recent studies in the UK (Anable et al., 2009; Lane & Banks, 2010) investigated recent purchasers of brand new or nearly-new vehicles and found the 'mpg' metric is rarely used by motorists to calculate future costs or to systematically compare vehicles. Instead, simplistic rules are used to decide on what is 'good' or 'bad' such as simple comparisons with the previously owned vehicle, or assuming all cars in a certain vehicle class will have approximately the same fuel economy. Once the initial 'ball park' criteria have been satisfied, no further comparisons or calculations are made. These are the simplifying heuristics highlighted in Table 6.

In both studies, around half the sample were able to quote their car's fuel economy in terms of miles per gallon and around 35% of the 2010 web-survey sample were able to volunteer a value for annual fuel cost. Consumers are most likely to offer a value for the most recent expenditure to fill up the tank, or an average weekly or monthly fuel cost. In the Cambridge Econometrics study (2008) only 17% were able to state the fuel efficiency band of the car they had purchased.

Other studies have set explicit exercises to test people's understanding of mpg. Larrick and Soll (2008) found the mpg metric is frequently misunderstood and can lead to inaccurate judgements. For instance, the idea that upgrading a car from 18mpg to 28mpg saves twice as much fuel for the same distance of driving as upgrading from 34mpg to 50mpg generally tends to catch people out. This reflects the fact that mpg does not capture the way people generally conceptualise fuel economy.

The inability of consumers to balance longer term running costs with upfront investment is otherwise known as consumer 'myopia' (Skinner et al., 2006). Lane (2005) identified a number of reasons why 'mpg' is reported by car buyers as a key decision factor, but in reality, little effort is made to compare fuel consumption data during the car-purchase process:

- car buyers assume a similar 'mpg' for all cars within a class;
- car buyers have little confidence in published fuel economy data;
- car buyers believe that improving 'mpg' compromises performance and safety; and
- fuel costs are too complex for consumers to compute (combining 'mpg' and pence per litre to give pence per mile).

There are three factors which may serve to strengthen the role that fuel economy plays in the choice of vehicles.

Firstly, rising oil/petrol prices may lead to more economically rational consideration by consumers. There is evidence of this in the UK market where UK motorists are now taking account of fuel economy and choosing more fuel-efficient cars as evidenced by the significant shift to smaller cars in recent years (SMMT, 2010a). However, the research by Anable et al. in the aftermath of the rising oil prices in the UK in 2008 showed that it is not the fuel economy metric itself which is conceptually driving behaviour (Anable et al., 2009). Although car buyers still refer to fuel economy (in terms of 'miles per gallon' or equivalent) it was more simply the cost to fill up the tank that instigated the change in behaviour towards more efficient vehicles.

Secondly, a related factor is the rate at which fuel prices may increase and the specific impact this has on behaviour. Smaller gains in fuel economy seem to be evaluated with a higher discount rate than larger ones (Santini & Vyas, 2005). Santini and Vyas argue that consumers are likely to pay more careful attention to fuel savings when the amounts are large. The differential can be due to technical efficiency, but can also be due to the rate with which oil prices rise. Anable et al. (2009) concluded that the rapidity with which prices had risen during 2008 had led to a threshold effect in which fuel costs had penetrated sufficiently into consumers' consciousness so as to stimulate new behaviours. Sovacool and Hirsh (2009) similarly concluded that the fuel price rises in the UK during 2008 had convinced some consumers to switch permanently from gas-guzzling to more energy-efficient automobiles. But it also appears that the motivations for this switch were not detailed economic analyses, but simple reactions to sharp increases in the price of fuel. Moreover, Kurani et al. (2007) observed that respondents appeared to assume that electricity would remain either constant in price, or would increase in price more slowly than gasoline.

Thirdly, the diversification of fuel choices and prices could have an impact on consumer decision-making processes, particularly in conjunction with volatile oil prices, awareness of oil dependence and security as well as new fuel economy instrumentation and CO_2 awareness (Kurani et al., 2007). Studies based on real consumer experience so far suggest that these new energy sources do not result in more attention being paid to fuel costs. For instance, Kurani (1992 cited in Kurani et al., 2007) studied Compressed Natural Gas (CNG) buyers in New Zealand and found that instead of calculating fuel costs, *relative* natural gas and gasoline prices were used to gauge satisfaction with their vehicle conversions. More recently, the same authors observed that drivers of PHEVs omitted their grid-based electricity use when discussing fuel economy even though many in-vehicle displays indicated the consumption of both sources of energy. Whilst different behaviours may be observed in BEVs, it seems plausible that consumers are accustomed to measuring vehicle fuel economy in a certain way and there is little indication of how electricity use will be conceptualised and evaluated.

Once again, the early adopter segment is often hypothesised as being atypical of how the market will develop (see Section 2.7). It could be, for example, that early adopters of EVs may not undertake any meaningful calculation of fuel consumption and cost as they are less motivated by financial savings. On the other hand, a finer segmentation of HEV early adopters between 2003 and 2007 in the US found four of the five segments they identified as clearly financially motivated in their own way (Klein, 2007). These motivations are outlined in Box 1.

BOX 1: Five Segments of Prius Car Buyers in the US (2003–2007)

The Prius costs less than the alternative

- Consumers are able to purchase and operate the Prius for less, sometimes far less, than they would have spent on a car if they had not purchased a hybrid.
- It cannot be assumed that the consumer is choosing between two otherwise identical cars and elects to purchase the hybrid car instead of the one with the conventional gas engine.
- Even those who would have spent an identical amount on a conventional car had a financial motivation—they believed that the Prius would save them money on gas.

Buyer calculated return on investment differently than the experts

- 16% of Prius buyers stated that the primary reason for buying the Prius was to save money on gas and given the various analyses that show hybrids do not save enough on gas to pay for their higher purchase price, there might be a tendency to view these people as making an uninformed choice.
- However, all analyses regarding the costs and benefits of a hybrid purchase are based on assumptions—whether or not hybrids make financial sense is very much in the eye of the beholder and a cash flow analysis of hybrid ownership costs coupled with intended length of ownership can lead to a conclusion that hybrids make economic sense.

Buyer bought the Prius to drive in the carpool lane

- For 12% of buyers, getting to drive in the carpool lane even when they were driving alone was their primary motivation for buying a Prius and far exceeds the incremental cost of the car.
- At the time of the study six states (Arizona, California, Florida, New Jersey, Utah, and Virginia) allow some hybrid drivers to drive in the carpool lane regardless of the number of passengers in the car.

Buyer bought the Prius as an inexpensive fun car

- 5% of the respondents purchased their Prius because they liked its image as a fun car.
- The Prius' distinct image was an important factor and all of these people would have bought a less expensive car if they had not purchased the Prius.

Early adopters

- 27% of the study sample comprised of people willing to pay a premium to help the environment or to be among the first to own a hybrid.

Source: Klein, 2007

The segmentation outlined by Klein has a parallel with Santini and Vyas' solution to the problem posed by the fact that consumers do not undertake any considered calculation of future running costs. They offer the hypothesis that "*once the pragmatic majority buyer decides that a technology is interesting, that buyer seeks out other scarce, but important, expert pragmatists to acquire the information needed to make an intelligent decision on whether to make a purchase. Thus…the fact that buyers do not know how to use Net Present Value*[7] *(NPV) analysis is not important — what is important is that they*

[7] Defined as the sum of the present values (PVs) of the individual cash flows/costs

know where to find information from someone who does do NPV analysis" (Santini & Vyas, 2005, p98).

Fuel economy can be a symbolic factor as well as a functional one. Lane and Banks (2010) believe the high importance that new UK car buyers attribute to fuel economy can be seen not only as one of the most important car purchase factors, but also as a way of conceptualising a car's environmental impact. Kurani et al. (2007) found fuel economy to be an important symbol among drivers who view resource conservation or thrift as important. They also noted that consumers also assign non-monetary meaning to fuel prices, for example seeing rising prices as evidence of conspiracy.

In addition to highlighting the limitations inherent in rational choice modelling of consumer behaviour, the findings on fuel economy have implications for incentivisation of EVs and recharge tariff structures discussed in Section 2.6. In summary, the evidence review suggests that whilst there is no question that widening the gap between electricity prices and fuel prices will make EVs more attractive, policy makers and modellers may have a tendency to over-emphasise the importance of rational deliberation of longer term running costs and payback periods. Similar conclusions apply to recharging behaviour where patterns may not be driven by cost savings but more by convenience.

2.3.5 Other running costs

Consumer myopia also applies to other relevant cost factors such as tax, maintenance, insurance, depreciation, disposal costs and, in the case of EVs, costs of battery replacement. These costs could be important in the uptake of EVs because of possible trade-offs between the higher capital cost and frequency of battery replacement, and the lower tax and maintenance costs (Ewing & Sarigöllü, 1998; Cao & Mokhtarian, 2003). Gärling and Johansson (1999) found that low maintenance costs were one of the perceived benefits most frequently in interviews of families who had used an EV for three months.

Table 8 showed that in simple ranking exercises these attributes are given less weight in the decision-making process. Service and maintenance costs have been examined in a variety of SP surveys (Table 7), often combined in a category covering all vehicle running costs. As expected, discrete modelling exercises conclude that these costs have a negative impact on preference and the effect is usually weaker than other measured attributes.

Perhaps as a consequence of this, they are rarely considered in any detail in studies of car purchasing behaviour. One exception is Ewing & Sarigöllü (1998) who estimate how much lower weekly commuting costs would have to be to compensate people for each $100 annual increment of maintenance costs for an EV. The conclusion was that to have competitive running costs, savings from the EV's lower operating costs should be triple any higher maintenance costs it may incur. This suggests that policies such as electronic road pricing or carbon taxes for non-EVs might be needed to help improve the image of the EV's relative operating costs.

Similarly, Potoglou and Kanaroglou (2007) estimated willingness to pay for acquiring benefits such as reduced maintenance and fuel costs, tax exemptions, and improved vehicle performance. They concluded that households would pay between $500 and $1200 to save $100 in annual maintenance cost.

Resale value is thought to be an important consideration in car purchasing and yet is rarely examined as a discrete adoption factor. In-depth interviews with recent purchasers of new cars found a fifth of the sample spontaneously mentioned resale value as a cost issue that had played a role in car choice (Anable et al., 2009). However, a similar unprompted questioning technique on a larger sample did not find people mentioning depreciation as an important factor (Lane & Banks, 2010). Using historic data in a nested logit model, EST (2007) found resale price to be an important determinant of household choice of new car.

The impact of battery replacement cost on consumer willingness to adopt EVs is virtually unexplored in the literature reviewed for this study. Santini and Vyas (2005) recommend including the lease cost of the battery pack as a proxy variable, but do not discuss the potential impact on preference.

Another cost factor specific to EVs is the possibility of generating revenue by selling electricity back to the grid. Vehicle-to-grid (V2G), combined with smart charging, has been proposed as one method to offset the additional costs of PHEVs. This concept has not been explored with UK consumers in any of the literature reviewed. However, Kurani et al. (2007) found that the drivers that did mention this technology were either employees of the electric utilities or were excited about the possibility of providing electricity to their home during electricity outages. Sovacool & Hirsh (2009) are pessimistic about this technology as they feel that even with technical problems resolved, the V2G concept may not gain widespread acceptance if the experience of the first-cost hurdle experienced in other technologies (e.g. home insulation, water heaters) are anything to go by. Nevertheless, the ideas of EVs providing extra revenue or emergency power may be valued by some consumers and is likely to be worth further evaluation in the UK context.

2.3.6 Performance

For EVs to gain mass market acceptance it is generally thought that the performance and drive aspects need to be similar or superior to conventional vehicle technology. Preferences for greater fuel efficiency are often found to be overshadowed by stronger affinities for power, acceleration and size (Thatchenkery, 2008; Axsen et al., 2009; Lane & Banks, 2010).

Yet assigning a standard measure of utility to a vehicle’s performance or other attributes is difficult as the level of utility depends on the individual’s perception (Alvarez-Daziono & Bolduc, 2009; Skinner et al., 2006). This is especially important with respect to vehicle performance as consumers have been found to have generally negative perceptions with regards to alternative vehicles’ attributes, especially with regards to performance.

For instance, in recent focus group discussions in London, EVs were the most widely known type of AFV (Lane & Albery, 2009). This may be because of the London setting of the research and the rapid uptake in recent years of G-Wiz electric quadricycles in the city due to their exemption from the Congestion Charge. There are also several electric charging points in Camden where the research took place. Yet, the researchers note that very few people are able to explain confidently how EVs work but nevertheless hold a general perception that EVs have a lower level of performance than conventional vehicles, with inferior acceleration, lower top speed and low range being common issues mentioned. It is interesting to note, however, that this lower performance is not always viewed as a disadvantage given the driving conditions in London. A second point worthy of note is that unlike similar surveys conducted a decade or so ago, Lane and Albery remark that ‘milk-floats’ are not mentioned by participants in any of the discussions, suggesting that evaluations of EVs have improved in recent years.

With respect to hybrid vehicles, a minority are often also confused about whether hybrid vehicles need to be recharged as well as refuelled (Lane & Albery, 2009; Axsen & Kurani, 2008). However, in the recent UK study, participants who had an opinion about this technology were generally positive about the level of performance and usability offered by hybrid vehicles. By contrast, in the USA, Greene et al. (2004) found that consumers think of fuel economy and low pollution, but not high performance in relation to hybrid vehicles.

Importantly, in the findings of the few EV vehicle trials that have been conducted (see Table 3), ratings of EV performance increases once consumers have gained some experience of the vehicles. Garwood and Skippon (2010) found that EVs were perceived by consumers as having better 0–30mph acceleration, better smoothness and lower noise than conventional vehicles after short drive-trials with four-seater Mitsubishi iMiEV vehicles.

Recent trials in the North East of England found that although the overall performance of the (two-seater Mercedes Smart) vehicles was rated as better than a similar-classed fossil fuelled vehicle, users rated the noise level and the environmental feel good factor of the EV more positively than other performance criteria (Carroll & Walsh, 2010).

In a study of drivers of converted Toyota Prius', Kurani et al. (2007) note that the most common request was for higher top speed and the ability for all-electric drive on highways, but that few commented on other related performance metrics such as acceleration times or passing power. This supports Santini and Vyas' (2005) argument for inclusion of at least one top-speed variable in SP surveys.

2.3.7 Size and carrying capacity

Size/practicality was ranked as the top decision-making factor when choosing a new car in a 2009 internet survey in the UK (GfK, 2009), and ranked second in the recent unprompted survey undertaken by Lane and Banks of over 1,000 purchasers of new vehicles in the UK (Lane & Banks, 2010) (Table 8). In parallel focus groups, vehicle size ranked as the most important purchase issue as measured by the number of discussion points generated during the focus groups, and was one of the top three factors in five of the six groups (*ibid.*). It is a vehicle attribute often traded off with fuel economy. As the reason most often given for the importance of vehicle size was the need to carry children, the choice of car was seen to be heavily influenced by life stage. The exception to this was when choosing a second car enabling respondents to choose a model more to their own liking rather than serving family requirements.

The authors note that for many participants, size was a common starting point for vehicle selection, and a factor which had priority over other purchase issues. Terms repeatedly mentioned are 'number of seats or doors', 'headroom', 'legroom', 'boot space', 'seat height' and 'physical size' of the vehicle. Similarly, Skinner et al. (2006) suggest that where size ranks lower in surveys this could be accounted for by the 'two stage' decision process wherein an initial filter is applied to select vehicles of the desired size and body type, after which other attributes are considered.

Traditional functional vehicle characteristics such as performance and vehicle size are still of considerable symbolic value alongside fuel economy and low CO_2 emissions. Symbolic values are discussed in Section 2.4.

2.3.8 Range / battery life

Several authors have compared current travel patterns with the likely range and charging infrastructure that may be available.

In the UK context, Element Energy has offered the most comprehensive analysis of travel patterns of existing EV owners and 'considerers' in addition to analysis of the UK National Travel Survey. Their findings are summarised in Box 2.

Box 2: What proportion of UK car mileage could be carried out using EVs?

Analysis of EV owners and 'considerers'

- For those with EVs already, the vehicles are most commonly used for travelling 10–20 miles a day, with some using them for up to 40 miles a day. They observe that the daily mileage of 'EV considerers' is generally greater than 40 miles and their journeys for commuting, visiting friends and family and school runs tend to be longer.
- EV owners typically have lower mileages than the population overall.

Results from the NTS Analysis

- The driving patterns of a significant proportion of the UK population are dominated by relatively low daily distances. For example, half the people in the sample analysed did not exceed 40km (25 miles) on any day of the travel diary week. This implies that the majority of trips for many drivers could be done by today's EVs.
- Commuting is the dominant trip purpose and around two-thirds of commuting trips are less than 16km (10 miles). This suggests that there are a significant number of commuters with round-trip commutes of less than 20 miles.
- An important distinction must be made between trips and distance. For example, a vehicle with a utilised range of 100km would account for over 90% of trips, but only 60% of overall UK car-km.
- Assuming a utilised range of 80km (note that the capable range is much higher, between 120km and 240km), 50% of all UK vehicle-km can be undertaken by EVs. The remaining distance is undertaken by a relatively small number of high mileage individuals.
- A combination of increased EV range and suitable range extension facilities (i.e. charging infrastructure and/or battery exchange networks) will be needed to achieve high EV car-kilometres and deep cuts in CO_2 emissions.
- To achieve an 80% reduction in CO_2, assuming that renewable electricity was used to charge EVs, would require a vehicle with a utilised range of approximately 200km (and therefore a capable range between 300km and 600km, assuming current behaviour patterns). Battery technology is unlikely to deliver this very high, single charge range in an affordable vehicle.
- If all drivers switched to PHEVs with electric range of 30km, up to 48% of all car-km could be done in electric mode. This percentage rises to 63% and 72% for PHEVs with electric range of 50km and 70km respectively.

Source: Element Energy, 2009

2.3.8.1 Range anxiety

Limited range and long refuelling times are significant barriers to the acceptance of EVs. The potentially lower operating costs of EVs compared to conventionally powered vehicles are not valued highly enough to overcome both the purchase price and this major disutility, especially for BEVs (Beggs et al., 1981; Chéron & Zins, 1997; Element Energy, 2009; Garwood & Skippon, 2010; Golob & Gould, 1998; Santini & Vyas, 2005).

The most comprehensive evidence to explore the issue of range has emerged from before and after studies of vehicle trial participants or existing owners of BEVs or PHEVs.

Table 9 summarises the seven studies reviewed in which trials had formed a major part of the investigation.

Table 9: Summary of before/after studies of vehicle 'trials'

Author	Which cars	Method	Who	Where	When	Data collection
CABLED (2010)	25 Mitsubishi iMiEVs (range 60–80 miles on full charge)	Vehicles loaned for 12 months	Members of public part of TSB/CABLED trial		Dec 2009- March 2010	Usage data (not charging) collected from demonstrator vehicles
Carroll & Walsh (2010)	4 BEVs (two seater: smart Mercedes, 60mph top speed)	1–4 vehicles loaned up to a month to fleet users/ managers & public 'test drives'	10 fleets, 195 drivers (7 local council, 2 private company, 1 university) & 69 members of public at 3 events	NE England	~2009	Fleet user (N=113), fleet manager (N=8) and public drive events before and after questionnaires
Gärling (2001)	BEVs (Renault Clio Electrique, 4 seater, 60–70km range, 10 hr charging time)	Loaned to families for three months, chosen from a random survey	42 families with at least one child & 32 Renault Clio owners	Sweden (Goteborg)	1998–2000	Before/after interviews; travel diaries in weeks with own car (before and after) and with the EV in alternate weeks during the trial (N=74)
Garwood & Skippon (2010)	BEVs (Mitsubishi iMiEV; 4 seats, 100 mile range, charging time 6–7 hours)	10 mile drive: pairs of participants each driving for half the round-trip OR commute home, recharge at home, return next day	92 employees of E.ON	UK (not specified)	2009–10	Post experience questionnaire (N=58)
Golob & Gould (1998)	BEVs (Manufacturer prototypes; two-seaters, range = 100m)	Loaned to families for two weeks	69 private individuals selected from survey sample	California	1995–96	Travel diary (N=63) & pre & post surveys (N=69)
Kurani et al. (2007)	15 PHEV conversions	Had all been operated for less than 12 months	23 individuals whose (private or company) HEVs had been converted	USA-wide (mainly California)	2006–07	Semi-structured interviews
Martin et al. (2009)	Hydrogen FCVs (Mercedes A-Class F-Cell)	Ride and drive clinics: 3 mile drives & visit to refuelling station in pairs	182 employees of public departments and the University	California	2007	Pre and post surveys (N=182)

A recent study of participants of a short-drive BEV trial in the UK concluded that BEVs with a range of 100 miles will start to be attractive as second cars; with a range of 150 miles they will start to be attractive as main cars (though not to high income consumers) (Garwood & Skippon, 2010). One study in Europe found that interest in owning EVs actually *decreased* after a few months of use due to concerns over range and that the range per charge should be at least 130km (compared to the 60–70km range of the Renault Clio Electrique trial vehicles) (Gärling, 2001). Golob and Gould found that experience with BEVs did not change perceptions about desired vehicle range. Even though keeping a travel diary gave users direct feedback that they were usually travelling less than 50 miles per day, there remained an expectation that vehicles should have a range of 100 miles or more (Golob & Gould 1998).

Thus, a high premium is placed on the ability to have the *option* to drive long distances, despite the fact that most consumers acknowledge that longer trips can be relatively rare (Element Energy 2009). The majority of participants in the Swedish study felt the range should be longer even though their experience in the trials was that the EV had fulfilled their travel needs and expectations (Gärling 2001). Golob and Gould suggest it may be to do with a "*psychological association between vehicle ownership and the freedom to travel with wider boundaries*" (Golob & Gould, 1998, p447).

2.3.8.2 Under-utilised range

In BEV/PHEV trials, drive data shows that users are over cautious when planning journeys. In recent BEV trials with public and private fleets in the North East of England, the maximum journey length was 18km, representing only 46% of the minimum vehicle range (Carroll & Walsh, 2010). The authors of this study suggest that range anxiety effects were significant throughout the trial with 93% of journeys commencing with over 50% battery state of charge and only 7% of journeys were undertaken when the battery was showing less than 50% state of charge. Moreover, users began modifying their driving style when the state of charge approached 50%.

The first data to be released from one of the UK's Technology Strategy Board (TSB) trials shows data for 25 Mitsubishi iMiEVs during the first three months of usage (using GIS data loggers) (CABLED, 2010). Approximately two-thirds of all journeys made were shorter than five miles in length (mean=six miles), with quite high frequency throughout the day, suggesting people use their cars for short journeys at lunch time or to collect children from school. The mean distance driven each day was approximately 22 miles.

Analysis of existing BEV users in the US suggested that between one third and one half of the technical range is actually used (Golob & Gould, 1998). In Swedish trials, around 50% of total driving range tended to be used and only two out of 74 participants said they had started to recharge after the warning light came on (Gärling, 2001). In Tokyo, battery utilisation rates were examined before and after fast charging was made available in the city (Tepco R&D Centre, cited in Element Energy, 2009). Beforehand, around one-third of the potential range was utilised, but this increased to two thirds following installation. This suggests that fast charging, as opposed to just number of charging points, could be a key factor in optimising EV range.

The BEV trial study in Sweden examined which trips were undertaken in the EV (Gärling, 2001). Trips with the BEV were shorter than those with the participants' own cars and most commonly used for work, chauffeuring and shopping. Indeed, the latter two journey purposes increased when the participants received the BEV. Interestingly, more than half of the participants reported a change in their travel behaviour and their way of driving to match the specific attributes of the BEV. About 15% of the participants stated that they had had to give up car trips, 30% that they had had problems with the limited driving range, 5% that they had had problems with the relatively long recharging time, and 25% stated that they had had problems with the limited cargo space.

Element Energy concluded that *"[i]n the early stages of EV adoption, concerns over infrastructure may limit exploitation of range to circa one third of technical capacity. Longer term this utilisation ratio should increase as users become more familiar with the technology and fast charging infrastructure becomes more widespread"* (Element Energy, 2009, p13).

2.3.8.3 Willingness to pay for extended range

In two choice experiments of both existing UK EV owners and 'considerers', participants were asked how much they would pay for additional range or how much range they would expect for a given cost (Element Energy, 2009). Whilst EV owners had a slight tendency to be willing to pay more than considerers, there was a wide range in values (between £45 and £111 per mile).

2.3.8.4 Will consumers prefer BEVs or PHEVs?

PHEVs do not suffer the same restrictions as BEVs given the range extension provided by the liquid fuel operation. Several studies have concluded that consumers are likely to prefer PHEVs (Axsen & Kurani, 2010; Axsen et al., 2010; Element Energy, 2009; Garwood & Skippon, 2010; Kurani et al., 2007).

In an experiment using a one-day diary, a tutorial on PHEVs and design games in which participants could create their own vehicles and set their own goals, there was a strong interest in increasing vehicle range, but not through all-electric range (AER). The strongest motivation was for higher fuel economy achieved through blended operation. All-electric operation was incorporated into the designs by only 2.7% and 3.9% of respondents in the higher and lower cost conditions respectively (Axsen & Kurani, 2008; Axsen et al., 2010). With respect to PHEVs, Kurani et al. (2007) found that most owners run their cars on electricity as much as possible when driving conditions permit.

These studies concluded that most of those who are interested in a PHEV are interested in less technologically advanced PHEVs than assumed by experts. Another study concluded that 20 miles of all-electric range seemed to be the minimal acceptable amount (Kurani et al., 2007). This study concluded that the solution is likely to be to offer PHEVs in a variety of configurations with some PHEVs which offer no AER but instead attain very high fuel economy with a lower purchase price, and others with higher AERs appealing to different segments of car buyers. This would include those who are strongly motivated by the symbolic meanings of PHEVs.

Element Energy found that EV owners are willing to pay slightly more for PHEVs than considerers of EVs, although even among these early adopters of EVs, the amount they are prepared to pay is lower than battery supply costs. Nevertheless, Element Energy conclude *"...that PHEVs with a range of 40 miles in electric mode could achieve significant market uptake while delivering electrification of the overwhelming majority of vehicle trips"* (Element Energy, 2009, p1).

Another possible solution is that households will adopt a multi-car solution to optimise range and recharging time and the choice of which vehicle to use (Chéron & Zins, 1997; Gärling, 2001; Golob & Gould, 1998). Indeed, Element Energy comment that nearly all the EV owners in their study also had access to a non-electric vehicle (Element Energy, 2009) and Golob and Gould (1998) found that whilst participants in the vehicle trial were able to use the EV for much of their daily travel, they switched to gasoline vehicles on days with longer trips. Kurani et al. (1996) developed the concept of 'hybrid households' to refer to households that own various vehicles to satisfy different travel needs.

2.3.9 Availability of charging points

Range anxiety is likely to be exacerbated in the current situation where public charging infrastructure is minimal (Element Energy, 2009; Carroll & Walsh, 2010). However, studies have generally found the lack of recharging infrastructure to be less of a concern to consumers than range *per se*. Indeed, the clear consensus in the evidence so far is that consumers will mainly recharge their EVs at home and in workplace car parks, and frequent recharging will be the norm at least at first (Garwood & Skippon, 2010; Gärling, 2001; Element Energy, 2010; Kurani et al., 2007).

Nevertheless, qualitative and quantitative research consistently reveals a concern from consumers about how and where they will be able to 'fuel' their vehicles (PlaNYC, 2010; Element Energy, 2010; Golob & Gould, 1998). A key issue in predicting the environmental benefits and fuel savings from PHEVs is the frequency and timing of recharging, especially when many studies assessing the impact of EVs on the electricity grid generally assume these vehicles will charge only during periods of off-peak power demand.

2.3.9.1 What patterns of charging behaviour might consumers adopt?

In the vehicle trial studies outlined in Table 9 and other studies of EV owners, recharging patterns have been documented.

A survey of 36 existing EV owners (unspecified types) in the UK found they primarily recharge their EVs at home and commercial owners at company premises (Element Energy, 2009). Similarly, in three month trials of EVs with 74 families in Sweden, the EVs were most often charged at home (66–82% of recharges) and there was no change in recharging behaviour over time (Gärling, 2001).

In the trial of fleet users in the North East of England, a mix of indoor and outdoor charging was used (Carroll & Marsh, 2010). Half of the public sector fleets had some access to dedicated recharging infrastructure and consequently rated charging facility availability and safety 20% and 13% higher than private fleets respectively. Overall there was a positive attitude towards charging which the authors believe shows that the users accepted the EV charging requirements, and did not draw comparison to refilling a conventional vehicle with fuel.

Table 10 summarises the different charging regimes used. Some users may have experienced all the charging regimes whilst others only a few.

Table 10: Recharging method, equipment and frequency in the Cenex EV trial

Recharging regime description	No of recharging regime experiences
Recharged at work	86
Recharged indoors	45
Recharged using dedicated recharging facilities	38
Recharged outdoors	39
Recharged using a normal indoor plug socket	39
Recharged using an extension lead	18
Recharged using a normal outdoor plug socket	9
Recharged at home	7
Total	**281**

Source: Carroll and Marsh, 2010

Usage data after three months of use of 22 Mitsubishi iMiEVs in the UK showed that each car is parked on average 97% of the time (Aston University, 2010). Usage data shows two main periods when a vehicle is parked (and thus can be charged): 8pm–7am when most cars will be at home locations provides the main opportunity for charging and 9am–3pm also provides a period when EVs are used less and thus could be charged. However, the authors suggest that because this trough is not too pronounced, if people do need to charge in this period, fast charging would be more appropriate. People tended to leave their EV plugged in overnight or even for several days if they were not using it. There was an initial peak between 6pm and 8pm and between 10pm and 2am when people set the timer on their charger so as to benefit from off-peak power. Other statistics associated with the charging data show that people charge their EV every 0.57 days, that is, approximately twice a day. Also the EV was plugged in for the equivalent of 22% of the time.

In observations of 15 PHEV conversions in the USA, nearly all vehicles were regularly charged during daytime business hours. When drivers had the capability to refuel from the electricity grid (which was often, as all could recharge from a common household outlet) and, as for many of these people, did not personally face the different costs of doing so, they recharged whenever possible. This included 'opportunity' charging at hotels, friends' houses and offices visited during the day. The vehicles that were plugged in most often were those that made short trips (less than 40 miles) and regularly returned to a single location where recharging was available. Many participants explained that since they were driving a PHEV, they wanted to take advantage of recharging (Kurani et al., 2007). However, in a study of driving patterns, parking and charging availability, home was identified as by far the most frequent location of recharge opportunities within respondents' existing travel and recharge potential. Neither work nor other non-home locations had recharge potential that was available for more than 9% of respondents for any 15 minute interval during the day (Axsen & Kurani, 2010).

2.3.9.2 Availability of parking

Parking affects recharging, and the patterns observed in private households and to some extent fleet vehicles will be dictated to a large degree by parking availability.

The English Household Condition Survey (CLG, 2007) offers an indication of the proportion of households with access to various types of parking facilities. Analysis of this dataset indicates that fewer than 50% of city centre households have access to adequate parking facilities, while around 95% of rural households do have parking (Element Energy, 2009). However, Element Energy note that both household car ownership and parking availability increase as rurality increases, which suggests that most car-owning households do have access to parking. In addition, their analysis of the ONS Omnibus survey also suggests that around 80% of car owning households use a garage or other off-street parking facility. They conclude "*[t]his suggests that in a world with mass uptake of EVs, a large proportion of EV owners would be expected to recharge at home and would not require additional infrastructure to keep their vehicles charged at home"* (Element Energy, 2009, p30).

Studies in California also agree that reliance on proxy aggregate variables such as housing types and parking availability can lead to underestimates of the potential to recharge. Estimates of parking availability could be overly pessimistic as households who buy new cars may be more likely to live in houses with dedicated parking facilities (Axsen & Kurani, 2008; Axsen & Kurani, 2010, Axsen et al., 2010). They suggest it is worth considering the opportunities for additional charging outlets that people may have. In addition to a web-based survey and the use of PHEV design games, they produced a travel diary which also asked people to record their proximity to the nearest charging plug every time they parked. A parking spot was considered to be viable for recharging if located within 25 feet of an electrical outlet. They believe this identified more home-charging opportunities than aggregated Census or other data identified. From these studies they conclude:

- at least half of the survey population (N=877) are already equipped for at-home vehicle recharging;
- people currently have little opportunity to recharge at their workplace or other locations: only 4.4% of respondents found outlets at work, and 9.1% found outlets at all other non-home locations (e.g. friend's home, school, or commercial site);
- recharge potential (i.e. the spatial-temporal correspondence between a parked vehicle and a 110-volt electrical outlet) peaks between 12am and 6am when most vehicles are parked at home and reaches a broad minimum from 10am to 4pm when most vehicles are parked at work or other locations or are being driven; and
- given the access to recharging and the distribution of PHEV designs from the games, the authors estimate that about one third of U.S. new vehicle buying households have both the required infrastructure and interest to purchase a vehicle with plug-in capabilities.

Survey research in New York noted that, of those who do own a car, many park their cars on the street or in commercial garages (PlaNYC, 2010). Nevertheless, they believe a large group of early adopters will be willing to change behaviour to accommodate EVs by paying more to obtain an assigned parking spot. These early adopters did not express a strong need for public charging infrastructure to be available through the city.

2.3.9.3 Average time parked at a destination

In the study of 36 EV owners (unspecified type) in the UK, many considered that additional recharging facilities on-street, at petrol stations, public car parks, supermarkets, and in the driveways/garages of friends and family offer moderate or high benefits (Element Energy, 2009). However, an estimation of the utility of publicly available slow charging facilities using the trip diary data in the UK National Travel Survey shows that when away from the home or office, the average resting time of a vehicle at its destination is around one hour (Element Energy, 2009). This suggests public slow charging facilities would be of limited value. Slow charging facilities at workplaces, on the other hand, could be of high value to commuters given that cars spend around seven hours on average parked at the workplace and around three-quarters of commuter cars are parked in private car parks.

This analysis, combined with the evidence cited above (i) from Tokyo that fast charging points are likely to promote increased utilisation of EVs and (ii) that public recharging infrastructure is not the primary barrier to uptake, suggests that any prioritisation of investment in slow charging facilitates could be misguided (Element Energy, 2009; PlaNYC, 2010). However, public charging infrastructure could play an important role in the diffusion of this technology by signalling its success and changing social norms.

2.3.10 Time spent recharging

Linked to the issues of range and charging infrastructure discussed above is the issue of the value of time spent refuelling or recharging vehicles. This falls into two issues: (i) the willingness to pay for faster recharging times in order to extend the flexibility and range of a vehicle and (ii) the value of time saved not having to visit petrol stations.

On the first issue, the evidence suggests that people do not seem willing to devote extra resources to reduce recharging time. In a simple choice exercise between cars with a range of either 50 or 100 miles and recharge time of three, six or 12 hours, range was found to be more important than recharging time unless the difference in recharging time for short and long range vehicles is large (Garwood & Skippon, 2010). Similarly, in a US study, few respondents were willing to devote resources to reduce recharging time (Axsen & Kurani, 2010). In a study of PHEV drivers in the US, rapid charging was not a priority for most drivers in this study; most were satisfied with 110V recharging.

However, this example illustrates that for some PHEV drivers, rapid charging is important (Kurani et al., 2007).

On the second issue, there is little evidence on the nuisance value associated with refuelling events. Qualitative research has found some people would value not having to go to a petrol station (Kurani & Turrentine, 2007). Another study looked at both diesel and hybrid powertrains and concluded that models must consider not only the value of time saved refuelling but also the nuisance cost of refuelling in order to correctly estimate the value of greater range (and presumably the lower physical effort and time spent personally refuelling with an EV) to consumers (Greene et al., 2004).

2.3.11 Emissions/environmental performance

Findings from studies on vehicle purchasing behaviour in general conclude that, in comparison with performance and capital cost attributes, environmental benefits are of relatively little importance in the purchase decision (Skinner et al., 2006; Lane, 2005; Lane & Banks, 2010; Anable et al., 2009; Angle et al., 2007; Roche et al., 2009). Even where consumers are aware of a car's environmental performance, the consumer is still unlikely to choose a car on this basis as other attributes are generally more important (Thatchenkery, 2008).

Despite recent changes in the UK to link Vehicle Excise Duty (VED) to CO_2 emissions rather than engine size, engine size still plays an important role in people's minds with respect to a vehicle's environmental impact and many believe that style and performance need to be compromised to 'be environmentally friendly' (Anable et al., 2009; Banks & Lane, 2010; Angle et al., 2007). Moreover, the concept of 'emissions' is much less familiar than the concept of fuel economy. In particular, car buyers are consistently more able to benchmark a figure quoted in 'miles per gallon' than they are a value of CO_2 emissions. Fuel economy is primarily perceived by car buyers as a running cost rather than as an environmental proxy—'cost effective' or 'cheap to run' are phrases often associated with 'fuel economy' and 'miles per gallon' or 'mpg'. Lower emissions are often seen as a 'bonus' once the primary objective of lower running costs has been secured (Lane & Banks, 2010).

However, a web survey of 1,000 recent car purchasers in the UK discovered that environmental attitudes did influence the rankings of the most important purchase factors so that those who claim to be most concerned ranked fuel economy higher and price lower than the average (Table 8) (Lane & Banks, 2010).

There is, however, much debate over the extent to which adopters of (H)EVs have or will have above average environmental awareness and/or preference for greater fuel efficiency. Studies on current (H)EV owners or participants of vehicle trials identify high rankings or ratings of environmental performance which would appear to differentiate them from the mass market (Element Energy, 2009; Carroll & Walsh, 2010). Other authors have concluded that some consumers would be prepared to pay more to drive a cleaner fuelled or zero-emissions vehicle that is similar to their own, but these studies tend to rely on the proposition that the alternative vehicles can match conventional types in performance (Martin et al., 2009; Ewing & Sarigöllü, 1998). Another study constructed a hybrid choice model of vehicle choice including perceptions and attitudes and defined an environment-related latent variable which enters directly into the choice process (Alvarez-Daziono & Bolduc, 2009). They concluded that the environmental concern variable has a significant impact on the vehicle purchase decision, but mainly among those who currently use public transport and among women, older people and more educated people.

Two studies in the US which analysed state-wide vehicle sales data found a correlation between environmental preference and the rate of uptake of HEVs (Kahn, 2006; Gallagher & Muehlegger, 2007). Using data on a community's share of green party voters as a proxy for community environmentalism, Kahn concludes that environmentalists are more likely to purchase HEVs than non-environmentalists. Gallagher and Muehlegger estimate the effect of state and local incentives, rising gasoline prices, and environmental ideology on hybrid vehicle sales and find all three to be important.

It is possible that early adopters will place a value on emissions reduction but that any model coefficient should drop to zero for majority buyers (Santini & Vyas, 2005). The appeal of (H)EVs for these early adopters is the belief that such a purchase would vividly demonstrate commitment to a cleaner environment and will act to offset some of the higher economic costs by conferring social benefits (Curtin et al., 2009). In such cases, high fuel economy may be valued more for its symbolism than for its marginal financial value (Turrentine & Kurani, 2007; Kurani et al., 2007).

However, Ziegler found that ‘environmental concern’ did not have any significant effect on the choice of hybrid vehicles, but did have a significant impact on the (stated) choice for an EV (Ziegler, 2010). An earlier study concluded that positive attitudes towards the environmental benefits of EVs are not generally accompanied by higher purchase intentions, and especially so in the presence of increased information about and experience of EVs where these benefits became a lower priority for buying EVs relative to other attributes in the SP survey after exposure (Golob & Gould, 1998).

It seems most likely that consumer interest in hybrid and EV technology, including the early adopters, is motivated jointly by concerns about the environment, increases in the price of fuel and a desire to be less dependent on petrol. Klein’s five segments of hybrid purchasers (Box 1) illustrates the various dominant attitudes that seem to have led to the purchase of hybrid vehicles in the US between 2003–2007, only one of which was clearly environmentally motivated. This illustrates the necessity for market segmentation to capture the fact that some segments will be prepared to pay higher premiums than others to capture the symbolic and altruistic motives that may be important for some consumers.

2.4 Psychological factors (affective and symbolic)

As section 2.2 argued, models of car choice are likely to be inadequate without consideration of impulsive or non-conscious regulatory processes. Even where consumer decision-making may be the result of conscious choices among an array of alternatives, these choices are systematically related to psychological processes (i.e., perception, attitudes, beliefs formation) and any models of vehicle choice need to make salient the role that non-instrumental factors play in consumer behaviour. Even when vehicles are equivalent in every way from an economic point of view, different makes, models, and styles connote different social messages about the owner (Curtin et al., 2009).

‘Attitude’ is a term which is used very loosely, in various contexts and may be used to describe any of the following personal attributes: awareness, concern, knowledge, understanding, opinion, personality, beliefs and cultural values (Lane, 2005). In this respect, a useful classification of decision factors relevant to understanding vehicle choice is the following:

- *Instrumental factors* refer to general practical or functional attributes of a vehicle; for example costs, driving range and maximum speed of a vehicle.
- *Affective factors* refer to the feelings evoked by owning or travelling in the vehicle, such as anticipated driving affect, satisfaction, excitement, pleasure or control.
- *Symbolic factors* relate to how consumer goods can serve as symbols or have wider meanings and how these can be used to express social status or personal identity and values; for example, being seen as ‘green’ or as someone who owns the latest technologies.

There is overlap between these three classes of decision-making factor. The functional and economic attributes discussed in the previous section can be clearly classed as instrumental motives. However, perceptions are relevant here because the choice process depends on how attribute levels are perceived by the individual beliefs of a consumer. In addition, emotional reactions to functional attributes such as speed can be classed as affective motives, and functional attributes can also take on symbolic meanings, as discussed below.

2.4.1 Affective factors

The literature on the non-instrumental attributes of vehicle choice is much less developed than the discussion on cost and functional attributes. Indeed, there is very little evidence on the role of affective as distinct from instrumental or symbolic factors. Only one text in the review (Gärling, 2001) specifically addresses the 'pleasure of driving' by asking EV trial participants to rate their experience on a five-point scale compared to their conventional vehicle. The results showed that more than 80% of the subjects thought that driving the EV gave the same or more pleasure than their conventional vehicle. In the qualitative study, the subjects' definition of the concept 'pleasure of driving' most often included words like reliable, ease of use, ease of maintenance, comfort, noiselessness, and speed, and so the cross-over with functional attributes is clear. In the UK Cenex trial, users rated the overall 'performance' of the vehicles compared to a similar classed fossil fuelled vehicle as 'good' as well as rating an environmental 'feel good factor' which can evoke emotional responses (Carroll & Walsh, 2010). Another study found that 'quiet', 'smooth' and 'silent' were offered to describe the sensation of driving an HEV in all-electric mode (Turrentine & Kurani, 2007). However, both of these latter studies comprise very crude measures of affect which are more akin to instrumental evaluations. Overall, the emotional response to driving an EV and the role it plays in vehicle choice is poorly understood.

Thøgersen and Gärling (2001) also measured 'complexity and perceived risk'. These items referred to perceived ease of maintenance, ease of driving, noise, safety and risk when recharging. Again, these are akin to evaluations of functional attributes, but tend to provoke emotional responses and together reflect the perceived complexity, or cognitive effort, of using an EV. They also measured he 'feeling of luxury' gained from driving an EV compared to a conventional vehicle of the same brand.

2.4.2 Symbolic factors

Symbolic motives, although potentially more elusive, have been studied in relation to vehicle choice, including EVs, albeit still not to the same extent as instrumental attributes. The majority of research in this area has originated from researchers at UC Davis who have examined HEVs and PHEVs in relation to the meanings afforded them and the identity constructed by buyers (see all references by Kurani, Heffner & Turrentine). Symbolic meanings associated with (P)HEVs are found to be multiple and multi-layered. For example, households in California that adopted these vehicles have been found to apply meanings such as:

- lower resource consumption/living lighter;
- independence from petroleum producers;
- advanced technology;
- financial responsibility;
- saving money;
- environmental and/or resource preservation;
- opposing war; and
- rising fuel prices as evidence of conspiracy.

These authors also propose that future research could concentrate on the ability of AFVs to symbolise the idea of 'extended personal territory', as EVs could potentially be able to provide (or store) electricity independently. These symbolic evaluations can relate to the whole vehicle or to more specific functional or financial attributes such as fuel economy to which meanings such as 'lower resource consumption' can be applied, even though fuel savings are likely to have never been calculated:

> *"High fuel economy, particularly numbers over 100 MPG may be valued more for their symbolism than for their marginal financial value. Seeing 100+ MPG on the fuel economy display, even if briefly, may signal to drivers that the vehicle has important qualities: it is unique, environmentally friendly, and financially sensible."*
>
> (Kurani et al., 2007, p13)

Important symbolic meanings are also attached to the technology itself. Kurani et al. found that the further their participants could drive their PHEVs on all electric range, the more they associated their cars with high technology, environmental preservation, economic sensibility and the freedom from petroleum fuels.

In addition, consumers infer connotations to these meanings such as 'behaving ethically', 'concern for others', 'being intelligent' or 'unique':

> *"Lowering their resource consumption becomes an important subplot in a narrative self identity, first symbolized then made real by the availability, purchase and use of a high fuel economy HEV."*
>
> (Kurani et al., 2006, p218)

These meanings relate, in turn, to self-identities which are expressed through buying, owing and using the vehicle. Utility is derived from presenting these identities or self images.

The importance of identity, self image and status is difficult to elicit in a research setting, but car advertisers are well aware of its importance and often play to the individual's sense of control, power, social status and self-esteem (Steg, 2004 cited in Skinner et al., 2006). In quantitative instruments, status or identity has likely been captured by measuring the importance of 'style/appearance' which, in a recent UK study, ranked as the second most important purchase issue after fuel economy (see Table 8 and Lane & Banks, 2010). Graham (2001), on the other hand, asked respondents to indicate the importance of 'attention/pioneer' as a reason to buy a HEV, which was selected by 33% of respondents (cited in Santini & Vyas, 2005).

Garwood and Skippon (2010) measured symbolic meanings through ten questionnaire items based on the domains of the five factor model of personality (openness, conscientiousness, agreeableness, extraversion and neuroticism) (Digman, 1990 and Saucier & Goldberg, 1996). The approach is based on the theory that the symbolic meanings of consumer products represent conscious or non-conscious signals to others about the user's personality traits. They found that driving an EV signals high openness, high conscientiousness and high agreeableness.

Another general personality trait that has been examined in the context of EVs is 'innovativeness' reflecting 'the degree to which an individual makes innovative decisions independently of the communicated experience of others' or, more precisely, 'domain specific innovativeness' which refers to a trait reflecting 'the tendency to learn about and adopt innovations (new products) within a specific domain of interest' (Thøgersen & Gärling, 2001). The authors find that innovativeness, combined with product knowledge, is a powerful combination of individual attributes to use to segment the population and understand perceptions of EVs and intention to purchase. High innovativeness is a precursor to early adoption but is not a prerequisite for more mainstream consumers of EVs once the technical and infrastructural concerns are mitigated.

Narcissism (individuals who see themselves, and who want others to see them, as special or superior) is hypothesised to be associated with greater interest in the symbolic rather than the functional value of products (Gärling & Thøgersen, 2001). Similarly, Allan and Ng (1999) concluded that the symbolic and affective meaning of car purchasing behaviour was greater when values were indirectly linked to purchase behaviour. Values can direct consumers' attention to products with similar meanings to the human values and the effect of the human value can be transferred to the evaluation of the product meaning. For instance, an individual's preference for the human value 'prestige' would direct his or her attention to products that have meanings similar to prestige, such as a Mercedes-Benz, and would contribute favourably to his or her positive evaluation of the automobile. Similarly, strong personal norms or values in favour of the environment could offset some of the higher economic costs of owning an EV by conferring social benefits onto any perceived superior environmental performance of these vehicles (Curtin et al., 2009; Jansson et al., 2009).

It may be that the symbolic meanings attached to EVs will take some time to become established and widely held as the market matures. However, symbolism is important to understand at an early stage as consumers attempt to differentiate them from other types of vehicles (Heffner et al., 2006).

2.5 Socio-demographic factors

Most studies of vehicle type choice reviewed for this report generally use disaggregate discrete choice models (multinomial logit and nested logit) for the vehicle type choice. Vehicle, individual and household characteristics are mainly considered as explanatory variables in the models. From these studies and other quantitative and qualitative evidence (sometimes relating to general levels of car ownership) we can make broad conclusions about the relationship between socio-demographic indicators and vehicle preference. These relationships are summarised in Table 11.

Table 11: The link between socio-demographic characteristics and vehicle choice

Factor	Evidence
Income	In general, car ownership propensity increases with income, although the elasticity varies by household and area type. Income elasticities fall as incomes increase, are higher in London and where the head of the household is retired (Whelan, 2007). In Switzerland, hybrid car buyers had a significantly higher household income and education level than owners of similar sized conventional vehicles (de Haan et al., 2006a) but a study in the UK found the higher people's income, the more likely they are to adopt an EV as a second car but not as a main car (Garwood & Skippon, 2010). Buyers' sensitivity to purchase price and maintenance costs are inversely affected by income. An example of variation by household income is that engine size in the UK increases from an average of 1.4 litres for households with mean income less than £9,000 to 1.8 litres for those with mean household income greater than £45,000 (Cambridge Econometrics, 2008). However, the coefficients are likely to be different across different income thresholds as higher-income consumers use a lower discount rate (Adler, 2003; Santini & Vyas, 2005; Potoglou & Kanaroglou, 2007). Lower income consumers are less able to afford the higher up-front premium for a hybrid and more likely to discount future fuel cost savings from a hybrid purchase (Diamond, 2009). The early adopters are likely to have higher incomes than the early majority who are themselves likely to have higher incomes than the average new car buyer (Santini & Vyas, 2005).

Gender	Women have a stronger preference for environmentally friendly cars which is consistent with the empirical studies which show that women have a stronger preference towards the environment and a stronger willingness to contribute (e.g. Torgler et al., 2008 cited in Ziegler, 2010; Gärling, 2001). As regards EVs, it seems that (on average) men are more reserved towards this technology than women (Carroll & Walsh, 2010; Dagsvik et al., 2002). Men have a significantly higher SP for hydrogen and somewhat less high for other AFVs than women. (Potoglou & Kanaroglou, 2007; Ziegler, 2010). Overall, it seems that women focus more on instrumental attributes (e.g. safety, reliability, price) and men more on symbolic attributes (e.g. size, power, brand image) (Mintel, 2009; Angle et al., 2007). Results from interviews show that females to a higher degree than males experienced EVs as safe, attractive, and useful for work and visiting trips (Gärling & Johansson, 1999). Female respondents are found to consider that a highly-priced car has a greater utility as a result of its perceived superior performance, but for men, the higher price is associated more with the ability to impress (Moutinho, 1996 cited by Skinner et al., 2006). In contradiction to this evidence, Element Energy (2009) found that nearly all EV owners and EV considerers in its survey in the UK were male. They suggest this may present a challenge if EVs are targeted at two car households where the lower mileage vehicle driver is female.
Education	Potoglou and Kanaroglou (2007) report a significantly positive effect of higher education on the choice of HEVs. This may be consistent with Skinner et al. (2006) who report that, in households with only one car, and where the head of the household is educated to college level, operating costs of the vehicle seem to be of more significance, which at least implies a greater awareness of lifetime running costs (Skinner et al., 2006).
Age	Ziegler (2010), Potoglou and Kanaroglou (2007) and Ewing and Sarigöllü (1998) all report a significantly negative effect of age on the stated choice for AFVs and report a significantly negative impact of age on the choice for fuel-efficient cars and EVs. Older respondents consider reliability; younger respondents mention style. Impact on the environment was more likely to be mentioned by older respondents (Angle et al. 2007).
Presence of children	Households with children are more likely to choose larger vehicles, vans/people-carriers or diesel-engined vehicles (Whelan, 2007; Angle et al., 2003).
Employment status	The number of adults in employment has a strongly significant effect on ownership levels over and above that generated by any additional household income. Take the example of a three adult household in a metropolitan area with two workers and a joint income of £25,000. Increasing the number of workers from two to three increases the probability of owning one or more cars from 84% to 85%, two or more cars from 54% to 59% and three or more cars from 22% to 29%. The net result is an increase in the forecast number of cars for that household from 1.42 to 1.53. Whilst this does not seem like a large change, it is significant when grossing up to the mass market (Whelan, 2007).

Existence of a company car/ other cars	The provision of a company vehicle significantly increases the probability that a household will acquire additional vehicles. For example, for a three adult household living in a metropolitan area with two workers and a joint annual income of £25,000, the provision of a company car increases the conditional probability that the household will own a second vehicle from 54% to 77% and increases the conditional probability that a household will acquire three or more vehicles from 22% to 28%. Were the household to acquire two company vehicles, the probability that they will own three or more cars is increased from 22% to 40% (Whelan 2007). Element Energy (2009) found that the majority of EV users (internationally and in the UK) are multi-car families. They point out that this is at odds with the idea of EVs being 'urban city cars' as car ownership (and parking availability) is lower in urban areas. However, they point out that in the UK, around 90% of all households are in the 'other urban centre', 'suburban residential' or 'rural residential' categories. They also acknowledge that multi-car households have higher disposable income and fit the idea that EVs may be adopted as a second car as a 'hedge' against the limitations of this new technology.
Car mileage	In a Dutch study, the authors make the observation that high mileage drivers are more likely to be attracted to lower fuel costs (Rouwendal & de Vries, 1999, cited in Lane, 2005). Diamond (2009) uses state registration data to evaluate the determinants of hybrid vehicle adoption. He finds average miles travelled per year in the state all significantly influence hybrid vehicle adoption. Average vehicle miles travelled (VMT) per capita was significant with coefficients between 0.8 and 1.5, meaning that a 10% increase in average per-capita miles travelled would result in an 8–15% increase in state hybrid market share, depending on the hybrid model. Gallaher and Mueller (2007) analysed US HEV sales data and other state wide data and found the relationship between fuel prices and high-economy hybrid sales is significantly more pronounced in states where the average per capita annual mileage is greatest. This is consistent with their prediction that high mileage individuals have the greatest incentive to adopt high-fuel economy hybrids in response to an increase in fuel prices. Santini and Vyas (2005) assume that the early buyers will be individuals who drive far more miles per year than the typical vehicle owner (or far more hours per year), but could not cite any evidence to back up this assumption.
Residential location	Even where there are high income levels in densely populated areas, the level of car ownership is not as high as might be expected, as public transport is often a more effective form of transport in these areas (Dargay & Gately, 1999 cited in Skinner et al., 2006). Car size has been found to be a function of population density, with a negative correlation between larger cars and population density (Whelan, 2007). Potoglou and Kanaroglou (2007) examined the relationship between vehicle choice and neighbourhood characteristics in Canada. Estimates from discrete choice models of households' latest vehicle-type choice suggest that preferences for less fuel-efficient vehicles are marginally affected by the diversity of land-uses at the place of residence (fewer SUVs are owned where land uses are heterogeneous), after controlling for travel to work attitudes and socio-demographic characteristics of individuals and households.

In conclusion, these findings suggest that the use of a single set of coefficients for a presumed single population may not be a sensible way to model consumer preference for EVs (Santini & Vyas, 2005). However, recent attempts to model vehicle choice in the

UK have concluded that not enough work has been done to investigate the socioeconomic drivers of car purchase behaviour and understand 'taste heterogeneity' and the estimation of confidence intervals around predicted elasticities (Cambridge Econometrics, 2008; Eftec, 2008).

2.6 Policy influences and incentives

Identifying the most relevant attributes and characteristics of early adopter and mainstream EV consumer segments is important for the design of effective incentives to promote uptake. However, despite the proliferation of incentive programs, particularly in the US with respect to HEVs, their efficacy is unclear. Particularly uncertain is the point in the decision-making process that fiscal or other incentives are likely to have the most influence on purchasing patterns and the ways in which instruments can be packaged together to have the optimum effect.

The literature review has not enabled clear answers to these questions to be presented here. Some empirical work has been carried out on RP market data to attempt to identify the independent impact of Government incentives, fuel price rises or more practical measures such as High Occupancy Vehicle (HOV) lanes. Others have included questions on incentives in SP surveys and have inferred an impact from discrete choice modelling. The remainder of this section reviews the evidence on different categories of incentive and draws some general conclusions on the nature of policy interventions in this area.

A range of forms of fiscal incentives could be applied to the EV market and are indeed already being used in many forms in many countries. These include subsidies for EV buyers (UK), subsidies for certain parts of the fleet (e.g. taxis, public agencies) (China), subsidies or feebates for 'green' vehicles (various European countries), tax credits or rebates (US), car tax exemptions (Germany, UK), and reduction of sales tax for EVs (Denmark)[8].

Some authors have drawn some strong conclusions from SP and modelling consumer preferences that fiscal incentives are required to compensate for both the higher capital costs and for barriers to uptake such as battery range (Element Energy, 2009; Ewing & Sarigöllü, 2000; de Haan et al., 2007).

The UK Climate Change Committee included in its second reporting period some analysis of the level of upfront support required to incentivise consumers to buy EVs and PHEVs over the period to 2020. In this case, the total subsidy is equivalent to the Net Present Value (NPV) of the lifetime costs of cars and based on varying assumptions about battery costs and discount rates. The latter is based on varying assumptions about consumer myopia and the degree to which they place weight on future fuel savings and is acknowledged as a critical uncertainty and risk to the efficacy of any upfront price support scheme. In any case, some have warned that even incentives which make the investment in an EV 'NPV neutral' to offset the higher capital costs with lower running costs would not be sufficient to overcome market barriers, particularly beyond the early adopters (Element Energy, 2009). They suggest "*even a significant intervention such as a grant to cover the additional capital cost of an EV (relative to the incumbent) would not of itself be enough to ensure significant uptake. There would remain the significant disutility associated with limited range of EVs*" (p11). In a UK survey which elicited 'willingness to pay', the authors found that a purchase incentive of approximately £2,000 would be sufficient for the early adopter group but larger incentives would be required for more mainstream consumers.

This chimes with rather less quantitative assessments based on recent consumer behaviour in New York. PlaNYC noted that the early adopters in New York City appear willing to pay a premium for the experience of owning an EV and are flexible about adjusting their driving behaviours to rely mostly on home charging. In the light of this,

[8] Caution should be taken as this is neither a fully up to date or exhaustive list as the information is based purely on the literature which materialised for this study, which did not specifically set out to look at incentives.

they suggest that actions such as investment in a high-density public infrastructure or *additional* financial incentives do not appear to stimulate significant incremental demand among the early adopters. But the federal tax credit for EVs amounts to up to $7,500 already and consumers beyond the early adopter segment are likely to need a higher incentive than this.

Moreover, there are running costs other than the fuel to consider. In an analysis of a range of instruments to alter the cost of both vehicles and travel (including time penalties and incentives such as HOV lanes), Ewing and Sarigöllü (1998) concluded that price subsidies for cleaner vehicles were the only type of instrument that is likely to achieve environmental objectives, albeit only realistic if commensurate taxes were applied to more polluting vehicles. They conclude that in order to have competitive running costs, savings from the EV's lower operating costs should be *triple* any higher maintenance costs it may have. This suggests that policies such as electronic road pricing or carbon taxes for non-EVs might be needed to help improve the image of the EV's relative operating costs.

In a European-based study which examined vehicle ownership and whether or not the person had benefited from a Canton based tax rebate (which vary from 10–100% of the car ownership tax) de Haan et al. (2007) concluded that rebates on car ownership taxes seemed to be effective and had increased sales of Prius cars by 25%.

In the UK, there is recent experience of a purchase subsidy, albeit not related to environmental objectives or EVs, that had high consumer reaction to it and accelerated market change to a greater extent than other fiscal instruments (such as a change to the first year circulation tax) have made. The scheme was designed to deliver a boost to the car industry at a time when it needed it most, offering a £2,000 grant to scrap an old car in exchange for a new one. The figures show that the scheme contributed to approximately one fifth (20%) of all new car registrations whilst in operation. Of those, 54% had never bought a new car before. Although never intended as an environmental incentive, the scrappage scheme also had the effect of amplifying the shift to smaller cars and HEVs which was already happening in response to the economic slowdown (Mintel, 2009). While the mini and super-mini segments normally account for around 40% of the new car market, they represent over 70% of cars registered through the scheme. Figures from SMMT show that cars registered under the incentive had an average CO_2 value of just over 133g/km, 10% below the new car average, and almost 50g/km below the average emissions of the vehicles scrapped (SMMT, 2010a). This could be taken as an indicator that such instruments are effective and the next step would be to design one with explicit objectives to accelerate the uptake of EVs.

However, in reality there is little consensus in the literature on either the potential efficacy of fiscal instruments to incentivise the uptake of EVs, or their most effective design. For example, at least three authors have analysed data on the registration of hybrid vehicles and correlated uptake with policy incentives and fuel prices, albeit all in the context of the US, and all three have conclude that other factors, particularly fuel price, may have more of an impact than subsidies themselves (see e.g. Diamond, 2009; Beresteanu et al., 2007).

Diamond compared HEV adoption patterns between 2001 and 2006 to the US average for specific states that have changed incentive policies, with a view to understanding whether the way in which the incentive was implemented had an impact. Averaging over the six years, he found that, overall, incentives had no significant impact on market share. For instance, he found that states who exceeded or lagged behind the US national average in terms of sales before the policy change also did so afterwards. In other words, any impact that individual policy changes may have had was less important than the other key determinants, which he found to be fuel prices, driving patterns and environmentalism (measured using an index reflecting each state's environmental management framework and commitment to green measures). Fuel prices were found to be the most significant, with a 10% increase in average prices resulting in, on average, a 72–93% increase in state HEV market share, depending on the vehicle.

Diamond (2009) notes that this finding may be consistent with other survey and interview findings that we noted in Section 2.3.4 and that consumers buy hybrids based on general notions of perceived savings rather than a detailed benefit-cost or lifecycle cost analysis. He believes that fuel prices serve as the most visible signal for consumers to think about fuel savings and fuel economy, so that relatively minor variations can lead to significant changes in adoption patterns, particularly for people in the market for a new car at the time of rising prices. He noted the 'symbolic' $4.00 a gallon marker that was reached in the summer of 2008 and suggests this prompted a significant change in driving habits and preference for fuel efficient vehicles. Moreover, he suggests that "*even if consumers did try to explicitly calculate the lifecycle costs of hybrid ownership, recent volatility and uncertainty in future gas prices over time would make this calculation difficult. Fuel prices are largely beyond consumers' control, which might make a hybrid attractive simply as an insurance policy or hedge against future volatility and price spikes*" (p982).

In a similar exercise, but simulating the effect of different fuel prices on HEV sales, Beresteanu (2009) found the effect of income tax deductions on HEV sales in the US in 2005 to be less than 5%, but this increased to 20% of sales when they were changed to be more favourable income tax credits of up to $3,400 (varied according to model) from 2006. However, he found that changes in fuel prices had a larger impact than these incentives. Had fuel prices stayed at the 1999 levels, HEV sales in 2006 would have been 37% lower, while the effect of the federal income tax credit program was estimated at only 20% in 2006. In the light of the considerable actual increase in fuel prices in the US he concludes that, in the absence of these increases, the sales of hybrid vehicle would have been significantly less.

Gallagher and Muehlegger (2007) also studied the relative effect of tax incentives, gasoline prices, social preferences and other non-monetary incentives (for example, preferential access to HOV lanes and parking etc.) on hybrid sales in the US. They found that tax incentives explain a 6% increase in hybrid vehicle sales, but that fuel prices explain 27% of the increase. They also found that changing travel intensity (per capita vehicle miles and average commuting time) or social preferences for environmental quality and energy security (based in state level per capita membership of a grassroots environmental organisation (the Sierra Club) are responsible for 33% of the increase from 2000–2006.

There is consensus that fiscal incentives need to be designed so that they are conceived separately from the purchase price. It seems that consumers are more sensitive to sales tax incentives than income tax incentives. Gallagher and Muehlegger (2007) for instance, found that a sales tax waiver of mean value $1,037 was associated with more than twice as large a demand effect as a tax credit of mean value $2,011. This is because the sales tax is more transparent at the time of purchase, rather than income incentives which must be known about and understood and so their impact is delayed.

This chimes with 'prospect theory' (see Table 6) which shows that consumers set a reference point and consider lower outcomes as losses and higher ones as gains (Mueller & de Haan, 2009). This has implications for survey measurement and modelling as subsidies are perhaps best explained as a reduction in upfront cost and measured as a coefficient (Axsen et al., 2009).

Overall, Diamond (2009) concluded that the dampening of the effect of monetary incentives on vehicle sales may be because dealers factor in these incentives into their pricing structure and charge consumers more for the vehicles. In this case, the subsidies effectively act as subsidies to car dealers without increasing adoption rates.

Indeed, there are broader questions raised about the social distribution of the benefits of fiscal incentivisation of EVs. The fact that EVs are likely to be adopted by higher income groups means that incentives are likely to disproportionately benefit higher income consumers who are more likely to purchase hybrids in the first place. On the basis of his analysis of HEVs in the US, Diamond (2009) concludes that, given the apparent weak or negligible effect of monetary incentives, this could result in incentive payments effectively creating a subsidy for the highest income consumers without significantly affecting their purchase decisions. Along the same lines, Curtin et al. (2009) note that tax credits are bound to make EV purchases more likely, but they believe that the fact that most buyers would have to finance the total price of the vehicle, including the premium, before they could claim the tax credit would limit their impact to the already narrow group of new vehicle buyers who were more likely to pay cash rather than finance the vehicle. The authors believe that if the tax credit could be converted into a reduction of the purchase price its impact on sales would be much greater and more equitable to those who purchased on credit. Skerlos and Winebrake (2010) believe that greater benefits could be achieved for the same Government investment if subsidies for EVs were targeted to where the social benefits are largest. They suggest subsidies would more effectively encourage new entrants to the EV market if they were offered to lower income individuals in a higher amount relative to individuals with affluent incomes and that different geographical areas would yield greater environmental, health, and energy security benefits.

This evidence is clearly superficial in breadth and depth and is limited by its main focus on HEVs rather than EVs. Nevertheless, overall, it seems to suggest a combination of economic and social incentives may be the most effective for the successful introduction of EVs. Some of these other incentives are discussed in Table 12**.**

Table 12: Summary of available incentives

Factor	Evidence
HOV Lanes	The majority of the commentary is in relation to HOV lanes in the US. HOV lanes are not common everywhere, but tend to be in areas with most congested traffic and air quality problems. States such as Virginia, California, New York, New Jersey, Florida, and Utah, allow hybrid owners waivers from high occupancy vehicle (HOV) lane restrictions on one or more highways in the state. Overall the evidence suggests that, whilst the presence of the HOV incentive does seem to have made a difference to sales, the impact of this as an incentive is very dependent on the circumstances in the wider locality. Both Diamond (2008) and Gallagher and Muehlegger (2007) found that Virginia's HOV lane seemed to have had an impact on market share in that state, but not elsewhere. Another study found the impact was only significant among those who are long distance commuters (Sangkapichai & Saphores, 2009). The value of HOV lanes to consumers have been assessed in SP studies alongside other incentives. In trying to work out the best measure to use, Santini and Vyas (2005) suggest a metric based on the value of time saving and the actual time saving to calculate the dollar equivalent savings per annum. However, they suggest that the value of time may be higher for high income earners and that the privilege of using HOV lanes for some drivers could, at least in principle, outweigh the value of the fuel savings. Also, the real value may be in the reduction in stress to some people. Nevertheless, in actual SP studies, HOVs are often not significant. For instance, an SP study in Canada including the elimination of vehicle sales tax, permission to drive in HOVs and free parking found the latter two incentives were not significant when purchasing and AFV or HEV (Potoglou & Kanaroglou, 2007). Similarly, in a study in California of diesel and HEVs, the provision of access to HOV lanes was generally a much lower-valued incentive compared to purchase taxes and providing free parking, likely because only a fraction of California vehicle owners travel in corridors where they

	can take advantage of these lanes (Adler et al., 2003).
Bus lanes	No evidence
Low emission zones	No evidence
Discounted parking	With respect to parking, in addition to the two SP studies cited above (Potoglou & Kanaroglou, 2007; Adler et al., 2003) – one of which did and the other did not find free parking to be a significant factor – the only other evidence was found in relation to actual EV ownership in London. Here the GLA plotted the geographical locations of current ownership of EVs and found that there is a band across London, from the north to the south west, where EVs are more popular (GLA, 2009). They claim that this can be explained in part by the policies of free and discounted parking in Camden and Westminster and the installation of charging points in these areas. However, no quantitative analysis has been carried out of the relative importance of various factors.
Congestion charging	In relation to the London congestion charge, HEVs and BEVs have been exempt from the charge (worth up to £2,000 per year). In 2009 there were over 1,7Rogers00 EVs and 15,000 hybrids are registered for the Congestion Charge discount relating to 0.06% and 0.5% of the total number of vehicles registered (GLA, 2009). This represents many times the proportion of (H)EV vehicles in the UK vehicle fleet as a whole and is some demonstration of the influence that this exemption has had on the local market for EVs. Element Energy (2009) remark that this type of incentive might be in keeping with the promotion of EVs as 'city cars' but is at odds with other necessary ingredients for their adoption, namely high car ownership and access to dedicated parking.
Electricity tariffs/time of use charging with peak/off peak pricing	This was only mentioned by Kurani et al. (2007) who acknowledge that various methods have been proposed including time of use rate schedules, smart timers and smart meters to discourage vehicle recharging during peak hours but also to potentially make EVs more attractive overall to consumers. Already they claim that unconstrained access to under-priced electricity could be an incentive, but time of day 'constraints' could also be repositioned to consumers as ways in which benefits could be further maximised.
Information	Lane and Albery (2009) observed in qualitative research in Camden (where EVs are more popular than many areas of the country), that many individual participants were aware of some measures that are designed to encourage the use/purchase of AFVs, but most are imprecise about the details. Incentives of which individuals are aware include: lower parking costs, preferential road tax rates and the Congestion Charge discount for AFVs. PlaNYC (2010) concluded that, given the likely strong demand among early adopters and the limited short-term supply of vehicles, initial actions would be most effective if they focused on helping early adopters enter the EV market. For example, likely early adopters may not fully understand the benefits and challenges of using an EV, so providing clear information could significantly boost early adoption. Survey respondents also voiced a desire to have a convenient and easy-to-understand process to install necessary charging equipment, at home or in a commercial garage.
Green electricity services	No evidence reviewed
Vehicle procurement	No evidence reviewed

2.7 Segmentation

The antecedents of EV adoption may be different across different sub-groups in the population. We have already discussed some of the different adoption behaviour and motivations that may exist between different socio-economic groups and between different markets such as fleet and private consumers. However, groups may also be defined by whether they are early or late entrants into the market, or by their diverse characteristics, motivations for uptake and receptivity towards the marketing of the innovation at a single point in time. In the former case, it is important for studies assessing the large scale adoption of EVs not only to identify the likely preferences of those individuals who can allow the technology to get its first significant foothold in the market, but to avoid basing model coefficients and predictions on the early adopters which are likely to have different requirements to the mainstream consumers (Element Energy, 2009; Santini & Vyas, 2005). In the latter case, it will also be necessary to capture the diversity in consumer preference at any one point in time and consider the option that many different configurations of EVs may have to be offered to appeal to different segments of car buyers.

2.7.1 Theory of technological substitution and 'early adopters'

The application of technological substitution theory can be appropriately applied to EVs given their new arrival in the marketplace compared to conventional vehicles. This theory suggests that the pattern of adoption of a new technology over time will follow a normal distribution as, faced with a new product, consumers can be classified into five categories: innovators, early adopters, early majority, late majority and laggards (Rogers, 1962; Santini & Vyas, 2006; GLA, 2009; Cao & Mokhtarian, 2003). The uptake of new products tends to be characterised by the relatively small group of innovators and early adopters. The former pursue new technology vigorously and their endorsement is important for early adopters through demonstration, word-of-mouth and imitation (Thøgersen & Gärling, 2001). The early adopters, on the other hand, do not necessarily hold the key to understanding the early majority and thus it is important to understand the potentially unique characteristics of these 'early' and 'mainstream' groups of EV consumers (Moore, 2002 cited in Santini & Vyas, 2006).

Figure 1 shows that the cumulative adoption of a new technology follows a sigmoid curve, with adoption growing slowly in its initial year, growing steeply as it reaches its half-way point, and growing flatly as it is close to its saturation level (maximum penetration). However, the specific shape of the curve is dependent on the rate of substitution, saturation level and adoption delay (Cao & Mokhtarian, 2003). For disruptive technologies which require a significant shift in behaviour by consumers, Moore (2002) believes there is a 'chasm' between the early adopters (the enthusiasts and visionaries) and the early majority (the pragmatists) who have very different expectations which require different targeting and positioning of the product using different marketing, pricing and distribution channels.

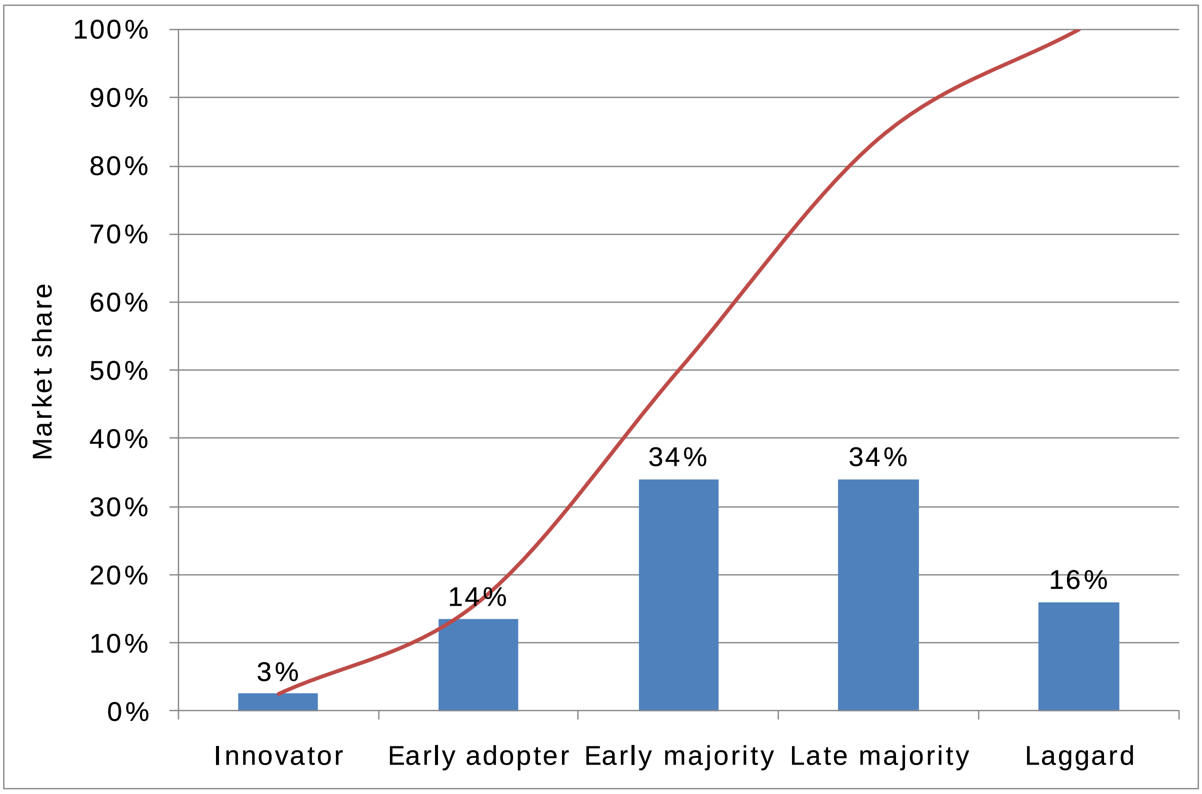


Figure 1: Distribution of Theory of Diffusion adopter groups

2.7.2 Who are likely to be the early adopters of EVs?

It has been hypothesised that the innovator/early adopter groups of EVs are likely to have similar traits to current hybrid and EV owners (GLA, 2009). However, there is little information on the profile of the low carbon car market in the UK, presumably on account of its relatively small size and commercial confidentiality of the data. Slightly more data exists in relation to HEV owners in the USA.

Table 13 summarises the potential characteristics of private early adopter and early majority adopters of EVs according to the literature, based on theoretical/SP studies and analysis of existing HEV/EV owners. From this, it can be seen that there is much speculation about the early adopter segment and currently very little discussion about who the 'early majority' EV consumer might be. There is also some disagreement over the extent to which the early adopter segment will be sensitive to the potential size of the premiums on EVs and the nature of their financial motivation *vis a vis* other symbolic motives such as innovativeness, the environment or the desire to be less dependent on oil.

Table 13: Potential characteristics of early EV adopter groups

	Innovators + Early adopter	Early majority
General	Early HEV owners in Switzerland had significantly higher household income and education than owners of similar sized conventional vehicles (de Haan et al., 2006a). Early petrol-hybrid owners were more likely to be female, older than average, very highly educated, from very high income households, drive lower than average mileage and keep their vehicle longer than average before resale (JD Power, 2004 cited in Lane, 2005). Tend to be wealthier than average, are new car purchasers and urban dwellers (Shell, 2004 cited in Lane, 2005). Tend to live in multi-car households (Element Energy, 2009; Gärling, 2001; Kurani et al., 1996).	
Common needs and wants	Purchase for a combination of altruism and 'bragging rights', fascinated with the technology of the car and may have philosophical reasons for wanting to reduce fuel (Santini & Vysas, 2005). More likely to buy highly fuel efficient models than the majority. Malesh noted that 86% of Honda Insight buyers said fuel economy "was extremely important" versus 44% among all new vehicle buyers, while Hermance (2003) gave an equivalent figure for Toyota Prius buyers of 80% (cited in Santini & Vyas, 2005). Currently own vehicles with higher than average fuel efficiency ratings (Curtin et al., 2009). Early HEV owners in Switzerland rated fuel consumption and technology higher at the expense of other criteria such as brand preferences and design (de Haan et al., 2006a). Individuals differing in innovativeness will evaluate the attributes of the vehicles differently (Thøgersen & Gärling, 2001).	The next generation of larger, more mainstream hybrids will emphasize luxury and power rather than environmental benefits (Lane, 2005).
Price	Willingness to buy at a higher price premium (PlaNYC, 2010). Sensitivity to on-going costs, particularly the price of fuel (Lane, 2005). Less sensitive to higher capital costs and more likely to account for lower running costs (Element Energy, 2010). They need a fuel efficient car: higher average income but higher annual driving characteristics thus place higher value on fuel cost. Therefore use NPV type considerations. However, the early adopters of the Honda Insight were not buying just to save fuel. Potential early adopters and/or early buyers indicated, through the national and California surveys, their willingness to "ignore" a high vehicle price if they liked other attributes (Santini & Vyas, 2005). More likely to believe fuel prices will remain high in the future (JD Power, 2004 cited in Lane, 2005). Although a first time PHEV buyer is likely to have	Capital cost is the primary factor (Element Energy, 2010). Will not support high price margins + less need to control fuel cost. Use NPV considerations (Santini & Vyas, 2005).

	relatively high income, these consumers were as sensitive as moderate or lower income consumers to the potential size of the premiums on PHEVs (Curtin et al., 2009). Klein (2007) believes the attitude towards price is more complex than the premium versus fuel cost model and offers a finer segmentation whereby four segments were clearly financially motivated, but *in their own way* (see Box 1). Some early adopter groups are more price sensitive than others (see Table 15) (Shell, 2004 cited in Lane, 2005).	
Incentives	Do not need high density public charging network. Large tax incentives may be unnecessary. Need information about benefits of owning an EV and 'recognition' for being early adopter (PlaNYC 2010).	
Charging, range and other attributes	Likely to place a higher value on such attributes as acceleration, luggage space, range, and top speed because they spend more time in the vehicle than the majority buyer. Similarly, since they also have higher income, early buyers value time more highly, so driver ability to accelerate quickly, drive fast, bypass refuelling stations, and spend less time in maintenance facilities are argued to be more valuable to this group (Santini & Vyas, 2005). Very positive about EVs and this may include switching from an on-street parking space to one in a local parking garage (PlaNYC, 2010). Will want ability to charge off-street overnight (GLA, 2009). First time PHEV buyers are likely to own their own home, have convenient access to an electric outlet, and relish the opportunity to avoid gas stations and recharge their vehicles overnight at off-peak pricing (Curtin et al., 2009).	As confidence in electric batteries grows and publicly accessible infrastructure becomes more visible on London's streets, it is expected that households without off-street parking will consider purchasing EVs as well (GLA, 2009).
Environmental attitude	High value on Green Motoring (Element Energy, 2010). A tendency to value environmental issues (Lane, 2005). Have expressed a desire to espouse an environmentally friendly lifestyle and already challenge themselves to reduce their fuel usage (PlaNYC, 2010). The first time buyer will be highly educated and think it is important to signal his or her commitment to a cleaner environment to others (Curtin et al., 2009). Environmental concern is not necessarily a characteristic of potential early buyers (Kurani et al., 1996).	'Green motoring' benefits less relevant (Element Energy, 2010).
Innovativeness	Current adopters of EVs and HEVs have been prepared to pay a premium for new technology which in some circumstances has functionality limitations (GLA, 2009). Propensity for new vehicle technology (Lane, 2010). Will pay to support new technology (Element Energy, 2010). Already possess vehicles with latest technology	Early adopters will recommend technology to early majority but need continual improvement in the technology for this to happen (Santini & Vyas,

	(PlaNYC, 2010). Will assign more 'points' (dollar value) to technological improvements than would the average consumer evaluating ICE technology (Santini & Vyas, 2005).	2005).

2.7.3 *What other subgroups of EV consumers might there be?*

The Greater London Authority has undertaken analysis of current EV and hybrid vehicle owners in London (GLA, 2009). Using postcode data on these owners, they have used the Mosaic geodemographic segmentation[9] to develop a picture of the likely dominant socio-economic characteristics of EV early adopters. The analysis found that most current EV owners and nearly 60% of hybrid owners fall in to five of the 61 Mosaic household types. These groups are listed in Table 14 as follows:

Table 14: Percentage of people who own electric or hybrid cars in London in 2009 by Mosaic type

Mosaic Type	Description	%		
		EV Owners	Hybrid Owners	All Londoners
Global connections	Affluent middle-aged singles living in central London	28	21	5
Cultural leadership	Professionals living in middle ring suburbs and working in Central London	14	13	4
New urban colonist	Ambitious singles or couples living in high density suburbs	14	10	10
City adventurers	Young and single skilled workers living in inner suburbs	9	9	7
Corporate chieftains	Business managers living in detached houses in outer suburbs	7	6	2
Other	(various)	28	41	72

Source: GLA, 2010

The Mosaic segmentation has been fused with a segmentation based on Anable (2005) to present a richer, attitudinal typology (Table 15). Using key characteristics of Mosaic segments including car trip making, lifestage, income and use of other travel modes, the Driver Type segmentation was tied to each postcode in London. Using the same data as above on the distribution of EVs and HEVs in London, the following segmentation of early adopters in London emerged:

[9] This tools draws on 400 nationwide data variables to characterise every UK postcode as one of 61 household types. See www.experian.co.uk.

Table 15: Percentage of people who own electric or hybrid cars in London in 2009 by Driver type (based on Mosaic)

Driver	Description	%		
		EV Owners	Hybrid Owners	All London
Car Free Lifestyle	Have chosen to live without relying on car and, even if they own a car, use it relatively infrequently preferring to travel by public transport, foot and cycle. They are the most likely to agree that *"I would be willing to pay higher taxes on car use if I knew the revenue would be used to support public transport"*	33	34	13
Environ-mentally Aware	Well educated and hence aware of environmental issues like climate change. This has not always fed through to their behaviour but nevertheless, they are above average users of rail and cycle modes, and they are the most likely to agree that *"Being environmentally responsible is important to me".*	32	29	14
Aspire to drive	Low current car ownership, but largely because they can not afford to run a car or owning a car is too much hassle.	16	10	37
Committed to car	A typical viewpoint is *"people should be allowed to use their cars as much as they like, even if it causes damage to the environment".* Least likely to want to reduce their car use or to support environmental taxes.	4	6	15
Dissatisfied Drivers	Use their cars a lot but do not enjoy doing so - the statement which typifies their viewpoint is: *"I drive because it's convenient and not because I enjoy it".*	3	8	13
Care Free Car	Greatest car usage and lowest bus usage. Still somewhat in denial about environmental issues and many of them believe that *"environmental threats such as global warming have been exaggerated".*	2	11	8
Can not be categorised		10	12	1

Source: compiled from (i) Steer Davis Gleave (undated) Introduction to Mosaic Driver: a geodemographic segmentation based on driver types. (ii) Girard, M. (2009) Promoting Electric Vehicles in London. TfL delivery Unit. Presentation to Brimsdown Freight Quality Partnership Conference.

What is apparent from this segmentation is the fact that just under 50% of current EV owners are potentially associated with attitudinal segments who otherwise would not own a car (the Car Free Lifestyle and the Aspire to Drive segments).

Another study cited in Lane (2005) also indicates that the profile of early adopters of AFVs is likely to be more complex than the characteristics offered in Table 15 suggest. The study had focused on consumer acceptance during the early growth phase of market development of new car fuels and technologies (liquefied petroleum gas (LPG), compressed natural gas (CNG), hydrogen, ethanol (E85), bio-fuels and gas-to-liquid

(GtL) fuels; and also hybrid-electric and fuel cell technologies). The report identified seven early adopter segments in the UK (Table 16).

Table 16: New fuel and vehicle technology early adopter segment definitions

Stars	Green papas	Ms Fast-tracker	Mr Fast-tracker	Individualists	Long hauler	Fleet buyers
Extremely fashionable High social status Low mileage / high frequency use Private use Emotional view of vehicles Urban dweller Not motivated by environmental concerns Interested in technology Cost insensitive Performance driven	Extremely sensitive to cost Middle class - "nest builder" Medium mileage and frequent use Private/professional use Functional view of vehicles Urban dweller Environmentally conscious Less interested in technology Insensitive to performance	Concerned with safety Medium mileage and frequent city user Private use Functional view of vehicles Urban dweller Less sensitive to environment No interest in technology Insensitive to performance	Fashionable middle class Medium mileage and frequent user Private use / commuting Emotional view of vehicles Urban dweller Not environment driven Interested in technology Insensitive to cost Performance driven	Medium mileage / usage frequency Private use Emotional view of vehicles Urban dweller Highly environmental sensitivity Interested in technology Demand similar refuelling experience Style driven	Extremely sensitive to cost and technology reliability High mileage and frequent use Commuting Functional view of vehicles Urban/rural dweller Less sensitive to environment Interested in technology Sensitive to availability and performance	Motivated by total cost of ownership Highly sensitive to financial incentives High mileage and frequent use Technology reliability paramount Centrally/ depot based Business/professional use Less interested in fashion Environmental issues not a priority

Source: Shell (2004) *Consumer acceptance of new fuels and vehicle technologies*. (Cambridge MBA students' study conducted on behalf of Shell). Presentation to the LowCVP, 2004 cited in Lane 2005.

Whilst all seven segments share common characteristics such as the fact that they are all new car purchasers, have higher than average wealth, are urban dwellers and are interested in technology and innovation, they are also different in terms of the fact that some segments are more price sensitive than others and engage with the market at slightly different times. HEV owners are likely to be mainly Stars, Individualists, Mr Fast-tracker, Ms Fast-tracker, Long haulers and Fleet buyers. Being the largest segment, Fleets play a key role in the early stages of market development and are seen as the key drivers of infrastructure and vehicle development. They therefore play an important role in raising awareness of new fuel/vehicle technologies.

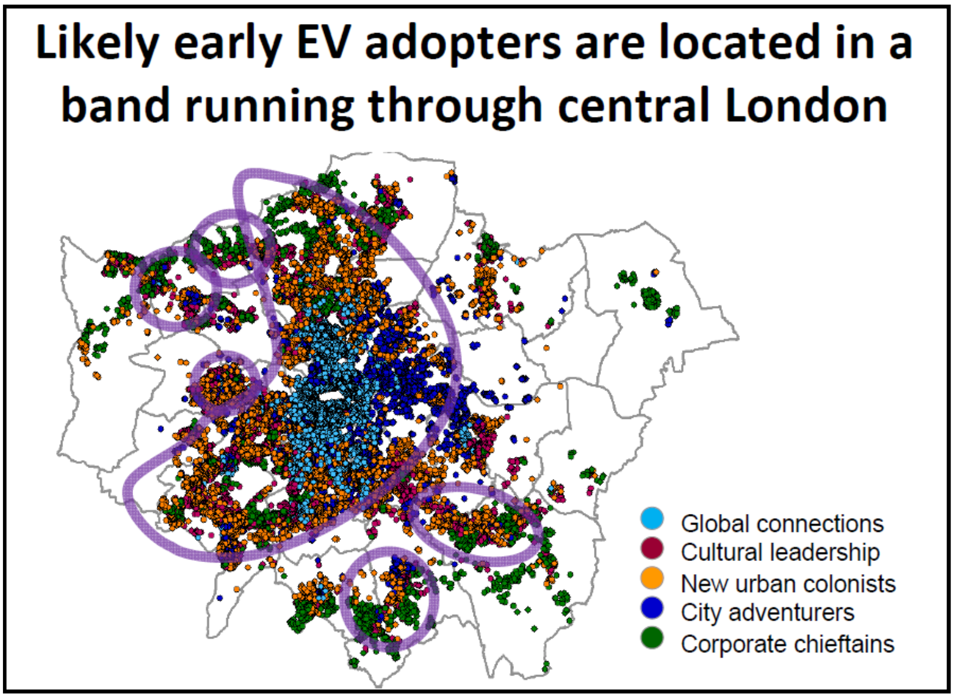
Finally, Thøgersen and Gärling (2001) offer a segmentation of potential adopters of EVs according to differences in attribute importance weights. They use structural equation modelling and confirmatory cluster analysis based on perceptions, knowledge about and attitudes towards EVs, innovativeness, environmental concern, demographic and background variables. The study identifies the importance of measuring 'objective' knowledge towards EVs as this is a stronger predictor of intention to buy an EV than other variables. They find that a combination of measures of innovativeness and product knowledge produces a useful segmentation with groups that vary in terms of the value placed on certain attributes (such as the compatibility of an EV with certain types of journey). Four groups based on a combination of high/low innovativeness and high/low product knowledge emerged. People with high innovativeness and high knowledge who also hold positive attitudes towards EVs are likely to be the early adopters, but the segment with high innovativeness and high knowledge but with unfavourable attitudes may also be a sensible target. Those in the high knowledge/low innovativeness segment are likely to be the most difficult targets as they hold the least favourable attitudes towards EVs on average.

2.7.4 *What might segmentation mean in terms of targeting and accelerating the uptake of EVs?*

With respect to current ownership of EVs and HEVs in London, they are primarily located in a band across London from the north to the south west. As mentioned in Section 2.6, this can be partially explained by incentives such as free and discounted parking and the installation of a large number of charging points already (GLA, 2009). The GLA have used their Mosaic segmentation to inform their strategy to invest in the installation of supplementary charging points at locations where utilisation is likely to be highest, i.e. at ‘hotspots’ (GLA, 2009). The Mosaic analysis was put together with the following location-specific factors:

- availability of off-street parking;
- locations where vehicle owners drive substantial distances (as this helps maximise the environmental benefit of EV usage); and
- multi-car ownership households where the likelihood of switching second cars to EVs is high.

Overlaying this information gives rise to a map (Figure 2) of the likely EV hotspots throughout London.



Source: GLA, 2009

Figure 2: GLA analysis of the location of likely early EV adopters in central London

2.8 Dynamic effects

Consumer preferences cannot be considered to be static, particularly over the longer term. It is likely that increased market penetration will alter the way in which consumers value EVs and choose among them. In addition, it is possible that consumers may use these vehicles differently to conventional vehicles. This section reviews the evidence on how values, attitudes and norms might change with direct or indirect exposure to EVs, and whether car ownership and travel patterns may change as a result of owning one.

2.8.1 Diffusion effects

The tendency for consumer preferences to change as technology becomes more prevalent in the market is known as the ‘neighbour effect’ or ‘spillover’ (Mau et al., 2008; Axsen et al., 2009; Heutel & Muehlegger, 2009). This captures the changes in social concerns, increased credibility and learning from others with more experience as well as marketing, education and shifts in social norms that will take place as the adoption rate increases (Axsen et al., 2009; Heutel & Muehlegger, 2009). This, in turn, feeds into the technological learning that refers to the increasing progress that is realised with increased diffusion (Heutink et al., 2009).

Many buyers value diversity in the marketplace so that the more vehicles that are available to the consumer, the more satisfied the consumer will be. For instance, a consumer may want to have a critical mass of companion owners in order to guarantee reliability and repair capability at many locations and may want to have a sufficient choice of makes and models available to them (EST, 2007; Santini & Vyas, 2005; Element Energy, 2009).

Stronger marketing and direct word of mouth are assumed to favour diffusion, providing feedback is favourable. No studies have estimated the potential impact of marketing, direct social exposure, and indirect word of mouth on the consumer uptake of EVs. Drivers of EVs, at work or in private, will promote EVs in their social networks, provided they are satisfied with the product, and the technology is demonstrated just by being in public streets and car parks (Gärling & Thøgersen, 2001). However, in mature car markets such as in the US, Europe, and Japan, the impact of direct word of mouth is likely to be small when EVs are introduced because the long lifetime of vehicles causes a lag in new vehicle sales (Struben & Sterman, 2008).

Mau et al. (2008) investigated these effects by eliciting consumer preferences for HEVs and hydrogen fuel-cell vehicles while triggering changes in their preferences by giving different groups different market penetration scenarios. The hypothetical market share ratios selected were: less than 1% (0.03%), 5%, 10% and 20%. The results suggested that changes in market share affect consumer behaviour and increase consumers' propensity to choose HEVs given equal monetary costs as compared to conventional vehicles. Interestingly, the importance consumers placed on the non-monetary attributes generally declined as market share increased. In a similar study, the importance that consumers placed on certain attributes of a new technology changed as the new technology gained market share (Leiby & Rubin, 2003 cited in Mau et al., 2008). Axsen et al. (2009) attempted to model these changes in intangible costs with increased market share but acknowledged that “*current preferences are difficult to disaggregate and future preference scenarios are highly speculative*” (p237). In a UK discrete choice modelling exercise, it was assumed that consumers apply a penalty to each new technology until a given penetration into the vehicle parc is reached (2.5% of the fleet akin to the proportion of consumers in the ‘innovator’ segment) (EST, 2007).

This review found one attempt to model the diffusion effect using RP data. Heutel & Muehlegger (2009) wanted to understand how learning caused by exposure to hybrids affected their diffusion in the US. They found that different models of HEV (Toyota Prius, Honda Insight) had different patterns of diffusion. They found that higher penetration rates of the Toyota Prius are associated with higher per-capita sales of all hybrid models, but especially for Toyota models compared to Honda models. Penetration rates of the Honda Insight have a negative effect on sales of new hybrids, and this effect is more negative for other Honda models. They attribute this to the fact that the Prius signalled a higher quality effect which is consistent with the anecdotal evidence from model sales and from stories in the media about these two models. They also attribute it to the theoretical models of learning and uncertainty described in this section. However, they also acknowledge that there may be other network effects such as the fact that higher HEV penetration in a state may lead to more mechanics able to serve them which would lower their costs in that state and increase adoption.

Although based on the diffusion of hydrogen vehicles, one study attempts an agent based modelling simulation to understand the importance that social networking might play in influencing the resulting pattern of uptake in the Netherlands (Heutink et al., 2009). The results indicate that when social network effects are taken into account, diffusion is slower than is found in many 'roadmapping' exercises. Moreover, it showed that quite a few more refuelling stations are necessary to reach the benchmark diffusion rates. In particular, it showed that an initial strategy to place infrastructure nationwide rather than in urban areas would be preferable, particularly if these are coupled with learning strategies.

2.8.2 Changing attitudes through direct experience with EVs

Exposure through media and information can change perceptions and preferences, but experience with vehicle trials to date shows that a direct experience with the technology can also have a powerful impact.

The results from recent trials generally show that drivers' expectations on various performance criteria were exceeded as a result of test driving the vehicles. In a UK trial, 58% of private users felt more positive about EVs after taking part (Carroll & Walsh, 2010). This shift was greatest for those who had had no previous experience with EVs and for younger users. Seventy-two percent of test drivers said they would use an EV as their regular car after their test drive compared with just 47% before the test drive. In a study of hydrogen fuel-cell vehicles, the proportion of people with safety concerns about the vehicle dropped from 30% to 7% (Martin et al., 2009).

Some vehicle features, such as range restrictions and fuel-efficient driving potential, may take time for consumers to understand and accommodate. In a longer term trial, such positive shifts were not found due to concerns about range (Gärling, 2001). Kurani et al. (2007) conclude that the in-car instrumentation will provide an important mechanism to develop the value of the vehicle to buyers.

2.8.3 Impacts on car ownership levels and travel behaviour

It is conceivable that the adoption of EVs could have rebound effects or unintended consequences which may counteract the efficiency gains. Direct rebound effects could include the following:

- *Car ownership*: average household car ownership could increase if people adopt an EV without disposing of an already owned vehicle or because the availability of EVs could make acquisition of a car attractive for the first time.
- *Upsizing*: people could tend to switch from already small/fuel efficient cars to a new hybrid car.
- *Car use*: the reduced cost per kilometre travelled and the assuaging of environmental guilt could encourage greater car use. The question is whether people will use EVs differently to conventional vehicles?

On the other hand, EV adoption could have two positive additional benefits:

- *Downsizing:* those who want to adopt EV technology may be forced to downsize in order to be able to afford these vehicles.
- *Driving style*: in order to preserve battery life and attain the highest fuel efficiency, drivers may change their driving style.

Table 17 reviews the evidence on each of these issues. It can be seen from the table that the evidence is limited and mixed on each issue apart from the impact on driving style. From this it can be concluded that it is too early to understand the magnitude of any rebound effects. As a general observation, de Haan et al., (2006b, p595) comment that:

"On the long run, hybrid cars, if they prove to be successful, will have a surplus sales price corresponding to the savings on fuel costs in the first, say, five years of car ownership. So rationally speaking, there is no room for economically justified rebound effects, as costs per vehicle kilometre do not change… So if a rebound effect is observed, we argue that its origin is primarily of socio-psychological nature… if the social cost and/or the psychological cost attributed to the cost of a given service is reduced."

Table 17: Evidence in support of possible direct or indirect effects of EV adoption

Impact	Evidence
Car ownership	A study of HEV purchasers in Switzerland showed that 14% of new Prius owners had not replaced another car (i.e. that the EV was additional) but this was the same rate for the control group (de Haan et al., 2006a). An unusually large proportion of Honda Insight buyers in the US bought the vehicle as an additional household vehicle rather than as a replacement vehicle. Although the fraction of all buyers who added a vehicle, according to Power, was 19% in 2000, the fraction that added the Insight was 43%. Even if the Insight were compared with 'sports cars', it still exceeded the 29% adding vehicles for this category (Malesh, 2000 cited in Santini & Vyas, 2005). A sample of 36 EV owners in the UK showed that most also have access to a non-EV car (Element Energy, 2009). The fact that EV owners are likely to reside in multi-car households has been shown elsewhere (e.g. Gärling, 2001; Kurani et al., 1996).
Upsizing/ downsizing	De Haan et al. (2006a) used empty vehicle weight as a surrogate for vehicle size and found empty vehicle weight only slightly increased after uptake of HEVs. Given that Toyota Prius cars are heavier to start with, the authors say this constitutes a small downsizing. In general, studies have found that households already in possession of a heavier vehicle were less likely to choose a subcompact vehicle (Skinner et al., 2006).
Car use	Little or no evidence. De Haan et al. (2006b) comment that it will be very difficult to confirm the occurrence or non-occurrence of this rebound effect for any given community of purchasers of a given car. Element Energy (2009) observe that when an EV is introduced to a multi-car household, it competes with the first car for use on trips and is used for a large proportion of short trips. However, they have not observed whether there is a net increase in the number of trips carried out by car. During an EV trial in Sweden, Gärling (2001) reported that relative to the first and eleventh weeks the kilometres driven increased about 10% and the number of trips by about 30% per week when the household got an extra car. In families owning one car the increase, both in kilometres and number of trips, was larger than in families owning more than one car. On the other hand, about 15% of the subjects stated that they had had to give up car trips, 30% that they had had problems with the limited driving range, 5% that they had had problems with the relatively long recharging time, and 25% stated that they had had problems with the limited cargo space.

Driving style	PHEVs and potentially BEVs are likely to be equipped with driver displays of fuel economy and state of battery charge. Kurani et al. (2007) recorded many drivers of PHEVs describing their excitement at seeing high mpg figures. They concluded that the driver instrumentation played an important role in making efficiency 'real' and encouraging fuel efficient driving styles. Data from the UK Cenex trial suggests that users modify their driving style when battery state of charge reduces below 50% (Cenex, 2010).

3 Implications for survey design

Given that plug-in vehicles are novel technologies that mainstream consumers have no experience of, there is a surprising amount of relevant literature to review. Whilst this body of evidence can essentially only contribute theoretical or experimental evidence regarding plug-in vehicles due to the lack of RP data and empirical studies, there is much to be learned about consumer behaviour by reviewing modelling and empirical research relating to conventional technologies and to HEVs.

However, the novelty of plug-in vehicle technology presents a significant challenge to the investigation of the consumer response to such vehicles and demands innovative survey techniques. Asking consumers to predict their interest in a radically new product that does not yet exist in the marketplace can result in notoriously inaccurate assessments. Since consumers have no experience with EVs, it is unlikely that many can predict whether they will buy one until they become more familiar with the new technology and how they might use it.

This review of the literature on consumer preferences for vehicles in general and EVs more specifically provided a number of clear indications of issues to be covered and challenges to be tackled in the design of primary data collection on this subject (see Sections 5.1, 6.1, 7.1 and 9.2). It helped to ground any empirical work in the fields of consumer choice and decision-making as well as any recent literature on consumer perceptions of or experience with hybrid or plug-in vehicle technology.

The purpose of this section was not to provide a detailed list of all possible issues to be included in qualitative or quantitative work being taken forward, but to briefly reflect on the main areas to be considered.

Firstly, there are challenges with respect to the demographic cohorts to be studied. The assumption is that EV owners will tend to be people who purchase brand new vehicles. Given that only 5% of UK households purchase a new car per annum, it would be very difficult to conduct a survey of new car users using a random probability method. Also, new car purchasers are currently older, but given that the younger people of today are likely to be the new car purchasers of tomorrow (particularly of EVs), it might also be worth surveying some younger purchasers, even though their preferences may change in the future. The qualitative recruitment matrix included participants across all age groups over 25. Also, it cannot be ruled out that some people who have tended to purchase used cars to date may purchase new cars in the future. Indeed, the introduction of a new technology which is less dependent on oil and represents technological and financial prowess, may attract a new type of car consumer to the market.

The main challenge is the accurate and balanced elicitation of economic, functional and psychological factors and allowing trade-offs between them to be observed. There are strong indications as to the symbolic motives that are likely to underpin both the early adopter and early majority markets relating to innovation, status, environmental values and fuel security. Indeed, cars are repositories of many high value meanings, some of which are important but not quantifiable, nor can they be allocated an equivalent monetary value. For more functional attributes that may provide great consumer value and can be monetised and traded off against one another, there also exists a challenge of accurate measurement. Many relevant attributes such as size, performance, range and refuelling/recharging time have been poorly measured in SP and more standard qualitative and quantitative survey techniques. Consequently we have a very poor understanding of the role that these instrumental factors may play in EV uptake.

The review has pointed out some sensitivities around the way in which fuel consumption, performance and size of vehicle are conceptualised. This assisted in linking the correct terminology in designing the survey instruments. However, the clearest finding is that survey participants find it very difficult to provide realistic answers to willingness to pay questions. This is an extension of the fact that people rarely carry out conscious and systematic comparisons and cost assessments of the various options open to them. Indeed, very few currently know their fuel consumption and calculate their vehicle running costs.

Thirdly, people have limited cognitive capacity and therefore rely on simplifying assumptions and quick decision tools. Hence, it may be that such heuristics are used when distilling information on new car attributes so that only a limited set of characteristics is used to make a decision. Likewise, when eliciting information through survey questions such as ‘how much would you pay for better fuel economy’, respondents may answer with an accessible rather than an accurate number. This simplifying effect can be exacerbated by the absence of direct experience when consumers attempt to answer preference questions.

Fourthly, the findings of the review challenge the idea that the use of a single set of coefficients, for a presumed single population, is an appropriate way to model consumer preferences towards EVs. Not only is there likely to be an early adopter and an early majority distinction, proper consideration of symbolic and affective motives leads to a finer grained sub-division of these groups. These segments will represent both demographic characteristics such as lifestage as well as the strength of the underlying personality and value characteristics which can have an overriding impact on preference.

Finally, based on the literature reviewed here, it would also be unwise to assume that preferences will remain static over time. There is no doubt that increased market penetration of EVs will alter the way in which consumers value EVs and choose among and use them. There is some indication of how this may be done, but given that current preferences are hard enough to disaggregate, the estimation of future preferences will be highly speculative.

In conclusion, in order to gain a deeper understanding of likely consumer response to EVs, it will be necessary to move away from traditional market research methods and use alternative approaches. The dominance of SP surveys is due to the attempt, since the early 1980s, to overcome the challenge of asking consumers to predict their interest in a radically new product that does not yet exist in the marketplace. However, this literature review forces a rethink of the merit of putting participants in front of predetermined optimisation problems, particularly if these only attempt to capture the functional attributes relating to an EV purchase. Alternative approaches include qualitative deliberative techniques, design games and simulations or providing real experience to participants. The goal is to equip participants with knowledge and mental stimulation equivalent to that which would exist in a more mature market place.

4 Summary of the main literature findings

Plug-in vehicles are novel technologies of which mainstream consumers have no experience. This presents a significant challenge to the investigation of the consumer response to such vehicles. This systematic review of the international evidence provides a solid understanding of consumer behaviour relating to the uptake of cars in general and EVs (including fully electric, plug-in hybrid and range extended EVs) in particular. This knowledge underpinned the primary data collection undertaken in the remainder of this project.

4.1 State of the evidence

The search for evidence generated approximately 160 pieces of literature of which 88 were taken forward for review. The literature falls into four broad categories. These include: (i) revealed and stated preference surveys of consumer behaviour regarding a variety of vehicle powertrains; (ii) qualitative and conventional questionnaire surveys eliciting consumer attitudes and perceptions of vehicle attributes, AFVs and policy incentives; (iii) evidence of consumer responses to EVs before and after small-scale vehicle trials; and (iv) theoretical texts relating to socio-technical transitions, symbolic behaviour and consumer segmentation.

The evidence is largely dominated by rational, economic modelling approaches using national data at the aggregate level or individual, disaggregate level which attempts to identify the factors that affect consumers' car buying behaviours, in order to estimate market share. However, sections of the literature reject such approaches or at least supplement them with insights from theories utilising environmental or social psychology, marketing, or models of transitions or social learning.

4.2 The UK car market

In 2009, non-private registrations (business and fleet) accounted for 49% of all new cars registered in the UK. A significant proportion of the non-private sector comprises individuals with a large degree of autonomy over their choice of company car ('user choosers'). Only 5% of households acquire a new car in any given year. Those in managerial and professional jobs are most important to the retail car market as they account for just over 40% of new cars currently owned and for 40% of new car purchases.

4.3 The relative importance of functional, affective and symbolic motives

There are a number of different types of factors, economic and non-economic, that influence how and why cars are purchased. Many of these are common to all powertrains, but some, such as availability of charging infrastructure, are specific to EVs.

In recent surveys examining general car purchasing behaviour which asked people to rank the vehicle attributes most important to them, respondents tended to assign approximately equal importance to a number of attributes of the vehicle. These include size, style, reliability and comfort in addition to fixed and variable cost attributes, such as purchase price, fuel consumption/running cost. According to these studies, of less importance are attributes such as impact on the environment and resale value. Used car purchasers pay more attention to price, reliability and fuel consumption and new car buyers place more emphasis on safety, style, design, comfort and quality.

There is mixed evidence on the role that purchase price plays and the premium which certain segments may be prepared to pay to own a fuel efficient vehicle or an EV. Overall, studies have found a good deal of interest among consumers for EVs, particularly PHEVs, as well as a good deal of resistance based on the estimated cost of this new technology. The high price of EVs has been noted as a main barrier to uptake in a few surveys and modelling evidence based on SP experiments suggests that purchase price has the greatest influence on car choice. However, consumer responses to increasing price premiums of plug-in vehicles in terms of purchase probabilities is generally greater than can be justified based on purely economic rationales. This means that consumer acceptance is not solely determined by costs as emotional and other non-economic and functional factors influence the likelihood of future purchases.

It is likely that early adopters of EVs will be willing to pay more for their purchase and many may not even compare the price difference with conventional vehicles. However, it is also likely that there will be more than one early adopter segment, most of which are driven by economic considerations in their own way. These include being less dependent on volatile oil prices, cash flow analyses rather than detailed payback calculations, and the high value placed on saving time refuelling and possibly parking or driving in HOV and bus lanes.

Clear evidence exists to suggest that most consumers do not even have the fundamental building blocks to be able to make detailed payback calculations. This is set to be exacerbated when fuel costs are subsumed by electricity bills. Studies in the US show that drivers of PHEVs omitted their grid-based electricity use when discussing fuel economy even though many in-vehicle displays indicated the consumption of both sources of energy. In terms of consumer perception of other costs such as battery replacement costs and resale value, there is no information to be gained from the literature on these factors.

However, rising oil prices may lead to more economically rational considerations, particularly if these prices rise rapidly. In particular, consumers are likely to pay attention to the *relative* costs of different fuels. In summary, the evidence review suggests that whilst there is no question that widening the gap between electricity prices and fuel prices will make EVs more attractive, policy makers and modellers may have a tendency to over-emphasise the importance of rational deliberation of longer term running costs and payback periods.

4.4 The importance of range and recharging infrastructure

Similar conclusions apply to recharging behaviour where patterns may not be driven by cost savings but more by convenience. The most comprehensive evidence on the issues of range and refuelling behaviour has emerged from before and after studies of vehicle trial participants or existing owners of BEVs or PHEVs.

Studies have generally found the lack of recharging infrastructure to be less of a concern to consumers than range *per se*. Indeed, the clear consensus in the evidence so far is that consumers will mainly recharge their EVs at home and in workplace car parks and frequent recharging will be the norm at least at first. Reliance on proxy aggregate variables such as housing types and parking availability can lead to underestimates of the potential to recharge given the greater propensity than the average for car owners to have parking facilities and other options for recharging, such as at workplaces. Many consumers are attracted to the idea of having their own source of fuel at home and to reducing the nuisance cost of refuelling at petrol stations.

Public recharging infrastructure is likely, however, to play a key role in the diffusion of this technology by signalling its success and changing social norms.

Nevertheless, on an individual basis, range seems to be more important than recharging *per se* and few are willing to devote resources to reducing recharging time. Despite acknowledgement by consumers that their travel patterns do not necessarily require ranges longer than around 50 miles for most journeys, there remains a high premium placed on the option to drive longer distances. Trial data consistently show users are over-cautious when planning journeys, using a fraction of the available range. EVs with a range of around 100 miles may start to be attractive as second cars but there is a wide variation in willingness to pay for extra range. Experimental and qualitative studies have shown that consumers are likely to prefer PHEVs rather than BEVs and that the optimal solution is likely to be a range of PHEVs which offer various degrees of high fuel economy at a range of prices to appeal to a number of segments.

4.5 Perceptions of EV performance

In general, preferences for greater fuel efficiency are often found to be overshadowed by stronger affinities for power, acceleration and size. Consumers have been found to have generally negative perceptions with regards to alternative vehicles' attributes, especially with regards to performance factors such as acceleration and top speed. Importantly, however, in the findings of the few EV vehicle trials that have been conducted, ratings of EV performance tends to increase once consumers have gained some experience of the vehicles.

Size and practicality are important purchase factors and are a common starting point for vehicle selection. Perceptions of size in relation to EVs have not been widely studied, however.

In comparison with performance, size and capital cost attributes, environmental benefits are of relatively little importance in the purchase decision. There is debate over the extent to which adopters of EVs have or will have above average environmental awareness. It seems that some consumers would be prepared to pay more to drive cleaner or zero emission vehicles, but this often relies on the idea that the alternative vehicles can match conventional types in performance. It seems most likely that there will be early adopter and early majority consumer segments which has stronger than average environmental motivations, but that these will not be the determinant factors in whether this technology is mainstreamed.

4.6 The influence of Government incentives

Despite the proliferation of incentive programs, particularly in the US with respect to HEVs, their efficacy is unclear. Particularly uncertain is the point in the decision-making process that fiscal or other incentives are likely to have the most influence on purchasing patterns and the ways in which instruments can be packaged together to have the optimum effect.

Studies of existing car purchase subsidies on conventional and HEV technology suggest that these have been effective in stimulating demand. However, there are two clear findings from the evidence. The first is that fiscal incentives need to be designed so that they are conceived separately from the purchase price. It seems that consumers are more sensitive to sales tax incentives than income tax incentives. The second is that purchase and tax incentives are likely to be less important than fuel price which is the main determinant.

With regard to other types of incentive such as preferential treatment for EVs with respect to HOV lanes and bus lanes, congestion and parking charges, there is only substantive evidence in relation the first of these. Evidence from the US suggests that HOV lanes could be important, but less important than other incentives and fuel prices, and very dependent on the specific local context including the level of congestion. The higher than average uptake of EVs in London and the location of people owning these vehicles does suggest that parking incentives and the congestion charge can influence the level of adoption.

4.7 Symbolic and emotional considerations

Models of car choice are likely to be inadequate without a proper consideration of impulsive or non-conscious regulatory processes including the role of affect (or emotion), identity/symbolism (the wider meaning of goods) and personality and values in car preference. There is overlap between the more functional and the psychological considerations as choices depend on how attribute levels are perceived and the emotional reactions they provoke.

Emotional reactions, such as how a car feels to drive and the pleasure gained from the experience or the complexity involved in maintenance or refuelling, are virtually unstudied. More attention has been paid to symbolic motives. For instance, we are beginning to understand that EVs may be associated with meanings such as lower resource consumption, independence from petroleum producers, advanced technology, financial responsibility, saving money, opposing war as well as environmental and/or resource preservation. These symbolic evaluations can relate to the whole vehicle or to more specific functional or financial attributes such as fuel economy. Consumers then infer connotations to these meanings such as ‘behaving ethically’, ‘concern for others’, ‘being intelligent’ or ‘unique’ and if these relate to self identities and values, they will be expressed through adoption of EVs.

Various personality traits may also be associated with EV adoption. Innovativeness reflects the degree to which an individual makes innovative decisions independently of the communicated experience of others and, when combined with product knowledge, are powerful individual attributes on which to segment consumers. Narcissism (individuals who see themselves, and who want others to see them, as special or superior) is also hypothesised to be associated with greater interest in the symbolic rather than the functional value of products in the context of EVs. Driving an EV has also been found to be associated with high openness, high conscientiousness and high agreeableness.

4.8 Consumer segments

Segmentation of current and potential future EV adopters has been largely based on the idea from technological diffusion theory that consumers can be classified into five categories: innovators, early adopters, early majority, late majority and laggards. The early adopters of EVs are generally thought to have higher income, car ownership and higher mileages than the average and tend to live in multi-car households. But in terms of motivation, there is unlikely to be one early adopter segment as some will be driven by altruism and philosophical reasons for wanting to reduce fuel consumption, and others will be driven by the technology or have a financial motivation not necessarily backed up by detailed payback calculations.

Other segmentations have combined the technology diffusion segments with attitudinal and other data. For instance, survey data and parking data has been combined with Mosaic geodemographic information to identify potential ‘hotspots’ in cities in which to target investment in public charging infrastructure.

4.9 Diffusion effects

Consumer preferences cannot be considered to be static, particularly over the longer term. It is likely that increased market penetration will alter the way in which consumers value EVs and choose among them. There is a tendency for consumer preferences to change as technology becomes more prevalent in the market due to the changes in social concerns, increased credibility and learning from others with more experience as well as marketing, education and shifts in social norms. A study of market data in the US found that different models of HEV had different patterns of diffusion and this was attributed to different signals of quality across different models fuelled by media stories and word of mouth. Market share ratios can be added to surveys to try and elicit consumer preference and spillover effects, although these techniques are highly speculative.

In addition, it is possible that consumers may use these vehicles differently to conventional vehicles and this could lead to rebound effects such as increased car ownership, more driving or ‘upsizing’ which could counteract efficiency gains. There may also be positive benefits to driving style given the imperative to preserve all electric driving range. There is very little evidence on any of these possible behaviour changes. EVs are likely to be adopted as second vehicles, but it is possible that this will mainly be in households which already own multiple vehicles. Figures on HEV adoption in Switzerland do not show additional car ownership, but in the US they do.

QUALITATIVE STUDIES

5 Long term EV use

Knowledge gained from the literature review (Sections 1 to 4) was used to inform a series of qualitative research tasks undertaken as part of the wider programme of work. This section presents the approach taken to understand long term users' views of EVs.

The purpose of the qualitative research was to identify attributes and themes that potential consumers consider in relation to EV purchase and use. These themes were then incorporated into the design of the quantitative survey (including the stated preference survey) to quantify their relative importance. The qualitative work also sought to explore consumer attitudes and behaviours towards EVs. Some of these were further explored in the quantitative work, whilst others provided recommendations for future research.

5.1 Method

5.1.1 Participants

Eleven interviews were conducted by TRL researchers with people who had used an EV for a minimum period of three months. Ten participants were male and one was female. One participant was in their seventies, five were in their early to mid sixties, with two in their fifties, one in their forties, one in their thirties and one in their twenties. Three of the 11 participants owned an EV, two were using them as part of a trial, two were testing the vehicles as part of their job and four had access to them through work. The participants had experienced a mix of vehicle makes and sizes and they had experience of urban, suburban and rural driving using EVs.

5.1.2 Interview schedule/Topic guide

An interview schedule was designed by University of Sussex researchers in collaboration with researchers from TRL, incorporating information from the literature review as well as feedback from other partners. The interview schedule was designed to encourage participants to discuss EV experiences in-depth. The interview schedule is included as Appendix A of this report.

The interview schedule provides a guide to conducting a semi-structured interview of 60-90 minutes' duration. 'Main questions' are identified in bold to ensure coverage of a range of topics defined by the research objectives. Main questions in each topic area can be followed up with prompt questions to be used at the interviewer's discretion so as to evoke richer descriptions of the current topic area or to guide the interviewee to another area. These impromptu questions were also designed to clarify understanding and to shed light on inadequately covered areas. All questions were phrased neutrally so as to avoid leading the interviewee or agenda-setting during the interview. Interviewers were trained to be flexible in relation to question order and use of prompt questions, but also to ensure that responses were provided to all main questions.

Main questions included those designed to explore participants'…

- experience of using an EV, including positive and negative evaluations;
- experience of recharging and perceptions of required recharging infrastructure;
- general understanding of electricity supply and costs;
- perceptions of and attitudes to EVs;
- affective (or emotional) response to EVs;

- perceptions of whether EV use positively or negatively affected their identity;
- normative beliefs (e.g. what they thought other people thought about EVs generally, whether they thought other people would adopt them in the future and what others thought of the participants themselves as EV users);
- confidence in using EVs and recharging them; and
- identification of factors that were most important to their overall evaluation of EVs.

5.1.3 Procedure

Telephone interviews were conducted by TRL researchers who had been trained at the University of Sussex. Interviewers were instructed not to answer any questions posed by the interviewees until the interview had ended. If a participant had experience of more than one type of EV they were asked to choose one to talk about. All interviews were recorded with participants' consent and transcribed verbatim into a Microsoft Word document by a transcription specialist. Immediately after the interview, a micro-survey involving quantitative data collection was conducted. Interviewees were asked to indicate on a seven-point response scale how they evaluated EVs and whether this had changed from when they first had access to an EV as well as their purchasing/leasing intentions in the future and whether these had changed as a consequence of EV use. Interviews lasted between 60 and 90 minutes.

5.1.4 Method of analysis

Version 8 of the software program NVivo was used to assist with analyses. This program has been developed to help organise and record the process of qualitative data analysis (Bazeley, 2007) as well as to assist in uncovering underlying conceptual structures within discourse (Bryman, 2008).

A preliminary Grounded Theory coding procedure (Strauss & Corbin, 1990, 1998) was employed. Specifically, 'open' coding was used to assign conceptual labels to topics, which were then refined through repeated inspection. This is the first stage of development of a Grounded Theory. The thematic structure was partly pre-defined by the research objectives of the study and partly embodied in the interview schedule structure. This combination of preliminary Grounded Theory coding procedures and thematic analysis of emerging content allowed detailed, response-driven extraction of participants' comments (from interview transcripts) as well as facilitating a theory-informed approach to identification of important assertions and themes. As such, our method falls between traditional Grounded Theory (Glaser & Strauss, 1967) and traditional content analysis.

5.2 Results

Table 18 shows the 28 themes which emerged from these analyses. These are presented in eight sections as follows:

1. Negative responses to the vehicle (5 themes)
2. Positive responses to the vehicle (3 themes)
3. Mixed responses to the vehicle (4 themes)
4. General themes relating to the vehicle (6 themes)
5. General themes relating to the recharging (2 themes)
6. Themes relating to the recharging infrastructure (3 themes)
7. Themes relating to incentives (3 themes)
8. Acceptance and Development themes (2 themes)

Table 18 also shows the sub-themes identified within each of these themes and the number of individual transcripts which contributed comments to each theme and sub-theme. The content of these themes is described in further detail with illustrative quotes from p.116 onwards, in blue text.

The results section concludes with a brief summary of results from specific questions and the post-interview micro survey. No statistical analyses were undertaken on the 11 responses to these questions.

Table 18: Coding themes

Themes			**Sub themes**	
Negative responses to the vehicle		**N**		**N**
Concerns about range	Any mention of the limitations of the vehicle range or concerns about the distance the vehicles can achieve.		Not enough range to meet needs	9
			Lack of confidence in vehicle range	7
Concerns about vehicle design	Any mention of the limitations of the vehicle design or concern about the vehicle design. This could include the size, aesthetics and instrumentation.	9		
Safety issues	Any mention of potential safety issues relating to the lack of vehicle power and to the silence of the vehicle.		Due to lack of power	2
			Due to silence of the vehicle	3
Initial cost of vehicle	Any negative mention of the initial cost of the vehicle either from the participant or from other people's responses to them regarding vehicle cost.		Participants' responses	10
			Other people's responses	3
Rebound effects	Any mention of a rebound effect. For example the financial savings from the running costs results in the participant driving more often or for longer distances.	1		
Positive responses to the vehicle				
Ease of use/simplicity of vehicle	Any mention of vehicle's ease of use for the driver, or simplicity of the vehicle.	10		
Environmentally friendly	Any mention of the vehicle being environmentally friendly.	10		
Financial savings	Any mention of the financial savings to be made from using a plug-in vehicle	6		

Mixed responses to the vehicle				
Vehicle performance	Any mention of negative and positive aspects relating to the vehicle's performance.		Concerns about vehicle performance	6
			Surprised or pleased with the vehicle's performance	8
Meeting needs	Any mention of negative and positive aspects relating to the vehicle meeting the participant's needs.		Vehicle does not meet needs	3
			Vehicle suits needs	5
Creature comforts	Any mention of negative and positive aspects relating to the vehicle's creature comforts.	5		
The driving experience	Any mention of a feel good factor or a feel bad factor while driving the vehicle.		Not fun to drive	2
			Feel good factor	10
General themes relating to the vehicle				
Suitability of trip type	Any mention of the type of trip/journey that these vehicles are suitable for	11		
Characterisation of typical plug-in driver	Any mention of the type of person suited to or associated with EVs	11		
Adaptation to the vehicle	Any mention of the participant adapting their driving, trips, mindset or lifestyle due to the vehicles	11		
Pro-active encouragement of adoption	Any mention of the participant being proactive in encouraging EVs	3		
Novelty factor	Any mention of driving the vehicle being a novelty	6		
Vehicle as an advert	Any mention of the vehicle advertising itself as a plug-in vehicle	7		
General themes relating to recharging				
Experience of recharging	Any mention of recharging being a hassle or recharging being easy.		Recharging is a hassle	3
			Recharging is easy	8
Safety issues relating to recharging	Any mention of safety issues when recharging	4		

Themes relating to the recharging infrastructure				
Public infrastructure issues	Any mention of issues that relate to public infrastructure, positive or negative.	8		
Private infrastructure issues	Any mention of issues that relate to private infrastructure, positive or negative.	4		
Servicing issues	Any mention of issues that relate to servicing the vehicle, positive or negative.	3		
Themes relating to incentives				
Financial incentives	Any mention of wanting financial incentives to use a plug-in vehicle	7		
Investment incentives	Any mention of wanting investment in the industry as an incentive to use a plug-in vehicle.	3		
Structural incentives	Any mention of wanting structural changes as an incentive to use a plug-in vehicle.	4		
Public acceptance and future development themes				
Public acceptance	Any mention of how others think negatively or respond positively to the vehicles		Negative responses from others	5
			Positive responses from others	7
Technological development	Any mention of how far the vehicle and/or infrastructure technology has come or how far it has to go, as well as the future viability of EVs	10		

5.2.1 Negative responses to the vehicle

5.2.1.1 Concerns about range

Nine of the 11 participants expressed some concern relating to the range of their vehicle. Their concerns were mainly due to the lack of distance that they could achieve without recharging which meant that they either had to use another vehicle for certain trips or they were unable to be flexible and had to plan driving very carefully.

Illustrative quotes include:

If you had to detour for some reason, if there was an accident and you had to travel more miles coming back, then you might not get back.

Some participants also reported that range was further restricted in bad weather and by use of electric heating, electric windows or air-conditioning, which all drain the batteries.

You're going to get around the 100 mile mark, or 120…the range is quite dependent on the weather, in that, if it's cold, like we had over winter, the batteries don't perform as well. Also, you turn on the heater, and the heating is….electric, it's basically just like an *electric heater at home…it just eats electricity. And so the range drops to about…70 miles.*

Several people mentioned that they were not confident about making longer trips and also not confident as to whether or not the vehicle could achieve the manufacturer-specified range.

Having the choice, I would only drive that vehicle on full charge and not go any more than…25 miles. Although it says it has a range of 60 miles, I don't know…really.

5.2.1.2 *Concerns about vehicle design*

Nine participants made reference to negative design features. These included poor instrumentation, lack of space in the boot, the size and weight of the battery and the small windows (e.g. making it hard to see behind when reversing).

The display we've got on the dash is very poor. I mean, I need glasses to read the display; it's no good to me.

Several people also commented on the poor aesthetics of the vehicles.

Well, it's not a nice looking car. So it's not a car I would personally buy.

5.2.1.3 *Safety issues relating to the vehicle*

Two of the 11 participants commented on safety concerns due to poor acceleration that could endanger the driver or others on faster roads.

It can limit the maximum speed…to a maximum of 30 miles an hour which, obviously on an A road it's maybe is 60…could be classed as being quite dangerous driving at that speed really, and…for other road users.

Three people also mentioned the potential dangers for pedestrians (especially children) and cyclists due to the silence of the engine.

There are no noises off it; there is just a little whine in the interior. And you get some people cross the road, you know, they're not looking and they don't hear anything coming and they don't look, so you've got to be wary of that sort of thing.

5.2.1.4 *Initial cost of the vehicle*

Ten of the 11 people interviewed expressed negative views relating to the initial purchasing costs of the vehicle.

I would say the average person, the cost of something like that now is just totally…is totally way off at the moment.

Some commented that the cost at present outweighs the benefits of owning one.

At the moment the cost is outweighing the benefit, they're about £10,000 more than a standard diesel car.

Three people also spoke about how others they had spoken to regarding EVs were very interested until they heard how much they cost.

And, you'd show them, because we thought it was so great, we showed them where you plug it in, and then they'd say to you, how much does it cost to run? And, of course I knew that, I'd always say, oh well, it's two or three pence, and especially at this time, petrol was going up and people would say, oh, that's great, that's great. I wouldn't mind one of them, how much do you pay? And, as soon as you said £18,000, they, you nearly had to pick them up off the floor.

5.2.1.5 Rebound effect

Although only one participant commented on rebound effects, it is a potentially important issue for mainstream roll out. An example of a rebound effect would be use of a more fuel-efficient car resulting in increased emissions because the car is driven further and more often.

...every day I drive a mile, I'm saving myself a bit, and so that means I can drive more often than I would have otherwise, you know, for the same cost.

5.2.2 Positive responses to the vehicle

5.2.2.1 Ease of use/simplicity of vehicle

Ten people commented on how easy it was to drive/handle their vehicle. Some felt that there were no challenges to driving EVs.

None whatsoever, no challenges. It's lovely. You know, you just get in, you know, there are no such things as gears or anything like that. You just put in drive and drive…it couldn't be simpler. It's totally idiot-proof.

Others commented that their EV had ergonomic advantages over fuel-driven cars.

Well, it's more of a direct thing…it's like an automatic, but it's so responsive. You're so aware of what you're doing.

Some also commented on the simplicity of the vehicle maintenance.

For instance, you won't have a burst radiator, because no matter how cold it is, there's no water in it to burst. You won't have to remember to put in anti-freeze, you don't have to remember to put in lots of things, because there's lots of things not there, so they are more simple.

5.2.2.2 Environmentally friendly

Ten people thought that driving an EV had an advantage over other vehicles because they had the potential to be good for the environment due to their efficiency and low/no exhaust emissions.

I think a massive advantage is obviously the efficiency that you get and I understand from a power generation if we can produce it in a cleaner manner and provide that power to electric vehicles it's much more efficient than a combustion engine...I think…having no tailpipe emissions in cities means…a much nicer environment to walk around. You can sit in traffic and the person behind me wasn't sucking in the fumes…if every other vehicle was electric…it would be very noticeable and people would be less conscious about keeping away from exhaust pipes.

5.2.2.3 Financial savings

Six people mentioned the financial savings that can be made from adopting a plug-in vehicle, compared to a petrol or diesel vehicle. The savings mentioned accrued from recharging (rather than refuelling), increased efficiency, less maintenance and from being exempt from parking fees, tax, and congestion charges.

Benefits are that it is cheaper to run, for the fuel, and there's no road tax, and no congestion charge, and free parking.

5.2.3 Mixed responses to the vehicle

5.2.3.1 Vehicle performance

Comments from six participants related to concerns over their vehicle's performance, particularly speed restrictions.

The only thing I dislike about it is the power side of it…although…I'm not a fast driver, if you wanted to get somewhere in a hurry, if you were wanting to go on the motorway…you would sit at 50 with one of these…Performance-wise, speed-wise, it's the only thing that gets to me and the distance it can travel.

Some were embarrassed by their lack of speed.

I've sometimes felt embarrassed if I'm going up a hill and I'm now to 20 miles an hour, and I'm conscious that I might be holding the traffic up, but that doesn't happen that often.

Others commented on the lack of acceleration after a certain speed.

But once you're stuck going down the A41…which is a 60 mile an hour road, which we have to use to pick up our daughters up from school, it does become…a bit of a pain when it doesn't have the acceleration and all the same benefits that you would expect on a gasoline or a diesel vehicle.

However, eight participants commented that the performance of their vehicle exceeded their expectations in some way.

I thought it was very sort of nippy and quite enjoyable to drive and not what I was expecting which was for it to be something very slow, cumbersome, you know, poor performance and poor handling associated with having big batteries in the vehicle. So, you know, generally it was very good.

5.2.3.2 Meeting needs

Three people expressed concerns that their vehicle was unable to meet their needs.

It's not for my own personal need, it's not the most practical of cars due to the fact of having a family, and in the nature of the way I use them. It's got limited mileage and power on the vehicle.

However, five of 11 participants concluded that their vehicles did suit their needs for particular trip types.

Well, it's lived up to my expectations as far as what it can achieve. It only has a maximum of 50 mile range and a maximum speed of 50 miles an hour. But on the sorts of journeys that I use it for, no more than 20 miles at a time, it's ideal.

However, in general, such comments were based on use of the EV as a second car.

It would be a second car for the family I think.

5.2.3.3 Creature comforts

The main concern regarding the comfort of the vehicle related to the inadequacies of the heating especially in the winter months.

It does have a heater, but it's almost negligible. The downside is if you put the heater on, of course, it uses the battery and reduces your range, so I tend not to use the heater in the winter unless it's really, really cold.

However, when heaters ran on diesel this was not a problem.

They are very comfortable. They've got a heater which comes off the diesel, you know, a bit of diesel, you know, for heating. You've got your radio, CD and all that sort of thing. It's just like driving a normal vehicle, apart from, you know, the performance.

5.2.3.4 The driving experience

Two of the interviewees suggested that their vehicles were not fun to drive.

You couldn't overtake a vehicle…you have to drive it like an electric car…there is no gear change, so you've lost that. So it is a bit more boring to drive.

On the other hand, ten people made comments which expressed some type of feel good factor associated with driving their EV. These included feeling satisfaction due to the vehicle being silent, nippy to get around in, easy to drive, economical to run, environmentally friendly, or fun to drive.

We both drive it around town, and it's the one that we use most of the time. We both want to drive it because it's good fun driving.

5.2.4 General themes relating to the vehicle

5.2.4.1 Suitability of trip type

All 11 people interviewed expressed their views of the types of trips appropriate for their vehicles. The majority thought that the vehicle was well suited for urban use due to their lack of power and/or for running around on short trips/errands due to lack of range.

To my view, it is purely for around town use, and that's all it's good for really, no more than 30 miles an hour. If you were stuck in a city centre where the maximum speed is 20 miles an hour, that would be perfect, that's what it's good for. Anything more than that, if you want to get somewhere quick, you might as well leave it at home.

Most of them felt that their vehicles were unsuitable for larger and faster roads such as motorways.

No, no I wouldn't go on a motorway with one, no. I mean, I felt safe on the A road, the maximum speed is 52 or 54, or something like that.

5.2.4.2 Characterisation of typical EV driver

All 11 participants also expressed views on the type of person that would drive an EV. Apart from comments on needing to be well-off to afford an EV, most views focused on being environmentally aware.

People like me that care about the environment and like to use a non-polluting vehicle and are willing to pay for the privilege just to show that they can do it.

Several people thought that they would appeal to the more mature driver, especially as they may be in less of a hurry, more careful and patient.

I mean, you're that wee bit older, you get a wee bit slower and you tend to be more careful. So I think a guy of maybe about 40 or on the retirement side of things is going to be more drawn towards it than what a young guy will be.

However, others thought that they would appeal to those who wanted to save money in the long run.

You also may be somebody who's interested in saving the pennies, which people…on a fixed income do…if you were somebody in town, you could quite easily be a young, trendy person, couldn't you? Because…you could save an awful lot of money, which must make all these young, trendy things feel good as well, because they would save far more than somebody like me, out here.

5.2.4.3 Adaptation to the vehicle

All those interviewed made some remarks on how they had adapted in some way to the vehicles since they started using them. Often this was adapting their trips by changing the routes they used.

Whereas I would normally have driven into Ipswich on the main A12 dual carriageway, I now go a back road, which is slightly longer, but it's a lower speed road with less risk. So, yes, I have changed my driving.

Others had adapted their driving style to suit how the power is delivered to the vehicle or to suit the vehicle's limitations in some way.

You tend to think environmentally once you drive an electric vehicle. Your driving habits change. For example, you will automatically switch your headlights off when you stop at a traffic light at night-time because it drains the battery, you know…You learn to drive differently and it almost becomes a competition to see how far you can get on the charge.

5.2.4.4 Pro-active encouragement of adoption

Three people made comments on how they were being pro-active in encouraging adoption and development of infrastructure. However, they did not feel supported by local and national Government.

It would be nice if the Government were able to be very sure about promoting electric vehicles. You know, when I approached the local council, they just kind of laughed and said, oh no, we won't be doing anything until we see other cities do something for parking and charging places. It would be nice if there was a sort of universal policy that actually encouraged people to buy and use electric vehicles.

5.2.4.5 Novelty factor

Six of the 11 interviewees mentioned the novelty value of their vehicle, either in relation to driving one, owning one, or from the responses they got from others. This may not be directly relevant to mainstream roll-out but may be helpful to early adoption.

Because there are so few electric vehicles around it's such a novelty that people want to see it, want to look at it, want to hear it moving around. Where are the batteries? Questions like that, forever pulling up the bit at the back where you can sort of see where the motor is and things like that so show people. So people found it a real novelty.

5.2.4.6 Vehicle as an advert

Seven participants' vehicles displayed signs/stickers indicating that they were driving an EV to make people aware. This was not always provided by the manufacturer and sometimes acted to excuse the car's lack of performance. Yet sometimes this was found to be unnecessary.

...so with the help of my son-in-law I had a picture of a plug-in socket, coming down like an electric lead, and the electric lead says the word electric over the main front door. I have it on both sides, and on the back, for safety reasons, I've got 'totally electric', so that…anybody who came up behind me, they'd realise there was a reason why I wasn't, sort of, accelerating quickly, but in actual fact, I've not found…I've found the driving so easy, that I needn't have put the bit on the back.

5.2.5 General themes relating to the recharging

5.2.5.1 Experience of recharging

Three participants expressed views that recharging was a hassle in some way. One interviewee felt that refuelling was simpler and required less planning.

Refuelling to be honest is far, far simpler. I mean, I don't do that much mileage within a week or two, and if I've got a full tank it can very often last me two weeks or more. And then you can forget about it...you don't have to worry about [it]...But you've always got to constantly make sure, certainly with the C1, that you've got enough charge in it.

Others mentioned that they either did not have access to enough recharging facilities, or it took too long, or the vehicle failed to recharge because of something they had done wrong.

Occasionally it hasn't charged because we just haven't done something correctly. Like I forget to turn the power switch on or something. The one at home in particular because that's on a timer, so if the timer is not set correctly then you get up in the morning and you find it hasn't charged overnight...it has happened a couple of times.

However, eight of the participants felt that recharging was straightforward and posed no problems for them. Here we see a real contrast in users' experiences, depending mainly on commitment to EV use.

The thing about the Mercedes one is it's a plain, straightforward, 13-amp plug. You plug it into a wall and that's it, you know.

Some even felt that it was easier and more pleasant than refuelling.

Very easy. It's just so quick and easy to do, and it's so much easier than going to a petrol station to fill up with fuel. It's a real…I really noticed it when I was driving a petrol car and the hassle of having to go to a petrol station, it's quite surprising actually at how much easier it is just to plug it in.

5.2.5.2 Safety issues in relation to recharging

Four people had some concerns with potential safety problems with recharging. These concerns included forgetting the vehicle was plugged in and driving off, electricity sockets being outside and therefore being exposed to rain or unattended at night, and concerns that the plug could be pulled out of the vehicle by others such as children as there was no locking mechanism. Finally, there was the issue of cables tripping people up.

There's no way of securing the actual electric that's there, someone taking the lead, or…it may be nothing other than just winding the person up that owns the vehicle, but I can see that becoming an issue.. as well depending on where it is if you've got cable, as short as it may be, you've got to obviously leave it to people's own discretion to park it sensibly, so the cable's not stretched. Or somewhere where someone could walk past it and catch themselves.

5.2.6 Themes relating to the recharging infrastructure

5.2.6.1 Public infrastructure issues

Eight of the 11 people interviewed talked about how they felt there was a shortage of public infrastructure and revealed uncertainties about the recharging technology.

Yes, I would like...somewhere within the town, because that would encourage people who've got them to come into town with them. I'd like to see them [recharging posts] in most retail stores. You know when you've got these supermarkets or, like, other *shopping centres, like DIY places, and they've got great big places...I would like to see them in garages, but I can see that garages can't possibly do it, unless you get a fast charge, and I'm not too sure if it's…I can't find anybody to answer my question. I think that you can do these fast charges, but I think you have to have a different plug, and I don't know too much about it.*

Another problem that was made salient by one person was the lack of standardisation of the allotted time you could stay and recharge your vehicle in public recharging bays as well as the lack of standardisation for lead fittings.

I don't think there is a standard lead fitting. There's not like an industry standard, so now I've got three different leads for the same car. One is for the wall charger, which I can use in normal plug as well, then there's another one, which I don't know what it's used for, and then there's a third one that I got last week, and it's just for shopping centres and this and that.

5.2.6.2 Private infrastructure issues

For some, recharging at home was not possible or advisable. This was either because they did not have off-street parking facilities or they felt that they needed a garage to make recharging at home safe. One person thought that if EVs were going to take off then new housing developments would need to incorporate off-road parking. They also pointed out that existing town houses would not be able to accommodate recharging facilities.

I'm thinking of my daughter's [house]...where they're all little terraced houses, and they've got nowhere to park the car and you couldn't have the plug over the pathway... that's the only thing that I could see that would be difficult. I cannot see anything wrong with the car.

5.2.6.3 Servicing issues

Servicing issues were mentioned by three of the participants. One mentioned that the nearest place that they could have their vehicle battery serviced was in London when they lived in Suffolk, another person said they were advised to pay someone to come to them to service their vehicle.

Well, at the moment, they're suggesting that I pay somebody to come out, to do it at home, because there's no way of getting it in without a trailer.

Two people did, however mention, that EVs required far less maintenance than petrol or diesel vehicles, although one of these interviewees noted that this could result in fewer garages being able to offer maintenance services.

5.2.7 Themes relating to incentives

Seven people talked about financial incentives that they thought they would like. The most common was the need for a grant to bring down the initial cost of purchasing a plug-in vehicle as planned by the previous Government.

Well I think the £5,000 incentive that's going to be offered will bring a lot of cars into the [affordable] range. I think they would drop the price into an area where you would think, well okay, it's more than I would normally spend on a petrol engine vehicle or a diesel but what's it going to save me over time?

Other financial incentives mentioned were reduced running costs through exemption from road tax, parking fees, and congestion charges (not just in London).

I wouldn't like congestion charges to be involved...I would like to see electric cars going in free.

Four people mentioned that investing more in infrastructure or allocated free parking spaces would be good incentives either by local councils or at work. In addition, three people thought that UK Government could do more, either by local councils starting to invest in the infrastructure in their local communities or through Government investment in UK car companies so they could start to manufacture EVs instead of shutting down.

I think that this country is daft that it hasn't encouraged the car businesses that are shutting down to start making them…Why the heck they couldn't have said, hang on a minute. We will put the money into making the cars in this country. That's what I'd like to see here.

5.2.8 Acceptance and Development theme

5.2.8.1 Public acceptance

Four people mentioned how others had responded negatively. One mentioned the oil industry's dislike of EVs, others talked about how certain people had said EVs were a bad idea and would never take off. Some commented that other drivers (predominantly young males) were often impatient with, or rude to, plug-in vehicle drivers on the road.

Aye, some of them just laugh! They say to you, what are you driving an electric vehicle for?

However, seven of those interviewed reported positive responses. Some of responses were from people who would love to own a plug-in vehicle themselves. Others had expressed surprise at how similar they are to petrol/diesel vehicles or how quiet or cheap they are to run.

I tell them how much it costs, compared to petrol for a mile, and they get, you know, gobsmacked, because it will cost anything up to 20 pence a mile.

5.2.8.2 Technological development

There were a couple of people interviewed who did not think that the vehicle technology was good enough.

It's just things that at the end of the day it's just more…there's more negatives to positives by quite a long way…

Others commented on how far EVs had come already.

I mean, what an electric vehicle can do has…it's come a long, long way from a milk float, if you want to put it that way.

Most of them, however, felt that they still had some way to go before they would really take off.

People need to develop these things and bring them forward a bit more, and then people would start sitting up and taking notice of it.

However, many did think that there was a future for EVs, at least in some capacity.

I think they're a good thing, yes. It's still early days, isn't it? I think it probably is the future, isn't it? Fifty years time, we'll probably all be driving electric vehicles.

5.2.9 Summary of specific interview questions

5.2.9.1 Order of important factors

Nine of the 11 people interviewed were asked to rank the factors they felt were important to them when considering EVs. The order varied from person to person; however there were 14 distinct factors mentioned. These were the vehicle range, the environmental benefits of EVs, the performance of the vehicle, comfort, financial savings from running costs, the initial purchasing cost, the aesthetics of the vehicle, the infrastructure, the silence of the vehicle, the size of the vehicle, the vehicle's reliability, the vehicle's instrumentation, safety, and being able to be self sufficient. The most widely cited factor across the nine people interviewed was range (N=6), environmental benefits (N=5), initial cost of vehicle (N=4), performance (N=4), economical to run (N=3), and comfort (N=2), with the remaining factors mentioned by one person each.

5.2.9.2 Acceptable range

Four people were asked what they thought would be an acceptable mileage range to them. Their answers varied from 120 miles to 200 miles. The average was around 150 miles.

5.2.9.3 Acceptable vehicle cost

Five people were asked if they would expect to pay more or less for a plug-in vehicle compared to a petrol or diesel equivalent. Four people felt that EVs cost too much and should be the same price as their petrol/diesel equivalent. One person thought that it was acceptable that they cost more as you made savings from the running costs.

5.2.9.4 Awareness of electricity supply and cost

Eight people were asked if they were aware of which company supplied their electricity at home. All of them were able to say which company it was and most of them had some idea either how much they were charged for their electricity per unit or at least had a rough idea of how much it cost them to fully recharge their vehicle at home or how much per mile it cost them to run their vehicles.

5.2.9.5 Recharging (when and where)

All 11 people were asked where and when they recharged their vehicles. Five of them recharged exclusively at work. Three people out of these five recharged it at night only, the fourth recharged in the day whilst he was working and the fifth person explained that he recharged at work whenever he was not using the vehicle. Five people recharged at home. Two of these people had home solar panels and therefore recharged in the day to make the most of the sunshine (therefore free electricity), they also recharged most days and sometimes multiple times a day. Three people recharged from home through the night; two of them recharged every night, the other was more erratic as he had learnt that he did not need to recharge every night as he had once believed. The final person had the facilities to recharge both at home and at work and made use of both facilities but preferred to recharge at work as he did not have to pay for the electricity.

Several of the participants had at least some experience of recharging in public places or at other people's homes but none of them recharged away from home or work on a regular basis.

5.2.9.6 Acceptability of public recharging costs and methods of payment

Although only some of the people interviewed had actually used public recharging facilities, those that were asked were generally accepting that one day they may have to pay to recharge in public places. However, they generally did not want to pay more than a few pounds for a top-up. One person explained that he would be prepared to pay more (e.g. £5) for a fast recharge on a motorway. None of the people that were asked about their preferred method to pay for public recharging wanted to pay an annual membership fee as they felt that they would not use it enough to make it worthwhile. All of them wanted to pay for the electricity that they had used. Generally they favoured using a debit/credit card, or would be happy to be billed on a monthly basis. Only one mentioned that they would be happy with a coin system.

5.2.9.7 Information requirements

When asked if they had any information requirements, three people expressed the need for more information regarding infrastructure. One mentioned they would like more information on where and how to get the vehicle serviced, another wanted more information about fast charging infrastructure and the other wanted information on how to locate existing recharging infrastructure.

Four people expressed the need for specific vehicle information. The types of information they required ranged from information on electricity cost, to insurance and vehicle warranties. One person was very interested in finding out about the environmental impact of EVs through their life-cycle.

5.2.9.8 Micro-survey

All the interviewees were asked to rate their attitude towards plug-in vehicles before they had experience of EVs and now that they had experience. This was done on a seven-point scale where one was very negative and seven was very positive.

Eight out of the 11 people interviewed felt that they had a more positive attitude towards plug-in vehicles since gaining experience. The shift ranged from a one point shift to a 3.5 point shift in a positive direction. One participant's attitude did not shift and remained very positive at seven. The remaining two participants had a negative shift in attitude since gaining hands-on experience; one had shifted down by one point and the other down by three points.

Seven of the eight participants who did not already own a plug-in vehicle were asked to indicate on the same seven-point scale how likely it was that they would have considered purchasing an EV before they had experience of one and again now that they had experience. Six of them felt that they were more likely to purchase/lease a plug-in vehicle in the next five years. This positive shift ranged from two points to 3.5 points. One participant indicated he was less likely to purchase an EV (minus 2 points) now that he had experience of them. The remaining interviewee was not asked the questions but had made it very clear that he was not impressed and would not consider purchasing an EV in the near future.

5.3 Summary of long term EV use study

The results of this thematic analysis of 11 interview transcripts endorse previous findings. Users find that the limited range, acceleration and speed of EVs mean that they are practical for short, urban journeys on low-speed roads. This characterisation, combined with high initial purchase costs means that they are viewed primarily as second cars for well-off environmentally-aware households. It is noteworthy that, for such households, there is a rebound risk as cheaper travel and other incentives could increase urban commuting when EVs are adopted as second cars. The most attractive incentives were thought to be purchase price subsidies.

The results also highlight users' recognition of the benefits of EVs, including the longer-term financial savings, the identity benefits of being seen to be protecting the environment and, for many, an acceptable and even enjoyable driving experience for short, urban trips. In addition, users were aware of a series of cost and effort savings in maintaining EVs (compared to fuel-driven cars). Finally, the caché of novelty experienced by participants may scaffold early adopters and so contribute to the momentum of mainstream roll out.

It is clear that technological and design advances could enhance the attractiveness of EVs. Enhanced range, increased power (especially at speeds above 30 miles an hour and on inclines) as well as a better top speed were viewed as especially important. Better ergonomic design including personal space and clear instrumentation were also highlighted. Available battery technology shaped perceptions of car comfort and recharging facilities. For example, while available batteries have limited power, users prefer peripherals, and especially heating and air conditioning, to be fuelled separately using diesel, in order to optimise range. Available batteries are not best suited to short bursts of recharging which may shorten battery life, so curtailing environmental benefit and escalating costs. Yet public recharging facilities may set a maximum of three hours and be policed by traffic wardens. In this case, recharging policies do not seem to reflect the technological realities faced by EV users. Differential pricing of fast charging (e.g. on motorways) could increase EV attractiveness by effectively increasing range. Finally, the aesthetics of EVs were seen as a barrier to purchase by some and this could be overcome using attractive exterior and interior design.

Reduced noise pollution can be viewed as an advantage of EV use but it is also seen as a safety hazard because pedestrians used to responding to the sound of cars do not respond to the approach of an EV.

Participants' experience of recharging was mixed. Some found it hard to make the adjustment and not everyone felt that their facilities were totally safe. Others found recharging preferable to refuelling. It is important to note, however, that exploring the recharging infrastructure needs of early adopters could be misleading because, by definition, these respondents have access to pre-arranged recharging facilities, whether these are their own domestic facilities or those provided by companies. Consequently, different recharging issues may arise in relation to mainstream roll out. For example, since off-street parking in urban areas is rare, it is unclear how night charging can be facilitated.

While EVs may require less servicing than a petrol or diesel vehicle, battery servicing was problematic for some. Most existing mechanics are not able to service batteries, requiring drivers to transport the vehicle long distances or pay for home servicing.

It is encouraging to see how some drivers adopt environmentally-friendly driving styles as a way of adapting to the limitations of their EV. Similarly, it is encouraging to note how, in early adoption, EVs can provide an advertisement for adoption and encourage users to become active campaigners for adoption and infrastructure development. Unfortunately, there was evidence that these early adopters were not necessarily receiving local or national support in relation to infrastructure development.

Finally, the results from the micro-survey suggest that for these early adopters, exposure to an EV for an extended period of time generally increases positive attitudes toward them and increases the likelihood that users would purchase one in the future.

A limitation of the study is that in some interviews not all 'main questions' were addressed. For example, some participants had no involvement in the charging process as charging took place at work by a maintenance team. It was therefore not possible to ask these participants about their experience of recharging and how the process of recharging the vehicle impacted on their lifestyle.

Overall, the results must be viewed cautiously as they are based on a small and diverse sample of 11 interviewees. It cannot be assumed that the sample is representative of the wider population. Nonetheless, the findings point to key positive and negative factors that shape drivers' experience of EVs. These provide hypotheses as to the attributes and technological developments and limitations that may determine widespread adoption. Such hypotheses should be explored qualitatively and quantitatively with more representative samples.

6 Short term EV use (household study)

This section presents the findings from two short-term qualitative research tasks within the wider programme of work. Firstly, the results of a thematic content analysis based on 22 short term users' perceptions of BEVs and PHEVs after exposure to them for a six-day period are presented. Secondly, a Grounded Theory analysis is presented for an expanded sample of 40 short term users.

In particular, the following areas were examined: 1) the level of ignorance/knowledge about EVs in pre-exposure interviews and how this changes after exposure, 2) the main factors shaping consumers' acceptance, potential purchase choice and use of plug-in vehicles and how these change after exposure, 3) factors likely to encourage adoption of EVs, and 4) perceptions of recharging and the recharging infrastructure.

6.1 Method

6.1.1 Participant recruitment procedure

Forty participants were recruited using the TRL database. This database includes more than 1,400 pedestrians, cyclists, equestrians, motorcyclists, and car, bus and HGV drivers from the Berkshire, Hampshire, and Surrey regions who have expressed a willingness to participate in research. A subset of 400 car drivers was contacted. We employed an 'illustrative sampling' method (Turrentine & Kurani, 2007) to generate a sample representing a mix of demographic and driving characteristics. Our sampling frame was defined by 1) gender, 2) marital status, 3) age, 4) weekly mileage, 5) number of cars in household, and 6) location (rural/urban). See Table 19 for details of participants' characteristics. The literature review highlighted that although current new car buyers tend to be older, younger generations of today may be the new car buyers of the future, therefore it was important to recruit across all age demographics.

Only one participant per household was included. Participants had to fulfil one of the following criteria:

- to have purchased or leased a new car or a car less than two years old in the last five years;
- to be in the process of looking for a new car (or one under two years old); or
- to be driving a company car less than two years old.

Participants were also selected on the basis that they felt they had independent responsibility for car purchasing decisions in their household or had as much influence on household car purchasing as anyone else (e.g. spouse/partner).

Only those who agreed to undergo familiarity training with an EV, to use an EV for one week, to participate in pre- and post-interviews, and to complete short questionnaires were included.

6.1.2 Travel diaries

Travel diaries were included in the methodology for the household study to explore differences in participants' journey patterns when using a plug-in vehicle compared to when using their own vehicle, and to record any noteworthy incidents in relation to the use of the plug-in vehicle. Travel diary data were gathered in addition to the in-depth interviews carried out with trial participants before and after gaining access to a trial vehicle.

6.1.3 The vehicles

Two BEVs and one PHEV were used. The BEV vehicles were a Citroen C1 converted to an electric car by the Electric Car Corporation, and a Mitsubishi iMiEV provided by the manufacturer. The PHEV was a Toyota Prius converted to a plug-in vehicle by Amberjac Projects. The Mitsubishi iMiEV was used for three participants with the remainder of the BEV trials being undertaken using the Citroen C1. All participants on the PHEV trial used the Toyota Prius.

6.1.4 Interview schedules and topic guides

Each participant was interviewed once before being loaned a plug-in vehicle for one week. Participants were interviewed again at the end of this week. The pre-interview lasted approximately 45 minutes and the post-interview approximately 70 minutes. Both the pre- and post-interviews were semi-structured and consisted of 'main questions' in order to ensure coverage of topics relevant to the research aims (see Appendix B and Appendix D). The main questions in each topic area could then be followed up with questions which were used at the interviewer's discretion so as to evoke richer descriptions of the current area or to guide the participants to another area. These impromptu questions were designed to clarify understanding and to shed light on inadequately covered areas. All questions were phrased neutrally so as to avoid leading the participant or 'agenda setting' in the interview. Interviewers were flexible with the order of questions within the topic areas to allow for a more natural flow in the interviews.

Full interview schedules are presented in Appendix B (pre-) and Appendix D (post-). These were based on the following pre-specified topic guide:

- **Past vehicle purchase narrative.** Participants were asked to describe their past vehicle purchasing/leasing decision processes. Prompts were used to encourage them to explain who was involved in the decision-making process, whether they had a clear idea of which vehicle they wanted or whether they changed their mind during the process, which alternatives they considered, and why they chose the vehicle they did. Finally they were asked how they would describe the vehicle to their friends and which attributes were important when making a vehicle purchase decision.
- **Knowledge and awareness of plug-in vehicles.** In this section the participants were asked what they knew about plug-in vehicles and what they knew about the difference between a BEV, a hybrid and a PHEV. Follow-up questions included asking the participants about any experience they may have had with plug-in vehicles, from where (if any) they had sourced their information on plug-ins, why they believed that these vehicles were being developed and manufactured, what they knew about how the vehicles work and recharging, whether they knew about any EV-relevant Government incentives or policies and, finally, how much they thought a plug-in vehicle would cost to purchase/lease and to run compared to their existing vehicle.
- **Attitudes and perceptions of plug-in vehicles.** Interviewers prompted the participants to talk generally about what they think about plug-in vehicles including any perceived benefits and disadvantages both in general and for them personally. Participants were also prompted to consider whether or not EVs could meet their and their family's mobility needs. Finally participants were prompted to reflect on what, if anything, would have to change for them to be encouraged to acquire an EV.
- **Affective responses.** Participants were asked how appealing or unappealing plug-in vehicles were to them, how satisfying or unsatisfying they felt driving a plug-in vehicle would be and how they thought they would feel using a plug-in vehicle for various types of journeys.
- **Identity responses.** Participants were asked to describe the kind of person they thought drove plug-in vehicles, and what they thought these vehicles 'say' about the

owners. They were also asked if they thought that driving a plug-in vehicle ‘fitted’ with the kind of person they are or would ideally like to be.

- **Normative responses.** Participants were asked whether other people that they knew would adopt EVs in the future and how they thought other people they knew would respond if the participant adopted a plug-in-vehicle.
- **Confidence in using plug-in vehicles**. Participants were asked how confident they felt about their ability to use a plug-in vehicle as well as what new challenges, if any, using a plug-in vehicle might present.
- **Behavioural intentions**. Participants were asked how they intended to use the vehicle over the next week and how they intended to recharge the battery.

The post-interview topic guide contained all the topic areas covered in the pre-interview apart from the past vehicle purchasing narrative. Question wordings were altered to reflect past experience over the week. The post-exposure interview also contained two new topics:

- **Their experience over the week.** This section included questions about what participants thought about the vehicle that they had used over the week. Participants were asked about their overall experience and to describe a particular journey. Follow-up questions focused on their driving experience, how driving the vehicle made them feel, whether they discussed the vehicle with anyone over the trial week, whether they sought further information regarding plug-in vehicles, whether the way they drove changed and whether they used the vehicle in the same was as their main conventional vehicle.
- **Their experience with recharging the battery.** Participants were asked when and where they recharged as well as what prompted them to recharge the battery, how they found the experience, whether they experienced problems and what, if anything, would have made the experience of recharging easier.

6.2 Data collection

6.2.1 Procedure

All interviews were carried out by researchers from TRL who were trained in qualitative interviewing techniques. They were instructed not to answer any questions that were posed by the participants either before or during the trial week.

A micro-survey was administered immediately after the pre-interview. This consisted of driving behaviour and vehicle ownership questions as well as personal demographics. Participants were also asked to indicate on a seven-point scale their attitudes and feelings towards plug-in vehicles. This latter request was repeated after the post-exposure interviews (see Appendix C and Appendix E).

Each interview was audio recorded and transcribed by a transcription specialist. Transcripts were converted into NVivo format prior to analyses.

6.3 Analysis

6.3.1 Thematic content analysis

Version 8 of the software program NVivo was used to assist with thematic content analyses. NVivo has been developed to help organise and record the processing of qualitative data (Bazeley, 2007) as well as to assist in uncovering underlying conceptual structures within discourse (Bryman, 2008).

Additionally, a preliminary 'Grounded Theory' coding procedure (Strauss & Corbin, 1990, 1998) was employed. Specifically, 'open' coding was used to assign conceptual labels to topics, which were then refined through repeated inspection. This is the first stage of development of a Grounded Theory. The thematic structure was partly pre-defined by the research objectives of the study and partly embodied in the interview schedule structure. This combination of preliminary Grounded Theory coding procedures and thematic analysis of emerging content allowed detailed, response-driven extraction of participants' comments (from interview transcripts) as well as facilitating a theory-informed approach to identification of important assertions and themes. As such, our method falls between traditional Grounded Theory (Glaser & Strauss, 1967) and traditional content analysis.

Data from 22 participants were analysed using thematic content analysis. Twelve participants were lent a PHEV for a week and ten were lent a BEV.

Table 19: Thematic analysis study sample (n=22)

Gender		Marital status		Age		Weekly mileage needs		No. of cars in household		Location	
Male	**11**	Single	1	18–34	3	Low (≤100)	5	Single	5	Urban	5
		Couple	7	35–55	4	High (≥100)	6	Multiple	6	Semi-urban	6
		Family	3	55+	4					Rural	0
Female	**11**	Single	2	18–34	3	Low (≤100)	4	Single	2	Urban	3
		Couple	2	35–55	7	High (≥100)	7	Multiple	9	Semi-urban	6
		Family	7	55+	1					Rural	2

6.3.2 Travel diary analysis

Examples of the travel diaries are presented in Appendix F. To ensure that participants understood what information they needed to record, and how to record it, TRL researchers briefed them on the correct completion of travel diaries. Furthermore, participants were provided with an information sheet and a completed example to which they could refer if unsure about how to record car journeys.

It had originally been intended that all household members using the plug-in vehicle should complete a travel diary, to provide a full picture of the household's mobility pattern. However, insurance requirements stipulated that household members would only be entitled to use the plug-in vehicle if they had participated in a vehicle familiarisation, and if their driving licence had been checked by a TRL researcher. No household member of any of the study participants underwent this procedure; hence, travel diaries were only completed by the main driver in the household for one week using their own vehicle and for one week using the plug-in trial vehicle. The assumption was made that during the week of access to the plug-in vehicle, participants would exclusively use the plug-in vehicle rather than using both the plug-in vehicle and their normal car. Findings that challenge this assumption are discussed later in this report.

Forty participants were asked to complete a seven-day travel diary when using their own vehicle, and another seven-day journal during the week they were using a hybrid or EV. Three participants did not complete one of the diaries, and so none of their data were used. Of the remaining 37 participants:

- 19 used a Toyota Prius;
- 15 used a Citroen C1; and
- three used a Mitsubishi i-MiEV.

The aim of the travel journals was to explore how participants used their own vehicle versus the plug-in vehicle in terms of:

- number of journeys undertaken;
- distance travelled;
- fuel/battery levels;
- parking;
- charging; and
- number of occupants.

Comparisons were made between the types of journeys in the two vehicles. As described above, these comparisons are explorative in nature, due to the small underlying sample size and should be used to generate hypotheses for further research.

6.3.3 Grounded Theory analysis

The full sample of interview transcripts was coded using 'Grounded Theory' analysis. This is a form of inductive positivist qualitative analysis with well-defined and systematic coding procedures, as outlined by Strauss and Corbin (1998).

All 80 transcripts of pre- and post-exposure interviews were read and reread. Initial 'open' coding was undertaken to assign conceptual labels to pertinent extracts, and these labels were refined as coding proceeded and new insights emerged resulting in a list of important themes.

For the 40 post-experience transcripts secondary 'axial' coding was undertaken, involving constructing more detailed data-driven links between concepts, organising these into higher-order categories and linking them to pre-existing theoretical constructs. Further 'selective' coding generated an understanding of how categories were interrelated, and permitted identification of a 'central category' which underpinned all other categories (Strauss & Corbin, 1998). This method has previously been successfully applied to developing psychological understandings of drivers' motives and experiences (Gardner & Abraham, 2007).

Table 20: Grounded Theory analysis study sample (n=40)

Gender		Marital status		Age		Weekly mileage needs		No. of cars in household		Location	
Male	**20**	Single Couple Family	5 9 6	18–34 35–55 55+	9 6 5	Low (≤100) High (≥100)	5 15	Single Multiple	5 15	Urban Semi-urban Rural	7 10 3
Female	**20**	Single Couple Family	5 4 11	18–34 35–55 55+	6 9 5	Low (≤100) High (≥100)	8 12	Single Multiple	4 16	Urban Semi-urban Rural	6 10 4

6.4 Results: Thematic content analysis

Findings are reported under seven main headings, listed below. In all sections, relevant direct quotes which illustrate the main themes discussed are given in blue text.

1. Initial awareness and knowledge of electric vehicle technology (Section 6.4.1)

This section includes: participants' awareness of EVs as well as what they know about the different types of drive-train and the differences between them, how they work, and whether awareness and knowledge increases post-exposure.

2. Cognitive responses (Section 6.4.2)

Within this category we discuss the following themes:

- **Confusion as a response to plug-in vehicles.** This includes responses pre- and post-exposure that result from a lack of knowledge and understanding.
- **Costs.** This theme includes reflections on the perceived purchase and running costs of the vehicle.
- **Evaluation of vehicle features/attributes.** This theme includes their appraisal of vehicle range, safety, performance, accommodation, comfort, special features, batteries, instrumentation and reliability.
- **Recharging facilities and maintenance support.** This theme encompasses responses to the public infrastructure, recharging time and availability of repair support.
- **The context of adoption.** This theme reports participants' discussion of the choice available to them, environmental issues, incentives to purchase, social acceptance of EVs and the future of EV technology.

3. Affect (Section 6.4.3)

This section discusses participants' affective responses. Within this category we discuss the following themes:

- **Aesthetic response.** This theme encompasses emotional responses to the vehicle appearance and design.
- **Feel good factor.** This theme reports the emotional responses to how the vehicle felt to drive or the emotional response to the silence of the vehicle.
- **Negative responses.** This theme includes unfavourable responses to using an EV such as embarrassment or intimidation from other vehicles.
- **Anxiety.** This theme encompasses the anxiety felt by many of the drivers due to lack of range and infrastructure.

4. Symbolic meaning and identity projection (Section 6.4.4)

This section discusses participants' understanding of the symbolic value of EVs including their capacity to project a particular image (positive or negative) of the driver.

5. Recharging experience and behaviour (Section 6.4.5)

This section highlights the participants' experiences of recharging the EV over the trial week. This includes: where, when, how long, what prompted them, and any positive or negative experiences they may have had.

6. Behavioural adaptations – driving style (Section 6.4.6)

This section considers the behavioural changes drivers made during the trial week in response to using the EVs.

7. Changes due to exposure (Section 6.4.7)

This section examines changes in attitudes and behavioural intentions due to exposure to the EVs. It includes three sub sections:

- **Quantitative pre-post mini survey**

  First, we describe the three-question quantitative mini survey we conducted in pre- and post-exposure interviews and report on trends in group scores, acknowledging the potential for bias in such small samples.

- **Some market segmentation hypotheses based on mini survey results**

  Second, we consider whether trends observed in this mini survey support any hypotheses that could be tested in substantially larger surveys.

- **Qualitative tracking of individual change**

  Third, we take each participant as a case study and consider the qualitative changes that are evident in comparing his/her pre- and post-exposure interview responses.

6.4.1 Initial awareness and knowledge of electric vehicles

Participants were asked what they knew about plug-in vehicles generally, including how EVs work, the difference between the technologies (i.e. Hybrids, PHEVs and BEVs), which brands they knew of and if they knew of any existing or planned incentives to encourage the public's adoption of EVs. These questions were asked pre-exposure to gauge the level of awareness and knowledge and post-exposure to explore whether they had changed.

Knowledge and awareness was low among our sample at pre-exposure. In general, knowledge of plug-in vehicles was very basic. None of the participants had any hands-on experience with EVs although a few had been a passenger in a Prius hybrid.

Illustrative quotes include:

...don't know anything about them…I know you've got to plug it in to charge up the battery to drive it, so you don't put petrol in it. (Participant 10, pre-exposure, BEV)

I don't know a lot about them whatsoever. It's a whole, new concept to me. (Participant 12, pre-exposure, PHEV)

I know obviously you don't fill them up with petrol although my husband told me you can get a combination. (Participant 13, pre-exposure, PHEV)

Most of the participants had some knowledge or awareness of a hybrid vehicle and most of them knew that they were dual fuel. Many knew what a plug-in BEV was but uncertainty was evident.

I believe the plug-in one just runs on electric, so if you don't plug it in, you're not going anywhere and I know one of them switches over, could be a hybrid electric. If you're going slower, it uses the electric and then if you go faster it switches over to the petrol, but I'm not sure about the hybrid one, on its own. (Participant 14, pre-exposure, BEV)

I think the hybrid plug-in you fill it up with petrol as well, whereas with the other one you don't, although I could be wrong. (Participant 2, pre-exposure, PHEV)

Unsurprisingly, only two participants could describe the difference between a hybrid vehicle, a plug-in EV and a battery EV and no one was totally confident about the differences.

I'm assuming that the electric just plugs in, it's just pure electric and the hybrid I believe, it has a tank and as you're driving and braking or something you actually recharge it, but I don't know if you actually plug a hybrid in, like an option or…Obviously you plug it in and the electricity charges the battery, then you just drive and that drains the battery, but if you want anything more than that, I haven't a clue. (Participant 13, pre-exposure, PHEV)

The majority of the participants had heard of at least one manufacturer associated with EV development, the most common being Toyota (Prius). Some could name several manufacturers and others none. After the one week trial the participants appeared more confident about EVs. Fewer than half of participants had done any research into EVs during the trial week and, at post exposure, there was still some confusion about technology differences.

6.4.2 Cognitive responses

6.4.2.1 Confusion as a response to plug-in vehicles

Due to the participants' lack of knowledge and experience it was not surprising to find that some of them expressed uncertainty as to how a PHEV worked and were confused as to when to expect a switch from one drive-train to the other. However, it should be remembered that, for some drivers, the mechanics of their car was of little interest to them.

And the idea that the petrol's actually being used to charge the battery hasn't sort of computed; I don't know how that works. (Participant 15, pre-exposure, PHEV)

I don't know how it works because this is a bit of both, it's got petrol, it has unleaded petrol in it plus it's a battery, so it has both doesn't it? I just sort of, I don't really know the mechanics of it, I'm not very good with things like that, it's just really not my, you know, expertise. (Participant 12, pre-exposure, PHEV)

Even after gaining experience of driving, confusion remained, especially in relation to PHEV operation.

…can't make its mind up whether it's going to be petrol-driven or both or not or electric and just keeps flipping between. Didn't feel right. (Participant 22, post-exposure, PHEV)

If you're cruising the electric should switch in but it wasn't happening and that disappointed me. (Participant 17, post-exposure, PHEV)

Such confusion was not alleviated by the hybrid vehicle instrumentation.

We didn't know whether we were electric or not, and the battery would, sort of, suddenly go quite low and then suddenly spike up again, so, I mean, we didn't really know, although we knew we charged the car, but I was a bit wary of how much… (Participant 13, post-exposure, PHEV)

I was partially surprised how long the batteries last and never needed charging up… there was no logic to it at all, you know, and so as soon as it got down to close to half, another two mile drive and it had gone back to full again. (Participant 17, post-exposure, PHEV)

I got to school, which was about a mile away, and it came up saying the battery was almost empty, which surprised me, and then I carried on going to a friend's house, and then the battery said it was fully charged, and throughout the day throughout my trips the battery seemed to keep fluctuating between almost full and almost dead, so I didn't understand that one. (Participant 6, post-exposure, PHEV)

Such confusion also left some of the participants unsure when they should recharge and or even concluding that the vehicle did not need recharging at all.

And I thought a couple of times, oh, I don't really need to do the battery. It became a bit confusing and I thought I will plug it in for just a couple of hours, and that's what I did. So I didn't charge it for long; but I noticed it didn't make an awful lot of difference with the battery. (Participant 12, post-exposure, PHEV)

Once you hit 30 it switches into petrol and you don't get any advantage of the electric. You're just driving a normal petrol based car. The other thing was that because of the nature of the journeys I was taking I never had the need to plug it in. (Participant 17, post-exposure, PHEV)

I don't really see any benefit in charging it, because to be honest, it lost its…it seemed to lose the power that I charged overnight anyway, and it actually seems to charge faster from actually coasting and braking. (Participant 12, post-exposure, PHEV)

Never plugged it in at all. The battery never showed lower than about three quarters to half full and then when I got on another journey it charged up again. Participant 17, post-exposure, PHEV)

6.4.2.2 Costs

Purchase cost

No one claimed that they would be willing to pay more for an EV and generally participants felt that they would not consider purchasing an EV if it was more expensive than the petrol/diesel equivalent. Most participants believed that EVs would cost more than a similar petrol or diesel vehicle and estimates ranged from £2,000 to three times the cost of a similar conventional vehicle. Other participants thought EVs would cost the same as a petrol/diesel vehicle and yet others thought that they would be less expensive either because they felt that they were simpler mechanically or that artificially-reduced costs would be used to encourage the public to purchase them. Appraisal of purchase costs did not vary substantially between pre- and post-exposure interviews.

Well, I would want to be able to get it for the same price that I could buy the car that I wanted to buy. (Participant 15, post-interview, PHEV)

I would imagine they would be more expensive at the moment, so no, that's most probably the reason I wouldn't buy it. (Participant 14, pre-interview, BEV)

I wouldn't want to pay more for an electric car than I paid for a petrol car. (Participant 5, post-interview, BEV)

I think they're a really good idea; I'd definitely like to buy one if, once they've come down in price a bit. (Participant 20, post-interview, PHEV)

I did, I said, definitely I wouldn't… [purchase an EV in the future]…you know; but now I definitely would if it was priced right. (Participant 9, post-interview, BEV)

Running costs

Both pre- and post-interviews showed that participants thought EVs would cost less to run than an equivalent, petrol/diesel vehicle and that this was one of their main benefits.

…benefit will be to the consumer's purse because it will be cheaper to run, hopefully, depending on how much your charges are. And that's really it, isn't it, in my opinion. (Participant 19, pre-interview, BEV)

The benefits would be that…they're a lot cheaper to run; that would be a major thing, that they're cheaper to run. (Participant 20, pre-interview, PHEV)

…on a like-for-like basis for the commute to work, I would think it would probably be £500 or £600 a year cheaper. (Participant 16, post-interview, BEV)

I think it would be a lot less to run a plug-in vehicle. (Participant 20, post-interview, PHEV)

Some participants took account of maintenance costs but others focused solely on comparisons between recharging and refuelling costs. Some participants also viewed petrol prices to be less stable than electricity costs.

Well, I'm rather assuming that insurance might be a little cheaper but I don't know the facts about that. (Participant 12, post-interview, BEV.

I like the fact that there is no road tax on an electric vehicle and obviously you don't need to fill up so I think once you've bought the car, other than your insurance…I'm guessing that servicing costs are a lot lower as well. That's why I find it quite appealing. (Participant 6, pre-interview, PHEV)

Tax would most probably be cheaper and the cost of fuel, you wouldn't be having and all the stuff – fluids – that run round the engine…Obviously, you can charge it into your electric or to your home and I'm not sure how much that would cost, kilowatts or whatever it is, per however long it takes to charge, per unit, to charge the battery. (Participant 14, pre-interview, BEV)

Probably less since you're not filling up a massive big tank of petrol. You're literally just charging electricity into the car. (Participant 13, pre-interview, PHEV)

Cost of running should be cheaper because it comes out of the electric bill, which is a damn site cheaper than a tank of petrol. (Participant 17, pre-interview, PHEV)

So, it's quite tricky to know, you know, over a long period of the life of the vehicle. I think looking at one, two, three, four years' life one assumes that running costs would claw back quite a significant amount of money. So, you could do your homework and try and figure out what would be the offset against acquisition cost might be. (Participant 11, post-interview, PHEV)

A few of the participants estimated that running costs would vary and could be on par with the running costs of a petrol/diesel vehicle and some anticipated unknown future costs.

Maintenance, one would expect to be the same. Whereas an engine needs maintaining, the battery technology needs maintaining and looking at. So I would think that maintenance wise, they would offset. (Participant 6, pre-interview, PHEV)

What I drove last week still needs the petrol engine maintained so…I guess the servicing would be more expensive. (Participant 17, post-interview, PHEV)

I'm quite sure that if everybody buys electric cars, the Government will just put extra tax on electricity. (Participant 22, post-interview, PHEV)

If I was going to purchase one, nasty bills out of the blue wouldn't be a good idea. (Participant 3, post-interview, PHEV)

6.4.2.3 Evaluation of vehicle features/attributes

Participants highlighted many separate car features, each of which might potentially be evaluated in a positive or negative manner. These included range, safety, performance, accommodation, comfort, special features, batteries, instrumentation and reliability.

Range

Anticipation of limited vehicle range was one of the most widely cited barriers to uptake before exposure.

I wouldn't rule it out, but I think they just need to go a little bit further, a little bit more like a normal car, before I'd probably really consider buying it. (Participant 5, pre-exposure interview, BEV)

The major drawback that I see of them is only being able to drive short distances. (Participant 15, pre-exposure interview, PHEV)

I'm not convinced about the convenience of plug-in vehicles. I mean I think you would always be tied down or worried about running out of power. (Participant 1, pre-exposure interview, PHEV)

Post exposure, participants still cited range as one of the main barriers to adoption as a primary vehicle, especially for BEVs.

I suppose a big advantage of the diesel over the electric cars is that there's never any worry about, how far is it going to go? (Participant 16, post-exposure interview - BEV)

I think if the range had just been a bit longer, it would have...ticked more boxes... (Participant 19, post-exposure interview, BEV)

Many participants, including both BEV and the PHEV users, appraised the vehicles as suitable only for specific journeys or only as a second vehicle due to limited range.

The range was a bit limiting, although having said that, if it was used as a second car it would be quite satisfactory for me. (Participant 9, post-exposure interview, BEV)

You do have to be aware that, you know, you're only likely to use it for relatively short trips and a short range. (Participant 11, post-exposure interview, BEV)

I guess people that commute a long way or do a lot of business miles. Probably it wouldn't be an option for them right now. (Participant 6, post-exposure interview, PHEV)

Safety

Participants considered several components of EV safety. The majority of participants appraised the safety of the vehicle in terms other roads users as a consequence of EV quietness and this was especially evident post-exposure. Some were concerned about a lack of robustness/solidness of vehicle structure while, for others, mixing electricity and water was a concern. Thus, 'safety' judgments involve multi-attribute evaluation. Other potential safety concerns mentioned in relation to BEVs included a lack of power making it difficult to get out of potentially unsafe driving situations, and a lack of both power and control when BEVs enter a reduced-power usage mode if the battery is at 25% charge or less, which may reduce maximum speed to 30mph to conserve the battery.

Silence…

I think because the car doesn't make hardly any noise a motorcyclist sort of pulled out almost in front of me at a crossing because I don't think he heard me, and then on the way home, driving through the estate, a cat ran right in front of me which I was scared of squashing because again, there is just so little engine noise, so I guess that's the only thing that sticks in my memory that concerned me a bit, and it made me more cautious when I've been out and about in it. (Participant 6, post-interview, PHEV)

They're not great for people who are either sight-impaired or if somebody wasn't necessarily aware of the vehicles around them, they might step out into the road. (Participant 21, pre-interview, BEV)

We were coming out of a pub car park after having lunch and I think some people didn't realise that we were coming up because obviously we were making no noise at all. So that's maybe one safety concern with electric cars is they are too quiet (Participant 3, post-interview, PHEV)

One of the things that concerned me was, can pedestrians hear it? Particularly now, when a lot of people now walk around with their iPod, that they don't even hear an ordinary car very well. You know, are they going to be able to hear an electric car, and are they going to still be dim-witted and step straight off the pavement? (Participant 10, post-interview, BEV)

Structure…

Presumably the cars are quite light because they're trying to…from a safety point of view, are they stable and are they as safe as a traditional car? (Participant 15, pre-interview, PHEV)

I think internally if they felt a bit more robust, I think that would make me feel a lot safer…and I don't know how this would work, because I know it needs to be very light, but if the tyres made you feel…you know, if everything felt a bit more sturdy, I reckon that might help. (Participant 7, post-interview, BEV)

Mixing water and electricity…

…risk of electrocution, because a lot of them run at 500V, 610V DC; that's well above capable of killing you. (Participant 16, pre-interview, BEV)

...I had left it out one day and it started to rain, my boyfriend reminded me that the extension lead was still out with the plug in, so to get it in. (Participant 14, post-interview, BEV)

Performance

The performance of the vehicles got mixed reviews from our sample. Many participants had concerns and were disappointed with the acceleration. However, others were very pleased with their car. This variability is probably due, in part, to initial expectations. Those who had low expectations appeared to be pleasantly surprised by the cars' performance.

I wasn't very happy with the acceleration; I felt that you were constantly going over...because they were saying about keeping it in the eco bit, which is the green bit. And it constantly goes over when you want to accelerate anywhere, into the other side. So I was a little bit concerned about that. (Participant 10, post-interview, BEV)

It is noticeable that the ability to accelerate and maintain speed up the hill is not good and that...although it's fine if you're maintaining speed, it's not good at sort of coming away from...Pulling away up the hill perhaps wasn't as good a performance as I would have liked. (Participant 16, post-interview, BEV)

I did struggle going up some of the hills...so that annoyed me a little bit. (Participant 19, post-interview, BEV)

Pulling away from traffic lights I found the car quite gutless, almost worryingly so - not that the car needs to be a Ferrari, but it should have a little bit more power pulling away from traffic lights. (Participant 1, post-interview, PHEV)

Some of the participants were also disappointed with the speed of the vehicles.

I thought it would be a bit faster than it is. (Participant 22, post-interview, PHEV)

I mean it's fine except that I thought on the motorway at motorway speeds that car's really struggling. (Participant 3, post-interview, PHEV)

Some of participants who had experienced PHEVs also commented that it did not handle well at higher speeds.

I found it handled...it's very wallowy. I found it a little bit slippery in the wet and yes, just doesn't give me any confidence really. And I think it doesn't feel confident at sort of speed on the motorway, sort of 70-odd. (Participant 22, post-interview, PHEV)

When I joined the A14 after putting petrol in yesterday I felt it was a bit dangerously underpowered. I felt I couldn't get up to motorway speed by the time I was joining the carriageway. (Participant 3, post-interview, PHEV)

However, others were pleased or at least pleasantly surprised with the vehicle's performance in one way or another.

I thought the steering was brilliant on it. I thought it was so comfortable, the way it handled corners, everything about it...the way you would pull away and I just thought it was a really lovely car to drive. (Participant 12, post-interview, PHEV)

I expected it to go a lot slower than it did…I thought it was quite nippy. (Participant 2, post-interview, PHEV)

Before I had it I thought that it would be very slow to accelerate and it wasn't. I was really surprised that it was just like a regular car…it accelerated up to 70 quite quickly and it remained at a good speed, so I like that fact that it did accelerate …I'd thought it would be a lot slower. (Participant 2, post-interview, PHEV)

What I was a little surprised about when you reached the pick up point going forward, you're starting to use the throttle and away you go, that immediate pick up was surprisingly fast, really sort of get going. (Participant 11, post-interview, BEV)

Accommodation

Accommodation refers to the size of the vehicle especially the space inside. A number of participants commented on the lack of space inside, especially in the boot.

It didn't have an awful lot of room in the boot, it wasn't as big as what I'm used to. I mean not that I ever had to fill it, but had I had to fill it, then that would have been difficult. (Participant 10, post-interview, BEV)

It would have been very difficult to have got, you know, three adults and two children in car seats in the little one. (Participant 11, post-interview, BEV)

The one I had wasn't big enough to put all of our bits in, so that was a problem as well. So that's a disadvantage. (Participant 19, post-interview, BEV)

However, other participants commented on how spacious the vehicles were.

…there was more room in the back than my car; okay I know it's a different car….

But I felt like I had loads of room and it just felt…it felt really comfortable. (Participant 10, post-interview, BEV)

It's spacious, it's quite practical - there's lots of sort of little cubby holders dotted around the inside of the car. (Participant 1, post-interview, PHEV)

Comfort

Whilst many participants mentioned, in pre-interviews, that comfort was a factor for them in their vehicle choice, there were few descriptions of what they meant by comfort. In the post-interviews the participants mentioned the comfort referring to accommodation, as discussed above, or driving comfort.

I noticed that when I was driving, you know, it's quite a comfortable car to drive. (Participant 12, post-interview, PHEV)

I really liked it. I, it was really comfortable to drive. (Participant 20, post-interview, PHEV)

I really liked it actually. It was really nice to drive. It was really comfortable, the steering was really easy. Actually when I got back into my car, it felt much harder and I thought I actually prefer the other car. (Participant 7, post-interview, BEV)

Special features

Special features encompass any vehicle 'extras' or creature comforts such as blue-tooth, air-conditioning and cigarette lighters.

...if they had the right features like child seats. I guess also features like air-conditioning and so forth. (Participant 4, post-interview, PHEV)

...it might be nice if they made a sporty version of it and they loaded it a bit more. I like my creature comforts and there was a lack of creature comforts in there, you know, and there's some lack of attention to detail. You know things now are powered by cigarette lighters. Where is the cigarette lighter in a Prius? (Participant 17, post-interview, PHEV)

I think is important as well, so things like, as I say, putting the Bluetooth in the car. I can't see that it wouldn't happen, so I imagine that would all be there, those extras. Yes, I don't think there would be any issue with the extras, but it's got to be available. (Participant 10, pre-interview, BEV)

Batteries

The main issue that relates to the battery is the novelty of the technology. Some participants were concerned about the life span of the battery and the cost and/or environmental implications if battery life is short. Views on battery technology are closely linked to anticipated cost and environmental concerns.

But my concern would be the life of the actual battery in the car itself. (Participant 14, post-interview, BEV)

I think also the overall battery life, and the residual value of the car, that if you want to change it, say after three or four years, you've only got a few years left on the battery's life so to speak. What is the cost of replacement? (Participant 18, post-interview, BEV)

...it's a big risk, isn't it? Because, basically if it's found that...the batteries go dead after two years and it costs ten grand or 12, 13 grand to replace them or whatever, that's a resale risk. (Participant 22, post-interview, PHEV)

I have a concern about the future use of the batteries. As I said before I don't have any idea what the realistic lifetime is, five, seven, ten years, I just don't know. And from the point of view of the disposal and all that, I'm slightly uneasy. I think that might be a downside to the eco side of it all. (Participant 11, pre-interview, BEV)

Instrumentation

Vehicle instrumentation as a mechanism of feedback was seen as important and participants felt there was room for improvement in this area. Responses suggest that such feedback, if clear and concise, could go some way to reduce confusion that can arise from being unaware of which drive-train the vehicle is using in PHEVs or reduce anxieties over range.

I liked being able to see miles per gallon and all the information on the touch screen; that was really good to be able to see that. I think that affected my driving a bit, being able to see. Because I could see how many miles per gallon it was doing, I would also try and stay at the most miles per gallon. And it was interesting to see, like, what speeds and how much it varied. (Participant 20, post-interview, PHEV)

…and also the EV light wasn't always on all the time when we were under 30, so we didn't know if we were in electric or not, and obviously it's very hard to look at the screen. I couldn't really tell…It does beep a lot obviously, and then when you look at the screen, it says EV mode invalid, or something like that. (Participant 13, post-interview, PHEV)

I think you need to have some sort of indicator on the dashboard to tell you when the actual engine is available because it can show a full display and the engine has not started. You can't tell, you know, it's stalled or it doesn't start, you know, you just think…some idiosyncrasies like that because I went to drive off, put my toe down and it didn't move because the engine hadn't fully booted. (Participant 17, post-interview, PHEV)

A couple of times it got to dusk…but the battery usage percentage doesn't show up basically in the dark…I really wanted to keep an eye on percentage usage…you'd need to consider sort of pulling over and having a look which you really don't want to do that. (Participant 11, post-interview, BEV)

Reliability

Reliability was appraised in different ways. For some reliability meant the confidence that the participants had that the vehicle could get them from A to B without any problems whereas for others it represented the confidence they felt towards the new and unfamiliar technology.

If I was convinced the technology was sound, reliable, then yes; I would certainly consider [buying] it. (Participant 1, pre-interview, PHEV)

Just the reliability really, that it's not, it's going to do what it's supposed to do, and I mean, because the battery, sort of, going down and then up again, I didn't really know where I was with it, so I would have to, sort of, get used to how it worked. (Participant 13, post-interview, PHEV)

I mean, reliability would still be an issue, I mean, I would still go and do a search and sort of see sort of failure rates and things. (Participant 15, post-interview, PHEV)

6.4.2.4 Recharging facilities and maintenance support

Cognitive evaluation of the vehicle was not only dependent on vehicle's features but on the availability of facilities to support their everyday use.

Public recharging infrastructure

Closely linked to the participant's assessment of the readiness of the technology was their evaluation of the availability of the recharging infrastructure and how this limitation can be viewed as a barrier; this became more evident to them after using an EV for a week.

I think in my travels I only saw one [recharging post] anywhere, not that I was massively looking out for them. (Participant 1, post-interview, PHEV)

I just don't think I'd do it, because I don't think the infrastructure's out there to get me by. (Participant 19, post-interview, BEV)

I would say I don't think there are enough plug-in points and things like that. I didn't see any. I mean, I became more aware of it when I was driving about, I didn't see any. And that was, sort of, a lot of cause for concern. (Participant 2, post-interview, PHEV)

A few of the participants mentioned how a proper recharging infrastructure would make them or the general public feel more confident in the vehicles.

No problems, no problems, so long as re-charging facilities are available. That’s where I’d like the confidence. (Participant 10, post-interview, BEV)

I guess it’s like if you had petrol stations that had a separate part or an area for you to plug in your car, then that would be fantastic, but the only problem is that doesn’t exist now so it’s just thinking, where am I going to charge up if you need to, and that’s a negative. (Participant 7, post-interview, BEV)

If anyone wants to push these cars out into general use, they've got to be, like a garage, they've got to be able to go somewhere to juice it up…I read that it would be in shopping centres and hospitals and places like that, so when you go and leave your car, you can plug it in, off you go, and then two hours later, come back and you've got a charge. So that's the way forward, I think…but it's a massive infrastructure. (Participant 19, post-interview, BEV)

As well as availability of recharging, speed of recharging was seen to be important to adoption.

You know, the other thing is that when you fill up with a tank of petrol, it takes you probably three or four minutes, maybe five minutes at the most…And I’m uncertain about how long it takes you to recharge your vehicle, you know; it won't be three or four minutes, I’m sure of that, even with fast charge. (Participant 17, pre-interview, PHEV)

So I think there are some rapid charge technologies coming out so, you know, you can charge it up in maybe ten, 15 minutes while you have a coffee - which would maybe make it okay but it's still a little bit inconvenient if you're in a hurry to get somewhere and you have to wait 15 minutes specifically to charge the car. (Participant 3, pre-interview, PHEV)

If you had one of those charging points in petrol stations, and it was quick charging; you know, if it was less than 15 minutes, for example, I think that would be quite good. (Participant 9, post-interview, BEV)

Servicing / maintenance issues

Participants had some concerns regarding what they saw as a lack of support offered or available after sales due to the novelty of the technology.

Yes, I mean it is…once the RAC came, and he didn’t know what to do. And he said, oh how do you start up? (Participant 15, post-interview, PHEV)

It might be hard to find somebody to repair a plug-in vehicle. So, you might have to rely on the manufacturer to take it back there and that can always be more expensive or a lot more expensive, usually, than it would be to get a normal or, like, your average mechanic to repair it. And the parts might be a lot more expensive. There could be *more things to go wrong with it. There might be more components involved and more things about it that would go wrong. (Participant 20, post-interview, PHEV)*

I imagine you'd have to take it back to a main dealership if you wanted any repairs done on it, because I don't know if mechanics know all what the differences are of an electric car. (Participant 14, post-interview, BEV)

6.4.2.5 The context of adoption

Participants' views of EVs were also shaped by the choice of cars available and by individual perspectives on the importance of reducing emissions and the capacity of EVs to contribute to emission reductions. Participants felt Government-initiated incentives (and especially financial incentives) were important and that greater efforts should be made to promote social acceptance of EVs. However, not all participants were persuaded of the future viability of EV technology.

Availability / choice

Increased availability and choice of brand or car type was important to some participants.

Well obviously more competition in the market place [would encourage me]. More models to choose from, even to the point of two door, four door, or five door hatchback type vehicles. (Participant 11, pre-interview, BEV)

Yes, I think if it becomes the case that you've got lots of varieties and things, I think it will become a lot more appealing that you have options the type of car you can buy and things. (Participant 2, pre-interview, PHEV)

I think it would be a consideration if suitable models were around, and they were sort of competitive and functional (Participant 4, pre-interview, PHEV)

Environmental issues

EVs were viewed by many of the participants to have the benefit of reduced emissions, being more sustainable, and generally having less of a negative impact on the environment.

The benefits would be that you're not polluting the atmosphere as much as the next person who's got a petrol car (Participant 20, pre-interview, PHEV)

One benefit would be if it's on electric, it's going to be cleaner, so you're not going to be pumping out carbon monoxide, which I guess for the environment is definitely a good thing. (Participant 1, pre-interview, PHEV)

With the emissions of the fuel, that we're getting gases, etc, into the climate, destroying everything and it's a greener way to drive. (Participant 14, pre-interview, BEV)

Although most participants were aware of the green credentials of EVs, some wondered if these were exaggerated.

There's a bit of a concern about the chemicals involved in making batteries, how long are they going to last, and the fact that you're using generated electricity. So, there's a little *bit of concern about how green at the end of the day is that. (Participant 11, post-interview, BEV)*

It's not without environmental impact in that there are magnets and all sort of things in it which themselves are scarce and…etc; battery-life; some of the chemistries are aggressive; risk of electrocution, because a lot of them run at 500V, 610V DC; that's well above capable of killing you. (Participant 16, pre-interview, BEV)

If I look at it logically, electricity is all based on exactly the same sort of fuels, so, you know, I guess I struggle slightly with this environmental sort of thing. (Participant 3, pre-interview, PHEV)

Moreover, environmental concerns were not important to all respondents.

Saving the planet didn't really cross my mind, because I wasn't thinking about things like that whilst driving the car. (Participant 14, post-interview, BEV)

I do care about the environment, but it's not like a major thing for me, which is pretty bad, I know, but it hasn't quite hit me yet; I'm sure it will in a few years. (Participant 5, post-interview, BEV)

Incentives to purchase

When prompted to talk about incentives, the participants were mainly interested in financial incentives.

Well, obviously it's all got to come down to money hasn't it? And it's going to be something monetary that's going to incentivise you really, I would imagine. (Participant 22, post-interview, PHEV)

I guess incentive if they had some money off, I suppose. That would be a big incentive. (Participant 22, post-interview, PHEV)

A reduction in the cost of the vehicle purchase price (so it was more in line with petrol/diesel vehicles) was seen to be the most beneficial to both BEV and PHEV users either via a scrappage scheme or a Government grant.

Well when you're spending your own money the cheaper the better, you know, financial of course…I think running it fades into the cost of living, you know, whether it costs £1 or 80 pence almost doesn't come into it, you know. It's whether it costs £15,000 or £30,000. (Participant 17, post-interview, PHEV)

A massive incentive from the Government. Some form of price reduction, cashback sort of thing, reduction in my tax level; any sort of incentive really that can make me at no disadvantage really, then of course you'd consider it. (Participant 22, pre-interview, PHEV)

Definitely if there was a Government incentive to buy one. Let's say if you traded in your car they gave you some money off for…just an incentive would go a long way in making my decision towards that. (Participant 6, post-interview, PHEV)

I think if they, you know, if they do something like the scrappage, you know, scrap your petrol car for a plug-in vehicle, that would be a good one. (Participant 10, post-interview, BEV)

Participants mentioned other financial mechanisms that could incentivise purchase. These focused on reducing running costs and included free or cheaper electricity, reductions in tax and insurance as well as exemption from congestion and parking charges. Non-financial incentives were only mentioned by a few participants. These included prolonged battery warranties, the right to use bus lanes and allocated parking facilities. The majority of interviewees felt it was the Government's responsibility to provide incentives.

Social acceptance and the media

For some of the participants the novelty of the vehicles was discouraging. For these people EVs would need to be widely accepted by others before they would be willing to buy one.

I think at the moment I'm still not sure. I like the concept, but I'd have to know that it was, sort of, quite a commonly used, common practice, where I knew I could charge...I don't know, it's a difficult thing, isn't it, because in five years...it could become a lot more popular and people could know a lot more about them, but at the moment, I think people are being a bit wary. (Participant 13, post-interview, PHEV)

Probably a wider general acceptance that the public at large would be persuaded to do this more. More charging points and more acceptance by some businesses and family… (Participant 11, post-interview, BEV)

Several participants mentioned the need for more media coverage to increase awareness and to encourage adoption.

I don't think the information's really out there at the moment to do that but I think it should be advertised more on the telly, on the radio just in the media to encourage people to take that route. (Participant 6, pre-interview, PHEV)

If the technology is there, I'm surprised it hasn't been publicised more than it has. Because I keep myself reasonably aware of what's going on in the world. I don't study things but, you know, I've not seen a lot of publicity about where we are with electric vehicles. (Participant 17, pre-interview, PHEV)

The future of EV technology

Generally participants were open-minded about the technology before the trial.

I think they're a good idea, and I hope that they can be developed so perhaps people's opinion of them is a bit better. (Participant 20, pre-interview, PHEV)

I think it's a great idea. I just think they've got to get…you know, there's an awful lot of work that they've got to do so that when people move over…because expectations are set, we've had cars a long time and the expectations are there. (Participant 19, pre-interview, BEV)

After exposure, many remained enthusiastic but some felt that the technology had some way to go.

I think they're great. I'd probably like to have one in the future depending on, you know, if it performs as well as a petrol car, a standard car. (Participant 3, post-interview, PHEV)

I think there's some way to go with the design and with the technology - I don't see it as a commercial viability proposition at the moment. (Participant 1, post-interview, PHEV)

I think there's a technical challenge, getting the performance of them to be sufficient to get mass market take-up. (Participant 16, post-interview, BEV)

6.4.3 Affective responses

Consumers' purchasing decisions are not always based on rational evaluations of utility. By affective responses we mean the feelings or emotions that EVs or EV use may generate. These can play an important role in product evaluation and purchase.

6.4.3.1 Aesthetic response

Design features may trigger emotions or memories (Costley & Brucks, 1992) that affect desirability. Such aesthetic evaluations are based on affective or emotional reactions to a product (Veryzer, 1993) and EV appearance was highlighted as an important element of acceptability and desirability.

I have to say, whilst I love the technology, I think the designs, unfortunately, are unnecessarily ugly; that is not an attractive-looking car…I don't see any reason why cars can't be attractive as well as functional. (Participant 1, pre-interview, PHEV)

I wouldn't want to drive something that looked like a supermarket trolley with a dome on the top just because it was green. It would have to, you know, look good as well. (Participant 6, pre-interview, PHEV)

To be honest; it's quite girly-looking as well…for example, I don't think [boyfriend's name omitted]...could feel comfortable driving it. (Participant 5, post-interview, BEV)

I wouldn't buy one just because I don't like the way any of the hybrid vehicles look actually. (Participant 3, post-interview, PHEV)

Some participants went on to explain that they do not wish their car to look different or stand out from other cars.

So I think it's important that it mustn't look too goony; it must look like an ordinary car. (Participant 17, pre-interview, PHEV)

Yes, as far as I…didn't have a problem with it. It didn't look stupid. It looked like a normal car. (Participant 19, post-interview, BEV)

They don't look out of place; they look like a normal car and I just quite like them. (Participant 12, post-interview, PHEV)

6.4.3.2 Feel good factor

It was apparent in this trial that many of the participants had experienced positive emotional reactions towards how the vehicle felt to drive.

I found it very satisfying; it was a joy to go out in it. (Participant 18, post-interview, BEV)

It was great fun driving in that car...I was quite chuffed to be in it, seriously. (Participant 19 post-interview, BEV)

As I said, quite amusing, quite pleasing to drive around town. (Participant 1, post-interview, PHEV)

I just love it. I find it relaxing. I love the fact that I can just get in and I'm sort of, you know, it's easy to get around. I feel that I'm in control, I quite like that. (Participant 12, post-interview, PHEV).

Although the silence of the EVs was a safety concern for many participants, for others quietness resulted in a positive emotional response.

And it was so quiet, as well. That was really nice…I think the vehicle, itself, is quite, sort of, sound-tight and you couldn't hear much of the outside noise. And that was nice. I think, if I'd have driven in my own car it wouldn't have been as nice. (Participant 20, post-interview, PHEV)

I liked the fact that it was quiet. (Participant 16, post-interview, BEV)

It's ever so quiet. It's actually very pleasant when you drive along. (Participant 19, post-interview, BEV)

6.4.3.3 Negative responses

Not all the emotional responses were positive. Some participants and/or family members felt moments of embarrassment because they felt the vehicle did not fit with their own image.

I, kind of, found myself [saying to others], oh, yes, it's just a trial, oh, no, I probably wouldn't get myself one. (Participant 5, post-interview, BEV)

I must admit, I mean, I found it a bit embarrassing at times. I met a new customer for the first time and sort of opened the door, and you know, they obviously clocked it, and I thought I'd mention it rather than…and sort of tell them all about it…I'm not a Prius man. That's what I was kind of…that's how I kind of felt. This isn't my image, you know, kind of thing, which is probably a bit snobby really. (Participant 22, post-interview, PHEV)

But I did have a passenger with me, so it wasn't quite so embarrassing, and she could take some of the embarrassment, but it was so slow. If I was behind the car I would have been tooting. (Participant 14, post-interview, BEV)

My husband thought it was…had this real thing about it. He wouldn't go in it. He said it was like a milk float. The boys laughed and said they would be embarrassed for their friends to see them in it. (Participant 19, post-interview, BEV)

Another negative emotion, experienced by some of the BEV users, was intimidation from other drivers.

I was going on the Broadmoor Bypass and I was going up the hill and it did take a while to actually gather speed and I did have a Touareg behind me that felt it was like three inches away from my bumper, so I did feel a bit intimidated. (Participant 7, post-interview, BEV)

As I said earlier, was the intimidation, you do notice that; you get tailgated, more by lorries on the motorway or the dual carriageway. You get the sort of response that is saying, what are you doing; because you're kind of slowing down, you're just trundling up to the lights and things like that, at junctions. (Participant 9, post-interview, BEV)

It's very intimidating, I find, sometimes on dual carriageways and motorways, and people are completely pushing you all the time. (Participant 19, post-interview, BEV)

Others expressed negative emotion regarding the driving experience more generally.

I don't know whether it's because it is lighter that's why I was feeling the movement from things passing, and the wind, yes. And that was a bit unnerving. (Participant 10, post-interview, BEV)

I just didn't enjoy the drive of it really. I mean, it does everything else very well. You know, it's not uncomfortable, it's quite soft and smooth [but]…it doesn't handle well…so we're used to something a bit more sort of sporty feeling. However, this was quite the opposite. (Participant 22, post-interview, PHEV).

But as a car very uninspired and boring and, you know, nothing that...you know, you couldn't get into it and say, oh isn't this a nice car…it was like a world without colour, you know, it was really like, I was just, ugh. (Participant 15, post-interview, PHEV)

6.4.3.4 Anxiety

Anxiety was the strongest negative emotional response reported. Participants anticipated feeling anxious about running out of power and being stranded before they had tried the cars.

I mean my worry…is, you know, how much charge do you have…to go anywhere? Obviously, I don't know that yet, and you know, I'd be thinking, ooh, can I get to Luton, you know, or will it make it to Brentwood? (Participant 10, pre-interview, BEV)

First experience would, most probably, be a bit scary, if I would run out of electric and unable to return from a journey but I'm sure, obviously, that's something that you would work out and it will be fine. (Participant 14, pre-interview, BEV)

The only thing that would worry me…is the fact that…it sort of makes you feel that would it just stop, you know? I'm sure that isn't the case, but it just worries you, you know, something different that you're driving. (Participant 12, pre-interview, PHEV)

Unfortunately, gaining experience with a vehicle for one week did not necessarily alleviate this 'range anxiety'.

The battery went down really quickly, and I didn't feel confident going out knowing I might not be able to charge it, and then be left somewhere, and I couldn't get back. (Participant 14, post-interview, BEV)

The rain came down… I was really worried about the battery…I was very conscious of the fact that I had windscreen wipers going, I had the de-mister going, I had the lights on, I had the back rear wiper going. I was thinking, my battery's going, my battery's going. And that was…it was a bit of a stress because I wasn't familiar with the car and its capabilities and how long that battery would last. (Participant 5, post-interview, BEV)

Range anxiety is perhaps not surprising among those using BEVs because running out of charge is a real possibility. However, it was surprising was that some PHEV users also continued to be anxious about the vehicle range and the fear of being stranded.

I'd say the only [disadvantage] that I can really think of is the range that the car will do because obviously I would feel uncomfortable doing a relatively long journey, worried that I wouldn't be able to get home as well. (Participant 6, post-interview, PHEV)

And maybe I'm being overly cautious and maybe I could easily make a journey up to Scotland, you know, to Aberdeen without worrying about it, but I don't know enough about it. I just think, you know, is that charge going to go right down? Am I going to worry for half the trip that I'm not going to make it? (Participant 2 post-interview, PHEV)

The perceived availability of recharging infrastructure was also closely linked to participants' range anxiety.

I suppose I would worry about where the next docking station for the vehicle would be but that's obviously at the moment because they're not everywhere. (Participant 13, pre-interview, PHEV)

I must say the only other disadvantage is if you were driving in the middle of nowhere and you couldn't charge it. I don't know if you'd gone a long run and for some reason you couldn't charge it, that would be the only thing that I would worry about maybe on a long, long journey. (Participant 12, post-interview, PHEV)

One thing that did concern me was that if I'd say gone to a hotel which was a long distance…how would I plug it in when I got there? That really bothered me. (Participant 10, post-interview, BEV)

6.4.4 Symbolic meaning and identity projection

Many of the participants believe EVs represent characteristics of their owners. For some participants, the symbolic meaning of EV included demonstrating a commitment to the environment or living a sustainable life. For others the EVs failed to project wealth, power and success.

You would appear to other people to be more concerned about the environment and more eco-friendly. (Participant 20, post-interview, PHEV)

I think it's really, you know, the sort of eco-green agenda. I'm quite concerned about the world, the way the world is going, with everyday things that we manufacture and the pollutants that go into the environment, the allergies that human beings are suffering as a result of all these processes. And the pollutants going into the air particularly in cities, is quite disturbing for the future. So the quicker we can get on top of that and try and remove that sort of a problem, the better. (Participant 11, pre-interview, BEV)

We need to…I'm not a…I don't bang the green drum, but we've got to save the planet long term for other people. And I think…and this is one route to do it. (Participant 18, post-interview, BEV)

Knowing that I wasn't polluting the environment would be a nice feeling. (Participant 20, pre-interview, PHEV)

I do like the idea that it is environmentally friendly. (Participant 10, post-interview, BEV)

Some of the participants saw using an EV as a positive opportunity to set an example to others.

I think it would be really good to own one just to be sort of out there as a, you know, trying to make some kind of change. (Participant 6, pre-interview, PHEV)

And other people could, I think, could see that I was driving an electric car and I, yes, I liked that because I think more people should drive them and it would've shown that I was perhaps more conscious of the environment. (Participant 20, post-interview, PHEV)

I've a friend coming over and I'm going to be quite proud of having it on my drive. (Participant 9, post-interview, BEV)

Some participants also saw use of EVs as reducing oil dependence in a global context.

I suppose it's a good thing if we don't become too reliant on petrol in terms of all the politics of all of that. (Participant 5, pre-interview, BEV)

But, you know, we can't go on…paying more and more money, running down the environment, getting cases like the oil in the Gulf, being held to ransom by terrorists or terrorist nations (Participant 17, pre-interview, PHEV)

However, for others, driving an EV represented a loss of identity and status.

So I suppose you, kind of, get that image of it, whereas like a car like the BMW that we've got, it's quite obviously reasonably good performance, quite nice-looking, a bit more aggressive-looking. Whereas that's a bit, kind of, meek and mild, I suppose. (Participant 5, post-interview, BEV)

Okay, negatives. I think…being quite shallow here – I think image, unfortunately. I think there might be people that will perceive a car like that as a bit of an image, sort of, crusher…I think if you go and put one on your drive that doesn't look snazzy and that, I think people are going to think, mmm, complete nerd… (Participant 19, pre-interview, BEV)

I wouldn't see a successful business person possibly driving around in this kind of car, not yet. (Participant 1, post-interview, PHEV)

I think it's probably a sort of stigma attached to them that, you know, these are only Mickey Mouse machines that nobody really…they're not going to be around for long. They're just a gimmick. (Participant 8, pre-interview, PHEV)

6.4.5 Recharging experience and behaviour

Participants generally recharged the vehicles at home. Although many of the participants had garages most opted to recharge the vehicles on their driveway or carport. This was to avoid having to move other vehicles or otherwise reorganise garages to accommodate the new vehicle. One participant experienced recharging at a public recharging bay (P9), one recharged the vehicle at work (P21), one at their parents' house (P20), one at a friend's house (P14) and one recharged at a public house, although this was not in a recharging bay (P21).

Many of the BEV users recharged at home every day or nearly every day, whereas the PHEV users recharged less often. Three of the participants who were using a PHEV never attempted to recharge the vehicle during the trial week. As noted previously, two PHEV users felt that the vehicle did not require recharging because the battery never fell low enough to warrant it.

Each time I went in to the car and started it and stopped...there's like a meter showing for the battery - it was almost at full each time so I thought, why do I need to plug it in if the battery's almost at full every time? (Participant 1, post-interview, PHEV)

The time of day for recharging varied from person to person. Some participants recharged in the morning or as soon as they arrived back home. Others found it easy to recharge over night. However, a couple of the participants commented on the fact that they were uncomfortable leaving the vehicle recharging whilst unattended.

I think probably because it was quite new, I liked to...I kept going to check it and make sure that everything was okay, but I'm sure, you know, if it was...if I'd had it longer and I was more used to it, I would have just left it overnight. (Participant 7, post-interview, BEV)

And then I found at night time, obviously I had to do it to shut the window, and the same with the shed. I didn't leave it out all…I didn't leave it all night. I think it was out until about two in the morning, and then I'd come…I got it plugged in again early in the morning, and purely because it meant leaving the shed open. (Participant 14, post-interview, BEV)

Recharging prompts also varied from person to person. For the PHEV users they either recharged after they had used it as they assumed that it would need recharging then, or because the information booklet recommended that it should be recharged regularly.

I think just reading the guide book, it says…don't leave it for more than two days sitting there. So I just thought because I'm so busy as well, it's just a good thing to get into the habit of doing it. (Participant 2, post-interview, PHEV)

Well, just because it said that you had to in the instructions. (Participant 8, post-interview, PHEV)

BEV users were prompted to recharge from the instrumentation indicating that the battery was getting low on power. For some, a capacity of 50% or less was a recharging prompt.

And I always just used to check what the percentage of the battery was on. So I think if it was...if it was on half then I was absolutely fine and I'd go wherever, not to London, but local. Yes, I think if it was less than about 30, I wouldn't have been happy to go out. (Participant 7, post-interview, BEV)

If I was home and it was 55 or below, or 60 or below, I'd charge it. In the first day I was like an absolute keeno, so I just wanted to charge it. So I was, like, straight away, charge it up even though it was 70, and then I, kind of, relaxed into it. (Participant 5, post-interview, BEV)

Yes, most probably when it went to about 50 percent. (Participant 14, post-interview, BEV)

All the participants indicated that recharging was easy or at least unproblematic. Several participants suggested that it was easier than having to refuel at petrol station.

It was easy...I mean, probably easier than going to the petrol station. I actually quite liked that. (Participant 14, post-interview, PHEV)

Oh, it's perfect. I hate filling my car with diesel, so it's just such a nice experience just to plug it in when you get home. It's just so easy. (Participant 6, post-interview, PHEV)

It's obviously much easier to plug in when you're at home than it is to pull into a service station and maybe have to wait in a queue to get to the pump. So that was potentially a lot more convenient. If you had a car that you could charge and it did 20 or 30 miles on charge then you'd probably hardly ever have to go to the petrol station so that would be nice. (Participant 3, post-interview, PHEV)

I mean I think it was possibly easier because, you know, you'd got your facilities there on tap as it were. Whereas you go to a garage sometimes you have to wait because you can't get to a pump, and then you find out that the pump that you've gone to hasn't got the petrol you want. It's just a bit frustrating. And then you're looking for the cheapest one as well, and all this sort of thing. So no, I think it's probably easier from that point of view. (Participant 10, post-interview, BEV)

In a way, most probably less hassle, because when you go to a petrol station, you've got to queue, you've got to go in and pay. (Participant 14, post-interview, BEV)

However, there were downsides to recharging. The most common was the access problems at home, the inconvenience of the plug-in point and how this problem would need addressing if they were to own an EV.

It was inconvenient that I had to move things to get to the socket easily. So that would be something that would have to come into play. So I'd have to re-jig my garage a bit more, you know, on a permanent basis. Again it would probably mean that I'd have to do more forward planning. (Participant 9, post-interview, BEV)

So, I think if you are going to own an electric vehicle or use it, you know, for more than a week, you either need ideally a lockable garage with a 13 amp power supply…or you'd have to consider getting an electrician to put a weather proof outside charging point, you know, at the most adjacent point to your house. (Participant 12, post-interview, BEV)

I suppose the only hassle is with the charging, I think you have to go back out later on at night and unplug it. It's not a big deal, but I just think that if it was raining, we were lucky with the weather, but it's just that thing of in the winter, if it's raining, it would be, I think, more of a hassle having to get up and not get ready for bed and things until you go and unplug it. (Participant 2, post-interview, PHEV)

I think, at the moment, where I live it was not ideal to have the cable crossing the path, and things, but the fact that I didn't need to charge it every night was, it didn't make it that much of any issue. But long term I think that it possibly wouldn't be ideal. (Participant 20, post-interview, PHEV)

Some participants felt that recharging at home was too slow and it tied them down.

I think the timing has got to be crucial, so I think it can't take all night to charge, it's going to be a real faff, isn't it? It's going to have to be something quick because we all want quick, we all want things done so quickly nowadays – we're just so intolerant and impatient. (Participant 19, post-interview, BEV)

I'm just constantly in a rush, to be honest, so having to be organised in terms of how it is it filled up is just a bit of a drawback. (Participant 5, post-interview, BEV)

Well the only thing is it takes quite a long time so if you were reliant on that alone I think it would be a bit disconcerting. (Participant 3, post-interview, PHEV)

6.4.6 Behavioural adaptations – driving style

In the post-interview many of the participants mentioned that they had changed or adapted their driving style during the trial week to suit the vehicle. For many this was an attempt to extend the battery range. This was sometimes triggered by the miles per gallon display unit. For some of the PHEV users their driving behaviour changed as they attempted to keep the vehicle in electric mode as much as possible.

I liked being able to see miles per gallon and all the information on the touch screen; that was really good to be able to see that. I think that affected my driving a bit, being able to see. Because I could see how many miles per gallon it was doing, I would also try and stay at the most miles per gallon. And it was interesting to see, like, what speeds and how much it varied. (Participant 20, post-interview, PHEV)

So I tried really hard sometimes to be really gentle with the accelerator, but in order to keep…stop it from going into the petrol mode, you'd have had to go too slow. (Participant 22, post-interview, PHEV)

I was a smooth operator. I was very careful with how I was driving, really watching my braking and accelerating; very smooth. (Participant 5, post-interview, BEV)

It just seems to have changed the style of driving...just you tend to drive more relaxed, so that's very good, (a) because it's a bit slower, and, (b) because you know it's got a limited range, so you tend to be careful, consciously careful about it. (Participant 9, post-interview, BEV)

A few of the participants mentioned that they drove more cautiously as they were concerned for the safety of other road users.

So maybe I was a bit more conscious of pedestrians not being aware of me. (Participant 10, post-interview, BEV)

I think because the car doesn't make hardly any noise a motorcyclist sort of pulled out almost in front of me at a crossing because I don't think he heard me, and then on the way home, driving through the estate, a cat ran right in front of me which I was scared *of squashing because again, there is just so little engine noise, so I guess that's the only thing that sticks in my memory that concerned me a bit, and it made me more cautious when I've been out and about in it. (Participant 6, post-interview, PHEV)*

6.4.7 Changes due to exposure

6.4.7.1 Quantitative pre-post mini survey

We aimed to understand whether gaining hands-on experience with an EV would increase the participants' knowledge and understanding of EVs and/or change their attitudes and behavioural intentions. In addition to the qualitative analysis we used a short quantitative survey at pre- and post-exposure to track any changes (see Appendix C and Appendix E) and to help develop hypotheses regarding the effect of hands-on experience. Participants were asked to answer three questions on seven-point response scales (with higher numbers representing a more positive response):

1. Overall, how would you describe your attitude towards plug-in vehicles?
2. How well would owning a plug-in vehicle fit with the kind of person you are?
3. How likely is it that you would consider having a plug-in vehicle as your main car in the next five years?

These questions are referred to as 1) 'pre-post attitude', 2) 'pre-post fit' and 3) 'pre-post purchase intention' respectively in Table 21 and Table 22. Table 21 shows results for PHEV users while Table 22 show results for BEV drivers.

Table 21: Pre-post responses to quantitative questions for PHEV users

Participant No.	Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
1	3	5	-	-	2	3
2	5	7	-	-	7	6
3	6	6	-	-	6	7
4	7	7	6	6	7	7
6	7	7	6	6	7	7
8	6	7	6	7	5	5
12	5	6	5	6	4	4
13	6	5	5	4	5	4
15	4	6	2	4	3	4
17	6	7	7	6	7	6
20	7	7	7	7	7	7
22	4	5	2	3	2	1
Mean	**5.5**	**6.2**	**5.1**	**5.4**	**5.1**	**5.0**
SD	1.3	0.8	1.9	1.4	1.9	1.9

Table 22: Pre-post responses to quantitative questions for BEV users

Participant No.	Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
5	3	6	3	2	2	5
7	6	7	7	7	6	6
9	6	6	5	6	1	7
10	4	4	4	5	3	3
11	7	7	7	5	6	6
14	5	3	3	2	3	2
16	6	6	5	4	1	1
18	5	6	6	7	6	4
19	5	6	5	5	4	5
21	3	4	5	2	4	1
Mean	**5.0**	**5.5**	**5.0**	**4.5**	**3.6**	**4.0**
SD	1.3	1.3	1.4	1.9	1.9	2.1

Results show that the PHEV users' attitudes towards plug-in vehicles shifted in a positive direction from an average of 5.5 before the trial to 6.2 after the trial. The change in PHEV attitude towards the vehicle fit was smaller but showed a positive shift from 5.1 to 5.4. However the PHEV users intentions to purchase slightly decreased from 5.1 to 5.0.

For BEV users their attitudes towards plug-in vehicles also shifted in a positive direction (5.0 to 5.5). Interestingly the average for 'vehicle fit' decreased from 5 to 4.5 yet the future purchasing intention increased from 3.6 to 4.

However looking across all the participants, generally attitudes were positive to begin with and only one participant decreased in their overall attitude score over the week, seven stayed the same and fourteen became more positive. Whereas eight of the participants indicated a decrease in how well they felt a plug-in vehicle fitted with the kind of person they are, five stayed the same, six increased and for three data were missing. Eight of the participants indicated that they would be less likely to purchase a plug-in vehicle after the trial, eight stayed the same and six increased.

It is noteworthy that a two point shift on a seven-point scale would normally be regarded as a large shift and there are several shifts of two or more places among the three scales. For example there are five participants whose attitude towards plug-in vehicles shifted two or more places from pre to post. Three participants shifted two or more places in their perception of vehicle fit and four participants shifted two or more points in regards to their future purchasing intentions.

The sample used here is too small to draw inferences about users more generally on the basis of these quantitative data. Nonetheless, these data suggest two hypotheses which could be tested in a larger survey. First, hands-on experience seems to result in more positive evaluations of EVs. Second, hands-on experience seems to generate a greater acceptance of BEVs as fitting with one's lifestyle but this is not necessarily the case for PHEVs. Finally, hands-on experience promotes intentions to purchase BEVs but not PHEVs.

As we illustrate below, the meaning of such shifts must be carefully considered and further work would be required to ensure that people interpreted the response options in the same way at pre- and post-interview. For example, participant 1 shifted two points in attitude from 3 to 5 on the quantitative survey, yet in the post-interview this participant was still not convinced that EVs were technologically viable or that they are unequivocally environmentally friendly. This respondent thought EVs were only suitable for local journeys and was not convinced they were viable yet.

6.4.7.2 Market segmentation hypotheses based on mini-survey results

This sample is too small to identify demographic characteristics that moderate attitudes, such as age or average mileage, or the processes by which evaluations and intentions change. Nonetheless, consideration of who gave higher or lower ratings in the mini-survey can generate hypotheses which could be tested in a larger quantitative study.

There is some suggestion that drivers aged over 60 have more positive initial attitudes then those under the age of 60 with an average attitude score of 6 for the former compared to 5.1 for the latter. It appears that those in their 40s and 50s increased in positive attitude the least with an average of 5 at pre-exposure to 5.3 at post-exposure, whereas those in their 20s and 30s increased the most from an average of 5.2 at pre-exposure to 6.2 post-exposure.

Overall, there does not appear to be much difference between high and medium/low mileage users in their pre- or post-attitude evaluation. High mileage users' (100+ miles per week) attitude score increased from 5.3 to 6.2, while the medium/low mileage users' (under 100 miles per week) shifted from an average of 5.6 at pre-exposure to 6.2 at post-exposure.

There was no evident difference in average attitudes towards EVs between men and women at pre-exposure (5.3 and 5.1) or at post-exposure (6.0 and 5.9). Generally both men and women increased in attitude score more at post-exposure for PHEVs (men=6.1; women=6.3) than for BEVs (men=5.8; women=5.4). It appears that women were more impressed with the PHEVs with a shift of 1.2 and less impressed with the BEVs with a shift of only 0.3.

There was also little indication of differences between urban and suburban home locations. In urban locations the average attitude score at pre-exposure was 5.6 and this shifted a small amount at post-exposure to 6.0. In the suburban locations attitude scores shifted from 5.1 to 5.8.

Finally, it is interesting to note that households with more than one vehicle had less positive attitudes at pre-exposure than those with just one vehicle (4.8 compared to 5.7). Both increased slightly in attitude after exposure (one-car households improved to 6.2, a 0.5 shift; and two plus car households improved to 5.5 which is a 0.7 shift).

As stated above, these observations are merely designed to stimulate potential hypotheses that can be tested using larger sample sizes in future research. The comparisons drawn here are not based on any formal inferential statistics as the sample sizes (especially when comparing the different sub-groups) are too small to allow such analyses.

6.4.7.3 Qualitative tracking of individual change

Below we present individual participants' results from the quantitative mini survey (pre- and post-) along with a summary of individual changes in attitudes and intentions as indicated by the content of pre- and post-interviews. The first 12 are from participants who used PHEVs followed by the ten that used BEVs.

Participant 1

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
3	5	-	-	2	3

Participant 1 was in his forties. He lived with his partner in an urban environment. They had access to two vehicles, and he estimated that he drove approximately 100 miles per week. In the pre-interview he felt that EVs may not be the right technology for the future because he felt that they simply swapped one energy source for another. He expected EVs to have poor aesthetic appeal and to lack prestige. He also thought that the recharging options were limited. After the one week trial he was still not convinced that EVs were the right technology or that they had true environmental benefits. He felt that they lacked power and acceleration at higher speed and were not appropriate for motorway driving. After the week, this participant thought EVs were no fun to drive, there was a lack of infrastructure, vehicle choice and size and they did not look good. Nonetheless he found the car easy to drive, especially around town; he felt the car was comfortable with a practical interior which was spacious and uncluttered. He concluded that EVs were fine for local journeys but not a true commercial proposition. He would only consider purchasing an EV if petrol prices were “sky high”.

Participant 2

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
5	7	-	-	7	6

Participant 2 was in her twenties. She lived with her partner in a rural location. They had use of two vehicles and she estimated that she drove approximately 300 miles per week. At the pre-interview she felt EVs were a good idea but wanted to know more as she lacked knowledge and understanding. She anticipated less driving excitement and a lack of charging infrastructure. She explained that make of vehicle (including brand status), availability of vehicle choice and vehicle reliability were important to her. She believed EVs were good for the environment, would save money, that EV silence would be a positive feature and that EVs would have a positive influence on others. She was surprised and pleased with the vehicle during the week as she found it easy to drive, very nippy, and she felt safe in the car. She had positive responses from others and felt like an early ambassador for EVs. She appreciated the silence but had come to see that this may have safety implications. She still felt confused by the instrumentation (e.g. in relation to battery charge) and felt she lacked confidence with the technology. Overall she was very impressed but still preferred her own vehicle. She was open to purchasing in the future but could not predict when.

Participant 3

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
6	6	-	-	6	7

Participant 3 was in his forties. He lived with his partner in a suburban location. They had one car and he estimated that he drove approximately 190 miles per week. At the pre-interview, he felt that EVs have range problems. He was unclear about the future of rapid charging and thought that even rapid charging may not fast enough for daily use. He also felt that the purchase price was a considerable barrier to purchase. However, he was optimistic and felt EV development should be supported because of their potential environmental impact, including noise reduction. Interestingly, he anticipated that widespread adoption would increase the house prices in city centres. After the trial week this participant thought that the vehicle had poor handling and was underpowered. He felt that the range went down too quickly and was confused by the battery charge. Finally, he thought that recharging was a hassle. His impression was mainly negative but he did not rule out every purchasing one, but felt this would only be as a second vehicle unless range improved.

Participant 4

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
7	7	6	6	7	7

Participant 4 was in his twenties. He lived with his partner and two children in an urban location. They had access to one vehicle and he estimated that he drove approximately 30 miles per week. In the pre-interview he thought EV technology was improving but range and infrastructure were still a problem. He would like to see more choice of models and brands and was concerned about unknown insurance and servicing costs. He appreciated potential environmental benefits, including less noise pollution. Over the trial week he did not use the vehicle much, but enjoyed the experience and had no real problems. He found the vehicle comfortable and smooth to drive. He did not recharge the vehicle and was confused by the state of battery charge. Although he liked the silence he realised that it had safety implications. He did not rule out buying an EV in the future and preferred the PHEV option to a fully-electric BEV.

Participant 6

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
7	7	6	6	7	7

Participant 6 was in her thirties. She lived with her partner and two children in an urban environment. They had access to two vehicles and she estimated that she drove approximately 200 miles per week. At pre-interview she thought that EVs were the way forward, due to the environmental benefits, lower running costs and freedom from refuelling at petrol stations. However, she also commented on lack of range, power, speed and infrastructure. She felt that she would need to know more before being able to make a decision to buy and there was a lack of information in the public domain. After exposure she said she loved the experience and thought it was a great concept. She was surprised by the acceleration, and thought the car was “brilliant” for driving around town but continued to be worried by driving it (a PHEV) on longer journeys. She expressed confusion over battery charge and found herself driving more cautiously due to the silence of the vehicle. She did not like the appearance of the vehicle inside or out but thought that she would replace their vehicle for an EV sometime soon in the future, as a main vehicle.

Participant 8

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
6	7	6	7	5	5

Participant 8 was in his sixties. He lived with his partner in the suburbs. They had access to two vehicles and he estimated that he drove approximately 60 miles per week. At pre-interview he indicated that he would be happy to own an EV if it was reliable and had a good range. However, he was concerned that speed, range and infrastructure would be problematic, feared being stranded and would have liked more information on infrastructure and range. He mentioned benefits to the environment and reduced servicing compared to liquid fuel cars. This participant was very happy with the vehicle during the trial week although he did not use it every day and had problems understanding the gear stick. He felt the acceleration was poor and that the silence created safety issues. He still felt that they did not know much about the vehicles and wanted to know more. He concluded that he might swap in the next few years, adopting an EV as his main vehicle.

Participant 12

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
5	6	5	6	4	4

Participant 12 was in her forties. She lived with her partner and two children in an urban environment. They had access to two vehicles and she estimated that she drove approximately 250 miles per week. At the pre-interview she felt that the concept of EVs was very new and alien to her. She had fears of running out of charge, was concerned about road side rescue and what was in place for EVs as well as being concerned that the purchase price was too high. She also hated the term “plug-in vehicles” and thought it sounded like a small appliance. Nevertheless she did feel that EVs had environmental benefits and were cheaper to run than petrol/diesel vehicles due to increases in petrol prices. This participant really liked the vehicle during the trial period. She found them easy to drive and park, comfortable with good steering. She realized that there was a benefit and a downside to the silence of the vehicle and was aware of the lack of public infrastructure. She was confused as to the state of the battery charge and when it was appropriate to recharge the vehicle but found recharging no problem at home. She did not feel like the vehicle looked out of place and commented on how it felt good doing something for the environment. She did say that they may swap in the future buy did not specify when.

Participant 13

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
6	5	5	4	5	4

Participant 13 was in her forties. She lived with her partner and two children in an urban environment. They had access to one vehicle and she indicated that she did not drive far but did not estimate her mileage. At the pre-interview, she talked about how EVs were the way forward but that she found them strange and unfamiliar and felt nervous of using them. She expressed concerns about a lack of infrastructure, as well as anxiety over the technology failing (i.e. not starting or stopping appropriately). She said that the vehicle would have to fit their vehicle requirements before they could consider purchasing. This participant found the experience of driving the EV “OK”, but felt that she had driven mainly in petrol mode because she usually drove at speeds greater than 30mph. She was unsure which drive-train was active when driving and found the instrumentation confusing. She did not risk taking the vehicle on longer trips because she did not feel confident of the range or supporting charging infrastructure. She had concerns about recharging safety in the rain as well as the possibility of sabotage. She was also concerned about the safety of other road users due to the silence. Nevertheless, she thought the vehicle was quite nippy with fast acceleration, she liked the fact they were good for the environment and might switch in the future but only if the vehicle had everything she needed.

Participant 15

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
4	6	2	4	3	4

Participant 15 was in her forties. She was single and lived in a rural area. She had access to one vehicle and estimated that she drove approximately 190 miles per week. During the pre-interview, she said she did not fully understand the technology and would like more information, although adoption of an EV was not a serious consideration at present. She had doubts about the green impact of the technology although she was aware that EVs do not generate tailpipe emissions. She saw lack of range as a major drawback. She was also concerned as to whether the batteries can hold charge in adverse weather conditions, such as extreme cold. Safety issues, reliability and lack of infrastructure were also seen to be important. She expressed image concerns likening EVs to “milk floats” and explained that the aesthetics of a vehicle was very important to her. She believed that PHEVs would look and drive like a normal vehicle, but still thought that other drivers may respond negatively to them. During the trial this participant had problems starting the vehicle and called a breakdown service for help. The breakdown service was unhelpful. Overall, she felt that the vehicle did a good job and was quite nice to drive. However she “hated” the aesthetics, viewing the car as drab and depressing and the interior as claustrophobic with poor visibility. She was embarrassed that other people might think that she had chosen to buy the car and therefore distanced herself from the vehicle by explaining that she was participating in a trial. She felt good not going to a petrol station but did not feel she had learnt much more about EVs. Consequently, many of her initial concerns remained although she had changed her mind about the car being like a “milk float” and had appreciated the quietness and greater “cleanliness” of the car. She would consider buying one if certain aspects could be improved.

Participant 17

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
6	7	7	6	7	6

Participant 17 was in his sixties. He lived with his partner in the suburbs. They had access to one vehicle and he estimated that he drove approximately 230 miles per week. At pre-interview, he was aware that EV technology has been developing quickly but was unsure how advanced it was. He was pessimistic that problems with transport emissions will be resolved in his lifetime. However, he believed that that future changes would benefit the environment and would also benefit people financially. He anticipated that using an EV would require more planning but would buy one tomorrow if there was a vehicle that “ticked all the boxes for him and his partner” and performed as well as a petrol/diesel vehicle. He valued the aesthetics of cars and the positive emotional experience of driving. He had concerns in relation to vehicle safety and potential vandalism when recharging. At the post-interview, this participant felt that the vehicle had driven predominantly in petrol mode as they mainly drove above 30 mph. He had expected that the vehicle would go into electric mode whilst cruising and was disappointed that it had not and judged the car to be uneconomical. He never recharged as he felt that the battery never got low enough. He also commented on safety issues following from the EV’s silence and suggested that noise should be added. For him, the lack of boot space was a problem. Overall, he was disappointed and concluded that EVs are only useful for city driving and so not suitable for his needs.

Participant 20

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
7	7	7	7	7	7

Participant 20 was in her twenties. She was single but lived in a house-share in an urban area. She had access to one vehicle and estimated that she drove approximately 60 miles per week. At the pre-interview she believed EVs were good for the environment and economical to run. She anticipated feeling good about driving an EV and judged recharging at home—rather than having to go to a petrol station—as an advantage. However, she thought they would be slower which she viewed as a potential problem on motorways. She saw limited range as a drawback and felt she would need to see improvements in public infrastructure and recharging times before she would purchase an EV. This participant was very impressed and really enjoyed her experience of driving an EV for a week. She felt comfortable and safe and enjoyed the silence when driving in electric mode. She drove more often than she normally would because she enjoyed it. Using the available instrumentation feedback she enjoyed trying to stay at a speed that maintained the highest miles per gallon usage. She did not feel that the vehicle struggled on the motorway but did have some problems with recharging at home. She would definitely buy an EV if the initial purchase price was reduced and if the range was good enough.

Participant 22

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
4	5	2	3	2	1

Participant 22 was in his twenties. He lived with his partner in an urban area. They had access to two vehicles and he estimated that he drove approximately 250 miles per week. At the pre-interview, he thought EVs were a good idea but still had some way to go before being a viable option. He suggested that hydrogen vehicles would be preferable. This participant identified range, infrastructure and recharging speed as being important issues yet to be resolved. He viewed EVs as beneficial in term of reduced emissions and greater efficiency but thought that the electricity usage would still have an environmental impact. Purchase price was also seen as a barrier along with depreciation due to a limited market. He did not see himself switching to an EV in the near future. This participant did not like the experience of using the EV over the trial week and found it “numb and dead”. He thought that the handling was “wallowy” and slippery in the wet which did not give him confidence when driving at speed. He found himself adapting his driving to maintain electric mode and fuel economy and felt good about saving energy. He found recharging “a bit of a faff” because he did not have an ideal recharging arrangement set up at home, but liked the fact it was cheap and easy to do. He was unclear whether the vehicle needed recharging because he thought it could recharge whilst cruising. He still viewed the limited range as a problem for longer trips. He did not see himself switching in the near future.

Participant 5

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
3	6	3	2	2	5

Participant five was in her twenties. She lived with her partner in the suburbs. They had access to two vehicles and she estimated that she drove approximately 300 miles per week. At the pre-interview, she thought that EVs had limited range, performance, that they were not suitable for motorways and had a poor image. She also thought that she would be bullied on the road, would experience range anxiety, and would find the logistics of recharging problematic. This interviewee was not confident that she knew the difference between the different drive-trains. Nevertheless she felt that EVs were beneficial for the environment, were cheaper to run, and that it was good thing that they were less reliant on oil. As a result of the trial experience, she expressed surprise that she had to charge the vehicle less than she thought she would. She also thought that the vehicle had better performance and range than expected and she found it very easy to park. The vehicle had fitted into her life easily and she had found it usable even without public infrastructure being in place. She felt that additional work was needed on the image of the vehicle and that public charging infrastructure would be helpful. She concluded that she would consider swapping to an EV within five years if greater support and infrastructure was in place.

Participant 7

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
6	7	7	7	6	6

Participant seven was in her thirties. She lived with her partner and one child in the suburbs. She had access to two vehicles and estimated that she drove for approximately 50 miles per week. At pre-interview, she thought that EVs had limited range, performance, space, choice and that recharging infrastructure and recharging time would be an issue. She felt that EVs would be beneficial for the environment and would be cheaper to run. After driving one, she found the vehicle to be easy to drive and park, comfortable and responsive. During the trial she became less anxious about the range and found that her driving style became more eco-friendly. The trial made her aware of, and concerned about, safety aspects of mixing water and electricity. She would have liked the vehicle to be more robust with better instrumentation and bigger boot space and for the purchase price to be reduced. She concluded that she would only consider purchasing an EV if the price reduced considerably and, even then, only as a second vehicle.

Participant 9

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
6	6	5	6	1	7

Participant nine was in his forties. He was single and lived in an urban environment. He had access to one vehicle and estimated that he drove approximately 130 miles per week. He was sceptical about plug-in vehicles and did not think they were sustainable for general use because of range and storage limitations. He acknowledged environmental benefits such as the reduced noise levels and thought that they were cheaper to run. However, he felt that EVs were unappealing aesthetically. After the trial, this participant was much more positive and thought that EVs were “great”. He thought the range was adequate but only for a second vehicle. He enjoyed using public recharging infrastructure and had no problems with it. He concluded that everyone should adopt EVs, especially in the city, but was still not happy with the appearance. He would consider swapping his main vehicle for an EV if the EV had a range of at least 100 miles and a reduced purchase price.

Participant 10

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
4	5	4	5	3	3

Participant 10 was in her fifties. She lived alone in the suburbs. She had access to one vehicle and estimated that she drove approximately 290 miles per week. At pre-interview she knew little about EVs and was surprised to hear you could plug them into a standard socket. She identified lack of range, infrastructure, image and accommodation as key barriers. However, she thought that EVs were good for the environment although she did think that they would have some negative impact on the environment. From the trial she found the vehicle to be unstable in high winds or at speed. She also thought the suspension was a little bumpy, the acceleration poor, they were too quiet, the battery went down too quickly and the instrumentation was poor. Generally she felt the vehicle had the wrong specification for her needs. Nonetheless she did find it easy to drive, and enjoyed the ease and freedom of recharging at home. Overall she thought that EVs were a good idea, but did not like the vehicle. She said that she would only consider an EV if they had the right specification for her.

Participant 11

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
7	7	7	5	6	6

Participant 11 was in his sixties. He lived with his partner in an urban environment. They had access to three vehicles and he estimated that he drove approximately 100 miles per week. At pre-interview he thought that EVs were a long way from being ready. He identified lack of range, battery life, infrastructure and a lack of market competition as the major barriers. He also felt that purchase costs would be too high, the silence would be problematic, and that the vehicle would not hold its value. Nevertheless, he felt that they could benefit the environment, would be cheaper to run and that recharging at home would be convenient. After one week of experience he concluded that the acceleration was good at lower speeds but not at higher speeds. He did not like that fact that you had to use the handbrake when starting the vehicle on a hill as there was no other way to stop you rolling backwards. He also found the instrumentation hard to read at dusk which meant he could not assess available range which created range anxiety. He thought his driving was more considered due to the range limitations and he refrained from using other gadgets in order to maximise range further. He was keen on the environmental benefits but unconvinced by the environmental impact of the batteries and of the generation of electricity. He also had concerns with the safety of mixing water and electricity. Overall he would prefer to see more development and wider acceptance from others before purchasing.

Participant 14

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
5	3	3	2	3	2

Participant 14 was in her forties. She lived with her two children in the suburbs. She had access to two vehicles and estimated that she drove approximately 750 miles per week. At the pre-interview she said she thought EVs were in the early stages of development and thought that lack of range, infrastructure, recharging speed, and lack of vehicle choice/brands would be the main barriers. She also felt they were limited to those with off-street parking. Nevertheless, she did believe that they were beneficial for the environment, were more economical to run especially in the city, created less noise, avoided queuing at petrol stations, and gave you freedom from fuel price changes. However she did not enjoy her experience of using the EV over the week. She found the vehicle too slow which made her embarrassed and she found the acceleration especially poor. She thought that the battery charge depleted too quickly and experienced range anxiety. She enjoyed the vehicle itself, its quietness and found the handling good. She found recharging easy and thought it beat queuing at a petrol station. This interviewee concluded that she would have to see better range, more advertising, cheaper purchase prices, increased public infrastructure and faster recharging before she would consider purchasing an EV.

Participant 16

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
6	6	5	4	1	1

Participant 16 was in his fifties. He lived with his partner and child in the suburbs. They had access to three vehicles and he estimated that he drove 450 miles per week. At the pre-interview he had a good general knowledge of EVs and battery technology. He thought that EVs were a good idea but thought that they were ten years off. He felt that the downsides were range and performance, battery life, and safety due to the mix of water and electricity. Nevertheless, he thought they were a good idea due to shortages in fossil fuels, reduced emissions and reduced running costs. He preferred the idea of PHEVs than a BEV which he felt would only work as a second vehicle. After the trial this interviewee expressed that he liked the vehicle, and thought that it did as it was meant to. However, he found that performance on inclines was a problem and the vehicle was generally no good on motorways. He liked the quietness and acceleration from standstill and concluded that it would be a great vehicle for around town. He experienced range anxiety, never took the vehicle on longer trips, and had safety concerns regarding water and electricity mix. He thought that they had a really useful place but thought the limited range and purchase price was a non-starter and believes that these problems will not be resolved for at least ten years.

Participant 18

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
5	6	6	7	6	4

Participant 18 was in his sixties. He lived with his partner in the suburbs. They had access to two vehicles and he estimated that he drove approximately 300 miles per week. At the pre-interview he felt that EV technology was the way forward due to reduced emissions and increased efficiency. However he felt that the battery life (and therefore vehicle depreciation) was a big barrier. He also thought that they were limited to households with off-street parking. He suggested leasing as preferable to purchasing due to high costs. However, after the one week experience he concluded that the vehicle was limited due to lack of performance, especially the acceleration uphill. He also felt that the lack of range and infrastructure would cause “anxiety”. He was concerned about safety issues due to the lack of power and the silence of the vehicle and found recharging at home a hassle. Nevertheless he expressed surprise at how easy and pleasurable the vehicle was to drive, and enjoyed the quietness of the vehicle. He concluded that EVs are a good thing and the “only way”. This interviewee thought that they are ideal for older retired people and thought that he would purchase in the future but was not sure when.

Participant 19

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
5	6	5	5	4	5

Participant 19 was in her forties. She lived with her partner and two children in the suburbs. She had access to three vehicles and estimated that she drove approximately 200 miles per week. She had limited knowledge before the trial but identified that the benefits would be to the environment and to consumers' pockets. She hoped that they would not cost too much more but believed that they would be cheaper to run. She identified image and infrastructure as the main barriers. This participant found the overall experience of using an EV "positive" and enjoyed driving it. She liked the fact that it felt like driving a "normal" car and nobody laughed at her. She worried about the safety of water and electricity mixing whilst driving through puddles, and suffered range anxiety when using extra electricity for windscreen wipers and the demister in the rain as she thought the battery depleted quickly. She felt that the vehicle lacked power up hills, did not feel as safe as her normal vehicle, and was not big enough for her needs. This interviewee commented that she drove more sedately due to the vehicle's limitations and did not take it on dual carriageways or motorways due to feelings of intimidation. Finally she found recharging easy but wished it could be faster and would have liked to see more public infrastructure. The experience had "opened up her eyes for the future possibility" and suggested that if range was better it would get closer to "ticking all the boxes" for them.

Participant 21

Pre-Attitude	Post-Attitude	Pre-Fit	Post-Fit	Pre-Purchase Intention	Post-Purchase Intention
3	4	5	2	4	1

Participant 21 was in his thirties. He lived with his partner in a house-share in the suburbs. They had access to three vehicles and he estimated that he drove approximately 100 miles per week. He felt that EVs would lack power so felt they would be suitable only for city driving. He also identified recharging frequency and time, and silence (especially for sight-impaired pedestrians) would be major barriers. Nevertheless he thought that their sustainable nature was a main benefit along with cheaper running costs. However he felt that petrol at the moment is still affordable. After the week's experience he concluded that EVs have potential to be quite a good vehicle for the city, but not for his own needs due to lack of top speed for motorway use and lack of recharging infrastructure in more rural areas. He experienced the vehicle going into reduced power on one trip and had to drive with his hazard lights on due to his reduced speed. Nevertheless he found the vehicle easy to use and comfortable, but did not enjoy recharging due to the frequency and time. He also considered the possibility that recharging would be inconvenient in bad weather and a safety issue due to electricity and water mixing. He concluded that he would only consider an EV if he moved to a big city and only then as a second vehicle. This interviewee suggested leasing as an option to avoid the high purchase costs. Overall he felt it was a good experience but decided that an EV was not suitable for him.

6.5 Results: Travel diary analysis

6.5.1 Limitations of the data

Despite the initial briefing on the correct completion of the travel diary, occasional misinterpretations of the travel journal and consequently incorrect entries occurred. In addition, details were omitted from some journeys. Limitations of the data include:

- Some journeys which should have been recorded as two trips were recorded as one (e.g. travelling from home to a shop and back).
- Not all start/end odometer readings were entered.
- Not all participants had use of the trial car for seven days; the minimum duration was six days (due to participant availability for collecting and returning the trial cars).
- The day of the week was not always recorded by participants and so comparisons of journeys undertaken on a particular day of the week could not be undertaken.
- As stated above, the participant sample is small and the travel diary data should only be used to inform the generation of further research questions/data gathering methods.

6.5.2 Number of journeys

The travel journals account for over 1,200 journeys. Overall, a similar number of journeys were made by participants in each category. As can be seen in Table 23, the comparison of the mean number of journeys per participant indicates that participants in the BEV group made slightly more journeys on average than those in the PHEV group. For both groups, the mean number of journeys per participant was similar when driving the trial car and their own vehicle.

Table 23: Total and mean number of journeys undertaken in participants' own vehicles compared to the plug-in vehicles

Trial car	Travel diary using...	Total number of journeys	Mean number of journeys per participant	Standard deviation
PHEV (n=19)	Own	295	15.5	7.7
	Hybrid	291	15.3	6.1
BEV (n=18)	Own	352	19.6	7.7
	Electric	334	18.6	6.1
Total	All	1,272	34.4	12.2

Figure 3 shows the change in the overall number of journeys made by each participant in the trial vehicle compared to their own vehicle. A similar proportion of participants in both groups used the trial vehicle for fewer journeys than their own vehicle.

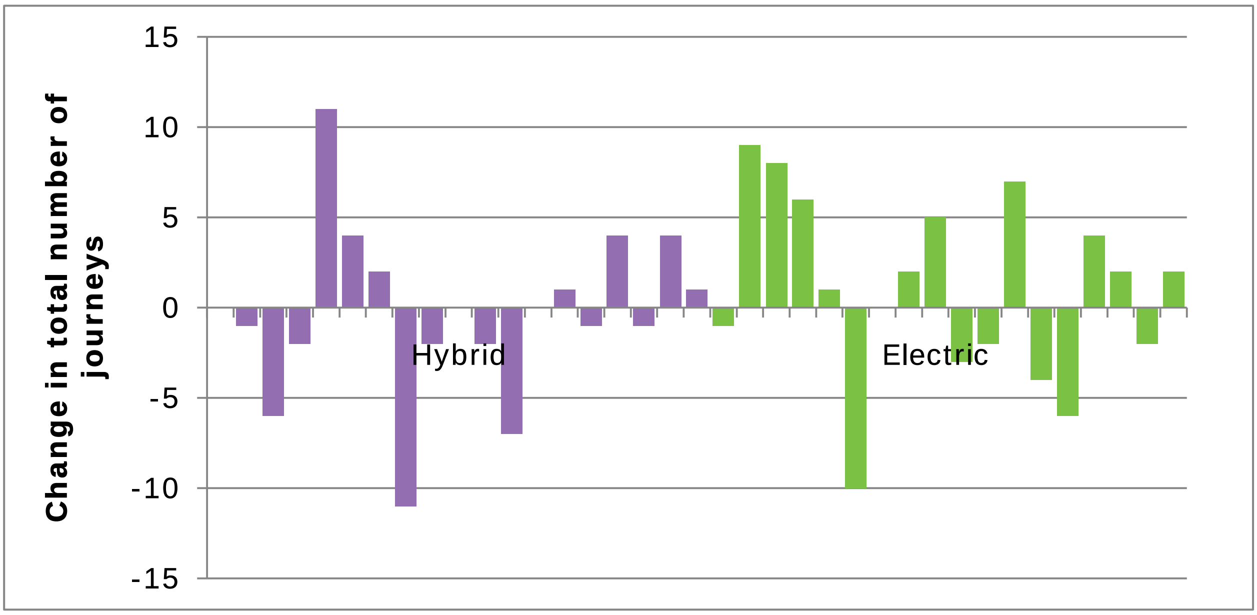


Figure 3: Total number of journeys made in trial vehicle compared to own vehicle for each participant[10]

6.5.3 *Number of days of vehicle use*

Figure 4 illustrates, for each of the 37 participants, the difference in the number of days each participant used the trial vehicle compared to their own vehicle. Thirteen of the 37 participants recorded using the trial vehicle for the same number of days as the normal vehicle. Six participants in both the EV and hybrid vehicle groups used the trial vehicle on more days than their own vehicle. The trial vehicle was used on fewer days by eight members of the PHEV group, and four members of the BEV group.

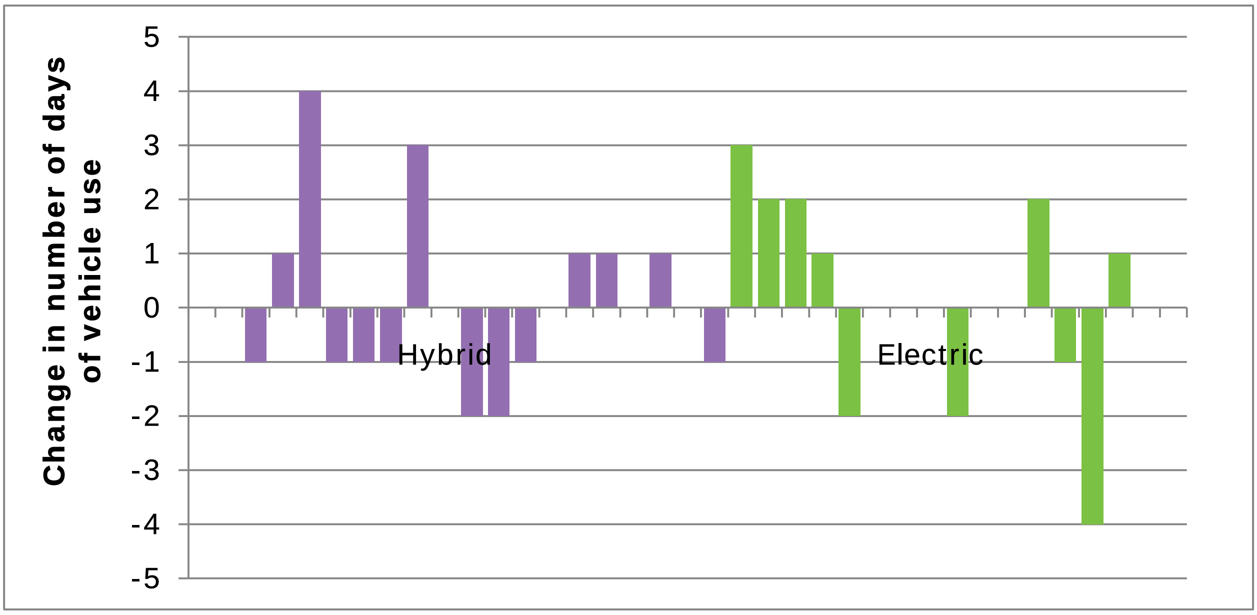


Figure 4: Number of days trial vehicle was used compared to own vehicle for each participant

[10] For this and subsequent graphs of a similar format, the bars show the change in behaviour in the trial vehicle compared to the participant's own vehicle. For example, in Figure 3, the first participant in the PHEV group made exactly the same number of journeys in their own vehicle as in the PHEV. The second participant made one less journey in the PHEV, and the fifth participant made 11 more journeys in the PHEV, compared to their own vehicle.

6.5.4 *Journey distance*

Participants were asked to record the odometer readings at the start and end of each trip, so that total trip distance could be calculated. These data were available for all of the 1,272 journeys made. Journeys taken in participants' own vehicles ranged from under one mile to 254 miles. Participants used the BEVs for journeys of between one and 26 miles, while the PHEV was used for journeys ranging from under one mile to 222 miles. Table 24 shows the total mileage covered in each vehicle during the journal period, the mean total distance travelled by each participant, and the mean journey distance, along with standard deviations.

Drivers in the PHEV group travelled on average a similar distance in the trial vehicle as in their own vehicle (252 and 232 miles respectively), whereas those in the BEV group used their own car to travel a much greater distance, on average, than in the BEV (149 and 76 miles respectively). The high standard deviations indicate significant variability in participants' driving patterns.

The mean journey distance was almost twice as great for participants in the BEV group when they were driving their own car compared with when they drove the BEV (7.6 and 4.1 miles respectively). Participants in the PHEV group had a slightly higher mean journey distance when using the PHEV compared to their own vehicle (16.4 and 15.0 miles respectively). The average journey distance of PHEV drivers was exactly four times greater than that of BEV drivers, while the average journey distance of these two groups of drivers when using their own vehicles was twice as great for the PHEV group.

Table 24: Total and mean distances travelled in participants' own and trial vehicles

Trial car	Travel diary using…	Total distance travelled (miles)	Mean total distance (miles)	Standard deviation	Mean journey distance (miles)	Standard deviation
PHEV (n=19)	Own	4,415	232.4	172.2	15.0	32.9
	Hybrid	4,782	251.7	178.8	16.4	30.5
BEV (n=18)	Own	2,688	149.3	68.3	7.6	8.7
	Electric	1,366	75.9	33.1	4.1	3.6
Total	All	13,251	179.1	146.6	10.4	22.6

Figure 5 illustrates the proportion of journeys undertaken of various distances. It shows that participants using a BEV were more likely than other groups to make shorter journeys, with 94% of journeys being ten miles or less, compared to 65% of journeys made in the PHEV. When using their own vehicles, the proportion of short journeys of ten miles or less was similar for both groups (78% for the BEV group and 69% for the PHEV group). Journeys made in the PHEV did not differ markedly from the distribution of the length of journeys made in participants' own vehicles.

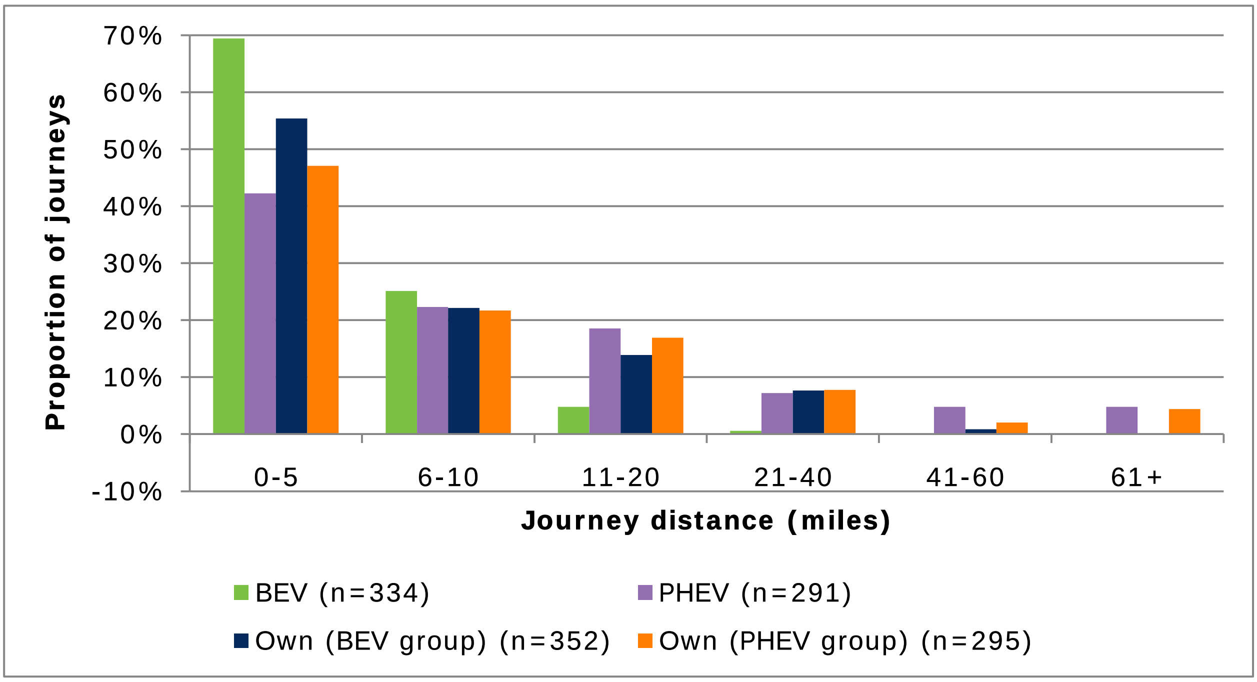


Figure 5: Proportion of journeys of different distances, by vehicle type

Figure 6 shows the mean journey distance for each participant in their trial vehicle compared to their own vehicle. Comparing the average journey length of each participant shows that participants who trialled the PHEV undertook similar length journeys in their own vehicle and the trial vehicle, with eight participants undertaking longer journeys in the hybrid vehicle, and 12 making longer journeys in their own vehicle. Two participants had a substantially lower mean journey distance for journeys in the hybrid vehicle. This was due in both cases to the participant undertaking a long return journey in their own vehicle.

All of the participants trialling an BEV undertook shorter journeys in the BEV than in their own vehicles.

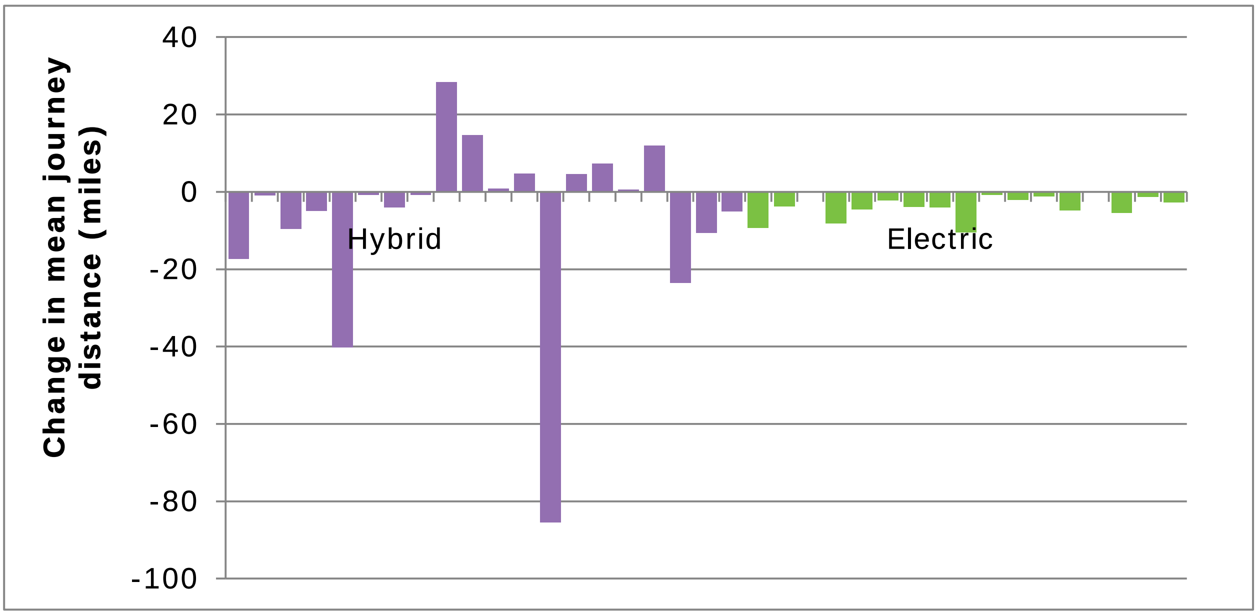


Figure 6. Mean distance of journeys made in trial vehicle compared to own vehicle for each participant

Figure 7 shows the total distance travelled during each participant's use of the BEV or PHEV, compared to their own vehicle.

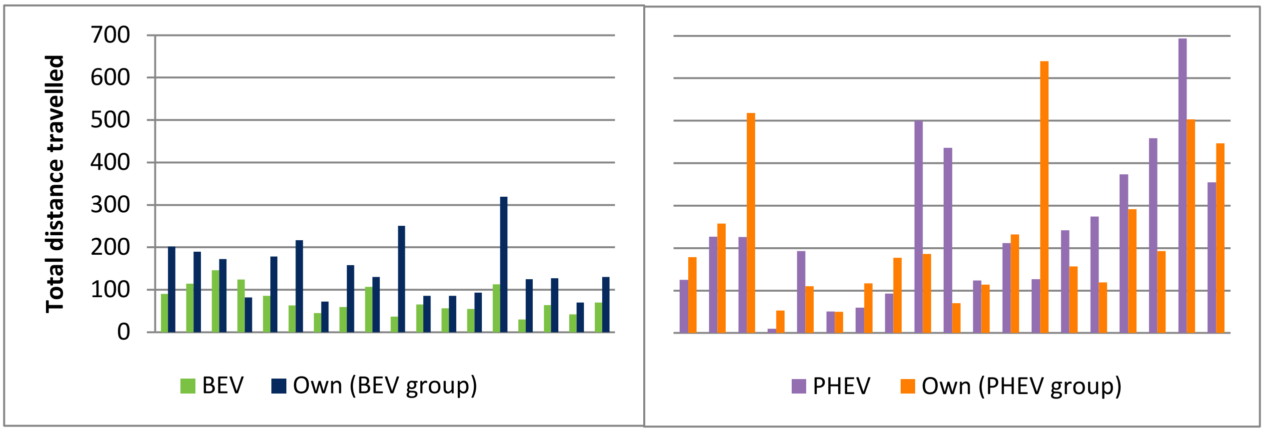


Figure 7. Total distance travelled by vehicle type

6.5.5 Occupants

Participants were asked to record the number of vehicle occupants (including themselves) for each journey. This information was recorded for all but 17 of the 1,272 journeys undertaken. Table 25 shows the mean number of occupants recorded which did not differ greatly between groups, ranging from 1.3 (for participants in the BEV group driving their own vehicle) to 1.5 (for participants in the PHEV group driving their own vehicle).

Table 25: Mean number of occupants in the vehicle

Trial car	Travel diary for...	Mean number of occupants	Standard deviation
PHEV (n=19)	Own	1.5	0.71
	Hybrid	1.4	0.59
EV (n=18)	Own	1.3	0.68
	Electric	1.4	0.79
Total	All	1.4	0.70

Figure 8 displays the proportion of journeys involving one, two, three, four or five occupants. The data show that for the majority of journeys no extra passengers were present in any of the vehicle groups (only the driver was present for between 66% and 78% of all journeys). One or more passengers were most likely to be carried by participants in the PHEV group when driving their own vehicle (34% of journeys), and least likely to be carried by participants in the BEV group driving their own vehicle (22% of journeys). When using the trial car, participants were only slightly more likely to carry passengers in the PHEV (30% compared to 28% in the BEV).

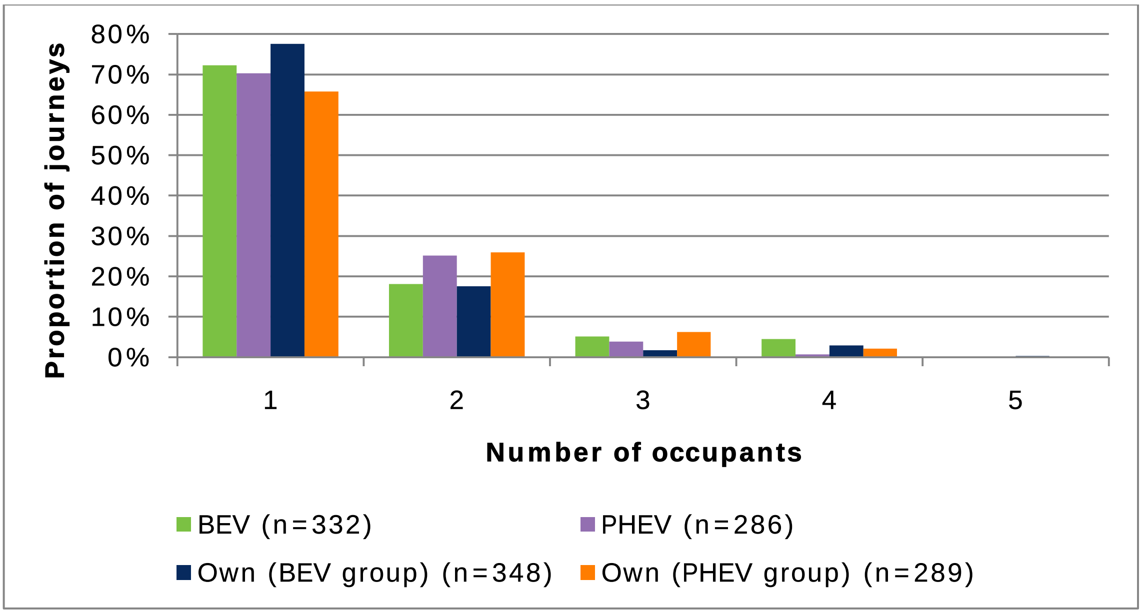


Figure 8: Proportion of journeys undertaken with 1, 2, 3, 4 or 5 occupants by vehicle group

Comparing the number of occupants for each participant (Figure 9) it can be seen that over half of the PHEV drivers carried more occupants when they used their own car. The opposite trend was found for drivers of BEVs, with all but four carrying more or the same number of occupants, on average, when they used the trial vehicle.

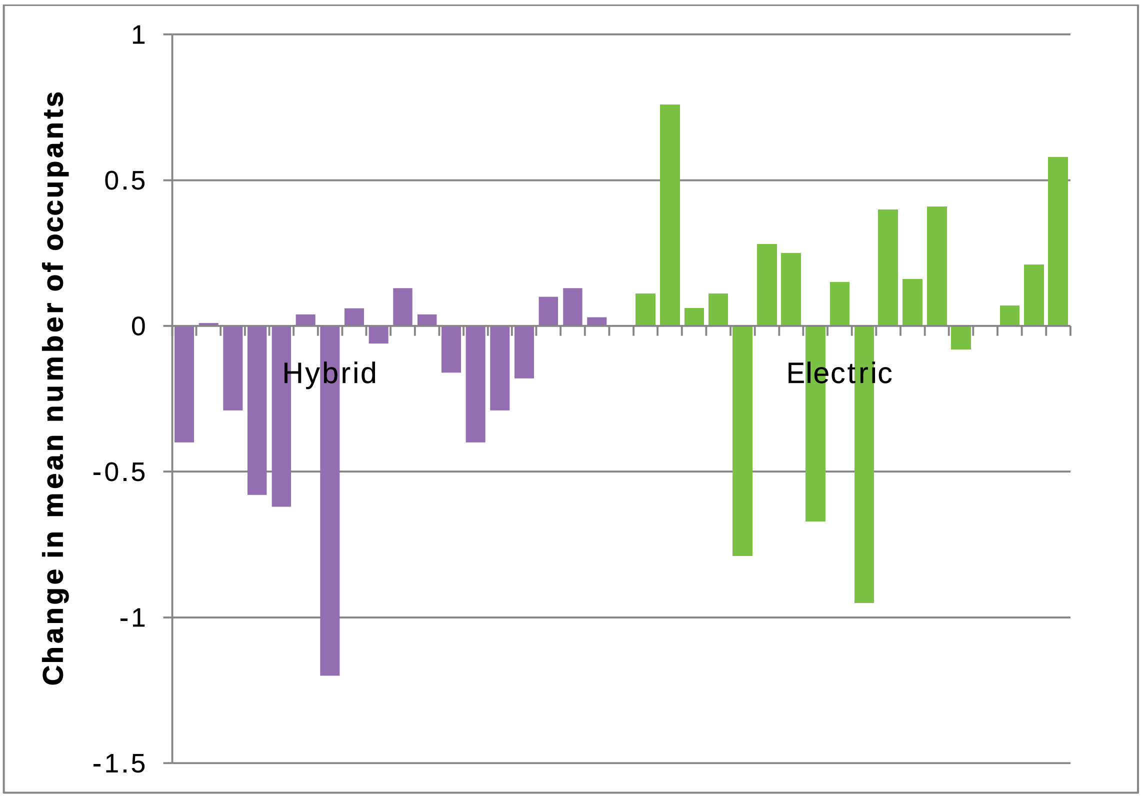


Figure 9: Mean number of occupants in trial vehicle compared to own vehicle for each participant

6.5.6 *Fuel and battery levels*

Figure 10 shows the fuel levels at the start of journeys for PHEVs and for participants' own vehicles. Figure 11 shows the battery levels at the start of journeys, comparing fully electric and hybrid vehicles.

As illustrated in Figure 10, the lowest fuel level at the start of a journey in a participant's own vehicle was 0%, and 10% in a hybrid vehicle. Participants driving their own vehicle seemed more willing to begin their journey with less than half a tank of petrol; overall, 33% of journeys began with a fuel level of 40% or less, compared to 20% of journeys undertaken in the PHEV.

The battery levels at the start of each journey made in BEVs and PHEVs were fairly similar. For example around 7% of journeys in both PHEVs and BEVs began with a battery level of 40% or less. Drivers of BEVs were slightly more likely to begin their journey with their battery at least 80% charged (60% of journeys, compared to 51% for PHEVs).

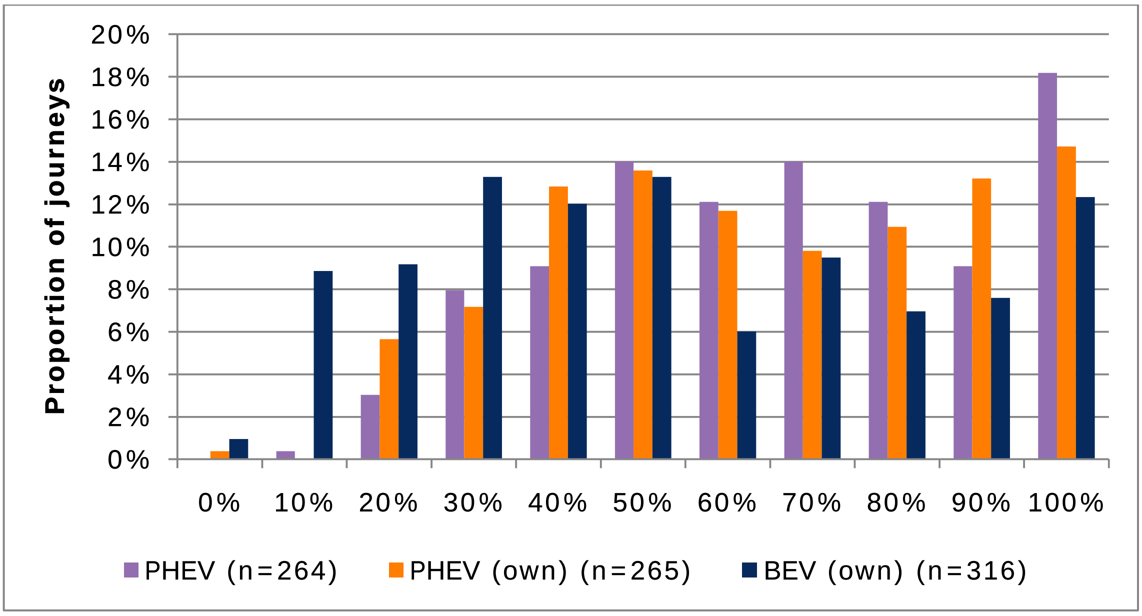


Figure 10: Proportion of journeys beginning with different fuel levels, by vehicle type

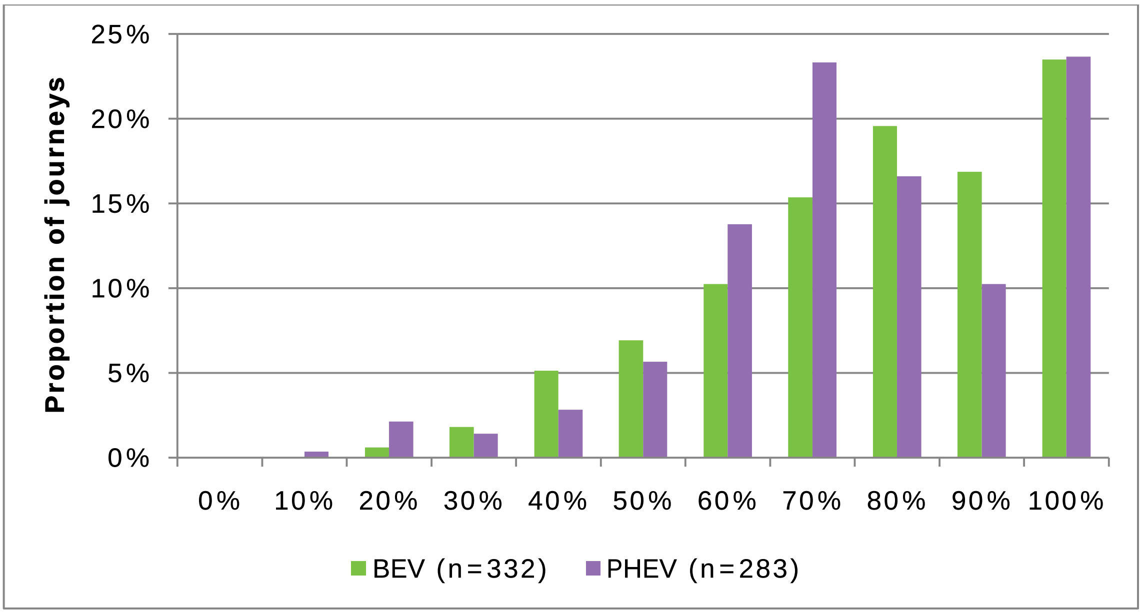


Figure 11: Proportion of journeys beginning with different battery charge levels, by vehicle type

6.5.7 Parking

Participants recorded whether they parked in a public or private area, and whether this was on-street or off-street. The parking location was not recorded for 67 journeys. As shown in Figure 12, the participants reported parking the car after the majority of journeys in a private, off-street location. For BEVs, parking in a private off-street location was proportionally higher (65%) than for hybrid vehicles (53%) or participants' own vehicles (59% on average).

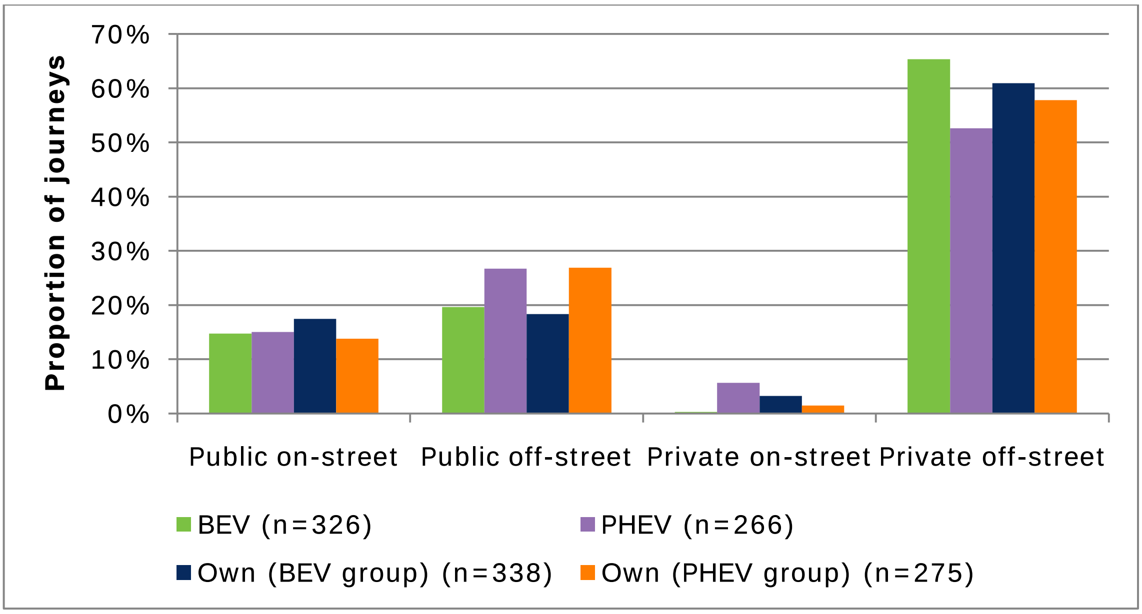


Figure 12: Proportion of journeys in which different parking locations were used, by vehicle type

Figure 13 shows the parking location used on occasions where the vehicle was charged. Charging of the vehicle was recorded on 79 occasions for BEVs and 54 occasions for PHEVs. On all but five occasions the EV was charged at a private, off-street location. For the hybrid vehicle charging took place at a private, off-street location on all but 12 occasions. The dominance of private off-street parking may be a reflection of the limited availability of public charging points at present, and the fact that participants tended to charge the vehicles overnight at their home.

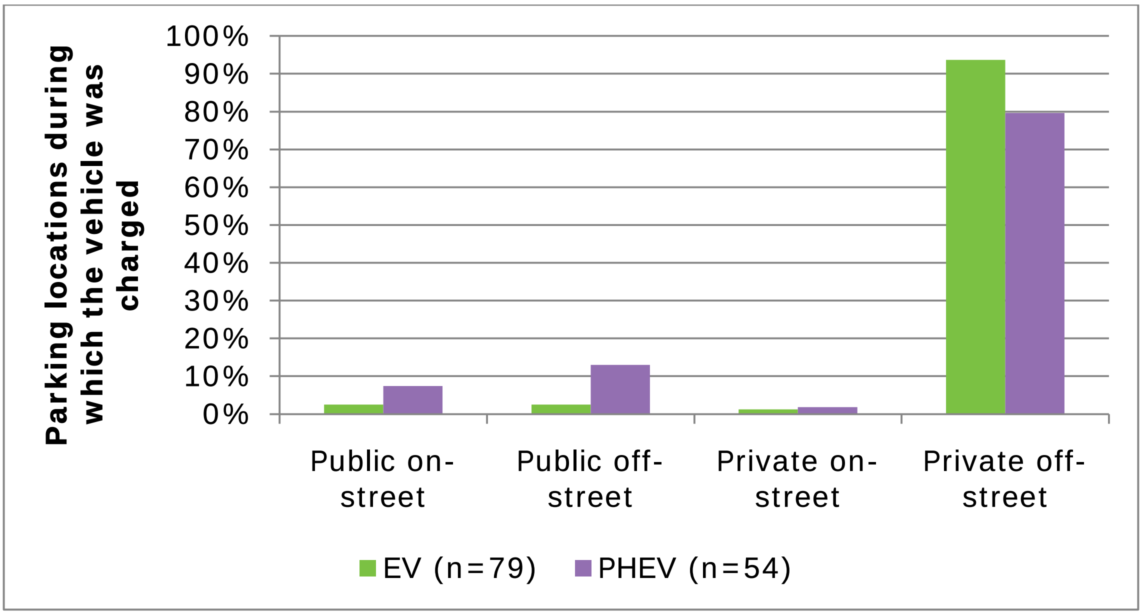


Figure 13: Proportion of parking locations of different types used for charging electric and plug-in hybrid vehicles

6.5.8 Availability of charging facilities

For each journey made in the PHEV or BEV, participants were asked to record whether charging facilities were available when they parked the vehicle. Charging facilities were 'easily available' at the end of 53% of the journeys made in a BEV, and 43% of journeys made in the PHEV, as shown in Figure 14.

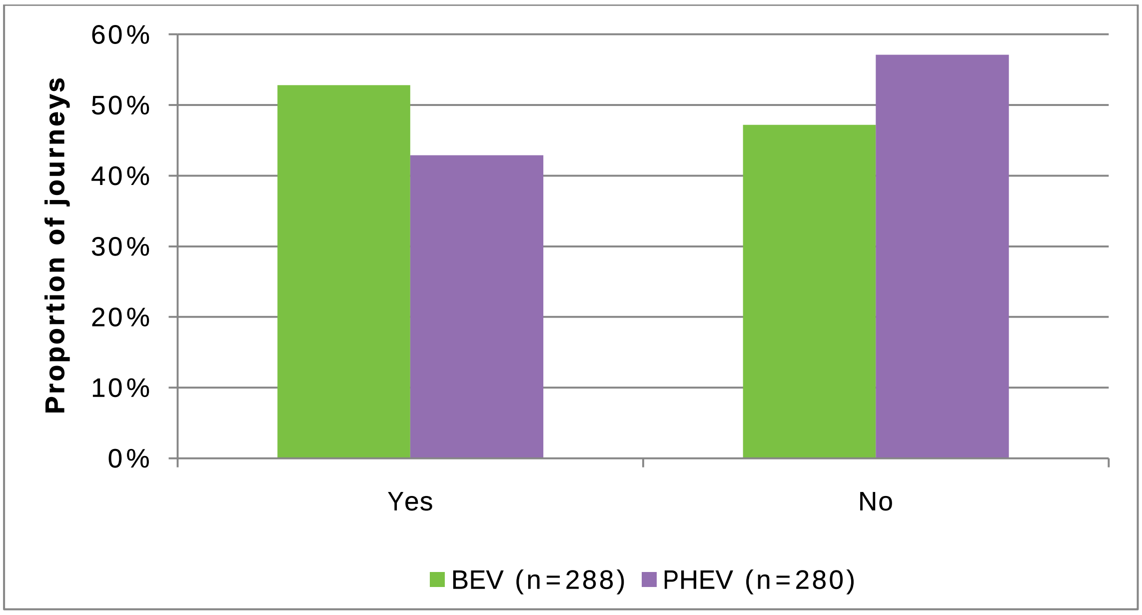


Figure 14: Availability of charging facilities at the end of a journey

If charging facilities were not available, participants were asked to record whether they would have liked to be able to charge the vehicle. Participants using a PHEV recorded that they would have liked to be able to charge their vehicle in 22% of cases. Similarly, participants using a BEV said they would have liked to be able to charge their vehicle in 21% of cases, as shown in Figure 15.

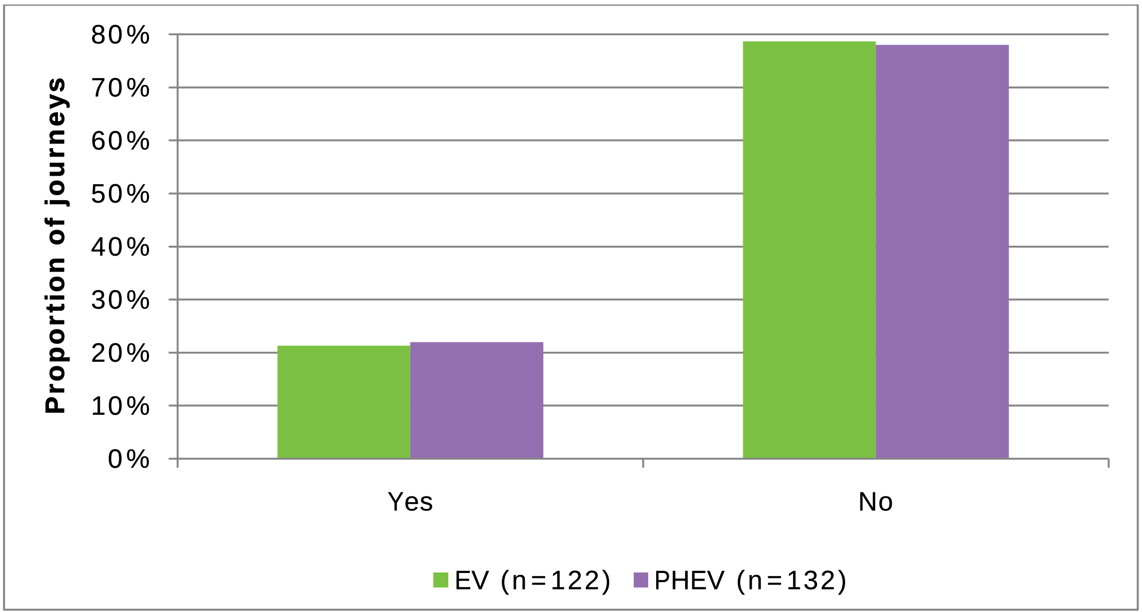


Figure 15: Desire to charge the vehicle when charging facilities were not available

6.5.9 Travel diary analysis summary

Thirty-seven travel journals were analysed to explore differences in participants' journey patterns when using an electric or plug-in hybrid vehicle compared to when using their own vehicle. Drivers who trialled both vehicle types tended to undertake a similar number of journeys in the trial vehicle as in their own vehicle.

A striking outcome is the difference in the distance travelled by participants trialling the BEV when using their own vehicle compared to the BEV. The mean total distance travelled per participant was almost double for participants using their own car (149 miles compared to 76 in the BEV). There were no outliers in these data; it appears to be a result of all participants making shorter journeys. Part of this may be a result of 'novelty' trips – taking friends and family round the block to demonstrate the BEV to them. However the principal explanation for the change in mileage is likely to be the low range of BEVs compared to conventional vehicles, causing participants to err on the side of caution and reduce their mean journey distance by up to 10 miles (4 miles on average). The effect of the limited range of BEVs also became apparent in the greater frequency of journeys less of than ten miles in length recorded for the trial week with the BEV, and the average journey distance in a BEV being 9.3 miles shorter than in a PHEV. It is possible that participants substituted their BEV mileage by using their normal car, or may have decided to travel with a friend or colleague in a different car on certain longer journeys. Nevertheless, it demonstrates that there is a large behavioural shift when using a BEV, which perhaps prompted people to reconsider journeys they did not have to make. Alternatively the underlying uncertainty about range and charging may have discouraged them from using the car.

For some participants, differences in the number of journeys, distance travelled, number of occupants, and other variables was attributable to the impact of pre-planned driving activities. For example, the fact that the total and mean journey distance was higher for the group trialling the PHEV compared to their own car is largely due to one participant undertaking a round journey of almost 450 miles during the trial week (and not doing this during the non-trial week). The small sample size means that any such outliers will have a substantial effect on the data. At the same time excluding outliers in such a small sample is difficult as the variability in journeys undertaken reflects participants' actual travel patterns and should therefore not be removed.

When vehicles were charged, the most common parking location was private, off-street parking (96% for BEVs, 78% for PHEVs), the majority of which would be at the participant's home. The available charging infrastructure did not appear to be a problem for most participants; however, further elucidation of infrastructure issues should emerge from the analysis of the participant interviews. Although charging facilities were only available in just over half of journeys, the majority of participants did not report a desire to charge their vehicle when facilities were not available.

6.5.10 Future travel journal design

Data analysis was limited to journey patterns reported for the use of either the conventional vehicle or the use of the trial vehicle by the main driver in the household. The assumption was made that during the week of access to the trial vehicle, participants would replace (almost) all journeys (with the exception of long journeys that exceed the range of BEV) commonly made in their conventional vehicle with journeys made in the trial vehicle. However, whilst travel diaries during the trial week were limited to recording the use of the trial vehicle, the lower number of days for which use of a vehicle was recorded could mean that participants still used their conventional car to some degree during the trial week. Future versions of a travel diary should therefore accommodate the use of a vehicle mix for journeys undertaken during the trial period of a plug-in vehicle.

As discussed earlier, insurance requirements limited the use of trial vehicles and thus of travel diaries to the main driver in the household. Whilst the current analyses provide interesting insights into changes in travel patterns for individual drivers, the exploration of overall household travel patterns will improve our understanding about the likely fit and use of plug-in vehicles with household mobility needs. The collection of household travel data could probably best be met with a vehicle log-book, whereby for every vehicle used in the household a log book would be created and completed by the respective driver for each journey undertaken.

Future iterations of the travel diary should include the following:

- Journey purpose – whilst the current diary asked for journey destinations and provided space for additional notes, the provision of categorised journey purposes e.g. commuting, business, leisure or school run may facilitate the ease of completion.
- Fuel/battery level at the end of each trip.
- Whether or not the vehicle was refuelled during the trip.
- Length of time vehicle recharged.
- Start/end location by postcode.
- Day of week.

The inclusion of these items will allow a more in-depth analysis of the journeys and comparison between different vehicle types.

6.6 Results: Grounded Theory analysis

6.6.1 Pre-post changes from the initial analysis

Responses from the pre-experience transcripts were initially compared with the post-experience transcripts to see if the experience had resulted in any marked changes in the participant's knowledge or attitudes towards EVs.

6.6.1.1 *Knowledge/understanding*

Participants were asked what they knew about plug-in vehicles. Knowledge was limited among participants at pre-exposure and only a few felt they had a good general knowledge of the technology. Only one participant had any hands-on experience with driving an EV (a hybrid) although a few had been a passenger in a hybrid. No participants had experience with a battery electric plug-in vehicle (BEV). Most of the participants had some knowledge of hybrid vehicles and knew that they were dual fuel, however almost all of them were unaware of PHEVs. Therefore it was not surprising that only a few participants could describe the difference between a hybrid vehicle, a PHEV and a BEV and no one was confident about the differences between them. Awareness of vehicle models and manufacturers of EVs and EV-relevant Government incentives or policies was mixed. Most participants were very unsure of what was available but a few were better informed. Many had a reasonable understanding of how to recharge an EV even though they had no experience. Finally, most participants were aware that EVs would cost more than petrol/diesel equivalents but generally did not know how much more.

At post-exposure the participants did not appear to have gained a greater understanding. Although most of the participants had discussed EVs with others during the trial week only a few had undertaken any research during the trial period, preferring to be guided by the 'hands-on' experience. This resulted in a clearer understanding of the benefits or barriers to the specific drive-train they were testing but not necessarily a better knowledge and understanding of EVs generally.

6.6.1.2 *Beliefs, attitudes and norms*

Perhaps surprisingly, there were few changes evident in participants' beliefs regarding EVs or driving EVs between pre- and post-experience transcripts. There was very little change in the way the participants described EV drivers and how they imagine others would respond to them if they were an EV driver. Nor were there any major changes in their level of confidence in driving the vehicle. Participants were confident both pre- and post-exposure in terms of the logistics of using the vehicles and recharging them. Generally they felt no more concern than they would when driving any new vehicle for the first time or swapping from using a gear shift to automatic vehicle although the change was often viewed as inconvenient. At pre-exposure many participants felt that vehicles had limitations (e.g. range, power) that made them feel less confident about using an EV than they would a new internal combustion enging vehicle. These concerns were still evident post-exposure.

Interviewers prompted the participants to talk generally about what they thought about EVs, including any perceived benefits and disadvantages both in general and for them personally. Pre-exposure the majority of participants felt that EVs were a good idea although many thought that they were not developed enough to generate widespread interest. A couple of the participants thought that they may not be the best alternative technology and favoured hydrogen. However, they all believed that EVs were a more sustainable form of transport than internal combustion engine (ICE) vehicles and understood that they had the advantage of reduced tailpipe emissions. Being less reliant on fossil fuels and oil was also viewed favourably by some. Several of the participants also felt that they were beneficial because they would reduce noise pollution. However, many were unconvinced that the environmental benefits were as significant as the manufacturers claim. These views did not change over the week.

At pre-exposure participants recognised the opportunity EVs offered to save on fuel costs and this was regarded as the most important personal advantage of EV use. Some felt that there would be reduced costs not only from replacing 'refuelling' with 'recharging' but also the potential of fewer servicing and maintenance costs for BEVs. Many also felt that recharging would be easier and more flexible compared to 'refuelling' at a petrol station. The most widely cited barriers identified were high purchase costs, lack of range and supporting infrastructure, and lack of power and acceleration making EVs inappropriate for motorway use. There was also a high degree of concern over slow recharging times, safety issues especially in relation to the silence of the cars, as well as poor aesthetics and image. Other perceived barriers included a lack of information in the public domain, a lack of incentives including a lack of choice or market competition. Some of the participants were also concerned that they would forget to plug an EV in or that the car could be vandalized whilst being recharged. Many participants felt that driving an EV could prompt negative responses from other drivers on the road. Some of the participants felt that EVs would be less fun to drive and that their value would depreciate faster than ICE vehicles due to the lack of demand and short battery life. Finally, EVs were viewed as inappropriate for those who did not have access to off-street parking.

Exposure to either a BEV or PHEV created a mixed response from the participants. Whether or not the participant's pre-exposure barriers or benefits remained after the trial period was dependent upon their experience with the vehicle and their personal mobility needs. This experience resulted in a more negative view of EVs for some, and more positive for others. In other cases the experience confirmed their pre-experience perceptions, both positive and/or negative.

Experience with an EV resulted in new barriers and benefits emerging. New barriers included reduced ability to be flexible and impulsive due to the range and power limits. A few participants also felt uncomfortable with the vehicle's lack of engine noise because they had mistakenly assumed they had stalled. There were also issues surrounding winter weather conditions such as a lack of fast and sufficient heating, an inability to demist or defrost windows, poor traction in adverse weather conditions due to automatic gears, and safety concerns in relation to the mix of rain water and electricity.

Many participants felt that they were not adequately equipped to recharge at home due to the position of their electricity source and the shortness of the supplied lead, making recharging difficult especially at night or in the rain. Some participants felt that there was a lack of recharging etiquette (social schema) regarding recharging at other people's homes or in public resulting in them thinking that they could not or should not recharge anywhere other than their home.

For the PHEV users the instrumentation feedback regarding the battery charge was often viewed as over-complicated and confusing as it fluctuated without explanation. This confusion resulted in a lack of understanding as to why and when the vehicle should be recharged. Although confusion did not arise from the visual display and feedback in the BEVs, some did find them hard to read especially in poor light. Some participants were not impressed with the fuel efficiency of the PHEVs if their journeys meant that they predominantly drove over 30mph. Consequently, some participants concluded that PHEVs were no better than a standard hybrid vehicle and only suitable for urban use. For several of the BEV drivers the power-save mode was negatively evaluated. This mode enables the car to take control of the vehicle speed when the battery charge is running low. Being forced to drive slowly on a low battery left some participants feeling vulnerable and/or embarrassed.

6.6.1.3 Positive affective responses following EV experience

Most participants were impressed or surprised with how easy and pleasurable the EVs were to drive, especially in town and high traffic areas. Others felt reassured that they were no different to drive than an ICE vehicle and most were impressed with how comfortable and silent the vehicles were. For several of the PHEV drivers and a few of the BEV drivers, anxiety about range and their ability to reach their destination was reduced after use. The BEVs visual display and feedback helped participants gauge range. The acceleration from standstill was well received and nearly everyone found recharging their vehicle easy.

6.6.1.4 Overall evaluation following EV experience

Twelve of 40 participants showed a positive increase in EV evaluation after experience. Eight of these had used a PHEV and four a BEV. For a couple of participants (one BEV and one PHEV) the experience resulted in them becoming more sceptical. The majority of the participants were neither put off nor greatly encouraged by the experience but concluded that barriers still outweighed the benefits at this stage of development, and questions they had at the beginning were still unanswered. The EVs were viewed as suitable for urban driving and for drivers with simple mobility needs. Although PHEVs were evaluated somewhat more positively than BEVs, it is possible that hybrids will be favoured over PHEVs unless better education is provided as to their advantages, and confusion created by current instrumentation is addressed. Nevertheless, most of the participants accepted that they would adopt this technology at some point in the future when either the main barriers were removed, technology improved, their lifestyle changed or the cost of fuel escalated.

6.6.2 Grounded Theory analysis of post-experience interviews

Since few pre-post experience changes in participants' responses to EVs were observed, we focused on the post-use interviews which reflected participants' experience of driving an EV. These provided the best data on which to model mainstream response to currently-available EVs.

Grounded Theory coding (as described above) generated six core categories:

- minimising costs;
- confidence in the vehicle;
- adaptation to an unfamiliar vehicle;
- environmental beliefs;
- image concerns and impression management; and
- conceptualisation of EVs as a 'work in progress'.

The final category was identified as a 'central category' because each of the other categories related directly to this overall view that EVs are at present 'under development'.

6.6.2.1 Minimising costs

Many drivers were concerned about the personal financial impact of purchasing and driving EVs, and attempted to forecast likely costs and savings incurred by EV use. EV-related costs were evaluated in relation to like-for-like costs incurred by ICE vehicles. Consequently, for most drivers, the comparatively high purchase cost of an EV was seen to be unjustified:

There is no way I would pay £22,000 for an £8,000 motor car…the numbers don't stack up. (Participant 23, BEV)

I would want to be able to get [a hybrid plug-in] for the same price that I could buy the [ICE] car that I [had otherwise] wanted to buy. (Participant 28, PHEV)

Drivers felt that the higher purchase cost of an EV should denote a vehicle that was superior to an ICE car in design, performance and durability, or could provide an enhanced driving experience. The EV largely failed to meet this expectation:

I wouldn't buy [a PHEV]. I don't see the advantage [over ICE cars]. There are no disadvantages, but no advantages. (Participant 17, PHEV)

Most drivers recognised that EVs could provide cheaper refuelling costs than ICE cars, and experiencing this benefit led to positive affect. Some hybrid users chose to drive below the speed threshold at which petrol is used to save money:

It's like a little game, you try and keep it on battery [power] for as long as you physically can, and you roll along at 31 [mph] thinking 'got it, got it!' A bit of a hill, 34 [mph], 'oh, still [running on the] battery'. So it's quite nice…to try and get the best possible economy I did try that. (Participant 28, PHEV)

Many drivers were not aware of the price of electricity, or how much electricity was used in charging their EV:

I don't know anything about electricity. I don't know how much a unit costs. [And] there's no indication to say how much electricity I've used last week. I worked out how much petrol I used, but there's no indication of how much electricity I used. It would be nice to say 'this will cost you £2.50 to fill up'. But how much does it cost? (Participant 28, PHEV)

Drivers who were able to calculate charging costs, or observe these via electricity monitors, derived satisfaction from doing so:

We've got the electricity meter and I think overnight it cost about 24p to charge it, so it was fantastic! (Participant 6, PHEV)

For one pure-electric driver, charging via the household electricity supply was pleasurable because the cost was deferred and so not salient:

It's probably nicer because you don't actually exchange any money on the spot, there's no giving of a card or anything. (Participant 40, BEV)

Drivers viewed decreased running costs as a way to "*claw back [the quite] significant amount of money*" (Participant 11, BEV) involved in purchasing an EV. Many drivers believed that they did not drive often enough or for sufficiently long journeys for the offsetting of initial purchase costs to be foreseeable:

It'd probably save me about, I think £2,000 worth of fuel in a year…I'd be running it for a few years before I saw any money back on that. (Participant 34, PHEV)

There was also some concern that the lifespan of the vehicle's components would be insufficient for running costs to ever offset purchase costs.

Would you need to replace the battery in a few years? And...what figure is that – thousands of pounds? (Participant 40, BEV)

Drivers were also unable to confidently forecast potential savings because they did not know the value of many costs, such as maintenance, insurance and road tax. There was also concern about greater depreciation of EVs:

No one knows [the cost of maintenance] yet, and...the batteries as well, the batteries last seven years and they run out, that's £2,500 after seven years. The car, after seven years, will probably only be worth £2,500 at most...that's a big problem. (Participant 9, BEV)

6.6.2.2 Confidence in the vehicle

EV performance was judged in comparison to ICE cars ("*the current benchmark*", Participant 26, PHEV), by which drivers felt that the power and performance of the EV was substandard:

After driving our car, which is just a 1.8 litre, the [PHEV] felt underpowered compared to that. (Participant 3, PHEV)

BEV drivers lacked confidence in driving in some situations, which raised safety concerns, and prompted avoidance of such situations:

[I] didn't overly like taking it up to kind of a normal driving speed, it was on a kind of 50 or 60 [mph speed limit] road, it didn't feel overly safe doing that, and tended to try and modify my route so I was always on either country roads or out on 30 [mph roads] and that kind of thing. I just felt a bit more at home on that kind of road. (Participant 31, BEV)

Consequently, many found driving an EV a less pleasurable experience than driving ICE vehicles:

You always want your next car…to be better than your last. So it's almost like a back step to driving something which just doesn't feel quite as safe and powerful and comfortable as what I've got at the moment. (Participant 40, BEV)

Drivers were uncertain about the durability of EV components, perhaps due to a lack of knowledge regarding EV mechanics, and most also anticipated poor availability of necessary maintenance support. This undermined confidence in the feasibility of everyday EV use:

I don't know whether…less can go wrong in terms of the fact that [pure-electric] cars haven't got an engine. I don't know whether they've got other things that can go wrong, like cam belts, or not. I can't imagine how expensive it must be if the battery goes on that thing…where would you go and get your parts from? I pretty much know what mechanics around here would do, whereas if I was driving that thing and it broke down, I wouldn't really know. (Participant 5, BEV)

BEV users also doubted that the battery life would be sufficient to enable journeys to be completed, or that charging points would be available en route. Such 'range anxiety' was enhanced when observing battery depletion while driving, when drivers could not forecast how far they could travel on the remaining battery level, or where journeys were unexpectedly extended:

[The battery level] went to 50 percent, and that started ringing alarm bells in my head. And I thought, well, if I leave to go to [the shop] now, I'm going to hit rush hour…so I was worried about sitting in rush hour and it just draining for whatever reason. I wasn't comfortable that I'd have enough to get there and back. (Participant 19, BEV)

Anxiety led many BEV users to make minimal use of battery-powered in-car facilities:

I haven't had the radio on and I haven't been using the CD player and that kind of thing, just purely to try and make things last a bit longer. I didn't like it…and I found it very limiting…I felt nervous that [the battery] was going to run out. I was trying to not use anything in the car…you are very mindful the whole time, can I do that, can I do this? It's quite prohibitive really. (Participant 31, BEV)

Many BEV drivers chose not to use the vehicle for long journeys, which were seen to involve a prohibitive risk of the battery depleting and the driver being stranded:

There's just some journeys I don't think I'd do. If it was a really long journey or if I was...on the M25 for any length of time I'd be worried the power would just drop off. (Participant 5, BEV)

Due to range restrictions, the BEV was typically seen to be suitable only as a second vehicle, feasible only for short, local journeys:

You need a vehicle where the range is probably 150 to 200 miles to have a useful threshold to use as an everyday car…what you've got [with the BEV] is ideal for commuting...but you couldn't have it as your only vehicle. (Participant 16, BEV)

Range concerns were generally not raised by PHEV drivers, as the availability of a back-up petrol fuel store provided reassurance:

As I was going through [the car park], it was the first time that I thought, 'I am glad that I've got the petrol', because [the battery level] dropped and I'm thinking, you know, 'I've got to get home tomorrow'. (Participant 24, PHEV)

Both BEV and PHEV drivers expressed safety concerns around charging in publicly accessible places:

It makes it quite vulnerable; it only needs a couple of yobs to be going past and yank out the [lead]. (Participant 32, PHEV).

6.6.2.3 Adaptation to an unfamiliar vehicle

Drivers were required to adapt in several ways to using an EV. A new refuelling routine was necessary. Charging was generally simpler than anticipated *("I now know how easy they are to plug in"*, Participant 12, PHEV), and charging at home was valued by some because it promoted autonomy:

You can actually plug it into your own mains, and you can plug that in whenever you want to plug that in. So whenever it suits you, you can do that…I think it was possibly easier [than refilling at a petrol station] because you've got your facilities there on tap as it were. (Participant 10, BEV)

Although generally seen as an unwelcome "hassle" (Participant 22, PHEV), visiting the petrol station was nonetheless part of established car use routines, and many drivers found it inconvenient to incorporate vehicle charging into these routines.

I did actually think it was a delight during the week not having to go to a petrol station. [But] it's just so normal to go to a petrol station. Whereas this, it was, like, 'oh, my God, this is something extra I've got to do'. (Participant 5, BEV)

Charging was made difficult by lengthy charge times and a lack of public charging points, differences made particularly salient when comparing EVs and ICE cars:

The whole refilling-your-car-with-petrol is a five minute experience and...in our car, we can go 550 miles without having to worry again...[There are] tens of thousands of garages in the country, there's millions of 13 amp sockets, but they're not accessible to you and you need six or seven hours. (Participant 16, BEV)

Drivers were concerned about the feasibility of adapting to the constraints imposed by the need for regular charging. Some reluctantly broke their journeys, or were unable to make some journeys due to the car being unavailable while charging:

While the car's plugged in it's marooned, it's in an un-driveable state. (Participant 1, PHEV)

There were numerous occasions where I just couldn't do what I needed to do in terms of driving out to some other locations…I ended up having to work [at one workplace for] six hours instead of my normal two, just to give the car enough time to charge up so it had enough to get me home again. So I had to move schedules around to give me enough time. (Participant 31, BEV)

Time spent waiting for the car to charge was commonly viewed as 'dead time', and waiting was seen to compromise freedom of movement, so negating a highly-valued affective benefit of driving.

Part of what puts me off in terms of the whole kind of driving experience and the freedom of driving and the spirit of 'out in the open road', is that you can have the open road but with a pure electric vehicle, then you have to plug it in for a few hours. You are forced to stop and it takes away an element of that freedom of driving…you lose the driving experience and the ethos of driving, just being able to jump in and drive. (Participant 36, PHEV)

While drivers complained about the restrictions imposed by long charging times this experience also showed how drivers adapted by planning their journeys more carefully.

It just made me a lot more aware of my lifestyle, and made me have to think about like if I was going to work, have I got everything I need to get me through all of my possessions for the day…once my car's parked up at work, that's it. It's going to stay there until the end of the day. (Participant 31, BEV)

Drivers were also required to adapt their driving technique so as to use EVs confidently and safely. Many were unused to the automatic transmission system used by the EVs. BEV drivers found it difficult to adjust to less powerful acceleration at higher speeds ("*you think you're putting your foot down and it doesn't seem to be going anywhere*", Participant 29, BEV).

The BEVs used in this trial electronically imposed limits on vehicle speed when battery levels fell below 25%, and this was seen to constrain drivers' control over the vehicle, causing frustration:

There were occasions where I knew I had enough charge to get me home under normal driving [conditions] and that was so frustrating because [the car] wouldn't let me drive normally…I am only five percent from home, and yet you are insisting on making me drive at 15 miles an hour because you've only got 15 percent left. I want to override that so I can drive normally, because I think that would be safer. And if I run out of juice, I run out of juice. That's my problem. (Participant 31, BEV)

Some PHEV users felt that their autonomy was compromised because they were unable to control whether the car ran on petrol or battery:

Sometimes I thought the technology has taken over and I [would have] liked a button just to say 'I'm in control now and I want you to put the engine and just leave it on'…the thing that's lacking is the sense that I'm actually driving… I felt like I was a passenger some of the time. (P36, PHEV)

Others found the dashboard display to be distracting, overly complicated and difficult to understand:

[It was] a little bit, not only confusing but quite off-putting because you kind of found yourself driving along looking at it because of what it was doing...at the end of the day, you don't really need to know it. It makes no difference to you whatsoever because it cuts in and charges it as and when it chooses to. (Participant 24, PHEV)

PHEV drivers that were able to understand the in-car display were better placed to monitor the appropriateness of their driving style. Some used visual feedback relating to the current power source to allow them to engage in "*a little bit of a game to try and keep at 31 [mph] or under battery power as much as possible*" (Participant 28, PHEV). 'Playing' this 'game' led to slower and more economical driving.

Two drivers felt that additional feedback regarding the environmental or financial benefits of a given driving style would be useful:

It would have been really nice if I had a little bit at the end to tell me how...eco [-friendly] I'd been, what percentage of the journey I'd been on battery. That would have been quite useful. (Participant 28, PHEV)

Many drivers commented on the lack of engine noise when using EVs. Some found that this made driving more pleasant:

It felt luxurious because it's silent at low speeds. (Participant 36, PHEV)

However, many drivers used engine noise to remain 'in tune' with the vehicle, and found it hard to adapt to the loss of this feedback:

There's this confusion in the fact that it doesn't make a noise so it's just about being more aware of your senses, of observing than, you know, when you're used to just hearing. (Participant 26, PHEV)

The lack of engine noise also posed safety problems for pedestrians and other road users:

A bike just came out straight in front of me without even looking...and got a shock when they saw me. (Participant 2, PHEV)

This required EV drivers to be more watchful and alert. Some drivers called for greater engine noise to be incorporated into EVs for this reason.

6.6.2.4 Environmental beliefs

Some drivers, and their passengers, derived a "*feel-good factor*" (Participant 26, PHEV) from EV use because of the associated environmental benefits. For some, the affective response to 'being green' related less to achieving positive affect than to alleviating guilt activated by awareness of the greater emissions generated by ICE car use:

I think you can feel a little less guilty maybe when you go out on your Sunday drives if you're in an electric car than you are in a petrol car. (Participant 3, PHEV)

Being an early adopter of a perceived innovative 'green' technology was socially desirable for some drivers:

I felt I was actually doing something for the environment and...something I should imagine that's coming in the future, so I feel quite good about it. (Participant 12, PHEV)

Many were however sceptical about the green credentials of EVs, and so did not derive satisfaction from their use. These drivers believed that electricity use relocates emissions from the exhaust pipe to power stations, yielding no net reductions.

You're just choosing the way you pollute the atmosphere. You're not polluting it at the point of use. You are polluting it at the power station. So unless you can convince me that the power station was green I don't believe you've saved anything. (Participant 23, BEV)

Drivers sought to assess the green credentials of EVs by evaluating the environmental impact of production and running of the vehicle, but were unsure of the emissions generated by some of these processes, leaving many uncertain of the environmental benefits. Some BEV users felt that manufacturers' claims of environmental benefits were therefore not credible.

I think they're a good thing from a point of view of emissions, initial emissions, but goodness knows what they do to the batteries and how they're made. So whether the actual carbon footprint is actually…beneficial to the environment or not - well, who knows? (Participant 22, PHEV)

Many drivers, regardless of whether using EVs or ICE cars, prioritised personal utility above environmental concern, and so did not derive any 'feel-good factor' from using EVs. When asked about the information they would require to make an informed vehicle purchase decision, drivers' responses tended to focus on cost, vehicle range and performance attributes, rather than potential environmental gains ("what do I gain from having [a PHEV] as opposed to [a non-] hybrid vehicle?", Participant 1, PHEV). Given their lack of confidence in EVs for meeting utility concerns, many drivers felt that using plug-in vehicles for environmental reasons required a personal sacrifice ("[you] have to make a lot of compromises to [use an EV] at the moment", Participant 36, PHEV).

6.6.2.5 *Image concerns and impression management*

Drivers were concerned that EVs, and particularly BEVs, did not have the same visual appeal as did ICE cars. Some were concerned about being seen to drive a visually unappealing car:

I don't desperately want to stand out when I'm driving – but you do want it to look nice. (Participant 10, BEV)

Most PHEV users felt that designers had prioritised practicality and undervalued visual appeal, which led some drivers to feel that the EV had "*no heart and soul*" (Participant 28, PHEV):

[The plug-in hybrid] is just a slab-sided, unimaginative design. It's like a machine has drawn up the car with no human intervention whatsoever. I don't want to be in a car like that. (P1, PHEV)

Many BEV drivers felt embarrassed to be associated with a vehicle of perceived substandard functionality, and perhaps consequently, did not want their vehicle to be clearly demarcated as a BEV.

My daughter said it was embarrassing…because it had the big plug on the side. (Participant 14, BEV)

Comparisons with more glamorous ICE cars increased embarrassment:

Our neighbour across the road had literally just been to Brands Hatch or somewhere for a Ferrari day. And he came over…and we were talking…secretly, I was quite impressed with the car…[but I] found myself saying 'oh yes, it's just a trial, oh no, I probably wouldn't get myself one', kind of distancing myself from one…because he'd just been back from a Ferrari day. (Participant 5, BEV)

Most BEV drivers also felt ashamed at being unable to drive as quickly or confidently as ICE drivers, and many reported that other road users reacted in an intimidating or disdainful manner to their EV driving style:

It was going really, really slow and I was getting overtaken by buses, lorries. I mean, when I came off the slip road I had to put my hazard lights on because I was getting beeped and all sorts, flashed…it was embarrassing. (Participant 35, BEV)

Exploration of drivers' expectations of how others would view them for using EVs revealed stereotypes of EV drivers. Two main subtypes emerged. The first focused on people with limited mobility needs ("*young mums, housewives, retired couples that just tootle around*", Participant 14, BEV), for whom the perceived limited functionality of the vehicle would be unproblematic. EV drivers were seen as valuing a car only because of its functionality and not deriving pleasure from driving:

[I think they're suitable for] perhaps someone who's not that thrilled by the whole driving experience. (Participant 40, BEV)

This group of drivers and their imagined lifestyles were typically viewed as being sensible and boring ("*quite a dull person*", Participant 15, PHEV; "*lacking that sense of fun*", Participant 5, BEV) and living slow-moving lifestyles, a stereotype from which most drivers were eager to distance themselves:

[EVs are suitable for] someone who's not so interested in having a performance vehicle, or an executive, like a classier car, or a brand even. Maybe someone who just wants to get from A to B.…someone who's perhaps not that thrilled by driving, someone who uses it as a form of transport…[but] I should be driving something slightly younger…something perhaps a little more exciting…I don't think it would fit my image. (Participant 40, BEV)

A second subtype of stereotypical EV drivers focused on those for whom the principle of using an EV could yield affective benefits. This included those who prioritise environmental concerns. 'Green' drivers were however derided by some participants as excessively and unrealistically environment-focused:

I would think [the typical pure-electric driver would be] a spinster lady currently working in a library, hugging trees and going to public meetings about saving the planet. (Participant 23, BEV)

A more positive stereotype concerned PHEV drivers who derive "*kudos*" (Participant 16, BEV) from adopting – or being seen to adopt – new and viable technologies at an early stage, a stereotype with which drivers were happy to be associated:

At this stage, it says they're quite innovative in that they're willing to try something different…I think if people knew it was a plug-in they'd think you're quite an early adopter in the market to try something new. (Participant 6, PHEV)

[Other people] would think that I was perhaps a forward-thinking person, modern, and perhaps on the pulse of technology. (Participant 20, PHEV)

A few BEV drivers reported being ridiculed because of their vehicle:

The initial reaction was always the same – complete and utter ridicule of the whole concept. It was a huge PR problem. (Participant 23, BEV)

However, reported responses from other people during the trial period were mostly related to curiosity about vehicle functionality:

I showed it to colleagues in my work, they thought it was great and they were asking lots of questions about it...they were curious about how it works...and my partner, he was interested and wanted to have a drive...and the neighbours as well, they were very keen to learn about it. (Participant 2, PHEV)

6.6.2.6 EVs as a 'work in progress'

Views towards EVs were underpinned by the belief that the design and implementation of EVs was an ongoing project, thereby identifying this theme as a unifying central category. Drivers believed that EVs were being developed to meet ICE vehicles in terms of performance, design, purchase cost, and the provision of a pleasurable driving experience. They felt that the trial cars were an unfinished, experimental prototype.

The considerable perceived discrepancy between BEV and ICE car benchmarks led pure-electric drivers to feel that their trial vehicle was particularly underdeveloped with regards to performance, safety and battery technology ("*it's not quite there yet*", Participant 9, BEV; "*I think there's more development work that has to be done on them*", Participant 10, BEV).

Charging and maintenance support for EVs, and particularly BEVs, was also thought to be underdeveloped ("*I don't think the UK is particularly well set up to support this kind of vehicle*", Participant 1, PHEV). Consequently, drivers tended to view EV technology and infrastructure as being "*in [the] early days*" of development (Participant 36, PHEV), and "*a bit of an experiment…at the moment*" (P26, PHEV).

I don't think we're at the endpoint of battery manufacture and I don't think this [PHEV] is as good as it gets. I think this is the second generation [PHEV] and we're making it better, but we've got some way to go. (Participant 28, PHEV)

Related to this view, current BEV purchase costs were believed to be inflated because the vehicles were not currently being mass-produced:

It's only because it's new technology, it's new technology and they can't make them in bulk can they, because they haven't got the orders. (Participant 5, BEV).

Some drivers felt that EVs had not been adequately promoted to ordinary drivers, and that the available range of EVs was too restricted for mainstream tastes:

It's not been pitched at the sort of people that are going to drive a revolution...if all the manufacturers started introducing it across their range, it was an option that you could tick when you go in to select a new car, then people would buy it…at the moment I think the marketing is pitching the car in quite a niche market and I don't think that's going to drive the innovation and drive the development that perhaps we need. (Participant 36, PHEV)

Drivers anticipated that the present perceived inadequacies of EVs would be rectified by technological improvements, reductions in purchase costs, a greater range of EV models, more public charging points and better maintenance facilities, with BEV drivers also anticipating gains in battery life and so vehicle range ("*the technology will, as always, get better and better and better and they'll get it right*", Participant 19, BEV). Greater social approval of EV use was expected to follow vehicle and infrastructural improvements. Most expected real improvements to be achieved and expected future EVs and support infrastructure would result in mass adoption some years into the future:

Possibly if it ticked enough boxes. And in five years' time, it might. Those boxes might be pretty much done, ticked. (Participant 19, BEV)

Drivers were unwilling to purchase EVs while they remained 'under development', because of the assumed risk of current vehicles rapidly becoming outdated, or depreciating due to expected decreases in vehicle cost. Some drivers also raised the more fundamental concern that electricity may be rendered obsolete as a 'green' source of energy:

Is [the EV] going to be a different beast in another two years to what it is now, and you are stuck with something that you've forked out [on] thinking you were doing a great job for the environment and general efficiency and you're left with something that's outdated, unsupported, heavily depreciated and not really offering that much benefit to the environment? (Participant 26, PHEV)

Willingness to purchase an EV in the future was largely conditional on the realisation of anticipated developments in EV technology and infrastructural support:

At the moment I think it is still very marginal as to whether it would make any sense whatsoever to buy a plug-in vehicle. [...] But it's a good starting point and it will be really good in a couple of years. (Participant 28, PHEV)

6.7 Summary of short term EV use

Use of in-depth, structured interviews and qualitative analysis has enabled us to specify important dimensions of EV evaluations as well as key misperceptions held by potential consumers. We have identified fears, identity needs and desires that affect the desirability of EVs to potential household consumers.

Affect, identity and symbolism are all important to people's assessment, and responses vary considerably across individuals. Nonetheless, we have also confirmed that utility judgments identified in previous research are relevant to many householders who are buying or leasing relatively new cars. These include negative evaluations of range, performance, recharging time, availability of public recharging infrastructure, car appearance and accommodation, safety, servicing/maintenance support and purchase cost. Our findings provide questions for future research and ideas for interventions designed to encourage positive EV evaluation and EV purchase.

Acknowledging and addressing the responses observed by the mainstream drivers in this trial is likely to be important in successfully encouraging ICE drivers to switch to EVs.

The Grounded Theory analysis emphasised the importance of perceived vehicle costs, including comparisons between ICE and EV purchase costs. Increasing liquid fuel prices are likely to improve the relative competitiveness of EV prices by highlighting competitive running costs but initial adoption may be facilitated by Government subsidies incorporating buyback, leasing or scrappage schemes.

Drivers viewed available EVs as a 'work in progress' and believed that future EVs would match the performance standards of ICE cars. This emphasises the need for manufactures to improve key elements of performance including speed, range, charging times and the capacity to power in-car comforts including air conditioning and sound systems. Already-available EVs suggest that improvements have been made and it will be important to market the next generation of EVs as finished products suitable for mass production and adoption. This needs to be underpinned by development of charging infrastructure to allay range anxieties.

Like ICE cars, EVs may need to be marketed differently for different groups of drivers. Our research suggests that adopters motivated by environmental concerns will need to be convinced of the environmental benefits of EVs including the carbon footprint associated with non-green electricity consumption and EV manufacturing processes. EV instrumentation providing feedback on cost and carbon savings may help nurture a feel-good EV driving experience. Emphasising local air quality and the benefits of noise reduction as well as associations with progress and technological advancement may help to create positive EV driving images. Finally, the importance of positive evaluations of freedom and power should not be underestimated in the context of current advertising of ICE cars.

Implications for future research are clear. New generation BEVs which better match the most popular family car designs are already available. A longer trial (e.g. one or two months) using these more advanced EVs and a more diverse range of families who have previously purchased similar ICE vehicles would be informative in terms of likely mass market response and key barriers to adoption.

7 The fleet perspective

As identified in the household study, we know that private consumers are driven by socio-demographic factors such as attitude, personality, lifestyle, and emotional attachment. The literature review identified that approximately half of new car purchases in the UK are from the fleet market. Therefore it is important to understand the fleet perspective on vehicle adoption if we are to fully understand the implications for EV uptake in the UK. This phase of the wider ETI research programme explores fleet managers' decision-making processes.

7.1 Method

7.1.1 Approach

In this study, structured telephone interviews followed by qualitative analyses were used to map levels of understanding and expectations of EVs among potential consumers from a fleet perspective. It was not feasible within the timescale of this study to loan BEVs and PHEVs out to organisations. As an alternative, an information sheet was provided (see Appendix H) to give as much relevant information as possible before the interviews were conducted (for more information, see Section 7.1.4).

In particular we examined:

- What the main factors were that informed fleet managers' decision-making processes with regard to the purchase of fleet vehicles.
- Fleet managers' knowledge and understanding about EVs, which sources of information they used to find out about EVs and any direct experiences with them.
- Fleet managers' perceptions of the advantages and drawbacks of EVs.
- What the potential would be for introducing EVs to fleets.

7.1.2 Participant recruitment procedure

TRL's previous experience of research with fleet and transport managers shows that they tend to be difficult to recruit for research purposes as they are typically busy and need to see clear benefits to agree to participation in research. The recruitment process for this task was equally challenging. The following approaches were taken in order to reach as many fleet or transport managers as possible:

- Adverts placed in relevant publications e.g. Fleet News, the Freight Transport Association publication, Fleet World and Linkedin (an example of which can be seen in Appendix I).
- Personal fleet contacts from TRL staff.
- A list of 1,000 fleet managers was purchased from a company called Data HQ. Each fleet manager on the list was contacted via email. The email contact yielded two participants. Following on from this, a TRL researcher telephoned those participants who had opened the email, but not responded, this yielded a further six participants.

In total, 20 people consented to take part in the interviews.

7.1.3 Organisation types

The UK Standard Industrial Classification of Economic Activities (UK SIC) is used to classify business establishments by the type of economic activities they are engaged in. Organisations involved in the research were divided into their respective SIC categories.

Table 26: Industry sectors of fleet interviewees

Participant number	Industry sector (SIC categories)	Company type
1	Transport and Communication	Taxi service
2	Transport and Communication	Courier/Taxi service
3	Financial services	Accountancy firm
4	Energy and utilities	Energy Supplier
5	Transport and Communication	Post and courier services
6	Public Administration	Civil Service
7	Property and Construction	Construction
8	Real estate activities	Social landlords
9	Manufacturing	Manufacturing and distribution of bottles
10	Transport and Communication	Transport activities (delivery of goods and services)
11	Energy and utilities	Energy Supplier
12	Recruitment and Human Resources	Recruitment consultants
13	Property and Construction	Engineering company
14	Health and Education	Healthcare Trust
15	Property and Construction	Installation company
16	Property and Construction	Construction company
17	Public Sector	Fire and rescue
18	Health and Education	University
19	Transport and Communication	Car rental
20	Property and Construction	Construction

7.1.4 Information letter and interview topic guide

Prior to each interview, participants were sent an information letter (see Appendix H). The purpose of the letter was to offer fleet managers:

- A high level overview of the main differences between conventional vehicles and plug-in hybrid vechicles (PHEVs) and battery electric vehicles (BEVs).
- More specific information about the differences between PHEV and BEV technologies.
- Useful information about company car tax.

Participants were asked to read the letter before their telephone interview so that during the interview, the discussion could focus on how EVs are assessed and rated from the perspective of a manager of car fleets used for work-related road journeys.

All interviews followed an interview guide which can be seen in Appendix J. This standardised approach ensured consistency irrespective of which TRL researcher conducted the interview.

7.1.5 Procedure

Twenty telephone interviews with fleet managers were conducted by three TRL researchers. The interviews were recorded using Digital Voice Recorders (DVRs). They were transcribed by an external company before content analysis was conducted by TRL researchers.

7.1.6 Method of analysis

The transcripts were analysed using Content Analysis (e.g. Neuendorff, 2002). The analysis was facilitated using XSight computer software. The software assisted the researchers in compiling and comparing the interview data. This then helped the researchers explore the relationships between the comments and thoughts put forward by the interviewees in an accessible and efficient way.

Qualitative content analysis involved condensing raw data into categories and themes based on inference and interpretation. Following good practice guidelines to ensure that the qualitative data were explored exhaustively, two researchers coded the data, comparing themes and sub-themes on a regular basis to ensure that any new themes emerging from the data were captured. The following sections describe the data under the high level topic areas and themes which emerged from the analysis. Within each section, important sub-themes are also described where present.

7.2 Results

It should be noted that the sample of organisations interviewed in this study was not fully representative of UK business types. Therefore all findings presented in this section should be seen as indicative, but not conclusive.

7.2.1 General information from the interview data

This section describes the demographic information reported by participants in the interviews to provide an overview of the sample used. Across the sample, the mean number of people who drove for work within a given fleet was 1,732. The range of drivers within a given fleet in the sample varied from a minimum of 20 drivers to a maximum of 11,000.

Vehicle types were largely associated with the organisations' business activities; most fleets were reported to consist predominantly of cars and vans, with some also using trucks and plant equipment. Motorcycles were also reported as being used in the courier industry.

Some organisations reported having dedicated car parks which have adequate parking for their staff. Others described a first come, first served arrangement or having no staff parking at all meaning that staff were required to pay to park in public car parks located near to the organisation.

As expected, journey purposes varied between organisations. The purposes reported included:

- meeting customers/sales;
- maintenance call-outs; and
- transporting customers/goods.

7.2.2 Current purchasing/leasing behaviours

In order to try and understand purchase patterns, fleet managers were asked to describe their last fleet vehicle purchases in terms of:

- vehicle types (including manufacturer and model, segment and fuel type);
- the process involved in buying/leasing/adopting new vehicles;
- information sources used and who was involved in the decision-making;
- whether they part-exchanged; and
- which manufacturers they considered and what influenced that decision.

7.2.3 The procedure for adopting new fleet vehicles

The outcome of this exercise was useful in terms of providing evidence of a diverse and seemingly non-standardised approach to vehicle adoption within the sample. The interview data suggest that vehicle types vary according to the journey purposes to be undertaken in them. The process involved in buying, leasing or adopting new vehicles varied. Some reported an informal process using their experience in the fleet industry and subsequently having 'a feel' for which process to follow. Others followed a more formal, evaluative approach, whereby they invited manufacturers and dealers to respond to invitations to tender.

We normally go straight to dealerships and manufacturers and we get all ours straight from dealers. The manufacturers normally come in to try and get business. They'll put forward what vehicles they have, ask us why we run the fleet we run, mainly down to size and price, so they try and compete. (Participant 13, Property and construction)

We indentify which manufacturers' vehicles meet the user requirement and we literally, once we've got this, we go out to the marketplace, to all the manufacturers and give them usually about 48 hours' time to respond. We say, well, this is the specification of the vehicle; we are going to buy 2,000 vehicles definitely, give us your best price. And then when they come back with their price, we plug that into a whole life cost model which takes into account fuel efficiency, maintenance requirements, tyres, accidents, breakdowns, warranty, you know, pretty much everything to determine the total cost of ownership of that vehicle. (Participant 11, Energy and utilities)

Purchase decisions were often made by a range of different people including senior management, transport managers, finance teams and procurement departments.

7.2.4 Driver choice

The amount of choice available to drivers fell into one of three categories: full choice, choice from a predetermined list and no choice. Where full choice was given, drivers within an organisation were given a list of all manufacturers and models to select from based on their grade within the organisation.

There are various rules within our policies, so dependent on grade you get a certain allowance and that allowance enables you to choose from a very wide range of cars. Pretty much all manufacturers are eligible and they make their choice based on their allowance. (Participant 11, Energy and utilities)

One fleet manager felt that this system gave drivers too much flexibility of choice:

It is entirely up to the individuals. A bit too much freedom for my money, but that is a different thing. (Participant 13, Property and construction)

Where drivers had a pre-determined list to choose from, filtering by the fleet manager had taken place to ensure that certain criteria (which varied from organisation to organisation) were met, examples of these include:

- CO_2 emissions

We also have CO_2 band policies. CO_2 on Band A is 135 grams, Band B is 150 and Band C is 160 grams. Now, our policy is to drop 2% each annum. So, when they come up to renew the vehicles, they would've had to drop their CO_2s for the next vehicle. (P13, Property and construction)

- Number of seats/doors

They can virtually choose anything, as long as it's got four doors. (P20, Property and construction)

- Fit for purpose (e.g. storage space, appearance)

Oh, boot space, because of our service we need to make sure people can stick their luggage, yes. (P1, Transport and communication)

- Brand

I pre-determine engine size and manufacturer…we only have two manufacturers that supply our vehicles. (P8, Real estate activities)

We kind of stick to a manufacturer that's still quite highly respected, so the company wouldn't choose a Skoda for example just because it has to be a car that people want to drive. (P12, Recruitment and Human Resources)

A small number of fleet mangers reported that there was very little choice (e.g. one construction company who allowed their drivers to select between a car and a van) or no choice at all, about which vehicles they could have, for example, in one company vehicles were allocated by job role:

If you're a sales person you only have one vehicle…an Astra hatchback. (P9, Manufacturing)

They're all Toyota Prius. (P3, Financial services)

7.2.5 Finance programmes

A range of finance programmes were reported, the different variations can be seen in Table 27.

Table 27: Frequency of reported finance systems

Financial system	Frequency
Contract hire	8
Outright purchase	4
Lease	4
Mix of contract hire and outright purchase	1
Mix of contract hire and operating lease	2
Mix of lease and outright purchase	1
Total	20

The most commonly reported finance programme was contract hire. Contract hire is defined as a system whereby organisations hire vehicles from a provider for a specified period and make regular monthly payments to rent them. The leasing company retains ownership of the vehicle and is responsible for the associated risks. Contract hire was considered to be the lowest maintenance solution for fleet managers. They described it as being particularly useful because it required minimum input from them. This reduced input in the day-to-day running and maintenance of their fleet vehicles meant that they could focus their time on core business activities, as illustrated by the following quotes.

It's like a one package and all I have to do is just to manage the cars, it's a one stop solution. (P12, Recruitment and Human Resources)

We use contract hire rates to acquire the vehicles and that's really it. It's best in terms of taxation for the company that allows you to have knowledge of what your outgoings are going to be every month without any surprises. (P3, Financial services)

Outright purchase (up-front purchase of vehicles by organisations) and the mixed finance programmes were described as being the most cost effective options for the organisations' business needs.

We like to keep the cars on our books as an asset. By buying outright, we can move the cars around as we please. For instance, with the recession we decided to extend it. Our normal cycle used to be three years, 80,000, and with the recession we increased it to four years, 100,000. By buying outright we can have more control over it. (P13, Property and construction)

We lease everything. On the cars we tend to go for full contract hire. On the vans we tend to use operating lease where we just finance the asset and then we pay for use, all the maintenance of the tires and what have you, and obviously as a scale of the operation we own the relationship with the tyre providers, the breakdown provider, the actual management providers, etc. (P11, Energy and utilities)

7.2.6 Important considerations in vehicle choice

In order to ensure that vehicles in the fleet met operational requirements, the following attributes were considered to be important by fleet managers when thinking about introducing new vehicles to their fleets:

- fit for purpose (i.e. size/number of seats, boot space, interior);
- (low) CO_2 emissions;
- efficient fuel consumption/mpg;
- reputable brand (manufacturer) – associated with image and reliability;
- comfort;
- safety;
- whole life cost; and
- availability of vehicles (i.e. if a fleet required 200 new vehicles, would this be possible?)

7.2.7 Knowledge of EVs

Prior to the telephone interviews, all participants were provided with an information letter. It was not possible to determine how much they knew prior to the interview, or indeed whether they had read the information letter, but by providing the information letter it was made more likely that feedback was based on at least a basic understanding of EVs. Depth of knowledge ranged from a basic overview to detailed, technical knowledge.

I know that they're fully electric obviously, zero emission, exempt from any charges in London, sort of and I know that at the moment my opinion is that they don't really last as long as you want to. (P1, Transport and communication)

Just about everything you want to know. There isn't much I don't know about it, because all the manufacturers stay fairly closely to me. I've driven all of the electric vehicles that are currently available. We have electric vehicles in our fleet already. We have mega trucks from France, which are electric vehicles. We have lots of other electric vehicles that we use in the contracts we run, so yes, I'm fairly up to speed on most plug-ins. (P8, Real estate activities)

Participants generally did not have any difficulty in describing the differences between EVs and hybrid vehicles. There was some confusion about what a PHEV was, despite this being explained in the pre-interview information letter.

P20: 'A hybrid starts off on a normal engine as in petrol, and then converts to your user's electric motor to drive after that. Then when it feels it needs charging it reverts back to the petrol engine. Whereas the electric plug-in is you plug in and it charges up, and you're using electric all of the time. If the battery runs out you stop.'

Interviewer: 'Are you aware of the plug-in hybrid electric vehicle?'

P20: 'Not off the top of my head.'

Several fleet managers reported having actually experienced driving EVs including one participant who already had EVs on his fleet. Most of those with direct experience of them regarded them in a positive light.

Yes, quite impressed actually, yes. It wasn't the change I thought I would experience as a driver sat behind the wheel; which made me think the technology could be adopted by our technicians if certain things are right in the future. (P7, Construction)

I love them! Fantastic acceleration, ever so quiet, and yes it's a different experience, but you get used to it fairly quickly. I notice that when I drove the Renault the last time you hardly ever have to put your foot on the brake because of the re-generation plate. As you take your foot off the accelerator, it automatically brakes on its own, so actually breaking is greatly reduced. But apart from that, it's just like driving a normal car. You know, you've got a steering wheel; you put your foot on the accelerator; it goes. The great thing is you don't have to change gear. So yes, it's all… as far as I'm concerned, it's all positive. (P8, Real estate activities)

The exception to the positive experiences was that of a courier company who had purchased an electric scooter, this fleet manager describes experiencing range challenges:

Yes, as I say, they're great, but they're... They advertise a range of 63 miles I think it was and realistically you get about 28 or 29. So bearing in mind the average bike rider does 90, 100 miles a day, it doesn't really work. (P1, Transport and communication)

The following quote is taken from a fleet manager who had run three electric vans on his fleet, and demonstrates buy-in and excitement about the technology despite negative experiences.

Well, they've been absolutely okay, the three that we bought, the mega vans, they're really not fit for purpose and they're not very strong. But they were very low cost entry into electric vehicles. We've had reliability issues, we've done them. We've had problems in terms of, you know, the parts failing. And I think that's probably to do with the quality of the manufacture as opposed to the actual vehicle, I think the principle's right. However, the Swiss EV that we're buying is based on the Ford Transit, and it's very much, you know, a conventional electric vehicle that, you know, has been tried and tested and is, you know, a product that's been around for quite a few years. So, we are expecting its performance to be, you know, comparable to a diesel. (P18, Health and Education)

Fleet managers reported using a variety of different sources to gain their knowledge of EVs, including:

- vehicle manufacturers;
- attendance at conferences/seminars;
- publications aimed at the fleet industry; and
- press releases/media information.

7.2.8 Knowledge of charging

In terms of participants' knowledge of charging EVs, it seemed that (despite being provided with indicative charging times in the pre-interview information letter) participants were still largely driven by their own pre-conceptions of the time taken to recharge EVs. This is supported by the diverse range of suggested charging time periods in the following quotes. There was also a lack of knowledge about different charging systems and their capabilities.

They say you use different charges. You get a quick charge and an overnight charge, I think. That's about it. (P13, Property and construction)

If we're looking at our home charge situation using domestic plugs, you're looking at about eight to ten hours, I believe. If you're going for a dedicated plug-in system that's... I think it's 16 amps, you reduce that quite considerably probably then to about four hours. But then it's getting dedicated plug-in points where you need them. (P17, Public Sector)

If you have a rapid charging system you can probably charge your vehicle up from start to finish in the space of about an hour or so. (P5, Transport and communication)

7.2.9 Perceived benefits and drawbacks associated with adoption of EVs into fleets

Having established what participants knew about EVs, they were then asked to describe what they thought the advantages and drawbacks of the vehicles were from a fleet management perspective. Participants offered a range of different benefits and drawbacks which they associated with adoption of EVs when compared to petrol or diesel vehicles. The content analysis enabled these factors to be categorised into one of three different groups: environmental, financial and business benefits.

7.2.9.1 Environmental benefits

The most frequently cited benefits associated with EVs were a combination of lower emissions and reduced use of fossil fuels. Participants tended to report an awareness of their organisation's responsibilities for carbon reduction which drove them to consider alternative fuel sources.

Our corporate responsibility in terms of carbon reduction, low emission. (P11, Energy and utilities)

We are actually trying to reduce all of our CO_2. (P8, Real estate activities)

I think we've got to start looking at reusing fuel and being a bit more economical... We do need to start talking about the environment and things now. There's not going to be any fossil fuels around, so it is important to have to look at the alternatives for all vehicles. (P2, Transport and communication)

There is a point when we can't continue to use the amount of fossil fuel that we're now using now and there is therefore an imperative, I think, that we should be looking at alternatives and electrics have a place within that. (P4, Energy and utilities)

Several participants had reported already using alternative fuel sources such as LPG and bio fuel.

We try to encourage our drivers to run their vehicles on bio fuel if they're diesel. We've got LPG vehicles as well, but basically, we try to incentivise them to use bio fuel and we ask them to use 100% bio fuel, 80% at the time as a minimum. (P2, Transport and communication)

We had a handful of LPG cars in the fleet at one stage. (P9, Manufacturing)

Others reported having already adopted 'eco' brands and hybrid vehicles into their fleets.

They're all Toyota Prius. Oh, there's a couple of Lexus hybrids as well, but only about half a dozen. (P3, Financial services)

We brought in 500 Seat Leon ecomotives which are 99g/km [of CO_2] and they're liveried cars. (P11, Energy and utilities)

7.2.9.2 Financial benefits

Lower running and maintenance costs were offered as financial benefits associated with the introduction of EVs. Cost of fuel was considered to be a negative factor for internal combustion engine (ICE) vehicles. When comparisons were made between the cost of recharging and the cost of refuelling, recharging was considered to be far lower than the cost than refuelling.

Fuel savings; we all know fuel's going through the roof. (P1, Transport and communication)

Benefits, obviously the big one is that the cost of the fuel is a lot less. (P15, Property and construction)

In terms of maintenance costs, the view was that the EV's electric motors would have fewer moving parts and as a result would cost less to maintain than an ICE, thus creating a financial benefit.

I think vehicle maintenance is going to be a lot easier to manage on an electric drive vehicle and there will be cost benefits associated with that maintenance management because it requires less maintenance. (P11, Energy and utilities)

There's very little service maintenance repair, at least simple electric motor. (P8, Real estate activities)

7.2.10 Business benefits

In terms of staff wellbeing, respondents (largely those who had direct experience with EVs) reported that the advantages of EVs were considered in terms of the driving experience with regard to quietness, responsiveness and reduced demands as a result of the automatic transmission.

They will relieve a lot of driving fatigue because, you know, they are fully automatic transmissions; they're very quiet, they're very responsive. I think the driving experience is actually enhanced I think for the driver, you know. (P11, Energy and utilities)

They're easy to drive, they're comfortable to drive. So, from a driving experience they're perfectly acceptable. (P4, Energy and utilities)

For businesses where short, localised journeys were required, it was felt that EVs would be a cost effective business option as they would be fit for purpose and would reduce fuel costs. Another business benefit identified was the image projected to customers by organisations having EVs on their fleet. This is discussed further in Section 7.2.10.4.

7.2.10.1 Environmental drawbacks

The batteries used in EVs were frequently cited as environmental concerns. This concern was two-fold; firstly, there was an issue with the materials used to produce the batteries, and secondly, how to dispose of the batteries at the end of their life.

Waste, what do they do with the waste after the battery needs replacement? What would they do if all these vehicles all had batteries and for example were at that stage, there would be piles and piles of waste? Have they even thought of recycling, have they even thought of disposal for that? (P12, Recruitment and Human Resources)

[I am aware of] arguments as to where do you dispose of your battery and if you need new batteries, who pays for the batteries? (P13, Property and construction)

Another question raised over EVs was related to the way in which the electricity used to power them was created. Participants were concerned that the green credentials of EVs were not actually as green as advertised.

You could say that they (EVs) are green, although I take a bit of an issue with that, to be honest with you at the moment. There's not really enough renewables so electric, I see at the moment as such, it's deceiving. (P15, Property and construction)

7.2.10.2 Financial drawbacks

The outright purchase cost and the costs associated with the batteries were common financial drawbacks. In addition to the costs involved in purchasing vehicles, fleet managers reported feeling uncertain about the resale value of EVs.

One of the things that, you know, is hard for us at the moment is determining a really robust total cost of ownership model that will enable us to bring this technology into our fleet, but not on a lifecycle that is so extended, you know, because we're having to extend the lifecycle because of a lack of confidence in residual values and the initial purchase price of the vehicles…we'll lose that opportunity of, you know, the technology advancements. (P11, Energy and utilities)

The purchase cost of EV batteries was considered to be a financial drawback according to several fleet managers interviewed. In addition to the cost, concerns were raised over the likely lifespan and servicing costs of the batteries.

Cost of batteries, huge costs, and that's what the lease…that's affected in the leasing costs. When the leasing companies look at it at the moment that's the biggest issue; that if you got to replace £8,000 worth of lithium ion batteries after five years where…who in the second-hand market's going to buy a second-hand vehicle and then go and have to pay eight grand for a set of batteries? So that's something that's a real problem at the moment is the batteries. (P8, Real estate activities)

The warranty of the battery. (P7, Property and construction)

Batteries, size of battery, using space, load space, and the cost of the battery. (P13, Property and construction)

7.2.10.3 Business drawbacks

The most frequently cited drawback associated with EVs was range. Range was almost always linked with available infrastructure. This also became apparent when considering key attributes and vehicle choice (see Section 7.2.6).

They have a limited mileage really, and the travel distance is limited. (P15, Property and construction)

The range of the vehicle isn't sufficient on the electric ones at the moment. (P16, Property and construction)

The range of electric vehicles is a major, major drawback; along with the time to recharge...fully recharge the battery. That's the biggest single drawback to a totally electric vehicle. (P17, Public Sector)

The uncertainty over the range: so, once the vehicle is charged if it can cover 60 miles maximum but the way you are driving means 40, you might run out of fuel or you see the gauge is low and you've got to find a filling station quite quickly. And for electric, if the thing stops then it basically stops until it is charged again; if it is nowhere near a charging point then you've got a big problem. So, we've got issues over range. (P7, Property and construction)

I think, you know, the two biggest anxieties around electric vehicles at the moment are infrastructure and range anxiety. (P11, Energy and utilities)

In addition to the issues regarding range and infrastructure, the time investments associated with EVs was deemed to be another business drawback. Fleet managers reported being concerned by the amount of time required to charge EVs and the potential impact that charging could have on business. The comparison was made between the amount of time taken to refuel using petrol or diesel and the time taken to fully charge an EV.

The refuelling infrastructure and operational down time. I can't afford to put any technology in the fleet that is going to in effect reduce the operational performance of the engineer. (P11, Energy and utilities)

As far as I know, it's a plug-in thing and it takes, you know, can take several hours to recharge. Again, it's time-consuming. (P16, Property and construction)

The actual physical availability of EVs on the market was a concern for some fleet managers, for whom lead times are important and delays in delivery can have operational impacts. Some other participants reported that they likened the EV market with the LPG market, which was considered to be a short lived novelty lacking in longevity. As such, fleet managers felt that EVs would be a big financial investment for something that may not last.

7.2.10.4 Perceptions of EVs from different business perspectives

Fleet managers' perceptions of what senior management/staff within their organisation thought about the idea of having EVs on their fleet was mixed. It was felt that some senior staff would consider it to be an advantageous and unique selling point when competing for business as illustrated in the following quote.

I think they would be quite keen. I think one thing we are quite keen to do is differentiate ourselves from other traditional maintenance and construction and build companies; and through that we would embrace selecting something that is a bit different and better. (P7, Property and construction)

However, it was felt by other industry sectors that use of EVs in their fleet would go against the image that they wanted to project. For example, a recruitment company made the following quote based on the fact that they viewed themselves to be a cool and trendy organisation in which image was everything.

They'd laugh at it. I think it needs a lot more marketing, a lot more of that to make it popular, probably get someone cool out there to make it popular for young people maybe or someone respectable in the corporate industry to make it, to get that image slightly better. (P12, Recruitment and Human Resources)

Interviewees thought that the reaction of drivers was likely to be mixed:

Again, this is a mixed reaction. Some of them are keen, some of them are actually, you know, would say they're a waste of time. (P15, Property and construction)

Unfortunately they're the type of people that don't like a lot of change. (P2, Transport and communication)

I think they would go for it. I think everyone's trying to be green. There is a lot of reason to go green. Sometimes drivers want to take the Toyota Prius, for example. P13 (Property and construction)

In general, most interviewees thought that their customers would view the introduction of EVs to their organisation's fleet as being a positive move.

I think they would see it as a good thing, we hope so. I mean, we think that, you know, taking the lead and being involved in certainly the low carbon vehicle procurement programme that's, you know, showing that we do operate in electric vehicles. I think it would perhaps enhance our brand. (P18, Health and education)

Most companies aren't particularly worried what we run around in. (P3, Financial services)

I think some of them would think it's a fantastic idea. I think some of them would think it's green wash [trying to pretend you have green credentials when really you haven't]. I think some of them would think aren't electric vehicles an awful lot more expensive to conventional vehicles, so why are you spending money on a more expensive vehicle than you actually need. So, we'd have a range of views. (P4, Energy and utilities)

7.2.11 Potential for adoption of EVs in the future

Participants were asked to estimate how likely their organisation would be to adopt EVs into their fleets in the future, and when they envisaged that happening. This section presents fleet managers' responses in terms of the likely impact on operations, the availability of infrastructure and summarises participants' feelings about the likelihood of EV adoption.

7.2.11.1 Potential operational impacts

When participants were asked to describe the potential for adopting EVs into their fleet, it was felt that for some of areas, EVs would fit well, such as lowering CO_2 emissions and ensuring efficient fuel consumption. However, an area of concern with regard to operational requirements was whether the EVs would be fit for purpose. Examples of these can be seen below for a taxi service and a construction firm.

The following two quotes illustrate that having a vehicle that was fit for purpose was the most important attribute for two participants who managed fleets within taxi services.

For me it's the interior, because obviously our passengers are looking for a high standard inside the vehicle, Oh, and boot space, because of our service we need to make sure people can fit their luggage in. (P1, Transport and communication)

There was a concern that the presence of the batteries required to power EVs would take up valuable boot space or space in other parts of the vehicle.

And the fact that you haven't got as much luggage space because they take up...the batteries tend to take up quite a lot of room in the boot. (P2, Transport and communication)

Fitness for purpose was also an important factor for the fleet manager at a construction company. The construction companies interviewed reported that vans were typically used for carrying large pieces of equipment; often it was the case that cars were used to transport toolboxes and smaller pieces of equipment.

In terms of important vehicle attributes, the following quotes give an indication of the importance of being able to provide fit for purpose vehicles:

Various things. If all our engineers' tools can fit in the vehicle and the vehicle is comfortable to drive, because our engineers do spend most of the day in the vehicle, and then service and repair costs. We've had Skodas on our fleet for about five years now. It's pretty difficult when we get another car because none of the toolboxes fit. (P13, Property and construction)

Other operational concerns were borne out of a cautiousness of new technology, as well as a lack of knowledge and experience. In terms of cautiousness, fleet managers reported that adopting EVs into their fleet would be a taking a chance with such new technology:

You're committing heavily to the current technology and possibly losing the opportune… you know, we feel there is going to be quite significant advancements in technology around electric vehicles and, you know, we would be stuck with what we've got. (P11, Energy and utilities)

You might find that in two years time it is really old and slow technology and you don't want them for another three years. So, there is a nervousness around getting in very early and thinking it is going to cost us more money and perhaps might not be the right thing to do. (P7, Property and construction)

On the other hand, one of the characteristics displayed by early adopters may be useful for future marketing strategies. Early adopters demonstrated a sense of pride when describing their own positive experiences of EVs. Quotes like the following may be useful to assuage some of the doubts expressed:

And in actual fact the University, I'm proud to say, is one of only two Universities that have signed up to the low carbon vehicle procurement programme which is being managed by the Department of Transport. And we're actually awaiting delivery of five electric panel vans from Smith EV. (P18, Health and education)

7.2.11.2 Likely infrastructure availability

Concerns over charging were raised in terms of organisations' potential for accommodation of charging infrastructure; this was particularly pertinent where there were not adequate parking arrangements or where the business premises did not belong to the organisations.

If we had our own freehold areas and we had our own yards and we could easily put things in that weren't impacting on the lease or on the rules covering the occupation that we've got there, then we would be in a different remit where probably the guys would be able to leave the vans to charge overnight and drive home in their cars. Because we don't have the space they take their vans home, and we don't want to get into a system where we are assessing from a safety and practicality point of view whether the guys can charge vehicles at home. I think it would be too much effort and not much reward. (P7, Property and construction)

First of all, we're tenants on this site, which is an office building, and it's going to be relatively complicated and expensive to get the recharging port installed in our underground car park. And also, there's another factor. We're moving offices within Uxbridge in two years time. (P9 , Manufacturing)

A lack of adequate parking arrangements posed a big challenge to organisations' abilities to introduce EVs to their fleets, as they would be reliant on available infrastructure. In situations where fleet vehicles were assigned to individual drivers, fleet managers described a worry that drivers would not be able to home-charge if did not have adequate off-road parking with electric supplies.

For most of the fleet managers interviewed, the specific details of how charging might work had not been considered, for example, whether they would charge employees to recharge their vehicles at work. Where EVs were already on the fleet at one of the participating organisations, charging facilities had been installed around the campus. Their strategy was to use their charging points as an incentive for other local EVs users and ultimately as a revenue source when EVs become more widely used.

We would allow our charging points to be used by the general public or staff or visitors who use electric cars to drive to campus. And at the moment we're considering providing that free as an incentive. Now the charging points for those vehicles have dedicated parking spaces, which again would be an incentive for anybody. So, that's our strategy at the moment. However, longer term as we probably acquire any and include more electric vehicles into a general fleet, then yes the recharging of those vehicles would be recharged back to the department. (P18, Health and education)

7.2.11.3 Predicted future adoption

Almost half of the sample reported feeling confident that EVs would be introduced into their fleet within the next five years. However, there was hesitancy over the adoption of fully electric BEVs. Participants suggested that the hybrids were more appealing as they offered the security of a fuel tank.

The hybrid vehicle; yes, I can see potential for that. (P16, Property and Construction)

Not all electric, mainly because of the range issue. I know there are some manufacturers looking at the hybrid electric which, you know, offer a much greater range. (P18, Health and education)

I would say over the next five years anyway, but whether they're actually purely electrical or hybrid vehicles, I couldn't actually say at the moment on that. (P15, Property and construction)

Participants also reported that within the five year time frame, they were realistic about what proportion of their fleet would be comprised of EVs given the availability of vehicles.

You know, probably, maybe 2% or 3%; maybe up to 5% of the fleet may go electric over the next five years. (P8, Real estate activities)

Five years; within the next five years I would like to think that there's at least one on the fleet. (P20, Property and Construction)

For those who did not envisage their organisations adopting EVs, this was largely as a result of the novelty of EV technology and a perception of 'unanswered questions'.

I think it's doubtful, but I've still got an open mind that if we have a situation where we have a specific use that keeps it within a specific area and where the range is within the battery capacity and it's down time is such that it allows recharging, then yes, we could probably make use of it. (P17, Public Sector)

Other unanswered considerations raised by fleet managers included:

- the actual purchase cost of EVs;
- whole life costs of EVs;
- residual and resale values; and
- (contract) hire costs.

7.3 Summary of the fleet perspective

- There did not seem to be a standard approach to purchasing fleet vehicles. However, the wide range of organisations could map on to an established decision-making categorisation structure (Nesbitt & Sperling, 2001).
- If EV purchase decisions are similar to ICE purchase decisions, marketing strategies will need to be targeted differently towards the different decision-making structures.
- A lack of understanding was apparent with regard to the different categories of EV. The fleet industry therefore needs to be provided with clearer information on EV attributes to inform their decision-making.
- There was a tentativeness associated with being an early adopter; participants expressed that they would rather base their decisions about whether to adopt on feedback and experiences of others. This feedback from other users, potentially in the form of case studies, could be a useful marketing strategy.
- The EV attributes that fleet managers considered to be advantageous over ICEs included:
    - the potential that EVs had to assist fleet managers in meeting their corporate carbon reduction targets;
    - the lower running and maintenance costs;
    - the potential to differentiate organisations from their competitors by being such a new and innovative technology; and
    - the preferable driving experience of EVs.
- The EV attributes that fleet managers considered to be disadvantageous over ICEs included:
    - Limited range; and
    - Limited availability of infrastructure, including:
        - inadequate parking facilities for the provision of charging infrastructure for employees, as well as a paucity of publicly available charging points;
        - a greater impact on operational efficiency due to recharging during the working day compared to refuelling at a petrol station; and
        - concern about the feasibility of home charging.
- The organisations interviewed were, on the whole, keen to introduce EVs into their fleets, but that introduction will be a gradual process.

QUANTITATIVE CONSUMER SURVEY

8 Introduction to quantitative consumer survey

The development of a two-wave survey questionnaire to assess responses to electric vehicles (EVs) with a representative sample of the British consumer population was informed by the work reported in previous chapters. This includes the literature review (Section 1 to Section 4)—written with the aim of contributing to the design of survey instruments to identify the unique factors that are likely to impact the customer response to plug-in technology—and a thematic analysis of the interviews from the first 22 participants involved in the household study (Section 6).

The two-part questionnaire was developed to assess responses to battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), with a sample consisting of drivers who had purchased new or nearly-new cars within the last five years. In addition to collecting information on socio-demographic indicators and current car ownership and use, the survey included a stated preference (SP) choice experiment in order to assist with the analysis of interrelationships and the quantification and prioritisation of factors influencing behaviour. The choice experiment is not discussed in this report.

The questionnaire (excluding the choice experiment) had two purposes. The first was to allow the project team to segment the responding population based on attitudinal and behavioural criteria; the attitudinal and behavioural segments were then mapped to the Mosaic groups and urbanity segments provided by Experian (Experian 2010a). The second purpose was to collect information on EVs that cannot be included in the choice experiment, including vehicle attributes that cannot be modelled, attitudes and behaviours towards EVs and the perceived suitability and use of EVs. The questionnaire also included items on infrastructure and incentives related to EVs.

Using a conceptual model, data from the questionnaire were analysed in order to understand the EV consumer segments in relation to various characteristics including:

- personal, household and travel characteristics;
- car ownership;
- knowledge and experience of EVs;
- attitudes towards EVs, the environment, and owning a car;
- personality and innovativeness;
- response to incentives; and
- likelihood of adoption.

The next chapter provides a summary of the survey methodology, general analysis of the sample, analysis of the consumer segments, and a geographical analysis.

9 Methodology

9.1 Segmentation of the car market and EV adopters

It is important for studies assessing the large scale adoption of EVs not only to identify the likely preferences of those individuals who can allow the technology to get its first significant foothold in the market, but to avoid basing model coefficients and predictions on the earliest adopters who are likely to have different requirements to those consumers who go on to be classified as ‘mainstream’ (Santini & Vyas, 2005). In the latter case, it will also be necessary to capture the diversity in consumer preference at any one point in time and the dynamic nature of preferences, symbolic meanings and behaviour.

Segmentation of current and potential EV adopters has to date been largely based on Rogers’ categories of innovators, early adopters, early majority, late majority and laggards. The uptake of new products tends to be characterised by the relatively small group of innovators and early adopters. The former pursue new technology vigorously and their endorsement is important for early adopters through demonstration, word-of-mouth and imitation (Thøgersen & Gärling, 2001). The early adopters of EVs are generally thought to have higher income, car ownership and higher mileages than the average and tend to live in multi-car households.

However, the early adopters do not necessarily hold the key to understanding the early majority and thus it is important to understand the potentially unique characteristics of these ‘early’ and ‘mainstream’ groups of EV consumers (Moore, 1992; cited in Santini & Vyas, 2005 *).* Moreover, in terms of motivation, there is potentially more than one early adopter segment as some will be driven by altruism and philosophical reasons for wanting to reduce fuel consumption and others will be driven by the technology or have a financial motivation not necessarily backed up by detailed payback calculations.

Segmentation studies in this arena have, however, largely identified these segments *a priori* from data measuring the basic characteristics of the different groups outlined by Rogers (1962). This in turn has resulted in a reliance on demographic data (largely around age, income, social class) and, if possible, some notion of innovativeness or openness to the uptake of new technology (though rarely specifically car technology). Empirical work has relied on SP studies to understand the importance attached to and willingness to pay for certain vehicle attributes, and RP data has also been used to understand the early adopters of HEV/EV owners (see Sections 1 to 4).

The literature review in Sections 1 to 4 detailed the multiple situational, demographic and attitudinal (instrumental, symbolic and affective) antecedents of EV adoption. Consequently, any attempt to identify subgroups needs to understand the role of these factors and use the most important ones as the bases for an empirically-based, post-hoc segmentation which does not specify the number of sub-groups in advance. The identification of theoretically based *a priori* sub-groups based on thorough exploratory analysis to understand the antecedents of vehicle adoption is the approach that this study has taken.

9.2 Survey development

The questionnaire development phase was informed by previous research phases within a larger programme of work. It included empirical evidence obtained in the literature review (see Sections 1 to 4) as well as the thematic analysis of the interviews from 22 participants involved in the household study (see Section 6). It was designed with input from a consortium of project partners (TRL, University of Aberdeen, Shell, Element Energy) and in consultation with ETI reviewers.

The research aims for the questionnaire were to (as far as possible) understand the attitudes of mainstream consumers towards EVs, and the behavioural choices that they would make if they had some understanding of the vehicles. It was anticipated that most respondents would have limited exposure to or knowledge of EVs. As such, in order to improve the validity[11] of the questionnaire its administration was split into two waves. At the end of wave one, participants were provided with information about EVs (Appendix L). Participants then completed the second wave of the questionnaire approximately two days after the first.

The delay between the first and second wave was necessary because if participants were to read the material and then immediately answer the questionnaire, their responses may be based on short term memory processes and 'conscious recall' of the information. Conscious recall does not necessarily represent the mental processes that people normally use when making choices or expressing attitudes (see for example Nisbett & Wilson, 1977). It was therefore considered that by enforcing a delay the validity of the responses would be improved; by having an interval between reading the material and responding to the questionnaire, it is more likely that the information can become integrated with other information through the associative processes believed to operate in long term memory (LTM) storage and retrieval (e.g. Collins & Loftus, 1975). Such processing is believed to link new information to the other contents of LTM. For instance, the new information on EVs may become integrated with attitudes towards cars and driving, environment, and lifestyle. It was reasoned that with the delay, subsequent responses to the questionnaire were then more likely to be based on the contents of LTM, which can be accessed both consciously and non-consciously when responding. This made the likely validity of the study itself higher since it was more likely to be measuring the outputs of mental processes that people actually rely on when making such decisions as buying new vehicles. An additional benefit of the delay was that it gave participants the opportunity to explore further publicly available information about plug-in electric vehicles, which is behaviour similar to the search for information when considering the purchase of a new car.

An initial version of the questionnaire was shortened based on the knowledge of the project team as to the most important questions to fit within the questionnaire timescales. The updated questionnaire was 'cognitively pre-tested' by 18 participants from the TRL participant database, representing a spread of demographics. The cognitive pre-testing phase allowed researchers to evaluate whether the questions being asked measured the construct they were intended to measure. This was done by conducting interviews with participants who had completed the questionnaire. During pre-testing, changes were made to the structure and wording of some questions to aid understanding.

The updated questionnaire was then programmed as a web-based survey, and distributed for further piloting. During this piloting, 136 participants completed phase one of the questionnaire, with 101 returning to complete phase two (see below for description of final questionnaire administration). This represents a two-phase response rate of 74%. The pilot showed that there was a need for some further rewording of questions; however no questions were removed based on either the cognitive pre-testing or the pilot.

9.3 Sampling and data collection

A market research company was used to undertake the data collection for this phase. They were selected on the basis that they had access to a panel of demographically diverse respondents who have subscribed to undertake such research. Therefore, the correct sample demographics required for each element of the survey could be specified. In addition to the required sample demographics, a pre-categorised sample of innovators (as defined by Rogers, 1962) was specifically required.

[11] Validity refers here to the extent to which the study design measures what the researchers want it to measure. It is a key issue in research with people, because participants' responses and behaviours are very context-dependent.

The rationale behind the deliberate selection of these innovators was based on evidence from Rogers (1962). Rogers' innovation theory describes the diffusion of new ideas and innovation through society. Within the theory, Rogers defines five adopter categories to classify individuals within a social system, allowing the theory to describe the uptake of new technology over time. The adopter categories are: innovators, early adopters, early majority, late majority and laggards.

Figure 16 demonstrates how the adopter categories support the rate of uptake of new ideas and market share. As can be seen by this figure, if Rogers' theory is to be followed, identifying an innovator group would be crucial to the initial development of the EV market. To identify innovators as described by Rogers, a filter question was used to oversample the number of "innovators" included in the survey, thus permitting measurement of relevant variables in this potentially important sub-group.

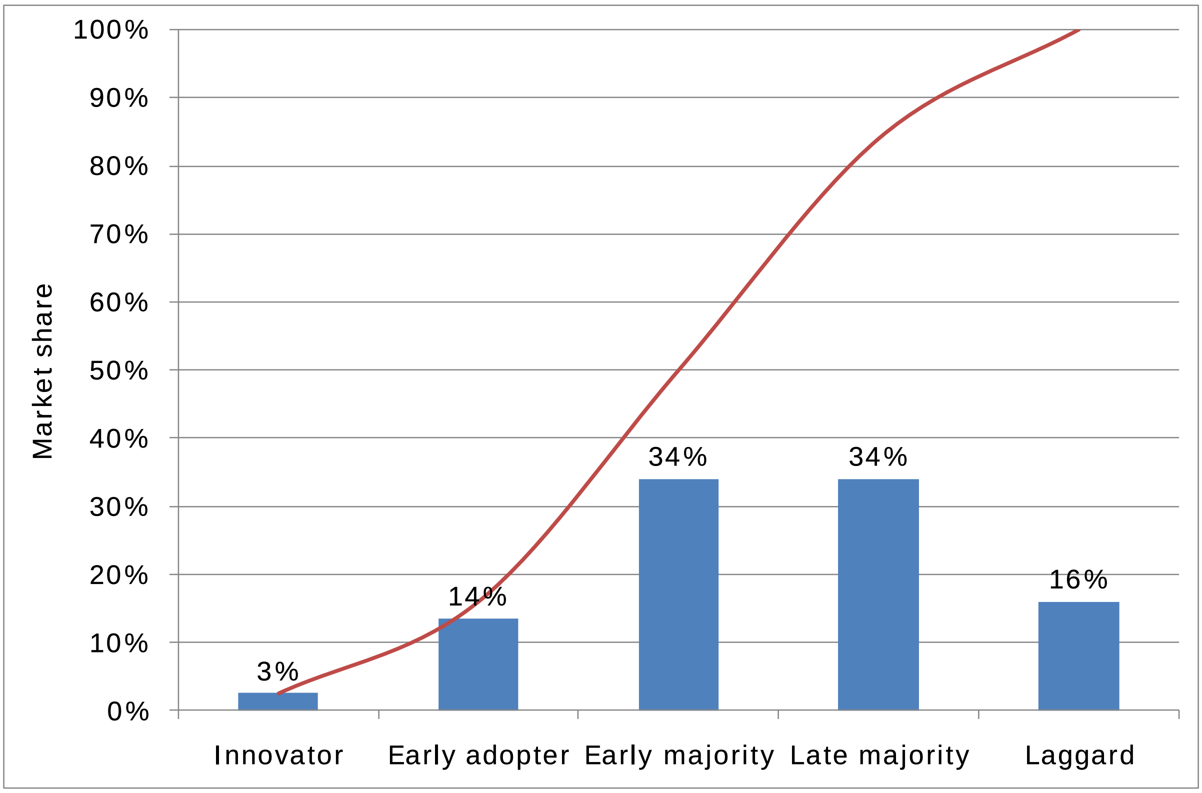


Figure 16: Expected rate of uptake and market share (Rogers, 1962)

9.4 Procedure

Participants were recruited from panels held by Research Now (www.researchnow.com). Research Now have a UK consumer panel of around 750,000 individuals. The participants are recruited to the panels by email and online marketing through affiliate websites and targeted website advertising. A sub-set of panel participants who owned a car were sent a recruitment email inviting them to complete the first questionnaire. Two filter questions were used to ensure participants were representative of new or nearly-new car buyers in the UK. The questions asked were:

1. In the past five years have you owned/leased or acquired (i.e. as a company car) a brand new car OR a car which was less than two years old that you drive?
2. Are you currently actively seeking to purchase a brand new car which you will drive?

Participants were only allowed to start the survey if they answered 'yes' to either of these questions. If the participant answered 'no' to both questions then they were thanked and informed that they could not proceed with the survey.

Those who completed the first wave of the questionnaire were contacted two days later via email asking them to complete the second wave of the questionnaire.

Participants who completed wave one or wave two (or both) in less than nine minutes were removed from the survey; it was felt that this was the minimum time needed to read and complete the survey fully.

9.5 Respondent sample

Invitations were sent to 49,501 individuals asking them to complete the wave one questionnaire (see Appendix K). Of these, 4,240 completed it (8%) and were sent an invitation asking them to complete the second stage two days later; 2,729 completed wave two (see Appendix M), which gave a response rate of 65% between the two surveys.

The average time to complete the survey was 21 minutes for wave one and 23 minutes for wave two; thus the mean time to complete the survey was substantially higher for both waves than the minimum time allowed. Seven percent of the wave one surveys were removed for being completed in less than nine minutes, as were an additional 15% of wave two (respondents were only included in the final sample if they had completed both waves in the required time).

10 Results

The results section is split into three parts. The first is a general analysis and overview of responses from the whole sample. The second introduces the approach to segmentation, details of the analysis undertaken, and a comparison of the sample when split by the identified consumer segments. The third section describes how the consumer segments have been geographically mapped across the UK at the postal sector level.

10.1 Analysis and overview of the whole sample

10.1.1 Age profile

The majority of respondents were between 35 and 75 years of age, with fewest respondents over 75 (Figure 17). The mean age was 46. Whilst these figures are not representative of the UK population, it is expected that they are more representative of the new and nearly-new car buyer population, which is known to be older than average (see Section 2.1.5).

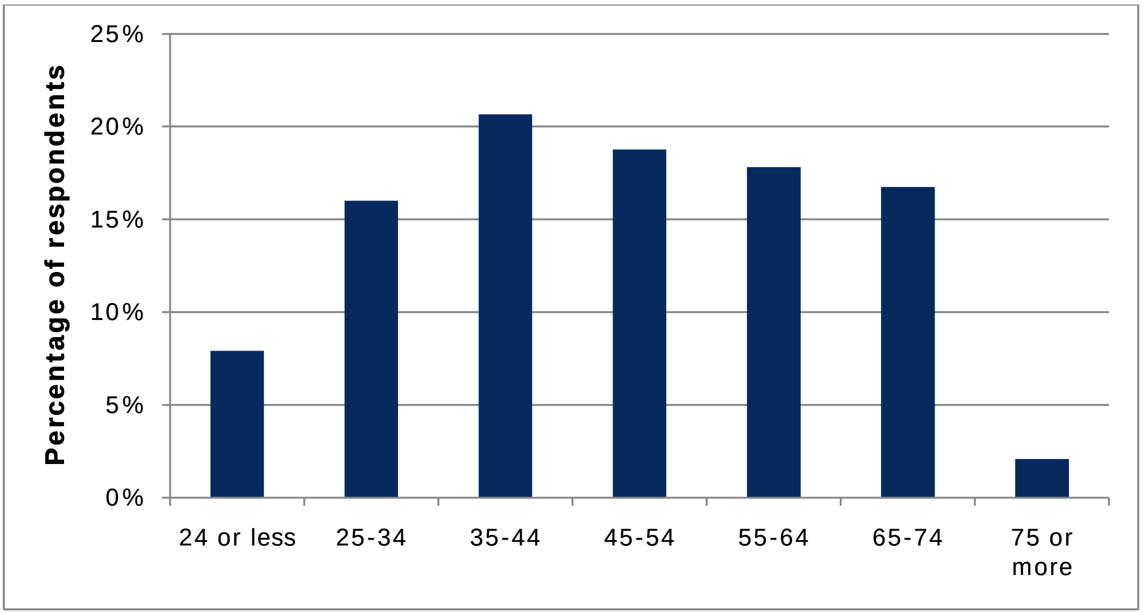


Figure 17: Age profile of respondents (n=2,729)

10.1.2 Gender

The percentage of males and females completing the survey was 48% and 52% respectively.

10.1.3 Household income

Very few respondents had gross household incomes under £9,999 per annum or over £75,000 per annum (Figure 18). The majority of respondents reported a household income between £20,000 and £74,999. Just over ten percent refused to answer this question which in the experience of the project team is typical for a survey of this kind.

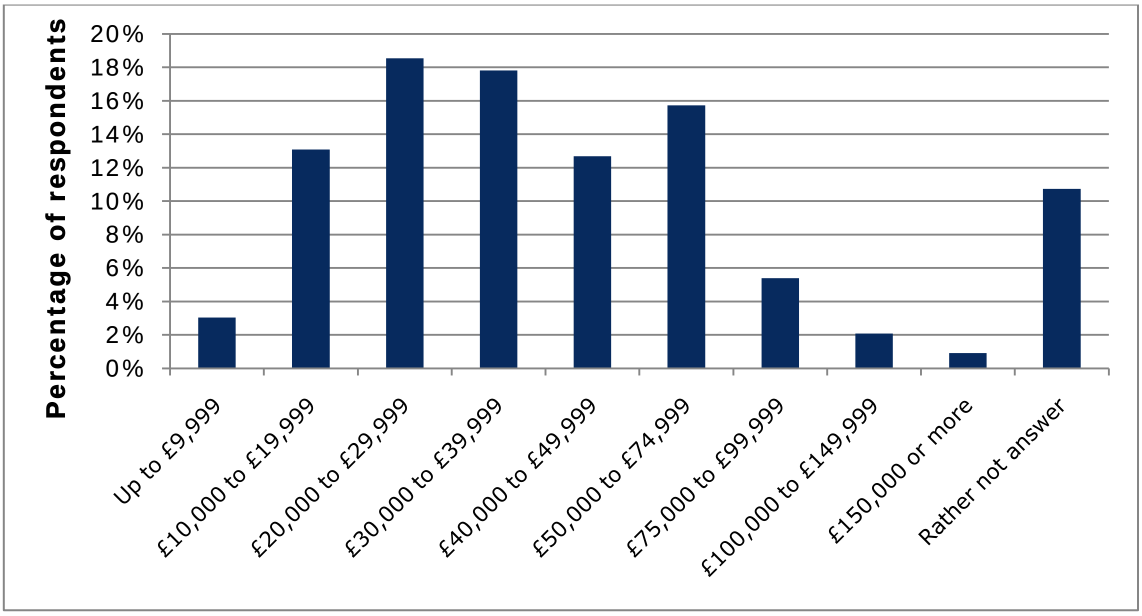


Figure 18: Household annual income profile of respondents (n=2,729)

10.1.4 Car ownership

Reflecting the UK car market, the vast majority of respondents tended to have privately owned cars rather than company cars as shown in Figure 19. Eighty-eight percent of respondents did not own a company car whilst just over 1% did not have a privately owned car. One-car households were the most common (45%) with only 9% owning three or more.

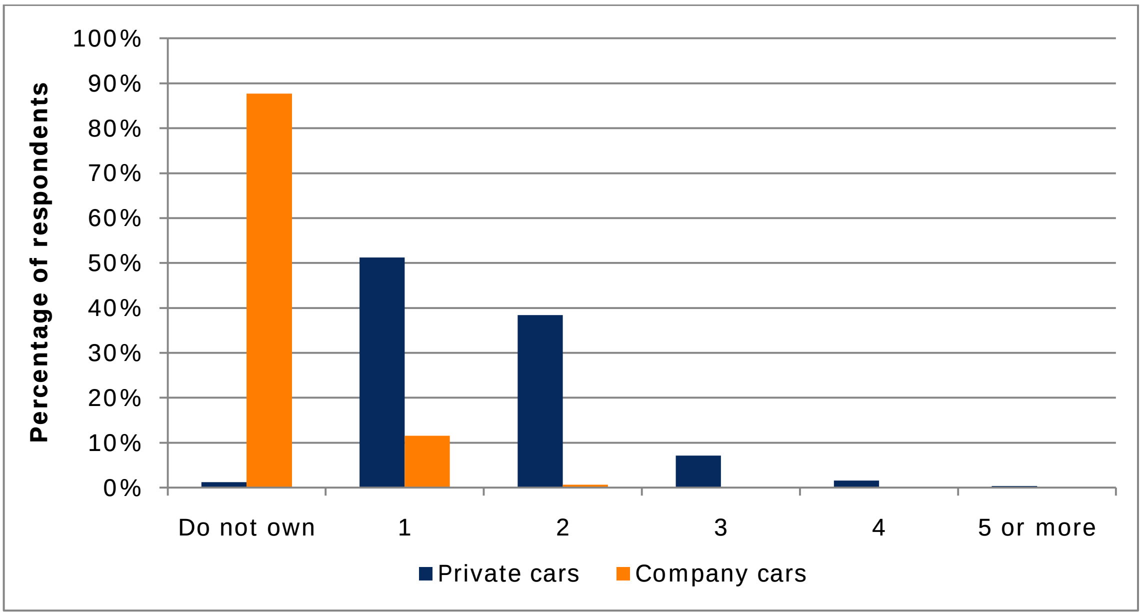


Figure 19: Private and company car ownership in households (n=2,729)

10.1.5 Parking and charging availability at home

Respondents were asked to indicate how many parking spaces they had available off-street (in a garage, driveway/carport or other) and on-street. For the off-street parking they were asked to indicate 'if you had to plug in an electrical appliance to work in this parking space (e.g. a vacuum cleaner), is there an electrical socket within reach?' They could respond to this by saying 'yes, easily', 'yes with an extension cord', 'no' or 'don't know'. Figure 20 shows these data. Overall, just under 80% of households in this sample claimed to have at least one type of off-street parking with some access to a charging point. The proportion of households with off-street parking is greater than the UK average but representative of car-owning households as documented in the English Household Conditions Survey 2007 (Communities and Local Government, 2010).

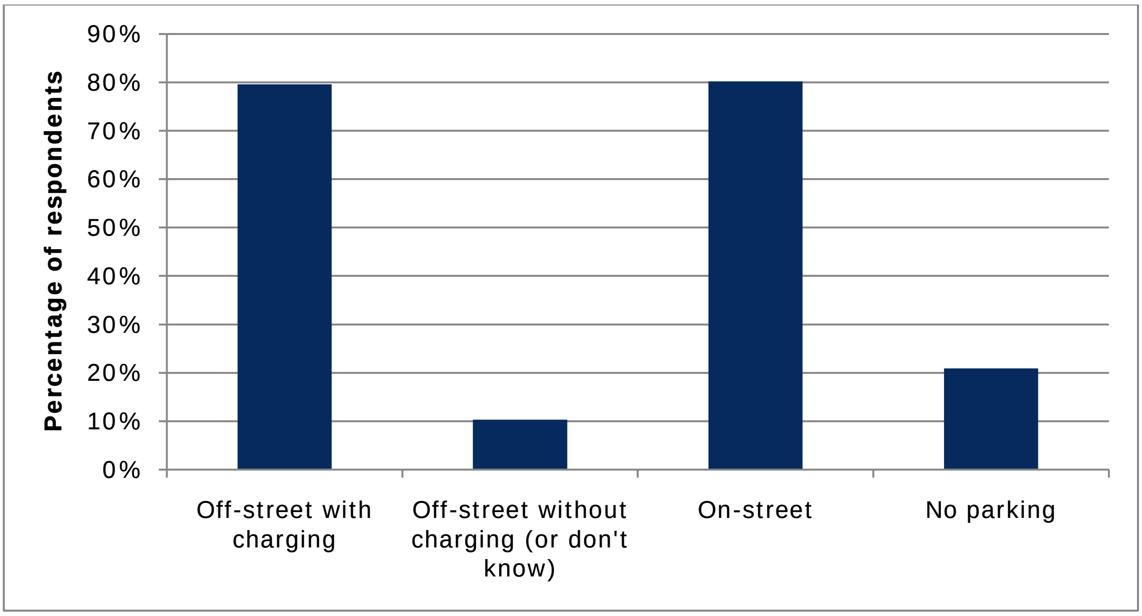


Figure 20: Parking and charging availability at home (n=2,729)

10.1.6 Employment profile

Fifty-six percent of respondents were employed, with a further 9% self-employed as shown in Figure 21. Twenty-three percent of respondents were retired. Similar to the findings reported in section 10.1.1 this is not unexpected due to the propensity for older people to purchase new or nearly-new cars.

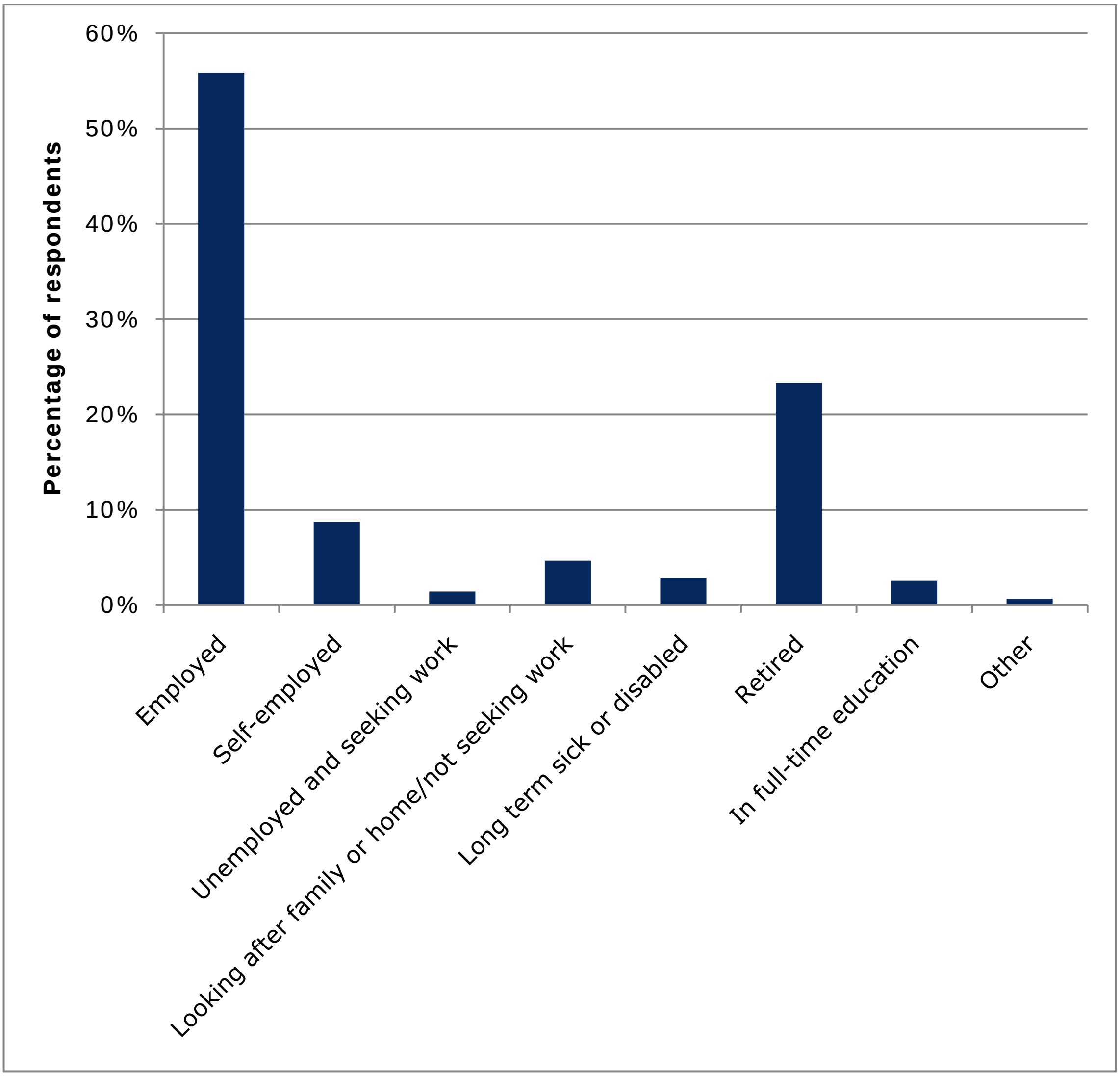


Figure 21: Employment profile of respondents (n=2,729)

10.1.7 Knowledge of EVs

10.1.7.1 Self-reported level of understanding of EVs (before pre-read material)

Before the 'pre-read' information was provided at the end of wave one of the questionnaire the majority of respondents felt uninformed about EVs as shown in Figure 22. Between the two waves of the questionnaires 25% of the participants read information in addition to that provided. The purpose of this split design was to allow information about EVs to transfer into long-term memory and facilitate the kind of (possibly non-conscious) processing that may better represent consumer choice processes in real world purchasing decisions. If respondents chose to supplement the pre-read material with additional information this is considered to reflect real market conditions where some people will choose to inform themselves more than others.

A tiny proportion claimed they had previous experience of a BEV or PHEV as a driver (<1%) or passenger (3-6%). Fourteen percent had some experience driving a standard HEV, with 24% having experience as a passenger.

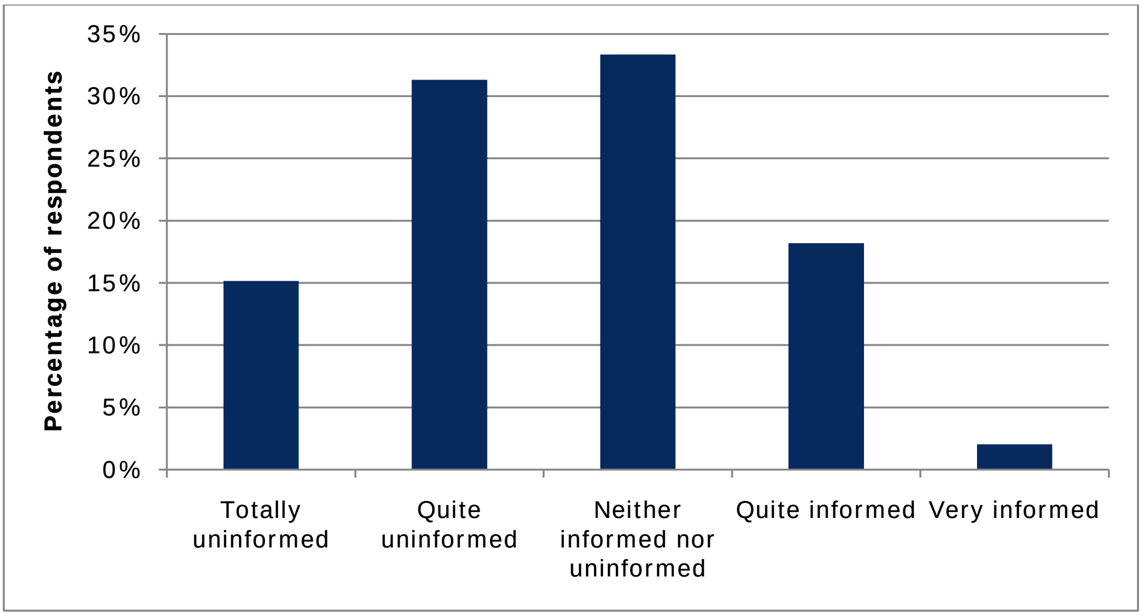


Figure 22: How informed respondents felt about EVs before being provided with the pre-read material (n=2,729)

10.1.8 Level of understanding (after pre-read material)

The qualitative household trial (see Section 6) found that some drivers of the PHEV were concerned about running out of charge, even though in such circumstances the vehicle would continue to run using the internal combustion engine. Information was therefore provided to respondents at the end of wave one of the survey that included how PHEVs operated and how they were charged (see Appendix L). The information included the following statement describing a PHEV: ‘it will keep on running even when it runs out of charge as long as there is petrol or diesel in the tank’.

During wave two, participants were asked to rate their level of agreement on a five-point scale from strongly disagree to strongly agree to the statement ’when driving a plug-in hybrid car, I would be worried about running out of charge‘. The responses can be seen in Figure 23.

As respondents had been provided with the technical information to be able to recognise that this should not be a concern, responses to this statement suggest that either this information was not read, not understood, or that despite the information, running out of charge remains a concern for the majority of respondents.

It is possible that this demonstrates that attempting to address consumers’ anxieties by improving their level of technical understanding will not necessarily address all of their concerns, nor the concerns of all.

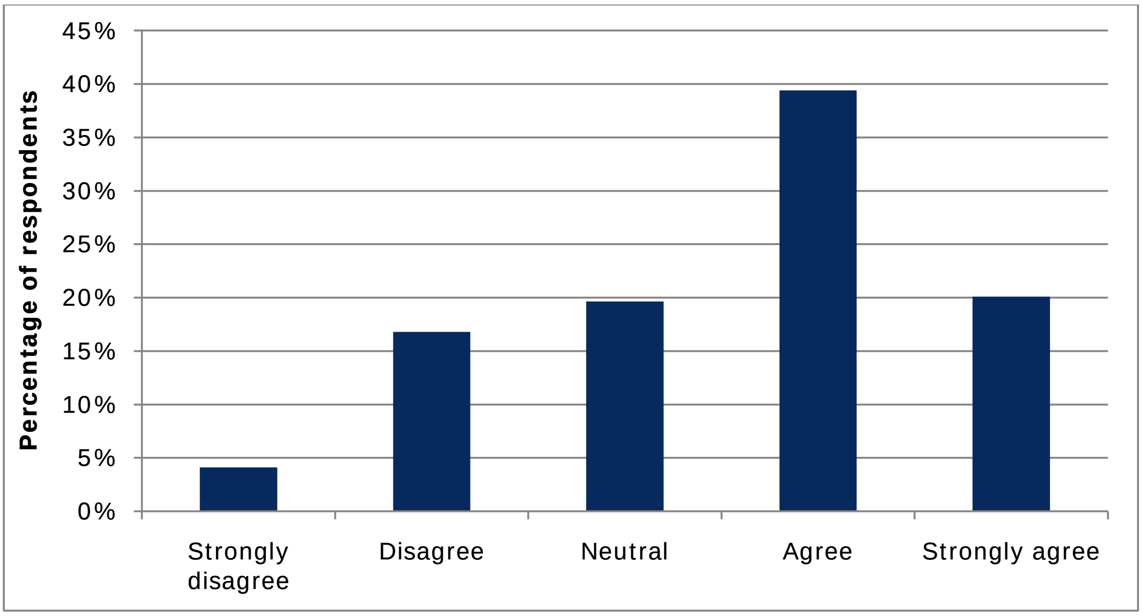


Figure 23: 'When driving a plug-in hybrid electric car, I would always be worried about running out of charge' (n=2,729)

10.1.9 Vehicles used

In addition to the number of company and private cars they had, respondents were asked to give further details (make and model, using a drop-down list) of the cars their household currently used. The vehicle types were re-coded into vehicle classifications as used by The Society of Motor Manufacturers and Traders Limited (SMMT). Figure 24 shows the percentage of vehicles in each segment including the car's status (first, second, third etc.). The number of vehicles in each segment is shown in brackets. For all vehicle statuses category B (small vehicle) was the most common, with the least common vehicle being category F (luxury saloon). This is consistent with data provided by SMMT; 37.2% of the car market in 2009 was category B, and 0.3% was category F (SMMT, 2010). Where respondents had more than one car in their household they were more likely to have a medium family (C) or large family (D) car as their first car rather than additional cars in the household, whilst the small (B) and urban/city (A) vehicles were more common as additional cars.

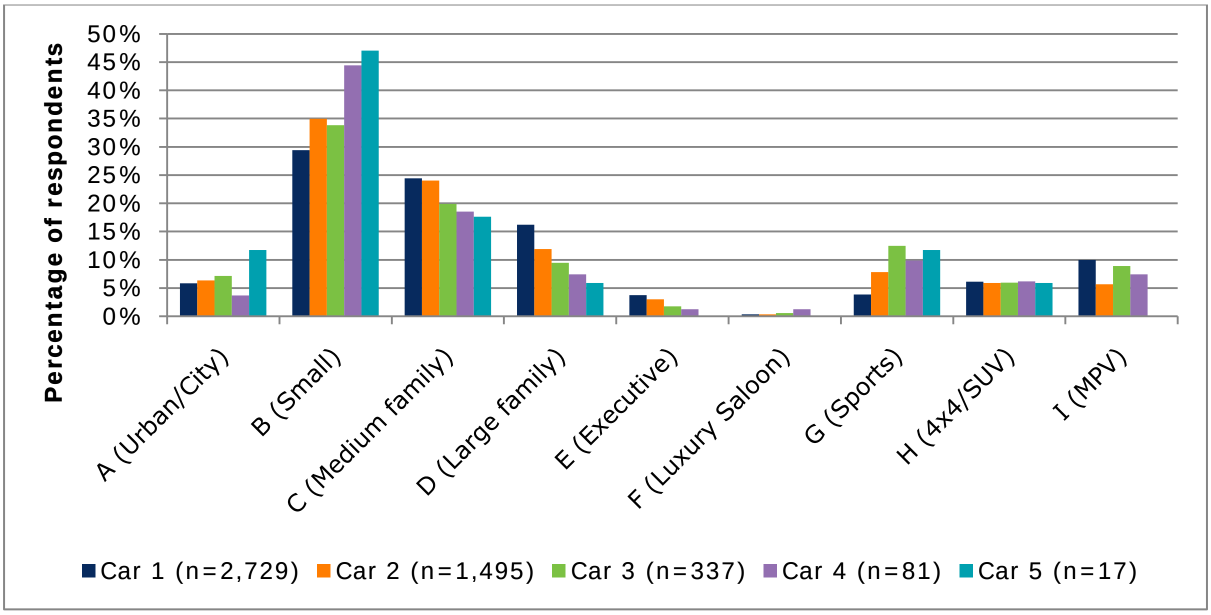


Figure 24: Car ownership by SMMT segment and vehicle status (n=4,739 cars)[12]

As well as being asked about the make and model of their vehicle, respondents were asked what fuel their vehicle used. 1.7% of respondents' vehicles were fuelled by something instead of (or as well as) petrol and diesel. This included biofuel blends, LPG and hybrid vehicles. Hybrid cars made up 0.7% of the cars in the sample.

Respondents were asked to indicate the fuel economy of their vehicle (mpg) and how satisfied they were with this. Sixteen percent indicated they did not know their mpg. Of those that gave an answer, just over half (54%) said they were very or quite satisfied with their fuel economy. However, this differed

[12] Note that the percentages are with respect to the number of respondents who said that they had 1, 2, 3, 4 or 5 cars in their household. For example 29% of the 2,729 'car 1' vehicles and 47% of the 17 'car 5' vehicles were category B (small).

according to the type of vehicle, as shown in

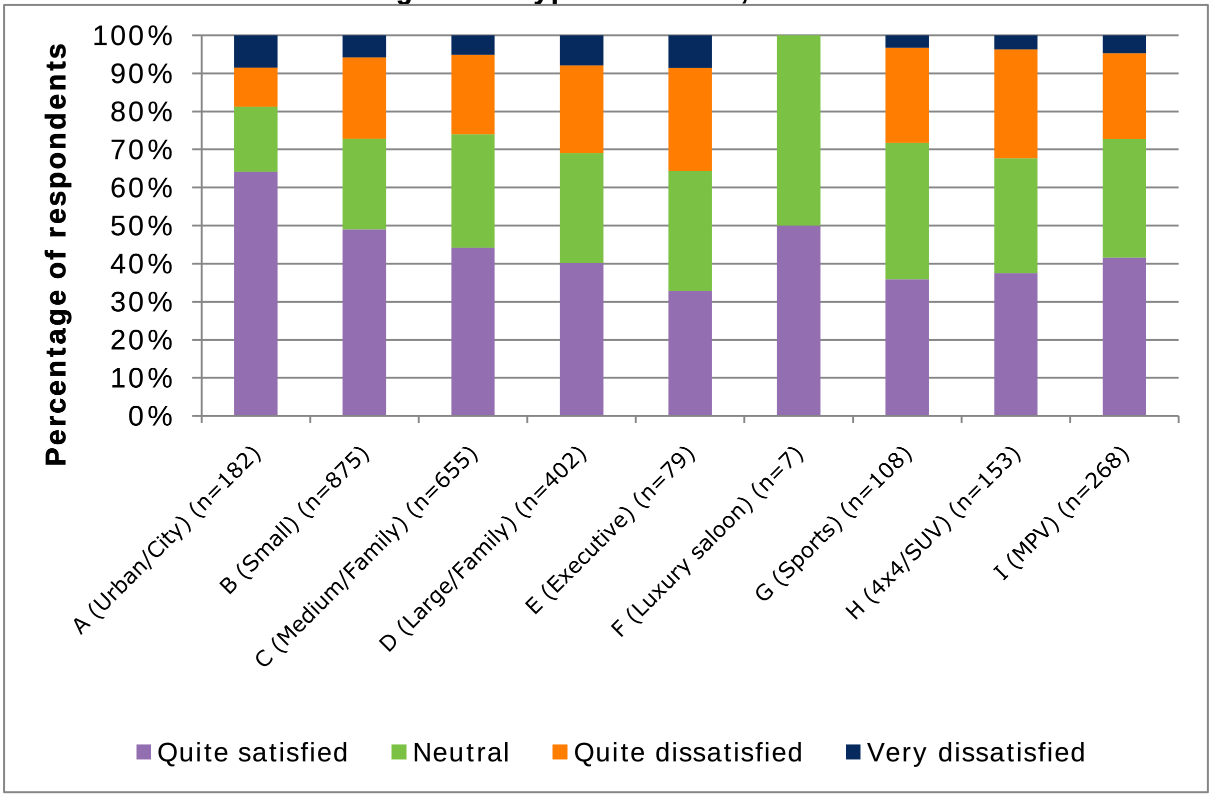


Figure 25. A much larger proportion of those driving urban city cars are very satisfied. The least satisfied are those driving executive vehicles.

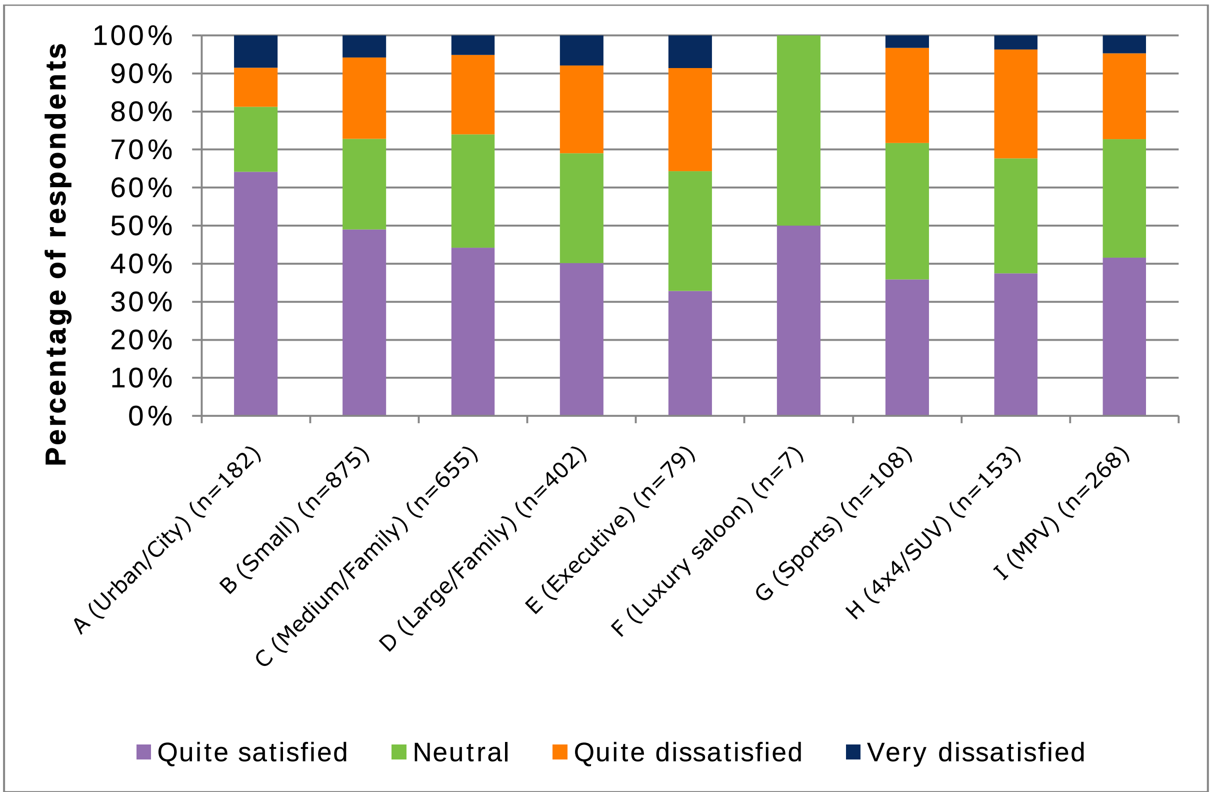

Percentage of respondents
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
A (Urban/City) (n=182)
B (Small) (n=875)
C (Medium/Family) (n=655)
D (Large/Family) (n=402)
E (Executive) (n=79)
F (Luxury saloon) (n=7)
G (Sports) (n=108)
H (4x4/SUV) (n=153)
I (MPV) (n=268)
Quite satisfied
Neutral
Quite dissatisfied
Very dissatisfied

Figure 25: Satisfaction with fuel economy by SMMT segment (n=2,729)

10.1.10 Car purchase decision making factors

Respondents were asked to state which factors were important to them when choosing their car. Ninety-seven percent of the sample claim to have at least equal say in which vehicle is chosen for their household, with some being the main or only decision-maker.

Three text boxes were provided, and respondents were asked to list, in their own words, up to three of the most important factors to them. The total list of 7,624 individual responses were then coded, and the 25 most frequent are shown in Table 28, in descending order (see Appendix G for the remaining factors not in the top 25).

The most frequently referenced factor was purchase cost/value for money, with almost 20% of respondents raising this. This is a similar finding to Mintel (2009) who found that the purchase price was the top-ranked attribute amongst 2,000 car purchasers/intenders. This factor was often mentioned in conjunction with the other costs associated with owning and running a vehicle; when combined, over a third of references made were in relation to costs (purchase price/value for money, economy/running costs, tax, insurance and servicing).

Just under 16% of references were made to ‘doors/seats/size’, for example ‘big enough for two adults and two children but not a huge car’, ‘compact car’, ‘five door hatchback for passengers’, ‘convenience’. This factor is analogous to the ‘size/practicality’ factor which was similarly ranked second by 1,000 respondents in Lane and Banks’ (2010) survey of purchasers/intenders.

Over 13% of references mentioned the running cost of the car, making this the third most frequently mentioned factor. In particular fuel consumption was a common theme. Fuel consumption and running cost were also ranked third in the Mintel (2009) study as well as Angle et al. (2007) (1,020 drivers involved in the car purchase decision).

References to the particular brand or model of the vehicle were made in 10.5% of cases (note that brand loyalty was coded separately). For example ‘the fact that it was made by VW’, ‘wanted a well-known brand’. Angle et al. (2007) found that brand/image/ reputation was ranked fourth. This is a similar finding, although image was ranked separately in the current study, being mentioned in 0.3% of responses.

The fifth most frequently-mentioned factor was comfort/smooth drive, which was referred to in just over 5% of cases, for example ‘comfort of the ride’, ‘comfort for long distance driving’, ‘a smooth drive’. Comfort was ranked fifth in two studies (Angle *et al*. (2007) and GFK (2009; 2,000 purchasers/intenders)).

The remaining factors were each mentioned in under 5% of references, and provide an indication of both cost and non-cost attributes that consumers give consideration to when purchasing a vehicle.

Table 28: Car choice factors

Factor	Examples	No. of references[13]	Percentage of responses
Purchase cost/ value for money	Purchase cost, special offers, part exchange	1,447	19.0%
Doors/seats/size	No. of doors/seats, up/downsizing, preference for smaller or bigger vehicle	1,199	15.7%
Economy/running costs	MPG, overall running costs	996	13.1%
Brand/model	Preference for a particular brand or model, reputation	798	10.5%
Comfort/smooth drive	'Drivability', comfort for driver, smooth ride	398	5.2%
Looks/style	Aesthetics, finish, uniqueness	370	4.9%
Performance	Acceleration, top speed,	255	3.3%
Boot space	Practicality, sufficient space for transporting luggage, pets, golf clubs etc	172	2.3%
Extras/gadgets	In-car entertainment, sat nav, 'toys'	169	2.2%
Safety	Airbags, ABS, N-CAP ratings	169	2.2%
Recommendations/ reviews	Recommended by friends or family, received positive reviews	140	1.8%
Engine size	Preference for large or small engine size	133	1.7%
Reliability	Trust in the vehicle, dependability	107	1.4%
Tax	Cost to tax	88	1.2%
Quality	Build quality, durability	86	1.1%
Colour	Ability to have preferred colour	78	1.0%
Fuel type	Preference for diesel/LPG/petrol fuelled	75	1.0%
Automatic transmission	Preference for automatic	67	0.9%
Handling	Steering, ease of parking, 'nippiness'	69	0.9%
Accessibility	Accessible for disabled/elderly drivers or passengers	66	0.9%
Design	Overall design, shape, weight, simplicity	63	0.8%
Insurance	Cost to insure	62	0.8%
Age/condition	Preference for new/older car, condition of vehicle	56	0.7%
Servicing costs	Servicing included, anticipated maintenance costs, cost of parts	46	0.6%
Convertible/cabriolet/ sport	Preference for car type	45	0.6%
Other	See Appendix G	470	6.2%
Total		**7,624**	**100.0%**

[13] The number of references reflects the number of times each factor was mentioned. Each respondent was given three 'response boxes' and may have mentioned more than one factor per box, e.g. 'style and colour'. Other respondents did not complete this item. It is also possible that a respondent would mention the same factor twice, for example by responding 'value for money' in the first box and 'reduced VAT offer' in the second box; these responses would both be coded as 'purchase price/value for money'. Therefore the total number of references reflects the number of times a factor was mentioned across all respondents, not the number of respondents.

10.1.11 Attitudes towards owning and driving a car

Respondents were shown a number of statements on general attitudes towards owning and running a car, and were asked to show their agreement with each question as shown in Figure 26.

Nearly half of respondents strongly agreed that they could not manage without a car. Only 12% of respondents disagreed or strongly disagreed with this statement. Only 17% of respondents agreed or strongly agreed that if they could they would gladly do without their car. Thus, the respondents in this sample have a high perceived reliance on cars and generally do not indicate that they are interested in reducing this reliance. When asked if they have ‘driven less in the past few years in response to higher fuel prices’ 41% strongly disagreed or disagreed, whilst 35% strongly agreed or agreed. Approximately one third of the respondents felt they had reduced the amount they drive due to increasing fuel prices. Seventy-nine percent of respondents also agreed or strongly agreed that getting good fuel economy out of their car gave them satisfaction.

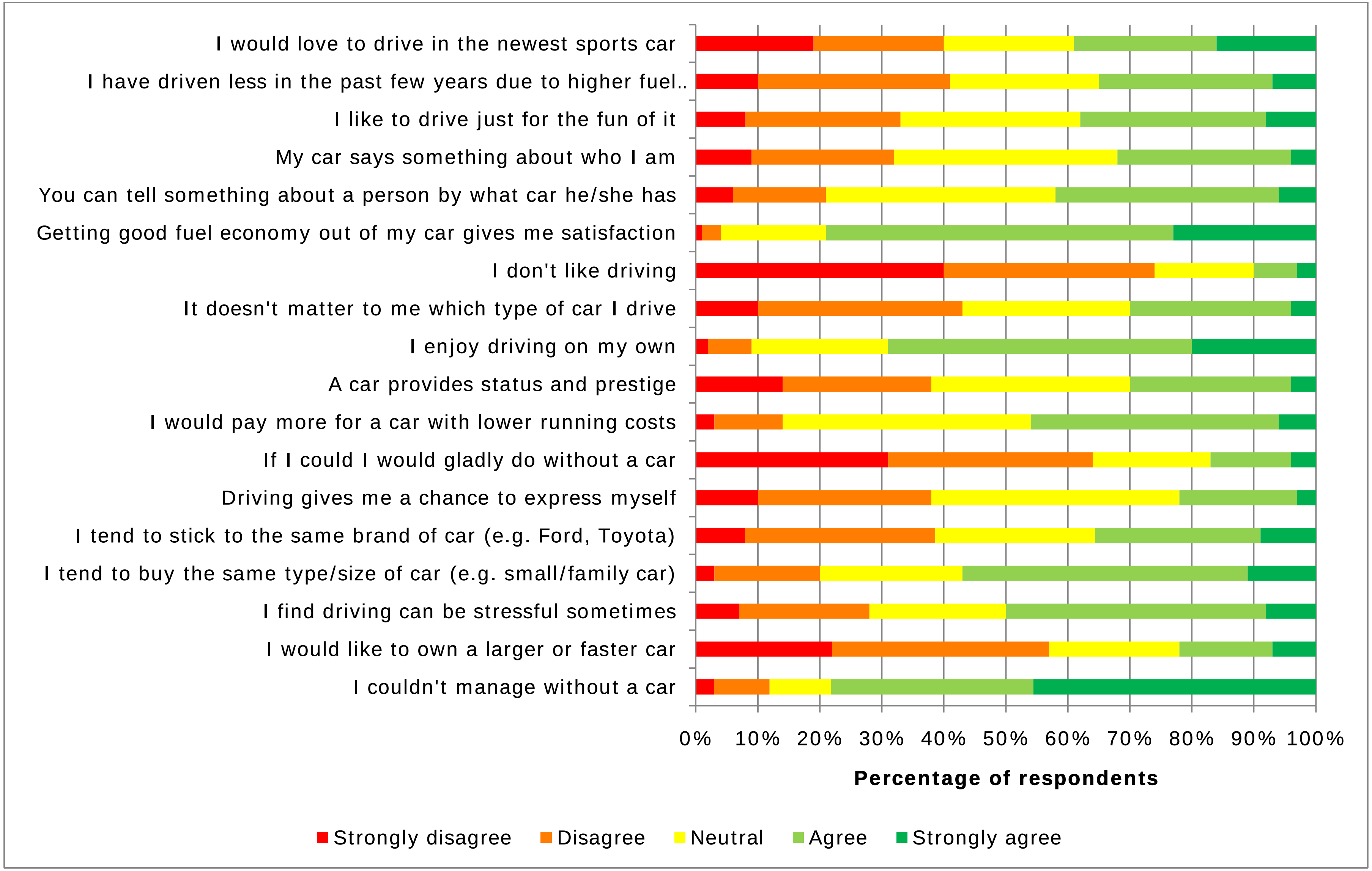


Figure 26: Attitudes towards owning and driving a car

Respondents were also asked about their interest in new technologies and new cars (Figure 27). Forty-nine percent agreed or strongly agreed that they liked to buy new and different technologies, however 67% also agreed or strongly agreed that they were *not* the type of person that needs to have the newest technology. When considering new specifically technology relating to cars, nearly half of respondents were neutral in their response to the statement 'I don't like to be the first to drive cars with the latest technology'; 33% disagreed or strongly disagreed with this statement. Similarly, 49% of respondents were neutral as to whether they would 'prefer [my] car to be powered by something other than petrol or diesel'; 35% of respondents agreed or strongly agreed.

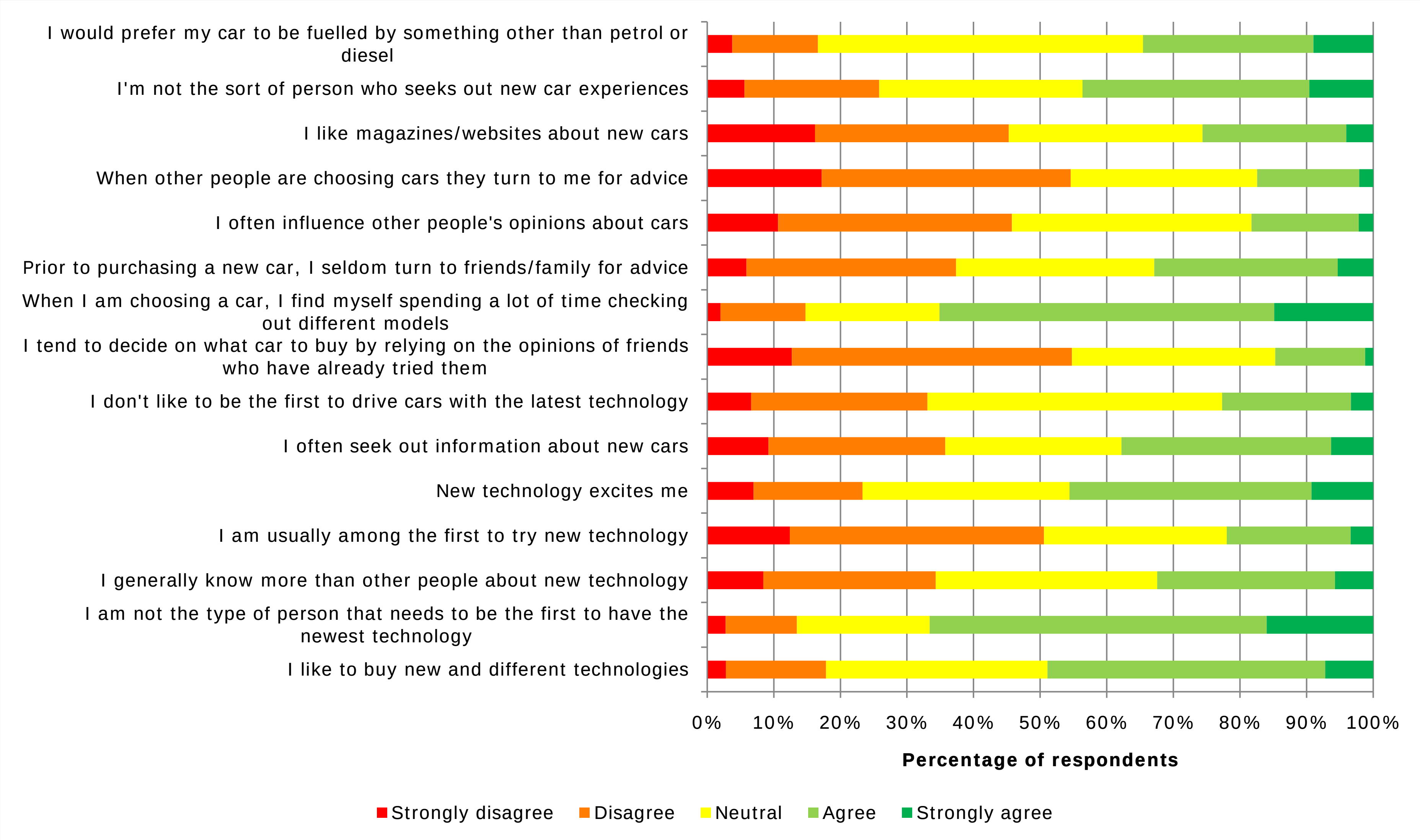


Figure 27: Attitudes towards new technologies and new car technologies

10.1.12 Typical mileage

Respondents were asked to enter their typical car driving mileage on a weekday and at the weekend in open text boxes. There were some respondents who entered large figures that were more consistent with annual mileage; an upper limit was therefore devised. The upper limit was calculated based on a person driving for 8 hours per day at 70 mph (i.e. 560 miles per day). Anything above 560 miles per day was deemed unrealistic as a typical daily mileage, even when driving for work, and respondents who stated mileages above this limit were removed from the analysis. Figure 28 shows the proportion of remaining respondents who drive within the derived mileage bands on weekdays and weekends.

Sixty-nine respondents stated that their typical weekday mileage was zero and 86 said that their typical weekend mileage was zero. Fifty-six percent of respondents reported typically driving less than 30 miles per day during the week, and 58% drive less than 30 miles per day at the weekend. Conversely, 12% of respondents report typically driving more than 100 miles per day during the week, and 8% drive more than 100 miles per day at the weekend.

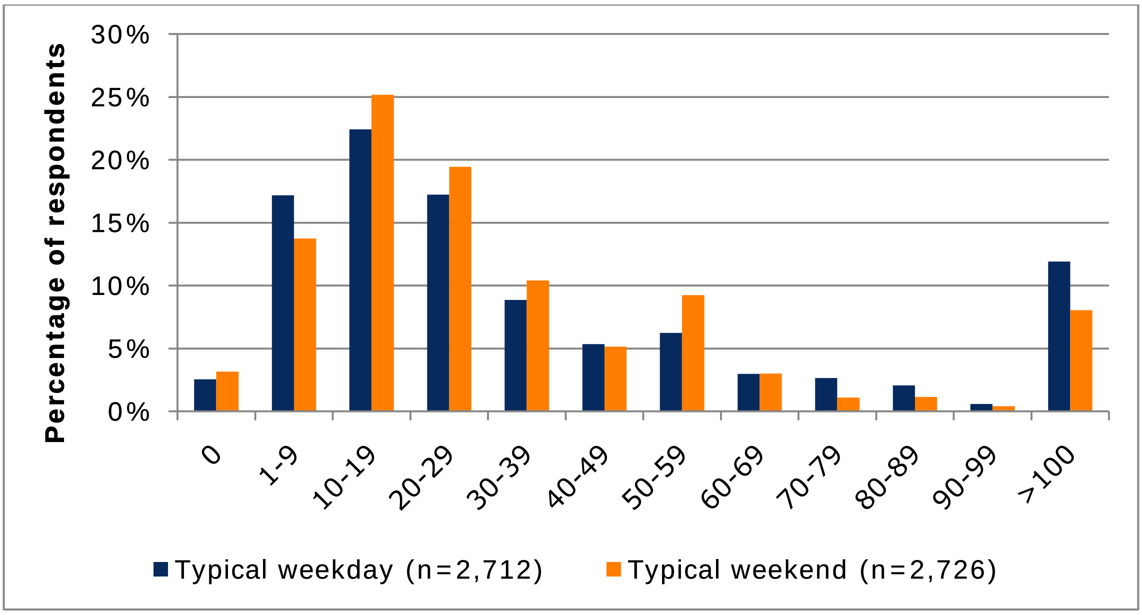


Figure 28: Typical weekday and weekend mileage (per day)

10.1.12.1 Commuting

Respondents were asked if they commuted to their workplace by car. Fifty-four percent (N=1,474) used their car to commute to their workplace. These respondents were asked how many days per week they commuted by car and the proportion by number of days can be seen Figure 29. Unsurprisingly, the majority of commuters used their car to commute for five days of the week, with 33% of commuters commuting by car for fewer days than this. Eight percent of respondents who commuted to work used their car to commute for six or seven days of the week.

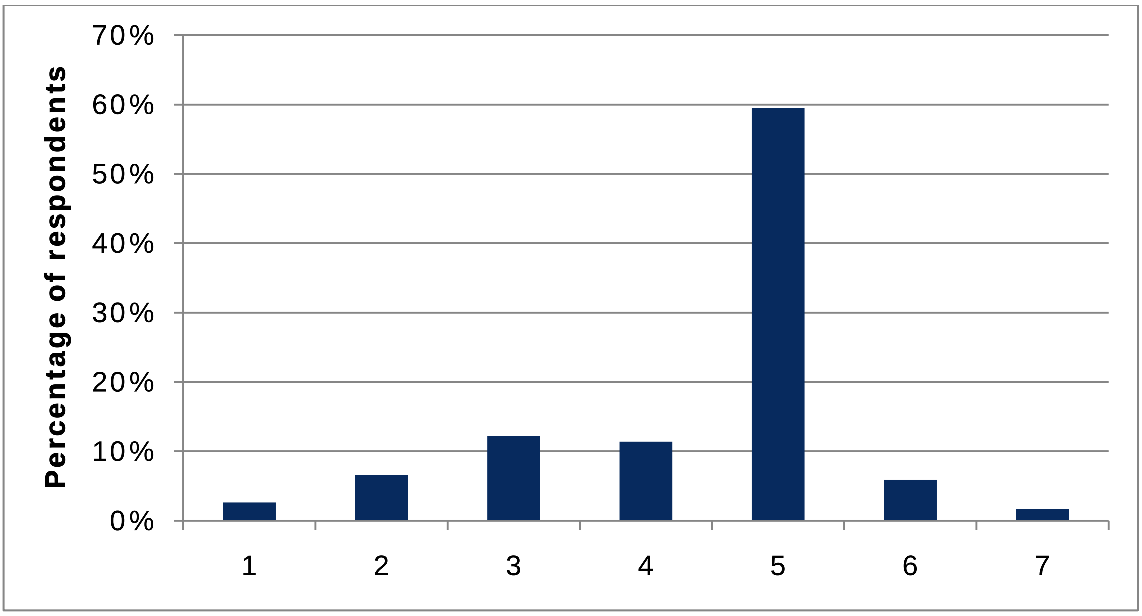


Figure 29: The number of days that car commuting respondents (N=1,474) drive to work

10.1.12.2 Drive for work?

Respondents who said they commuted by car were asked what proportion of the mileage is carried out on business trips. This did not include driving to and from work. Table 29 shows the results of this question; 38.5% of respondents did no driving for work, with 4.1% doing over 80% of their driving for work.

Table 29: What proportion of the mileage you drive in your car is carried out on business trips?

	Frequency	Percent
None	568	38.5
1-20%	391	26.5
21-40%	173	11.7
41-60%	135	9.1
61-80%	149	10.1
81-100%	61	4.1

10.1.13 Type of driving

Very few respondents considered themselves as mainly an out-of-town or motorway driver. Most respondents either saw themselves as mainly a town/city or urban driver, or someone who drives fairly equally around town and out-of-town, with an even split between the two categories, as shown in Table 30.

Table 30: Which one of these would you describe yourself as?

	Frequency	Percent
Mainly a town/city/urban driver	1,146	42.0
Mainly an out-of-town/motorway driver	436	16.0
Someone who drives fairly equally around town and out-of-town	1,147	42.0

10.1.13.1 Other use

To understand where respondents mainly relied on the use of the car, they were asked to rate which of a number of options they would miss the most if they did not have a car in their household (Table 31). The ability to get to work was the most frequent response (34.3%) followed by shopping (25.1%). Taking the children to school (2.8%) and carrying out business trips (4.7%) were the least frequent.

Table 31: What would you miss the most if you did not have a car in the household?

	Frequency	Percent
Ability to get to work	937	34.3
Ability to go shopping	685	25.1
Going to leisure activities	446	16.3
Visiting relatives	321	11.8
Going on holiday	136	5.0
Ability to carry out business trips	128	4.7
Taking children to school	76	2.8

10.1.14 Likelihood to choose a BEV or PHEV

Thirty-three percent of respondents say they are likely to choose a PHEV and 13% a BEV as a main car in the next five years. From Figure 30 it can be seen that respondents' reported likelihood of adopting a PHEV as both a main and second car increased between wave one and wave two, as it did for BEV as a second car; however respondents' reported likelihood reduced slightly for BEV as a main car.

The segmentation analysis in section 10.2 considers the likelihood to choose a BEV or PHEV in relation to demographic and attitudinal factors in more detail.

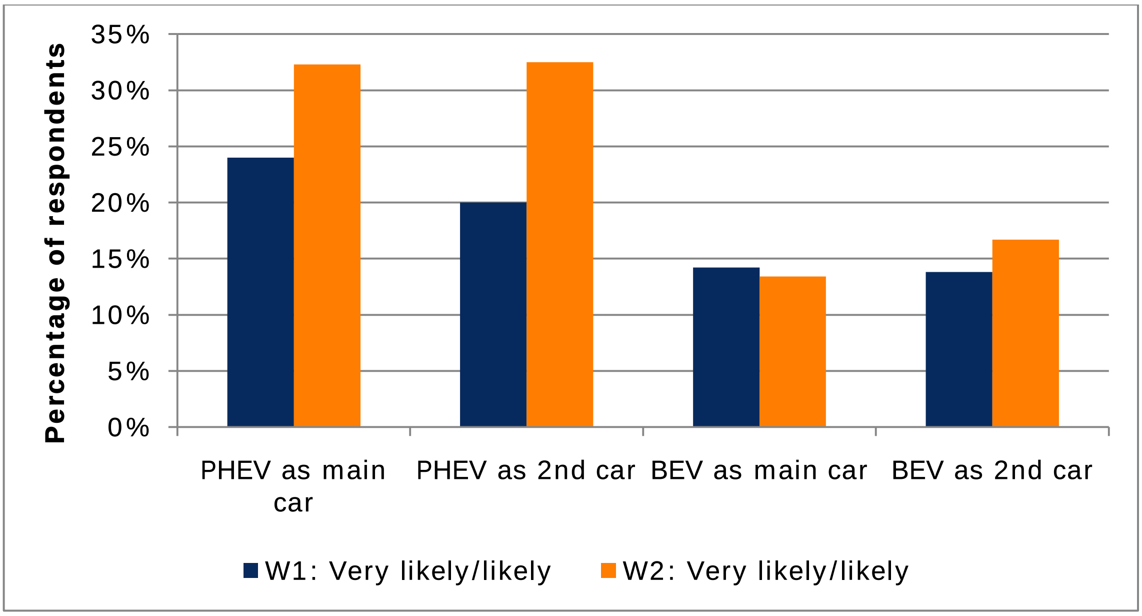


Figure 30: Percentage of respondents likely or very likely to buy an EV in the next five years (n=2,729)

Figure 30 is an aggregate picture of the likelihood to adopt which, in each case, is the net result of a proportion of people increasing their likelihood and a proportion reducing it. Figure 31 shows that opinions were generally not static across the waves with, for each car type, over 50% of the sample changing their evaluation either up or down in each case.

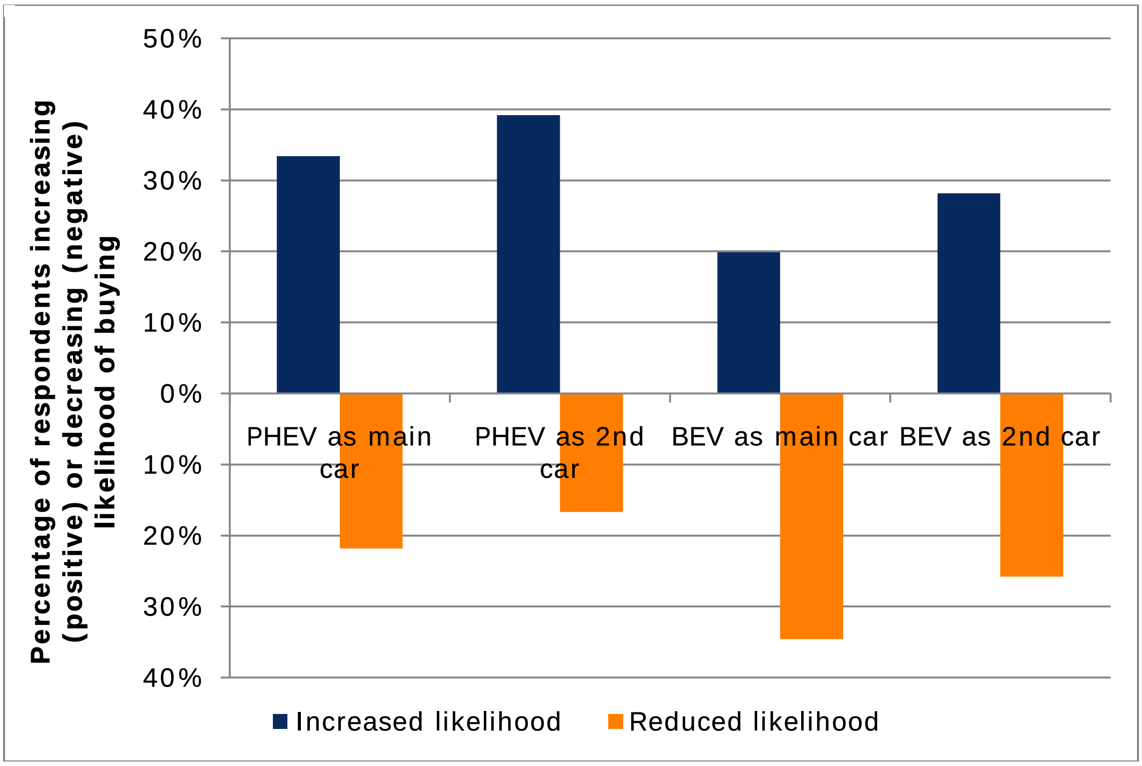


Figure 31: Percentage of respondents reducing or increasing their likelihood to buy between wave one and two (n=2,729)

10.1.15 Policy incentives

Respondents were asked how much more likely they would be to purchase an EV based on the availability of different incentives. Figure 32 shows that a Government grant would be the incentive that would most encourage participants to purchase an EV, followed by extended warranties for battery performance with exemption from congestion charges, and reduction in company car tax encouraging them the least.

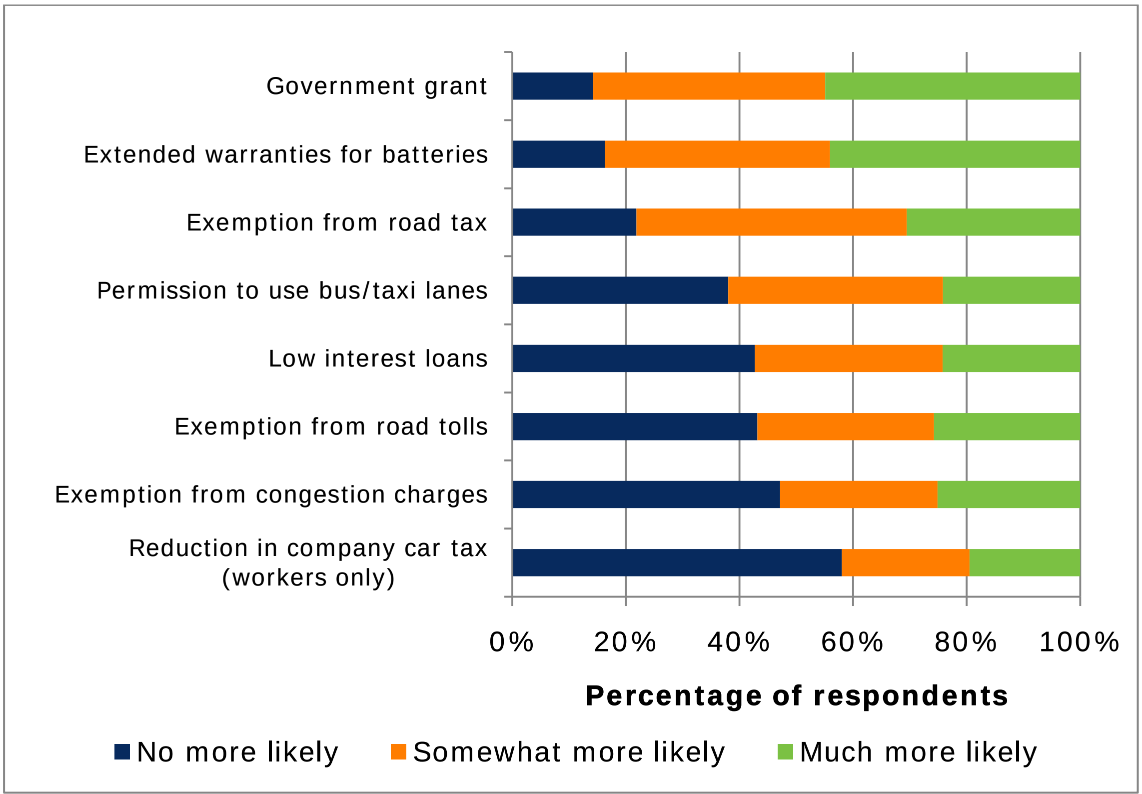


Figure 32: Additional likelihood of purchasing an EV with different incentives (n=2,729)

However, it should be borne in mind that respondents were asked to complete this question in relation to how likely they had said they were to adopt PHEVs or BEVs. From a policy perspective, it is necessary to understand whether incentivisation will attract more buyers to market or will essentially benefit those that would have purchased a vehicle anyway without the incentive. In order to examine this, respondents were split in to two groups for each car type (very likely/quite likely to adopt or very unlikely/quite unlikely to adopt) and the proportion who agreed that an incentive would make them even more likely was calculated. The results can be seen in Table 32 and reveal that all of the policy measures are likely to have much less of an impact on people who start off from a position of saying they are unlikely to adopt, but the relative influence of measures (i.e. the fact that Government grants and extended warranties are the most popular) is the same, regardless of the starting point.

Table 32: Relative influence of different policy incentives according to 'original' likelihood to adopt

% saying adoption would be much more likely if there was/were…	Unlikely/very unlikely to adopt		Likely/very likely to adopt	
	PHEV	BEV	PHEV	BEV
A Government grant	26	36	68	77
Extended warranties for battery performance	26	35	66	77
Exemption from road tax	16	23	50	62
Higher fuel costs for petrol and diesel cars	14	19	47	48
Priority lanes	13	18	41	52
Low interest loans	12	16	41	52
Exemption from road tolls	13	18	43	55
Exemption from congestion charges	14	18	42	56

10.1.16 Cost of charging

Respondents were asked how the cost of charging an EV would impact on their likelihood of adopting an EV. Over 50% of respondents thought that if the cost of electricity from public charging points was the same as petrol or diesel then they would be less likely to adopt an EV. When the cost of electricity from public charging points dropped to half as much as petrol or diesel, then just over 10% said they would be less likely to adopt an EV; 65% of respondents, however would be more likely to adopt a vehicle in this circumstance, increasing to 84% if the electricity from public infrastructure was free.

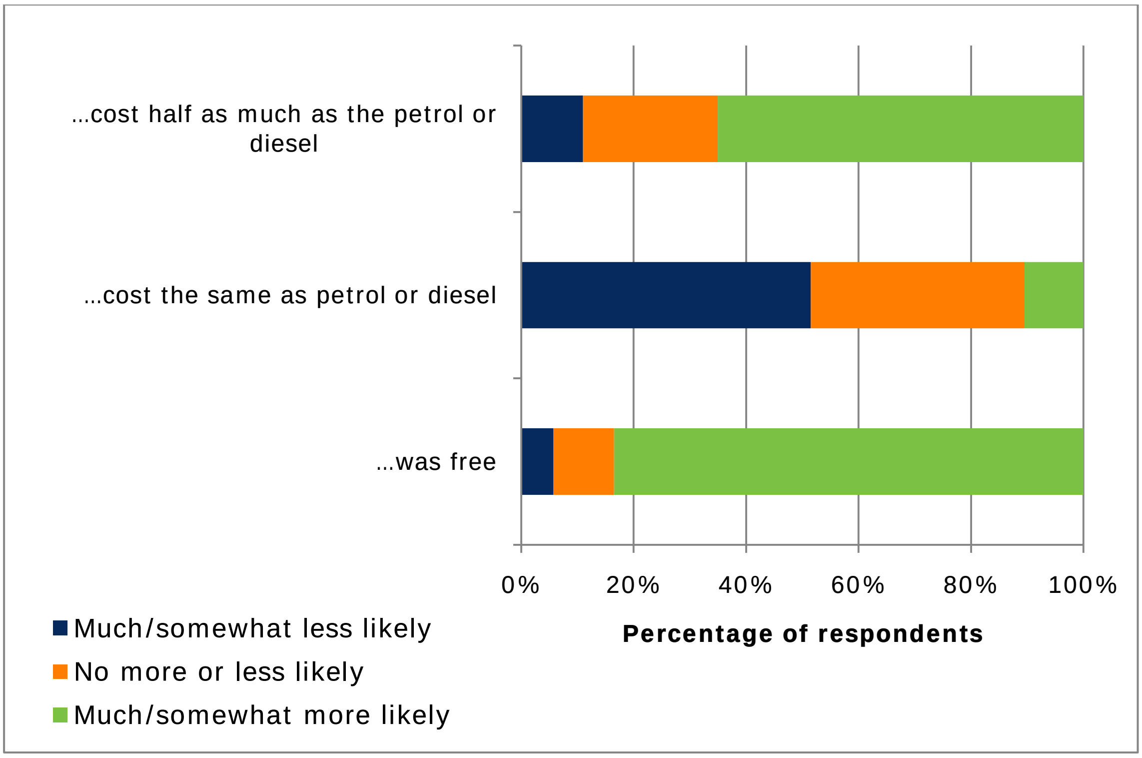


Figure 33: Change in likelihood of buying a plug-in car based if the electricity from public charging points...

10.2 Segmentation

The identification of segments from the data requires a number of stages with some iteration between them. The detail of the decisions taken in each of these stages, including variables used and statistical output, is described in Appendix P. Here we summarise the various stages prior to the profiling of the segments.

10.2.1 Step 1: Data reduction

Various statistical techniques (primarily linear regression, Analysis of Variance or 'ANOVA', and bivariate correlations) were used to understand the relationship between the demographic and attitudinal variables on the questionnaire and the self-reported 'likelihood to adopt' a BEV or a PHEV in the next five years (as a main or a second car).

In doing so, the attitudinal variables on the survey were subjected to factor analysis in order to reduce the variables to a smaller set of underlying dimensions or psychologically meaningful constructs (see Appendix N for full details of the factor analysis). In factor analysis, variables that show similar patterns of variation across respondents are assumed to be associated with the same underlying construct. The factor analysis led to the 106 attitude statements (each measured on a five-point scale (usually strongly agree to strongly disagree)) being reduced to 15 factors. Table 33 outlines these dimensions.

Table 33: Factor variables derived from the original attitude statements

Factor	Interpretation
EV Positives	Belief in environmental and general benefits of BEVs/PHEVs
EV Openness	Desire for oil independence and excitement about EV technology
BEV Anxieties	Concern about some practical aspects of BEVs (e.g. range anxiety)
PHEV Anxieties	Concern about some practical aspects of PHEVs (e.g. range anxiety)
EV Willingness to pay	Willingness to pay more for EV technology and environmental benefits
EV Infrastructure	Desire to wait for rapid charging infrastructure
EV Instrumental	Belief in reliability and economy compared to 'normal' cars
EV Symbolic	Embarrassment/pride in owning and driving an EV
EV Affect	Beliefs about performance and driving experience of EVs
Environmental identity	Concern for and identity with environmental issues
Innovativeness	A desire to own and be seen with the latest technology
Car Authority	General car enthusiasm/self-proclaimed knowledge about cars
Car Symbolism*	Belief that cars are an expression of personality and status
Driving Affect*	General enjoyment of driving and emotional aspects
Car Loyalty*	Tendency to stick to the same brand and size/type of car

*not taken forward into the cluster analysis. See Step 2 for an explanation

These factors are a very valuable set of internally consistent constructs to be used in further analyses to understand consumer perceptions and motivations. In addition, a few attitude statements did not load on to any of the factors but stand alone as single item measures of specific issues. These included:

- PHEV Identity – whether a person feels they know many other people who are the type to adopt one of these vehicles
- BEV Identity – whether a person feels they know many other people who are the type to adopt one of these vehicles
- Perceived parking difficulty – perceived ease or difficulty of finding somewhere to park and charge at home
- WTP fuel savings – the willingness to pay for low fuel costs
- Safety – perceptions of safety of EVs for driver and passengers*
- BEV noise – perceptions of safety of EVs for those outside the car*

[* not taken forward into the cluster analysis. See Step 2 for an explanation]

10.2.2 Step 2: Understanding the antecedents of EV adoption

The task then remained to identify which variables to take forward using cluster analysis (see step 4). Choosing the variables along which to group observations is the most fundamental step in the application of cluster analysis and thus perhaps the most important. Segmentation works best using a small number of highly relevant and discriminating variables. As cluster analysis derives the most internally consistent groups across all variables, irrelevant variables can cause deterioration of a solution's validity.

In order to have the best chance of identifying meaningful segments that varied in terms of their likely adoption of EVs, the strongest antecedents of the likelihood variables needed to be understood.

In summary, all of the factors included in Table 33 except for the last three (Driving Affect, Car Symbolism and Car Loyalty) plus four out of the six attitude statements (excluding the last two relating to safety) were found to be consistently significant predictors of likelihood of adoption across PHEVs and BEVs whether for a main or a second car. These 16 variables were the ones used in the cluster analysis described in Step 4.

10.2.3 Step 3: Extracting a-priori segments

In order to create meaningful subgroups for the purposes of understanding and modelling EV uptake, a hybrid approach was used which combined the extraction of groups in advance of the statistical analysis—*a priori* segments—with those created *post-hoc* using statistical segmentation. The two groups formed *a priori* were company car drivers and niche innovators, described in Sections 10.2.3.1 and 10.2.3.2.

10.2.3.1 Company car drivers

Those respondents who indicated that their ‘main car’ (the household car driven most often) was a company car were separated from the main sample. Although mostly having access to other household cars (as will be discussed), the decision-making factors influencing company car adoption are likely to be different from private consumers, with different priorities and patterns of use. Thus, this group formed a distinct segment.

This procedure identified a cluster with 216 respondents. These were given the label of ‘Company Car Drivers’.

10.2.3.2 The earliest adopters/ niche innovator group

As indicated above, identifying the equivalent of Rogers’ earliest adopter group (the ‘Innovators’) is crucial to understanding how the market will begin to develop. By definition, this is a small group and it proved challenging for it to emerge statistically using cluster analysis, despite various attempts using a number of different clustering algorithms. This is likely to be because the members of this subgroup represent outliers and were insufficiently covered by the sampling procedure used, despite an attempt to oversample innovators as defined by the Rogers scale. As we shall see, the measure of innovation is not the only characteristic which defines this group.

Consequently, this niche segment was extracted *a priori* using a number of known criteria that define such a group (e.g. high income) and from the exploratory analysis found to be the key determinants of likelihood (namely willingness to pay more for a BEV/EV) as well as scores on the likelihood variable itself. The respondents were extracted using the set of criteria outlined in Figure 34.

EARLIEST ADOPTER SELECTION CRITERIA:

Income >£40k

AND

VERY likely to adopt a PHEV and/or BEV as a main and/or second car in the next five years

AND

I would be prepared to pay more for a plug-in hybrid electric car than a normal car = strongly agree

AND/OR

I would be prepared to pay more for a plug-in fully electric car than a normal car = strongly agree

AND/OR

I would be willing to pay more for a car if I knew it was less harmful to the environment = strongly agree

AND/OR

I would pay more for a car with lower running costs = strongly agree

Figure 34: Criteria used for identifying earliest adopters

This procedure identified a cluster with 48 respondents. These were given the label of 'Plug-in Pioneers'.

10.2.4 Step 4: Cluster analysis

The cluster analysis phase represents the test of whether the respondents fall into naturally occurring groups on the basis of their attitudes towards EVs, car ownership and the environment.

Cluster analysis is the name for a group of multivariate techniques and is the most frequently used method of segmenting a market. Without making any prior assumptions about the important differences within a population, it identifies homogenous groups of respondents according to their similarity on any number of combinations of variables. It does this by maximising the differences between groups whilst simultaneously minimising the differences within a group on the variables used.

Like factor analysis, however, the procedure presents a complex challenge requiring several methodological choices that determine the quality of the final solution. A combination of two types of method has been used in this analysis. A hierarchical method is used first in an exploratory 'structure-seeking' phase to create solutions and cluster centres, followed by the iterative partitioning method (K-means) to 'fine tune' the analysis. Whist being more time consuming, research has shown that this two stage approach increases the validity of solutions (Ketchen & Shook, 1996; Punj & Stewart, 1983). Details of the exact bases, classification algorithms and validation procedures used in this study to choose the optimum number of clusters are provided in Appendix P.

10.2.5 Step 5: Interpretation and profiling

The ultimate test of a set of clusters is its usefulness. Usefulness is defined here as the ability of this process to shed light on the characteristics of consumers most likely to adopt a plug-in vehicle and their motivations, psychological processes, response to incentives and obstacles to this behaviour.

The cluster analysis concluded that six relatively stable groups could be identified. By virtue of the clustering procedure and its use of attitudinal variables mainly created by the factor analysis, each of these clusters has a unique psychographic profile. However, the main objective of this analysis is not only to highlight the unique features of each cluster with respect to the attitudinal variables used to create them, but to assess whether these attitudinal groupings have any predictive value with respect to the likely adoption of EVs. This involves describing the characteristics of each cluster in order to explain how they vary on relevant dimensions as follows:

- likelihood of adoption;
- personal and household characteristics;
- current car ownership;
- travel behaviour characteristics;
- attitudes towards charging infrastructure and range;
- knowledge and experience of EVs;
- instrumental attitudes;
- affective attitudes;
- symbolic factors;
- personality and innovativeness;
- response to incentives; and
- where they might live (geographical analysis)

10.2.6 Statistical approach and reporting

The remainder of this section is structured to profile the segments according to each of these areas in turn. However, before turning to the analysis, a few notes on the approach to the analysis and interpretation are necessary.

Firstly, Table 34 outlines the main statistical tests used in this report:

Table 34: Definition of statistical tests used in this report

ANOVA	F	Analysis of Variance: a test of statistical significance of the overall differences among mean scores of two or more groups on one or more variables. (It is an extension of the t-test which can handle only two groups or two conditions.) Involves computing the F-ratio of the variance between groups to the variance within the groups.
Chi Square	X^2	For most cross-tabulations/categorical data the test statistic is the traditional Chi Square. The larger the observed frequency is in comparison with expected frequency, the larger the Chi Square statistic and the more likely it is that the difference between the expected and observed frequencies is statistically significant.
Post-hoc tests		The Chi Square and ANOVA tests tell you whether at least one group differs from at least one other group. However, if there are more than two groups, the Chi Square and ANOVA tests do not pinpoint where the significant differences lie, i.e. between which specific group(s) and which other group(s). For Chi Square tests, where categorical data cannot be turned into interval data (e.g. education levels, types of car ownership) it is only possible to say whether there is a significant difference between observed and expected values, and not precisely how this difference manifests. For ANOVA tests, it is possible to carry out a 'test of multiple post-hoc comparison' in order to detect whether all the groups differ from one another or whether there is simply an 'odd one out'. The tests used are outlined in Appendix P.
Correlation Coefficient	r	Measures the degree to which two variables (e.g. A and B) are related. It ranges from –1 to +1. The greater its magnitude in either direction, the stronger the relationship is. A positive sign implies that the relationship is positive (that the higher is A, the higher is B) and a negative one that the relationship is negative (the higher is A, the lower is B). A correlation coefficient of 0 means that there is no relationship between the variables. Usually, in behavioural analysis, correlations in the range of 0.3 to 0.5 are considered to be of moderate magnitude and correlations exceeding 0.5 indicate strong relationships.
Cluster Analysis		Multivariate technique which finds associations between observations. It seeks to identify homogenous subgroups of cases in a population such that the statistical variance among the elements grouped together is minimised while between groups is maximised.
Cronbach's Alpha	α	A measure of internal reliability or consistency of variables in a scale. It ranges from 0 to 1. Scores toward the higher end of the range (e.g. above 0.70) suggest that the items in an index are measuring the same thing. (Also called coefficient alpha.)
Degrees of Freedom	*df*	Tells you how many data have been used to calculate a particular statistic and is usually 1 less than the number of variables.
Factor Analysis		Multivariate technique allowing a reduction of variables into a smaller number of variables. A group of highly intercorrelated variables is a factor.
Statistical Significance	*p* NS	Tells how significant the relationship in the model is – if less than 0.05 ($p<0.05$), the relationship is considered to be significant at the 95% confidence level and if it is less than 0.01 ($p<0.01$) it is considered significant at the 99% level.

Secondly, it is important to note that the results of the tests of significance (Chi Square and ANOVA) and the significance levels are not reported within the main text but are instead detailed in Appendix P. However, unless otherwise stated, the differences commented on between the segments are only reported where these are statistically significant, unless the absence of a significant result is noteworthy in itself. The use of the word 'significant' in the text only relates to statistical significance at the $p<0.05$ level or greater – i.e. where we can be 95% confident that such a difference has not occurred due to natural variability in the data.

Finally, as noted above, the Plug-in Pioneers are a niche group with a small sample size (N=48, 1.7% of the sample). Whilst statistical tests are undertaken where appropriate to understand whether the differences between the segments are likely to have occurred for reasons other than natural variability in the data, the small sample size of this group should result in caution being applied to the findings as they relate to this group.

10.2.7 Understanding the EV consumer segments

This section describes the detailed profiling of the segments, structured according to different sections on the questionnaire and conceptual components such as their likelihood to adopt, current travel behaviour and instrumental, symbolic and affective motives.

10.2.8 Summary segment profiles

The *a priori* identification of the Plug-in Pioneers and Company Car Drivers combined with the *post-hoc* identification of remaining segments using cluster analysis, resulted in the identification of eight distinct segments. Their relative size and indicative labels can be seen in Figure 35.

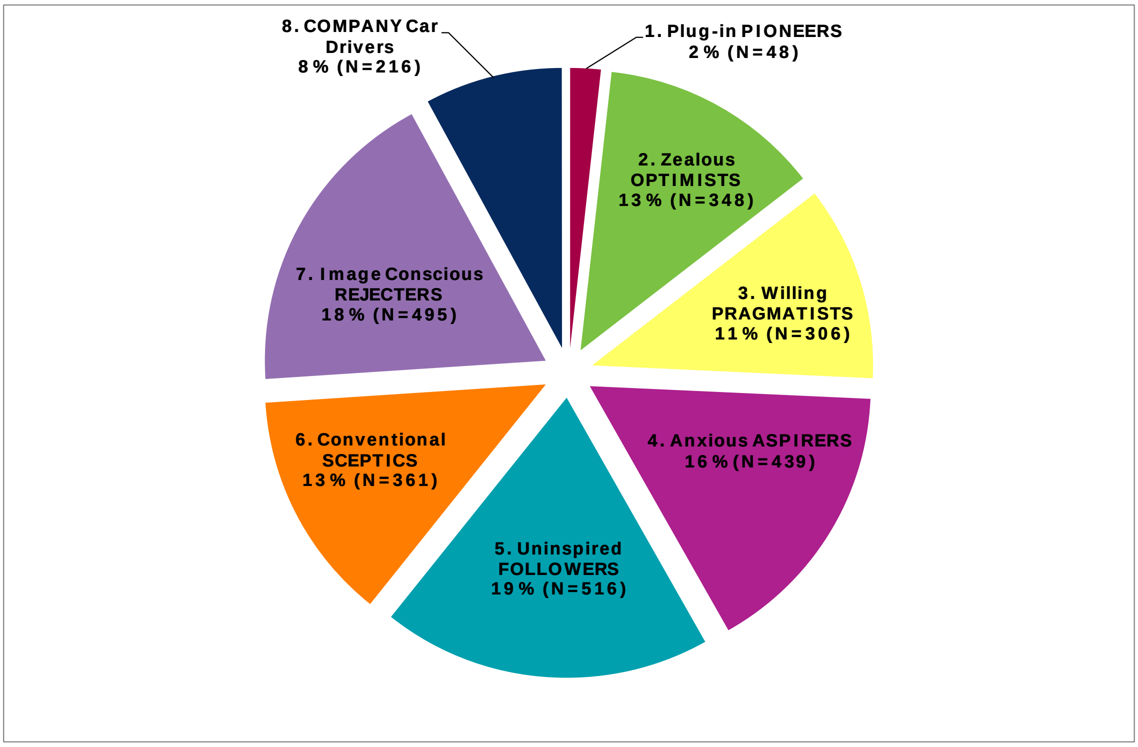


Figure 35: Segment labels and sizes (N=2,729)

The segments have varying degrees of self-reported likelihood to adopt EVs, current car ownership and travel patterns, access to parking and charging, world views and specific beliefs about EVs and their suitability for their own lifestyle and self-image.

Before going on to profile the segments on each of these domains, it is first useful to understand the relative contribution of the variables used to create the clusters and what variables contribute to distinctions between the groups. Table 35 ranks each variable according to which constructs vary the most between groups and therefore will be the most important to understanding group differences[14].

Table 35: Ranking of variables in terms of their importance in defining the cluster solution

'Rank'	Variable	Sum of Squares	df	Mean Square	F	Sig.
1	BEV Identity	1199.406	5	239.881	570.435	.000
2	PHEV Identity	1087.696	5	217.539	512.795	.000
3	PHEV Anxieties	479.039	5	95.808	287.714	.000
4	Parking Difficulty	1787.585	5	357.517	284.833	.000
5	BEV Anxieties	443.653	5	88.731	279.560	.000
6	EV Willingness to Pay	543.903	5	108.781	259.111	.000
7	EV Symbolic	335.103	5	67.021	173.176	.000
8	EV Openness	283.061	5	56.612	160.329	.000
9	EV Instrumental	164.967	5	32.993	122.563	.000
10	EV Positives	164.764	5	32.953	112.103	.000
11	WTP Fuel savings	326.911	5	65.382	111.809	.000
12	EV Affect	105.238	5	21.048	102.704	.000
13	Environmental Identity	167.440	5	33.488	85.784	.000
14	Innovativeness	270.458	5	54.092	84.490	.000
15	EV Infrastructure	127.474	5	25.495	43.065	.000
16	Car Authority	131.212	5	26.242	39.566	.000

Note: The observed significance levels should not be interpreted in their usual fashion because the cluster analysis, by definition, has selected groups which maximise the differences between the clusters. However, this ranking provides some information about each variable's contribution to the separation of the clusters. The differences between clusters can be seen from their representative values such as mean values of the input variables from each cluster. See Appendix P for *post-hoc* comparisons of the differences in order to understand which segments differ from each other on each of these variables.

[14] This is done by ordering the variables on their F-ratio (the ratio of the variance between groups to the variance within the groups) calculated using ANOVA.

In summary, the eight segments can be characterised as follows, and are further detailed in Table 36:

Plug-in Pioneer

Excited about plug-in technology and optimistic about its suitability to their lifestyle and their image. Believes there to be some trade-off between performance and environmental benefits, but thinks this is a price worth paying. Oriented as much to shopping and leisure as to the commute. Already driving new expensive cars, but also uses other modes of transport. Likely to be attracted by extended warranties and grants. Male, high income, highly educated and a tendency toward urban living.

Zealous Optimist

Highly enthusiastic and optimistic about the technology, including the driving experience. High willingness to pay for fuel savings and possibly for environmental benefits. Commutes a lot by car and tends to already own fuel efficient vehicles. Strongly believes an EV would fit their identity and they would be proud to own one. Likely to be attracted by all policy incentives, particularly grants and extended warranties. Male, high income but lower education than the Plug-in Pioneers.

Willing Pragmatist

Extremely polarised in their opinions – being very enthusiastic about PHEVs and virtually the most pessimistic of all groups about BEVs. They are motivated more by the functional attributes of vehicles than the symbolic ones and are attracted to the fuel economy benefits of the PHEV, although they show high environmental awareness. They have some concerns about safety and reliability. Oldest of all the groups, with a high proportion of retired but high education and income.

Anxious Aspirer

Enthusiastic about the technology and would be proud to own an EV, but have some of the greatest reservations about range, safety and reliability. They have some basis for their concerns as they are the least likely to have off-street parking at home. They consider themselves to be a bit of an authority on cars although tend to own relatively smaller and cheaper vehicles. Combined with their lower than average income, this may mean they have some concerns about price, although they have a high willingness to pay for fuel economy. Tend to be female, young and with lower income.

Uninspired Follower

This group is unengaged with the technology and whilst they do not show particularly negative views towards plug-in vehicles, this is mainly because they have not yet formed strong opinions. They claim, however, that they would be embarrassed to own one and this suggests they tend to adhere to perceived social norms. They are very low innovators and score low on ‘car authority’ which supports this. They have little faith in the green credentials of EVs. They may be curious to learn more, but policy incentives are unlikely to attract them so long as they are unengaged with this technology. Female, older, high proportion of retired.

Conventional Sceptic

Very negative about all the functional aspects of EVs and do not believe they would suit their lifestyle or that they would find it easy to charge at home. They would not be particularly embarrassed to own one, but this is more because they do not appear to believe that a car is an extension of their identity. They demand a similar refuelling experience to the one they have today and also believe that EVs will cost more to buy and run than a ‘normal car’. Male, average age and income but lower education.

Image-conscious Rejecter

Extremely negative about all aspects of EVs and do not believe that they associate with the type of people who own EVs. Despite possibly having some of the most conducive travel patterns, including very high reliance on the car for relatively short commutes, they do not believe plug-in vehicles would suit their needs. They do not seem to be motivated by fuel economy savings and are sceptical about environmental issues. Young, female with average income.

Company Car Drivers

High mileage, particularly work-related journeys and place particular importance on size, practicality, fuel economy and performance attributes of vehicles. Nevertheless, although they have some concerns about performance, range, reliability and image of EVs, they are relatively open to the idea of plug-in vehicles, particularly as a second car. This fits with the fact that they come from high car owning households and carry out a lot of additional mileage in cars other than the company car, including much at weekends. Male, very high income and education, likely to have children.

Table 36: Summary of consumer segments

	1 Plug-in PIONEERS	2 Zealous OPTIMISTS	3 Willing PRAGMATISTS	4 Anxious ASPIRERS	5 Uninspired FOLLOWERS	6 Conventional SCEPTICS	7 Image-conscious REJECTERS	8 COMPANY Car Drivers
%	2%	13%	11%	16%	19%	13%	18%	8%
Most likely to say:	*It's about time. Why wouldn't you?*	*Yes please. It would save me how much fuel?*	*Yes please. But make it a PHEV for now, thanks.*	*Great, but not sure where I would charge it.*	*If everyone else is, then maybe.*	*Will they save the planet? Don't think so (and don't care)*	*I'd never be seen in one of those.*	*With my mileage? Convince me.*
PHEV adoption	Very high	High	High/medium	Medium	Medium/low	Medium/low	Very low	Medium
BEV adoption	Very high	High	Low	Medium/low	Medium/low	Low	Very low	Medium
Innovativeness	Very high	High	Medium	High	Very low	High	Low	Very high
Greenness	Very high	High	Very high	High	High	Very low	Low	Medium
Who are they?	Male, young, very high income, employed, high education, high children.	Male, older, high income, mostly employed, low education.	Male, oldest, high income, high retired, high education.	Female, young, lower income, employed, ave. education.	Female, older, low income, high retired, lowest education.	Male, ave. age, ave. income, mostly employed, low education.	Female, younger, ave. income, mostly employed, low education.	Male, youngest, very high income, very employed, very high education, high children.
What do they currently drive?	Brand-new, relatively expensive and large, high incidence of AFVs	Small with high mpg and high incidence of AFVs.	Medium/large but with average mpg.	Tendency toward second hand, older, smaller and least expensive, with high mpg.	Smaller, cheaper, not particularly high mpg, low incidence of AFV.	Brand new, medium sized and priced but not particularly fuel efficient.	Medium sized and priced but not particularly fuel efficient.	High car ownership, newest, largest, most efficient and most expensive.
How much do they travel?	High commute and weekend distances. Shopping and leisure as important as commuting. Low commuting by car. Highest use of alternatives. High urban/town, low out of town.	Above average mileage with high commuting by car. Business travel and leisure trips are also important. Low use of alternative modes. Neither urban nor extra urban.	Medium mileage. High car commuting with slightly longer distances. Low use of alternative modes. High use of the motorway.	Quite high mileage. Less dependence on the car for commuting and lower commute distances. Relatively high use of alternatives. High in town driving and low motorway.	Medium mileage and short commutes with lower car dependence. Shopping & commuting equal importance. Low use of alternatives. High in town driving and low out of town.	Low mileage including commuting. Less dominated by commuting, more about shopping and leisure. Low business travel and low use of the motorway.	Above average mileage and commute distances. Car use is dominated by the commute. High motorway use. Least likely to say they could manage without a car.	Very high mileage. High business use, also high mileage carried out in other family cars and at weekend. Highest proportion commute by car. Some use of alternatives, train. Very high motorway.

What are they influenced by?	Likes driving. Image conscious. High car authority. Very well informed. Motivated more by running costs than price. Very high WTP for fuel economy and for environmental benefits, also high desire for oil independence.	Medium car authority. Well informed. High WTP for fuel economy and some willingness for environmental benefits.	Likes driving. Medium car authority. Well informed but not especially curious to know more. Generally does not attach status and meaning to cars – more motivated by functional attributes. High WTP for fuel economy but not for environment.	High car authority. Moderately informed. High environmental identity and desire for oil independence. High WTP for fuel economy and some for the environment.	Least likely to say they enjoy driving. Very low car authority. Not well informed. Place brand higher than running cost. Not WTP for fuel economy nor environmental benefits.	Moderately informed. Lowest environmental identity. Not WTP for fuel economy and strongly against paying for environmental benefits.	Low car authority. Style and performance driven. Place brand higher than running cost. Not WTP for running costs and strongly against paying for environmental benefits.	High car authority and enjoys driving. Motivated more by size/ practicality and running cost than price. Moderate green identity but high desire to be independent from oil. Low WTP for environmental benefits.
What do they like about EVs?	Excited by the technology. Would feel very proud to own and high association with EV owners. Highly optimistic about the suitability of EVs to their lifestyle. Least concerned about BEV range. Very high perceived desirability to refuel at home. Very high off-street parking. Unanimous faith that they will rely on home or work charging. Relatively optimistic about performance and driving experience. No real concerns about safety and reliability.	Strong belief BEV fits social identity. Highly optimistic about the suitability of EVs to their lifestyle. Low range anxiety. Very high off-street parking, high perceived ease of charging at home. Very high desirability to refuel at home. Relatively low perceived need to wait for rapid charging. Most optimistic about performance and driving experience. High faith in green credentials but higher attachment to oil independence. Highest faith in safety and reliability.	Highly optimistic about suitability of PHEVs but extreme pessimism about BEVs, particularly range anxiety. Very high off-street parking, slightly lower perceived ease of charging at home (but still very high). High desirability to refuel at home. Low perceived need for rapid charging for PHEVs. Believe EVs will be more expensive to buy but have high faith in running cost savings. Believe PHEVs will be pleasant to drive.	High desirability to charge at home. Some concerns about performance but relatively neutral assessment of the driving experience of EVs.	Low range anxiety but not enthusiastic about the technology anyway. No strong opinion about performance or driving experience.	Would not feel embarrassed to own an EV but this is more because they tend not to attach symbolic meanings to cars. Some acknowledgement that PHEVs and BEVs would suit their travel patterns. Attracted to refuelling at home.	Little if anything.	Relatively optimistic about suitability. Quite high off-street parking but quite high perceived difficulty of charging at home and slightly tempered desirability.

What are the main barriers?	Slight familiarity penalty – majority still want to wait for rapid charging points and for more choice	Opinions still being formed.	Embarrassed to own a BEV. High range anxiety. Quite concerned about safety and reliability. Strong belief that BEVs suffer from poor performance.	Concerns about the image. Relatively low off-street parking and very low perceived ease of charging at home. High range anxiety. Relatively pessimistic about suitability of EVs to their travel patterns. Very high desire for rapid charging. Concerns about safety, especially outside the vehicle, and worried about breaking down.	Some embarrassment about owning and low association with EV owners. High 'neutral scoring' = indifference and lack of engagement. Quite high off-street parking but relatively low perceived ease of charging at home and tempered desirability. Low faith in the 'green credentials' of EVs.	High range anxiety. Quite high off-street parking but low perceived ease of charging. Demand similar refuelling experience and high desire for rapid charging. Believe that EVs will cost more to run and have poor performance. Worried about breaking down.	Embarrassed to own. Low association with EV owners. Extreme pessimism about suitability despite possibly having most suitable travel patterns. Clearly believe EVs are a hassle. High range anxiety. Relatively low off-street parking and very low perceived ease of charging at home but lowest desirability. Unconvinced of green credentials Believe will be poor to drive. Do not consider EVs to be similar to normal cars and most concerned about safety and reliability.	Some concerns about the image projected by EVs. High concerns about BEV range. Some concerns about reliability. Concerns about performance but neutral about the driving experience. High desire for rapid charging. Will need a lot of convincing to shift their views.
What are the main incentives?	All incentives, especially longer warranties. Likely to be highly responsive to information.	All incentives, particularly grants and warranties. Curious to learn more.	Not enthusiastic about incentives but attracted by fuel economy savings.	Grants if anxieties alleviated. Curious to learn more. Most to gain from trials?	Higher petrol and diesel prices almost equally as strong an effect as policy incentives.	Grants if anxieties alleviated. Something to gain from trials if can be motivated but low curiosity.	Not persuaded by incentives. The most entrenched in their views and difficult to influence.	Congestion charge, company car tax, toll roads.

10.2.9 Likelihood of adoption

Key findings:

- Of the eight segments, there is a clear niche segment (the Plug-in Pioneers (1.7%)) which displays strong and early enthusiasm for both PHEVs and BEVs. The self-reported likelihood of adoption displayed by this group is far higher than any of the other segments.
- There are at least two segments which are likely to join the Plug-in Pioneers in preceding the mobilisation of 'mainstream' consumers. Self-reported likelihood of adoption of these two groups is much lower than the Plug-in Pioneers, but nevertheless stronger than other segments.
- One of these pre-mainstream groups, the Willing Pragmatists, is polarised in its opinions and is clearly keen on PHEVs but not BEVs. The other group, the Zealous Optimists, have slightly more enthusiasm for PHEVs than BEVs, but are enthusiastic about both technologies when compared to all but the Plug-in Pioneers. Three additional groups have similar levels of tempered enthusiasm and can only be distinguished by looking further at demographic and motivational factors.
- The Company Car Drivers' self-reported likelihood ratings reveal some budding enthusiasm for EV technology, with a greater likelihood of being attracted to PHEVs and, somewhat surprisingly, a greater likelihood to adopt a BEV as a main car rather than a second car, presumably in addition to their company car rather than as a substitute for it.
- One group, the Image-conscious Rejecters, stands out as being very negative towards EVs and the reasons for this are revealed by the importance attached to performance and symbolic car attributes (revealed in later sections).
- Whether each type of car is more likely to be owned as a main car or as a second car differs between the segments. For instance, the Plug-in Pioneers are more likely to own a PHEV as a main car, whereas Company Car Drivers are most likely to see this as a second car. Overall, both types of car are slightly more likely to be considered as a main car.
- However, those who currently own two or more cars are much more likely than one-car households to say they will adopt a BEV as a main car and more likely to say they will adopt it as a main car than a second car. This may be because those in households with more than one car perceive they will have a choice of an internal combustion engine (ICE) car even if they were to adopt a BEV as a main car.
- Overall, those in households with only one car are less likely to say they will adopt an EV as a second car but there are indications that EVs may be adopted in 15–25% these households to supplement their one car.

Table 37: Segment likelihood of adoption

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
LIKELIHOOD TO ADOPT - % saying 'very likely' in the next 5 years:								
PHEV Main	73%	14%	7%	5%	1%	2%	1%	6%
PHEV 2nd	42%	11%	5%	4%	2%	2%	1%	7%
BEV Main	44%	9%	0%	2%	1%	1%	0%	3%
BEV 2nd	38%	8%	1%	2%	2%	1%	0%	4%
LIKELIHOOD TO ADOPT - % saying 'not at all likely' in the next 5 years:								
PHEV Main	8%	16%	25%	30%	36%	39%	78%	38%
PHEV 2nd	10%	19%	26%	26%	34%	40%	69%	29%
BEV Main	25%	36%	93%	59%	58%	66%	94%	68%
BEV 2nd	10%	29%	72%	49%	51%	64%	88%	54%

Note: In each comparison overall group differences when testing across all eight segments are statistically significant at P<0.05. See Appendix P for further detail. In this table, we have extracted the proportion of respondents answering 'very likely' or 'not at all unlikely' to the likelihood questions in addition to average responses on this measure as it is common practice in market research to attach more weight to the extreme ends of the scale.

Table 38: Segment likelihood of adoption – summary

Segment	Likelihood of adoption – summary
1 (Plug-in Pioneers)	Very strong enthusiasm for PHEVs and BEVs. Stronger for the first than the second car for PHEVs but essentially the same for BEVs. Much higher than all other groups.
2 (Zealous Optimists)	Relatively high enthusiasm for both PHEVs and BEVs (though still only around 10% in the 'very likely' categories).
3 (Willing Pragmatists)	High-medium for PHEVs but very low for BEVs.
4 (Anxious Aspirers)	Medium enthusiasm, slightly tempered, especially for BEVs. Maintains or increases enthusiasm for second cars.
5 (Uninspired Followers)	Low for PHEVs and low for BEVs but some signs of enthusiasm if take in the whole scale.
6 (Conventional Sceptics)	Very low if only consider 'very likely' category, otherwise medium-low enthusiasm.
7 (Image-conscious Rejecters)	Consistently very negative about both types of car but especially BEVs.
8 (Company Car Drivers)	Medium enthusiasm for PHEVs and BEVs, but slightly higher in both cases as a second car.

10.2.9.1 Likelihood to choose a PHEV or BEV

Previous analysis of this dataset (Anable et al., 2011) revealed that in the sample as a whole, 32% of respondents said they are likely to choose a PHEV and 13% a BEV as a main car in the next five years. The equivalent figures for a second car were 33% and 17%. The objective of this segmentation exercise is to identify the characteristics of those most likely to adopt EVs in the near and medium term on the understanding that the characteristics of those people who are attracted to EVs do not necessarily co-exist as one homogenous group in terms of their motivations and the type and timing of their uptake.

Figure 36 provides a visual summary of the strength of each group's self-reported likelihood to adopt each vehicle as a main or second car. To aid interpretation, the strength of self-reported likelihood has been displayed here as the mean score on the five-point Likert-type scale (1=very unlikely, 5=very likely to adopt in the next five years). Figure 52 to Figure 40 show these trends in more detail by depicting the proportion in each group saying they are 'very likely', 'quite likely' etc. From this it can be observed that:

- The Plug-in Pioneers have a consistently high enthusiasm for both PHEVs and BEVs, though PHEV as a main car appears to be the preferred option in the next five years. Figure 37 to Figure 40 show that this enthusiasm is marked by very high numbers saying they are 'very likely' to choose such vehicles, especially PHEVs which achieved a 73% 'very likely response'.
- In addition, there are two other groups which could be described as having above average enthusiasm: The Zealous Optimists and the Willing Pragmatists. The former are similar to the Plug-in Pioneers in that they are consistently enthusiastic about each type of vehicle with the PHEV winning greatest favour, but their enthusiasm is tempered in comparison. The Willing Pragmatists, however, have a clear polarisation of opinion – being a high scorer on PHEVs, but a relatively low scorer on BEVs. Importantly, Figure 37 to Figure 40 show that the mean scores for this group mainly comprised of most people answering 'fairly likely' rather than 'very likely'. For instance, albeit higher than the remaining groups, only 14% of the Zealous Optimists and 7% of the Willing Pragmatists said they are 'very likely' to choose a PHEV as a main car.
- The Company Car Drivers score neither above nor below average on the likelihood ratings. It is as though they are currently hedging their bets – not dismissing this technology outright but certainty not convinced of its short-term benefits. They show most enthusiasm for PHEVs and, unusually, possibly for these as a second car – presumably in addition to their company car rather than as a substitute for it.
- The Anxious Aspirers are a group which shows some potential to become attracted to PiEVs given their openness to the technology and its fuel economy and environmental benefits (as will be seen in the following sections), but are held back by some strong anxieties about the technology. This means that their likelihood ratings are barely any more positive than the remaining three groups who are even more sceptical about the technology.
- The Uninspired Followers and Conservative Sceptics differ very little from each other in terms of their self-reported likelihood ratings. The main differences between these groups are in their outlook and demographic characteristics explored in the following sections.
- The Image-conscious Rejecters have a markedly lower inclination to say they are likely to choose EVs. Figure 37 to Figure 40 reveal just how few respondents say they are 'very likely' or 'quite likely' to adopt.

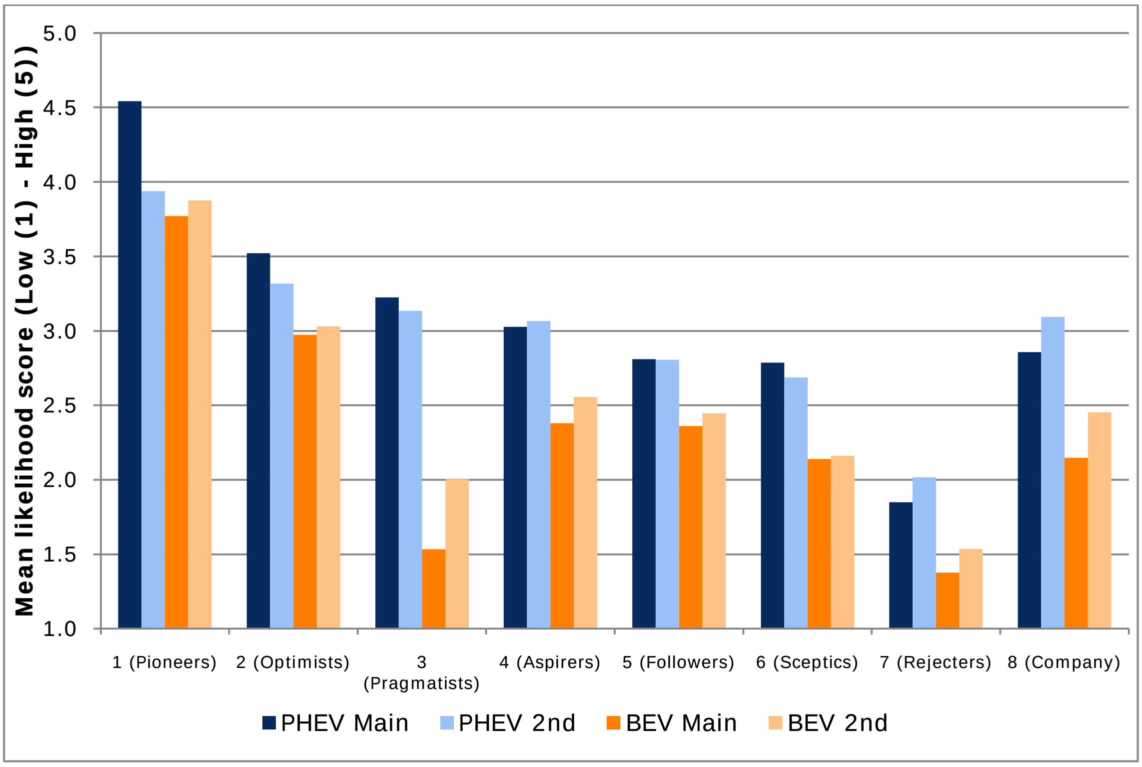


Figure 36: Average (mean) self-reported likelihood to adopt an EV in the next five years by each segment and car type (N=2,729)

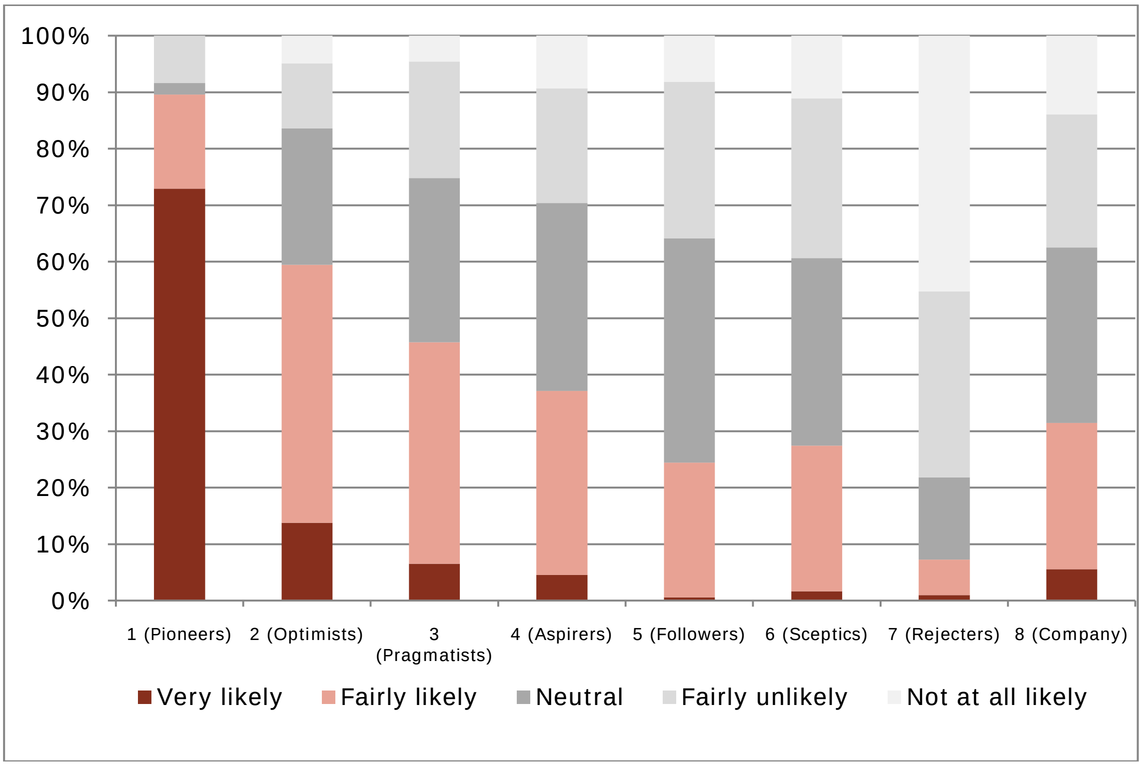


Figure 37: Detailed self-reported likelihood to adopt a PHEV as a MAIN car in the next five years by each segment (N=2,729)

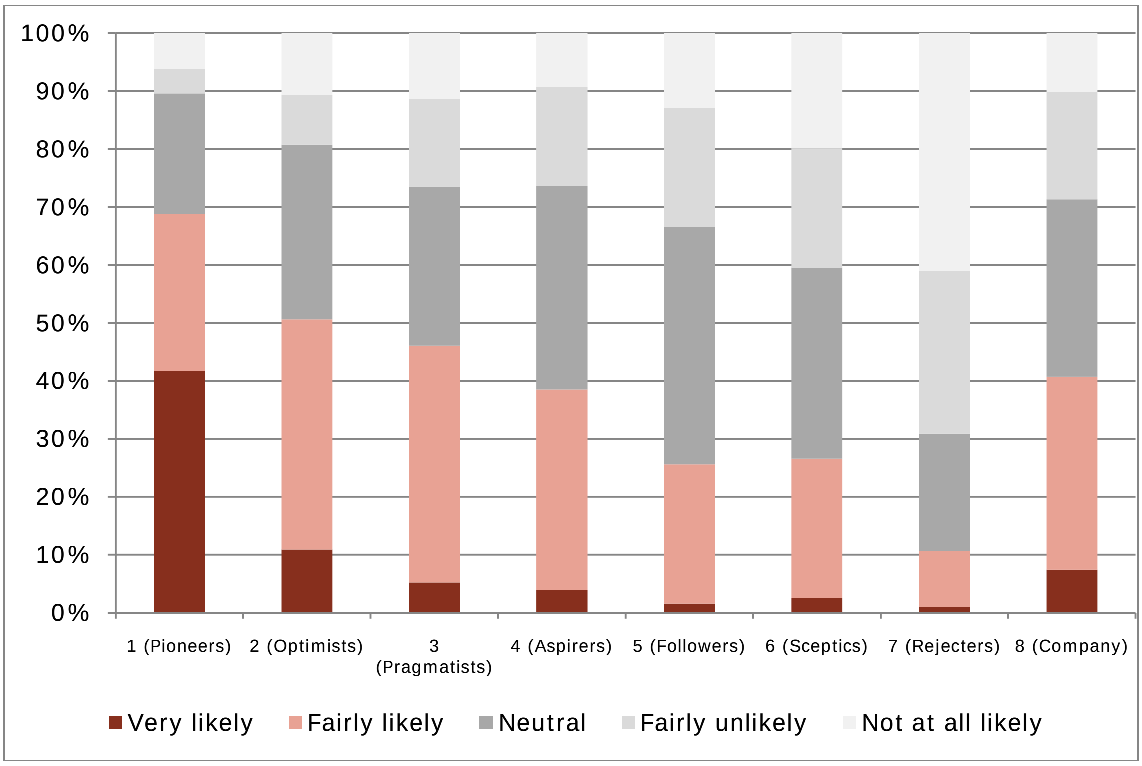


Figure 38: Detailed self-reported likelihood to adopt a PHEV as a SECOND car in the next five years by each segment (N=2,729)

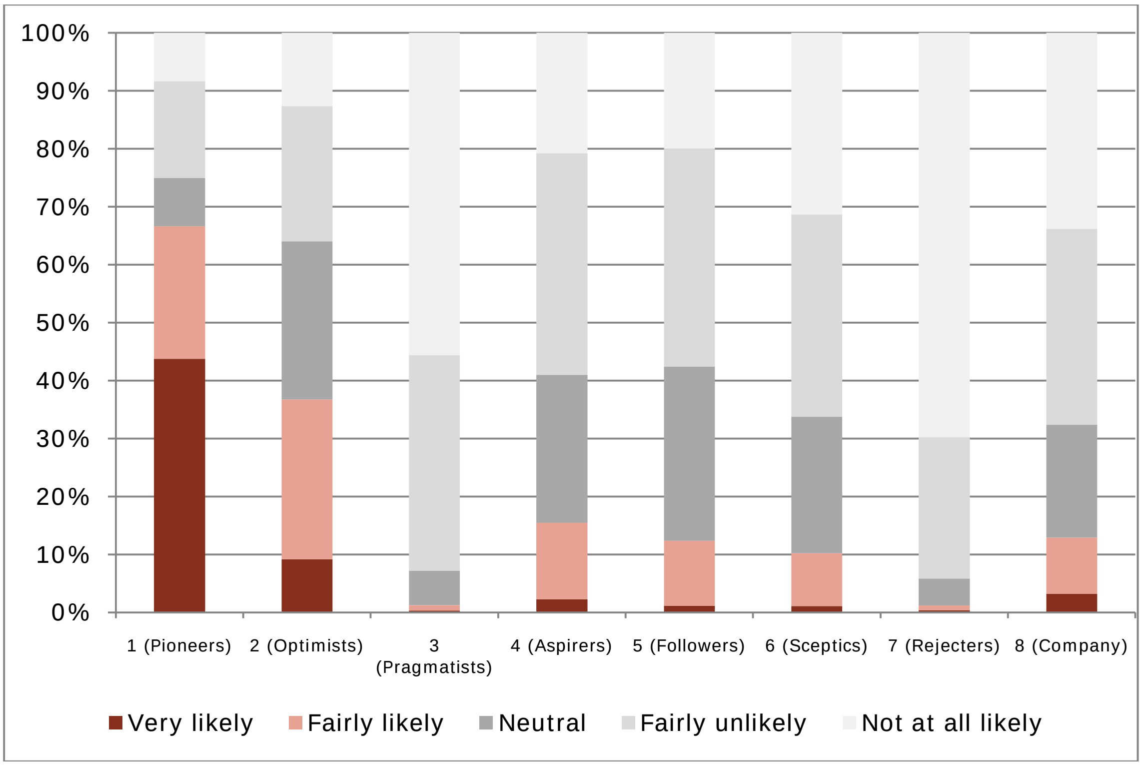


Figure 39: Detailed self-reported likelihood to adopt a BEV as a MAIN car in the next five years by each segment (N=2,729)

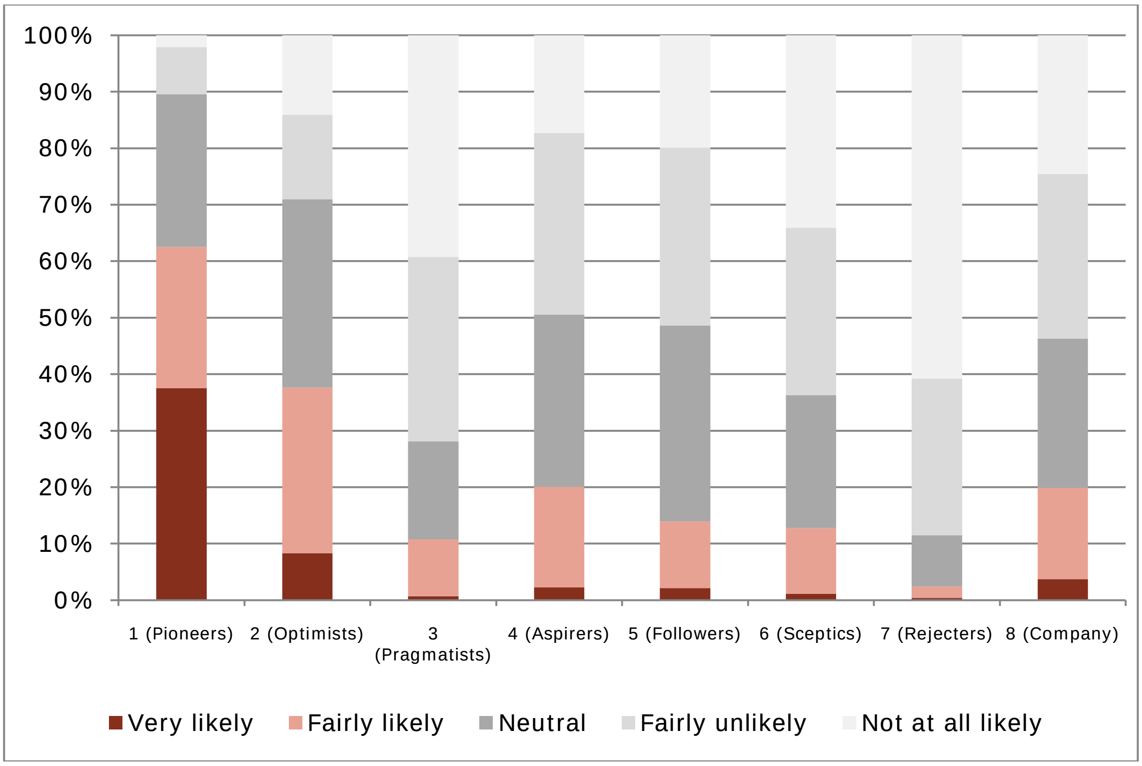


Figure 40: Detailed self-reported likelihood to adopt a BEV as a SECOND car in the next five years by each segment (N=2,729)

10.2.9.2 Adoption of an EV as a second household car

It is worth exploring further the issue of second car adoption to understand the degree to which uptake may be driven by the second car market either in households who currently own more than one car, or potentially in households who may acquire more than one car in order to place an EV alongside an existing ICE car.

Figure 41 compares self-reported likelihood to adopt from respondents in households with only one car (N=1,234) with those with two or more cars (N=1,495). This shows that:

- As expected, those in households with one car are less likely to say they will adopt an EV as a second car. However, around 25% of those in households who currently have only one car say they might adopt a PHEV and 15% BEVs as a second car, thereby indicating that EVs may be used in some cases to increase the number of cars per household.
- Those who currently own two or more cars are (i) much more likely than one-car households to say they will adopt a BEV as a main car, and (ii) more likely to say they will adopt it as a main car than a second car. This may be because those in households with more than one car perceive they will have a choice of an ICE even if they were to adopt a BEV as a main car.

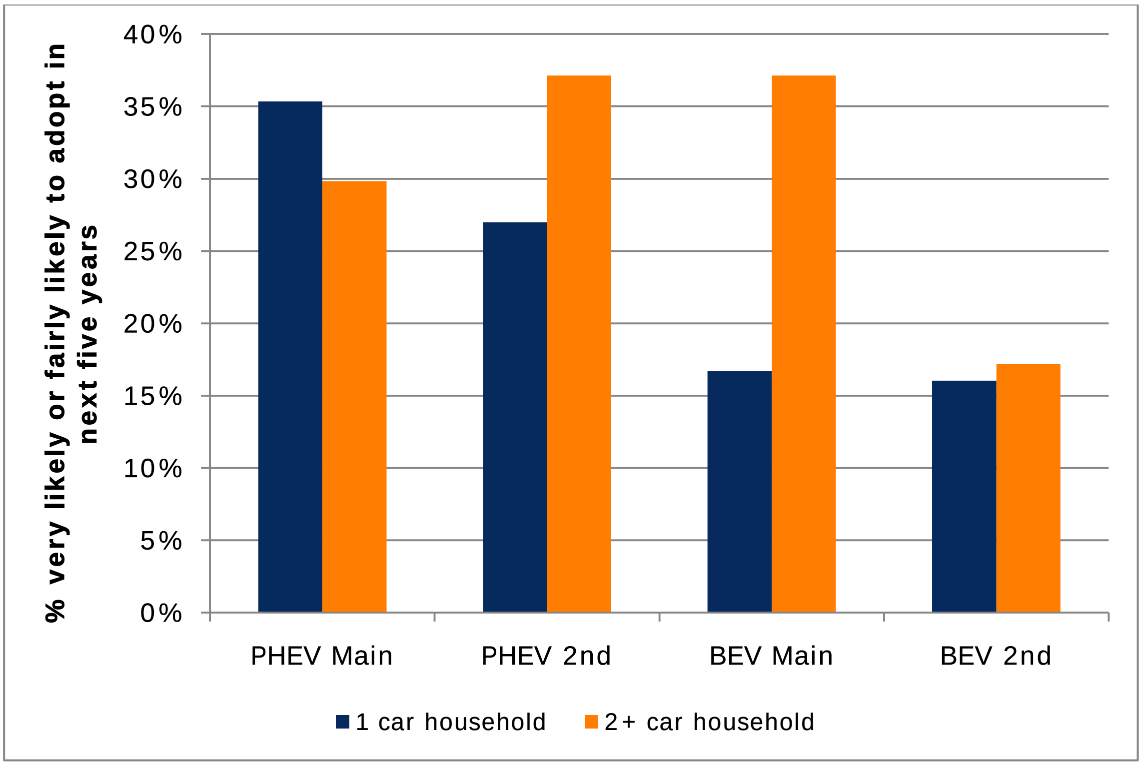
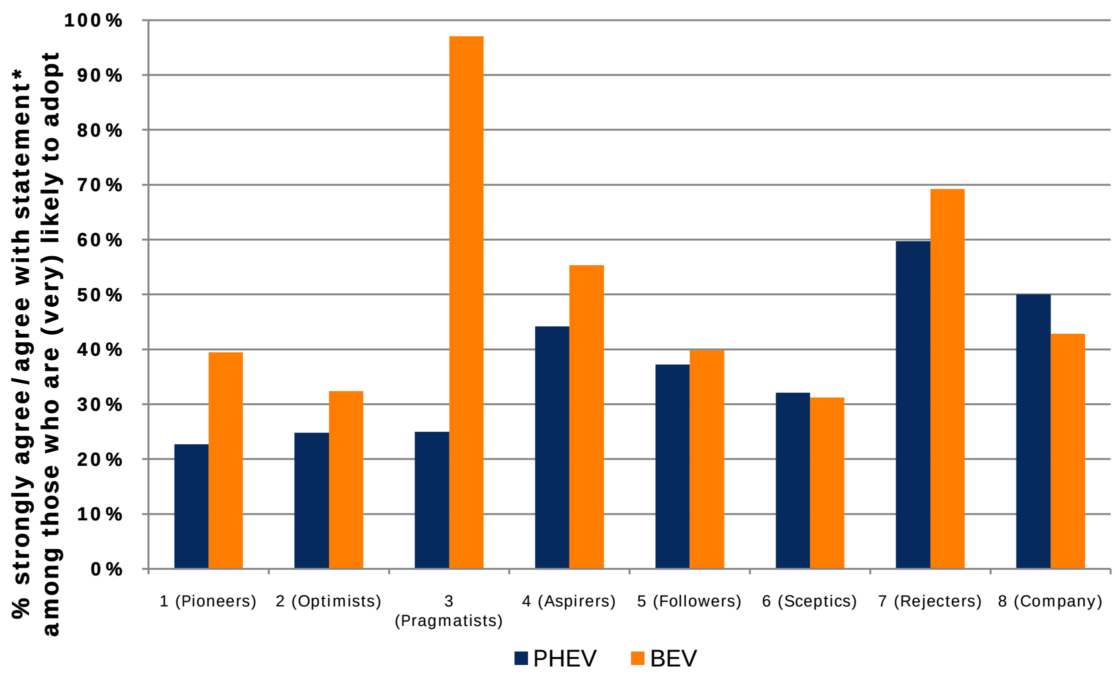


Figure 41: Self-reported likelihood to adopt an EV in the next five years in households with different levels of car ownership (N=2,729)

The question then remains whether specific segments are more likely to adopt an EV as a main or second car. We saw from Figure 36 (and Figure 37 to Figure 40) that likelihood to adopt each type of EV is overall generally slightly higher as a main car. The exception is the Company Car Drivers who may be more likely to adopt a PHEV as a second car. A different way of examining this was through two single attitude statements (one for PHEVs and one for BEVs) asking for the level of agreement with the statement 'if I had a PHEV/BEV, it would be unlikely to be my only car'. The results are displayed in Figure 42 for those who said they were very likely or fairly likely to adopt a PHEV or BEV (N=1,212 and 587 respectively). This shows that among people who are considering adopting at least one of these technologies:

- With the exception of the Image-conscious Rejecters (where agreement with the statement is above 50%), PHEVs are seen more as a main car than as a second car for all segments.
- To the extent they are considered at all by the Willing Pragmatists and the Image-conscious Rejecters, BEVs are seen predominantly as a second car. However, BEVs appear to be predominantly thought of as a main car for all other segments.
- Relative to PHEVs, however, BEVs are more likely to be owned as second car than PHEVs for most segments.

Apart from the Company Car Drivers who own more cars per household, average car ownership is similar among the other segments and so this cannot be the reason for any differences in the average propensity for each group to be more or less attracted to the idea of second car ownership. The differences are therefore more likely to be down to the different ways in which EVs are being envisaged to fit in to existing lifestyles.



* *"If I had a (BEV/PHEV) It would be unlikely to be my main/only car"* (Qc2g/ Qd2h)

Figure 42: Likely adoption of PHEV/BEV as a main or only car among likely adopters in each segment (N=1,212/587[15])

10.2.10 Personal and household characteristics

Key findings:

- Certain demographic characteristics help to strongly distinguish each segment.
- The Plug-in Pioneers tend to be male, young, highly educated and relatively wealthy but also relatively more likely to have children at home.
- The Willing Pragmatists are disproportionately more likely to be retired and are the oldest of all the groups. However, they are still relatively wealthy and more highly educated than the average.
- The most enthusiastic segments (Plug-in Pioneers, Zealous Optimists, Willing Pragmatists) tend to be largely male and wealthier than the sample average.
- The Company Car Drivers are the youngest and wealthiest of all the groups.
- The four less enthusiastic segments are more diverse with a mixture of male and female and relatively old or young profiles. However, they consistently tend to be less wealthy and less well educated than the more enthusiastic groups.

Grouping the respondents into distinct motivational subgroups has also helped to clarify the relationship between demographic or life-stage characteristics and likely uptake of EVs. The outcome is that certain demographic characteristics help to strongly distinguish certain segments but it is the combination of demographics and life-stage which provides the most useful understanding of likely EV uptake. For example, two segments might be characterised as comparatively young, but

[15] Pioneers N=10/15 (PHEV/BEV); Optimists N=62/58; Pragmatists N=48/33; Aspirers N=103/62; Followers N=70/39; Sceptics N=43/20; Rejecters N=40/9; Company N=52/21.

each would have very different outlooks and levels of enthusiasm for EVs. Table 39 reproduces the key demographic characteristics for each segment.

Table 39: Segment demographic characteristics

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
GENDER								
% male	56%	61%	58%	42%	35%	58%	37%	66%
AGE								
% <34 years	29%	17%	13%	44%	19%	19%	24%	27%
% >65 yrs	19%	22%	27%	11%	25%	20%	18%	3%
WORK STATUS								
% employed*	73%	63%	57%	73%	55%	62%	62%	93%
% retired	17%	25%	36%	13%	31%	27%	22%	3%
EDUCATION								
% degree/ higher degree	50%	38%	50%	44%	29%	37%	35%	52%
INCOME[16]								
% earning > £50k p.a.	33%	28%	32%	23%	19%	26%	25%	50%
CHILDREN								
% with children	42%	26%	21%	31%	26%	26%	22%	43%

Notes: In each comparison overall group differences when testing across all eight segments are statistically significant at P<0.05. See Appendix P for further detail.
*includes self employed

[16] The relationship between income and likelihood to adopt a BEV or PHEV is complex and appears to be mediated on other factors as demonstrated by the variation of high income earners across segments.

Table 40: Segment demographic characteristics summary

Segment	Demographic characteristics summary
1 (Plug-in Pioneers)	Male, young, very high income, high employment, high education, with children
2 (Zealous Optimists)	Male, older, high income, mostly employed, low education
3 (Willing Pragmatists)	Male, oldest, high income, high retired, high education
4 (Anxious Aspirers)	Female, young, lower income, high employment, average education
5 (Uninspired Followers)	Female, older, low income, high retired, lowest education
6 (Conventional Sceptics)	Male, average age, average income, mostly employed, low education
7 (Image-conscious Rejecters)	Female, younger, average income, mostly employed, low education
8 (Company Car Drivers)	Male, youngest, very high income, very high employment, very high education

10.2.10.1 Gender

Table 39 shows that the segments fall along quite distinct gender lines, despite the fact that the proportion of males and females in the sample was essentially equal. Males are overrepresented in the 'top three' most enthusiastic groups (Plug-in Pioneers, Zealous Optimists and Willing Pragmatists) although they also dominate the Conventional Sceptics. Females on the other hand characterise the Anxious Aspirers, Uninspired Followers and also the Image-conscious Rejecters.

10.2.10.2 Age

Enthusiasm for EVs cuts across age bands and it is the combination of age and outlook which best predicts segment membership and likely uptake. The youngest segments are the Anxious Aspirers, Company Car Drivers and the Plug-in Pioneers; the oldest are the Willing Pragmatists, Zealous Optimists and Uninspired Followers. Figure 43 shows these data.

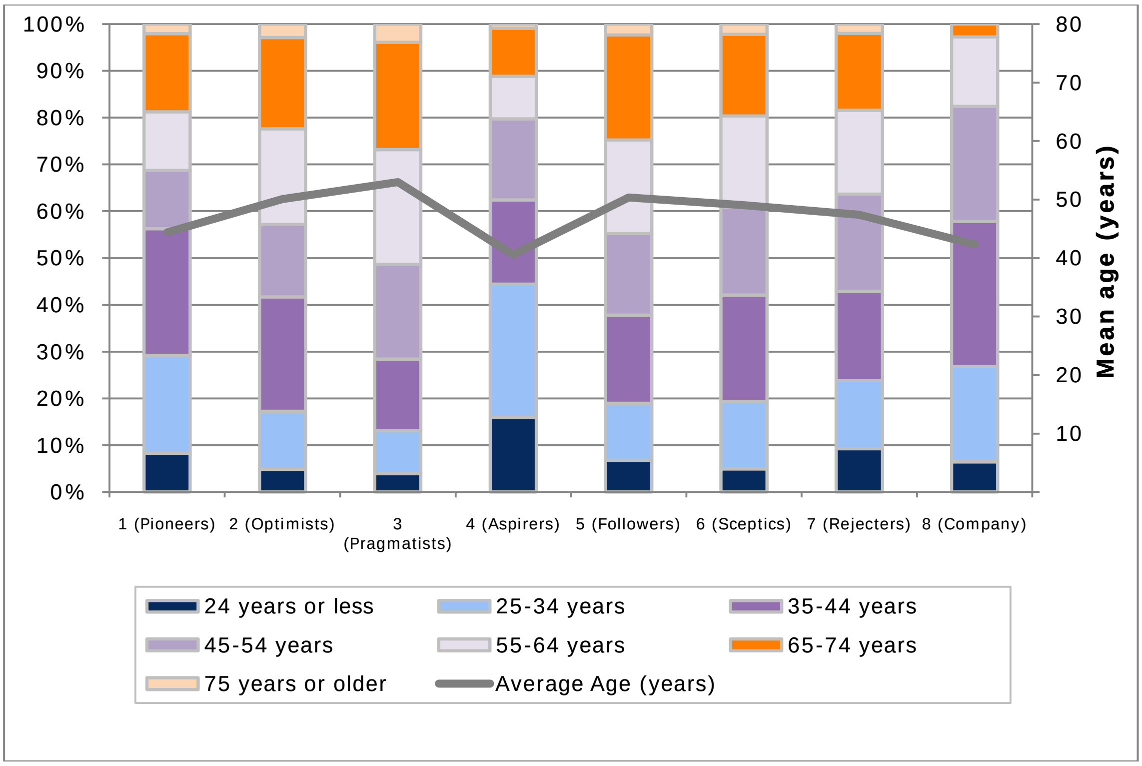


Figure 43: Age distribution in each segment (N=2,729)

10.2.11 Work Status

As expected, almost all the Company Car Drivers are in full time employment, including self-employment. The Plug-in Pioneers, Anxious Aspirers, Conventional Sceptics and Image-conscious Rejecters are also dominated by those in work, whereas the Uninspired Followers and Willing Pragmatists have disproportionate numbers of those in retirement. Thus work status is not a good predictor of EV uptake and further analysis (Section 10.2.13) will confirm that commuting is not the most important journey purpose for some segments.

10.2.11.1 Education

Education to degree level or above has some relationship with the likelihood to purchase EVs. For instance, the Plug-in Pioneers and Willing Pragmatists are comparatively well educated. However, the Zealous Optimists do not follow this pattern, demonstrating average levels of education for the sample as a whole.

10.2.11.2 Household Composition

It is interesting to note the differences in household composition between the Plug-in Pioneers and Company Car Drivers on the one hand, and all the other segments. The former two groups have a statistically significantly higher tendency to have children at home than all the other groups. This remains the case even when we control for the difference in the average ages of each segment (by only looking at those of employment age) as there is no difference in the presence of children in the household between any of the other groups (Figure 44).

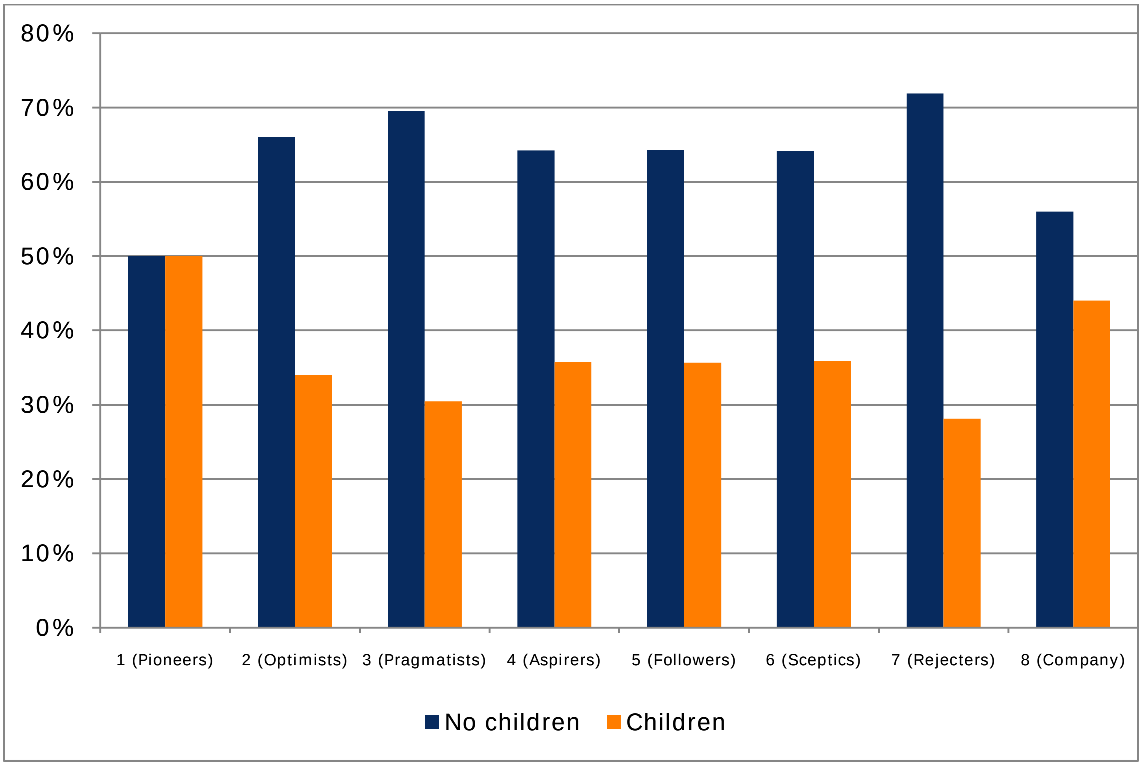


Figure 44: Presence of children in each segment for those not in retirement (N=2,093[17])

10.2.11.3 Income

It would appear from this analysis that the population segments with the highest likelihood of adopting EVs in the near to mid-term have higher incomes than the average car buyers. The Company Car Drivers and the Plug-in Pioneers are the wealthiest segments, followed by the Willing Pragmatists and the Zealous Optimists. The Uninspired Followers are the least wealthy. Figure 45 provides a breakdown of the proportion of respondents in each household income bracket in each segment. This pattern holds true even if we only look at those in employment in each group.

[17] Pioneers N=40; Optimists N=262; Pragmatists N=197; Aspirers N=383; Followers N=356; Sceptics N=262; Rejecters N=384; Company N=209.

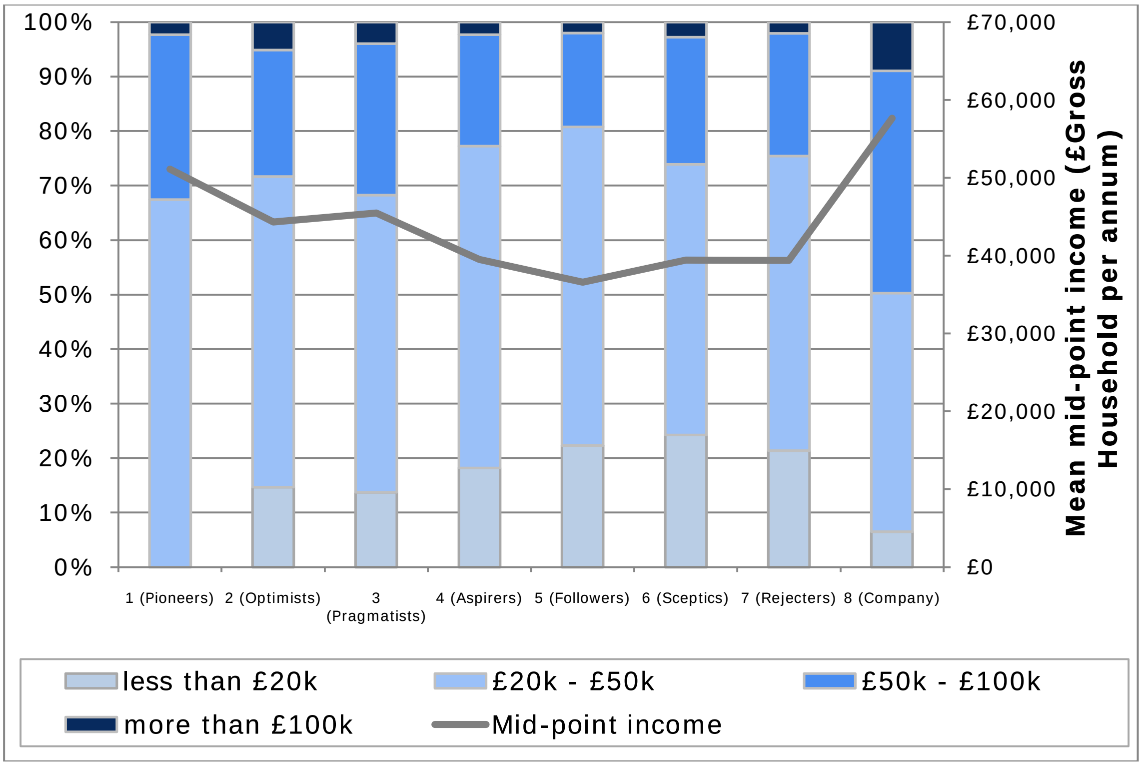


Figure 45: Household annual income (gross) in each segment (N=2,729)

10.2.12 Current car ownership

Key findings:

- It is a mixed picture as to whether current car ownership is a guide to future EV ownership. It appears that a tendency to purchase new cars and cars with high fuel economy are good indicators. However, it cannot be said that the more enthusiastic segments tend to be attracted to a certain size or type of car. Therefore, it cannot be concluded that the current car market is a good guide to the future EV consumer.
- Other than for the Company Car Drivers who tend to own a greater number of cars, the average number of cars in a household is similar for each of the segments.
- The Plug-in Pioneers predominantly buy new and larger cars and they currently spend about 20% more on average than all other groups.
- The Zealous Optimists and Willing Pragmatists are also more likely to go for new or nearly-new cars rather than second hand.
- Company Car Drivers own the largest cars with the majority in the 'medium family' or 'large family' categories. However, among the six post-hoc segments it is difficult to detect clear patterns in ownership. There is some indication that the Willing Pragmatists are also attracted to relatively large cars and the Anxious Aspirers and Uninspired Followers to smaller ones.
- Segments which are most enthusiastic about EV technology currently tend to already own more efficient cars, claim to be achieving higher fuel economy and are disproportionately more likely to be current owners of AFVs.

Table 41: Segment car ownership characteristics

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
NO. OF CARS OWNED PER HOUSEHOLD								
Mean no.~	1.65	1.74	1.65	1.60	1.66	1.60	1.72	2.27
% owning 1 car~	56%	46%	46%	52%	47%	52%	45%	12%
AGE/ ORIGIN OF MAIN CAR								
Average age (years)	3.17	3.17	3.36	3.38	3.17	3.11	3.09	2.56
Brand new	81.3%	57.5%	57.2%	45.6%	56.8%	60.4%	55.8%	80.1 %
Nearly-new	12.5%	29.9%	31.4%	31.7%	26.6%	24.4%	27.5%	16.2 %
Second Hand	6.3%	12.6%	11.4%	22.8%	16.7%	15.2%	16.8%	3.7%
PURCHASE PRICE								
Mean (All)	£16,292	£12,261	£13,401	£11,059	£11,165	£12,816	£12,135	£19, 972
Mean (New)	£18,974	£14,893	£16,792	£15,826	£14,053	£15,373	£15,236	£21, 375
SIZE/ TYPE								
Urban/city/ small~	35%	43%	37%	42%	45%	40%	38%	13%
Executive/ Luxury/ Sports/SUV/ MPV~	31%	23%	24%	19%	23%	21%	22%	27%
MPG								
Average MPG of 'Main car'*	40.3	40.5	39.5	40.0	38.5	38.5	39.1	40.8
% driving main car with > 51mpg	18%	19%	12%	17%	10%	11%	12%	15%
FUEL TYPE								
% households with an AFV*	4%	3%	1%	2%	1%	1%	2%	3%

Note: In each comparison except * overall group differences when testing across all eight segments are statistically significant at p<0.05. See note under Table 34 and Appendix P for further detail. ~ Post-hoc comparisons (using Chi Square tests on different groups of segments only) reveal that the Company car drivers and the Plug-in Pioneers have a different profile of type of car ownership to the rest of the segments and mostly also from each other.

Table 42: Segment car ownership characteristics – summary

Segment	Car owning characteristics summary
1 (Plug-in Pioneers)	Very high proportion of brand-new, relatively expensive, larger cars and possibly a higher incidence of AFVs.
2 (Zealous Optimists)	No particular tendency towards new/second hand but smaller cars with higher fuel economy and possibly a higher incidence of AFVs.
3 (Willing Pragmatists)	No particular tendency towards new/second hand, medium sized or larger cars, moderately expensive with medium fuel economy.
4 (Anxious Aspirers)	Tendency toward second hand, older and least expensive cars, but smaller and with good fuel economy.
5 (Uninspired Followers)	Tendency towards second hand, smaller and less expensive cars but not particularly fuel efficient.
6 (Conventional Sceptics)	Tendency toward brand new, medium sized and priced but not particularly fuel efficient.
7 (Image-conscious Rejecters)	Tendency towards second hand medium sized and priced but not particularly fuel efficient.
8 (Company Car Drivers)	High car ownership, newest, largest, most efficient and most expensive vehicles and possibly a relatively high incidence of AFV.

Note: Post-hoc comparisons (using Chi Square tests on different groups of segments only) reveal that, on some indicators (number of cars owned and car type) the Company Car Drivers and the Pioneers have a different profile of type of car ownership to the rest of the segments and mostly from each other, but the remaining segments show no statistically significant differences. This allows us to conclude that the Company Car Drivers and Plug-in Pioneers tend to drive larger cars than the other segments. However, given the difficulty of treating this categorical data with post-hoc tests, we have nevertheless drawn some conclusions about possible car ownership tendencies. However, these should be treated with caution.

10.2.12.1 Number of cars owned

Section 10.2.9 showed that there was a difference in the self-reported likelihood of uptake between those in households with one car compared to multiple car owning households. Figure 46 shows there is not much difference between the segments in terms of average number of cars owned per household, apart from the Company Car Drivers who tend to own a greater number of cars on average, with only a small minority of these households owning one car (12%). There is a slight tendency for the Plug-in Pioneers to be more likely to own only one car than the average, although their mean car ownership is no different to the other segments apart from the Company Car Drivers.

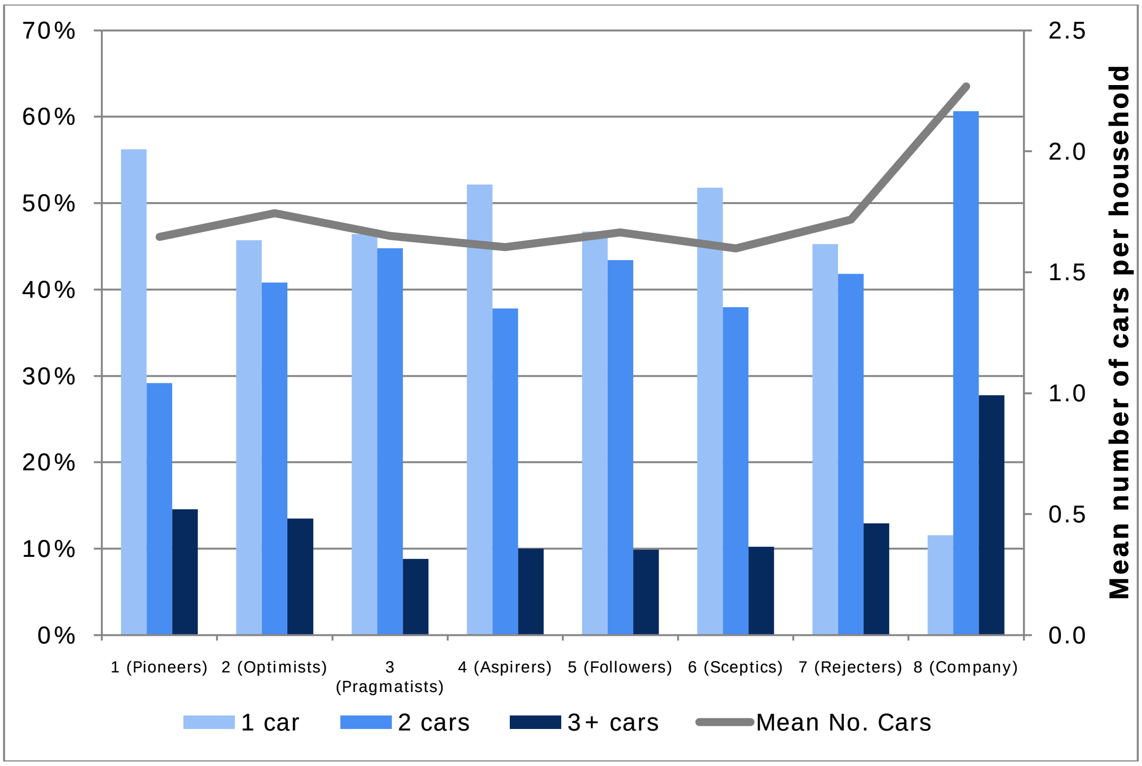


Figure 46: Household car ownership in each segment (N=2,729)

10.2.12.2 Type of cars owned

There are differences between the segments in the type of cars owned with respect to their purchase price, the proportion of cars bought new or second hand and the types of cars purchased. However, the conclusion from these data is that, apart from factors which are themselves related to income and purchasing power, there is only a weak link between the types of cars to which segment members are currently attracted and their likelihood to purchase an EV.

A tendency to buy brand new cars and the purchase price of the main car is put forward as a potential guide to future EV uptake (Stannard et al., 2010). Figure 47 shows that over 80% of the main cars currently owned by the Plug-in Pioneers have been purchased as brand new. This compares to a sample average of 58%. The mean price of the brand new cars purchased by this group is around 20% higher than the average. In addition, the Zealous Optimists and Willing Pragmatists are more likely to go for new or nearly-new cars rather than second hand. In contrast, the Anxious Aspirers are the most frequent buyers of second hand vehicles which is consistent with their relatively lower incomes. Average purchase prices of new vehicles are also consistent with income, with the Willing Pragmatists demonstrating relatively higher purchasing power and the Anxious Aspirers the least.

In terms of type of car, there are some differences although the patterns are relatively weak. Once again the Plug-in Pioneers stand out as being particularly distinctive with a tendency to go for larger cars with a marked over-representation as purchasers of 4x4s, Executive and Luxury Saloons (Figure 48). As would be expected, Company Car Drivers own the largest cars with the majority in the 'medium family' or 'large family' categories. However, among the six *post-hoc* segments it is difficult to detect clear patterns in ownership. There is some indication that the Willing Pragmatists are also attracted to relatively large cars and the Anxious Aspirers and Uninspired Followers to smaller ones. Overall, however, it cannot be said that the more enthusiastic segments tend to be attracted to a certain type of car and therefore it cannot be concluded that the current car market is a good guide to the future EV consumer.

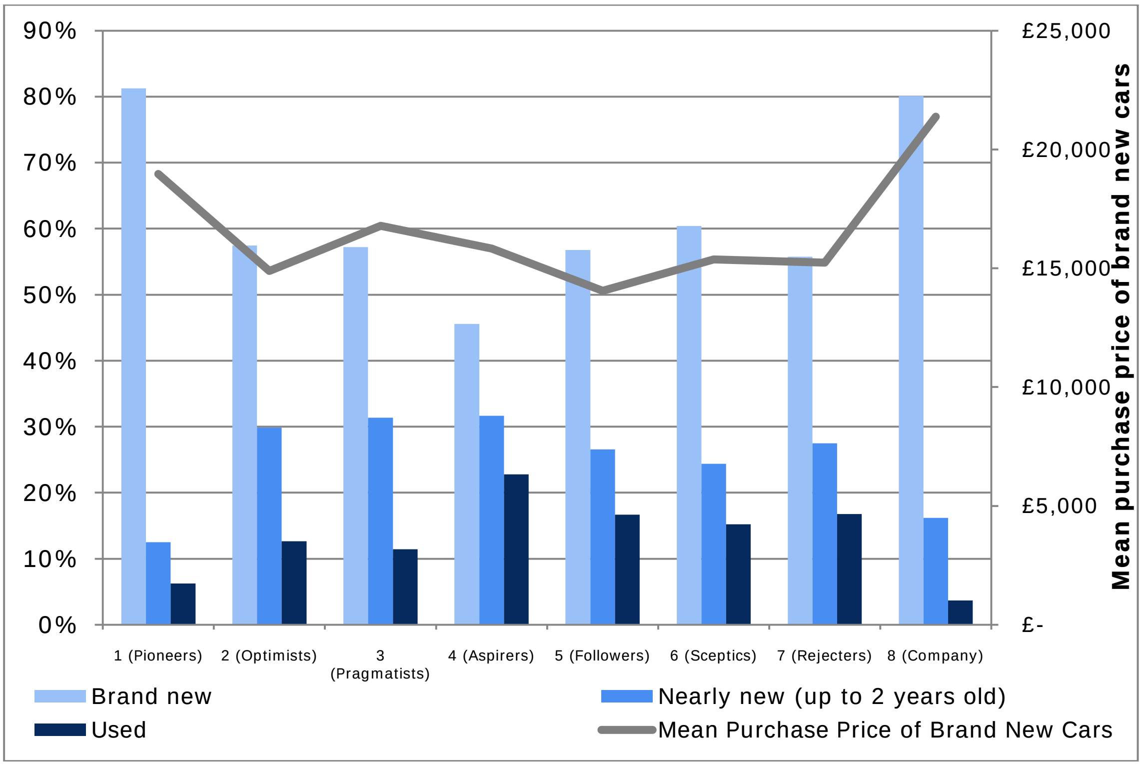


Figure 47: Brand new car ownership and average purchasing price in each segment (N=2,729)

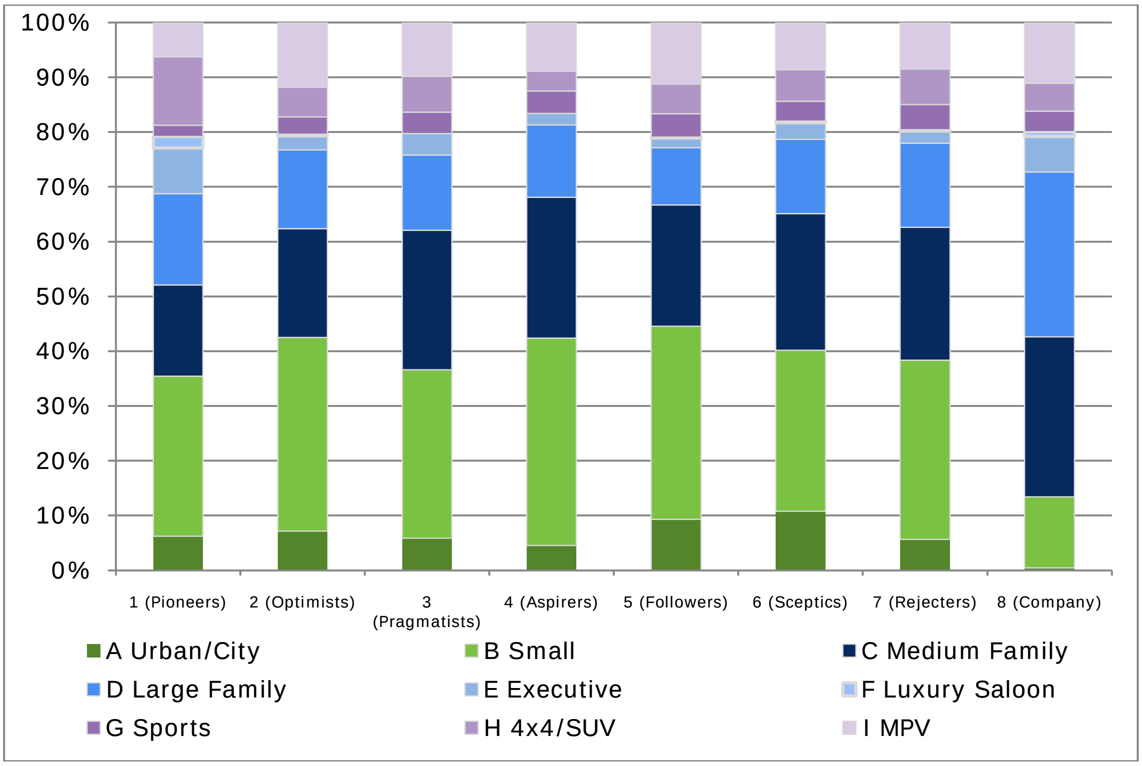


Figure 48: Types of cars owned in each segment (N=2,729)

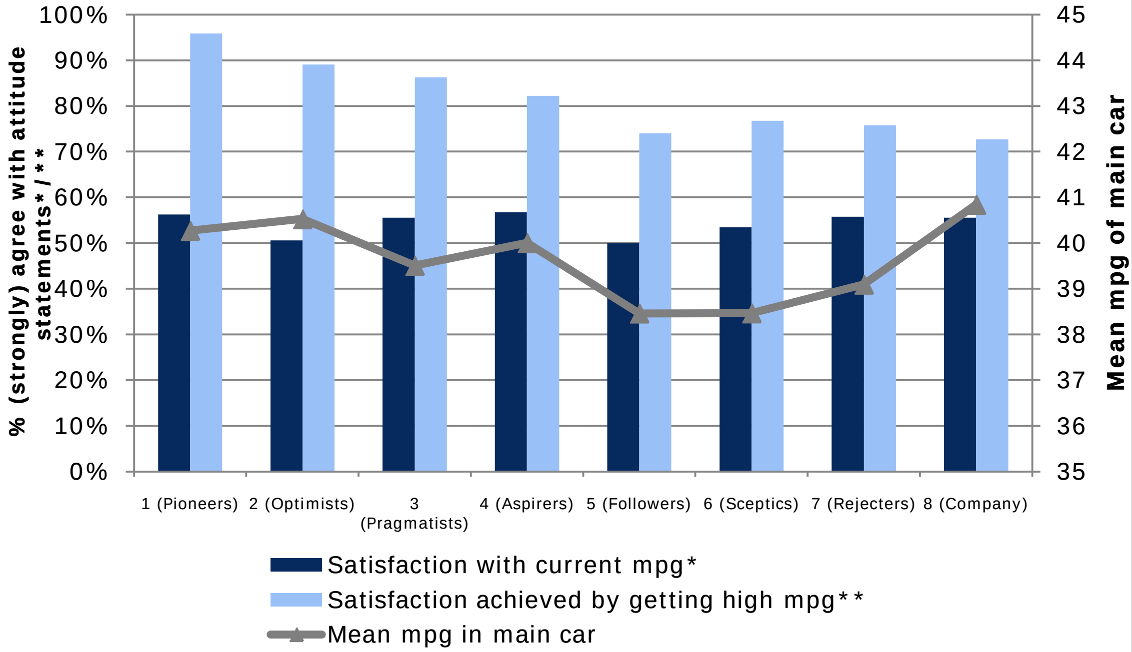
Note: there are no statistically significant differences on this measure between the six post-hoc segments. It would appear that the Company Car Drivers and the Pioneers have a different profile of type of car ownership to the rest of the segments and from each other.

10.2.12.3 Satisfaction with fuel economy

Figure 49 shows the average self-reported fuel economy of the main car alongside self-reported satisfaction with this fuel economy and the degree to which achievement of ‘good’ fuel economy itself provides satisfaction. There is a difference between the average self-reported fuel economy of currently owned vehicles. Segments which are most enthusiastic about EV technology tend to already own more efficient cars. This is consistent with other research evidence showing that the early adopters of alternatively fuelled vehicles tend to be people who currently already purchase more efficient cars (Curtin, Shrago & Mikkelson, 2009; Santini & Vyas, 2005). However, the Willing Pragmatists are not entirely consistent with this as they drive relatively large and inefficient vehicles.

Satisfaction with current fuel economy was measured in response to recent data from Nissan Leaf adopters in the US which found high levels of dissatisfaction to be an important distinguishing characteristic of this group (allcarselectric.com, 2011). However, this research did not find any evidence that satisfaction or dissatisfaction with the fuel economy of the currently owned vehicle was any greater in the EV adopter segments. There is, though, a significant difference in the importance attached to fuel efficiency as measured by the level of agreement with a single attitude statement, getting good fuel economy out of my car gives me satisfaction’ (Figure 49).

The Company Car Drivers claim to currently achieve the highest mpg, possibly due to the relative newness of their vehicles. However, they are no more satisfied with this as a result as the difference between the segments on this indicator is not statistically significant.



* "How satisfied are you with the fuel economy / mpg of this car?" [NB difference between groups is not statistically significant at P<0.05]

Figure 49: Current mpg, satisfaction with this mpg and importance attached to mpg in each segment (N=2,729)

10.2.12.4 Current ownership of alternatively fuelled vehicles

It has been hypothesised that the innovator/early adopter groups of EVs are likely to have similar traits to current hybrid and potentially other alternatively fuelled vehicle (AFV) owners (GLA, 2009). We did not set out to over-sample owners of such vehicles and we can therefore conclude very little from the 47 respondents in our sample that had access to at least one AFV in their household. Nevertheless, we have examined these owners given that they represent 1.4% of respondents which is double the proportion of UK new registrations of AFVs in recent years[18].

Figure 50 confirms that the segments who are portrayed as being the most likely to adopt EVs may indeed be the most likely to be current owners of AFVs. However, the very small number of responses involved in this analysis (N=47) means that the differences between the groups on this measure are not statistically significant. Although it is unwise to read much into these very small number of respondents, the general picture from this data is that the Plug-in Pioneers' responses are as expected; as a group they report already having over 4% of their household vehicles fuelled by an alternative fuel (in this case HEVs). The equivalent figure for Zealous Optimists is around 3%. The Company Car Drivers also own above average numbers of AFVs. Of the main cars driven as company cars, 2% of these (N=4) were HEVs and 1% (N=2) were Biofuel/CNG.

[18] In 2009, 1,994,999 new cars were registered in the UK of which 0.75% were AFVs. The equivalent figure in 2008 was 0.74% (SMMT, 2010).

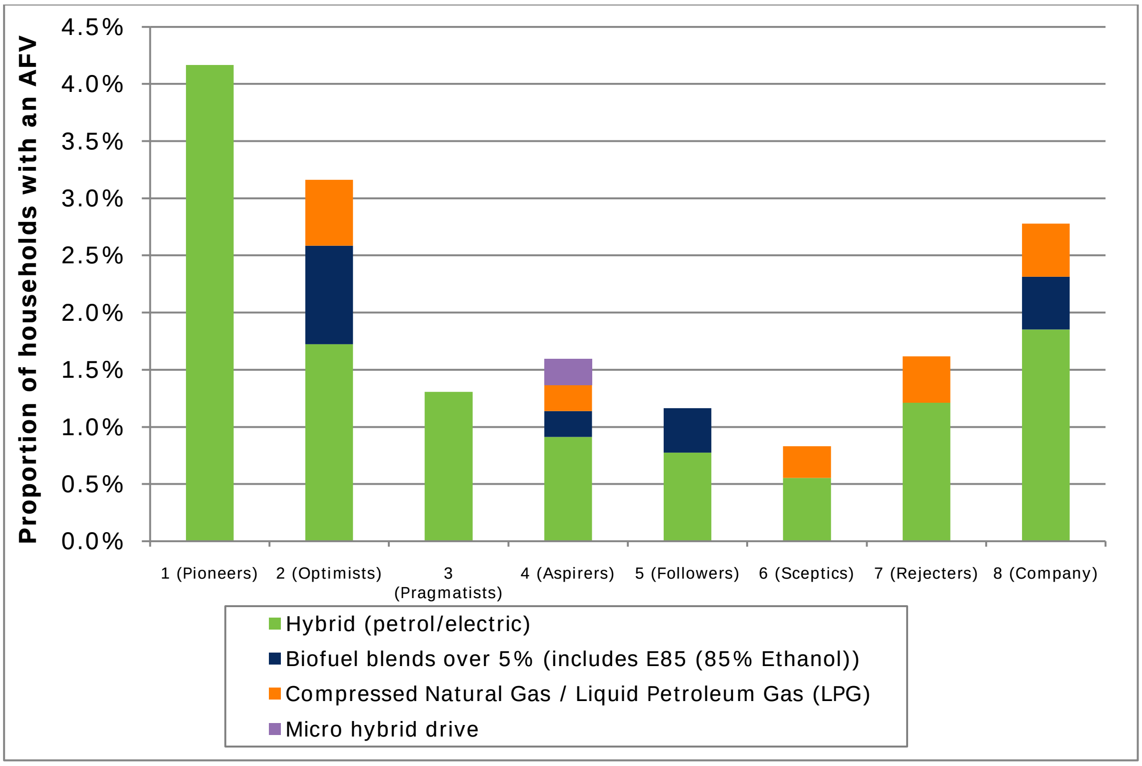


Figure 50: Ownership of AFVs in each segment (N=47 (current owners of AFVs))

10.2.13 Travel behaviour characteristics

Key findings:

- A significant proportion of car mileage is undertaken in cars other than a person's 'main car' (ranging from an additional 38% to 62% of the distance undertaken in the main car). This could be an indicator of a flexible use of cars which could become an increasingly important behavioural strategy to assimilate an EV into a household.
- The commute journey cannot be assumed to be the most important use of the car and the travel characteristic upon which to base predictions of charging behaviour. Several segments place equal importance with regard to their car use on shopping and leisure as for commuting and much of the typical weekday daily total mileages cannot be fully explained by the commute journey.
- Other than some differences in the proportion of workers commuting by car, the travel patterns of the six *post-hoc* segments are relatively similar and cannot therefore be considered an important factor to explain their different attitudes towards EVs.
- The Plug-in Pioneers are high car users but demonstrate particularly diverse patterns of travel. Use of the car for commuting is lower than average. Group members also attach less importance to commuting and a greater role for shopping and leisure journeys than some other groups, especially at weekends. Their car use is more urban based than other segments.
- The Company Car Drivers undoubtedly have a distinct travel profile. They are very high users of the car for commuting and business but also have high typical daily mileage totals at the weekend which indicates a heavy reliance on the car for activities other than work-related travel.
- It is possible that EVs will fit more easily into a lifestyle that is less dependent on the car and satisfies accessibility needs using a range of different modes of transport. The high use of public transport and cycling by the Plug-in Pioneers suggests this may be true and shows a possible tendency to use the most appropriate mode for each journey. Apart from this group, however, few conclusions can be drawn from this dataset about the relationship between the use of different transport modes and EV adoption.

Table 43: Segment travel patterns

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
CAR DISTANCE								
Mean miles in main car~	10,875	10,434	10,059	10,772	9,428	8,828	10,614	20,157
Mean miles in all cars~	16,813	15,454	14,111	15,421	14,955	12,163	15,582	32,574
Typical distance driven on a weekday (miles)~	49.4	48.0	37.8	41.2	37.2	39.1	35.3	98.5
Typical distance driven on weekend day (miles)~	49.5	36.8	31.9	33.9	30.0	31.1	37.6	44.3
COMMUTING AND BUSINESS TRAVEL								
% commuting to a workplace by car	54%	53%	44%	59%	46%	53%	53%	83%
% of workers commuting by car	74%	81%	82%	77%	76%	82%	83%	88%
Mean one way commute distance (miles)	23.2	15.5	15.4	11.8	11.1	11.8	14.5	27.6
% of workers undertaking no business mileage	23%	39%	44%	36%	49%	48%	45%	7%
TYPES OF ROADS USED								
Mainly in town/city/ urban	46%	36%	35%	48%	46%	42%	44%	32%
Mainly out of town/ motorway	8%	15%	22%	14%	12%	12%	17%	29%

FREQUENCY OF USE OF TRAVEL MODES (% using mode 5–7 days a week)

Car as driver*	73%	70%	63%	65%	65%	71%	69%	73%
Car as passenger	15%	5%	6%	5%	7%	3%	6%	15%
Bus/Tram/ Tube	17%	3%	2%	6%	2%	4%	3%	17%
Train	8%	3%	2%	3%	2%	3%	3%	8%
Bicycle	4%	2%	2%	3%	2%	1%	1%	4%
Walk	33%	19%	18%	22%	16%	17%	14%	15%

Note: In each comparison except * overall group differences when testing across all eight segments are statistically significant at $p<0.05$. See note under Table 34 and Appendix P for further detail. ~ Post-hoc comparisons reveal significant differences between the Company Car Drivers and all other segments on these measures, but not between any of the other segments. This allows us to conclude that the Company Car Drivers have, on average, a distinct travel profile on these indicators, but the other segments did not.

Table 44: Segment travel patterns – summary

Segment	Travel pattern characteristics – summary
1 (Plug-in Pioneers)	High average commuting distance and daily weekend-day totals (especially weekend), but shopping and leisure is as important as commuting. Lowest proportion of workers commutes by car and highest use of alternative travel modes across all journey purposes. High urban/town and low motorway/out of town.
2 (Zealous Optimists)	Above average mileage. High weekday daily distances and slightly higher commute distances with high commuting by car. Business travel and leisure trips are also important. Low use of alternative modes. Neither urban nor extra urban.
3 (Willing Pragmatists)	Medium annual car mileage but those that work tend to commute by car with slightly longer distances. Low use of alternative modes. High use of motorways.
4 (Anxious Aspirers)	Quite high mileage but less dependence on the car for commuting and lower commute distances. Relatively high use of public transport and walking. High in town driving and low motorway.
5 (Uninspired Followers)	Medium annual car mileage and short commutes with lower dependence on the car for the commute. Equal importance attached to shopping as commuting. Low use of alternatives. High in town driving and low motorway/out of town.
6 (Conventional Sceptics)	Low annual mileage and commuting and daily totals. The car is important for those who work but overall less dominated by commuting and more about shopping and leisure. Low business travel and low use of motorways.
7 (Image-conscious Rejecters)	Above average mileage and commute distances and dependence on the car for work, but lower daily totals, especially at weekends – suggests car use is dominated by the commute. High motorway use.
8 (Company Car Drivers)	Very high annual mileage and daily totals, including at the weekend. High business mileage but also high mileage carried out in other family cars. Highest proportion of workers commutes by car. Some use of alternative modes, particularly the train. Very high motorway use.

Note: Post-hoc comparisons reveal significant differences between the Company Car Drivers and all other segments on annual mileage distance measures, but not between any of the other segments. This allows us to conclude that the Company Car Drivers travel on average much longer distances by car but the other segments have similar profiles. The comparisons made have been inferred by taking a whole series of indicators together but should nevertheless be treated with caution.

10.2.13.1 Car mileage

There are various indicators of car mileage distance that can be used to gauge typical travel patterns and typical daily car distance ranges. Figure 51 places all of these indicators together – both the annual mileages driven in the main car or all cars, and the daily commute or typical daily distances – in order to see the relationship between these two sets of figures. This Figure should be examined alongside Figure 52 to Figure 56 and Table 43 which illuminate other aspects of travel patterns such as the proportion of business travel and the proportion of car travel distance spent travelling on certain types of roads.

Car travel distances are important for two main reasons. Firstly, typical daily driving distances and patterns (i.e. to or from a workplace) may determine the potential charging pattern of the vehicles and the importance attached to charging infrastructure by individuals. Secondly, those who drive higher mileages may be more likely to be interested in the fuel saving potential of EVs. We address these aspects in later sections.

Overall, Figure 51 shows that it is important to understand the distance driven in both the main car and in total across all cars driven by a respondent. Whilst the two totals tend to mirror each other, some groups tend to split their time across different vehicles more than others, with the additional mileage carried out in cars other than the main car. This ranges from an additional 38% to 62% of the total miles carried out in the main car. This could be an indicator of a propensity to 'mix and match' cars which could become an increasingly important behavioural strategy to assimilate an EV into households. It is also an indicator that respondents are likely to often have an influence on the choice of more than just the one 'main' car.

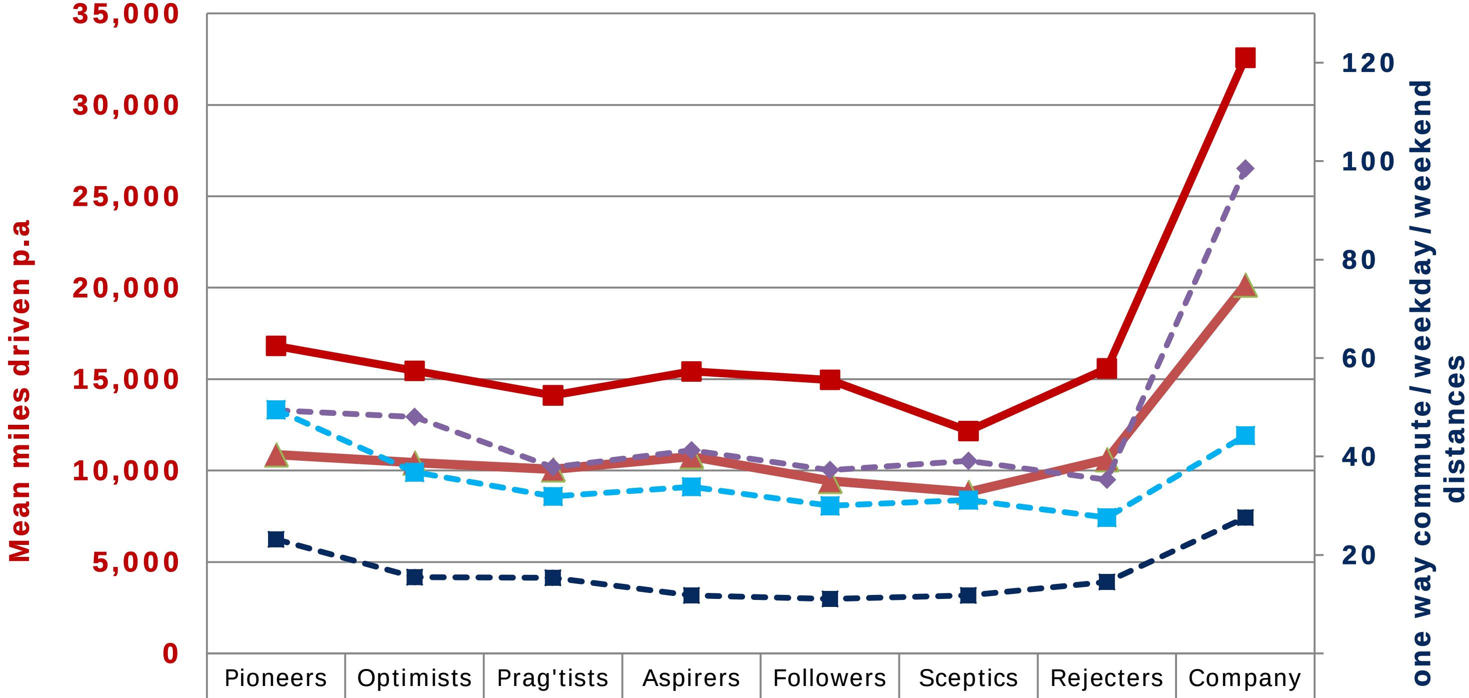
The Company Car Drivers are particularly distinctive with very high annual car mileage totals – both in their main company car and through the use of additional cars in their household which add, on average, an additional 60% on top of the company car use. One way commute distances are high, but in particular the typical daily total is very high. The high participation in business travel is likely to contribute to this, with around 50% of Company Car Drivers saying that approximately 50% of their car distance is comprised of business miles (see Figure 51). However, their typical daily total miles at the weekend are also high which indicates a heavy reliance on the car for activities other than commuting and business travel. They also carry out a relatively high proportion of their car miles on motorways and out of town routes.

The Plug-in Pioneers are also relatively high car users, although they drive considerably less in terms of the annual and weekday totals than the Company Car Drivers. Average car commute distances are around 23 miles one-way (50% above the average) and typical total weekday and weekend-day mileages across all journey purposes are above the average. The high daily weekday total may be explained by the lengthier commute but the weekend-day total is potentially explained by Figure 54 which indicates that this group would miss the car equally for shopping and leisure journeys as for the commute. The relatively low importance of the commute is also indicated by the fact that among car commuters there is less attachment to the car in this group than in any other group as fewer workers commute by car (Figure 52). Figure 55 shows that the majority would consider themselves to be mainly urban/town drivers and also this group, more than any other, appears to mix and match its travel modes, not relying on the car to such an extent as all the other segments (Figure 56). This may be indicative of a tendency to choose the most appropriate mode for each journey which could of course include a plug-in vehicle. In summary, the multi-modal, and multi-purpose pattern of car use is quite a distinct pattern and would suggest that Plug-in Pioneers have particularly diverse and flexible patterns of travel, possibly more urban based than other segments, and possibly less tied to the car, particularly commuting.

The travel patterns of the six *post-hoc* segments are relatively similar as indicated by the lack of statistically significant differences on some of the indicators (see Figure 51). The segments do vary significantly on commute distance, typical weekend distance and the proportion of workers who commute by car.

The degree to which commuting dominates the use of the car and dictates levels of car use can be examined to some extent with these data. This has implications for actual potential patterns of EV charging as well as perceived dependence on the car and perceived ease of charging options.

As a proportion of people employed in each segment (which itself varies), in all cases at least three-quarters of workers travel by car. However, this proportion is variable. Aside from the Company Car Drivers (most car dependent at 88%) and the Plug-in Pioneers (least car dependent at 74%), the Image-conscious Rejecters, Conventional Sceptics, Willing Pragmatists and Zealous Optimists all have high levels of car commuting (over 80%), and the Uninspired Followers and Anxious Aspirers have the least (around 75%). Figure 54 also gives us an indication of the importance attached to car commuting *vis a vis* other journey purposes. This suggests that leisure journeys are also relatively important for the Zealous Optimists and Image-conscious rejecters, shopping for the Uninspired Followers and Conventional Sceptics, and visiting friends and relatives for the Willing Pragmatists.



	Pioneers	Optimists	Prag'tists	Aspirers	Followers	Sceptics	Rejecters	Company
Total miles driven in all cars p.a.	16813	15454	14111	15421	14955	12163	15582	32574
Miles driven in main car p.a.	10875	10434	10059	10772	9428	8828	10614	20157
Typical total weekday mileage	49.39	48.03	37.80	41.24	37.24	39.09	35.25	98.53
Typical total weekend day mileage	49.49	36.81	31.90	33.85	29.97	31.14	27.58	44.25
One-way commute distance (miles)	23.2	15.5	15.4	11.8	11.1	11.8	14.5	27.6

Figure 51: Car driver distance in each segment (N=2,729[19])

(Note: Other than mean one-way commuting distance and typical weekend-day miles, only the Company Car Drivers show significantly different travel patterns)

[19] Or N=1,474 commuters for the question relating to one-way commute distance.

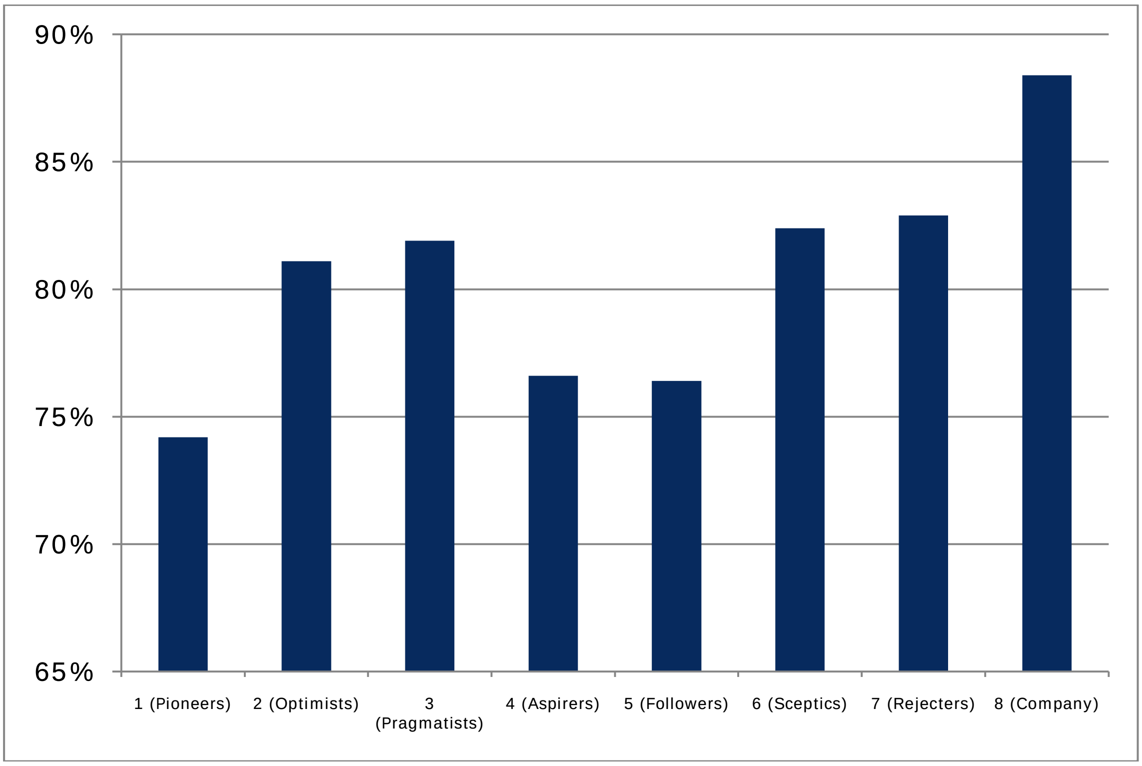


Figure 52: Proportion of workers commuting by car in each segment (N=1,525 (employed respondents only, not including self-employed))

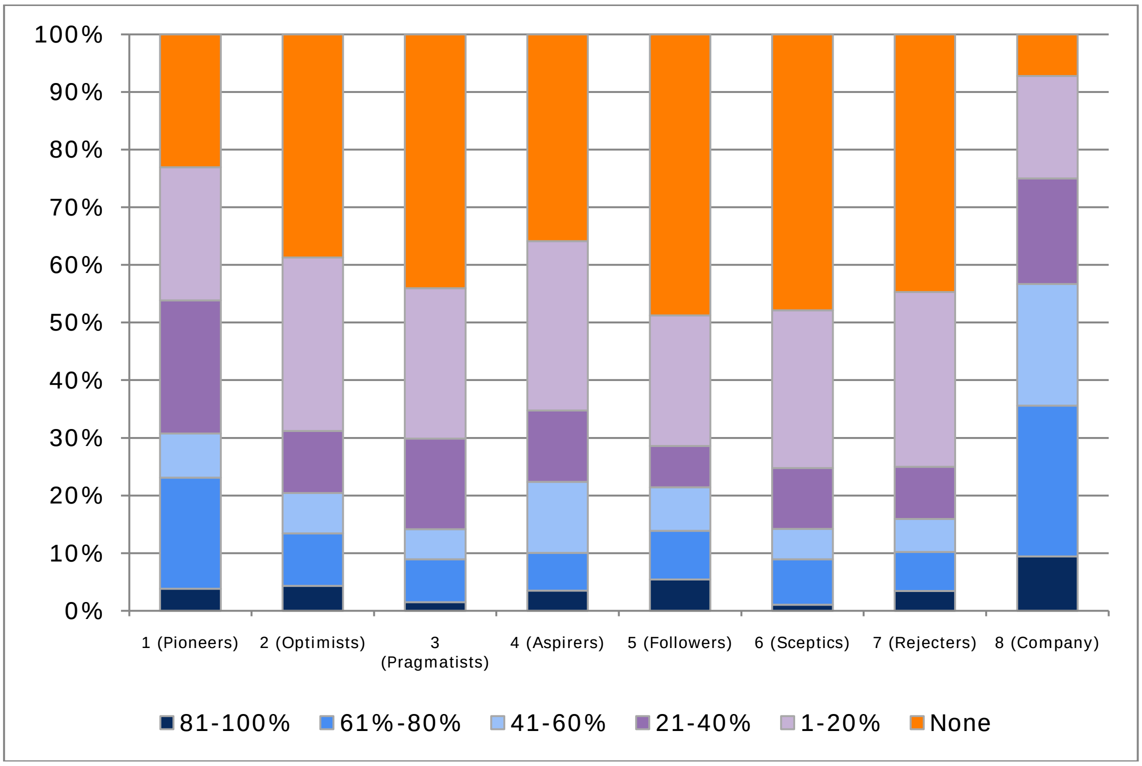


Figure 53: Proportion of car miles undertaken on business trips in each segment (N=1,477 (car commuters only))

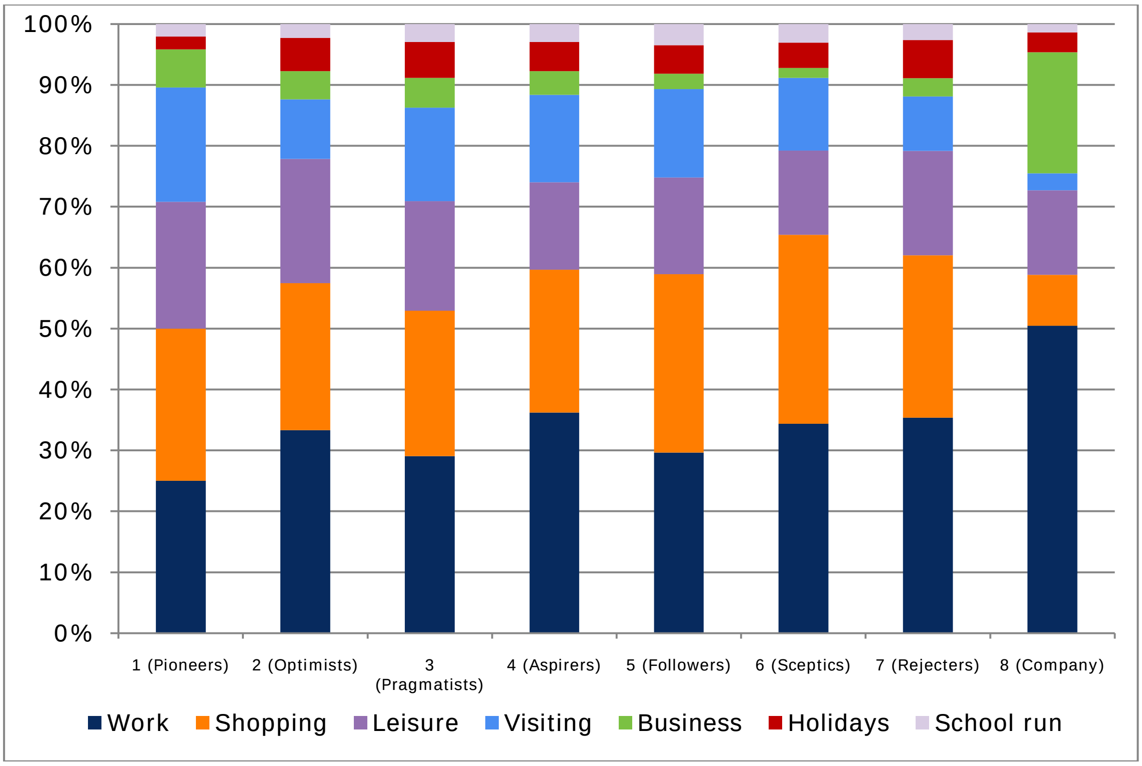


Figure 54: Journey purpose that would be missed the most if a car was not available in each segment (N=2,729)

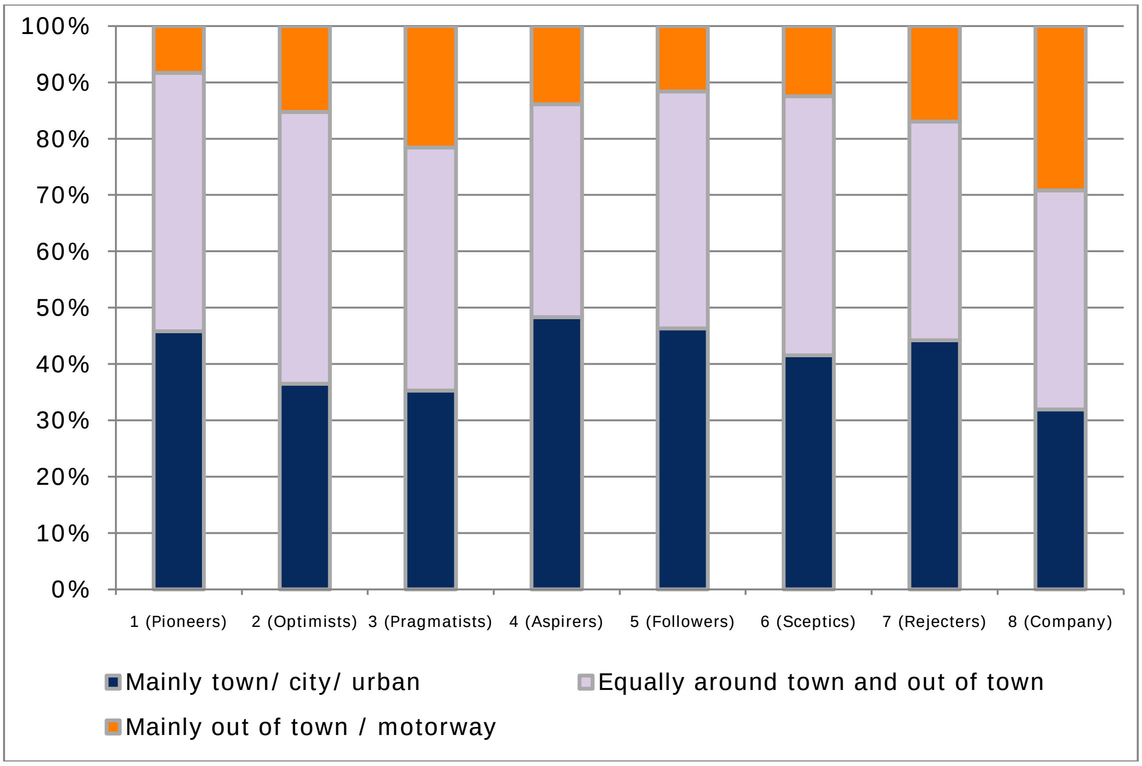


Figure 55: Use of the car on different road types in each segment (N=2,729)

10.2.14 Frequency of use of transport modes other than the car

It is possible that EVs will fit more easily into a lifestyle that is *less* dependent on the car and satisfies accessibility needs using a range of different modes of transport. This survey included a crude measure of frequency of use of a variety of transport modes and there proved to be statistically significant differences between the groups on the frequency of use of modes.

The Plug-in Pioneers appear to be the most ‘multi’ modal of all groups. Their use of buses/trams or the underground is particularly high in comparison to all other groups (17% say they use it between five and seven days a week, compared to 4% on average for the other groups), as is their use of the train. They also appear to travel by car as a passenger much more than most.

The Anxious Aspirers are also relatively heavy users of local public transport and walking. Apart from the Plug-in Pioneers, however, few conclusions can be drawn from this dataset about the relationship between the use of travel modes other than the car and EVs.

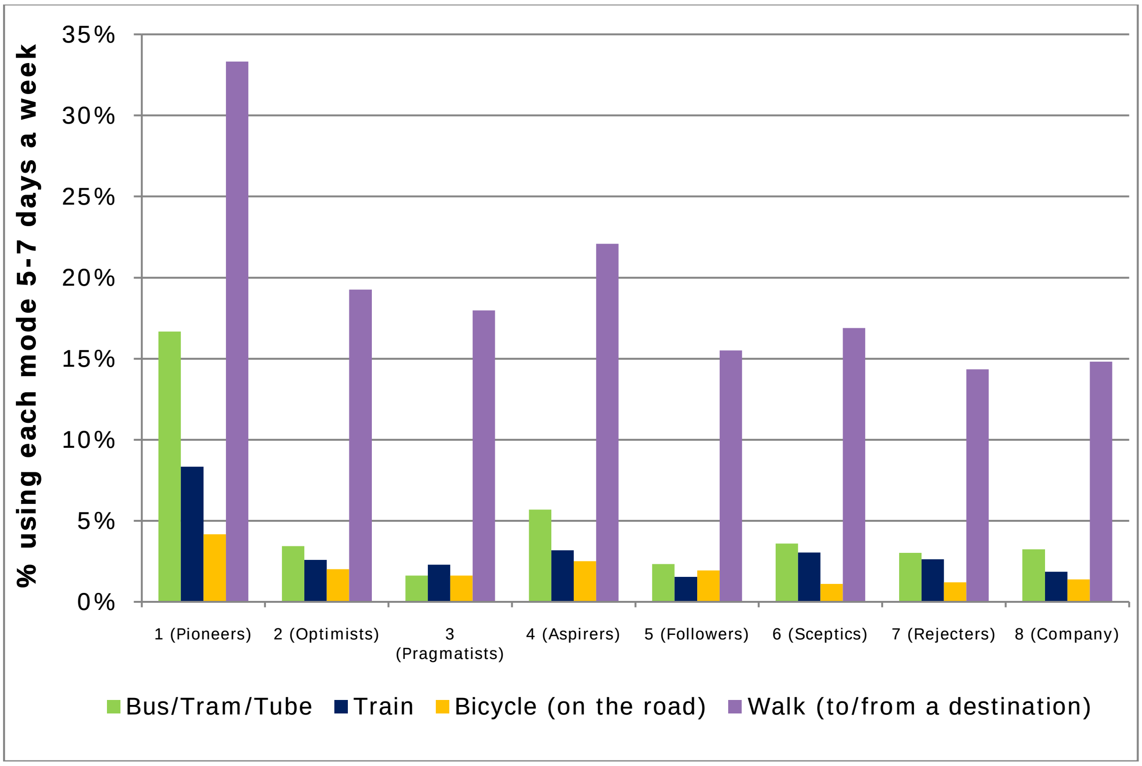


Figure 56: Frequency of use of different types of travel mode in each segment (N=2,729)

10.2.15 Attitudes towards charging infrastructure and range

Key findings:

- For the sample as a whole, 17% of commute trips, 27% of daily total distances and 23% of typical weekend-daily totals take place outside of an indicative utilised range for an EV of 80km.
- There are no segments for which it can be said that BEVs are not compatible with the majority of trips undertaken. However, from these data, it is possible that the segments with the most conducive travel patterns have the least favourable attitudes towards EVs.
- The perception of suitability of EVs to travel patterns is subject to large variation between segments. In general, people believe PHEVs will suit their daily travel patterns better than BEVs. Overall, however, most groups are much more inclined to believe that EVs would not suit their travel patterns than their self-reported commute and daily car mileage distances would suggest.
- The Plug-in Pioneers and Zealous Optimists are convinced that EVs will suit their travel patterns. The Image-conscious Rejecters on the other hand are extremely pessimistic even though their travel patterns may be among the most suited to such vehicles.
- The polarised opinions of the Willing Pragmatists are exposed by this measure as 84% of them believe PHEVs would suit their travel patterns compared to only 15% for BEVs.
- The Company Car Drivers are relatively positive about EVs given that their travel patterns may be the least suitable. However, as already discovered, these respondents drive many more miles in cars other than their company car and at weekends, and may therefore believe that EVs have some role in this part of their travel lifestyle.
- Measures of beliefs and concerns about charging and range clearly indicate that BEVs, and even PHEVs, are far from being regarded as ‘normal’. Even PHEVs are perceived as requiring significant pre-planning of journeys and attention to their state of charge. Anxiety is especially high among the Anxious Aspirers and the Image-conscious Rejecters.
- However, independence from refuelling at petrol stations by being able to charge at home is an attractive proposition to all the segments with almost 100% of the Plug-in Pioneers and the Zealous Optimists believing this to be a good idea.
- Overall, 80% of the sample has access to off-street parking with charging but this varies from 63% to 93% across the segments. Generally, the segments with the more enthusiastic outlook towards EVs also have the highest parking and charging capacity at home.
- The existence of a parking space is not the same as it being thought about as a convenient place to park and charge a vehicle. For instance, 59% of respondents have a garage, 90% of which are said to have an electrical socket, but only 56% of garage owners use it to park a car.
- Charging a car at home is perceived to be much more difficult than the ‘objective’ measure of parking capacity suggests it should be. For instance, only 37% of the Anxious Aspirers say they do not have off-street parking with charging, yet 91% believe it would be difficult for them to charge at home.
- The majority of respondents in all cases believe that they will be able to mainly rely on home or workplace charging options. The Plug-in Pioneers have unanimous faith in this as an option. Nevertheless, even though workplace and home charging are believed to be the most important sources of recharging, over 50% of even the Plug-

in Pioneers still believe PHEVs will only be feasible with access to a rapid charging point, and 70% for BEVs.

Table 45: Segment attitudes towards charging and range

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
COMPATIBILITY BETWEEN TRAVEL PATTERNS AND EVs								
One-way commute > 25 miles	12%	19%	19%	14%	10%	12%	15%	45%
Typical weekday daily total > 50 miles	27%	28%	23%	25%	23%	21%	23%	62%
Typical weekend-day daily total > 50 miles	35%	25%	26%	25%	21%	22%	17%	31%
PERCEIVED SUITABILITY OF EVs (% strongly agree + agree)								
% agreeing PHEV will suit their travel patterns	90%	84%	84%	61%	50%	63%	28%	51%
% agreeing BEV will suit their travel patterns	75%	67%	15%	34%	31%	41%	5%	27%
RANGE ANXIETY (% strongly agree + agree)								
% agreeing PHEV journeys will need planning	54%	57%	28%	76%	60%	66%	80%	67%
% agreeing BEV journeys will need planning	75%	82%	98%	88%	70%	91%	94%	85%
% always worried about running out of charge in PHEV	38%	41%	25%	74%	55%	66%	84%	58%
% always worried about running out of charge in BEV	52%	60%	98%	88%	62%	86%	95%	77%

PARKING CAPACITY AT HOME								
Off-street with charging	90%	93%	91%	63%	83%	83%	70%	83%
Off-street without charging (or don't know)	4%	4%	5%	20%	9%	7%	15%	9%
On-street	2%	3%	3%	15%	6%	8%	13%	6%
No parking	4%	1%	2%	3%	3%	1%	3%	1%
DESIRE FOR RAPID CHARGING INFRASTRUCTURE (% strongly agree + agree)								
Belief in the need for rapid charging as a prerequisite to adoption ...for PHEV	56%	44%	39%	81%	51%	72%	67%	59%
... for BEV	71%	54%	75%	80%	52%	76%	63%	68%

Note: In each comparison overall group differences when testing across all eight segments are statistically significant at $p<0.05$. See Appendix P for further detail.

Table 46: Segment attitudes towards charging and range – summary

Segment	Attitudes towards charging and range - summary
1 (Plug-in Pioneers)	Highly optimistic about the suitability of EVs to their lifestyle and the least concerned about BEV range but still maintain the need to plan journeys carefully. Very high perceived desirability to refuel at home. Very high off-street parking and unanimous faith that they will rely on home or work charging. However, majority still want to wait for rapid charging points.
2 (Zealous Optimists)	Highly optimistic about the suitability of EVs to their lifestyle and low range anxiety. Very high off-street parking, high perceived ease of charging at home. Very high desirability to refuel at home and relatively low perceived need to wait for rapid charging.
3 (Willing Pragmatists)	Highly optimistic about suitability of PHEVs but extreme pessimism about BEVs, particularly range anxiety. Very high off-street parking, slightly lower perceived ease of charging at home (but still very high) and high desirability to refuel at home. Low perceived need for rapid charging for PHEVs.
4 (Anxious Aspirers)	Relatively pessimistic about suitability of EVs to their travel patterns. Very high range anxiety, relatively low off-street parking and very low perceived ease of charging at home but high desirability to do so. Very high desire for rapid charging.
5 (Uninspired Followers)	High 'neutral scoring' on all attitudes indicating high level of indifference and lack of engagement with the issues. Quite high off-street parking but relatively low perceived ease of charging at home and tempered desirability.
6 (Conventional Sceptics)	Some acknowledgement that PHEVs and BEVs would suit their travel patterns but high range anxiety. Quite high off-street parking but low perceived ease of charging but high desirability to refuel at home. High desire for rapid charging.
7 (Image-conscious Rejecters)	Extreme pessimism about suitability of both PHEVs and BEVs despite possibly having the most suitable travel patterns. Clearly believe EVs are a hassle and high range anxiety. Relatively low off-street parking and very low perceived ease of charging at home but lowest desirability to do so.
8 (Company Car Drivers)	Relatively optimistic about suitability although high concerns about BEV range. Quite high off-street parking but quite high perceived difficulty of charging at home and slightly tempered desirability. High desire for rapid charging.

10.2.15.1 Travel patterns and EV suitability

Using the analysis of travel patterns presented in Section 10.2.8 above, it is possible to comment on the proportion of mileage that could be carried out using an EV. In order to relate the survey data to EV potential, we have assumed a utilised range of 80km (50 miles)[20] and Figure 57 identifies the proportion of each segment's mileage carried out for commuting or total weekday or weekend-day activities that is within this range. For the sample as a whole, only 17% of commute *trips*, 27% of daily total distances and 23% of typical weekend-daily totals take place outside of this utilised range. This is in line with analysis carried out using the National Travel Survey which finds that 90% of all UK car *trips* and 60% of overall car-*km* could be accounted for with a vehicle with a similar utilised range[21].

Qualitative analysis undertaken as part of this project together with the literature review, however, tells us that even direct experience or feedback about EV range does not change perceptions about *desired* vehicle range as a high premium is placed on the ability to have the option to drive longer distances, even if they are relatively rare. We were able to collect some information to shed light on these consumer perceptions and desires using a number of attitudinal statements examining the issue of range and charging.

Figure 57 contrasts the proportion of trips or daily distance totals within the range offered by a vehicle with a utilised range of 80km (50 miles) with the perception that people have about whether a PHEV or BEV would suit their travel patterns. From this it can be seen:

- How much more suitable people believe PHEVs to be than BEVs.
- How optimistic the Plug-in Pioneers and the Zealous Optimists are in relation to their self-reported travel patterns. In these groups, members seem to believe these vehicles are *more* suitable than their daily distance totals suggest they might be.
- How pessimistic the Image-conscious Rejecters are about both PHEVs and BEVs, particularly considering their travel patterns may be among the *most* suitable to such vehicles.
- Just how much more pessimistic the Willing Pragmatists are about BEVs compared to PHEVs. Only 3% of them believe PHEVs would *not* suit their travel patterns compared to 65% with respect to BEVs.
- How relatively optimistic Company Car Drivers are given that their travel patterns may be the least conducive to EVs. However, as discovered in Section 10.2.13, these respondents drive many more miles in cars other than their company car and at weekends. We also know that they may see a role for these cars as second vehicles. Hence, it may be that these respondents have some faith that EVs may fit into their 'portfolio' of household cars.

Overall, there are no segments for which it can be said that BEVs are not compatible with the majority of trips undertaken. The Company Car Drivers have the least compatible journey patterns. However, from these data, it is possible that the segments with the most conducive travel patterns have the least favourable attitudes towards EVs.

[20] As reported and discussed in the literature review for this project (WP1-3-1), this was one of the ranges used by Element Energy (2009).
[21] Ibid. 100km range was used for this analysis.

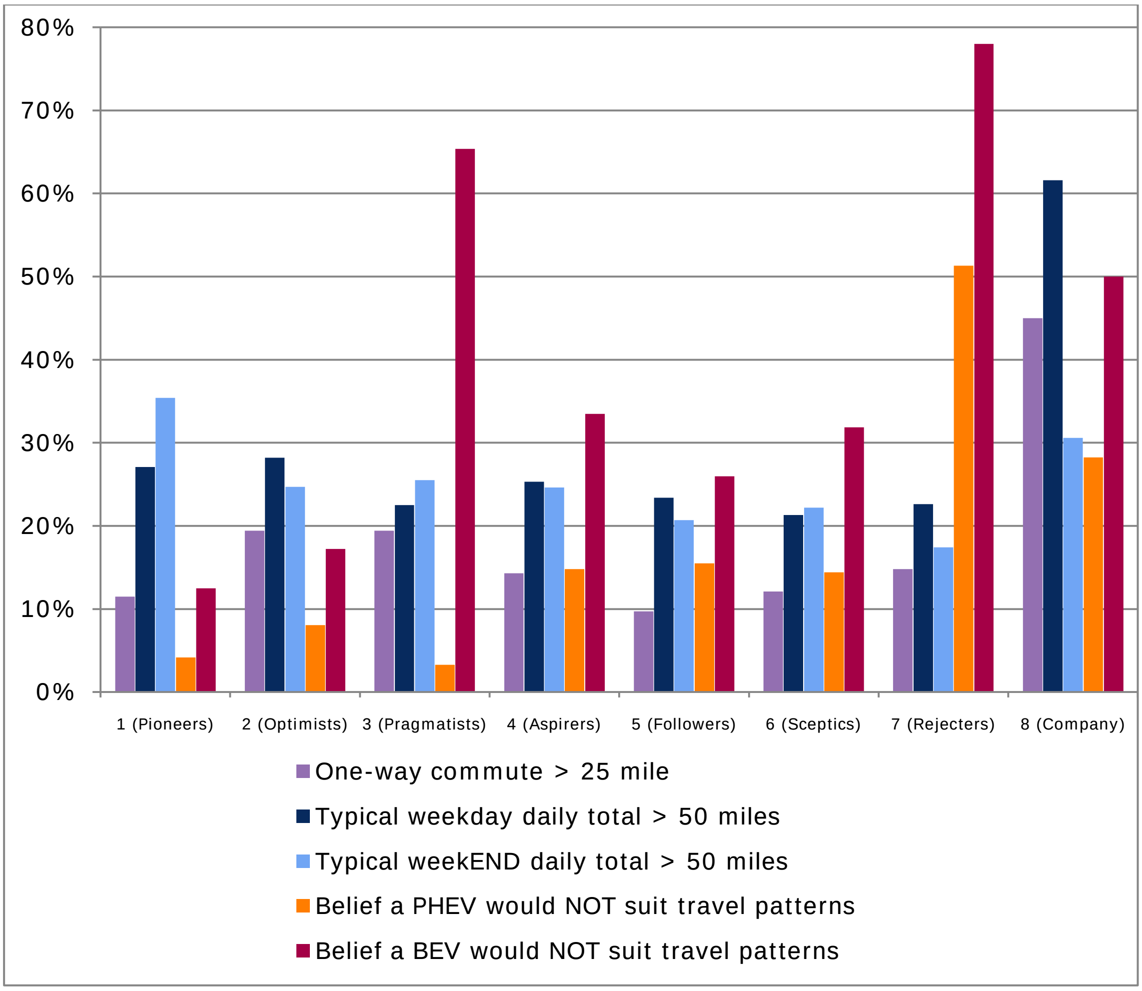


Figure 57: Comparison between 'actual' and perceived suitability of travel patterns to EVs (N=2,729)

10.2.15.2 Concerns about running out of charge

Respondents were also asked a number of questions relating to the cognitive effort they believe would be involved in operating an EV – namely how much they would have to plan journeys and how worried they would be about running out of charge.

Figure 58 compares the level of concern in relation to PHEVs and BEVs and across segments. It is notable from this how much even PHEVs are perceived as requiring significant pre-planning of journeys and attention to the state of charge of the battery. With the exception of the Willing Pragmatists, who we know are keen on PHEVs, the majority of respondents in all groups believe that PHEVs would require careful planning of journeys and a smaller proportion say they would be worried about running out of charge in these vehicles.

Response to this question could indicate a misunderstanding of the technology, and if so it indicates that the Willing Pragmatists are indeed very well informed about PHEVs, the Plug-in Pioneers and Zealous Optimists *relatively* well informed but still with over a third having anxieties about the need to charge PHEVs when driving them, but over half of the remaining groups, including the Company Car Drivers, have such concerns about PHEVs. Anxiety is especially high among the Anxious Aspirers and the Image-conscious Rejecters.

However, this cannot be taken entirely as a measure of 'objective knowledge' as the desire to keep a PHEV well-charged may be more about a concern for fuel economy than a misunderstanding of the technology. We know from the literature review that PHEV owners are enthusiastic about wanting to take advantage of the all-electric range and take every opportunity to recharge (Kurani, Heffner & Turrentine, 2007). Nevertheless, this result clearly indicates that PHEVS, and particularly BEVs, are far from being regarded as 'normal' cars.

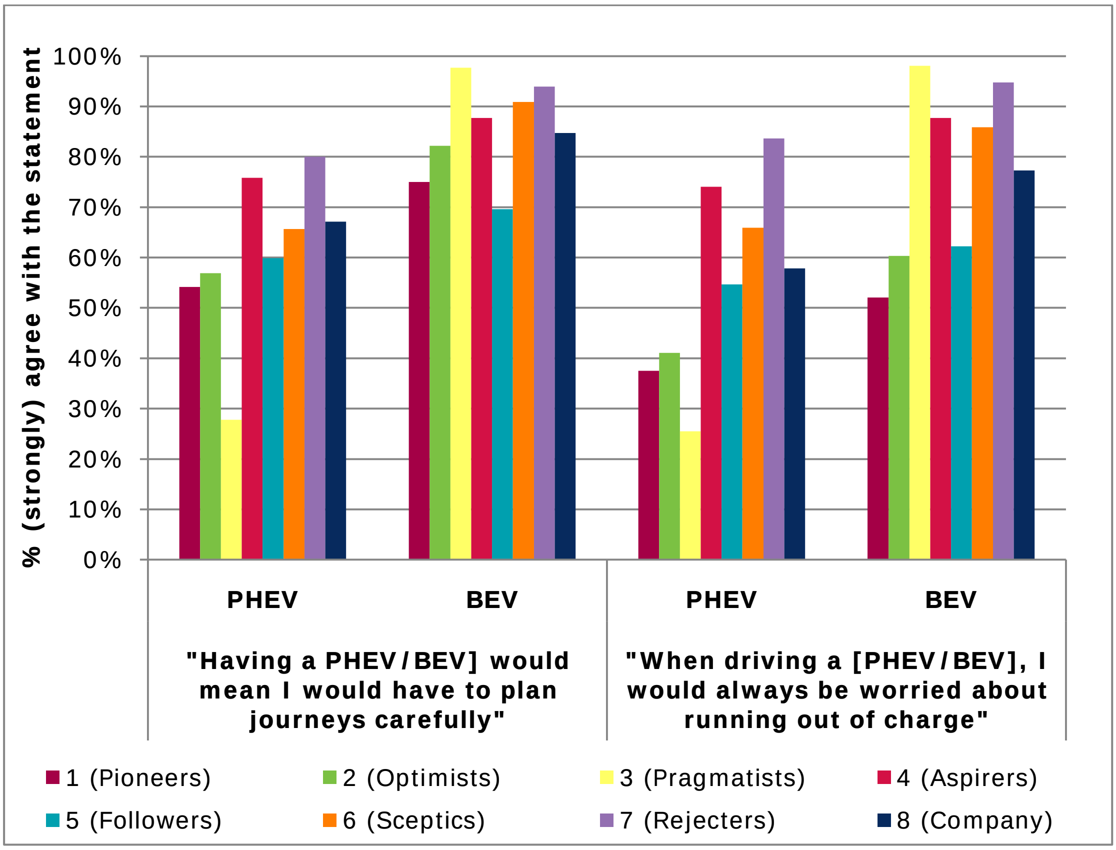


Figure 58: Beliefs about to the need for journey planning and range anxiety with respect to PHEVs and BEVs (N=2,729)

10.2.15.3 Parking and charging capacity at home

Segments were compared on their reported availability of off-street parking spaces with access to electric power[22]. Across the sample as a whole, 80% of respondents have access to off-street parking with charging. However, there are some differences between segments, with the Zealous Optimists and Plug-in Pioneers having 90% or above and the Image-conscious Rejecters and Anxious Aspirers having 60-70% (Table 45 and Figure 59). Generally, the segments with the more enthusiastic outlook towards EVs also have the highest parking and charging capacity.

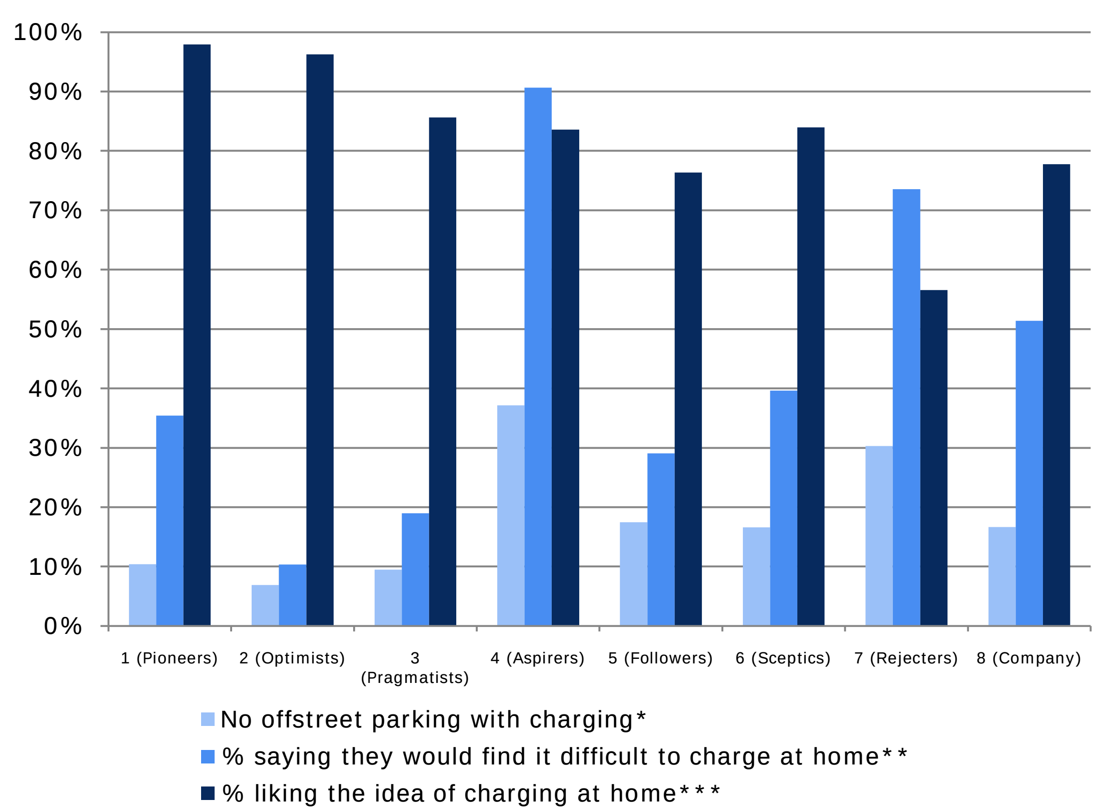
However, this 'objective' measure (albeit subject to possible inaccuracies in assessment by respondents of the availability of an electric socket within reach of their parking space(s)) can be contrasted with a measure of *perceived* ease or difficulty of plugging in a car to charge at home. Figure 59 shows that these two measures are not necessarily consistent with each other: the perceived difficulty of charging a car at home is much greater than the measure of household parking capacity suggests. The difference is particularly acute for the Anxious Aspirers, 91% of whom strongly agree or agree that

[22] Respondents were asked to indicate how many parking spaces they had available off-street (in a garage, driveway/carport or other) and on-street. For the off-street parking they were asked to indicate "if you had to plug in an electrical appliance to work in this parking space (e.g. a vacuum cleaner), is there an electrical socket within reach?" They could respond to this by saying 'yes, easily', 'yes with an extension cord', 'no' or 'don't know'.

finding somewhere to park at home to plug in a car near a socket would be difficult for them, despite 37% claiming not to have off-street parking with charging. This is in keeping with the generally high or negative scores that this group tends to give to any issues relating to range and charging. However, the gap between 'actual' and perceived home-charging capacity is also large for most other segments with the exception of the Zealous Optimists who generally have an exceptionally positive outlook with respect to charging capability but who also seem to be most likely to have the capacity to charge at home.

This gap between 'actual' and perceived charging capacity is difficult to explain entirely from the data but does lend caution to the reliance on official published statistics on housing type and off-street parking in the UK. One factor may be the difference between the physical availability of a parking space and the ease of use of that space. For instance, although 59% of respondents have a garage, 90% of which are said to have an electrical socket, only 56% of garage owners use it to park a car. Thus the existence of a garage is not the same as it being thought about as a convenient place to park.

These two measures can also be contrasted to the desirability of refuelling at home. Figure 59 also includes agreement with a statement about the attraction of refuelling at home as opposed to having to visit petrol stations. This is one indication of the potential motivation for adopting plug-in technology. Independence from refuelling at petrol stations is an attractive proposition to all the segments with the Plug-in Pioneers and the Zealous Optimists being most attracted and the Image-conscious Rejecters and the Uninspired Followers being the least attracted to the idea. However, the greatest disgruntlement (i.e. perceived difficulty of home charging being greater than desirability) is experienced by the Anxious Aspirers. Disgruntlement is also high for the Image-conscious Rejecters but with less of a potential consequence given their general negativity toward the technology.



* Those without a garage/driveway or other offstreet parking with an electric socket within easy reach or with an extension cord (Qb1-b5)

** Strongly agree + agree with: "*Finding somewhere at home to park a plug-in car near an electric socket would be difficult for me*" (Qb2a)

*** Strongly agree + agree with: "*I like the idea of being able to refuel at home rather than have to go to petrol stations*" (Qb2d)

Figure 59: Parking capacity and perceived ease of at home charging in each segment (N=2,729)

10.2.15.4 The desire for rapid charging

Range anxiety is likely to be exacerbated in the current situation where public charging infrastructure is minimal. However, studies have generally found the lack of recharging infrastructure to be less of a concern to consumers than range *per se*. The clear consensus from the literature to date is that consumers will mainly recharge their EVs at home and in workplace car parks, and frequent recharging will be the norm, at least at first.

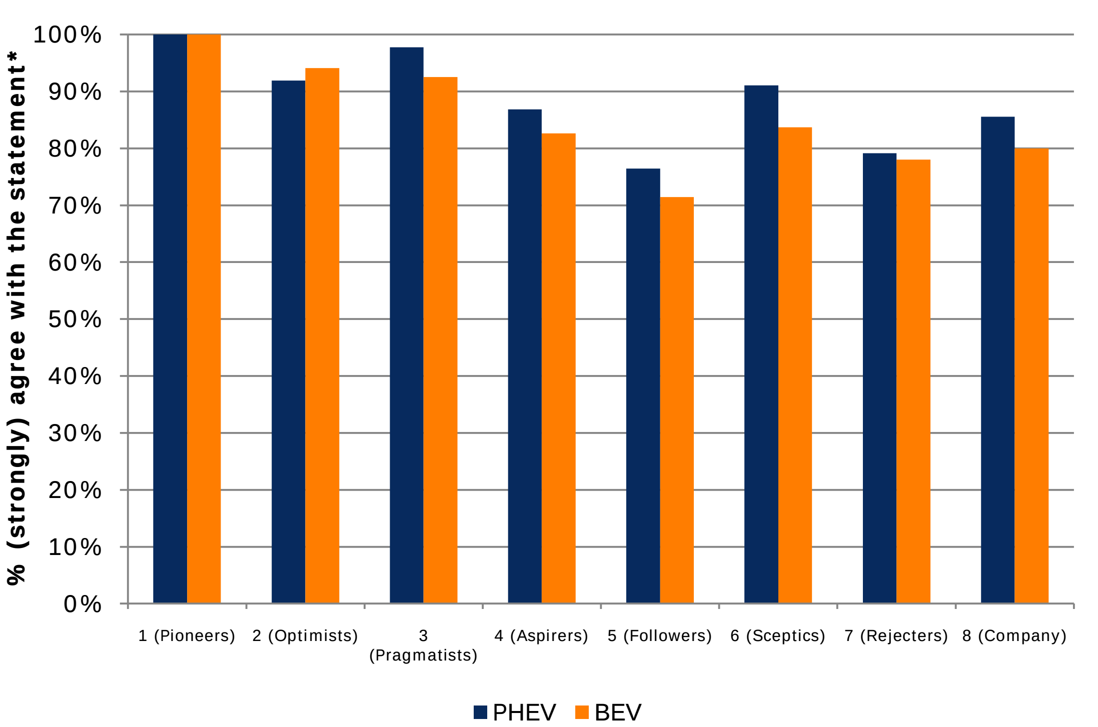
This study was not able to examine such behaviour in depth. Instead, two specific questions addressed the likely reliance on home or workplace charging and the perceived necessity to have access to rapid charging. One question in the survey asked respondents to indicate how strongly they believed that 'if I had a [PHEV/BEV], I would mainly charge it at home or work', in order to tease out the perceived need for on-street and public charging points as opposed to workplace or home charging. Controlling for variable levels of employment between segments, Figure 60 looks only at those people who commute to a workplace by car, and compares responses to this question. Figure 61 displays answers to the complementary question 'I would only consider a (PHEV/BEV) if I knew I had access to a rapid charging point (i.e. somewhere where it would charge less than half an hour)'.

The Plug-in Pioneers can be seen to have unanimous faith that they will be able to *mainly* rely on workplace or home charging and this is one of the defining characteristics of this early niche adopter group. This also fits with the above analysis which found them to have potentially diverse but more urban-based travel patterns. Indeed, the majority of respondents in all cases believe that they will be able to mainly rely on these private charging options. However, the Uninspired Followers, Image-conscious Rejecters and Anxious Aspirers are less convinced, as are the Company Car Drivers who are likely to have concerns that the home or workplace options are not sufficient for when they are out and about on longer distance business trips.

Nevertheless, even though workplace and home charging is believed to be the most important source of recharging, more than half of the Plug-in Pioneers still believe PHEVs will only be feasible with access to a rapid charging point, and over 70% for BEVs. It is notable and perhaps somewhat curious that this desire to have access to rapid charging looks to be higher than some other segments such as the Zealous Optimists and the Willing Pragmatists (with respect to PHEVs only) who once again have a very positive outlook by being the least likely to say that a rapid charging point is a prerequisite[23].

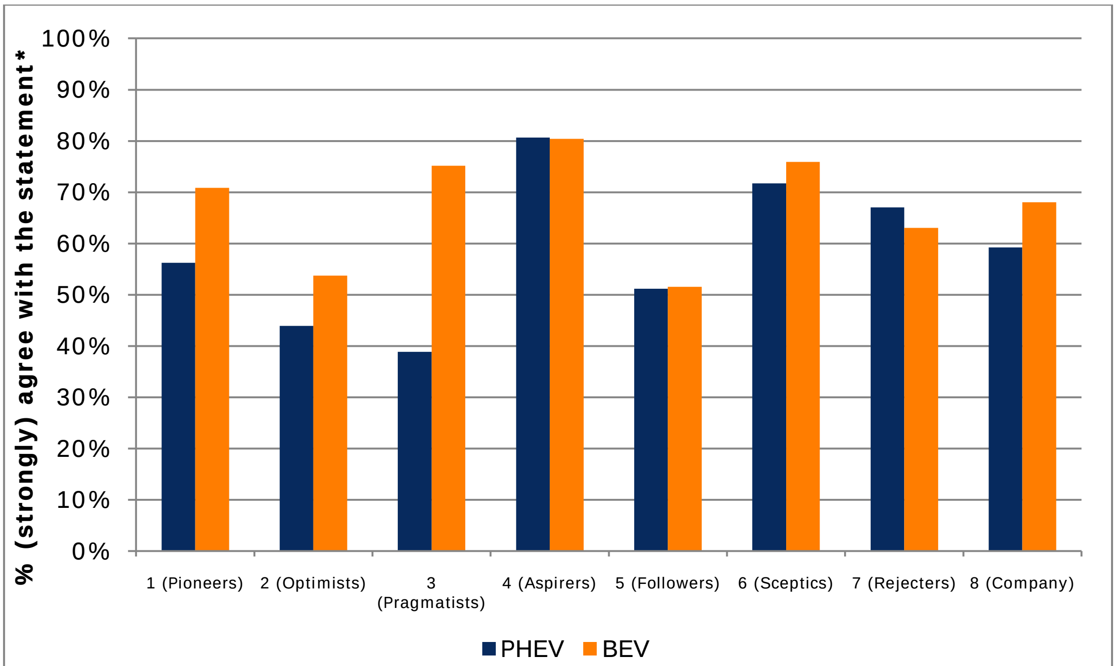
One statement potentially captures the preceding measures in one indicator and clearly reveals the contrast between the segments and between the two car technologies. Respondents were asked to indicate agreement with the statement ‘adapting to charging a PHEV/BEV would be difficult for me’. Figure 62 demonstrates most clearly the relative optimism of the Zealous Optimists as they are even more positive than the Plug-in Pioneers, and the negativity of the Image-conscious Rejecters.

[23] It should be noted that the seemingly more optimistic outlook shown by the Uninspired Followers on these questions and the ones above relating to range anxiety are due mainly to the very high proportion of ‘neutral’ scores rather than to a more optimistic outlook. This suggests either indifference or that this group is genuinely uncertain of the answer to these questions.



* "*If I had a [PHEV/BEV] car, I would mainly charge it at home or work*" (Qc2e &

Figure 60: Attitudes towards charging mainly at home or work among car commuters (N=1,477)



* "*I would only consider a [PHEV/BEV] if I knew I had access to a rapid charging point (i.e. somewhere it would charge in less than half an hour)*" (Qc2J & Qd2k)

Figure 61: Belief about the need to wait for rapid charging infrastructure (N=2,729)

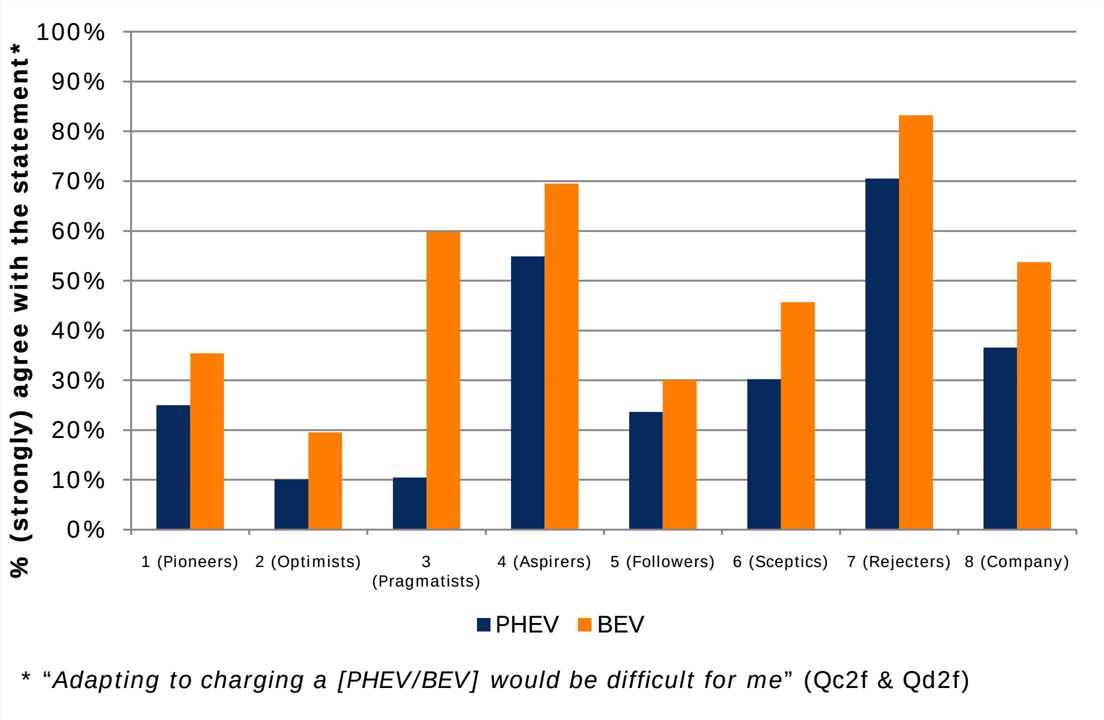


Figure 62: Belief that adapting to charging would be difficult (N=2,729)

10.2.16 Knowledge and experience of EVs

Key findings:

- Those who already feel the most informed or are already the most enthusiastic about EVs are also the most likely to seek out new information. Similarly, after information about EVs was provided to respondents, opinion was most malleable among those groups already considered to be the most enthusiastic.
- This suggests that attitudes themselves influence the degree to which knowledge is sought, filtered and absorbed.
- It also suggests that opinions in the most enthusiastic groups, even the Plug-in Pioneers, are still far from fixed and could potentially swing both in favour and against EVs.
- For some segments (e.g. the Image-conscious Rejecters and the Conventional Sceptics), opinions seem to be relatively stable and information, if anything, reinforced their negativity towards BEVs. This suggests that their negative feelings towards EVs are quite entrenched and will be difficult to influence.
- Experience with a conventional hybrid has a relatively strong relationship with likely adoption of EVs, and there is some indication that experience with a BEV does too.

Table 47: Segment functional and instrumental attitudes

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
KNOWLEDGE and EXPERIENCE (% strongly agree + agree)								
'Very' informed about EVs	17%	3%	2%	1%	0%	1%	2%	2%
Totally uninformed	6%	10%	7%	14%	23%	12%	23%	13%
EXPERIENCE (% strongly agree + agree)								
'A lot' of experience of:								
HEV as driver	15%	7%	3%	6%	6%	4%	6%	6%
PHEV as driver	10%	1%	0%	1%	0%	1%	0%	0%
BEV as driver	10%	1%	0%	1%	1%	0%	0%	0%

Note: In each comparison except * overall group differences when testing across all eight segments are statistically significant at $p<0.05$. See Appendix P for further detail.

Table 48: Segment knowledge and experience – summary

Segment	Knowledge and experience – summary
1 (Plug-in Pioneers)	Very well informed, well above average experience with all vehicle types and curious to learn more. Opinion is still being shaped and likely to be highly responsive to information about and experiences with EVs.
2 (Zealous Optimists)	Well informed, moderately experienced and curious to learn more. Opinions still being formed.
3 (Willing Pragmatists)	Well informed but not especially curious to know more, especially about BEVs. Very changeable opinions, but mainly appears to be 'gathering' information to support the preference for PHEVs over BEVs.
4 (Anxious Aspirers)	Moderately informed, but curious to know more.
5 (Uninspired Followers)	Not well informed but seems relatively keen to know more perhaps out of curiosity to understand what all the 'fuss' is about.
6 (Conventional Sceptics)	Moderately informed but low curiosity and fairly static opinions.
7 (Image-conscious Rejecters)	Neither informed nor curious. The most entrenched in their views and difficult to influence.
8 (Company Car Drivers)	Moderately informed, moderately curious but opinions are fairly well set and they will need a lot of convincing to shift their views.

Since beliefs represent the information that people have about their world, be it right or wrong, it is purported that factual knowledge about the attitude object, in this case EVs, is a necessary precondition for the development of attitudes and perceptions (Kaiser, Wolfing & Fuhrer, 1999). Specifically in relation to EVs, others identify the importance of measuring objective knowledge of EVs as this is a stronger predictor of intention to buy than other variables (Thøgersen & Gärling, 2001). Knowledge may itself be based on experience with driving or riding in an HEV or a plug-in vehicle and this was also measured in the survey.

10.2.16.1 Self-reported knowledge about EVs

We were able to measure a number of indicators of 'objective knowledge', respondents' appetite for information on EVs and the impact of the assimilation of information on self-reported likelihood to adopt. These have been reported elsewhere for the sample as a whole (Anable et al., 2011), but we examine these data now to understand whether different segments are starting from different positions with regards to their knowledge and awareness of these vehicles.

Figure 63 contrasts the proportion of people in each segment who feel totally or quite informed about EVs with the proportion who went in search of information over and above the pre-read material provided. Here we see a general pattern – those who already feel the most informed or are the most enthusiastic about EVs, are also the most likely to seek out new information. There are a couple of exceptions to this:

- The Willing Pragmatists claim to be relatively well informed (although this is just over a quarter of people only), but were relatively less likely to seek out information than some groups – perhaps because they appear to be very knowledgeable already about PHEVs and demonstrably have little interest in BEVs.

- The Uninspired Followers regard themselves as the least informed but a relatively high number went in search of information. This could suggest that their relatively heavy use of the 'neutral' response option on many of the survey questions indicates a lack of knowledge and genuine inability to respond one way or another rather than a lack of interest in EVs.
- The Anxious Aspirers consider themselves to be relatively less well informed than some groups, but were relatively more likely to seek out information – being consistent with their keen approach to this technology.

Figure 63 also shows that the Uninspired Followers and the Image-conscious Rejecters consider themselves to be the most uninformed groups but are also less likely to seek out extra information. This suggests that attitudes themselves may influence the degree to which knowledge is sought, filtered and absorbed rather than knowledge being a precursor to attitudes and intention.

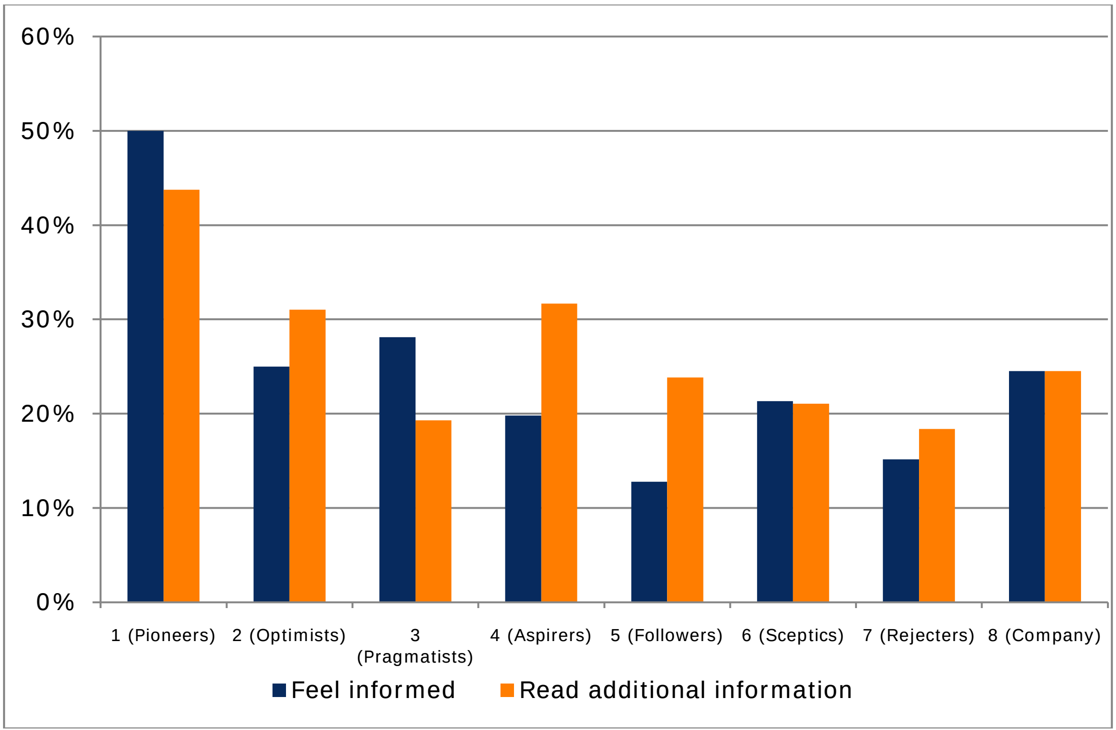


Figure 63: Self-reported knowledge about EVs and attempt to find additional information during Wave 1 and Wave 2 (N=2,729)

10.2.16.2 Experience of driving or riding in an (H)EV

There is of course a problem with relying on self-reported levels of knowledge given the unfamiliarity most respondents have with the technology. For instance, in another indicator in the questionnaire (and see Figure 58) respondents were asked about their concerns that they will run out of charge when driving a PHEV, and it was suggested that responses to this question could indicate a degree of misunderstanding of how the vehicles work, despite the information that had been given to them.

Knowledge may of course be related to experience of an EV as a driver or a passenger. Figure 64 suggests:

- Experience with a conventional hybrid has a clear relationship with likely adoption of EVs. From this it is not possible to determine the direction of causality – do those people with attitudinal predispositions gravitate towards using and testing alternative vehicle technology or do the experiences with the vehicles themselves make people more predisposed to alternative technologies? It is likely to be a mutually reinforcing and therefore 'multi-directional' relationship. We know from the literature on recent

EV vehicle trials, for example, that drivers feel more positive about EVs after taking part in even very short vehicle trials (Carroll & Walsh, 2010; Stannard et al., 2010).

- Experience with BEVs may have some relationship with their likely adoption. For instance, the Image-conscious Rejecters have very limited experience with BEVs so far and the Plug-in Pioneers, Zealous Optimists and Anxious Aspirers have greater experience. Interestingly, the Company Car Drivers also have some experience which may explain their partial enthusiasm for the technology[24].
- Somewhat surprisingly, the Willing Pragmatists who are very keen on plug-in hybrids, have a relatively low experience with conventional hybrids.
- Many groups claim to have had some experience with PHEVs, particularly the Plug-in Pioneers whereby around one fifth to one quarter claim they have driven them or been a passenger. This seems relatively unlikely given their availability in the marketplace and causes concern about the real state of knowledge and understanding in this group (although caution must be exercised with respect to the very low number of respondents).

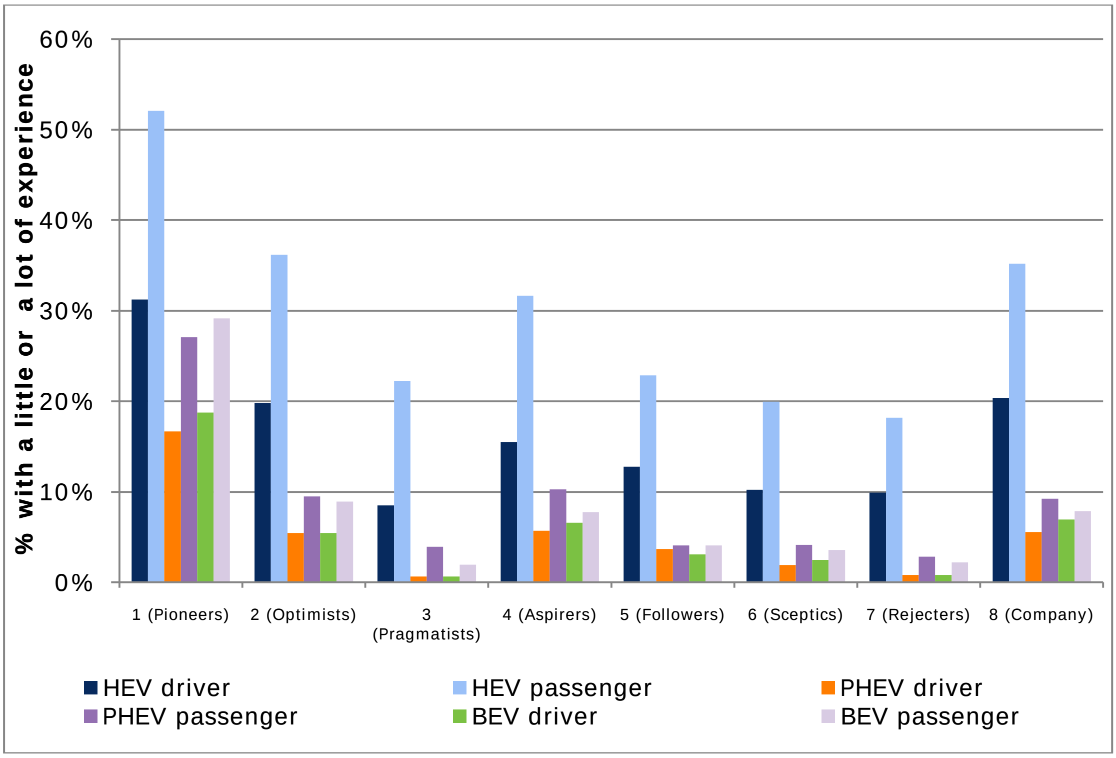


Figure 64: Experience with (H)EVs as a driver or passenger in each segment (N=2,729)

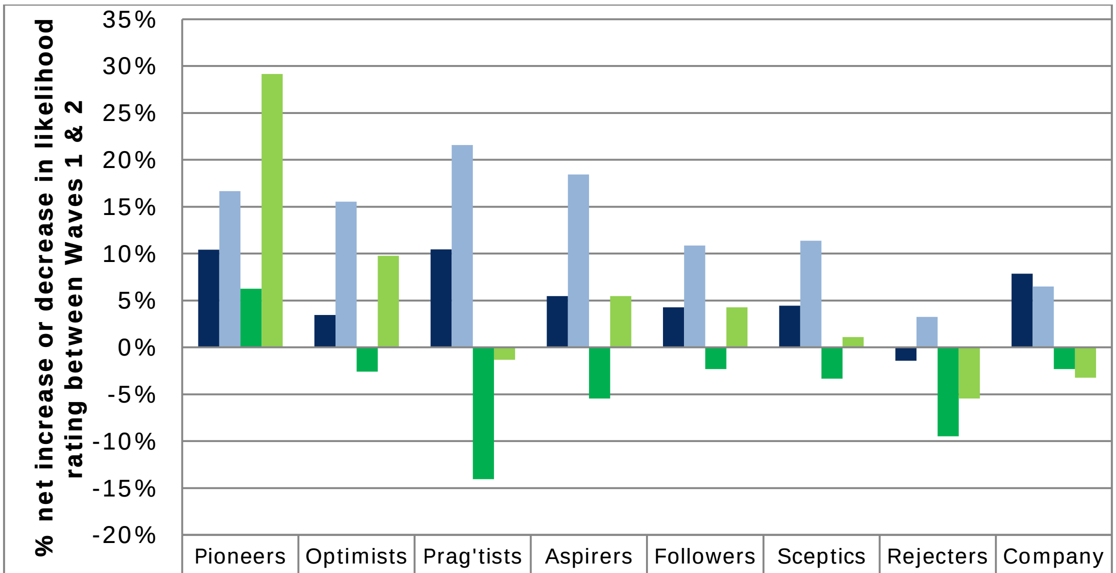
10.2.16.3 Change in self-reported likelihood to adopt after the 'pre-read' information

Opinion on the likelihood to adopt was not static across the Waves with around half of the sample changing their rating upwards or downwards for at least one car type. Paired t-tests showed that respondents became more convinced about PHEVs as a main or second car and BEV as a second car, but less convinced about BEVs as a main car.

In order to understand whether some groups were more malleable or changeable in their outlook than others, Figure 65 shows the net change in each group for each car type. The results are somewhat surprising:

[24] The differences in experience are significant at the 99% confidence interval. However, caution should still be exercised given the small number of data points and the potential for falsely claiming experience of this technology.

- Opinion was most malleable among those groups considered to be the most enthusiastic with high net swings of 15–20% towards PHEVs, particularly as a second car. Given that these groups were also the ones to seek out extra information, this suggests that their opinions are still far from fixed and could potentially swing both in favour and against EVs. It may also indicate that these groups may be open to gaining real experience with the vehicles and this is likely to have a measurable impact on attitudes.
- The Willing Pragmatists demonstrated one of the most changeable swings away from BEVs and towards PHEVs. One explanation for this changeability is that this group may have benefited from reading and processing the information in order to clarify the distinction between the two types of technology.
- The Image-conscious Rejecters changed the least, but if anything only became even more convinced that EVs, particularly BEVs, are not for them. This suggests that their negative feelings towards EVs are quite entrenched and will be difficult to influence.



	Pioneers	Optimists	Prag'tists	Aspirers	Followers	Sceptics	Rejecters	Company
PHEV Main	10%	3%	10%	5%	4%	4%	-1%	8%
PHEV 2nd	17%	16%	22%	18%	11%	11%	3%	6%
BEV Main	6%	-3%	-14%	-5%	-2%	-3%	-9%	-2%
BEV 2nd	29%	10%	-1%	5%	4%	1%	-5%	-3%

Figure 65: Change in likelihood to adopt between Wave 1 and Wave 2 in each segment (N=2,729)

10.2.17 Instrumental attitudes

Key findings:

- The same four instrumental attributes appear as the top four priorities of all segments. All are motivated strongly by purchase price, size/practicality, running costs and model/brand. Performance is generally ranked much lower than most other functional attributes.
- The Plug-in Pioneers and the Company Car Drivers appear to have slightly different priorities to the other groups. For the Pioneers, running costs are rated more highly than purchase price. Also, they are the only group to identify the environment as important. For the Company Car Drivers, price is less important than size/practicality and running costs. Comfort and performance are also ranked higher than most.
- There is a general agreement that EV technology ‘is a really good idea’ even among the groups who are less than enthusiastic about BEVs or PHEVs. However, BEVs are considered to be something quite different from ‘normal cars’. This highlights the step change in behaviour that consumers are being asked to make.
- Willingness to pay is one of the issues which most strongly differentiates the segments. The preparedness to pay for a PHEV is roughly the same as a BEV for most segments, apart from the Willing Pragmatists who once again show a strong bias in favour of PHEVs.
- The willingness to pay for fuel savings is much greater than the willingness to pay for environmental benefits although the Plug-in Pioneers are almost willing to pay equally for each type of benefit.
- None of the groups apart from the Plug-in Pioneers are prepared to pay on balance for the technology for its own sake. The Conventional Sceptics and the Image-conscious Rejecters show a particularly strong objection to paying more for the technology.
- The majority of respondents in all segments believe EVs will be more expensive to buy. However, there is more variation in the perceived running costs, with the majority of the ‘top three’ segments believing EVs will be cheaper, but only a minority in the remaining segments believing this to be the case.
- Overall, two thirds of the sample agreed and less than 10% disagreed that EVs were as safe for the driver and passenger as normal cars. These opinions were generally consistent across segments although the Rejecters are typically negative and there is also a slightly tentative view on this from the Company Car Drivers. There is a bigger concern with respect to the lack of engine noise from BEVs whereby, on balance, more people thought this was an issue than did not apart from in the Plug-in Pioneers and the Zealous Optimists.
- The picture is more negative for reliability. Overall there is net agreement with the idea that the technology may be too new to be reliable and the chances of breaking down are high. This suggests a familiarity penalty exists which means that opinion about this issue could shift very quickly.

Table 49: Segment instrumental attitudes

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
WILLINGNESS TO PAY (% strongly agree + agree)								
Would pay more for a car with lower running costs	89.6%	68.4%	57.8%	69.9%	38.2%	15.2%	29.9%	46.8%
Willing to pay more for environmental benefits	70.8%	38.2%	24.5%	33.3%	20.3%	1.4%	8.3%	28.2%
PERCEPTIONS OF SAFETY AND RELIABILITY (% strongly agree + agree)								
EVs are generally as safe for driver and passenger	83.3%	82.5%	72.5%	62.4%	60.9%	68.4%	54.1%	69.4%
EVs are too new to be reliable	29.2%	16.4%	30.4%	38.0%	18.0%	38.8%	49.7%	33.3%

Note: In each comparison overall group differences when testing across all eight segments are statistically significant at $p<0.05$. See Appendix P for further detail.

Table 50: Segment instrumental attitudes – summary

Segment	Instrumental attitudes – summary
1 (Plug-in Pioneers)	Motivated more by running costs than purchase price. The only segment to rank environmental attributes in its top ten. High WTP for fuel economy and for environmental benefits. On balance, no real concerns about safety and reliability.
2 (Zealous Optimists)	High WTP for fuel economy and some WTP for environmental benefits. On balance, highest faith in safety and reliability.
3 (Willing Pragmatists)	High WTP for fuel economy but not for the environment. Believe EVs will be more expensive to buy but have high faith in running cost savings. Quite concerned about safety and reliability.
4 (Anxious Aspirers)	High WTP for fuel economy and some for the environment. Some concerns about safety, especially outside the vehicle, and worried about breaking down.
5 (Uninspired Followers)	Place brand higher than running cost. On balance, not WTP for fuel economy benefits or environmental benefits but not overly concerned about safety and reliability.
6 (Conventional Sceptics)	On balance not WTP for running costs and strongly against paying for environmental benefits yet believe that EVs will cost more to run. Worried about breaking down.
7 (Image-conscious Rejecters)	Place brand higher than running cost. On balance not WTP for running costs and strongly against paying for environmental benefits. Do not consider BEVs or PHEVS to be similar to normal cars and most concerned about safety and reliability.
8 (Company Car Drivers)	Motivated more by size/practicality and running cost than purchase price. Places highest importance on performance of all the segments. On balance, not WTP for fuel economy benefits or environmental benefits. Some concerns about reliability.

Even where consumer decision-making on car choice may be the result of conscious choices among an array of alternatives, these choices are systematically related to psychological processes (i.e. perception, attitudes, belief formation). ‘Attitudes’ refer to a variety of personal attributes such as concern, awareness, understanding, opinion, and beliefs, and decision factors can themselves be classed as instrumental (factors relating to general practical or functional attributes), affective (factors related to the feelings evoked by owning or travelling) and symbolic (relating to how consumer goods can convey wider meanings). There is overlap between these as functional attributes can provoke emotional and affective reactions. However, we consider each of these in turn in the following sections. Profiling the segments on these variables enables deeper understanding of the underlying belief structures and motivations of each group and can be the key to distinguishing between people who may have relatively similar current behavioural patterns and even similar expressions of likelihood to adopt EVs, but will respond to different stimuli in relation to EV adoption.

10.2.17.1 Car purchasing decision making factors

Respondents were asked to list in their own words the three factors that were most important to them when choosing their main car. Table 51 highlights the top ten attributes for each segment. There is a great deal of consistency between segments as the same four attributes appear in the top four of all the groups with some slight differences in priorities among them as follows:

- Purchase price and practicality (size/doors/seats) are the top two most important factors for all six post-hoc segments. In most cases around 20% of the attributes that were mentioned related to purchase price or value for money.
- Interestingly, the Plug-in Pioneers prioritise fuel economy/running costs, although purchase costs were a close second.
- For the Company Car Drivers, price is less important than size/practicality and running costs. Comfort and performance are also ranked higher than most.
- The Image-conscious Rejecters place brand/model above running costs and give one of the highest ranks of all segments to image/style.
- It is interesting to note that the environment/CO_2 was only ranked among the top ten factors by the Plug-in Pioneers who prioritise it above reliability and looks/style, which were attributes rated highly by other segments.
- Performance is most highly rated by the Company Car Drivers but is generally ranked much lower than most functional attributes.

Table 51: Ranking of car purchase attributes by each segment

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
Purchase price/VFM	2	**1**	**1**	**1**	**1**	**1**	**1**	3
Doors/seats/size	3	2	2	2	2	2	2	**1**
Economy/running costs	**1**	3	3	3	4	3	4	2
Brand/model	4	4	4	4	3	4	3	4
Reliability	10	5	5	6	5	5	6	8
Looks/style	8	6	7	5	7	6	5	6
Comfort/smooth drive	5	7	6	7	6	7	7	5
Performance	9	8	8	9	10	9	8	7
Safety		9			9			
Extras/gadgets	7	10	10			8		9
Boot space			9	8	8	10	10	
Insurance				10				
Engine size							9	
Environment/CO_2	6							
No/limited choice								10

10.2.17.2 General enthusiasm for plug-in car technology

Before examining the beliefs, perceptions and attitudes towards specific attributes of plug-in vehicles by each segment, it is worth understanding the general enthusiasm for this vehicle technology and the degree to which it is considered to be something very different from current car technology. Figure 66 presents this using two questions repeated for each type of EV. Most notable is the fact that even among the groups who we have seen to be less than enthusiastic about BEVs or PHEVs, there is a general agreement that the technology 'is a really good idea'. With the exception of the Image-conscious Rejecters for both types of EV, at least 50% of each group believe this to be true. For the Plug-in Pioneers and the Zealous Optimists there is almost unanimous agreement about this.

Secondly, it must be noted how BEVs are really not considered to be 'similar to normal cars in most respects'. Apart from in the two most enthusiastic groups where around 55% to 60% agree that BEVs are 'similar to normal cars in most respects', the majority of people in all other groups do not agree with this statement.

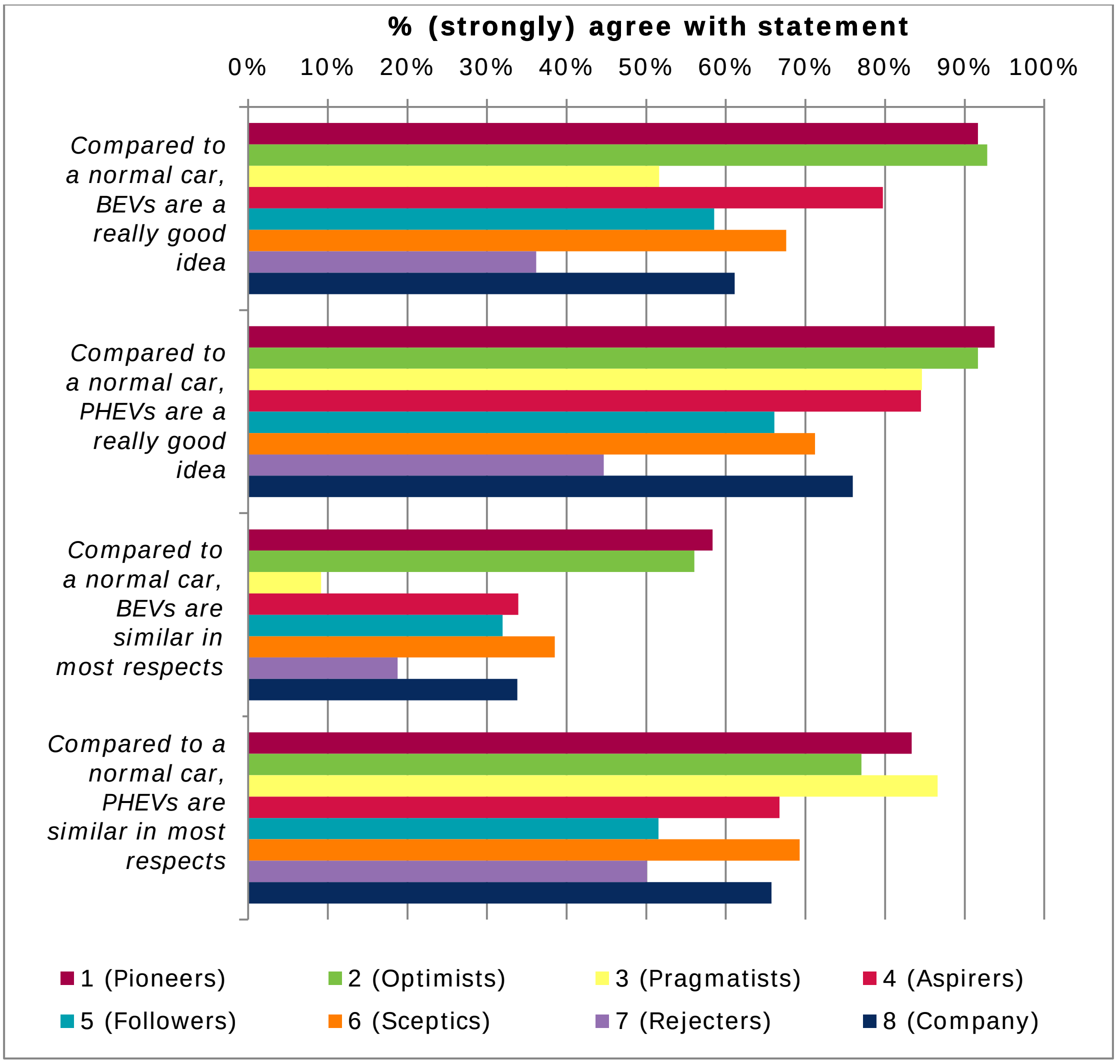


Figure 66: General enthusiasm for plug-in car technology in each segment (N=2,729)

10.2.17.3 Willingness to pay

As we have seen, analysis of the whole sample revealed that the most frequently cited car choice attributes are related to purchase price/value for money. Fuel economy/running costs was also in the top three. In addition to these choice factors, we asked respondents to rate agreement with questions relating to their preparedness to pay more for PHEVs or BEVs 'than a normal car' and specifically their willingness to pay for fuel economy or environmental benefits. Willingness to pay is one of the issues which most strongly differentiates the segments[25].

The results of this are displayed in Figure 67 (a-d) which shows the level of agreement and disagreement on four relevant attitude statements. The conclusions are as follows:

- The preparedness to pay for a PHEV (a) is roughly the same as a BEV (b) for most segments, apart from the Willing Pragmatists who once again show a strong bias in favour of PHEVs.

[25] See Appendix N which shows the variation in factor scores for each of the factor variables used in the cluster analysis. One factor (F_EV_Willingness_to_pay) can be seen to vary across segments more than most others.

- The willingness to pay for fuel savings (d) is much greater than the willingness to pay for environmental benefits (e) although the Plug-in Pioneers are almost willing to pay equally for each type of benefit.
- All groups apart from the Conventional Sceptics are on balance willing to pay for lower running costs. However, only the Plug-in Pioneers, Zealous Optimists and Anxious Aspirers are also prepared on balance to pay for environmental benefits.
- The willingness to pay for the technology *per se* (a or b) is much less than the willingness to pay for fuel economy savings (c). Indeed none of the groups apart from the Plug-in Pioneers are prepared to pay on balance for the technology for its own sake. The Conventional Sceptics and the Image-conscious Rejecters show a particularly strong objection to paying more for the technology.

10.2.17.4 Perceptions about purchase price and running costs

Figure 67 and Figure 68 provide the responses for each segment in relation to a number of questions asked about purchase price and running costs of PHEVs and BEVs. The majority of respondents in all segments believe EVs will be more expensive to buy: the Anxious Aspirers are the most pessimistic about purchase cost and the Uninspired Followers the least. There is more variation about the perceived running costs, with the majority of the ‘top three’ segments on balance believing EVs will be cheaper, but with the remaining segments only a small minority believe this to be the case. However, all segments think that both PHEVs and BEVs will be cheaper over the longer term.

a.

"I would be prepared to pay more for a PHEV than a normal car"

b.

"I would be prepared to pay more for a BEV car than a normal car"

c.

"I would pay more for a car with lower running costs"

d.

"I would be willing to pay more for a car if I knew it was less harmful to the environment"

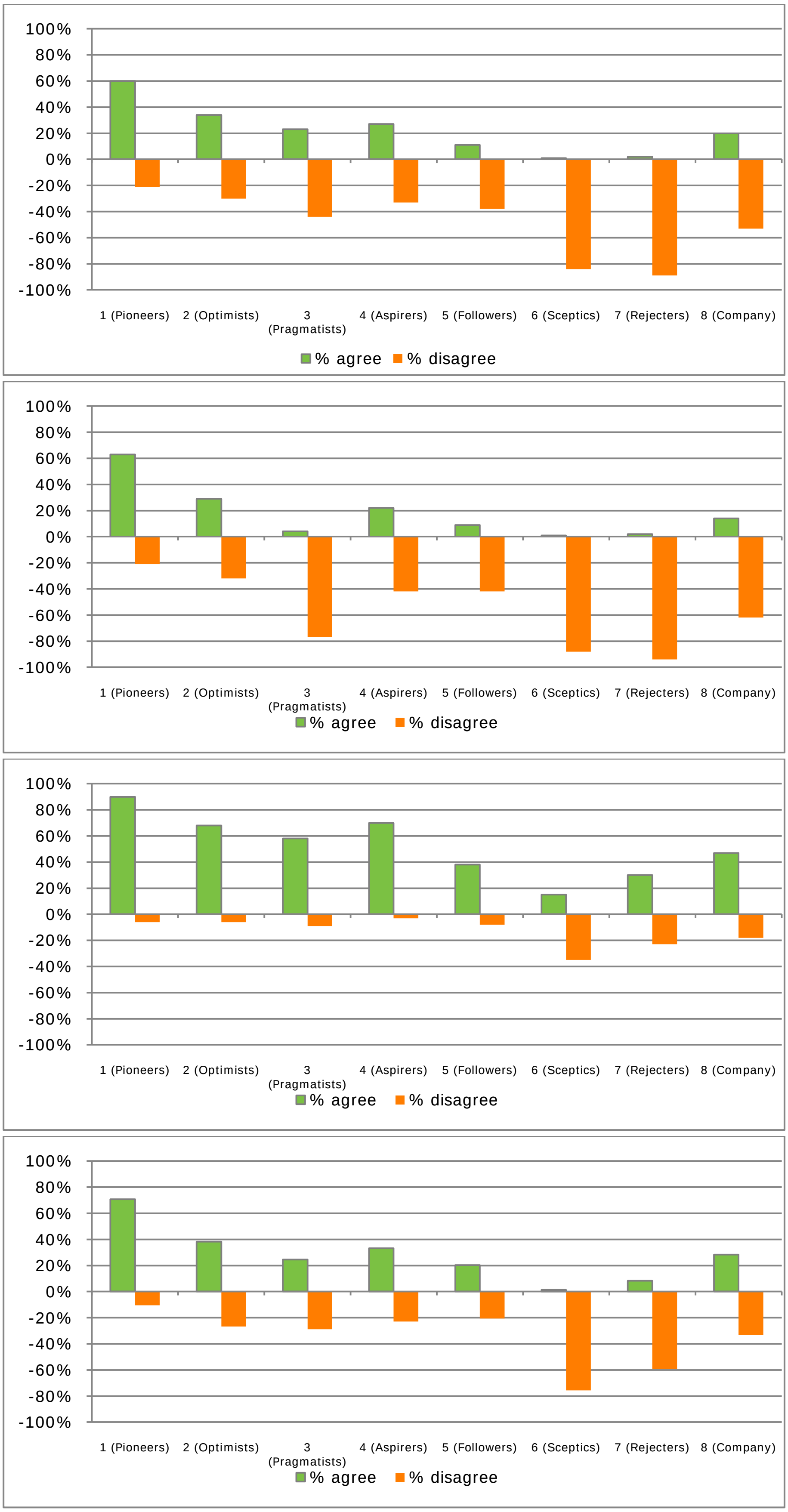
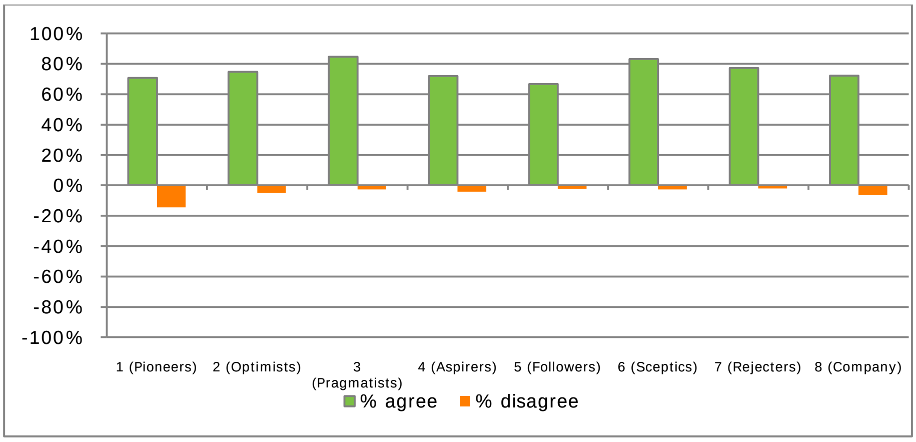


Figure 67 (a-d): Willingness to pay in each segment (N=2,729)

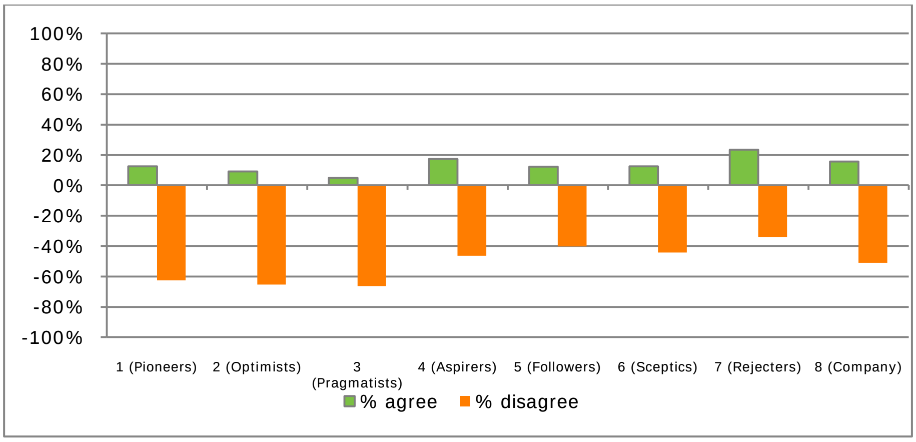
a.

"Plug-in cars are generally more expensive to BUY than normal cars"



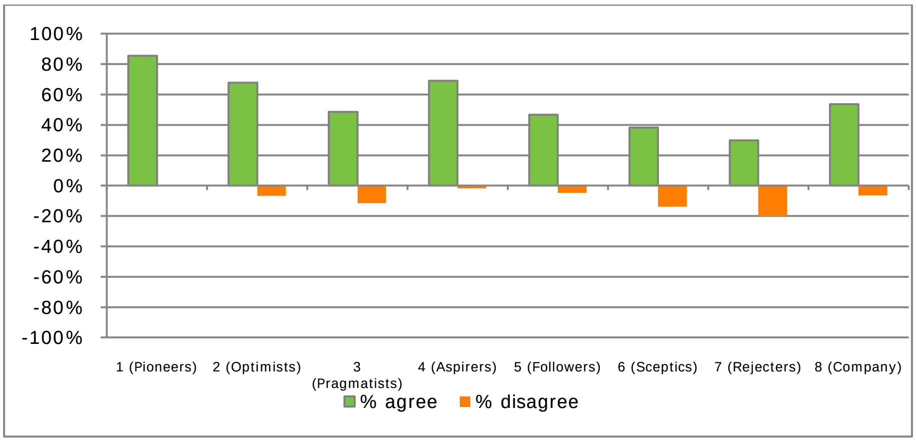
b.

"Plug-in cars are generally more expensive to RUN than normal cars"



c.

"PHEVs are cheaper over the longer term"



d.

"BEVs are cheaper over the longer term"

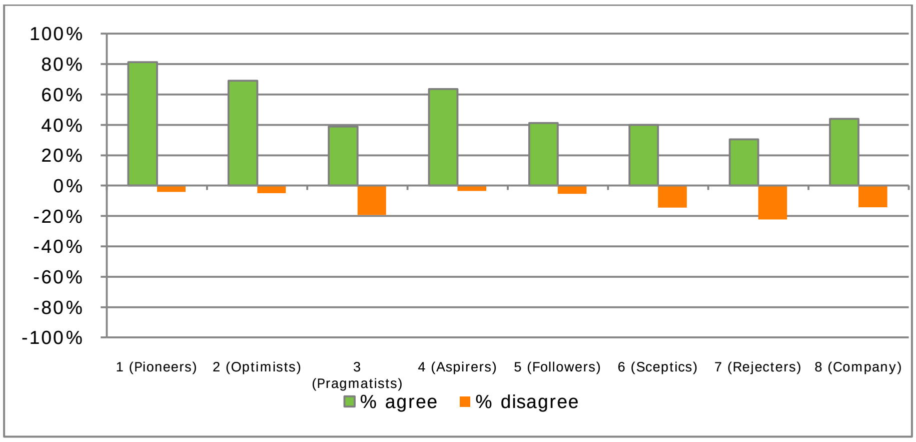


Figure 68 (a-d): Perceptions about the purchase price and running costs of EVs in each segment (N=2,729)

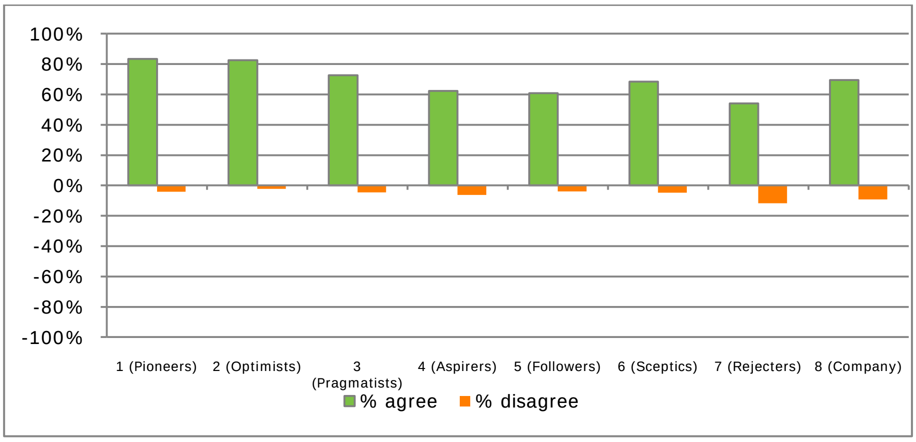
10.2.17.5 Safety and Reliability

In the qualitative research carried out as part of this study, participants considered several components of EV safety. The majority of participants appraised the safety of the vehicle in terms of other road users as a consequence of EV quietness, and this was especially evident post-exposure. Some participants were concerned about a lack of robustness/solidness of vehicle structure while, for others, mixing electricity and water was a concern. Thus, 'safety' judgments involve multi-attribute evaluation. Other potential safety concerns mentioned in relation to BEVs included a lack of power making it difficult to get out of potentially unsafe driving situations, and a lack of both power and control when BEVs enter a reduced-power usage mode if the battery is at 25% charge or less, which may reduce maximum speed to 30mph to conserve the battery.

The quantitative data found perceptions of safety of these vehicles to be generally positive. Overall, two thirds of the sample agreed and less than 10% disagreed that EVs were as safe for the driver and passenger as normal cars. These opinions were generally consistent across segments although the Rejecters were typically negative; there is also a slightly tentative view on this from the Company Car Drivers. There is a bigger concern with respect to the lack of engine noise from BEVs whereby, on balance, more people thought this was an issue than did not. Only the Plug-in Pioneers and the Zealous Optimists did not, on balance, feel this was a concern.

a.

"EVs are generally as safe for the driver and passengers as normal cars"



b.

"BEVs are NOT a danger to people outside the car because of the lack of engine noise"

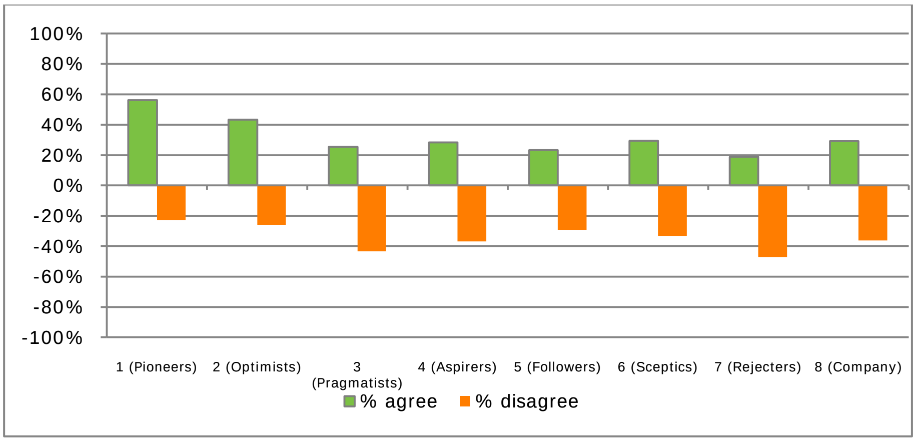


Figure 69 (a+b): Safety concerns in each segment (N=2,729)

10.2.17.6 Reliability

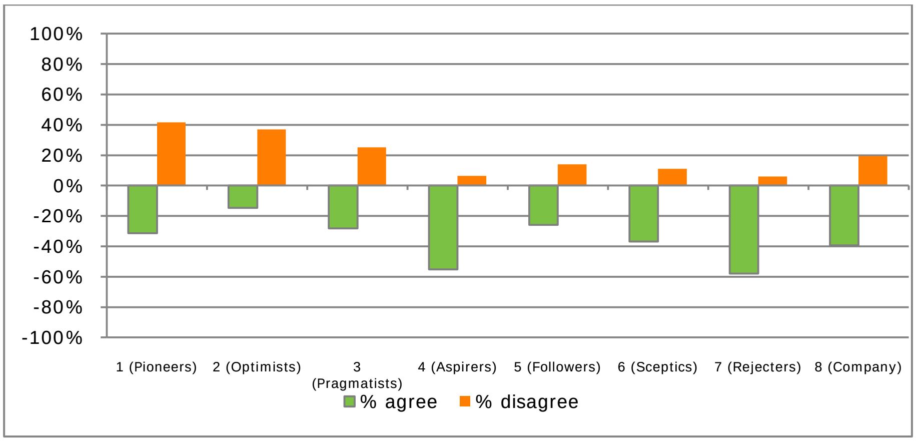
In the qualitative research that preceded this survey, reliability was appraised in different ways. For some reliability meant the confidence that the vehicles could get them from A to B without any problems whereas for others it represented the confidence they felt towards the new and unfamiliar technology.

Figure 70 provides a picture of the state of opinion on reliability of BEVs. The picture is slightly more negative than for safety in that overall there is net agreement with the idea that the technology may be too new to be reliable and the chances of breaking down are high. In this case it is the Zealous Optimists who are most positive on balance. The Anxious Aspirers once again have some of the greatest concerns.

Concerns about breaking down correlate with the responses to the idea that EVs are 'too new to be reliable'. This suggests that there may be a familiarity penalty at work which means that opinion about this issue could shift very quickly. Of course, this depends on peoples' perceptions not being reinforced by their practical experiences or through the media.

a.

"The chances of breaking down in a plug-in car are higher than in a normal car"



b.

"EVs are generally too new to be reliable"

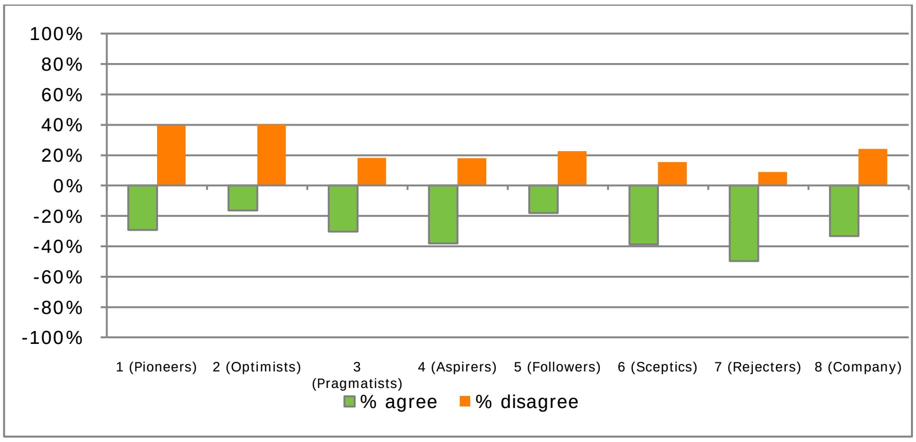


Figure 70 (a+b): Reliability concerns in each segment (N=2,729)

10.2.18 Affective attitudes

Key findings:

- Even in those segments otherwise enthusiastic about EVs, there is a relatively strong belief that the performance of EVs is inferior to that of normal cars. However, it would seem that this is less of a priority for some segments such as the Plug-in Pioneers and so the trade-off between performance and other factors is not seen as a particularly negative issue. Also, it is possible that the perceptions held by these segments are open to influence given that they show signs of being open to information about EVs.
- When asked about perceptions of the driving experience, the Plug-in Pioneers and the Zealous Optimists were also positive about this aspect, but there was a high tendency for all the other segments to remain neutral. Therefore, it seems that performance and ‘driving experience’ are evaluated separately and, unlike performance, it seems that people do not feel similarly negative about the driving experience itself.
- It would appear that the Zealous Optimists and Plug-in Pioneers are both groups which tend to enjoy driving and potentially use driving as a means of self expression. Nevertheless, they also both rate the EV driving experience very high and hence their willingness to consider these modes. The Conventional Sceptics and Rejecters, on the other hand, are less enthusiastic about driving but their assessment of the EV driving experience is even lower.

Table 52: Segment affective attitudes

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
Affective evaluations (% strongly agree + agree)								
I like driving	81.3%	77.9%	79.7%	70.2%	69.0%	78.4%	74.5%	72.7%
PHEVs inferior performance	29.2%	19.3%	16.7%	33.0%	20.3%	31.9%	43.4%	36.6%
PHEVs pleasant to drive	79.2%	64.9%	40.2%	49.0%	22.3%	33.8%	19.8%	35.2%
BEVs inferior performance	39.6%	30.5%	58.2%	39.0%	24.4%	45.4%	60.4%	52.3%
BEVs pleasant to drive	66.7%	67.2%	22.5%	41.0%	19.0%	25.8%	12.1%	28.2%

Note: In each comparison overall group differences when testing across all eight segments are statistically significant at $p<0.05$. See Appendix P for further detail.

Table 53: Segment affective attitudes – summary

Segment	Affective attitudes – summary
1 (Plug-in Pioneers)	Relatively optimistic about performance. Enjoy driving but also strong belief that EVs will be pleasant to drive.
2 (Zealous Optimists)	Most optimistic about EV performance and strong belief they will be pleasant to drive.
3 (Willing Pragmatists)	Strong belief that BEVs suffer from poor performance. Some faith that PHEVs will be pleasant to drive, but not BEVs.
4 (Anxious Aspirers)	Some concerns about performance but some faith that BEVs, especially PHEVs, will be pleasant to drive.
5 (Uninspired Followers)	No strong opinion about performance of driving experience. Least likely to say they enjoy driving.
6 (Conventional Sceptics)	Strong belief that EVs will be inferior in terms of performance but neutral about driving experience.
7 (Image-conscious Rejecters)	Very strong belief that EVs are inferior in terms of performance and relatively strong negative perceptions of the driving experience.
8 (Company Car Drivers)	Concerns about performance but neutral about the driving experience of PHEVs, but more negative about BEVs. Enjoy driving.

This survey set out to capture the importance attached by respondents to various experiential and emotional aspects of driving and beliefs about how far these emotional needs or desires would be met by the EV driving experience. In the qualitative study, the participants' definitions of the concept of 'pleasure of driving' often included words such as reliable, ease of use, ease of maintenance, comfort, noiselessness and speed, and so the cross-over between affective factors and instrumental factors is clear.

10.2.18.1 Perceptions of EV performance

Performance is one such attribute that can have instrumental or affective meanings and also symbolic ones. We include a general rating of 'performance' as potentially capturing driving experience and associated emotional responses. Respondents were asked to indicate whether they believed the performance of PHEVs or BEVs is inferior to a 'normal' car.

In other studies, consumers have been found to have generally negative perceptions with regards to alternative vehicles' performance factors such as acceleration and top speed (Lane & Albery, 2009; Greene et al., 2004). In this study, these attitude statements polarised opinion. Figure 71 shows the agreement and disagreement with the statement and shows that even the most positive segments register relatively high proportions of members as believing EV performance would be inferior. There are particularly high numbers believing that BEVs are inferior among the Rejecters, Sceptics and Company Car Drivers, but even a third of Plug-in Pioneers agree with this proposition. Typically the Uninspired Followers are less extreme in their views, but this is because they seem either relatively indifferent on the issue or reluctant to express a view due to a lack of knowledge.

Nevertheless, we saw from Table 51 that performance is not a top priority for any of the segments and therefore this negativity among the otherwise enthusiastic segments may not necessarily be seen as a particular disadvantage. In addition, we know from the findings of a few EV vehicle trials that ratings of EV performance tend to increase once consumers have gained some direct experience of the vehicles (Carroll & Walsh, 2010 and see Stannard et al., 2010 for a review). Given that we know that the enthusiastic segments show signs of being open to information about EVs, it is possible that their relatively negative opinions about EV performance can be influenced by further information on these issues but also by the chance to have direct experience of driving the vehicles. Even though performance is less important to these segments, it is important they have informed opinions as they are likely to be 'opinion leaders' and influence the perceptions of other segments on these issues.

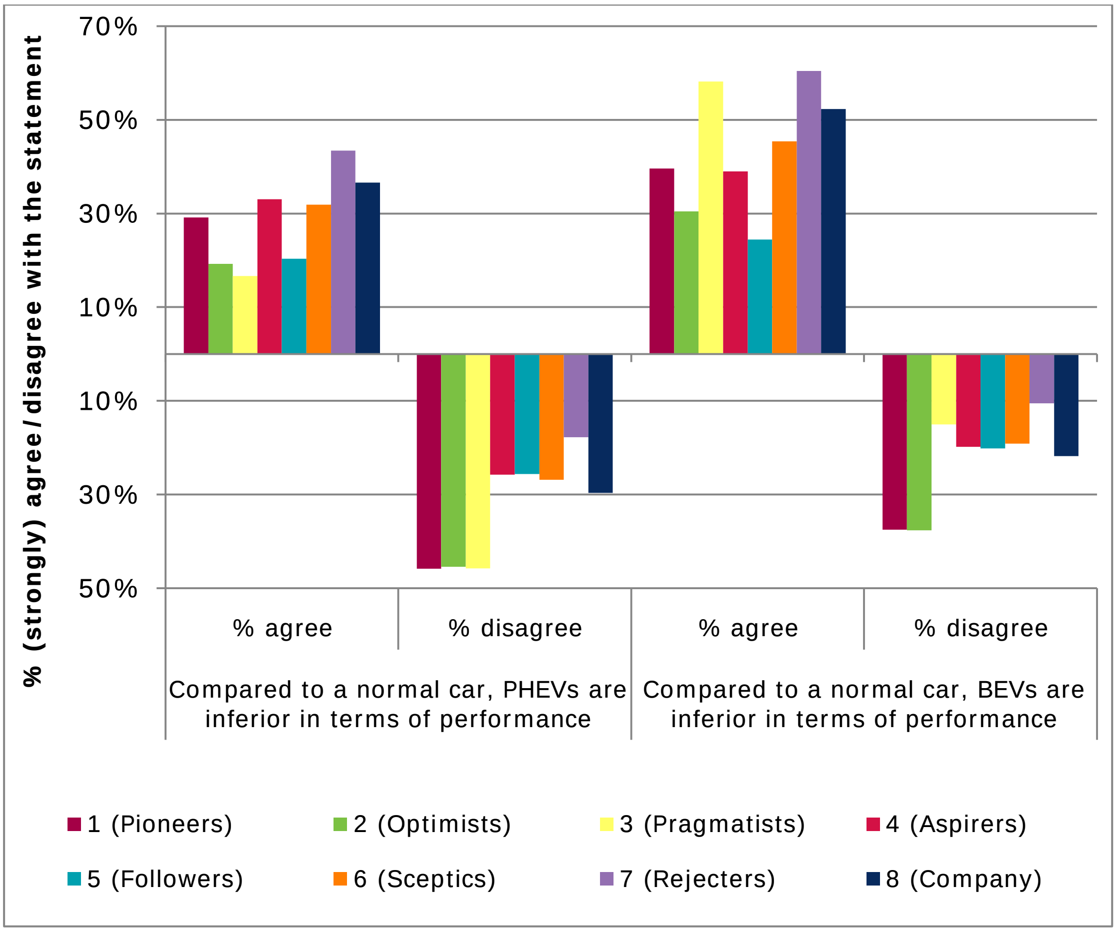


Figure 71: Perceptions about EV performance in each segment (N=2,729)

10.2.18.2 Perceptions of EV driving experience

Respondents were asked how pleasant they believed PHEVs and BEVs would be to drive, compared to a 'normal' car. Curiously, unlike the question about performance, there was a high tendency for all but the Plug-in Pioneers and the Zealous Optimists to remain neutral on this question. This suggests that driving experience and performance are evaluated separately. It also could indicate that perceptions on the issue of driving experience are not yet formed due, potentially, to less attention being paid to this more emotional aspect in the media and in literature on EVs compared to other factors including performance. However, the strong neutral position can at least be taken to mean that strong negative perceptions around the feelings evoked by the driving experience do not (yet) exist. Figure 72 and Figure 73 show the positive evaluations of the Pioneers and the Optimists and the general lack of negativity of all the other segments.

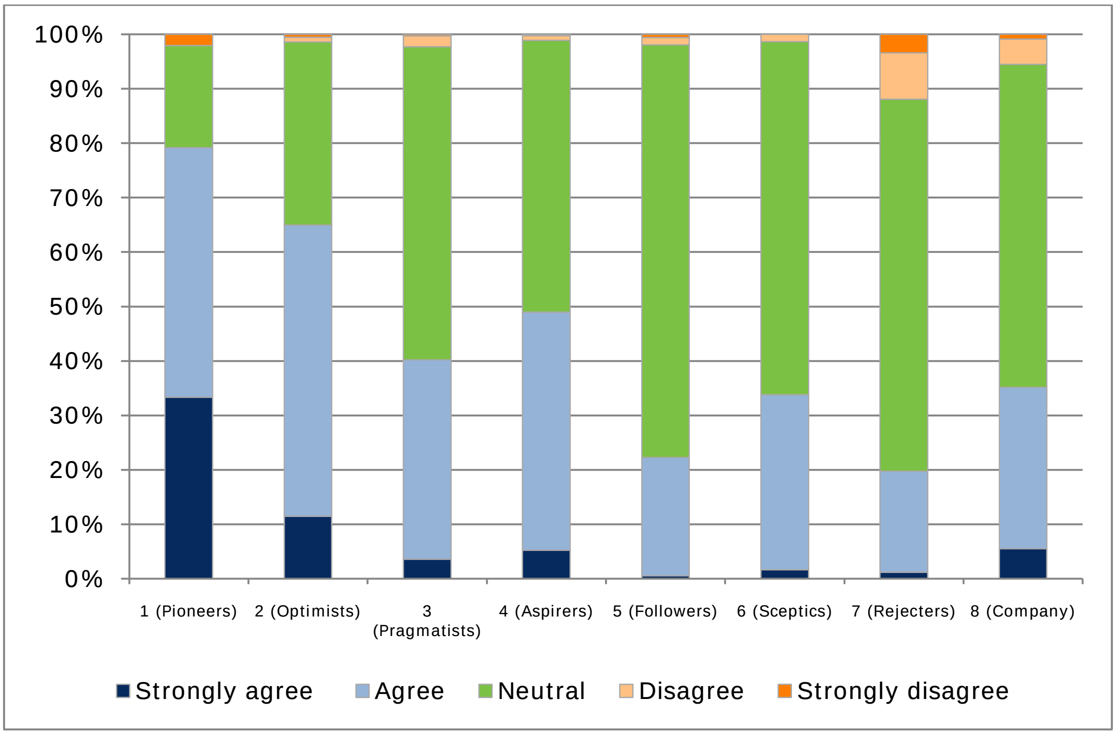


Figure 72: Perceptions about the PHEV driving experience in each segment [compared to a normal car, PHEVs are pleasant to drive] (N=2,729)

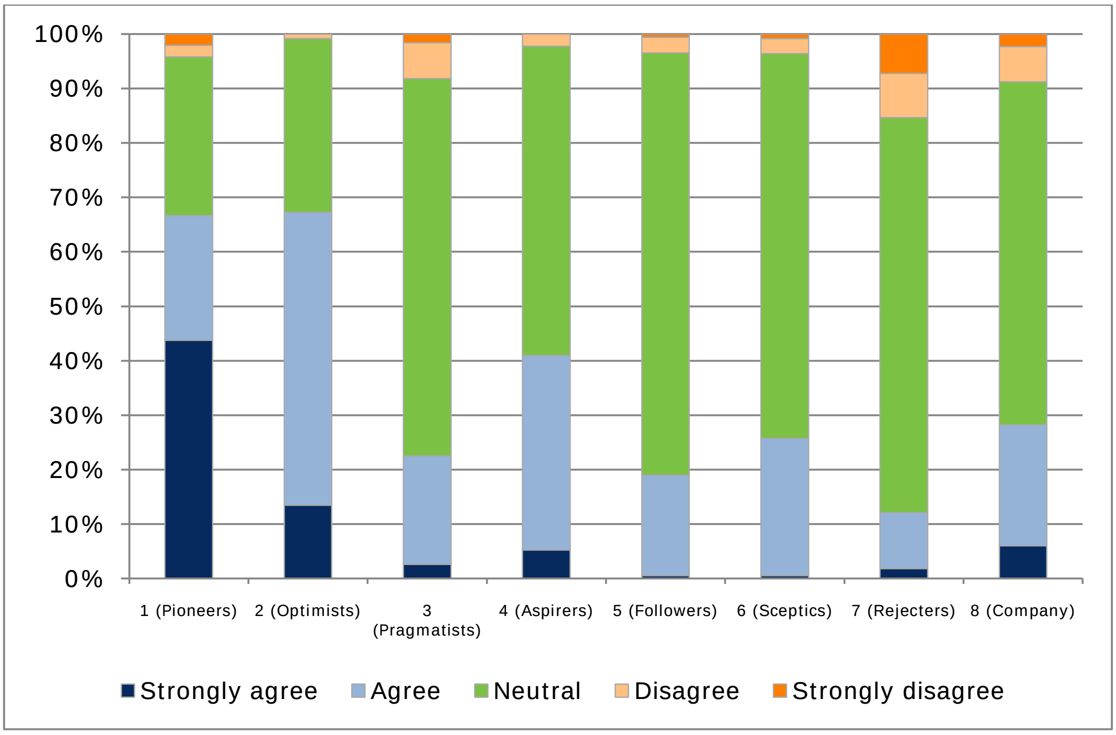


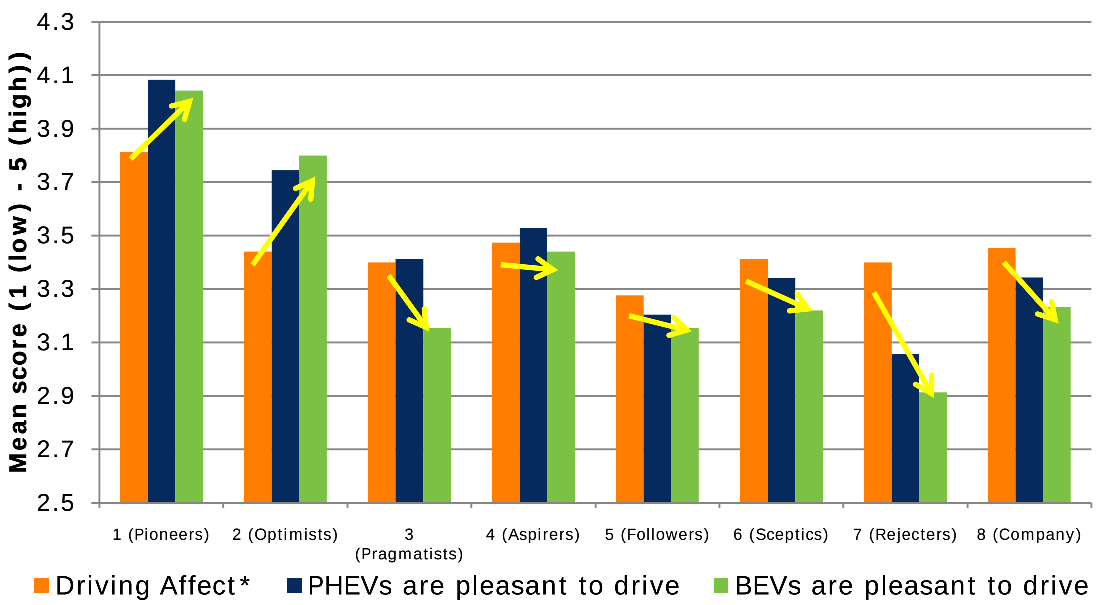
Figure 73: Perceptions about the BEV driving experience in each segment [compared to a normal car, BEVs are pleasant to drive] (N=2,729)

10.2.18.3 General driving enjoyment

The above two measures of perceptions of the EV driving experience can be compared to the degree to which individuals enjoy driving in general. Affective motives have been found in other literature related to travel behaviour to be an important predictor of car use (Mann & Abraham, 2006; Anable & Gatersleben, 2005).

Four questions were used to measure general enjoyment of driving and some aspects of driving style. These four statements in Figure 74 loaded strongly onto one construct in the exploratory factor analysis and demonstrate an internally consistent measure of general driving affect. Here they have been combined to provide a mean score and this has been compared to the mean scores on perceptions of EV driving experience.

The point of this analysis is to try and understand the degree to which any disconnect between the importance of driving affect and the evaluation of EV driving affect may be a factor which distinguishes segments and contributes to their propensity to adopt. Figure 74 indicates that there is a relationship between the likelihood to adopt EVs and whether or not the average assessment of the EV driving experience is higher or lower than the self-reported enjoyment of driving or driving affect. For example, it would appear that the Zealous Optimists and Plug-in Pioneers are both groups which tend to enjoy driving and potentially use driving as a means of self expression. Nevertheless, they also both rate the EV driving experience very high and hence their willingness to consider these modes. The Conventional Sceptics and Rejecters, on the other hand, are less enthusiastic about driving but their assessment of the EV driving experience is even lower.



* Mean score on 4 attitude statements (*I like driving; I enjoy driving on my own; I like to drive just for the fun of it; Driving gives me a chance to express myself*). These loaded on one construct in the factor analysis (C-Alpha =0.75).

Figure 74: Comparison between 'driving affect' and 'PHEV/BEV driving affect' in each segment (N=2,729)

10.2.19 Symbolic factors

Key findings:

- The car is regarded as essential by between 72% and 83% of participants in each of the segments. Hence EV ownership can be considered among people who regard the car as a fundamental part of their lifestyle. However, those who are most positive about EVs are also most likely to agree that a lifestyle without a car altogether would be a good thing.
- The idea that EVs will project certain meanings to others (EV Symbolism) has proven to be a strong predictor of likely EV uptake and one of the defining characteristics of the segments.
- The Plug-in Pioneers and Zealous Optimists feel strongly that they would be proud to own such vehicles. On the other hand, the Image-conscious Rejecters are convinced that they would find it embarrassing to own an EV.
- General Car Symbolism does not vary as strongly across the segments as EV Symbolism. This could be an indication that the symbolic meanings of EVs are still being formulated and will take time to become established. This fluctuation could lead to the ‘tipping’ of people from one segment to another or the development of entirely new segments.
- Knowing many people who are believed to be interested in adopting a PHEV or BEV proved to be the strongest discriminator between the segments. The Image-conscious Rejecters have a strong belief that they do not know many people who would be attracted to either vehicle. By contrast, the Zealous Optimists almost unanimously believe that they do associate with such people.
- For some segments, symbolic factors are likely to play as strong a role as economic or functional attributes. For instance, the performance advantages of EVs are rated much lower than the environmental advantages and some of the largest trade-offs between these two attributes are perceived to exist in the minds of the most enthusiastic segments.
- Some segments are clearly more status-driven than others. However, even where segments may have status as a common driver, symbolic meaning may be fulfilled in different ways for each of them.
- Overall, environmental values are an important predictor of EV adoption, but are not necessarily a stronger motivator than some other factors such as the desire to be less dependent on oil (which may also have an environmental association). For some, status and identity are achieved through environmental values, for others it is through being less dependent on oil (prices) and the acquisition of a fuel efficient car.

Table 54: Segment symbolic attitudes

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
General car symbolism and environmental identity (strongly agree + agree)								
A car provides status and prestige	47.9%	36.2%	25.2%	37.4%	19.6%	27.1%	30.1%	41.7%
I would like to be less dependent oil companies	97.9%	95.4%	86.3%	87.2%	79.7%	83.7%	61.8%	84.7%
Being environment-ally responsible is an important part of who I am	87.5%	75.9%	70.3%	71.5%	60.9%	38.0%	45.3%	59.3%
PHEV symbolism (strongly agree + agree)								
I would feel proud of having a PHEV outside my house	81.3%	63.5%	33.0%	41.9%	20.3%	18.8%	7.3%	31.0%
I know many people whom I think would be attracted to a PHEV	66.7%	78.7%	35.0%	55.1%	9.9%	15.2%	0.2%	30.6%
PHEVs are good for the environment	89.6%	90.8%	79.7%	91.8%	75.2%	75.6%	68.9%	76.4%
BEV Symbolism (strongly agree + agree)								
I would feel proud of having a BEV outside my house	75.0%	63.5%	18.6%	34.9%	16.1%	17.5%	5.5%	23.1%
I know many people whom I think would be attracted to a BEV	64.6%	66.7%	2.0%	37.6%	6.6%	9.1%	0.0%	22.7%
BEVs are good for the environment	93.8%	93.7%	77.8%	90.2%	72.3%	77.0%	69.1%	73.1%

Note: In each comparison overall group differences when testing across all eight segments are statistically significant at $p<0.05$. See Appendix P for further detail.

Table 55: Segment symbolic attitudes – summary

Segment	Symbolic attitudes – summary
1 (Plug-in Pioneers)	High desirability to live without the car altogether. Would feel very proud to own an EV and high association with EV owners. High environmental identity and highest faith in EV 'green' credentials, but also high desire for oil independence. Perceive large trade-off between environmental benefits and performance.
2 (Zealous Optimists)	Highly likely to say they could live without a car and most likely to find this desirable. Would feel proud to own an EV and very high association with EV owners. High faith in environmental benefits but attachment to oil independence is much greater.
3 (Willing Pragmatists)	Least likely to say they could manage without the car. Would feel some embarrassment about owning a BEV. Generally do not attach status and meaning to cars – more motivated by functional attributes.
4 (Anxious Aspirers)	Have some concerns about the image projected by EVs. High environmental identity and desire for oil independence, but due to anxieties about performance, perceive large trade-off.
5 (Uninspired Followers)	Most likely to say they could live without a car. Would feel some embarrassment about owning an EV and low association with EV owners. Quite high environmental identity, but lower faith in the 'green credentials' of EVs.
6 (Conventional Sceptics)	Would not feel embarrassed to own an EV but this is more because they tend not to attach symbolic meanings to cars. Lowest environmental identity.
7 (Image-conscious Rejecters)	Least likely to say they could manage without a car. Would feel embarrassed to own an EV and convinced they do not associate with EV owners. Low green identity and most likely to believe that green credentials have been over exaggerated.
8 (Company Car Drivers)	Have some concerns about the image projected by EVs. High motivation to be less dependent on oil companies but only moderate green identity and faith in environmental benefits.

Symbolic factors relate to how consumer goods can serve as symbols or have wider meanings, and how these can be used to express social status or personal identity and values; for example being seen as green or someone who owns the latest technologies. These are not entirely distinct from functional and affective factors as the former can take on symbolic meanings and consumers may have emotional reactions to them. In this section we explore the meanings attached to cars and potentially to EVs and the identity constructed by the buyers.

10.2.19.1 General car 'dependence'

Firstly, a number of attitude statements on the questionnaire were used to try and understand general attachment to cars, both behaviourally in terms of travel patterns, and psychologically in terms of how vital a car is perceived to be to underpin a person's lifestyle. This is of course a complex issue and is implicit in more than one of the attitudinal and behavioural questions. So far we have learnt, for example, that the Plug-in Pioneers are possibly the least behaviourally attached to their car given that they appear to demonstrate a high level of use for other forms of transport for the journey to work and other purposes; the Uninspired Followers seem to have lower annual mileages and commute distances, but the Image-conscious Rejecters and Company Car Drivers are very high car users, being particularly dependent on their car for the journey to work.

Two attitudinal questions attempted to understand the degree to which respondents felt they could live without the car. Neither of these statements loaded onto the symbolic or affective factors discussed below, and neither do they load strongly together as a factor, and so are assumed here to have captured the need for the car for diverse and complex reasons which are likely to be a combination of functional, symbolic and affective motives.

Figure 75 shows the scores on these statements and suggests the following:

- The car is regarded as essential by between 72% and 83% of participants in each of the groups. This is typical of a number of studies which find about 20% to 30% of people admit their car is not essential or absolutely necessary[26].
- There is no discernable relationship between those who are most likely to say they could not manage without the car and enthusiasm for EVs. Some of the least enthusiastic groups (Conventional Sceptics and Image-conscious Rejecters) *and* most positive (Zealous Optimists) are likely to score highly on this dependence measure. This suggests that EV ownership can be considered among people who regard the car as a fundamental part of their lifestyle.
- There is a relationship, however, between those who are most likely to agree that it would be good to be less dependent on the car and EV enthusiasm. Agreement that living without a car would be a good thing is a minority opinion in all cases. Nevertheless, those who are most positive about EVs are also more likely to agree that a lifestyle without a car altogether would be a good thing. This is likely to be tapping in to symbolic notions of identity, freedom and independence from the transport and energy ‘systems’, but also related to issues of cost, the environment and other issues. These issues are now explored.

[26] For example, the 2010 RAC report on motoring found 86% who agreed they would find it difficult to adjust to life without a car. Also see Stradling, Anable, Anderson, & Cronberg (2008).

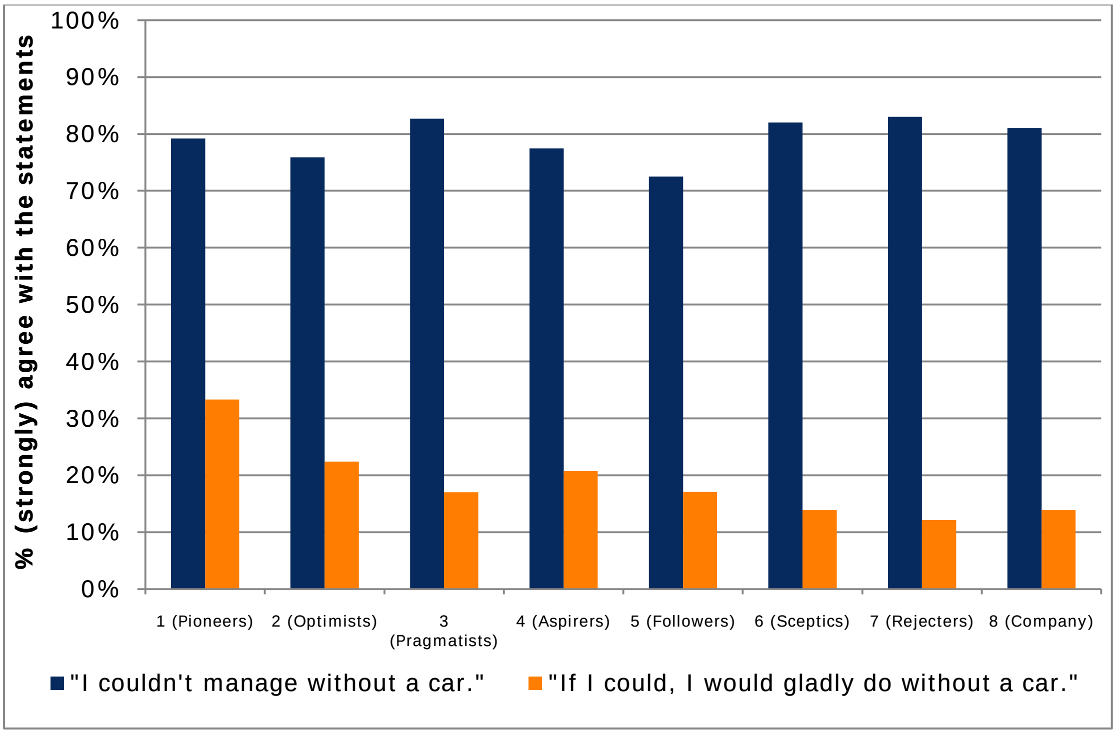


Figure 75: Attitudes towards 'car dependence' in each segment (N=2,729)

10.2.19.2 Symbolic meaning of cars

In other studies, conventional hybrids (HEVs) and EVs have been found to be associated with symbolic meanings such as lower resource consumption, independence from petroleum producers, advanced technology, financial responsibility, saving money, opposing war as well as environmental and/or resource preservation (Heffner, Kurani & Turrentine, 2007; see also the Literature Review in this report). These symbolic evaluations can relate to the whole vehicle or to more specific functional or financial attributes such as fuel economy. Consumers then infer connotations to these meanings such as 'behaving ethically', 'concern for others', 'being intelligent' or 'unique' and if these relate to self identities and values, they may be expressed through adoption of EVs.

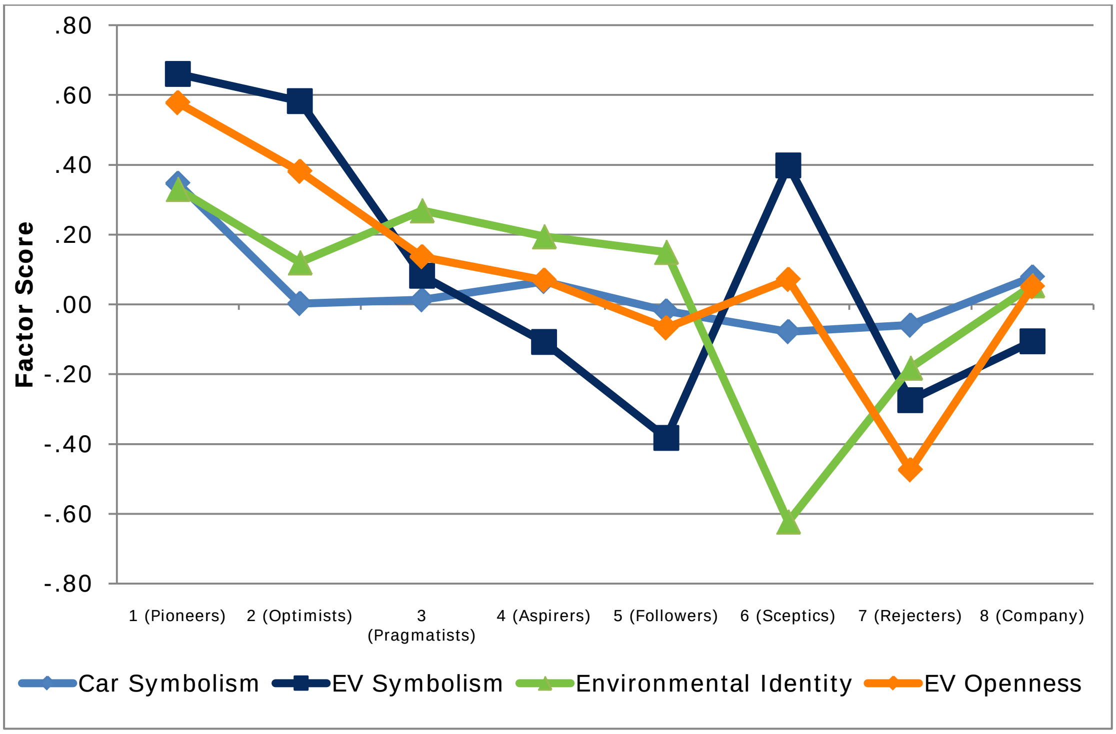
We have not measured environmental values or 'world view' and the potential symbolic associations with more functional attributes such as the importance of fuel economy and the desire for independence from oil companies. Thus, the assessment of symbolic meaning in this study was based on a large number of attitudinal factors. We base the following analysis on the composite factor scores derived during the exploratory analysis (Anable et al., 2011) . In this analysis, several groups of attitude statements loaded together to indicate the presence of four strong and internally consistent underlying constructs relating to symbolic meanings. The attitudinal statements which comprise each factor are listed in Table 56.

Table 56: Attitude statements loading on the factors relating to symbolism

		Cronbach's Alpha*	Interpretation
Car Symbolism			
D1i.	A car provides status and prestige	0.82	Belief that cars are an expression of personality and status
D1o.	My car says something about who I am		
D1d.	I tend to buy the same type/ size of car (e.g. small car, family estate) (REVERSE CODED)		
EV Symbolism			
Qd2l.	I would feel embarrassed to drive a plug-in fully electric car (REVERSE CODED)	0.82	Embarrassment/pride in owning and driving an EV
Qc2k.	I would feel embarrassed to drive a plug-in hybrid electric car (REVERSE CODED)		
Qd2n.	I would feel proud of having a plug-in fully electric car outside my house		
Qc2m.	I would feel proud of having a plug-in hybrid electric car outside my house		
EV Openness			
Qb2e.	I would like to be less dependent on oil companies for fuelling my car	0.87	Desire for oil independence and excitement about EV technology and EV identity
Qb2d.	I like the idea of being able to refuel at home rather than have to go to petrol stations		
Qb2f.	Plug-in cars are a good thing because it makes us less dependent on oil		
Qb2g.	Driving a plug-in car would give me a 'feel good factor' because of its green credentials		
Qb2i.	I am the type of person who would drive a plug-in car		
Qb1a.	Compared to a normal car, plug in cars are generally a very exciting new technology		
Environmental Identity			
Qf1f.	I am not the type of person to worry about being 'green' (REVERSE CODED)	0.88	Concern for and identity with environmental issues
Qf1b.	Being environmentally responsible is an important part of who I am		
Qf1e.	What I do in life doesn't make any real difference to the environment (REVERSE CODED)		
Qf1d.	I feel a moral obligation to reduce my emission of greenhouse gases		
Qf1g.	The so called 'environmental crisis' has been greatly exaggerated (REVERSE CODED)		
Qf1j.	Reducing my car's environmental impact would make me feel good		
Qf1k.	Reducing my car's environmental impact would be good for society		
Qf1c.	It's not worth me doing things to help the environment if others don't do the same (REVERSE CODED)		
Qf1m.	I would not buy a more efficient car just because it is environmentally friendly (REVERSE CODED)		

*A scale is internally consistent to the extent that items are correlated. Cronbach's Alpha provides a summary statistic to this effect. Alpha coefficients range from 0 to 1 and may be used to describe the reliability of each factor. Consistent with the literature, 0.6 was considered to be an acceptable reliability coefficient. In each case, items which did not appear to be measuring the same construct thereby causing a lower alpha value were deleted.

These factors capture constructs of self identity, self image or status which are expressed through buying, owning and using the vehicle. Figure 76 shows the position of each of the segments in relation to these constructs, based on the average factor scores for each segment*[27]. In Figure 76 we see that 'EV symbolism' (the degree to which someone would feel embarrassed or proud to drive an EV') is the factor which varies the most from segment to segment and tends to differentiate strongly between them. The Pioneers and Optimists score very highly on this construct. Interestingly, the Sceptics also score high on this and so do not appear to be put off from EVs because they would be embarrassed to own one, but it seems instead they are much less convinced by their environmental and technological advantages. Car symbolism (the degree to which cars are generally seen as an expression of identity or a status symbol) is a less powerful discriminator suggesting that the specific image of plug in cars is much more important at this stage. Environmental identity does not vary greatly across most of the segments although the Sceptics and Rejecters are notably less motivated by this.



Note: The attitude statements were scored so that a high score denotes a 'positive' attitude towards cars/electric vehicles/environment.

Figure 76: Measures of symbolic meanings relating to cars, EVs and the environment in each segment (N=2,729)

By understanding the relative role of these symbolic meanings we can begin to understand some of the differences in outlook between each of the segments. In particular, the analysis reveals that for some segments, symbolic factors seem to play as strong a role as economic or functional attributes.

Overall, the belief that the ownership of an EV would project certain meanings to others (EV Symbolism) proved to be one of the strongest predictors of likely EV uptake in the exploratory regression analysis (Anable et al., 2011). This was measured by asking people how proud or embarrassed they would be to own a PHEV or BEV.

[27] The factor scores are composite variables which provide information about an individual's placement on a factor. They are standardised to a mean of zero and a standard deviation of 1.

It is important to observe that general Car Symbolism does not vary as strongly across the segments as EV symbolism[28]. This could be an indication that the symbolic meanings of EVs are still being formulated and will take time to become established in the market place. This is something worth exploring at regular intervals in the early stages of the market as it is likely to fluctuate and could be a factor in ‘tipping’ people from one segment to another or turning a segment from an EV rejecter to a considerer and an adopter. The analysis of Car and EV Symbolism shows:

- The issue of whether a BEV is embarrassing to own polarises opinion. This is one reason why the construct of EV symbolism has proven to be a strong predictor of likely EV uptake and one of the defining characteristics of the segments.
- The Plug-in Pioneers and Zealous Optimists feel strongly that they would feel proud to own such vehicles and appear to differentiate them from other types of vehicles.
- The Anxious Aspirers and Company Car owners, however, clearly have some concerns about the image projected by EVs and this is important given that they attach some importance to this aspect.
- The Conventional Sceptics and Uninspired Followers stand out yet again as their scores suggest that they would not feel embarrassed about owning such a car. From their scores on Car Symbolism this is likely to be because they do not associate cars with such status meanings anyway. Certainly the Conventional Sceptics are more driven by functional motives. They are also the least environmentally conscious.
- The Image-conscious Rejecters are convinced that they would find it embarrassing to own an EV. Although they seemingly attach less importance to the issue of ‘identity’ than most other groups, the disconnect between their scores on Car Symbolism and EV Symbolism here suggests that this may still be cognitively uncomfortable for them and a factor in their rejection of the technology at this stage.
- Upon further examination of the answers to these questions, it is apparent that in all groups other than the Pioneers, Optimists and the Rejecters, a high proportion have made use of the ‘neutral’ scoring on the questions about PHEV or BEV identity. This fits with the idea that symbolic meanings attached to EVs may take some time to form and for these groups, a position on these issues is likely to still be in the process of being established. This suggests that their opinions may change quickly on these issues.

EV Openness is a complex factor which captures a variety of reasons why EVs may provide a ‘feel good’ factor. The top loading statements in this construct relate to the desire to be less dependent on oil and would appear to be separate from environmental identity which is a separate strong factor. The desire for oil independence is likely to capture a number of unique affective, symbolic and instrumental motives such as negative feelings towards oil companies, the desire to be less vulnerable to fluctuating oil prices and even the hassle of having to fill up with fuel in petrol stations. These factors would be worthy of further research in order to explore the extent to which the desire for oil independence is related to environmental issues, ‘peak oil’ and energy security, negative perceptions of ‘Big Oil’ or other issues. Nevertheless, it is apparent from Figure 76 (as it was with the exploratory regression analysis preceding the segmentation) that environmental values are an important predictor of EV adoption, but are not necessarily a stronger motivator than some other factors such as the desire to be less dependent on oil. Although the latter may also have environmental motivations, the analysis suggests that they are somewhat different constructs.

Some segments are clearly more status-driven than others. However, this analysis suggests that even where segments may have status as a common driver, this symbolic meaning may be fulfilled in different ways for each of them. For some, status and

[28] Indeed there was only a weak statistically significant difference in Car Symbolism scores across segments (P=0.068). The weakness of this variable as a predictor of likely EV adoption meant that this factor was not used as a basis for the cluster analysis.

identity are achieved through environmental values, for others it is through being less dependent on oil (prices) – although this may also have an environmental association. So, for example:

- Plug-in Pioneers score high relative to other sectors on both general car symbolism and EV symbolism suggesting that they believe a car defines something about who they are and that an EV relates to and expresses this in some way. For them, environmental symbolism, an identity with the technology and being less dependent on oil all appear to be symbolic.
- The Zealous Optimists attach high symbolic meaning to EVs, but these would appear to be more about oil independence than environmental motives. This is similar for the Anxious Aspirers and the Company Car Drivers.
- The Conventional Sceptics, on the other hand, attach lower status and identity meanings to their car in general, but have a relatively strong desire to be less dependent on oil.
- The Uninspired Followers have a relatively high environmental identity.

10.2.19.3 Social influence

Other studies have highlighted the role of injunctive norms (beliefs about the expectations of 'significant others' and whether they approve of a particular action) and behavioural/descriptive norms (perceptions of whether these 'significant others' themselves actually perform the behaviour) in behavioural choice and pro-environmental behaviours (Ajzen, 2001).

Behavioural norms were captured in this survey by asking respondents whether they knew many people who they believed would buy a PHEV or BEV. Again this proved to be a relatively strong and significant predictor of likely EV uptake in the preceding regression analysis and proved to be the strongest discriminator between the segments (see Section 10.2.8). It can be seen again here to be an issue which strongly distinguishes between segments. Particularly apparent is the strong belief by the Image-conscious Rejecters that they do not associate with the type of people they consider would adopt EVs. None of the members of this group agree that they know many people who would be attracted to either vehicle. By contrast, an equally strong position on this, but in the opposite direction, is that of the Zealous Optimists who believe almost unanimously that they do associate with such people.

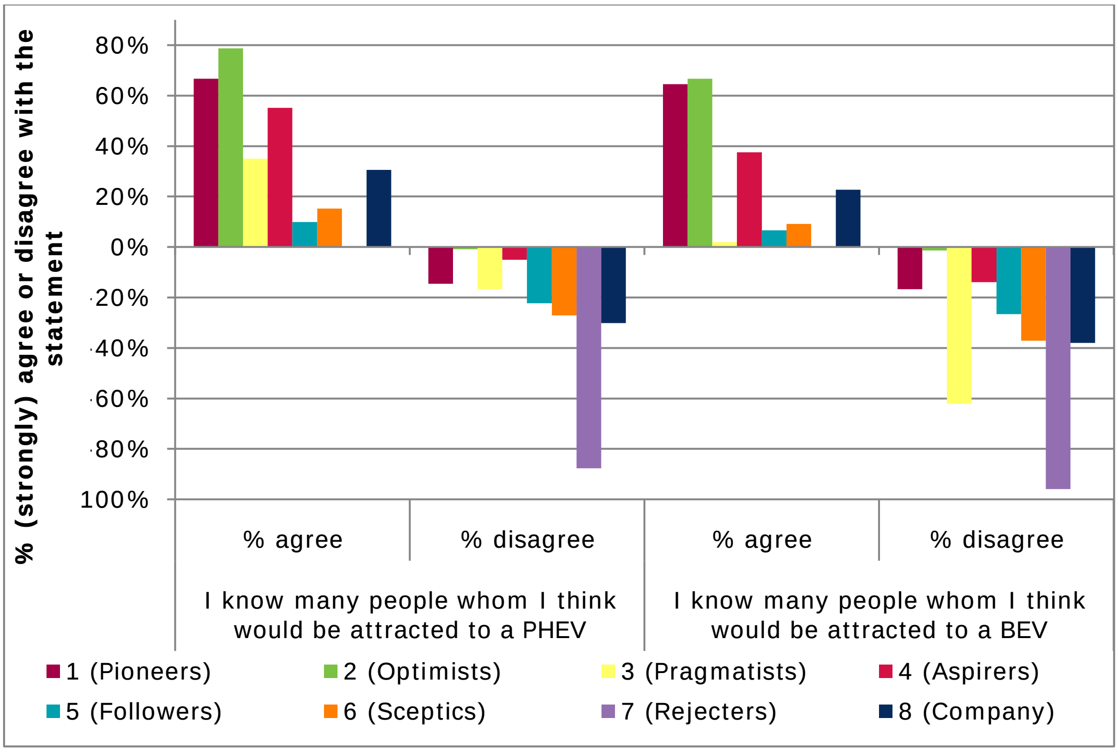


Figure 77: Social Influence attitude scores in each segment (N=2,729)

10.2.19.4 Environmental beliefs

We have seen from preceding analyses that environmental identity proves to be a distinct underlying construct which has moderate predictive power in relation to likelihood to adopt – ranking overall less powerful than other symbolic factors for BEVs and willingness to pay, but more important than affective and instrumental motives and general measures of innovativeness. It seems that at least some consumers would be prepared to pay more to drive cleaner or zero emission vehicles, but this often relies on a *belief* that the vehicles are genuinely more 'environmentally friendly' and that alternative vehicles can match conventional types in performance.

Figure 78 shows the degree of scepticism that EVs are indeed more environmentally beneficial than 'normal cars' and Figure 79 shows the trade-off believed necessary between environmental benefits and vehicle performance for each segment.

Overall, environmental scepticism is high with a quarter of the sample disputing the statement that the environmental benefits of EVs have been exaggerated and no more than half the people in any segment prepared to defend the environmental advantages of this technology. Scepticism is greatest among the Conventional Sceptics and the Image-conscious Rejecters.

Despite the popular notion that the environmental benefits may have been over-played, the majority (80%) still believe that EVs have a relative advantage compared to 'normal cars'. However, Figure 79 shows how the performance advantages of EVs are rated much lower than the environmental advantages. Interestingly, the perceived trade-off between environmental benefit and vehicle performance is greatest for the Plug-in Pioneers and also relatively large for the Zealous Optimists, but on balance the vehicles are still perceived as performing similarly to normal cars by these groups. The largest discrepancy exists for the Anxious Aspirers who have faith in the environmental benefits, but relatively low faith in the vehicle performance. The Willing Pragmatists appear to be making the lowest perceived trade-off as they have relatively low faith in the environmental benefits but do not believe that PHEVs (but not BEVs) will require a compromise on performance.

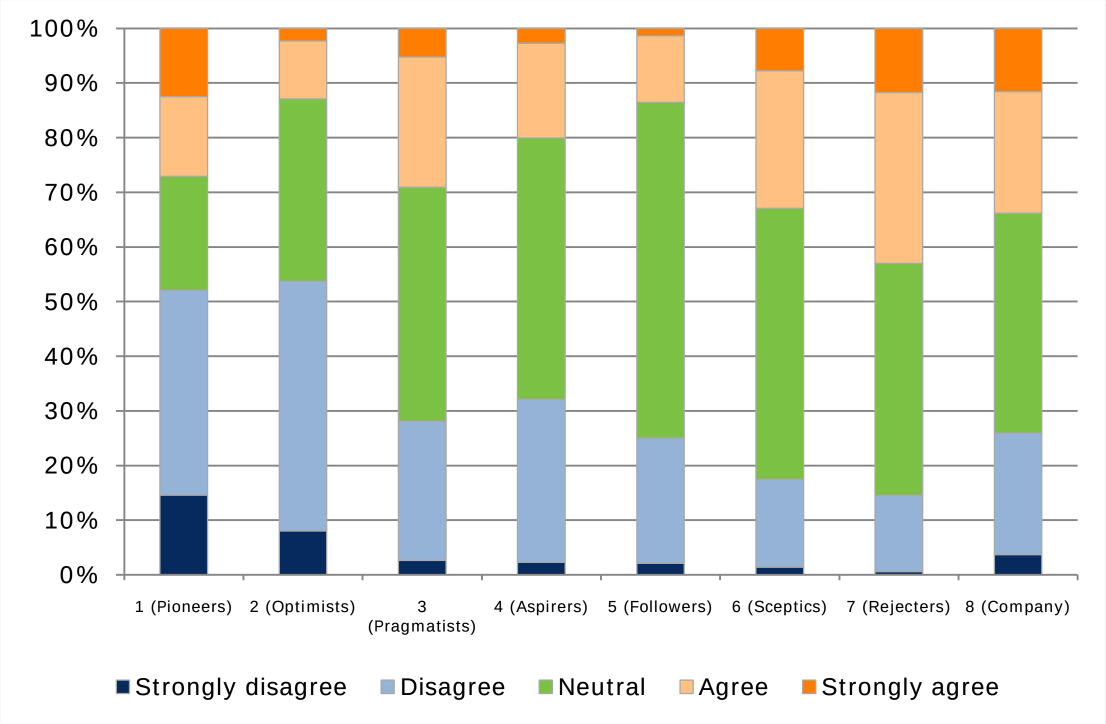


Figure 78: Agreement with the statement 'The environmental benefits of EVs have been exaggerated' in each segment (N=2,729)

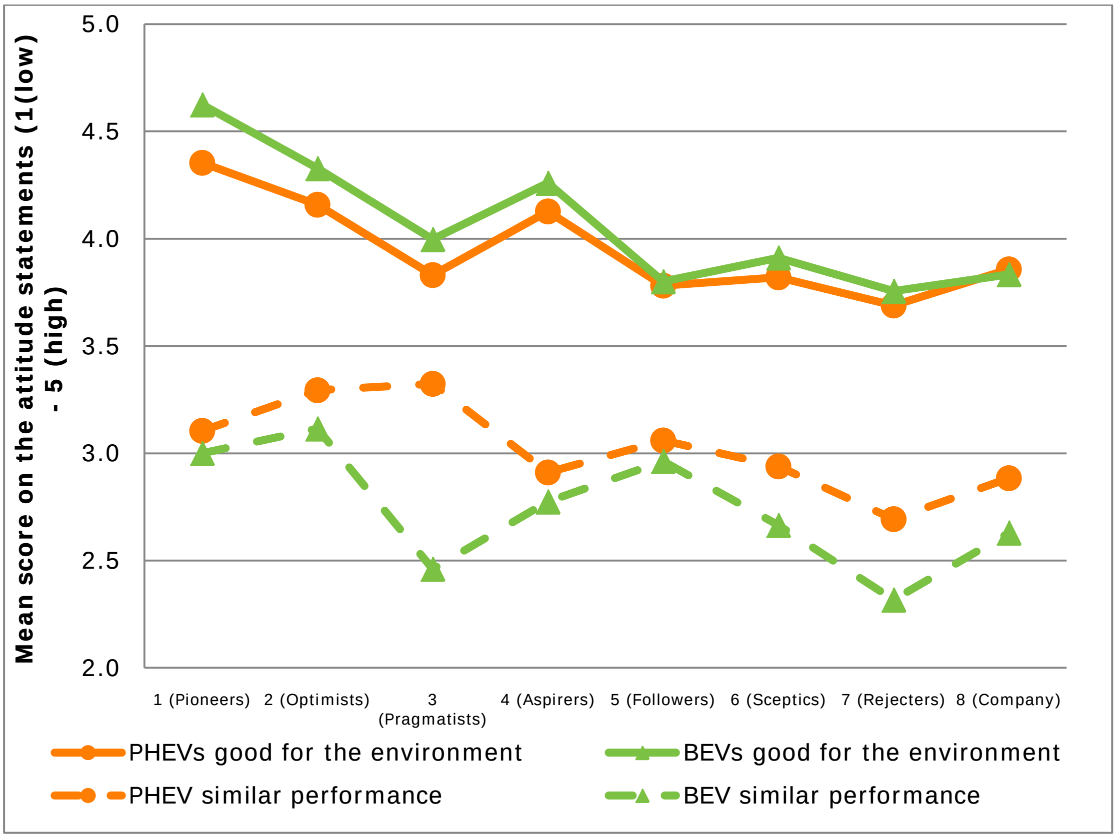


Figure 79: Perceived trade-off between environmental and performance benefits in each segment (N=2,729)

10.2.20 Personality and innovativeness

Key findings:

- There is a significant relationship between Rogers' 'diffusion of innovation' segments and the EV segments. However, the relationship is complex and demonstrates the inadequacy of relying on the generic 'innovativeness' categorisations as defined by Rogers.
- Although the Plug-in Pioneers do seem to dominate the 'Innovator' group (and conform to being young, wealthy and highly educated as defined by Rogers) and the Uninspired Followers dominate the 'Laggards' (and conform to be the oldest and least wealthy as defined by Rogers), each of the Rogers' groups are defined by more than one EV segment.
- In particular, more than one segment can be described as an 'early adopter'. The Zealous Optimists, Anxious Aspirers and Company Car Drivers all score relatively highly in this category.
- Although the earlier adopters of EVs are more likely to be high innovators, this is not an absolute prerequisite to early adoption, at least not for PHEVs (e.g. Willing Pragmatists). The most powerful combination occurs where innovativeness is combined with favourable attitudes about the specific technology.
- General product innovativeness and self-proclaimed enthusiasm or knowledge about cars ('authority') are two useful dimensions on which to profile the segments in relation to their likelihood to adopt EVs. Those segments that score highly on both dimensions are most likely to adopt EVs. Those in the low authority/low innovativeness segment are likely to be the most difficult targets as they hold the least favourable attitudes towards EVs.
- The Conventional Sceptics go against this trend as they are relatively high innovators but they also score low on car authority. This demonstrates the fact that measures of product-specific innovativeness may be more useful than general innovativeness. It may also be a useful way of identifying segments to target in order to turn around unfavourable attitudes towards EVs by targeting those with high general innovativeness but specific poor perceptions and lack of knowledge about EVs.
- There is evidence of the existence of a 'familiarity penalty'. For instance, even in the Plug-in Pioneers group over half suggest they want to wait until the technology is somewhat established/there is fair choice before they adopt it. More work is needed to understand what this means and its implications.
- With the exception of the link between neuroticism and the degree to which driving is found to be stressful, there were no meaningful relationships found between the five personality domains and the attitudinal variables, including the likelihood to adopt EVs.
- The Plug-in Pioneers have a distinct personality profile signalling higher openness, conscientiousness, extraversion and agreeableness, and lower neuroticism, than the overall sample and each of the other segments. However, most of the segments differed to only a modest extent on the five personality domains.

Table 57: Innovativeness – summary

Segment	Innovativeness – summary
1 (Plug-in Pioneers)	Very high innovators and high car authority. However, relatively high familiarity penalty with over half saying they would prefer to wait until EV technology is somewhat established.
2 (Zealous Optimists)	High innovativeness and medium car authority. Most likely to believe EVs are here to stay.
3 (Willing Pragmatists)	Medium innovativeness and medium car authority. High faith than EVs are here to stay.
4 (Anxious Aspirers)	High innovator and high car authority.
5 (Uninspired Followers)	Very low innovativeness and very low car authority.
6 (Conventional Sceptics)	Medium innovator but low car authority.
7 (Image-conscious Rejecters)	Very low innovator and low car authority. Most likely to say that EVs are just a temporary fad.
8 (Company Car Drivers)	Very high innovator and high car authority.

10.2.20.1 Innovativeness

Consumer innovation, as a trait that leads to innovative behaviour, has been cited and researched in the context of the adoption and diffusion of alternative vehicle technology (Thøgersen & Gärling, 2001; Santini & Vyas, 2005). Innovativeness reflects 'the degree to which an individual makes innovative decisions independently of the communicated experience of others' or, more precisely, 'domain specific innovativeness' which refers to a trait reflecting 'the tendency to learn about and adopt innovations (new products) within a specific domain of interest' (Thøgersen & Gärling, 2001). Individuals differing in innovativeness will evaluate the attributes of the vehicles differently and will attach more importance to technological improvements than would the average consumer evaluating ICE technology (Santini & Vyas, 2005).

Innovativeness was firstly measured using an established scale to place respondents automatically in one of Rogers' (1962) theory of diffusion adopter groups[29]. Figure 80 shows that there are significant differences between the segments on this measure. Whilst there is a significant relationship between Rogers' segments and the EV segments, the relationship is complex and demonstrates the inadequacy of relying on the generic 'innovativeness' definitions as proposed by Rogers. Although the Plug-in Pioneers do seem to dominate the 'Innovator' group (and conform to being young, wealthy and highly educated as defined by Rogers) and the Uninspired Followers the 'Laggards' (and conform to being the oldest and least wealthy as defined by Rogers), each of the Rogers' groups are defined by more than one EV segment. In particular, more than one segment can be described as an 'early adopter' as defined by the

[29] Five types of adopters can be distinguished: Innovators: first individuals to adopt an innovation; willing to take risks, youngest in age, highest social class, great financial lucidity, very social and have closest contact to scientific sources and interaction with other innovators; Early adopters: second fastest category of individuals to adopt an innovation; typically younger in age, have a higher social status, have more financial lucidity, advanced education, and are more socially forward than late adopters; Early majority: tend to be slower in the adoption process, above average social status, contact with early adopters; Late majority: adopt an innovation after the average member of society; typically sceptical about an innovation, below average social status, very little financial lucidity, in contact with others in late majority and early majority; Laggards: last to adopt an innovation; typically focused on 'traditions', lowest social status, lowest financial fluidity, oldest of all other adopters, in contact with only family and close friends.

statement 'I may not be the first, but I like to own the latest technology before most people'. The Zealous Optimists, Anxious Aspirers and Company Car Drivers all score relatively highly in this category.

The Conventional Sceptics are interesting as they score relatively high on innovativeness overall but generally do not seem to adhere to any one innovator profile. Similarly, the Willing Pragmatists score low on innovativeness, but have favourable attitudes towards PHEVs and appear likely to be an early adopter of this technology. This suggests that, although the earlier adopters of EVs are more likely to be high innovators, this is not an absolute prerequisite to early adoption. More important is that attitudes towards EVs are favourable. The most powerful combination occurs where innovativeness is combined with favourable attitudes about the specific technology.

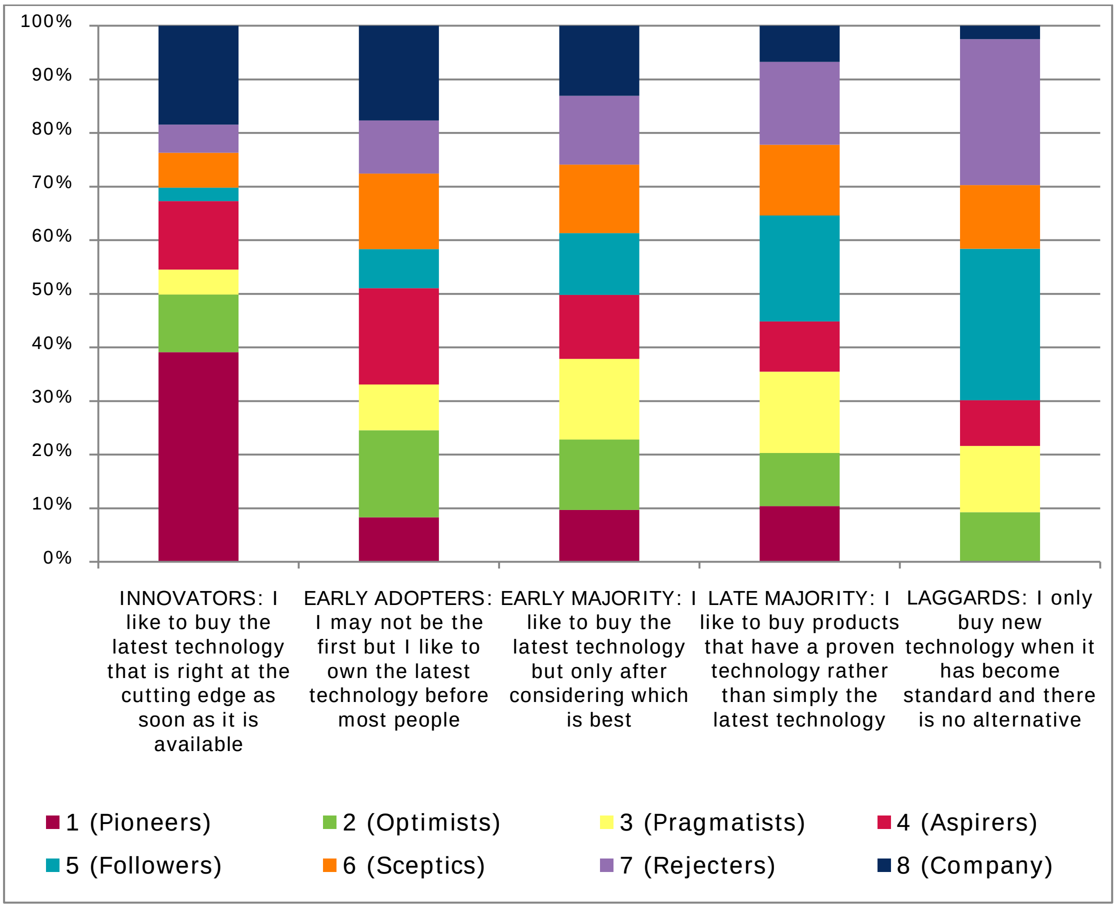


Figure 80: Relationship between Rogers' theory of diffusion adopter groups and the EV segments (N=2,729)

Innovativeness was measured in a number of additional ways to reflect the different theoretical definitions of this construct including opinion leadership, social innovativeness and consumer independent judgment making. We base the following analysis on the composite factor scores derived during the exploratory analysis (Anable et al., 2011). In this analysis, several groups of attitude statements loaded together on two strong and internally consistent underlying constructs relating to innovativeness. The attitudinal statements which comprise each factor are listed in Table 58.

Table 58: Attitude statements loading on the factors relating to symbolism

		Cronbach's Alpha*	Interpretation
Innovativeness			
E1d.	I am usually among the first to try new technology	0.89	A desire to own and be seen with the latest technology
E1e.	New technology excites me		
E1a.	I like to buy new and different technologies		
E1c.	I generally know more than other people about new technology		
Car Authority			
E1l.	When other people are choosing a car to buy, they turn to me for advice	0.84	General car enthusiasm/self-proclaimed knowledge about cars
E1k.	I often influence other people's opinions about cars		
E1m.	I like magazines/websites about new cars		
E1f.	I often seek out information about new cars		

Scores on these two factors are contrasted for each segment in Figure 81. The two measures—general product innovativeness and self-proclaimed enthusiasm or knowledge about cars ('authority')—are two useful dimensions on which to profile the segments in relation to their likelihood to adopt EVs[30]. In general, those segments that are most likely to adopt EVs score highly on both dimensions, and those with the least propensity score low on both dimensions. Those in the low authority/low innovativeness segment are likely to be the most difficult targets as they hold the least favourable attitudes towards EVs on average. However, the Conventional Sceptics go against this trend as they are relatively high innovators but are a relatively low authority and a relatively unenthusiastic group. This demonstrates the fact that measures of product-specific innovativeness may be more useful than general innovativeness. It may also be a useful way of identifying segments to target in order to turn around unfavourable attitudes towards EVs. For instance, if the Conventional Sceptics group were to overcome some of their reservations and begin to score more highly on the 'Car Authority' scale in relation to EVs, they might move in to the top right-hand corner of Figure 81. Interestingly, none of the segments fall into the high authority/low innovator category.

[30] Car authority can be compared to a measure of objective knowledge – namely the proportion of people who claim to know or not know their mpg. For example, the Anxious Aspirers are most likely to say they do not know the mpg of their main car (22% of them), despite the fact that they score relatively highly on 'car authority'. Consequently, we cannot take 'car authority' to denote actual detailed knowledge about cars but it seems more to suggest a general enthusiasm and interest in cars.

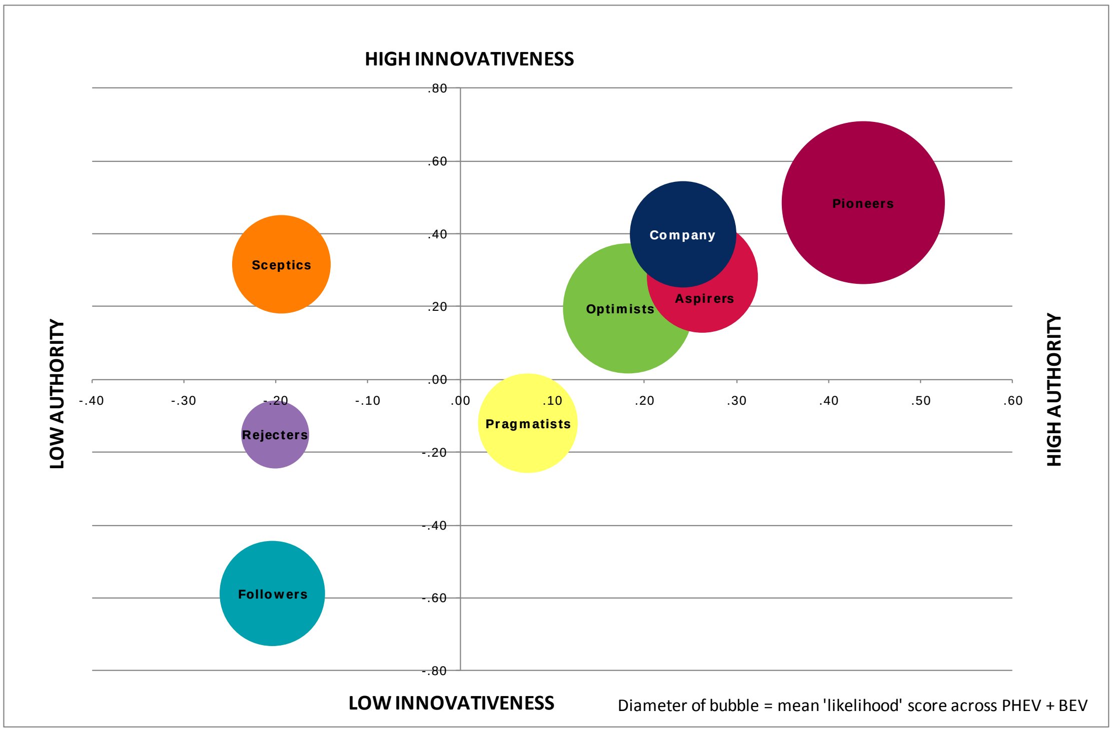


Figure 81: Segment scores on two dimensions: general innovativeness and car authority (N=2,729)

This was not well covered in the questionnaire and would benefit from some further research. However, two questions touched upon the issue of the ‘familiarity penalty’ (the preference to wait until a technology is better established in the market before adopting it), as shown in Figure 82. Somewhat surprisingly, over 50% of the Plug-in Pioneers suggest they want to wait until the technology is somewhat established or there is fair choice before they adopt it. They are also seemingly more likely than all but the Rejecters to think that the technology may be a current fad. Perhaps this high score demonstrates the risk taking trait that is identified by Rogers as characteristic of the Innovator segment. As expected, the Anxious Aspirers are especially likely to prefer to wait but the Zealous Optimists have the greatest faith that the technology is here to stay[31].

[31] For the less enthusiastic segments, this data must be treated with some caution as the statement ‘I would only consider…’ may provoke a negative reaction if a respondent believes they are unlikely to consider, whatever the circumstances.

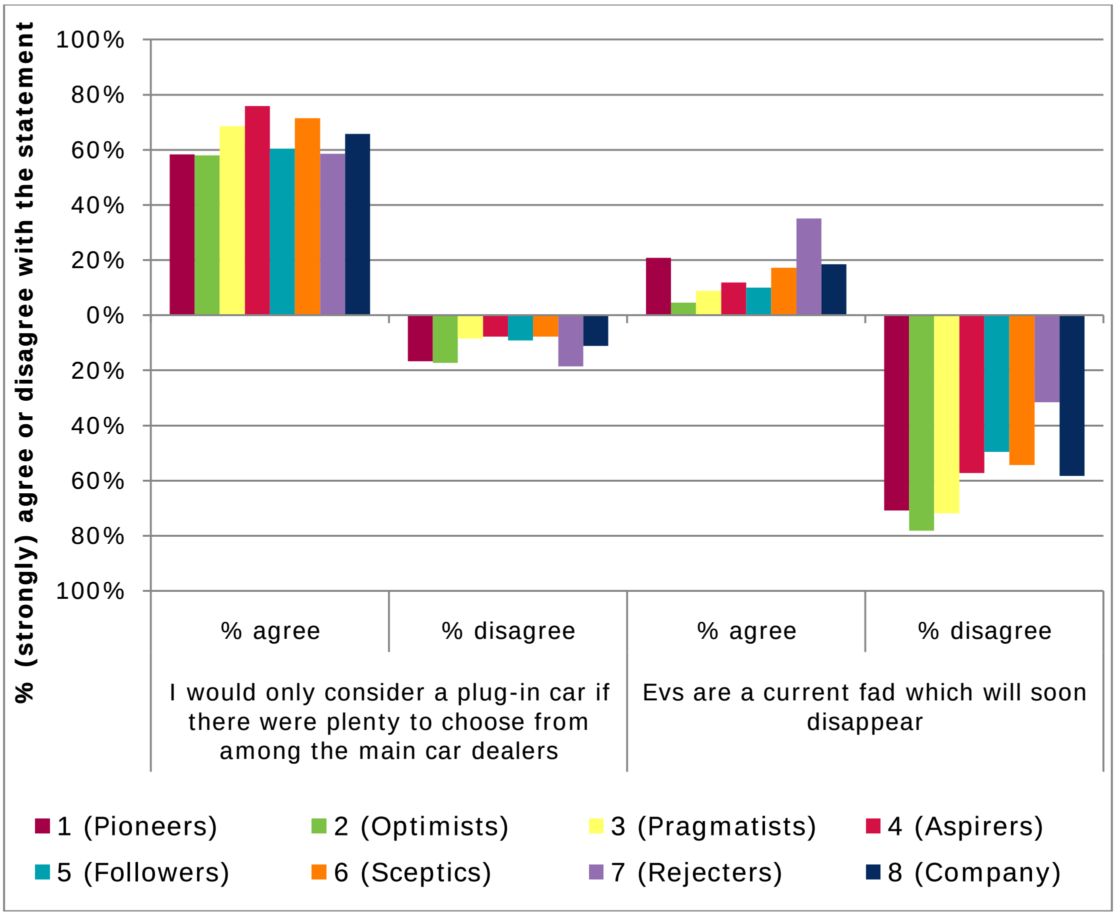


Figure 82: 'Risk taking' attitude scores in each segment (N=2,729)

10.2.20.2 Personality

Technology adoption and driving an EV have been found to be related to at least some elements of personality. This is based on the theory that the symbolic meanings of consumer products represent conscious or non-conscious signals to others about the user's personality traits.

Personality was measured using the 12 items of the Newcastle Personality Assessor (NPA; Nettle, 2007), which provides a simple measure of the five personality traits or 'domains' in the widely accepted Five-Factor model of personality (Costa & McRae, 1995; McCrae & Costa, 2003). The five domains are:

- openness to experience (how willing people are to make adjustments in notions and activities in accordance with new ideas or situations);
- conscientiousness (how much a person considers others when making decisions);
- extraversion (a keen interest in people and other events and venturing with confidence into unknown situations);
- agreeableness (how well people are able to get along with others); and
- neuroticism (the strength with which negative emotions such as anxiety and anger are experienced).

The domains are independent of each other, so a person's score on any one domain does not predict their score on any other. Individual personality scores are made meaningful by relating them to the distribution of scores obtained from a large sample of the relevant comparison population, which is referred to as a 'norm group'[32]. When using personality questionnaires it is good practice when possible to use local norms, i.e. norm data from a population similar to that from which the study participants are drawn. Nettle (2007) provided UK norm data for the NPA; however our own sample was much larger than Nettle's norm group, so for this analysis the sample was treated as its own norm group. Thus the raw scores from our sample were converted to T scores, rescaled so that the *sample* mean T score for each personality domain was 50, and one *sample* standard deviation was rescaled to 10.

Spearman's rho correlation coefficients were calculated to test for relationships between the T scores for openness, conscientiousness, extraversion, agreeableness and neuroticism, and attitudinal variables measured in the survey[33]. Many of the correlation coefficients were statistically significant, because of the large sample size, but too small to be psychologically meaningful. The only exception was a significant correlation between Neuroticism and the item 'I find driving can be stressful sometimes'.

The absence of meaningful correlations is consistent with the view that personality domains, which represent broad dispositions towards patterns of behaviour, are only weak predictors of attitudes and behaviours in specific situations (Ajzen, 2005). One-way analyses of variance were carried out to compare the mean T scores for each personality domain for each of the eight segments identified in the study. Table 59 shows the results.

Table 59: Segment mean (standard deviation) T scores on the domains of the five factor model of personality

Domain	Pioneers	Optimists	Pragmatists	Aspirers	Followers	Sceptics	Rejecters	Company
Openness	55.9 (10.6)	51.0 (10.2)	50.0 (9.7)	52.1 10.0)	49.4 (9.6)	48.9 (9.6)	48.4 (10.3)	49.7 (9.5)
Conscientious-ness	53.7 (14.2)	49.4 (9.3)	49.9 (9.3)	52.0 (10.2)	49.7 (9.9)	48.8 (9.9)	50.4 (10.1)	48.2 (9.7)
Extraversion	57.3 (12.6)	51.3 (9.9)	48.8 (9.8)	51.7 (9.8)	50.1 (9.3)	48.9 (10.0)	48.1 (10.0)	50.2 (10.5)
Agreeableness	54.0 (11.0)	50.7 (10.1)	49.3 (10.2)	52.2 (9.9)	48.5 (9.4)	49.6 (9.3)	49.7 (10.3)	49.5 (10.5)
Neuroticism	47.4 (13.3)	48.7 (9.8)	48.4 (9.4)	52.1 (9.4)	50.3 (9.6)	49.3 (9.9)	50.6 (10.9)	49.5 (9.7)

Note: The pattern of differences in means between segments was significant for each personality domain. See Appendix P for more detail.

[32] For each domain, a z score is calculated, which relates the individual's score to the norm group mean, standardised by the norm group standard deviation. Thus a z score of zero represents a score that is the same as the norm group mean, whilst a z score of +1 means that the individual scored the same as members of the norm group whose scores were one standard deviation above the norm group mean. Z scores are often re-scaled as T scores, in which the norm group mean is scaled to 50 and the norm group standard deviation is scaled to 10.

[33] Spearman's rho was used in this analysis rather than Pearson's r, to avoid the necessity to assume that participants' attitudinal responses were interval data.

Most of the segments differed to only a modest extent in mean T scores on the five personality domains. The notable exception was the Plug-in Pioneer segment, which was higher in openness, conscientiousness, extraversion and agreeableness, and lower in neuroticism, than the overall sample and each of the other segments[34].

Thus we conclude that the Plug-in Pioneer segment had, on average, a distinct personality profile, but the other segments did not.

10.2.21 Response to incentives

Key findings:

- Whilst there are statistically significant differences in the attractiveness of policy incentives between the segments, the overall ranking of the instruments does not vary greatly between them. For instance, Government grants and extended warranties are clearly the most popular for each group.
- The Plug-in Pioneers and the Willing Pragmatists are more attracted to extended warranties than Government grants. Given that these are two of the earliest adopters, this may have implications for how the market is stimulated in the early years.
- The Willing Pragmatists and the Uninspired Followers are relatively more likely to respond to increased petrol and diesel prices, which is consistent with the high importance they attach to fuel economy.
- There was a large difference between the segments in terms of the uptake of the UK Car Scrappage scheme[35] when it was available. The Plug-in Pioneers and Zealous Optimists seem more open to incentivisation. The Anxious Aspirers and the Conventional Sceptics are similarly incentivised and this may suggest that, should some of their fears about plug-in vehicles reduce, they could be induced by Government grants towards the adoption of EVs. It seems that the Willing Pragmatists are less persuaded generally by policy incentives and, if they have decided something is a good idea, are likely to act regardless.
- Over 50% of ALL segments suggest that they would be much more likely to adopt an EV if electricity from charging points was free. Those segments who are already least likely to adopt also say they would be even less likely if electricity costs were no cheaper than petrol or diesel. Even a minority of the Plug-in Pioneers could be put off if electricity prices were no less than petrol or diesel. The Image-conscious Rejecters are unlikely to even consider EVs unless electricity is free.

[34] Post-hoc Bonferroni comparisons revealed significant ($p<0.05$) pairwise differences between the Pioneer segment and all the other segments except Anxious Aspirers for openness; between the Plug-in Pioneers and the Conventional Sceptics and Company Car segments for conscientiousness; between the Plug-in Pioneers and all other segments for extraversion; between Plug-in Pioneers and Followers for agreeableness. Post-hoc Bonferroni pairwise comparisons between the Plug-in Pioneers and other segments for neuroticism were not significant.

[35] This ran between 18th May 2009 and 31st March 2010, scrapping a car of more than ten years old and purchasing a new car with a £2,000 allowance.

Table 60: Segment response to incentives

	1 Pioneers	2 Optimists	3 Pragmatists	4 Aspirers	5 Followers	6 Sceptics	7 Rejecters	8 Company
Increased likelihood of adoption with policy incentives								
% much more likely to adopt if:								
Government grant	81%	71%	45%	54%	36%	51%	20%	43%
Extended battery warranty	90%	71%	48%	51%	36%	47%	19%	43%
Exemption from road tax	71%	51%	26%	40%	25%	32%	14%	25%
Brand new (main) cars purchased using Scrappage grant								
% purchased with Scrappage grant	23%	10%	5%	12%	9%	8%	7%	1%
Influence of electricity prices								
% much more likely to adopt if electricity costs:								
Same as petrol or diesel	16.7%	2.0%	1.0%	3.0%	1.7%	0.6%	1.4%	1.4%
Half as much as petrol or diesel	45.8%	20.7%	12.1%	16.9%	9.9%	10.8%	5.7%	13.0%
Free	87.5%	79.6%	69.9%	72.9%	54.7%	67.6%	46.3%	64.4%

Note: In each comparison overall group differences when testing across all eight segments are statistically significant at $p<0.05$. See Appendix P for further detail.

Table 61: Segment response to incentives – summary

Segment	Response to incentives – summary
1 (Plug-in Pioneers)	Most persuaded by incentives, particularly extended warranties, Government grants and congestion charge exemptions. Least persuaded by low interest loans. Almost 25% took advantage of the Scrappage scheme. A minority could be put off if electricity prices were no less than petrol or diesel.
2 (Zealous Optimists)	Very persuaded by incentives, particularly grants and extended warranties. Least persuaded by priority lane access.
3 (Willing Pragmatists)	If they want to do something, they are likely to do it regardless of incentives. Warranties are the most attractive and the higher cost of petrol and diesel will also have an impact.
4 (Anxious Aspirers)	Possibly incentivised by Government grants if some of their anxieties were alleviated. Relatively high uptake of the Scrappage scheme.
5 (Uninspired Followers)	The minority are likely to be incentivised by policy incentives. Higher petrol and diesel prices will have almost equally as strong an effect on uptake as any policy incentives.
6 (Conventional Sceptics)	Possibly incentivised by Government grants if some of their anxieties were alleviated.
7 (Image-conscious Rejecters)	Remain unpersuaded by incentives and unlikely to even start considering uptake unless electricity was free.
8 (Company Car Drivers)	Incentivised by Government grants, extended warranties and reductions in Company Car Tax. Least persuaded by low interest loans.

10.2.21.1 Impact of policy incentives

Respondents were asked how much more likely they would be to purchase an EV based on the availability of different incentives. Figure 83 orders these incentives (see legend) from highest to lowest according to the proportion of people who say the incentive would make them 'much more likely' to adopt an EV on average across the sample. It also highlights which incentives are most popular for each segment.

Whilst there are statistically significant differences in the attractiveness of the incentives between the segments, the overall ranking of the instruments does not vary greatly between them. For instance, Government grants and extended warranties are clearly the most popular for each group, with the only differences being the almost equal popularity of company car tax discounts for the Company Car Drivers, and the fact that the Plug-in Pioneers and the Willing Pragmatists are more attracted to extended warranties than grants themselves. Given that these are two of the earliest adopters, this may have implications for how the market is stimulated in the early years. The Anxious Aspirers and the Conventional Sceptics are less open to incentives than the Pioneers and the Optimists but have similar levels of incentivisation to each other. This may suggest that, should some of their fears about plug-in vehicles reduce, they could be induced by Government grants towards the adoption of EVs. The Willing Pragmatists and the Uninspired Followers are also relatively more likely to respond to increased petrol and diesel prices – this is consistent with the high importance they attach to fuel economy.

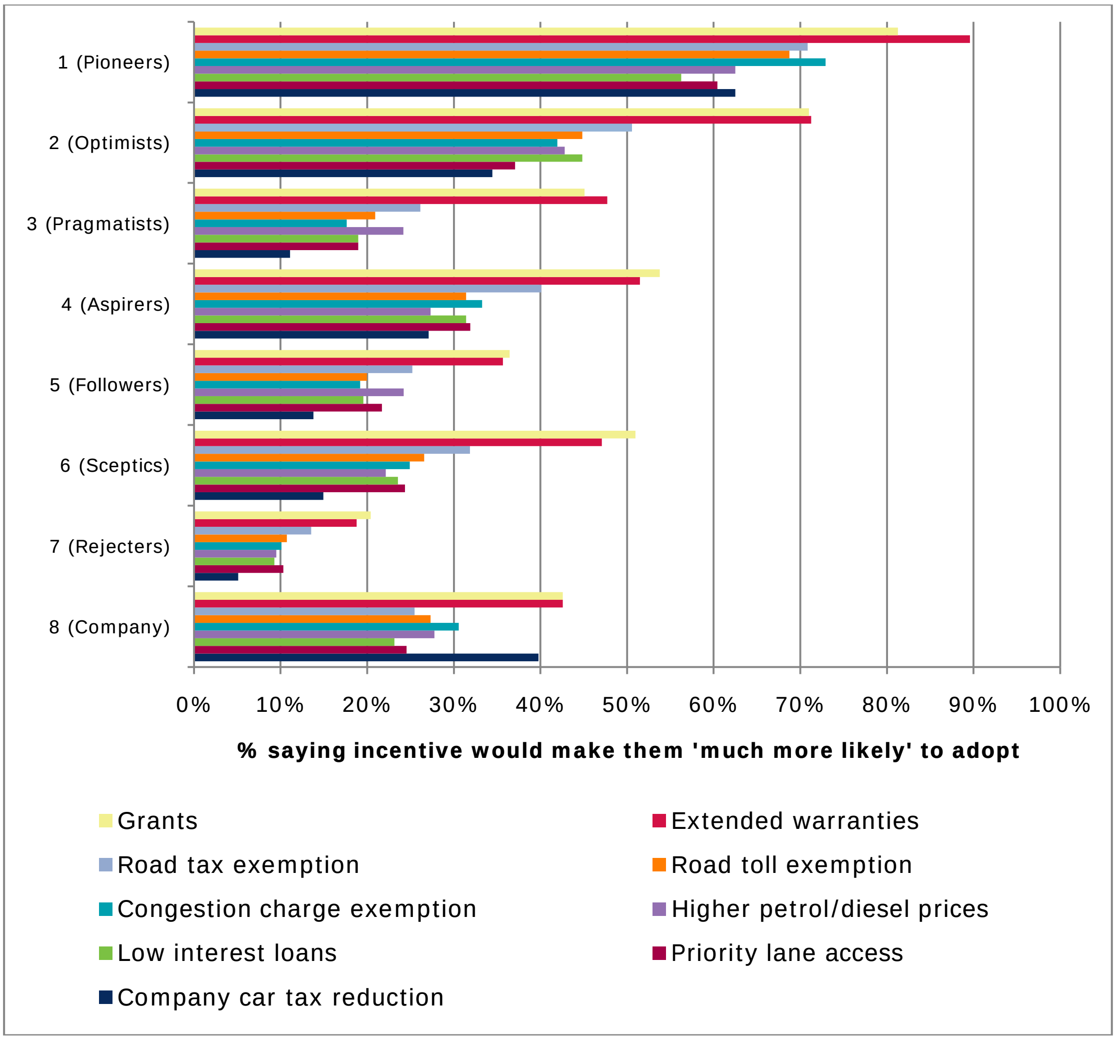


Figure 83: Attractiveness of policy incentives in each segment (N=2,729 (or 1,025 for Company Car tax (workers only))

Interestingly, there is quite a difference between the segments in terms of the proportion of members who had taken advantage of the scrappage scheme when purchasing their last car (where the main car was purchased brand new only). The Plug-in Pioneers, Anxious Aspirers and to some extent the Zealous Optimists seem more open to incentivisation which broadly conforms with Figure 83. Once again, it seems that the Willing Pragmatists are less persuaded generally by policy incentives and, if they have decided something is a good idea, are likely to act regardless. In this case, however, the Willing Pragmatists have a long way to go before they believe that BEVs would suit them.

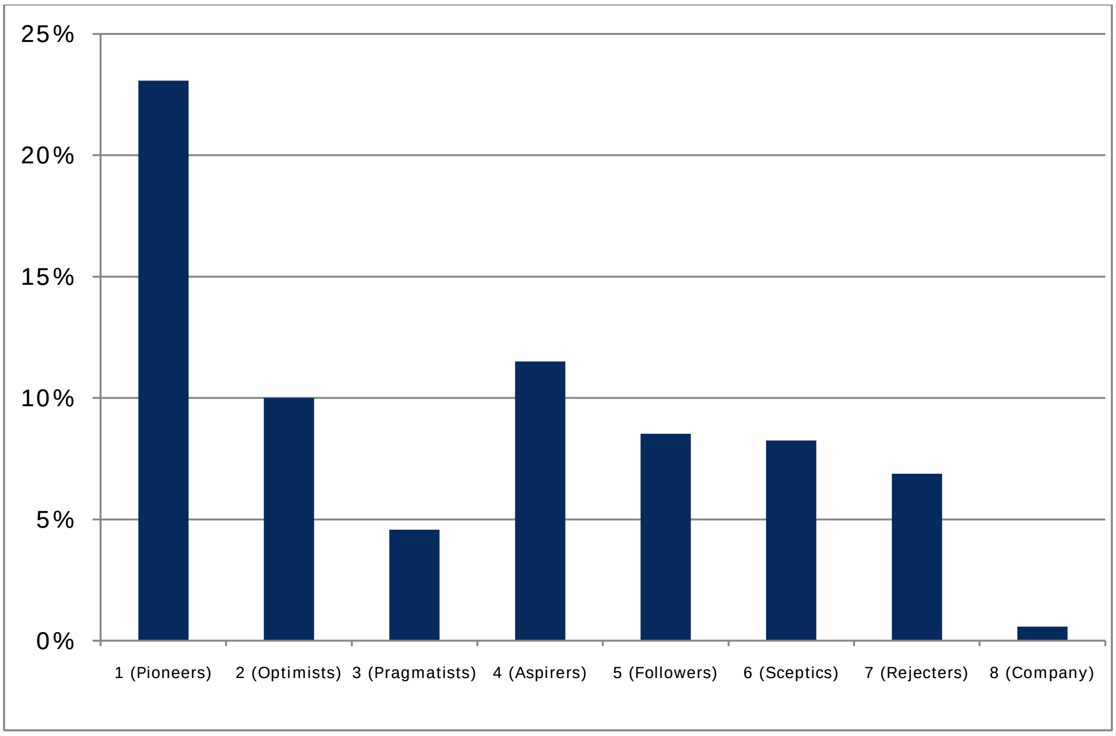


Figure 84: Scrappage Scheme uptake in each segment (N=1,574 (main car = brand new only))

10.2.21.2 Cost of charging

Respondents were asked how the cost of charging would impact on their likelihood of adopting an EV. Figure 85 shows the net likelihood (by subtracting those who say they were much less likely to adopt from those who say they are much more likely) as a result of the cost of electricity in comparison to petrol or diesel to travel an equivalent distance. From this we can conclude that over 50% of *all* segments suggest that they would be much more likely to adopt an EV if electricity from charging points was free. If electricity cost the same as petrol or diesel, those segments who are already least likely to adopt are also those who say they would be even less likely to be attracted to these vehicles, and a minority of even the Plug-in Pioneers could be put off if electricity prices were no less than petrol or diesel. The Image-conscious Rejecters are unlikely to even consider EVs unless electricity is free.

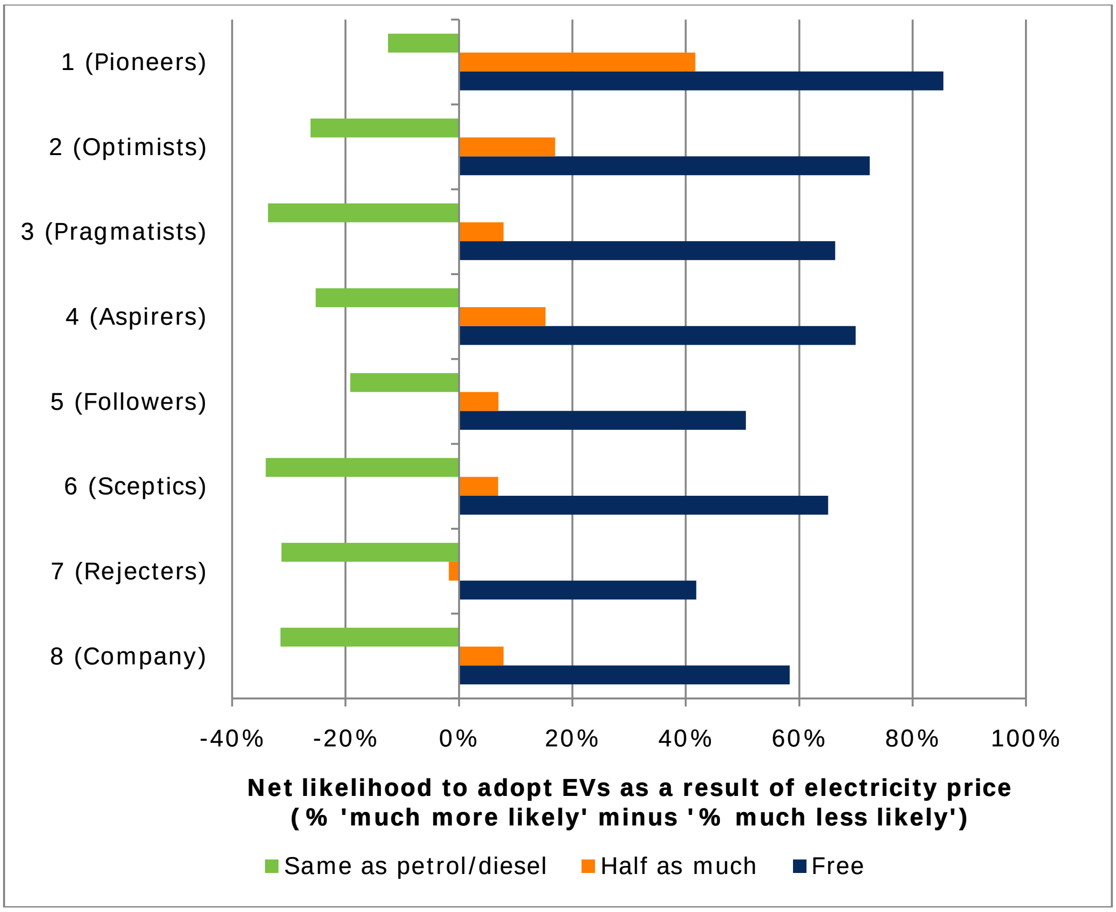


Figure 85: Impact of cost of electricity at charging points on likelihood to adopt (N=2,729)

10.3 Geographical analysis

The segments derived allow us to understand the attitudes held by consumer types that are differentiated by their likelihood to choose a plug-in vehicle. We can use these segments to (proportionately) represent new or nearly new car buyers in the UK population to enable modelling of market uptake of plug-in EVs. To do this, the segments must be associated with an existing measure of UK population data. One way of doing this is by understanding the geographical representation of our respondents and their respective consumer segments across the UK.

This chapter reports on the exploration to determine a link between the consumer segments and a measure that enables their geographical mapping.

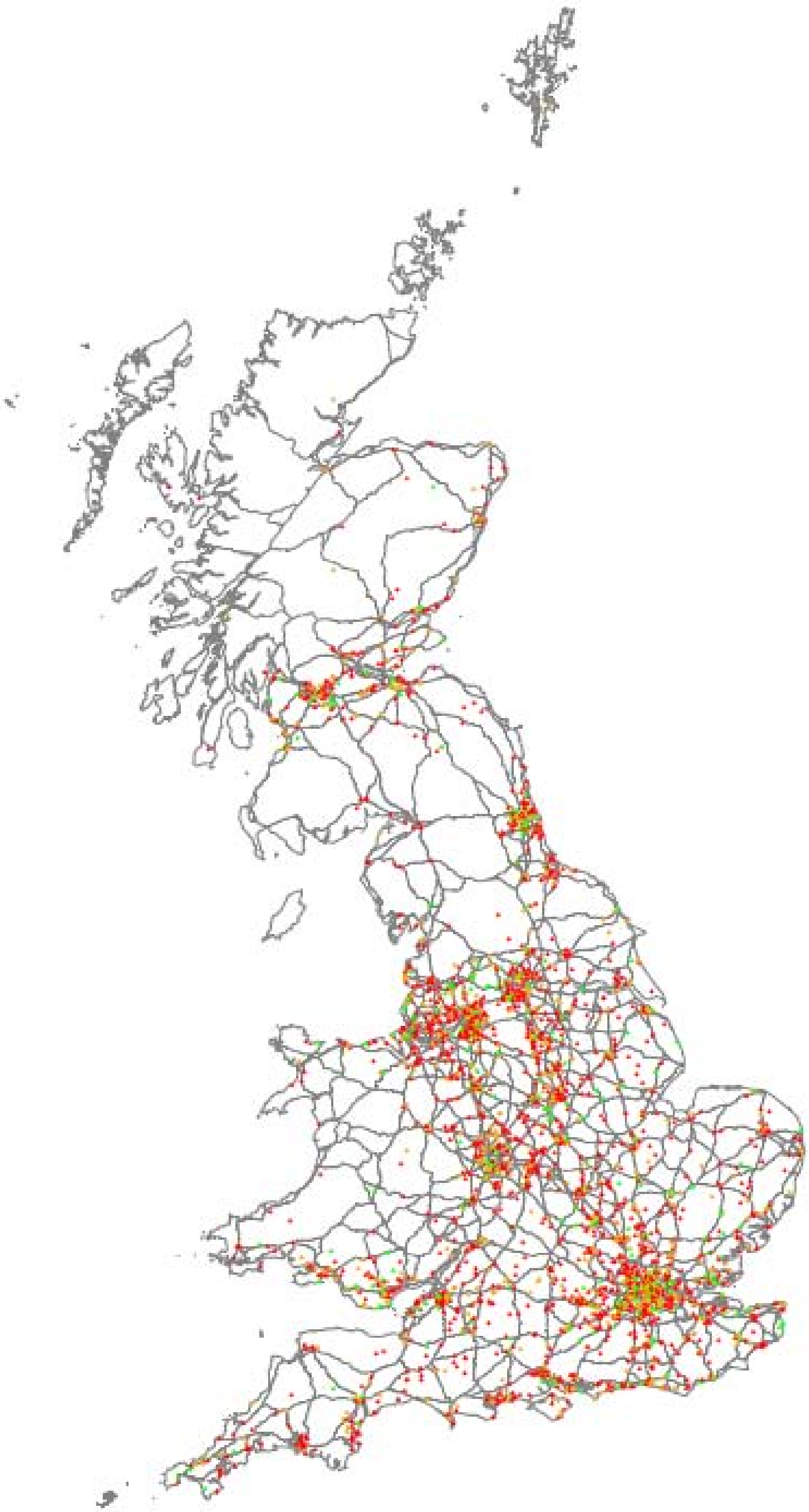
10.3.1 Our Sample

Postcode data obtained from our sample[36] was plotted onto a map of the UK to represent visually the distribution (and clusters) of respondents across the UK. Each respondent's location was averaged across their full postcode and plotted on the map. Each dot therefore represents a single respondent. The map is presented in Figure 86. The following four pages repeat this map but with respondents differentiated to denote their likelihood to choose a BEV or PHEV as a main or second vehicle (see Figure 88 to Figure 90). While it is difficult to draw any significant conclusions from a visual representation of responses, the maps demonstrate the degree of likelihood to adopt a BEV or PHEV across the UK within our sample.

[36] The vast majority of the sample voluntarily entered their postcode when completing the survey. Where postcodes were unidentifiable or missing, some remaining postcodes (n=354) were provided by the survey panel supplier in line with the Data Protection Act 1998.

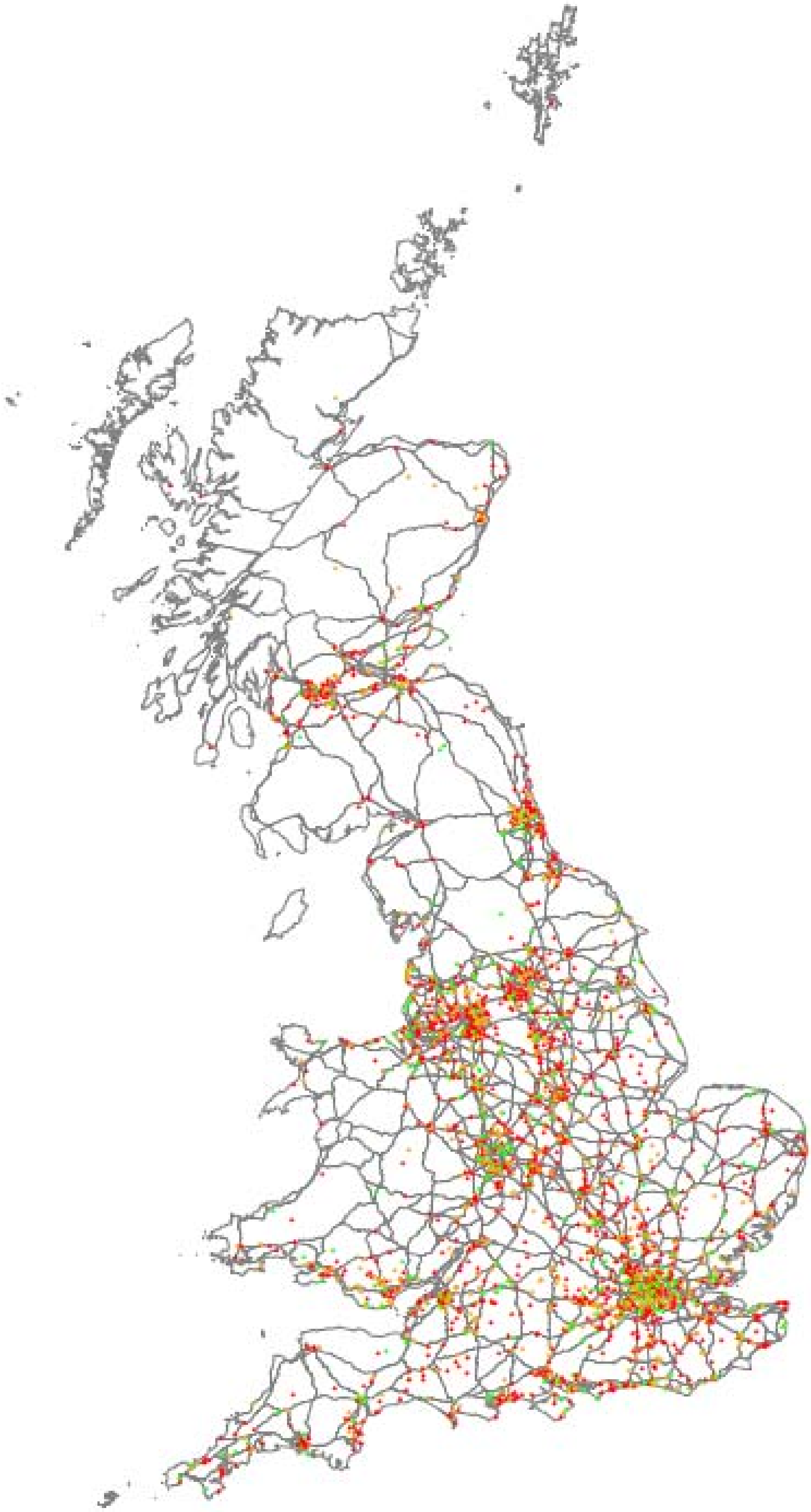
Figure 86: Distribution of survey respondents across the UK (N=2,690)

Note: grey lines represent major UK roads



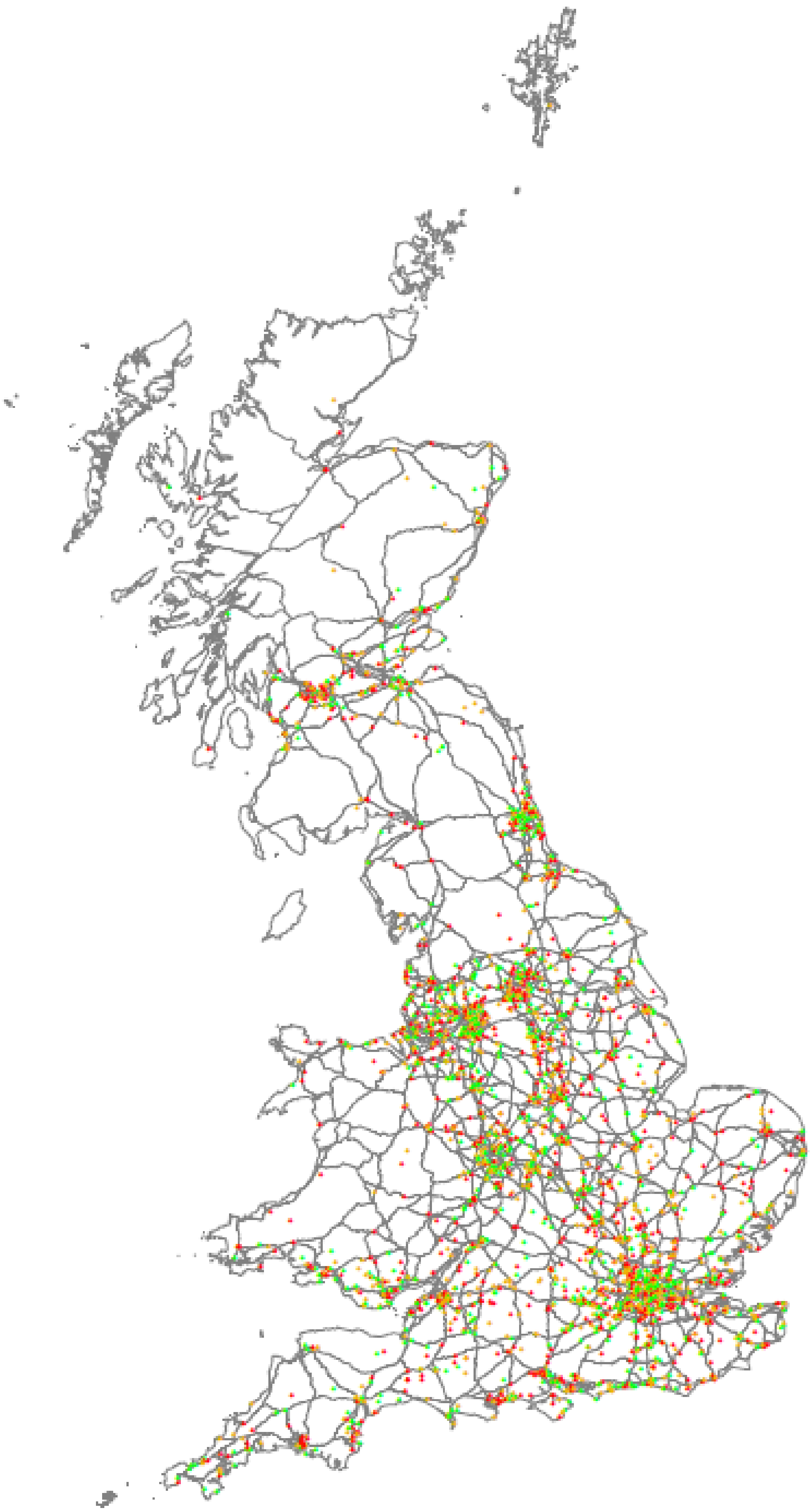
Key: Red = Not at all likely / Fairly unlikely; Orange = Neutral; Green = Fairly likely / Very likely

Figure 87: Distribution map of respondents across the UK by likelihood to choose a BEV as a MAIN car (N=2,690)



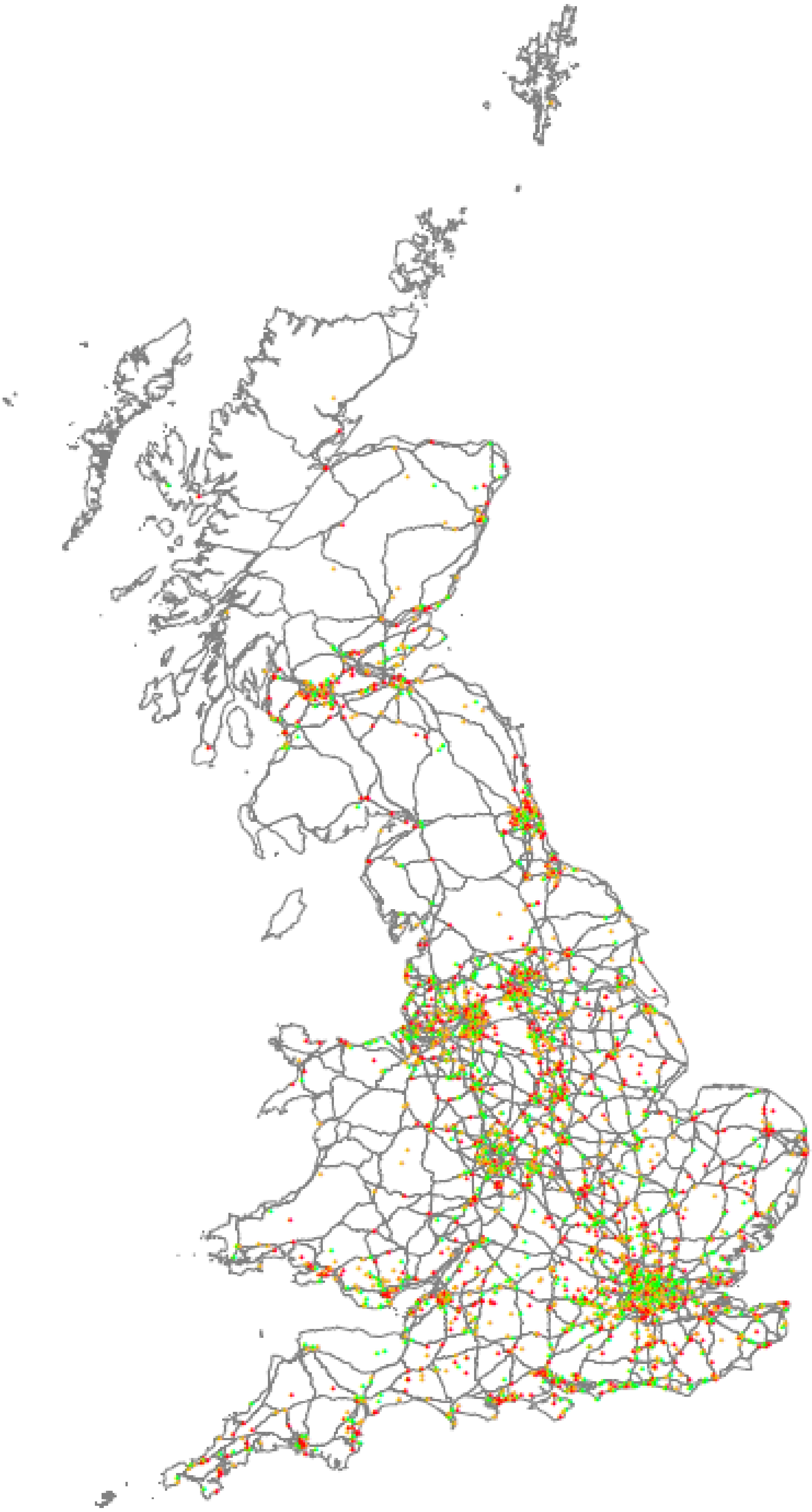
Key: Red = Not at all likely / Fairly unlikely; Orange = Neutral; Green = Fairly likely / Very likely

Figure 88: Distribution map of respondents across the UK by likelihood to choose a BEV as a SECOND car (N = 2,690)



Key: Red=Not at all likely/Fairly unlikely; Orange=Neutral; Green= Fairly likely/Very likely

Figure 89: Distribution map of respondents across the UK by likelihood to choose a PHEV as a MAIN car (N=2,690)



Key: Red=Not at all likely/Fairly unlikely; Orange=Neutral; Green= Fairly likely/Very likely

Figure 90: Distribution map of respondents across the UK by likelihood to choose a PHEV as a SECOND car (N=2,690)

10.3.2 Mosaic UK

Mosaic UK is a classification of UK households developed by Experian. It is a commercially available geodemographic[37] system that creates consumer segments based on household and individual data collected from a variety of sources.

Experian report that a total of 440 data elements were used to build Mosaic UK in 2009 (Experian, 2010a). Much of the information used to build Mosaic UK is sourced from a combination of data that includes Experian's UK Consumerview database; this includes data from the edited Electoral Roll, Council Tax property valuations, house sale prices, self-reported lifestyle surveys and other compiled consumer data[38]. Mosaic UK is also based on 2001 Census data that has been updated with estimated changes. In addition to these forms of classification data, Mosaic UK also incorporates data from media and market research.

Mosaic UK includes 155 person types aggregated into 67 household types and 15 groups, to create a three-tier classification that can be used at the individual, household or postcode level. The current project has focused on the use of the 15 Mosaic groups at postcode level (about 20 properties).

The precise way in which Experian uses the various data to profile consumer segments is not specified. Unfortunately, this means that where there is any association between Mosaic UK and our own consumer segments, it is not possible to fully understand the mechanism mediating this association. It is possible that there are attributes profiled by Mosaic UK that are also profiled in our segmentation (e.g. environmental attitudes) that could inflate the strength of any observed association between the two segmentation sets. Without knowing how the Mosaic UK profiles have been created it cannot be determined whether there is any overlap of variables.

Table 62 compares the percentage of UK households in each Mosaic group, and the percentage of our sample in each Mosaic group. It would be preferable to compare our sample with the propotion of people within each Mosaic group but as this is determined at a household level this is not possible. The sample of new and nearly new car buyers accessed for our survey is not expected to be representative of the whole UK population. Nevertheless, there is a reasonable match in proportions (of Mosaic groups) between the UK population and our sample with the largest difference occurring in Group B, Professional Rewards. Given the nature of our sample (of new and nearly new car buyers) it is unsurprising that those in a category defined as 'executives and managers in their 40's, 50's and 60's' are overrepresented (Experian, 2010a). This comparison suggests that in terms of current Mosaic profiles, there can be confidence that the sample is reasonably representative of the UK population, although obviously biased towards new and nearly-new car buyers.

[37] Geodemographic segmentation is a multivariate statistical classification technique for indentifying if individuals in a given population fall into different groups by making quantitative comparisons of multiple characteristics, with the assumption that the differences within any group should be less than the differences between groups.
[38] More detailed background information can be found at: http://www.experian.co.uk/business-strategies/mosaic-uk-2009.html

Table 62: Comparison of the percentage of the UK households in each Mosaic group with our sample

	Alpha Territory	Professional Rewards	Rural Solitude	Small Town Diversity	Active Retirement	Suburban Mindsets	Careers and Kids	New Homemakers	Ex Council Community	Claimant Cultures	Upper Floor Living	Elderly Needs	Industrial Heritage	Terraced Melting Pot	Liberal Opinions	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Total %
% of UK households	4.3	9.5	4.8	9.2	3.4	13.2	5.3	4.0	10.6	4.5	4.3	4.0	7.4	6.6	8.9	100
% of our sample	4.1	14.7	4.3	10.6	3.7	14.0	8.2	6.4	7.2	2.7	1.7	2.5	8.9	4.4	6.6	100
% dfference*	-0.2	5.2	-0.5	1.4	0.3	0.8	2.9	2.4	-3.4	-1.8	-2.6	-1.5	1.5	-2.2	-2.3	

*red shading denotes less in our sample and green denotes more

As Table 63 and Figure 91 demonstrate, there is not a clear-cut distinction whereby one consumer segment (e.g. Plug-in Pioneers) is largely represented in only one Mosaic group (e.g. professional rewards); there is variation for each segment across all Mosaic groups. Nevertheless, analysis revealed a statistically significant association between our consumer segments and Mosaic groups (see Appendix P). As noted earlier, due to not having knowledge of the data used to create the segmentation of Mosaic groups, it is not possible to determine the precise nature and mechanism of the association. While this is unsatisfactory, it is still possible that the proportion of our segments within each Mosaic group can be used to represent our segments in the UK population with geographic locations at the postal sector level. Table 63 shows the number of respondents in each segment that are classified as members of each Mosaic group based on their postcode and Figure 91 shows the proportion of each segment within each Mosaic group.

Table 63: Number of respondents in each Mosaic group by segment

	Alpha Territory	Professional Rewards	Rural Solitude	Small Town Diversity	Active Retirement	Suburban Mindsets	Careers and Kids	New Homemakers	Ex Council Community	Claimant Cultures	Upper Floor Living	Elderly Needs	Industrial Heritage	Terraced Melting Pot	Liberal Opinions	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Total
Pioneers	3	9	0	5	4	4	3	3	3	0	4	2	0	1	7	48
Optimists	15	60	19	47	11	55	24	21	21	10	3	4	26	14	15	345
Pragmatists	17	67	20	33	14	40	33	14	12	4	5	2	24	11	9	305
Aspirers	16	33	13	33	14	48	19	31	38	23	9	13	52	33	61	436
Followers	20	87	20	60	21	78	29	32	37	9	11	18	53	19	20	514
Sceptics	12	50	16	40	12	56	38	21	27	6	4	9	34	15	20	360
Rejecters	18	63	20	42	18	76	48	32	41	16	9	17	41	23	28	492
Company	11	30	8	27	7	22	29	19	16	4	2	4	10	4	18	211
Total	112	399	116	287	101	379	223	173	195	72	47	69	240	120	178	2,711

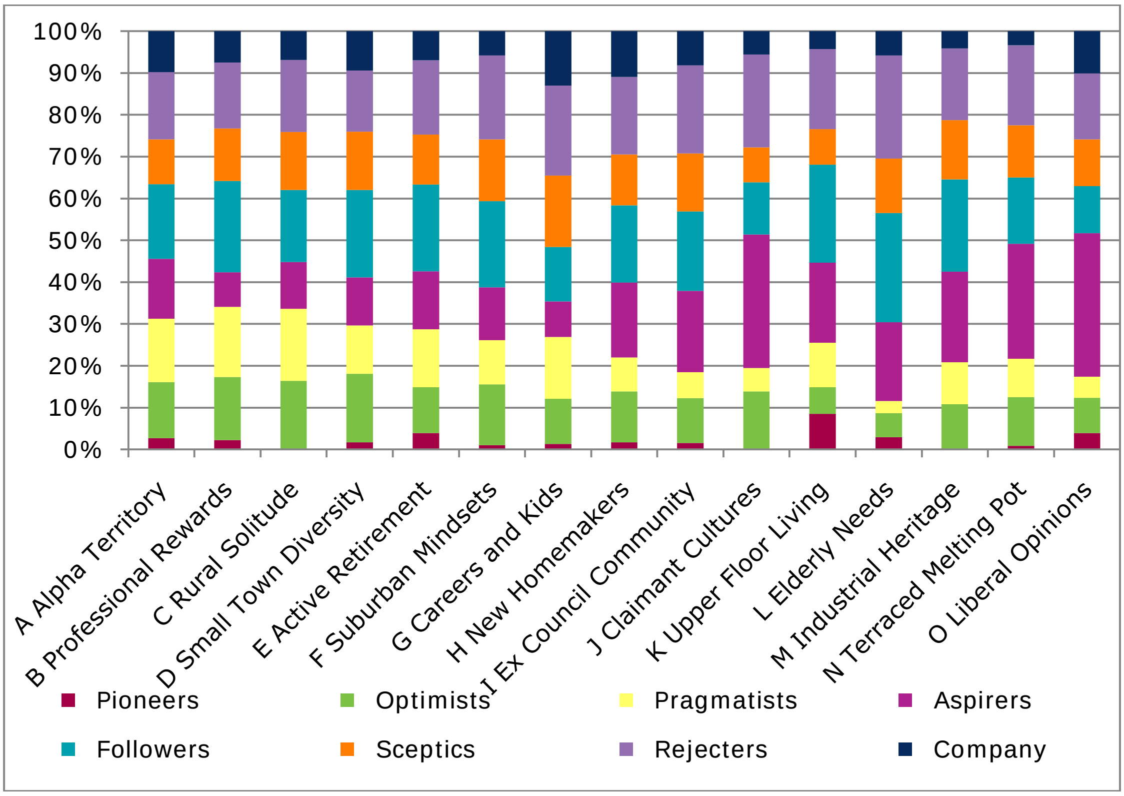


Figure 91: Proportion of each segment within each Mosaic group

10.3.3 Rural/urban classification

Experian developed a classification of 11 types of urbanity in 2004, with the last update released in May 2010. Each of the 11 rural/urban types is derived from a combination of postal sector and output area data. Data relating to density, area, agriculture, occupancy, and daytime population are used to derive the rural/urban segments (see Appendix Q for the full list of input data). Cluster analysis was performed to create the initial segment areas with both postal sectors and output areas allocated to the same classifications to ensure consistency at the two levels of geography (Experian, 2010b).

This classification system differs from Mosaic UK by the data inputted to derive the segments. Mosaic UK includes geographic and population data in addition to social marketing and media data. As noted previously, this type of data could overlap with the data used in the consumer segments derived in the current study (e.g. environmental attitudes). The rural/urban classifications are based only on geographic and population data that are not included in the segmentation of the current study. Again the precise mechanism of any association between our segments and the rural/urban classifications cannot be determined (because we do not have the data used to create the rural/urban classifications). However we can be reasonably confident that the association is not due to ‘double-counting’ of similar measures (like environmental attitudes, as mentioned previously). Table 64 describes each of the 11 rural/urban classifications.

Table 64: Description of Rural/Urban Classes (Experian, 2010b)

Class	Class Label	Class Description
1	Extremely Rural	This type consists of the most rural areas in the country. Population density is very low indeed, and there is high incidence of farming businesses. On average, those that do live here enjoy large houses.
2	Very Rural	Population density is again very low, if to a lesser degree than type 1. Farming is also a popular occupation. Existence of small villages means that a few people journey to these areas to work.
3	Rural	Slightly more accessible than types 1 and 2, there are also a few more people living in these areas. However, the houses are still larger than average and agriculture a popular occupation.
4	Urban/Rural Edge	Areas in type 4 are beginning to be a bit more built up than any of the preceding types, although by no means could be called urban. Typically, they exist either as the very edge of large conurbations, or as villages in their own right.
5	Outer Urban	On average more than twice as densely populated as type 4, this type contains large swathes of suburbia. As a result, daytime population is very small in comparison to residential population, although there are very small centres to attract workers.
6	Mid Urban	This type contains large residential areas of any town or city in the country. Large numbers of people live here, although this type also displays the largest degree of emptying during working hours. Houses are smaller than any of the more rural types, although there is still very low incidence of high or mid rise accommodation.

7	Urban	Although considered more urban than type 6, fewer people actually live in this type. However, existence of regional centres, including some shops, mean that a larger number of people work in these areas during the day. However, these areas are still less urbanised than the really large cities.
8	Inner City Living	This type encompasses many inner city living areas and can be found in nearly all major cities. Population and household density is high, although many people travel to other areas to work, principally the nearby large city centres.
9	City High Rise	As the name implies, these areas are very highly built up, with high incidence of tower blocks. Accommodation is quite often cramped. Such areas are to be found in the very inner parts of major cities.
10	Town and City Centres	This type forms the centre of medium to large cities. Residential population is very low, but daytime population is very large. What residential population exists tends to be in high rise accommodation, and houses or flats are often cramped.
11	Large City Centres	Forming the very centre of only the largest city centres, this type is the most urban of all. As in type 10, daytime population is huge, and what residents there are tend to live in high rise accommodation. London dominates this type.

Table 65 compares the percentage of the UK population above 18 years old in each rural/urban classification against the percentage of our sample within each classification. The largest differences occur in very rural, and outer and mid urban classes. It appears that the sample in the current survey is overrepresented within certain urban classifications but underrepresented in the very rural classification. There are a number of reasons that might account for this, the obvious one being that the current sample represents new and nearly-new car buyers rather than the general population. It may also reflect the nature of the survey methodology whereby an online panel supplier was used, which may not represent rural areas very well given that internet speeds are traditionally weaker in very rural areas.

In line with the UK population there are few respondents from the upper two urban classes: town and city centres, and large city centres. These two classes are only represented by a total of seven participants in the current sample (see Table 66). This is not surprising given the class descriptions note that the residential population in these areas is very low. Respondents in these classes were removed from any further analysis as the sample size was not large enough to be representative. Given the lack of residential living in these areas, it is not considered problematic to the requirements of the research to exclude them from further analysis.

Table 65: Comparison of the percentage of the UK postal sectors in each rural/urban class with our sample

	Extremely Rural	Very rural	Rural	Urban/rural edge	Outer urban	Mid urban	Urban	Inner City Living	City High Rise	Town and city centres	Large city centres	Unclassified	Total %
% of UK population aged 18+ years	4.9	20.9	3.4	9.7	23.1	15.3	11.4	5.8	2.4	0.3	0.1	2.7	100
% of our sample	5.2	10.4	4.4	7.1	32.1	27.0	5.5	5.9	2.2	0.1	0.1	N/A	100
% difference*	0.3	-10.5	1	-2.6	9	11.7	-5.9	0.1	-0.2	-0.2	0		

*red shading denotes less in our sample and green denotes more

The data in Table 66 is shown as a proportion of each segment within each rural/urban classification in Figure 92. It can be seen in Figure 92 that Plug-in Pioneers are mostly represented in the city high rise class, while Aspirers are also more likely to be represented in more urban classifications. Other segments also demonstrate variation across the rural/urban classes. Analysis revealed a significant association between the segments and rural/urban class and it is therefore possible to proportionately map EV consumer types using the rural/urban classification.

Table 66: Number of respondents in each rural/urban classification by segment

	Extremely Rural	Very rural	Rural	Urban/rural edge	Outer urban	Mid urban	Urban	Inner City Living	City High Rise	Town and city centres	Large city centres	Total
Pioneers	1	4	3	6	8	13	2	1	7	0	0	45
Optimists	21	42	14	22	126	83	13	16	6	1	1	345
Pragmatists	24	40	16	30	102	57	18	10	4	2	0	303
Aspirers	14	31	12	19	109	146	26	51	20	0	1	429
Followers	31	50	31	32	163	137	32	18	10	0	1	505
Sceptics	16	37	16	27	118	93	19	21	4	0	0	351
Rejecters	20	47	20	35	166	143	26	24	5	0	0	486
Company	11	27	5	18	65	50	12	17	3	1	0	209
Total	138	278	117	189	857	722	148	158	59	4	3	2,673

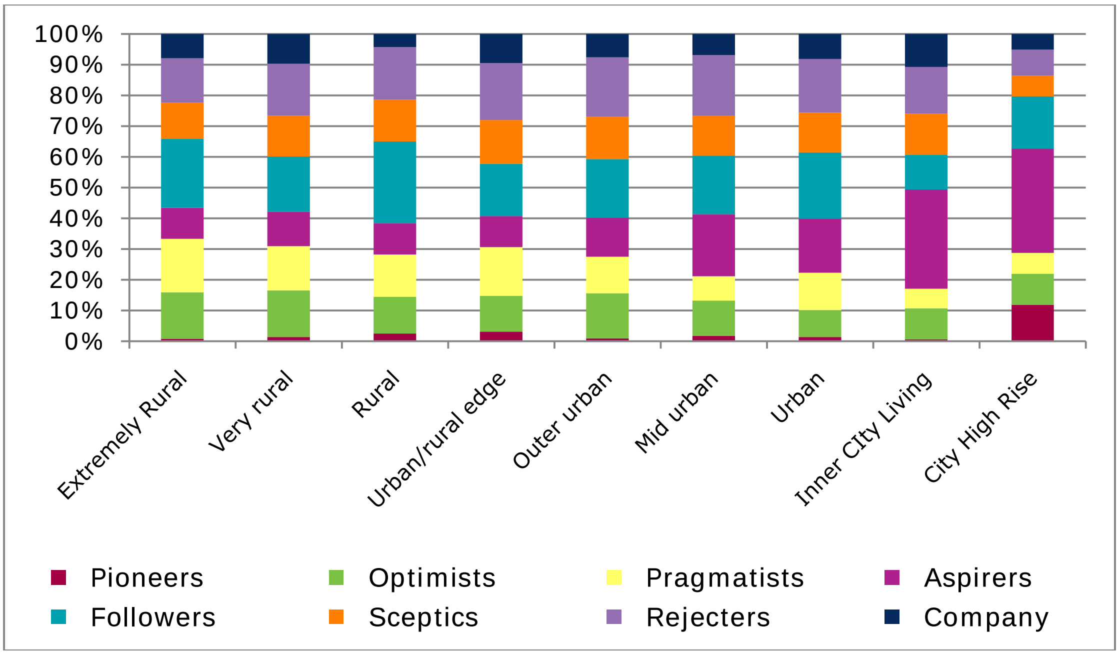


Figure 92: Proportion of segments within each rural/urban classification

10.3.4 Summary of geographical analysis

It is desirable to use the EV consumer segments derived here to be representative of new and nearly-new car buyers in the UK population and to geographically map where these different consumer types live. To do this, it was necessary to map the segments with an existing profile of the UK population that included a geographic determinant. Two types of coded data that could be used were presented: Experian's Mosaic UK and Experian's Rural/Urban Classifications.

Both codes were statistically associated with the segments profiled from the survey and could therefore be used to map EV consumer types across the UK. However there are advantages and disadvantages to using each. Mosaic UK offers a more detailed and refined breakdown of geographical area, by virtue of having a greater number of possible categories and the possibility for greater resolution. In addition, our sample is well represented in all categories and at a similar proportionate level as the UK population. However, it is unknown how much of the association between our data and the Mosaic groups is due to the measurement of similar variables like environmental attitudes, and potentially others. Without knowing this, there will always be doubt regarding the validity of the association.

When considering the rural/urban classification, the sample did not match as well (proportionately) to what would be expected on the UK population as a whole. It is likely that this can be explained by the survey methodology and the resulting sample characteristics (i.e. focusing on people who are active in buying cars). There was also no representation of the most urban categories, although these are largely business areas with low residential populations. However, the rural/urban classification is based on geographical and population-based data only and therefore has less chance of being falsely associated with our segments due to 'double counting'. It is likely that Experian's rural/urban classification data is incorporated within Mosaic group segments and it is interesting to note that despite the additional information used to create Mosaic groups on top of the rural/urban classification data, there is no greater strength in the association with our segments of EV consumers. In short, Mosaic UK appears to add nothing statistically or theoretically to the association with our segmentation provided by the rural/urban classifications.

The fact that there is a precedent for using Mosaic to understand the car market may also be considered an advantage; however one important caveat to this is that what has happened in the car market in the past is not necessarily a guide to the future of EVs. The shift to EVs requires consumers to make a step change in their behaviour with plug-in cars; a change in lifestyle and travel planning. It is notable that the analysis of the relationship between current car types (SMMT segments) and our segments shows a weak relationship, suggesting attitudes towards EVs are cutting across traditional car buyer and car user profiles.

This research has developed a unique segmentation of potential EV consumers and it may be prudent *not* to relate our segments with previous consumer segmentation (Mosaic UK) and instead associate it with more objective geographic, population based data (rural/urban classification). In summary, it is recommended that the rural/urban classification provides a simple and effective dataset with which to map our segments. Switching to a geodemographic classification like Mosaic UK could be considered in the future, but only if a more robust association can be justified.

10.4 Summary of quantitative consumer survey

The initial analysis outlined some largely descriptive results of the questionnaire survey in order to assess the quality of the sample and gain some initial insights into the factors influencing self-reported 'likelihood to adopt' a PHEV or BEV. The unique two-wave split survey design which gave participants information about EVs between each wave has demonstrated that consumer attitudes about EVs, and their self-reported rating of the likelihood to adopt EVs are still being formulated and shaped.

There are strong, internal underlying psychological constructs that exist to capture different anxieties about PHEVs and BEVs, their symbolic meaning, a general openness to the technology, innovativeness and environmental values. When used alongside demographic factors to understand the strongest predictors of the likelihood to adopt, these attitudinal constructs appear to play a stronger role than factors such as income, age or employment status.

Demographic factors such as income, education, gender and employment status proved to be important distinguishing characteristics, but less important than symbolic motivations, perceptions of EV suitability (including range and performance anxieties), willingness to pay for the technology, fuel economy or the environment and 'innovativeness'. Whilst demographic factors are an important profiling variable, the segmentation process has proven invaluable in understanding why people with the same or similar demographic characteristics can behave in very different ways. For instance, the Plug-in Pioneers and the Zealous Optimists appear to typically be higher income males, but have different outlooks in terms of willingness to pay and symbolic motives (the Plug-in Pioneers have a very high WTP and belief in a car saying something about one's identity). Nevertheless, demographic relationships play an important role in understanding life stage and constraints on behaviour such as income or parking availability. However, this survey has shown that segmentation is much richer and more useful where it is able to explain any demographic differences rather than merely describe them.

The next section discusses the results of the consumer segmentation in more detail (and within the context of the literature review and qualitative studies) and draws conclusions. Recommendations for future research are also presented and aim to build on the results of this comprehensive body of work.

CONCLUSIONS AND RECOMMENDATIONS

11 Conclusions

11.1 Previous research

- Overall, studies have found high levels of interest among consumers for EVs, particularly PHEVs, but also a good deal of resistance based on the estimated cost of this new technology. The high price of EVs has been noted as a main barrier to uptake, particularly in modelling evidence based on stated preference experiments. However, consumer responses to the greater price premiums of plug-in vehicles in terms of purchase probabilities is generally greater than can be justified based on purely economic rationale. This means that consumer acceptance is not solely determined by purchase price, but also emotional and other non-economic and functional factors.
- Evidence so far is heavily based on revealed preference research from HEV early adopter segments. A detailed study of expectations around payback periods for EVs has not been explored in the UK context.
- Existing literature is not sufficient to provide an overall understanding of consumer wants, needs and perceptions in relation to EVs.

11.2 Purchase decision making

- It is tempting to conceptualise that consumers will base their purchase decision on the result of conscious cost-benefit analyses by the weighing of economic and utility values. However, the results of the household trial suggest that potential consumers' appraisals are affected by processes which are not easily represented by expectancy-value assessments and, in some cases, may not be readily available to conscious reflection.
- Policy makers and modellers may have a tendency to over-emphasise the importance of rational deliberation of longer term running costs and payback periods. This is set to be exacerbated when fuel costs are subsumed in to electricity bills. Studies in the US show that drivers of PHEVs omitted their grid-based electricity use when discussing fuel economy even though many in-vehicle displays indicated the consumption of both sources of energy. In terms of consumer perception of other costs such as battery replacement costs and resale value, there is little to be gleaned from the literature on these factors.
- Caution must be attached to survey designs which rely on respondents basing decisions on detailed payback period calculations and complex attribute trade-offs. Studies should attempt to gain a better understanding of consumer expectations around electricity prices, maintenance costs and depreciation.
- The evidence suggests it is not the cost of oil *per se* that makes the most difference, but the speed with which prices rise and the relative cost *vis-à-vis* electricity prices.
- Studies should attempt to understand consumer expectations of electricity prices as well as oil prices and the impact of the relative cost differences on car purchasing behaviour.
- The literature is almost entirely dominated by research on private consumers or decision-making processes within fleets which assume 'user choosers'.
- The EV attributes that fleet managers considered to be advantageous over ICEs included environmental, financial and business factors. The most frequently cited advantage was the potential that EVs had to assist fleet managers in meeting their

corporate carbon reduction targets. CO_2 reduction was important to fleet managers across the sample, in some cases it was the most important vehicle attribute of all. From a financial perspective, the lower running and maintenance costs were considered to be advantageous. From the business perspective, interviewees felt that the benefits of EVs over ICEs were twofold; firstly, they had the potential to differentiate organisations from their competitors by being such a new and innovative technology. Secondly, the driving experience of EVs was thought to be preferable from a wellbeing perspective given that EVs offer quiet, responsive driving with automatic transmissions reducing driver workload.

- In terms of barriers to introduction of EVs into fleets, the two most frequently cited were the available range and the availability of infrastructure. These drawbacks were often synonymous with one another, whereby even if range was less of a problem, the lack of available infrastructure would be the main barrier against adoption. The charging process was a further area of concern for the fleet managers within our sample. Many described inadequate parking facilities for the provision of charging infrastructure for their employees, as well as a paucity of publicly available charging points. There was a fear that should EVs need recharging during the working day, the time taken to charge would have a far greater impact on operational efficiency than refuelling at a petrol station would. Feasibility of home charging was also a concern for some fleet managers who felt that they would not be able to incorporate EVs into their fleet if their drivers did not have facilities (such as off-road parking with an electrical power supply) with which to charge.

11.3 Vehicle type

- Experimental and qualitative studies (mainly in the US) have shown that consumers are likely to prefer PHEVs rather than BEVs as most are interested in high fuel economy and extended range provided by blended operation. These studies suggest that the optimal solution is likely to be a range of PHEVs or range-extended EVs (REEVs) which offer various degrees of high fuel economy at a range of prices to appeal to a number of consumer segments.
- Studies need to explore the desire for all-electric range versus various degrees of blended operation. The majority of the literature concentrates on insights gained from current HEV owners or from recent short or medium-length trials of BEVs. Less is known, particularly in the UK context, about consumer expectations and experience of PHEVs or REEVs.

11.4 Incentives

- Despite the proliferation of incentive programs, particularly in the US with respect to HEVs, their efficacy is unclear. Evidence from the US shows consumers are more sensitive to sales tax incentives than income tax incentives, but that neither of these have had a greater impact than rising fuel prices. More recent studies of BEV trials in the UK do not shed light on the role of incentives as these participants have generally not gone through a true purchase process or benefited from fiscal inducements.
- The role of incentives, both fiscal and in the form of other inducements such as electricity tariff structures and parking or HOV (High Occupancy Vehicle) lane benefits, need detailed and thorough examination in the UK context. Particularly uncertain is the point in the decision-making process that fiscal or other incentives are likely to have the most influence on purchasing patterns and the ways in which instruments can be packaged together to have the optimum effect.
- Evidence from the US suggests that HOV lanes could be important, but less important than other incentives and fuel prices, and very dependent on the specific local context including the level of congestion. The higher than average uptake of EVs

in London and the location of people owning these vehicles does suggest that parking incentives and the congestion charge can influence the level of adoption.

- The qualitative research indicated that participants believed that Government-led, financial incentives would be most effective in encouraging purchase. However, it was pointed out that this method was unfair because tax payers would be compensating those that could afford higher priced vehicles and suggested that providing low interest loans could be viewed as more progressive. The idea of leasing rather than purchasing was also mentioned by several participants as a way of overcoming fears of limited battery life and vehicle depreciation.

11.5 EV use

- Some drivers report adopting environmentally-friendly driving styles as a way of adapting to the limitations of their EV.
- Many using the PHEV enjoyed adapting their driving style to increase fuel efficiency either by attempting to keep the vehicle in electric mode and/or using instrumentation feedback to gauge which behaviour resulted in the highest miles per gallon. This emphasises the importance of clear instrumentation that provides good performance and consumption feedback.
- The data suggest technological development and instrumentation improvement should focus on reducing range anxiety. Feeling anxious is, by definition, unpleasant and many of the interviewees highlighted their range anxiety. Even after a week's experience of driving an EV they were concerned about running out of power and being stranded. Other negative emotional responses included embarrassment and a fear of being bullied by other drivers. Manufacturers need to think creatively to challenge these emotionally-salient, negative expectations.
- By contrast, some drivers, and perhaps especially those with lower initial expectations, enjoyed driving EVs. Quietness, ease-of-use, a spacious and practical interior and reasonable top speeds all contributed to a feel-good driving experience for some participants.
- Technological and design advances could enhance the attractiveness of EVs. Enhanced range, increased power (especially at speeds above 30 miles an hour and on inclines) as well as better top speeds were viewed as especially important. Better ergonomic design including personal space was also highlighted. Well-lit, easy-to-understand instrumentation (providing feedback) could also be developed. It was also suggested that the state of battery charge should be reported in 'miles remaining' as opposed to 'percentage remaining' as such a reading would facilitate understanding of how far the car can travel.
- Echoing previous work (Kurani et al., 2008), BEV drivers in particular were concerned by the limited range of the vehicle, which aroused anxiety when driving and prevented many participants from attempting to use BEVs for longer journeys. Many BEV drivers chose not to use in-car facilities (e.g. stereo, electric windows, heating system) to preserve battery power and so maximise range. This may limit the pleasure and comfort that drivers derive from creating a personalised environment through using such facilities in ICE cars (Gardner & Abraham, 2007). Due to 'range anxiety', many drivers may find BEV journeys less enjoyable than those undertaken by ICE cars.

11.6 Infrastructure and charging behaviour

- Previous EV trials show that users are overcautious when planning journeys, typically using less than half of the technical range. One study in Tokyo showed that utilisation increased following the installation of fast charging in the city. The clear consensus in the evidence so far is that consumers will mainly recharge their EVs at home and in workplace car parks and frequent recharging will be the norm, at least at first. Overall there is a positive attitude towards home charging. In the UK, 80% of car owning households use dedicated parking facilities at home (although it is not clear how many of these have an electric point nearby) and, given typical driving patterns, public 'slow' charging points would be of limited value. However, public charging infrastructure will play a vital role in spreading awareness and confidence in the technology.

- An understanding of the symbolic and functional role of public charging infrastructure is urgently required, including the optimum distribution and public expectations of such infrastructure, especially fast charging facilities. Little is known about the proportion of UK workplaces with existing charging facilities and the relationship between household dedicated parking and access to electricity supply. The acceptability and potential impact of varied electricity charging tariffs and controlled/smart charging is another candidate for research.
- Participants' experiences of recharging in our trial were mixed. Although most found recharging easy, several commented that their garages were not set up to recharge at home. Some participants were also concerned about recharging safety and the possibility of vandalism. However, others found recharging preferable to refuelling, enjoying the freedom to choose when to recharge and the financial savings. Access to off-road recharging facilities was an inclusion criterion for this trial. Consequently, new recharging issues may arise in relation to mainstream roll out. For example, since off-street parking in urban areas is limited, it is unclear how night charging can be facilitated for many drivers or how drivers who cannot guarantee parking outside their homes would manage regular recharging.
- Drivers were confident that EVs would be subject to further technological and infrastructural developments and significant price decreases, and most were unwilling to commit to purchasing EVs until sufficient advancements had been made. Underpinning this assumption was the belief that technological developments will continue until EVs match or supersede ICE cars in serving drivers' mobility needs, at equal or less financial cost. This belief is problematic, for two reasons. Firstly, purchase costs are likely to remain relatively high due to the scarcity of materials sourced for lithium ion batteries (Tahil, 2006), which are the current battery choice within many EVs. Secondly, from a policy perspective, investment in EV infrastructure, technology and promotion may cease if drivers are not seen to be willing to use EVs. Promotion campaigns that persuade drivers that the next generation of EVs are 'finished products' may stimulate the market. Extending Government subsidies to incorporate buyback, leasing or scrappage schemes may allay some concerns around depreciation or obsolescence.
- Despite acknowledgement by consumers that their travel patterns do not necessarily require ranges longer than around 50 miles for most journeys, there remains a high premium placed on the option to drive longer distances. Experience of driving these vehicles in trials does not necessarily alleviate these concerns. There is a wide variation in willingness to pay for extra range or devote resources to reducing recharging time.
- A greater understanding of consumer perception and expectation regarding driving range, including willingness to pay for extra range, is required.

11.7 Consumer perceptions of EVs

- In previous research consumers have been found to have generally negative perceptions with regards to alternative vehicles' attributes, especially with regards to performance factors such as acceleration and top speed. Importantly, however, in the findings of a few EV vehicle trials that have been conducted, ratings of EV performance tend to increase once consumers have gained some experience of the vehicles. However, in longer term trials, some studies have shown interest in owning EVs has decreased after a few months due to concerns about range and reliability/maintenance.

- EVs have been found to be associated with meanings such as lower resource consumption, independence from petroleum producers, advanced technology, financial responsibility, saving money, opposing war as well as environmental and/or resource preservation. These symbolic evaluations can relate to the whole vehicle or to more specific functional or financial attributes such as fuel economy. Consumers then infer connotations to these meanings such as 'behaving ethically', 'concern for others', 'being intelligent' or 'unique' and if these relate to self identities and values, they will be expressed through adoption of EVs. For some consumer segments, symbolic factors are likely to play as strong a role as economic or functional attributes.
- Amongst participants in our household trial there was considerable individual variation in EV evaluation. The data suggest that age, 'green' identity and average journey length may influence potential users' responses to EVs.
- Users find that the limited range, acceleration and speed of EVs mean that they are practical for short, urban journeys on low-speed roads. This characterisation, combined with high initial purchase costs means that they are viewed primarily as second cars for well-off environmentally-aware households.
- Enhanced range, increased power (especially at speeds above 30 miles an hour and on inclines) as well as a better top speed were viewed as especially important attributes. Better ergonomic design, including personal space and clear instrumentation, was also highlighted.
- Long term users' recognition of the benefits of EVs include the longer-term financial savings, the identity benefits of being seen to be protecting the environment and, for many, an acceptable and even enjoyable driving experience for short, urban trips. In addition, users were aware of a series of cost and effort savings in maintaining EVs (compared to fuel-driven cars).
- Poor knowledge and understanding can result in confusion and frustration which inhibits positive evaluations and purchase intentions. Confusion shapes evaluation negatively. This is especially relevant to PHEV usage. Many participants experienced confusion because they did not understand the technology or the daily energy usage of the PHEV used in our trial. This typically led to negative appraisals of the technology more generally. Clarification of how the technology works through media exposure and development of better instrumentation for drivers appear to be major challenges for PHEV manufacturers.
- Some misperceptions were based on a lack of information such as a fear of rain because "water and electricity do not mix well". Another misperception was that there is no need to recharge a PHEV because it can recharge itself whilst cruising.
- A wealth of research indicates that vehicle ownership can be a valued source of positive affect and self-esteem (Steg, 2005). Cars are often used as symbols of social status, power and identity, often based on their visual appeal (Jensen, 1999; Steg et al., 2001). However, in our trial, EVs were experienced as affectively uninspiring, or 'soulless'.
- In the absence of positive imagery and in light of limited functionality, the BEV was seen to represent a lack of power and a substandard performance, and drivers found it embarrassing to be associated with these vehicles. These findings highlight the importance of anticipating negative views towards BEVs, and countering these through positive and aspirational imagery, so as to create social norms of acceptance and desirability.

- For some drivers, using EVs was a source of positive social identity and pride because it emphasised a commitment to sustainable energy use and care for the environment. For others, the same identity connotations were negatively perceived. In particular, BEV drivers motivated by environmental concern were viewed disparagingly, because they were seen to irrationally compromise their personal mobility for the purpose of the environment.

11.8 Environmental considerations

- There is debate over the extent to which adopters of EVs have or will have above average environmental awareness. It seems that some consumers would be prepared to pay more to drive cleaner or zero emission vehicles, but this often relies on the idea that the alternative vehicles can match conventional types in performance.
- While some drivers derived pleasure from cutting their carbon emissions, others were sceptical about the net environmental benefits of using electricity to power cars. Underlying this belief was the assumption that carbon emissions generated at source are as harmful as those from the exhaust pipe.
- Environmental concerns were not prioritised by most of our participants. However, pro-environmental behaviour need not be prompted only by environmental concern. In line with past research (Kurani et al., 2008), we found that some PHEV drivers ‘played a game’ whereby they drove under 30mph where possible, to prevent the vehicle drivetrain switching from electricity to ICE.
- So called ‘rebound’ effects may be relevant to consideration of EV adoption. Such effects can arise when the energy efficiency of products results in increased use which eliminates potential energy savings (Plepys, 2002). A recent study found that drivers who perceived their cars as being an environmentally-friendly ‘eco-car’ drove 1.64 times further than those that did not perceive their car as an ‘eco-car’ (Fujii, 2010). This effect was most noticeable for those who felt that ‘eco-cars’ could solve environmental problems. Further research is needed to explore how to communicate energy savings without stimulating greater consumption.
- Reduced noise pollution can be viewed as an advantage of EV use but it is also seen as a safety hazard because pedestrians used to responding to the sound of cars do not respond to the approach of an EV.

11.9 Consumer types

- Literature suggests that the early adopter and innovator segments combined are typically thought to represent ca. 15% of the market. However, analysis of the most recent purchasers of HEVs suggests that the early adopter segment is itself heterogeneous, particularly in terms of the motivations for purchasing these vehicles. For instance, whilst they appear to be willing to pay a premium for their purchase and many may not even compare the price difference with conventional vehicles, most groups can justify their purchase on a variety of economic grounds. These include being less dependent on volatile oil prices, cash flow considerations rather than detailed payback calculations, and the high value placed on saving time refuelling and possibly parking or driving in HOV and bus lanes. Only a very small proportion is purely environmentally motivated. There is likely to be an equally diverse set of consumer segments within the early majority market.
- Evidence from previous research suggests that current EV and HEV owners are more willing to pay for extended range or be enthusiastic about the adoption of EVs. They are also wealthier, from multi-car households and are willing to pay a higher price premium for a variety of reasons including altruism, bragging rights and a sense of economic ‘saviness’, particularly due to the importance of fuel economy benefitting their often greater than average driving distances. However, whilst it is likely that the

early entrants to the EV market may have similar characteristics, the mainstream consumer will be less preoccupied with running costs. In addition, whilst early adopters will recommend the technology to the early majority, they will need continual improvement in the technology for it to be attractive.

- Eight distinct segments have been discovered in the current research from a large sample of the UK new and nearly-new car buying population. Each of these represents a unique combination of self-reported likelihood to adopt a BEV or PHEV and differ in terms of perceptions, anxieties and symbolic motives. Profiling the segments on these variables has enabled a deeper understanding of the underlying belief structures and motivations of each group. The process has also distinguished between people who may have relatively similar *current* behavioural patterns, demographic characteristics and even similar expressions of likelihood to adopt EVs, but seem likely to *respond* to different stimuli in relation to EV adoption.
- Overall the analysis has identified more than one early adopter group distinguished by their level of enthusiasm towards different plug-in vehicles. While the **Plug-in Pioneers** are likely to lead the way, the **Zealous Optimists** are particularly enthusiastic about BEVs and the other, the **Willing Pragmatists**, are extremely negative about BEVs, but very keen on PHEVs. In addition, their motivations are different with the Zealous Optimists attaching much importance to symbolic meanings such as environmental benefits and the potential to be less dependent on oil (as a society and as an individual), whereas the Willing Pragmatists are more focused on fuel economy savings. A further group is perhaps somewhat surprisingly the **Company Car** owners who are highly innovative and informed about the vehicles and recognise many benefits in the technology. EVs may be considered as household cars rather than for work-related use, but some concerns about image and performance still need to be addressed. In any case, the results show that it will be necessary to capture the diversity in consumer preference at any one point in time and consider the option that many different configurations of EVs may have to be offered to appeal to different segments of car buyers.
- The results also suggest there may be more than one mainstream or laggard group, but with differing potential for uptake to be accelerated so that they become earlier adopters. For instance, the **Anxious Aspirers** have some real constraints and perceived constraints (e.g. parking and range respectively) on the suitability of plug-in technology for them. This group demonstrates archetypal concerns around range anxiety, reliability and performance of plug-in vehicles. Nevertheless, they remain positive about many aspects and, subject to affordability, may be a target for focused information and trials/demonstrators to directly address these concerns. In addition, perhaps somewhat counter-intuitively, another group appears to be more of a laggard *now* but has the potential to become an earlier adopter if concerns can be alleviated: the **Conventional Sceptics**. This group appears to be less motivated by image and identity than some other groups and this presents an opportunity to target them with information about functional attributes of EVs. However, environmental performance is not a motivator for this group and there are large obstacles such as their willingness to pay for fuel savings. However, despite their potential, both of these groups are likely to be very vulnerable to negative ‘press’ and continual improvements in the technology and charging infrastructure availability will be necessary for them to move from potential to actual adopters. The **Uninspired Followers** are likely to represent those influenced by general trends in the market and their likelihood to adopt will be influenced by the adoption rates of other consumer groups.
- The most negative group, the **Image-conscious Rejecters**, clearly present a challenge in this market place. They are resolutely negative about all aspects of the technology and this is coupled with a strong desire to project the ‘right image’, yet EVs are not deemed to fit in to this at all. For this group to become interested, their main opinion formers would have to become convinced of the positive aspects of EVs

at which stage a 'tipping point' could occur. This is not impossible, but it is unlikely to happen without using information from studies such as this one to understand the diffusion of social innovations and the potential to influence the dynamic nature of human preferences.

- What is clear is that plug-in vehicles are seen as far from 'normal' and require a step change in the decision processes people use around car adoption at the individual and household levels. For some, this novelty is a positive force, but other segments are demanding similar refuelling and driving experiences to conventional vehicles. Even the most enthusiastic groups indicate some desire to wait for more choice in the market or the safety net of rapid charging capability. Further work needs to explore this notion of 'normality' and the preparedness to change aspects of lifestyle and the way a car is used rather than a more simple focus on the degree to which EVs can be matched to current lifestyles and preferences. This can only be investigated through further research which focuses on longitudinal processes of attitudinal and behavioural change. These segments are an invaluable starting point for testing a whole range of issues relating to how people may respond to information, incentives, technology development, experience and the broader social and economic context.

11.10 Personality

- Innovativeness reflects the degree to which an individual makes innovative decisions independently of the communicated experience of others and, when combined with product knowledge, are powerful individual attributes on which to segment consumers. Narcissism (individuals who see themselves, and who want others to see them, as special or superior) is also hypothesised to be associated with greater interest in the symbolic rather than the functional value of products in the context of EVs. Driving an EV has also been found to be associated with high openness, high conscientiousness and high agreeableness.
- The **Plug-in Pioneers** in our survey have a distinct personality profile signalling higher openness, conscientiousness, extraversion and agreeableness, and lower in neuroticism, than the overall sample and each of the other segments. However, most of the remaining segments differed to only a modest extent on the five personality domains.

11.11 Influences on uptake

- Increased market penetration will alter the way in which consumers value EVs and choose among them. There is a tendency for consumer preferences to change as technology becomes more prevalent in the market due to the changes in social concerns, increased credibility and learning from others with more experience as well as marketing, education and shifts in social norms. A consumer may want to have a critical mass of companion owners in order to guarantee reliability and repair capability at many locations and may want to have a sufficient choice of makes and models available to them. A study of market data in the US found that different models of HEV had different patterns of diffusion and this was attributed to different signals of quality across different models fuelled by media stories and word of mouth.
- The aesthetics of EVs were seen as a barrier to purchase by some in our household trial which is likely to be overcome as more manufacturers and models enter the market.
- Potential purchasers perceive a variety of barriers to adoption, including limited range, relatively poor performance, restricted accommodation (especially reduced boot space), unattractive appearance, recharging time, lack of public recharging infrastructure, safety, a lack of servicing/maintenance support and the relatively high initial purchase cost.

- However, participants also acknowledged the potential benefits for society including reduced CO_2 emissions, cleaner air and reduced noise pollution (although this is also associated with safety concerns).
- Individual benefits encouraging adoption were also recognised. These included lower running costs and the convenience of home recharging compared to refuelling at petrol stations.
- The thematic content analysis suggests that people who are currently buying and leasing new or relatively new vehicles could be persuaded to view EVs positively. However, for most potential consumers, combinations of perceived disadvantages and especially limited range, poor publicly-available charging infrastructure and relatively long charging (i.e. refuelling) times combined with relatively high purchase prices will discourage them from buying electric in the short term.
- There was no clear evidence that exposure to an EV increased people's purchase intentions but involvement in the trial encouraged many participants to consider possible future purchase, once specific barriers had been removed and the technology had advanced.
- The symbolic meaning of cars and their capacity to project drivers' identities is important to potential consumers and especially important to some. For some participants, use of an EV is a source of positive social identity and pride emphasising their commitment to sustainable energy use and care of the environment. For others, the same identity connotations are construed negatively (e.g. 'tree hugger cars'). For these drivers, EVs may fail to project valued driver images implying wealth, taste, power and success and this may be decisive in purchasing decisions.
- EVs in general represent 'work in progress' rather than cars ready for mass market promotion. Drivers' evaluations of EVs were strongly influenced by comparisons with ICE vehicles.
- The importance of monetary costs to drivers is well documented (e.g. Jakobsson, Fujii & Gärling, 2002), and drivers strive to minimise costs regardless of personal income (Gardner & Abraham, 2007). Unsurprisingly, we found cost minimisation to be important to EV participants. While low running costs were acknowledged, most voiced concern about the more salient price of purchasing an EV. Uncertainties about EV durability, and maintenance and servicing costs, led many to doubt that EV purchase costs would realistically be offset by lower running costs. Marketing campaigns should emphasise to consumers the economic benefits of EVs, such as the availability of Government subsidies to reduce purchase cost. Likely increases in petrol prices may also shift future payoff perceptions. Previous research into cognitive representations of driving costs has shown that drivers typically discount less salient costs (Gardner & Abraham, 2007). There may therefore be potential to redistribute rather than reduce costs.
- In agreement with previous work (Gardner & Abraham, 2007), environmental benefits of EVs were not highly valued by most drivers in this trial. Rather, the utility of EVs was primarily evaluated in light of whether they could meet personal mobility needs to the same extent as do ICE cars. Previous work has shown that drivers value (ICE) cars for achieving both utilitarian goals, such as minimising travel times and physical effort involved in making journeys, and positive affective experiences arising from independence, autonomy and a personalised space (Mann & Abraham, 2006). Our participants lacked confidence in the utility of EVs for achieving these goals.

11.12 Limitations

- Limitations of our study should be acknowledged. Vehicle trials provide drivers with the opportunity to gain first-hand experience of using EV (Kurani et al., 2008), but a seven-day trial may not be sufficient to reflect responses to EVs following longer periods of use. For example, our participants experienced difficulty in adapting to driving an EV, and refuelling procedures were viewed as inconvenient. Many drivers have ingrained ICE use habits and routines (Aarts, Verplanken, & van Knippenberg, 1998). Changing these habits requires conscious forethought and planning, which can take time and may be experienced as stressful while new routines are being established. Over time however, drivers are likely to adjust to these new routines, such that new EV-based habits develop and driving and refuelling become less cognitively effortful (Lally, Wardle & Gardner, in press). Such adjustment is likely to require longer than a week (Lally, van Jaarsveld, Potts & Wardle, 2010). Interim data from a recent trial of 25 electric vehicles that were fitted with GPS and data loggers suggested that EV drivers adapt to their vehicles, becoming willing to drive longer distances, and adopting habitual recharging behaviours similar to how they may recharge a mobile phone or laptop (CABLED, 2010). Additionally, due to the short exposure time many challenges such as exploring public infrastructure, or recharging at friends and family homes were not, or only rarely, encountered. Our findings may therefore reflect only initial concerns about EV use, which may diminish over longer periods. Nonetheless, in so doing, our data may capture important first-impressions among ICE drivers. More longitudinal research is, however, needed to understand reactions and possible psychological adaptations to EVs over extended periods.

- Our sample for the household trial may not adequately represent mainstream consumers, because participants were drawn from a pool of drivers interested in participating in transport research. However, this subgroup may be an important target group for EV promotion, given that they use their cars frequently and are interested in driving.
- We were only able to interview one person per household. It would have been interesting to observe differing perspectives and debates that may contribute to household vehicle purchases. Finally, the vehicle size and specification often did not match the participants' own vehicle size and specification. Thus the EVs were often being evaluated in direct comparison to quite a different car type. For example, a Mitsubishi iMiEV may be viewed less positively when compared to a BMW 3-series car, regardless of electric versus liquid-fuel contrasts. It would have been preferable to have matched vehicle size and power as this may have resulted in more realistic comparisons and more favourable evaluations.
- In the quantitative survey, the assumption that the sample is representative of the population of UK new and nearly new car buyers has not been validated against any existing measure.
- Information regarding EVs given to participants at the end of the wave one data collection in the quantitative survey was brief, and it is also possible that not all participants read the information in full. There was also no control over any further sources of information that participants may have accessed.
- The analysis of the survey data represents a snap shot of the market at an early stage, and future analyses based on a more mature market may be necessary to gain a more comprehensive understanding of some issues.

12 Recommendations

Research of the potential development of the EV consumer market outlined in this report represents a much more in depth and finer grained understanding of the market place for plug-in vehicles than is typical of the literature in this area. Nevertheless, it is based on cross-sectional analysis and is therefore just a snapshot of current attitudes and behaviours, albeit with some indications of attitudinal and behavioural trajectories. Although grounded in theory and prior qualitative investigation, the consumer segments in particular have been derived statistically and need to be tested on different samples with a variety of research methodologies in order to validate them and allow even richer profiling to take place. In light of the above, the following areas have been identified as beneficial for further investigation.

Longitudinal research

Consumer preferences cannot be considered to be static, particularly over the longer term. It is likely that increased market penetration will alter the way in which consumers value EVs and choose among them. It will be necessary to investigate key questions about how consumers will respond to information, experience, media coverage and social influence in order to maximise the utility of the segments. Key questions remain about how people are likely to change (from one segment to another or through the creation of entirely new segments). How do different segments react when they are exposed to real vehicles and experience as opposed to just information about them? How much more effective is targeted as opposed to generic information? How will the symbolic meanings of EVs develop and how does this impact on social learning and the diffusion of preferences and behaviour? Do people respond in the ways that can be expected from the data or are preferences changing too rapidly? What are the secondary impacts of EVs in terms of travel patterns, driving behaviour and car ownership? What are the responses in 'real time' to increased fuel prices, media coverage, and infrastructure development?

All of these questions require some form of longitudinal analysis that would benefit from the use of the 'golden questions' in order to be able select respondents and further the understanding of the segments over time. It would also benefit from the development of a well-incentivised and large-scale panel of respondents that could be used as a test-bed for all the issues outlined in this section. This may also allow easier designing in of comparison groups within studies.

Replication of the segments and 'golden questions'

In order for this segmentation model to be used beyond the lifetime of this project and be tested and developed in the next phase, the segments must be replicable using a consistent methodology. Future research should re-analyse the data with the goal of identifying the method which achieves the highest rate of accuracy with an agreed number of questions. Distinct sets of guidance will be required for use in qualitative and quantitative applications. Replicating the segments in quantitative datasets requires a high level of accuracy, and therefore a probabilistic solution, based on an algorithm. Running such an algorithm results in all respondents being allocated to a unique segment. The algorithm is based on responses to a fixed number of questions, being those which discriminate best between the segments (and thus these tend to be known as 'golden questions'). These questions may be the same needed by researchers in order to recruit to the segments in 'real time' (or as near to that as is possible) for recruitment of participants to qualitative work or for EV trials.

Travel patterns, driving style and car ownership

We still lack understanding of the relationship between current travel patterns and consumer perceptions and preferences towards EVs. For instance, might people have to change their lifestyle in order to adopt EVs or will people have to delay adoption if they want a BEV to fit in to their lifestyle? To what extent are EVs more conducive to adoption as a second vehicle? Connected to this is an understanding of how the adoption of a plug-in vehicle alters people's travel horizons, journey planning, driving style and even their uptake of vehicles. The reduced cost per kilometre travelled and the assuaging of environmental guilt could encourage greater car use. EVs are likely to be equipped with driver displays of fuel economy and state of battery charge. The question is whether people will use EVs differently to conventional vehicles? People could tend to switch from already small/fuel efficient cars to a new hybrid car and car ownership could increase if people adopt an EV without disposing of an already owned vehicle or because the availability of EVs could make acquisition of a car attractive for the first time.

These responses may be different for different segments and require further investigation.

Household decision making

Research in this area is overwhelmingly focused on individual perceptions and decision making. Yet car ownership and use are often household-level decisions. It is likely that households will adopt a multi-car solution to optimise range and recharging time. More understanding is required of what happens when an EV is introduced into a multi-car household. Does it compete with other cars for use on short journeys? How does the 'negotiation' of who uses which car in the household change? Is there a net increase at a household level of the number of trips carried out by car?

Symbolism

The results of this research have suggested that the symbolic meanings attached to EVs are potentially more important than economic considerations for some groups of consumers, but are still being formulated. It is possible that symbolic motivations may be a factor in 'tipping' people from one segment to another or turning a segment from an EV 'rejecter' or laggard into a mainstream consumer segment. The meanings themselves and their propensity to influence and fluctuate needs in-depth investigation at regular intervals in the early stages of the market. Other studies have found EVs to be associated with meanings such as lower resource consumption, independence from petroleum producers, advanced technology, financial responsibility, saving money, opposing war as well as environmental and/or resource preservation. These symbolic evaluations can relate to the whole vehicle or to more specific functional or financial attributes such as fuel economy. Environmental issues are themselves complex as the environmental performance of EVs is itself related to the carbon intensity of the electricity grid which may or may not be uppermost in people's minds when they are considering these issues. Although this study probed on these issues and found some important effects, there is scope for much deeper investigation using both qualitative and quantitative techniques.

Affect

Participants in all studies were generally found to have negative perceptions of alternative vehicles' performance attributes (although some consumer segments were more positive than others). However, how people perceive of and construe 'performance' is not well understood. Even more poorly understood are notions of the 'driver experience' and the emotional or affective reactions experienced when driving an EV. Affective motives did not appear to factor strongly in the definition of the segments or the uptake of EVs in this study, despite being known to be an overriding factor for some in the travel choices they make. It is likely that this motive was not probed adequately enough in this study due to a lack of prior in-depth understanding as to the issues. Thus, it is recommended that further research investigates the emotional responses to driving the vehicles once consumers have had direct, hands on experience. It may be that for some segments it will be worth emphasising the positive driving experience of EVs in order to stimulate interest in these vehicles.

The impact of the media and marketing

Segmentation is a tool widely used in commercial marketing in order to design targeted marketing campaigns. The effect that the media might have on each consumer segment needs to be tested. As a related issue, there is a need to understand which media sources consumers in each segment are currently paying attention to and what impact media messages are having on their perceptions and intention to adopt EVs.

Interpersonal and dynamic influences

There is a tendency for consumer preferences to change as technology becomes more prevalent in the market due to the changes in social concerns, increased credibility and learning from others with more experience as well as marketing, education and shifts in social norms. A consumer may want to have a critical mass of companion owners in order to guarantee reliability and repair capability at many locations and may want to have a sufficient choice of makes and models available to them. One of the strongest influences on uptake may be a ‘neighbour effect’ as EVs become more widespread and consumers become influenced by others and more confident in the technology. Familiarity penalties and ‘spillover’ effects are also potentially useful parameters to include in the modelling of EV uptake. However, these questions remain empirical ones and require further understanding in relation to how the consumer segments are likely to develop over time.

Response to policy incentives

Although indications of the relative ranking of policy instruments were measured in this study, the degree to which different policy incentives are likely to accelerate uptake of EVs as opposed to appealing to those segments who are already contemplating ownership requires further understanding. To study this would not require exclusive reliance on techniques using stated preference as there are current developments in the market place worthy of investigation. These include consumer responses to recent increases in fuel costs and an investigation (in relation to the segments for example) of who is taking advantage of the UK Government’s grant subsidy of up to £5,000 towards electric vehicles. In addition to understanding the potential for specific policy instruments to influence behaviour, consumer perceptions of what will happen to electricity prices in the future and preferences in relation to charging tariffs and payment structures will be necessary. It will also become increasingly necessary to understand the extent to which consumers are aware of the potential for vehicle-to-grid technology and how, if at all, this factors in to any decision making.

Expectations about charging needs

This research found mixed results as to whether the issue of charging infrastructure availability was more or less important than range *per se*. These two issues are clearly linked, but for some segments, the ease of access to a parking place with charging at home appeared to have very strong influence on attitudes to EVs. In addition, the perception of the convenience of charging appeared to be somewhat mismatched with the more objective measurements of parking availability. The ease of access to charging at work was not directly studied here. Hence the ‘option value’ of being able to drive longer distances than the norm, and the definition of ‘easy access to charging’ together with the trade off between these two issues is in need of much more sophisticated understanding.

Current (H)EV owners

There were too few owners of AFVs in this study to be confident about our conclusions on the relationship between our segments and current ownership (i.e. the fact that the Plug-in Pioneers and Zealous Optimists were the most likely to own any AFVs that were present in the sample). It may be worth validating the segmentation with these consumers using the ‘golden questions’ and seeing whether individual owners tend to fall into these two segments as expected.

The difference between different plug-in vehicle technologies

This survey has given a strong indication that PHEVs and BEVs are perceived differently and are likely to be attractive to different people. The reasons for this have not been fully understood. It may tie in with experimental and qualitative studies (mainly in the US) which have shown that consumers are likely to prefer PHEVs rather than BEVs as most are interested in high fuel economy and extended range provided by blended operation. These studies suggest that the optimal solution is likely to be a range of low carbon vehicle technologies with different configurations of all-electric range which offer various degrees of high fuel economy at a range of prices to appeal to a number of segments. Further study is required to explore the desire for all-electric range versus various degrees of blended operation, the (mis)perceptions of the technology by consumers and how these different powertrains may be attractive to different segments.

Company car decision-making processes and likely future uptake

A diverse range of organisations were interviewed for the fleet management task. The interviews identified a lack of understanding with regard to different categories of EV. At the very least, the fleet industry therefore needs clearer information on EV attributes and charging routines in order for them to evaluate the likely impact that EV adoption would have on their operational needs. The manner in which organisations become informed about EVs may influence their attitudes, opinions and future decision making and is worthy of further investigation.

Organisations’ current decision-making processes map onto an established system for categorising decision-making structures (Nesbitt & Sperling, 2001). It is not clear whether these decision-making structures would be the same for EV purchasing decisions. If EV purchase decisions are similar to current purchase patterns, this suggests that EV marketing strategies will need to be targeted differently towards the different structures of decision-making within different companies.

Despite the apparent emphasis being placed on the drawbacks associated with the introduction of EVs, the organisations within the sample were, on the whole, keen to introduce EVs into their fleets, but fleet managers suggest that this will be a gradual process. The fleet managers interviewed in this study reported that they were likely to adopt a small number of EVs into their fleet in the next five years and would be keen for others to ‘test’ the technology before they invested. Further understanding of fleet managers’ decision-making processes would be beneficial to understand what ‘triggers’ (e.g. specific vehicle characteristics and infrastructure) might result in a shift towards EV uptake.

Geographical analysis

The association between our derived consumer segments and a classification of geographic urbanity permits the proportionality of our segments to be mapped across the UK. This mapping, at sub-postcode level, can be used as an input into the model of EV uptake, however, greater resolution and understanding of the association would be beneficial.

The challenges experienced in this study in relation to the prediction of consumer responses and the mapping of segments at a sub-postcode level were not unexpected or surprising. The findings are typical of the difference between research based attitudinal segments and quantifiable segments at the local market level. However, this identification of potential geographical 'hotspots' from which a shift in consumer behaviour towards EVs will diffuse would benefit from further investigation. It was beyond the scope of this study to undertake detailed modelling to understand further the demographic correlates with our segments and to map these on to existing indicators at a local level. This may use model-based techniques to combine our survey data with a set of associated predictor variables available at a local level of geography.

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Appendix A Long term user topic guide

INTRODUCTION

I would like to ask you some questions regarding your experience of using a plug-in vehicle.

There are **no right or wrong answers** and please just be as honest as you can. It does not matter if you feel you can't or don't want to answer some of the questions.

Unfortunately I am unable to answer any questions or queries you may have during this interview as we are interested in what you **think and feel** but I can answer questions afterwards.

We would like to **tape the interview** to avoid having to scribble everything down as you speak. (We may however make notes here and there if something you say brings further questions to mind.) We will only use the recording to help with writing the report. Once we have transcribed the audio recording, the audio files will be destroyed. All information will be anonymous at all times, and so there will be no way for us to link anything you say with you personally. You will not be personally identifiable in any reports that come out of this work. Are you ok with this?

I expect this interview to **last about 60 minutes**. Is this ok?

Firstly, can you please tell me your age?

How have you been using the electric vehicle?
- For work use only? Work and social use?
- Was most of your driving in urban or rural areas, or a mixture of both?

A. Their experience with the plug-in vehicle

1. **What do you think of the plug-in vehicle you have been using?**

2. **Tell me about your experience with the plug-in vehicle.**

- What do your family think of it?

3. **Can you describe a particular journey that you had in the plug-in vehicle?**

- Any trip that sticks in your mind for whatever reason. Talk me through it from start to finish

4. **How do you find the experience of driving the plug-in vehicle?**

- Tell me some of the things you like about driving the vehicle and also some of the things you dislike? How does the vehicle compare to a petrol/diesel vehicle? Has your experiences changed over the period of time you have been using the vehicle?

5. **During the time you have had this vehicle have you discussed plug-in vehicles with anyone?**

- If yes – who did you speak to and what did you talk about? What was their opinion?

6. **During the time you have had this vehicle have you searched for further information regarding plug-in vehicles?**

- If yes – where from and what?

7. **Does the way you drive this plug-in vehicle differ to the way you drive a petrol/diesel vehicle?**

- If yes, then how? Is this a problem? Has the way you drive changed over the period of time you have had the vehicle?

8. **Do you use the vehicle for trips that you would use a petrol/diesel vehicle for? If not, why not?**

- Which trips do you use the vehicle for, and why?
- Which trips do you not use the plug-in vehicle for, and why?
- Has the way you use the vehicle changed over the time you have had the vehicle?

B. Their experience with recharging the vehicle

9. How often do you charge the vehicle?

- What, if anything prompts you to recharge the vehicle? Do you only charge once the battery is low? If so, how low? or do you top-up often?

10. What time of day/night do you recharge the vehicle?

- Do you use any timing device to control when your vehicle charges?

11. Where do you recharge the vehicle?

12. If you recharge in more than one place which location do you prefer and why?

13. How long does it usually take to recharge your vehicle?

14. In general, how do you find the process of recharging?

- How does charging compare to petrol/diesel refuelling? Is there anything you like about charging? Is there anything you disliked about charging? Has the way you recharge the vehicle changed over the period you have been using it?

15. Have you had any problems with recharging?

- Have you ever run out of battery charge? Have you had any problems with the actual practicalities of recharging (e.g. different connectors at different locations), the time it took, how frequently the vehicle needed charging.

16. If yes: Can you think of any solutions to the problems you have had with recharging?

17. Have you changed any of your driving routes to accommodate the battery range/recharging infrastructure?

18. Is there anywhere you would like to recharge but can't as there aren't the facilities to do so at the moment?

19. How many miles between charging points do you feel comfortable driving?

20. Have you used any public recharging points?

- **If yes:** how did you find out about the recharging point? Did you know in advance if it would be available for you to use? If yes, is this important to you? Did you wait while you recharged the vehicle or did you do something else?
- **If no:** is there something preventing you from using public recharging points?

21. Have you ever charged your vehicle somewhere private, other than your home, for example at a friend's house?

- **If yes:** Can you tell me about the experience?
- **If no:** Is there anything preventing you from doing this?

22. Is there anything that you haven't mentioned so far that you feel could make recharging a plug-in vehicle easier for you?

C. Electricity supply and costs

23. Do you know which company supplies your electricity at home?

24. Do you know if you are on an economy 7 tariff that charges you different rates for peak and off-peak times of the day?

25. Do you know if you are on a green tariff with your electricity supplier?

26. How much do you think it costs to fully charge your vehicle?

27. If you could charge the vehicle in half the time but at an additional cost, would you be willing to pay extra?

28. Do you recharge at peak times? (e.g. do you plug the car in as soon as you return home from work in the evening)?

- What if anything would encourage you to switch to recharging at off peak times (e.g. after midnight)?

29. In future, it may be possible for your electricity supplier to control when your vehicle can charge. For example, you could plug it in when you arrive home, but it would only charge during the night when it is cheaper. Would you be happy to use a system like this? If not, why not?

30. Have you had to pay to recharge your battery away from home?

- **If yes:** how much did it cost?
- **If no:** have you recharged for free but then had to pay to park there?

31. If you haven't had to pay to recharge your vehicle away from home <u>how would you feel</u> if you <u>did</u> have to pay in the future?

- Would this put you off recharging away from home or do you think it is expectable?

32. If you are <u>happy</u> to pay to recharge your vehicle away from home <u>how would you prefer to pay</u>?

- E.g. a simple coin in meter system, a flat membership fee or a swipe card or billing system.

D. Attitudes and perceptions

33. What do you <u>think</u> of plug-in vehicles?

- Have your opinions of plug-in vehicles changed since you got the vehicle?

NB: Throughout this section if the interviewee talks about benefits/disadvantages in general then ask about benefits/disadvantages for them personally.

If interviewee talks about personal benefits/disadvantages then ask about more general benefits/disadvantages.

34. Do you think that plug-in vehicles are a <u>good thing or a bad thing</u>?

35. What do you think are the <u>benefits of plug-in vehicles</u> compared to petrol/diesel vehicles?

36. What do you think are the <u>negative aspects of plug-in vehicles</u> compared to petrol/diesel vehicles?

37. Do you think that you will <u>switch</u> from a petrol/diesel vehicle to a plug-in vehicle in future?

- **If yes:** Would this be to replace your main vehicle – or in addition to your main vehicle?
- **If yes:** When do you imagine this might happen?
- **If no:** What is the primary reason?

38. To what extent do you think that plug-in vehicles could meet <u>your mobility needs</u>? (e.g. getting from A to B)

- What about your family's mobility needs?

39. Imagine you were thinking about buying/leasing/acquiring a new vehicle in the future. What information would you require in order to <u>make an informed choice</u> about whether to choose a plug-in vehicle?

40. What would <u>encourage you</u> to buy/lease/acquire a plug-in vehicle?

- Can you think of any kind of incentives or policies that would encourage you to buy/lease/acquire a plug-in vehicle? Who would you want to provide these incentives (government, energy providers etc)?

Note: Try and get them to clarify which incentives would encourage them and if they related to financial incentives try to find out how much would incentivise them.

IMPORTANT: IF THEY LIST MORE THAN ONE INCENTIVE/POLICY THEN ASK THEM TO RANK THEM IN ORDER OF IMPORTANCE.

E. Affective responses

41. Now that you have had access to a plug-in vehicle for a reasonable period of time, how <u>appealing or unappealing</u> are plug-in vehicles to you?

- What could make them more appealing to you?

42. How <u>satisfying or unsatisfying</u> is it driving a plug-in vehicle?

- How does it compare to a driving a petrol/diesel car?

43. When you use the plug-in vehicle for <u>your regular journeys</u>, how does that feel?

44. When you use the plug-in vehicle for <u>your less frequent/less regular journeys</u>, how does that <u>feel</u>?

- To what extent do you think the experience of driving a plug-in vehicle differs to driving a petrol/diesel vehicle?

F. Identity responses

45. What do you think a plug-in vehicle <u>says about its owner</u>?

46. Can you describe the <u>kind of person</u> who drives a plug-in vehicle?

47. Think about the kind of person you are. Does driving a plug-in vehicle <u>fit with the kind of person you are</u>?

- Why/why not?

48. Does driving a plug-in vehicle <u>fit with who you would ideally like to be</u>? Why / why not?

G. Normative responses

49. When you drive the plug-in vehicle, how do <u>other people respond to you on the roads</u>?

- If different to responses in a petrol/diesel car, how?

50. When others see a plug-in vehicle parked outside your house, how do you think <u>other people see you</u>?

- Ensure participant specifies who they are thinking about.
- Are there other people you know who might feel differently?

51. Do you think that <u>any of the people you know will buy / lease</u> plug-in vehicles in the future (e.g. in the next five years)?

- Ensure participant specifies who they are thinking about.
- Are there other people you know who might feel differently?

H. Assessing confidence

52. <u>How confident do you feel</u> using a plug-in vehicle?

- Why?

53. <u>What challenges</u>, if any, has using a plug-in vehicle presented for you?

- Do you feel you can drive it just as well as you can a petrol/diesel vehicle?
- Do you have any thoughts about the mechanical differences between a plug-in vehicle and a petrol/diesel vehicle?

- Do you feel confident in the infrastructure?

I. Important factors

54. During this interview you have mentioned several <u>factors</u> that are <u>important to you</u> when you consider plug-in vehicles. Please could you list these in order of importance to you?

J. Closing questions

55. So, all in all, <u>do you prefer</u> the plug-in vehicle or a petrol/diesel car?

- Why?

56. Is there anything else you would like to add that we haven't mentioned?

AND FINALLY…

[TURN OVER FOR QUANTITATIVE QUESTIONS]

Post -exposure quantitative questions

The next four questions we would like you to rate your feelings on a scale of 1 to 7.

1. **How would you have described your attitude towards plug-in vehicles before the trial / you owned one / experienced driving one?**

Very negative	1	2	3	4	5	6	7	Very positive

2. **How would you describe your attitude towards plug-in vehicles now?**

Very negative	1	2	3	4	5	6	7	Very positive

ONLY ASK THE FOLLOWING QUESTIONS IF PARTICIPANT **DOES NOT** OWN THE PLUG-IN VEHICLE:

3. **How likely was it that you would have seriously considered buying a plug-in vehicle before the trial / you experienced driving one?**

Extremely Unlikely	1	2	3	4	5	6	7	Extremely Likely

4. **How likely is it that you would seriously consider buying a plug-in vehicle now?**

Extremely Unlikely	1	2	3	4	5	6	7	Extremely Likely

Appendix B Pre-exposure interviews

INTRODUCTION

We are carrying out some research to find out about people's attitudes, beliefs and feelings towards plug-in vehicles.

There are **no right or wrong answers** and please just be as honest as you can. It does not matter if you feel you can't or don't want to answer some of the questions.

Unfortunately I am unable to answer any questions or queries you may have during this interview as we are interested in what **you think and feel**. So, I will be saying as little as possible during the interview.

We would like to **tape the interview** to avoid having to scribble everything down as you speak. (We may however make notes here and there if something you say brings further questions to mind.) We will only use the recording to help with writing the report. Once we have transcribed the audio recording, the audio files will be destroyed. All information will be anonymous at all times, and so there will be no way for us to link anything you say with you personally. You will not be personally identifiable in any reports that come out of this work. Are you ok with this?

I expect this interview to **last about 45 minutes to an hour**. Is this ok?

After the interview I will be asking you to fill in a quick paper questionnaire. This should only take 5 minutes.

A. Past vehicle purchasing, attitudes and behaviour

1. Tell me about <u>your last</u> vehicle purchase?

- How did you go about buying/leasing it?
- Where did you look? Who was involved in the decision making process?
- Did you change your mind during the purchasing/leasing discussion?
- Did you have a shortlist or was it clear which vehicle you were going to buy/lease?
- Why did you choose that particular vehicle?
- What alternatives did you consider seriously?
- Did you part-exchange?

2. How would you <u>describe this vehicle</u> to your friends?

3. When considering a purchase / lease what makes a vehicle <u>appealing</u> to you?

- Are there any other attributes which are important to you when choosing a vehicle?

4. What do you know about the <u>fuel consumption</u> of this vehicle?

- What prompts you to fill up with fuel? I.e. only when empty, at half a tank or at regular intervals?

B. Knowledge and awareness of plug-in vehicles

5. Can you tell me <u>what you know</u> about plug-in vehicles?

- Can you tell me what they are?
- Could you explain the difference between a hybrid vehicle, a battery electric plug-in vehicle, and a hybrid electric plug-in vehicle?

6. Have you any experience of any kind with any type of plug-in vehicle?

- Perhaps you have used one before, or you know somebody who has used one?
- If they have direct experience – Tell me more about your experience and was it positive or negative?
- If they know somebody who has used one – What did they tell you about their experience? Was it positive or negative?

7. From which source(s), if any, have you gained your knowledge and opinions of plug-in vehicles?

8. Are you aware of any plug-in vehicle on the market at the moment or which are going to be released on the market soon?

- Can you name any particular models or manufacturers?

9. Why do you think plug-in vehicles are being developed and manufactured ?

10. What do you know about how a plug-in vehicle works?

11. What do you know about how to recharge a plug-in vehicle?

12. Do you know about any incentives or policies in this country to encourage people to buy / lease / acquire plug-in vehicles?

- If yes - What are these?

13. How much more or less expensive do you think it would cost to buy / lease / acquire a plug-in equivalent of your current vehicle?

- A little, a lot, etc? Can you put a figure on this?

14. Compared to your current vehicle, how much more or less expensive do you think it would cost to run a plug-in vehicle?

- A little, a lot, etc? Can you put a figure on this?

C. Attitudes and perceptions of plug-in vehicles

15. What do you think of plug-in vehicles?

- **NOTE:** Throughout this section if the interviewee talks about benefits/disadvantages in general, then ask about benefits/disadvantages for them personally.
- **NOTE:** If interviewee talks about personal benefits/disadvantages, then ask about more general benefits/disadvantages.

16. Do you think that plug-in vehicles are a good thing or a bad thing?

17. What do you think are the benefits of plug-in vehicles compared to petrol / diesel vehicles?

18. What do you think are the negative aspects of plug-in vehicles compared to petrol / diesel vehicles?

19. Do you think that you will switch from a petrol / diesel vehicle to a plug-in vehicle in future?

- **If yes**: Would this be to replace your main vehicle – or in addition to your main vehicle?
- **If yes**: When do you imagine this might happen?
- **If no**: What is the primary reason?

20. To what extent do you think that plug-in vehicles could meet your mobility needs? (e.g. getting from A to B)

- What about your family's mobility needs?

21. Imagine you were thinking about buying / leasing / acquiring a new vehicle in the future. What information would you require in order to make an informed choice about whether to choose a plug-in vehicle?

22. What would encourage you to buy / lease / acquire a plug-in vehicle?

- Can you think of any kind of incentives or policies that would encourage you to buy/lease/acquire a plug-in vehicle?
- Who would you want to provide these incentives (government, energy providers etc)?
- **Note:** Try and get them to clarify which incentives would encourage them and if they related to financial incentives try to find out how much would incentivise them.

> *IMPORTANT: IF THEY LIST MORE THAN ONE INCENTIVE/POLICY THEN ASK THEM TO RANK THEM IN ORDER OF IMPORTANCE.*

D. Affective responses

23. How appealing or unappealing are plug-in vehicles to you?

- What could make them more appealing to you?

24. How satisfying or unsatisfying would driving a plug-in vehicle be?

- How would it compare to your current/a petrol/diesel car?
- What do you find satisfying about driving?

25. Imagine using a plug-in vehicle for your regular journeys. How do you think that would feel?

26. Imagine using a plug-in vehicle for your less frequent journeys. How do you think that would feel?

- To what extent do you think the experience of driving a plug-in vehicle would differ to driving a petrol/diesel vehicle?

E. Identity responses

27. What do you think a plug-in vehicle says about its owner?

28. Can you describe the kind of person who drives a plug-in vehicle?

- Think about the kind of person you are. Does driving a plug-in vehicle fit with the kind of person you are? Why/why not?
- Does driving a plug-in vehicle fit with who you would ideally like to be? Why/why not?

F. Normative responses to plug-in vehicles

29. Imagine yourself as the driver of a plug-in vehicle. How do you think other people would respond to you on the roads?

- If different to responses in current/petrol/diesel car, how?

30. Imagine yourself as the owner of a plug-in vehicle. Visualise the vehicle as it is parked outside your home. How do you think other people would see you?

- Ensure participant specifies who they are thinking about.

31. Do you think that any of the people you know will buy/lease/acquire plug-in vehicles in the future (e.g. in the next five years)?

- Ensure participant specifies who they are thinking about.
- Are there other people you know who might feel differently?

G. Important factors

32. During this interview you have mentioned several factors which are important to you when you consider plug-in vehicles. Please could you list them in order of importance to you?

H. Behavioural intentions over the next week

33. How do you intend to use the plug-in vehicle over the next week?

- What trips do you intend to use it for, which trips do you not intend using it for and why? Have you made plans regarding when or which journeys you're going to use it for?

34. How do you intend to recharge the battery?

- Do you have off-street parking? If not how will you do it?

I. Assessing confidence in using a plug-in vehicles

35. How confident do you feel about your ability to use a plug-in vehicle? (Why?)

36. What new challenges, if any, might using a plug-in vehicle present for you?

- Do you feel you would be able to drive it just as well?
- Do you have any thoughts about the mechanical differences between a plug-in and petrol/diesel vehicle?
- Do you feel confident in charging the vehicle?

37. Is there anything that concerns or worries you about using a plug-in vehicle?

38. Is there anything else you would like to add that we haven't mentioned?

CLOSE SPOKEN INTERVIEW

HAND PARTICIPANT WRITTEN QUESTIONNAIRE

Appendix C Pre-exposure questionnaire

Pre-exposure questions

For, the next three questions we would like you to rate your feelings on a scale of 1 to 7.

Please indicate the number by circling it.

1. **Overall, how would you describe your attitude towards plug-in vehicles?**

Very negative	1	2	3	4	5	6	7	Very positive

2. **How well would owning a plug-in vehicle fit with the kind of person you are?**

Not very well	1	2	3	4	5	6	7	Very Well

3. **How likely is it that you would consider having a plug-in vehicle as a main car in the next 5 years?**

Extremely Unlikely	1	2	3	4	5	6	7	Extremely Likely

Driving behaviour and vehicle ownership

Please tick the relevant box or write your answers on the dotted line. If you do not know the answer please indicate with: [I don't know]

1. **How many vehicles do you own or otherwise have access to in your household?**

1 ☐ 2 ☐ 3 ☐ 4 ☐

2. **What is the make, model and engine capacity of the vehicle/s?**

	Make	Model	Engine capacity
Example	***FORD***	***FOCUS***	***1.4***
Vehicle One			
Vehicle Two			
Vehicle Three			
Vehicle Four			

3. **If you have more than one vehicle in your household, which one of these would you describe as your main vehicle?**

----

4. Please complete the table below to give us an indication of how many __miles each__ of your cars covers in a year and what __percentage__ of this mileage *you personally* do in each car?

	How many miles does the car cover in a year?	What percentage of the mileage do you personally drive?
Vehicle 1	miles	%
Vehicle 2	miles	%
Vehicle 3	miles	%
Vehicle 4	miles	%

5. On average, how __often do you drive?__

Every day	☐1	4–6 days per week	☐2	1–3 days per week	☐3
Fortnightly	☐4	Monthly	☐5	Less than monthly	☐6

6. How many __hours per week__ do you spend driving?

----

7. What are the __main reasons for you driving?__ Could you rank order the following purposes? 1 being the highest (main purpose for driving).

☐ *Commuting* ☐ *Shopping*

☐ *School run* ☐ *Transporting children*

☐ *Leisure purposes* ☐ *Business trips*

☐ *Other (please describe):*

Personal demographics

1. What was your age on your last birthday? ☐☐ years

2. What is your highest educational level?

None ☐1 GCSE or vocational equivalent ☐2

A Levels or vocational equivalent ☐3 Graduate or above ☐4

3. What is your marital status?

Single (never married)	☐1	Living with a partner	☐2
Married	☐3	Separated	☐4
Divorced	☐5	Widowed	☐6

4. Which one of the following best describes your ethnic background?

Any white background	☐1	Asian and white background	☐2
Black African and white background	☐3	Any other mixed ethnic background	☐4
Bangladeshi	☐5	Indian	☐6
Pakistani	☐7	Any other Asian background	☐8
African	☐9	Caribbean	☐10
Any other black background	☐11	Any Chinese background	☐12
Arab	☐13	Any other ethnic background	☐14
Gypsy/ Irish or Scottish Traveller	☐15	**Prefer not to say**	☐16

5. Which of the following best describes the area that you live in?

Rural	☐1	Suburb	☐2
City	☐3		

6. How many adults (18 or over) live in your household?

____

7. Do you have any children?

Yes ☐1 No ☐2

a. If yes, how many and what are their ages?

____

____

b. How many of them live with you?

____

8. Are you:

Employed full-time	☐1	Employed part-time	☐2
Self-employed	☐3	Retired or not working	☐4

9. Please tick the box that best describes your occupation. If you have retired, please tick the box that best describes your situation before you retired.

Senior managerial, administrative or professional	☐	1
Junior managerial, administrative or professional, supervisory and clerical	☐	2
Skilled manual worker	☐	3
Semi-skilled or unskilled manual worker	☐	4
Student, housewife/house husband, unemployed	☐	5

10. What is your total household income before tax (i.e. your income plus that of a spouse and/or anyone who lives with you?

£20,000 or less	☐	1	£21,000-40,000	☐	2
£41,000-70,000	☐	3	£71,000-100,000	☐	4
£101,000-150,000	☐	5	Above £150,000	☐	6

THANK YOU!

PLEASE PLACE THIS QUESTIONNAIRE IN THE ENVELOPE PROVIDED AND HAND IT TO THE TRL RESEARCHER

Appendix D Post-exposure interviews

INTRODUCTION

Now that you have had some experience with a plug-in vehicle I would like to ask you some questions regarding your household's experience and feelings over the last week. Some of these will be the same questions that I asked you last week because we're interested in how you think and feel now you have experiences of plug-in vehicles.

There are **no right or wrong answers** and please just be as honest as you can. We just want to know what you think and how you feel about plug-in vehicles.

As with the interview last week, I am unable to answer any questions or queries you may have during this interview but I can answer questions afterwards.

We would like to **tape the interview** to avoid having to scribble everything down as you speak. As we mentioned last week, we will only use this to help with writing the report and all information will be anonymous and the audio files destroyed after they've been transcribed. Are you ok with this?

I expect this interview to **last about 70 minutes**. Is this ok?

After the interview I will be asking you to fill in a quick paper questionnaire. This should only take 5 minutes.

A. Their experience over the week

1. **What did you think of the plug-in vehicle your have been using?**

2. **Tell me about your experience with the plug-in vehicle in the last week?**
- What did your family make of it?

3. **Can you describe a particular journey that you had in the plug-in vehicle last week?**
- Any trip that sticks in your mind for whatever reason. Talk us through it from start to finish.

4. **How did you find the experience of driving the plug-in vehicle?**
- Tell me some of the things you liked about driving the vehicle and also some of the things you disliked? How did the vehicle compare to your main vehicle?

5. **During the trial week did you discuss the subject of plug-in vehicles with anyone?**
- If yes – who did you speak to and what did you talk about? What was their opinion?

6. **During the trial week did you seek out further information regarding plug-in vehicles?**
- If yes – where from?

7. **Did the way you drive this plug-in vehicle differ to the way you drive your main vehicle?**
- If yes, then how? Was this a problem?

8. **Did you use the vehicle for trips that you would use your main vehicle? If not, why not?**
- Which trips did you use the vehicle for, and why?
- Which trips did you not use the vehicle for, and why?

B. Their experience with recharging the vehicle

9. How <u>often</u> did you charge the vehicle?

- What, if anything prompted you to charge the battery? Did you only charge once the battery was low? If so, how low? Or did you top-up often?

10. What <u>time of day / night</u> did you recharge the vehicle?

11. Where did you <u>recharge</u> the vehicle?

12. How did you find the <u>experience</u> of recharging?

- How does charging compare to refuelling a petrol/diesel vehicle? Was there anything you liked about charging? Was there anything you disliked about charging?

13. Did you have <u>any problems</u> with recharging?

- Did you ever run out of battery charge? Did you have any problems with the actual practicalities of recharging? (e.g. different connectors at different locations). The time it took? How frequently the vehicle needed charging?

14. If yes: Can you think of any <u>solutions</u> to the problems you have had with recharging?

15. How many <u>miles</u> between charging points did you feel <u>comfortable</u> driving?

C. Knowledge and awareness – post exposure

16. Can you tell me <u>what you now know</u> about plug-in vehicles?

- Can you tell me what they are?
- Could you explain the <u>difference</u> between a hybrid vehicle, a battery electric plug-in vehicle, and a hybrid electric plug-in vehicle?

17. What do you know about <u>how a plug-in vehicle works?</u>

18. What do you know about <u>how to recharge</u> a plug-in vehicle?

19. Do you know about <u>any incentives or policies</u> in this country to encourage people to buy / lease / acquire plug-in vehicles?

- If yes - What are these?

20. How much <u>more or less expensive</u> do you think it would cost to buy / lease / acquire a plug-in equivalent of your current vehicle?

- A little, a lot, etc? Can you put a figure on this?

21. Compared to your current vehicle, <u>how much or less expensive</u> do you think it would cost to <u>run</u> a plug-in vehicle?

- A little, a lot, etc? Can you put a figure on this?

D. Attitudes and perceptions – post exposure

22. What do you think of plug-in vehicles?

- **NOTE:** Throughout this section if the interviewee talks about benefits/disadvantages in general, then ask about benefits/disadvantages for them personally.
- **NOTE:** If interviewee talks about personal benefits/disadvantages, then ask about more general benefits/disadvantages.

23. Do you think that plug-in vehicles are a good thing or a bad thing?

24. What do you think are the benefits of plug-in vehicles compared to petrol/diesel vehicles?

25. What do you think are the negative aspects of plug-in vehicles compared to petrol/diesel vehicles?

26. Do you think that you will switch from a petrol/diesel vehicle to a plug-in vehicle in future?

- **If yes**: Would this be to replace your main vehicle – or in addition to your main vehicle?
- **If yes**: When do you imagine this might happen?
- **If no**: What is the primary reason?

27. To what extent do you think that plug-in vehicles could meet your mobility needs? (e.g. getting from A to B)

- What about your family's mobility needs?

28. Imagine you were thinking about buying/leasing/acquiring a new vehicle in the future. What information would you require in order to make an informed choice about whether to choose a plug-in vehicle?

29. What would encourage you to buy/lease/acquire a plug-in vehicle?

- Can you think of any kind of incentives or policies that would encourage you to buy/lease/acquire a plug-in vehicle?
- Who would you want to provide these incentives (government, energy providers etc)?
- **Note:** Try and get them to clarify which incentives would encourage them and if they related to financial incentives try to find out how much would incentivise them.

IMPORTANT: IF THEY LIST MORE THAN ONE INCENTIVE/POLICY THEN ASK THEM TO RANK THEM IN ORDER OF IMPORTANCE.

E. Affective responses – post exposure

30. How <u>appealing or unappealing</u> are plug-in vehicles to you?

- What could make them more appealing to you?

31. How <u>satisfying or unsatisfying</u> would driving a plug-in vehicle be?

- How would it compare to your current/a petrol/diesel car?
- What do you find satisfying about driving?

32. When you used the plug-in vehicle for your <u>regular journeys</u> how did that feel?

33. When you used the plug-in vehicle for your more <u>infrequent journeys</u> how did that <u>feel</u>?

- To what extent did you think the experience of driving a plug-in vehicle differed to driving a petrol/diesel vehicle?

F. Identity responses – post exposure

34. What do you think a plug-in vehicle <u>says about its owner</u>?

35. Can you describe the <u>kind of person</u> who drives a plug-in vehicle?

- Think about the kind of person you are. Does driving a plug-in vehicle fit with the kind of person you are? Why/why not?
- Does driving a plug-in vehicle fit with who you would ideally like to be? Why/why not?

G. Normative responses – post exposure

36. When you were driving the plug-in vehicle how did <u>other people respond</u> to you on the roads?

  - If different to responses in current/petrol/diesel car, how?

37. Imagine yourself as the owner of a plug-in vehicle. Visualise the vehicle as it is parked outside your home. How do you think <u>other people would see you</u>?

  - Ensure participant specifies who they are thinking about.

38. Do you think that any of the <u>people you know</u> will buy/lease/acquire plug-in vehicles in the future (e.g. in the next five years)?

  - Ensure participant specifies who they are thinking about.
  - Are there other people you know who might feel differently?

H. Important factors

39. During this interview you have mentioned several factors which are <u>important to you</u> when you consider plug-in vehicles. Please could you list them in order of importance to you?

I. Assessing confidence in using a plug-in vehicles

40. How <u>confident do you feel</u> about your ability to use a plug-in vehicle? (Why?)

41. What <u>new challenges</u>, if any, might using a plug-in vehicle present for you?

- Do you feel you would be able to drive it just as well?
- Do you have any thoughts about the mechanical differences between a plug-in and petrol/diesel vehicle?
- Do you feel confident in charging the vehicle?

42. Is there anything that <u>concerns or worries</u> you about using a plug-in vehicle?

43. Is there <u>anything else</u> you would like to add that we haven't mentioned?

J. Closing question

44. So, all in all, do you <u>prefer</u> the plug-in vehicle or the petrol/diesel car? Why?

CLOSE SPOKEN INTERVIEW

HAND PARTICIPANT WRITTEN QUESTIONNAIRE

Appendix E Post-exposure questionnaire

Post -exposure quantitative questions

For, the next four questions we would like you to rate your feelings on a scale of 1 to 7.

Please indicate the number by circling it.

1. **Overall, how would you describe your attitude towards plug-in vehicles?**

Very negative	1	2	3	4	5	6	7	Very positive

2. **How well would owning a plug-in vehicle fit with the kind of person you are?**

Very negative	1	2	3	4	5	6	7	Very positive

3. **How likely is it that you would consider having a plug-in vehicle as a main car in the next 5 years?**

Extremely Unlikely	1	2	3	4	5	6	7	Extremely Likely

What is the make, model and registration number of your current car:

Make: __________________________

Model: __________________________

Registration No: __________________________

Please rate on a scale of 1 to 7 how likely it is that the following policies would encourage you to purchase a plug-in vehicle to replace your current car

POLICY	**Please indicate your response to the following questions by circling the answer.**						
	Not Likely						**Very Likely**
Exemption from road tax (Vehicle Excise Duty) for owners of plug-in vehicles	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Free electricity from public charging points (e.g. at supermarkets or public car parks)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Free parking at public charging points	**1**	**2**	**3**	**4**	**5**	**6**	**7**
A Government grant (i.e. money off the purchase price of a plug-in vehicle)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Exemption from congestion charging	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Exemption from tolls on toll roads	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Higher fuel costs for petrol and diesel cars	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Low interest loans available when purchasing plug-in vehicles	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Priority lanes (e.g. permissions to use bus/taxi lanes)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Extended warranties for battery performance (for example batteries guaranteed for the life of the vehicle)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Only answer the next question if you pay company car tax:							
Reduction in company car tax	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Please rate on a scale of 1 to 7 how important the following attributes would be if you were to replace your current car with a plug-in vehicle.

VEHICLE ATTRIBUTES	**Please indicate your response to the following questions by circling the answer.**						
	Not Important						**Extremely Important**
Purchase price of the vehicle	1	2	3	4	5	6	7
Vehicle uses advanced/novel engine technology	1	2	3	4	5	6	7
Fuel consumption - e.g. miles per gallon	1	2	3	4	5	6	7
Annual fuel bill	1	2	3	4	5	6	7
Annual cost of Road Tax (Vehicle Excise Duty)	1	2	3	4	5	6	7
Annual service costs	1	2	3	4	5	6	7
CO_2 emissions	1	2	3	4	5	6	7
Vehicle range – e.g. miles that can be covered from a full charge	1	2	3	4	5	6	7
Performance – engine power (horsepower)	1	2	3	4	5	6	7
Performance – 0-60 time in seconds	1	2	3	4	5	6	7
Amount of luggage/boot space	1	2	3	4	5	6	7
Availability of infrastructure for refuelling/recharging vehicle e.g. charge points at workplaces, shopping centres	1	2	3	4	5	6	7
Comfort/ride quality	1	2	3	4	5	6	7
Number of manufacturers offering this type of vehicle (similar to the one you are considering)	1	2	3	4	5	6	7
Depreciation – Decrease in vehicle’s value	1	2	3	4	5	6	7
Comprehensive service/warranty agreement	1	2	3	4	5	6	7
Safety – e.g. EuroNCAP test rating	1	2	3	4	5	6	7
Size/type of car (e.g. 2 seater, supermini, saloon, people carrier etc)	1	2	3	4	5	6	7
Any other issue (please specify)	1	2	3	4	5	6	7

Appendix F Travel diaries

F.1 EV travel diary

TRIP 1	TODAY'S DATE:	
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End: Total distance:

Battery level at start of trip										
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full

Passengers					**Journey notes**
☐	☐	☐	☐	☐	
0	1	2	3	4	

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Are charging facilities easily available?	
Yes ☐ Did you charge the vehicle? Yes ☐ No ☐	**No** ☐ Would you like to be able to charge the vehicle? Yes ☐ No ☐

TRIP 2		
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End: Total distance:

Battery level at start of trip										
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full

Passengers					**Journey notes**
☐	☐	☐	☐	☐	
0	1	2	3	4	

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Are charging facilities easily available?	
Yes ☐ Did you charge the vehicle? Yes ☐ No ☐	**No** ☐ Would you like to be able to charge the vehicle? Yes ☐ No ☐

TRIP 3		
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End: Total distance:

Battery level at start of trip										
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full

Passengers					**Journey notes**
☐	☐	☐	☐	☐	
0	1	2	3	4	

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Are charging facilities easily available?	
Yes ☐ Did you charge the vehicle? Yes ☐ No ☐	**No** ☐ Would you like to be able to charge the vehicle? Yes ☐ No ☐

F.2 PHEV travel diary

TRIP 1	TODAY'S DATE:	
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End:
		Total distance:

Fuel/battery level at start of trip	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full
Fuel	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Battery	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Passengers	**Journey notes**
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4	

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Are charging facilities easily available?

Yes ☐	**No** ☐
Did you charge the vehicle? Yes ☐ No ☐	Would you like to be able to charge the vehicle? Yes ☐ No ☐

TRIP 2		
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End:
		Total distance:

Fuel/battery level at start of trip	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full
Fuel	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Battery	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Passengers	**Journey notes**
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4	

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Are charging facilities easily available?

Yes ☐	**No** ☐
Did you charge the vehicle? Yes ☐ No ☐	Would you like to be able to charge the vehicle? Yes ☐ No ☐

TRIP 3		
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End:
		Total distance:

Fuel/battery level at start of trip	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full
Fuel	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Battery	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Passengers	**Journey notes**
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4	

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Are charging facilities easily available?

Yes ☐	**No** ☐
Did you charge the vehicle? Yes ☐ No ☐	Would you like to be able to charge the vehicle? Yes ☐ No ☐

F.3 Participants' regular vehicle travel diary

TRIP 1	**TODAY'S DATE:**	
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End:
		Total distance:

Fuel level at start of trip

☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Passengers

☐	☐	☐	☐	☐
0	1	2	3	4

Journey notes

TRIP 2		
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End:
		Total distance:

Fuel level at start of trip

☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Passengers

☐	☐	☐	☐	☐
0	1	2	3	4

Journey notes

TRIP 3		
Start time:	**Location** Start:	**Odometer** Start:
End time:	End:	End:
		Total distance:

Fuel level at start of trip

☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	Full

Parking	Public	Private
On-street	☐	☐
Off-street	☐	☐

Passengers

☐	☐	☐	☐	☐
0	1	2	3	4

Journey notes

Appendix G Car choice factors which did not rank in the 'top 25'

Factor	No. of references	Percentage of responses
4 x 4	45	0.6
Environment/CO2	44	0.6
Loyalty to brand/car	44	0.6
Specification	39	0.5
Mileage	34	0.4
Interior	33	0.4
No/limited choice	30	0.4
Dealer purchased from	29	0.4
Warranty	28	0.4
Image	24	0.3
Suitability for needs	24	0.3
Availability	20	0.3
Tow	18	0.2
Resale value	14	0.2
Fun	12	0.2
Visibility	9	0.1
Hybrid	8	0.1
Luxury	7	0.1
Scrappage scheme	4	0.1
Manual transmission	4	0.1

Appendix H Fleet manager information letter

Dear Participant,

Thank you for agreeing to take part in our research project on plug-in electric and plug-in hybrid vehicles. As we explained when we organised the interview, TRL is currently investigating drivers' and organisations' attitudes and behaviours towards electric vehicles. The interview we have arranged aims to improve our understanding of the factors that are likely to drive organisations' adoption and use of electric and plug-in hybrid vehicles. Because such vehicles are new technologies that are not part of the mainstream we thought it would be helpful to provide you with a brief overview of facts in preparation for the interview. As such, this document offers you:

- A high level overview of the main differences between conventional vehicles and plug-in hybrid vechicles (PHEV) and battery electric vehicles (BEV).
- More specific information about the differences between PHEV and BEV technologies.
- Useful information about company car tax.

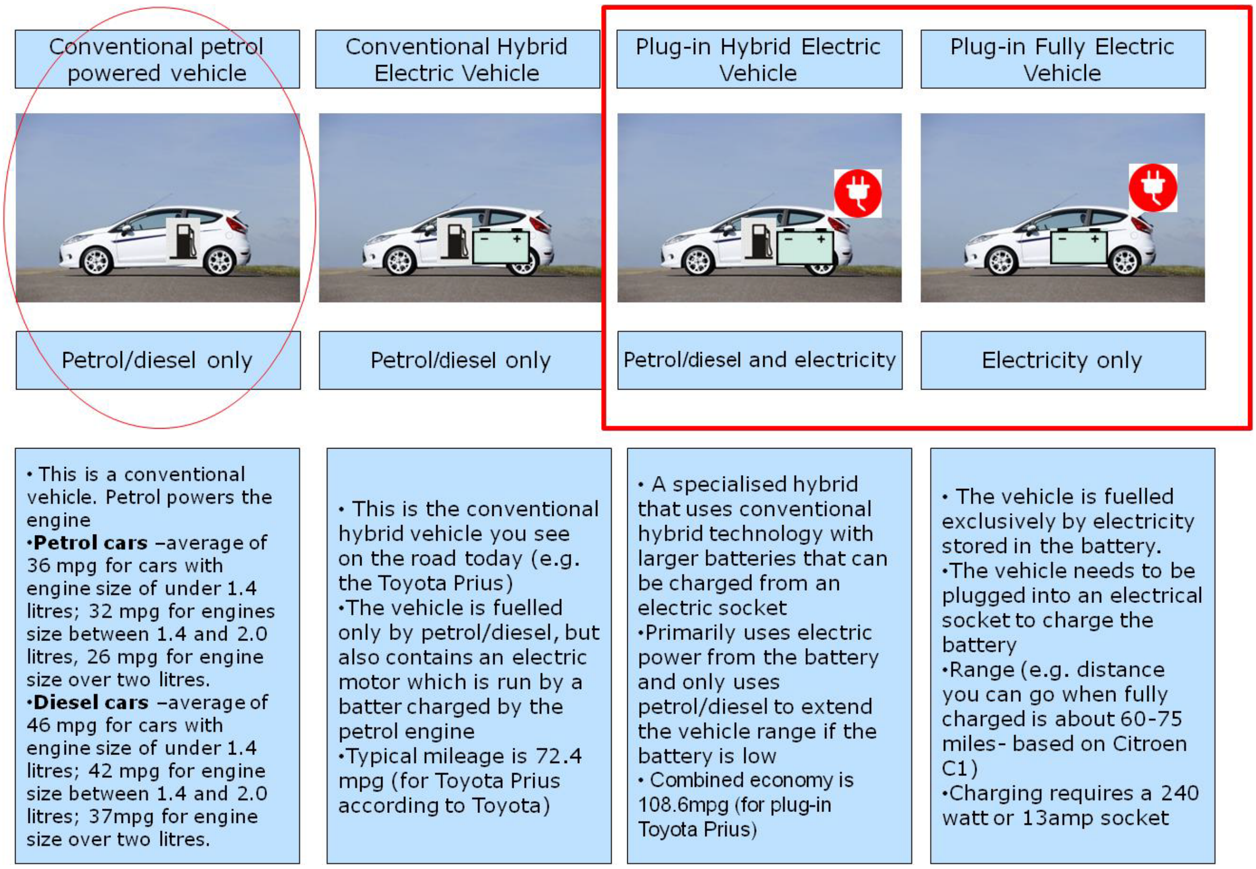
Please read this document before your telephone interview so that during the interview, we can discuss how you assess and rate them from the perspective of a manager of car fleets used for work-related road journeys.

Many thanks again for your participation,

Rebecca Hutchins

Researcher

Figure 1 shows plug-in hybrid electric vehicles and plug-in fully electric vehicles (marked by a red box) which form the focus of our research project in comparison with current mainstream vehicle technology (marked by a red ellipse).



Information about the different types of plug-in vehicles

There are two types of plug-in vehicle:	Plug-in Hybrid Vehicle	Plug-in Electric Vehicle (EV)
Driving	• A hybrid vehicle will automatically switch between the petrol/diesel engine and the electric motor depending on the power needed by the driver. • Generally, in slow traffic (e.g. up to 30mph) the car will use the electric motor.	• An electric motor has no gears and is therefore like driving an automatic. The acceleration is smooth and quiet.
Performance	• A plug-in vehicle will use power from the electric motor to accelerate unless more power is required, at which point the conventional engine will provide additional power.	• Electric motors have very good acceleration and often accelerate faster than an equivalent petrol/diesel car. • Top speed is not as high as petrol/diesel cars although it is sufficient to match legal speed limits on UK roads.
Comfort & Practicality	• A plug-in hybrid vehicle can be any size of vehicle although the electric power may be less effective on larger vehicles. • Comfort and practicality should be the same as conventional vehicles.	• EVs provide the same level of comfort and practicality as equivalent conventional vehicles. • The use of air-con and heating can use battery power and reduce range, however.
Range	• A plug-in hybrid has the same range as a standard petrol/diesel car.	• On a full charge, EVs cannot travel as far as petrol/diesel cars can on a full tank. • Range can be limited to under 100 miles on a full charge.
Safety and Reliability	• A plug-in hybrid has both a petrol/diesel engine and an electric motor and should be as safe and reliable as any other car. • Battery life may reduce after a few years. • Safety features are the same • Pedestrians may not hear the vehicle approaching when using the electric motor.	• Electric cars have an electric motor instead of an engine and have fewer moving parts. • They are expected to be reliable although battery life may reduce after a few years. • Safety features are the same although pedestrians may not hear an electric vehicle approaching or when the PHEV is in electric mode.
Refuelling / Recharging	• A hybrid requires standard refuelling at a service station and recharging by attaching a cable to the car and plugging the other end into a standard household plug socket. • Charging points exist in some parking places.	• An EV is recharged by attaching a cable to the car and plugging the other end into a standard household plug socket. • A full charge can take approximately 6 hours although the battery can be topped up in shorter bursts (for both BEVs and PHEVs). • Charging points exist in some parking places.
Running Costs	• A full charge is likely to cost less than £1 and re-fuelling costs should be reduced by enhanced miles per gallon (mpg) due to using the electric motor.	• A full charge costs approximately £1. • There is no road tax or London congestion charge.
Vehicle Excise Duty	• Most hybrids are charged less than their conventional equivalents due to their lower emissions of CO_2. Hybrids typically use 15%–30% less fuel per mile	• EVs are currently exempt from paying Vehicle Excise Duty

Plug-in hybrid electric vehicles and plug-in fully electric vehicles are furthermore different with regards to the tax a driver will need to pay for their use as a company car (comprehensive guidance on company car taxation can be found in guidance published by the HMRC (HMRC 480, 2010). Table 67 below shows the taxable percentage of the list price for vehicles with different levels of CO_2 emissions.

An example calculation is supplied below the table to illustrate the calculation process.

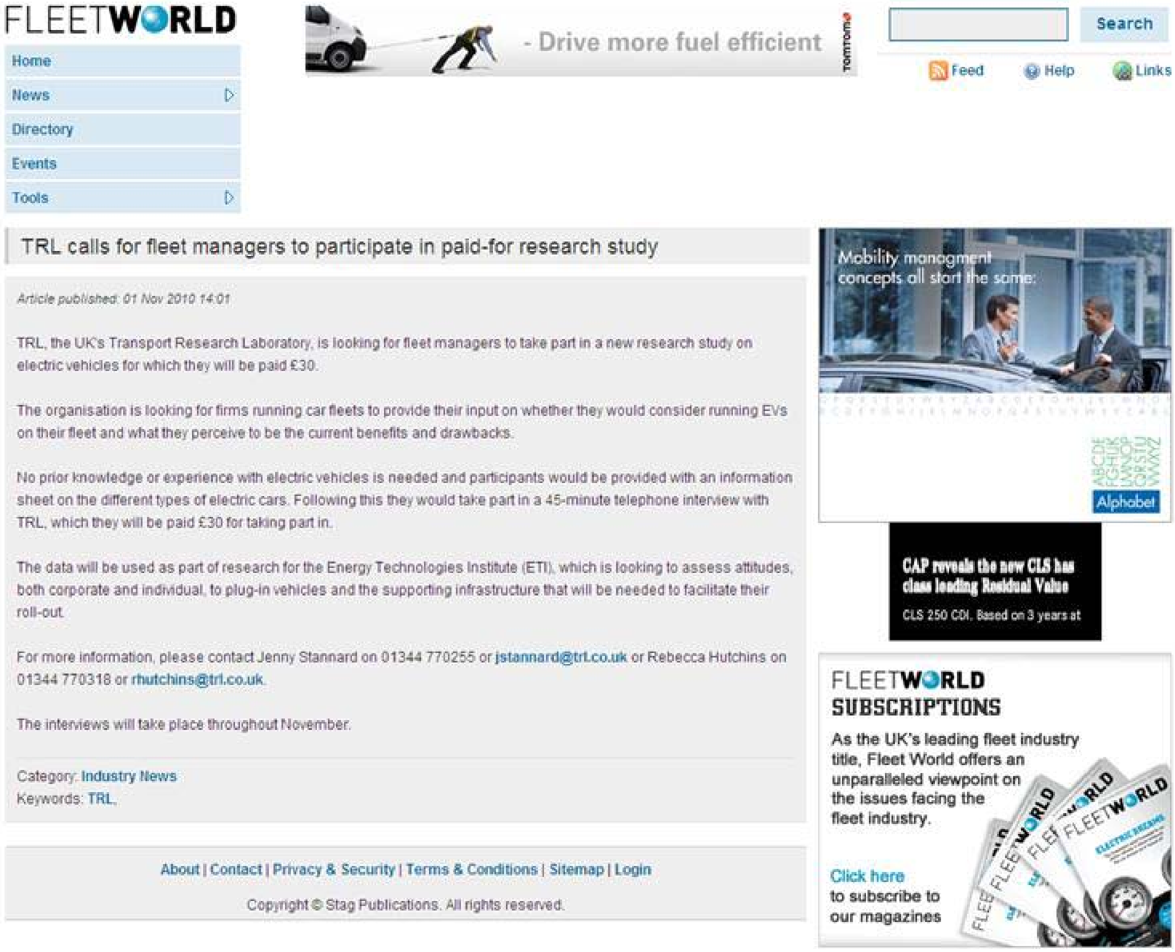
Example tax calculation for the year 2011/12:

- Employee pays 40% tax
- List price of the vehicle: £25,000
- % charge for 154 g/km: 20%
- Benefit in kind: £5000
- Tax payable: £2000

Table 67: Taxable percentage of list price

CO_2 (g/km)	2010/11	2011/12	2012/13
0	0	0	0
1–75	5	5	5
76–99	10	10	10
100–104	10	10	11
105–109	10	10	12
110–114	10	10	13
115–119	10	10	14
120–124	15	15	15
125–129	15	15	16
130–134	15	16	17
135–139	16	17	18
140–144	17	18	19
145–149	18	19	20
150–154	19	20	21
155–159	20	21	22
160–164	21	22	23
165–169	22	23	24
170–174	23	24	25
175–179	24	25	26
180–184	25	26	27
185–189	26	27	28
190–194	27	28	29
195–199	28	29	30
200–204	29	30	31
205–209	30	31	32
210–214	31	32	33
215–219	32	33	34
220–224	33	34	35
225–229	34	35	35
230–234	35	35	35
235 or over	35	35	35

Appendix I Example of advert used to recruit fleet managers



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TRL calls for fleet managers to participate in paid-for research study

Article published: 01 Nov 2010 14:01

TRL, the UK's Transport Research Laboratory, is looking for fleet managers to take part in a new research study on electric vehicles for which they will be paid £30.

The organisation is looking for firms running car fleets to provide their input on whether they would consider running EVs on their fleet and what they perceive to be the current benefits and drawbacks.

No prior knowledge or experience with electric vehicles is needed and participants would be provided with an information sheet on the different types of electric cars. Following this they would take part in a 45-minute telephone interview with TRL, which they will be paid £30 for taking part in.

The data will be used as part of research for the Energy Technologies Institute (ETI), which is looking to assess attitudes, both corporate and individual, to plug-in vehicles and the supporting infrastructure that will be needed to facilitate their roll-out.

For more information, please contact Jenny Stannard on 01344 770255 or jstannard@trl.co.uk or Rebecca Hutchins on 01344 770318 or rhutchins@trl.co.uk.

The interviews will take place throughout November.

Category: Industry News
Keywords: TRL,

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Appendix J Fleet manager interview topic guide

INTRODUCTION

We are carrying out research to find out what fleet managers know about plug-in vehicles and how they assess and rate them. As part of the research we also carry out interviews with private users of such vehicles, but today I'm specifically interested in your views about plug-in electric or plug-in hybrid vehicles from a fleet manager's perspective.

There are **no right or wrong answers** and please just be as honest as you can. It is ok if you feel you can't or don't want to answer some of the questions.

Because we want to find out what fleet managers currently know and think about plug-in vehicles, I will be saying as little as possible during the interview and will listen to you.
I would like to **record the interview** to avoid having to scribble everything down as you speak (I may, however, make notes here and there if something you say reminds me of further questions to ask). We will only use the recording to help with writing the report. Once we have transcribed the audio recording, the audio files will be destroyed. All information will be anonymous at all times, and so there will be no way for us to link anything you say with you personally. You will not be personally identifiable in any reports that come out of this work. Are you ok with this?

I expect this interview to **last about 45 minutes to an hour**. Is this ok?

A. Background information

1. **Can you give us some background on how your company operates (the nature of the business, how many staff work for the organisation, what your role entails)?**

2. **How many people drive for work in your organisation?**

3. **Would you describe your GB office location(s) as being rural, urban or suburban? Please consider all company locations where company fleet vehicles you are responsible for are operated.**

4. **Can you describe the parking arrangements at your place of work?**
   - How many parking spaces are available?
   - Are there any constraints on these (e.g. not enough)? If yes, how are parking spaces allocated?
   - Do you offer priority spaces, e.g. for those who car-share?
   - Do company vehicle users have dedicated parking spaces/areas at work?

5. **Of each of the following vehicle types, how many are used for work in your organisation?**

   ☐ Cars ________________

   And how many of these are company cars versus privately-owned cars used for work purposes?

   _________________ company cars
   _________________ private cars used for work purposes

   ☐ Vans (<3.5t) ________________
   ☐ Trucks (>3.5t) ________________
   ☐ Motorcycles ________________
   ☐ Others (specify) ________________

6. **Does your company use pool vehicles?**
   - If yes, how many are there?
   - What sort of journeys do they undertake?
   - How long are the journeys they are used for?
   - When do they take place (how often and under what circumstances)?
   - What roads do they typically use?

7. **How are company cars allocated in your company?**
   - Who qualifies?

8. **Is there a user-chooser scheme and if so, what aspects of the vehicle choice are predetermined?**

9. **You said that you have approximately N company cars. For how many of these company cars (excluding privately owned vehicles used for work) do you as transport manager have control over the selection of the vehicle?**

10. **What are the purposes of your organisation's company car journeys?**
    - How long are they,
    - When do they take place?
    - What road environments do they typically drive in?

11. How do you monitor the work-related mileage of your car driving employees?

- For those who drive a company car, or a pool car?
- What is the typical annual mileage?

12. Do you keep a record of your employees' locations while they are driving for work?

- If yes, how?
- If yes, does this apply to all vehicle types in your fleet?

13. Can you describe the finance programme(s) that you use for your fleet vehicles?

- What influenced your decision to use that system?

B. Past vehicle purchasing, attitudes and behaviour

14. Tell me about the last cars that you adopted into your fleet?

- What type of vehicles are they? E.g. manufacturer and model, segment, petrol/diesel, etc.
- How did you go about buying/leasing/adopting them?
- Where did you search for cars/what information sources did you use? Who was involved in the decision making process?
- Did you have a shortlist or was it clear which vehicle you were going to buy/lease?
- If yes, why did you choose that particular vehicle?
- Which alternatives did you consider seriously?
- Did you part-exchange?
- Which manufacturers did you consider? What made you consider these brands? Did you have existing relationships, access to good prices etc?

15. As a transport manager, when considering a purchase/lease what makes a car appealing to you?

- Are there any other attributes which are important to you when choosing a car?

16. What metrics do you use when comparing vehicles?

- Examples might include: total cost of ownership over the life of the vehicle, discount rates or commercially available software (e.g. KwikCarCost (formerly EmmoxCarCost).

17. Have you considered alternative fuel sources (e.g. electric/hydrogen/biofuel)? Why/why not?

C. Knowledge and awareness of plug-in vehicles

18.Can you tell me <u>what you know</u> about plug-in electric vehicles?

- Can you tell me what they are?
- Could you explain the difference between a hybrid vehicle, a battery electric plug-in vehicle, and a hybrid electric plug-in vehicle?

19.Have you any experience with any type of plug-in electric vehicle?

- Have you used one before, or has somebody you know used one?
- *If interviewee had direct experience* – Tell me more about your experience and was it positive or negative?
- *If interviewee knows somebody who has used one* – What did they tell you about their experience?

20.From which source(s) have you gained your knowledge and opinions of plug-in vehicles?

D. Charging plug-in vehicles

- Does your company have on-site fuelling (e.g. an onsite tank/pump to fill up fleet vehicles)? If yes, can you briefly explain how the system works, e.g. charging for fuel?
- What potential is there for the installation of infrastructure for plug-in electric or hybrid company cars or private cars? How could you imagine that working?
- If re-charging infrastructure were installed on the company's premises, would the company charge (£) employees to re-charge company cars? If so, how?

E. Attitudes and perceptions of plug-in vehicles

22.What do you think are the benefits of plug-in vehicles compared to petrol/diesel vehicles?

23.What do you think are the negative aspects of plug-in vehicles compared to petrol/diesel vehicles?

24.Do you think that your fleet will adopt plug-in vehicles in future?

- **If yes**: Can you describe, how/for what kind of driving you think these electric vehicles would be used?
- **If yes**: What timeframe for their introduction in your organisation would you envisage?
- **If no**: What is the primary reason for not considering the use of plug-in vehicles? What other reasons play a role?

25.What do you think other senior staff/management think about plug-in vehicles (why)?

26.What do you think that employees driving for work in your organisation think about plug-in vehicles (why)?

27. What do you think that your customers would think about your organisation using plug-in vehicles?

28. To what extent do you think that plug-in vehicles could meet your organisation's mobility needs?

29. Imagine you were thinking about acquiring a new company car in the future. What information would you require in order to make an informed choice about whether to choose a plug-in vehicle?

30. What would encourage you to adopt plug-in vehicles into your fleet?

- Can you think of any kind of incentives or policies that would encourage you to buy/lease/acquire a plug-in vehicle?
- Are you aware of any incentives currently offered by the government to encourage the adoption of plug-in vehicles?
- Who would you want to provide these incentives (government, energy providers etc)?
- **Note:** Try and get them to clarify which incentives would encourage them and if they related to financial incentives try to find out how much would incentivise them.

IMPORTANT: IF THEY LIST MORE THAN ONE INCENTIVE/POLICY THEN ASK THEM TO RANK THEM IN ORDER OF IMPORTANCE.

F. Important factors

31. During this interview you have mentioned several factors which are important to you when you consider plug-in vehicles. Please could you list them in order of importance to you?

32. Is there anything that you'd like to add?

Close spoken interview

Appendix K Quantitative questionnaire: Wave 1

K.1.1 SCREENING QUESTIONS

S.1 In the past 5 years have you owned/leased or acquired (i.e. as a company car) a brand new car OR a car which was less than two years old that you drive?

☐ YES ➔ Go to S3
☐ NO ➔ Go to S2

S.2 Are you currently actively seeking to purchase a brand new car which you will drive?

☐ YES ➔ Go to S3
☐ NO ➔ Thank and end

S.3 Which of the following best describes your own personal behaviour?

☐ I like to buy the latest technology that is right at the cutting edge as soon as it is available
☐ I may not be the first but I like to own the latest technology before most people
☐ I like to buy the latest technology but only after considering which is best
☐ I like to buy products that have a proven technology rather than simply the latest technology
☐ I only buy new technology when it has become standard and there is no alternative

---

Dear participant

Thank you very much for agreeing to take part in this study. The study is part of a project investigating which cars people currently use. We will also ask your opinion about new technologies that are beginning to enter the market, such as electric vehicles. We will be providing some information about these new technologies, so there is no need to have any previous knowledge or experience of them.

This survey is in two parts which will require you to complete part 1 (which takes about 15 minutes and includes reading some information about electric vehicles) and come back 2 days later to complete part 2 (which takes another 15 minutes). Once you have completed part 1, you will receive a reminder by email to complete the second half of the survey.

If you decide that you wish to withdraw from the study, simply click on the button which says exit at any time.

All the information you provide will be strictly anonymous. No data collected allows you to be identified. The postcode information we ask for will be used only for geographical references that will help us describe the data and we give you our word that we will not use the information for anything other than this research or pass it on to any third parties.

We hope you find this survey interesting. We appreciate and value your input into this important study which will help to inform UK transport policy.

PART 1

A. CAR OWNERSHIP

Later in the survey we will ask you about the sorts of cars you might consider choosing in the future. Before that, we would like to know about the car(s) you currently have access to in your household.

A1. How many people in total in your household hold a valid driving licence?

____

A2. Do you hold a valid driving licence? ☐ Yes ☐ No

A3. How many of the following cars are kept in this household?

Private cars ____________

Company cars ____________

A4. Using the drop-down list, please select the car make(s)/ model(s) that apply to the car(s) in your household.

Car 1 (Main household car)	Car 2	Car 3	Car 4	Car 5
DROP DOWN LIST	DROP DOWN LIST	DROP DOWN LIST	DROP DOWN LIST	DROP DOWN LIST

A5. For all the cars you have included, please indicate which ones are: *Please tick all that apply*

	Car 1	Car 2	Car 3	Car 4	Ca
Private	☐	☐	☐	☐	☐
Company car	☐	☐	☐	☐	☐

A6. For each of the cars you have included above, please tell us the fuel type (*Tick one per column*)

	Car 1 tick one	Car 2 tick one	Car 3 tick one	Car 4 tick one	Car tick one
Petrol	☐	☐	☐	☐	☐
Diesel	☐	☐	☐	☐	☐
Biofuel blends over 5% (includes E85 (85% Ethanol))	☐	☐	☐	☐	☐
Compressed Natural Gas / Liquid Petroleum Gas (LPG)	☐	☐	☐	☐	☐
Hybrid (petrol/electric)	☐	☐	☐	☐	☐
Electric only	☐	☐	☐	☐	☐
Other, please write in ______________________________	☐	☐	☐	☐	☐

For all the cars you have included, please indicate:					
	Car 1	Car 2	Car 3	Car 4	Car
A7. In the past 12 months, roughly how many MILES did you drive each car? ur best guess is fine; if you do not drive it, put '0')	___	___	___	___	___
A8. Which one would you say you drive MOST OFTEN? (i.e. on more days of the week than any other car) *please tick one only*	☐	☐	☐	☐	☐

THINKING OF THE CAR YOU DRIVE MOST OFTEN, PLEASE COMPLETE THE FOLLOWING QUESTIONS (A9 TO A16):

A9. In what year did you first acquire this car? _____________

A10. When you got this car, was it: *Tick ONE box only.*

☐ Brand new
☐ Nearly new (up to 2 years old)
☐ Used (more than 2 years old)

A11. What was the purchase price? *Tick ONE box only.*

Less than £6k	£6k - £10k	£11k - £15k	£16k- £20k	£21k - £25k	£26k - £30k	£31k - £40k	More than £40k	Don't know
☐	☐	☐	☐	☐	☐	☐	☐	☐

A12. Was this car bought as part of the scrappage scheme? This would have been between 18th May 2009 and 31st March 2010, scrapping a car of more than 10 years old and purchasing a new car with a £2,000 allowance.

☐ Yes ☐ No

A13. On average, how many miles per gallon do you get in this car? *Tick ONE box only.*

10 mpg or less	11 – 20 mpg	21 – 30 mpg	31 – 40 mpg	41 – 50 mpg	51 – 60 mpg	61 – 70 mpg	71or more mpg	Don't know
☐	☐	☐	☐	☐	☐	☐	☐	☐

A14. How satisfied are you with the fuel economy / mpg of this car? *Tick ONE box only.*

Very dissatisfied	**Quite dissatisfied**	**Neutral**	**Quite satisfied**	**Very satisfied**
☐	☐	☐	☐	☐

A15. What factors were important when choosing this car (e.g. cost, brand, size, acceleration)?
In your own words, list UP TO THREE of the most important factors in the text boxes provided:

Factor 1:	Factor 2:	Factor 3:
________________________ ___	________________________ ___	________________________ ___

A16. Generally speaking, which one of the following statements best describes your role when it comes to choosing a car for your household?
- ☐ I alone decide which car(s) to buy
- ☐ I have the main say, but take others' views into account
- ☐ I have equal say in which car(s) to buy
- ☐ I have some influence, but someone else has the main say
- ☐ I have no say in which car(s) is/are bought

B. PARKING

We would like to get an idea of the spaces you have to park your car(s) at or near your home, even if you do not use these spaces.

B1a. Do you have a GARAGE? ☐ Yes ☐ No [If no, go to B2a]

B1b. Do you usually park your car(s) in this garage? ☐ Yes ☐ No

B1c. How many cars *could* you park in this garage? *Tick ONE box only.*

1 car	2 cars	3+ cars
☐	☐	☐

B1d. If you had to plug in an electrical appliance to work in this garage (e.g. a vacuum cleaner), is there an electrical socket within reach? *Tick ONE box only.*

Yes, easily	Yes, with an extension cord only	No	Don't know
☐	☐	☐	☐

B2a. Do you have a DRIVEWAY/ CARPORT? ☐ Yes ☐ No [If no, go to B3a]

B2b. How many cars *could* you park on this driveway/ carport? *Tick ONE box only.*

1 car	2 cars	3+ cars
☐	☐	☐

B2c. If you had to plug in an electrical appliance to work in this parking space (e.g. a vacuum cleaner), is there an electrical socket within reach? *Tick ONE box only.*

Yes, easily	Yes, with an extension cord only	No	Don't know
☐	☐	☐	☐

B3a. Do you have any other OFF-street (e.g. a dedicated space in a car park near to your home)?

☐ Yes ☐ No [If no, go to B4a]

B3b. How many cars *could* you park here? *Tick ONE box only.*

1 car	2 cars	3+ cars
☐	☐	☐

B3c. If you had to plug in an electrical appliance to work in this parking space (e.g. a vacuum cleaner), is there an electrical socket within reach? *Tick ONE box only.*

Yes, easily	Yes, with an extension cord only	No	Don't know
☐	☐	☐	☐

B4a. Do you have any DEDICATED ON STREET space(s) (i.e. that are specifically saved for your household)?

☐ Yes ☐ No [If no, go to B5]

B4b. How many cars *could* you park here? *Tick ONE box only.*

1 car	2 cars	3+ cars
☐	☐	☐

B5. Do you have any other ON STREET parking?

☐ Yes ☐ No

C. GENERAL TRAVEL PATTERNS

C1. For all journeys combined, in an average year, how frequently have you used each type of transport? *Please tick one box per row*

	Never	Less than once a month	1-3 days/ month	About 1 day/ week	2-4 days/week	5-7 days/week
...car as a driver	☐	☐	☐	☐	☐	☐
...car as a passenger	☐	☐	☐	☐	☐	☐
...local bus, tram, tube	☐	☐	☐	☐	☐	☐
... train	☐	☐	☐	☐	☐	☐
...bicycle (on the road)	☐	☐	☐	☐	☐	☐
...walk to/from a destination	☐	☐	☐	☐	☐	☐
...scooter/motorcycle	☐	☐	☐	☐	☐	☐
...taxi	☐	☐	☐	☐	☐	☐

C2a. Do you commute to a workplace by driving a car? ☐ Yes ☐ No [if No, *go to C4*]

C2b. On how many days a week do you typically drive to work? _________ days per week

C2c. What is the typical ONE WAY distance of your journey from home to work? __________ miles

C3. What proportion of the mileage you DRIVE in a car is carried out on business/work trips not including travelling to and from work?

None	1-20%	21-40%	41-60%	61%-80%	81-100%
☐	☐	☐	☐	☐	☐

C4. Please can you answer the following:

a. My typical total car driving mileage on a *weekday* is: ____________ miles

b. My typical total car driving mileage on a day at the *weekend* is: ____________ miles

C5. Which ONE of these would you describe yourself as? *Tick ONE box only.*

☐ Mainly a town/ city/ urban driver
☐ Mainly an out of town / motorway driver
☐ Someone who drives fairly equally around town and out of town

C6. Looking at the following list, what would you miss the most if you didn't have a car in the household?
Please tick ONE box only to reflect the most important choice.

☐ Ability to go shopping
☐ Ability to get to work
☐ Ability to carry out business trips
☐ Going to leisure activities
☐ Visiting relatives
☐ Going on holiday
☐ Taking children to school

D. ATTITUDES TOWARDS OWNING AND DRIVING A CAR

In the next two sections we are going to ask you how far you agree or disagree with a number of statements to do with owning and choosing a car. There are no right or wrong answers, so please be completely honest as we are very interested in your views!

D1. We would now like to ask you a few questions about owning a car. How far do you agree or disagree with the following statements? *Please tick one box on each line*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I couldn't manage without a car	☐	☐	☐	☐	☐
I would like to own a larger or faster car	☐	☐	☐	☐	☐
I find driving can be stressful sometimes	☐	☐	☐	☐	☐
I tend to buy the same type/ size of car (e.g. small car, family estate)	☐	☐	☐	☐	☐
I tend to stick to the same *brand* of car (e.g. Ford, Toyota, Nissan)	☐	☐	☐	☐	☐
Driving gives me a chance to express myself	☐	☐	☐	☐	☐
If I could, I would gladly do without a car	☐	☐	☐	☐	☐
I would pay more for a car with lower running costs	☐	☐	☐	☐	☐
A car provides status and prestige	☐	☐	☐	☐	☐
I enjoy driving on my own	☐	☐	☐	☐	☐
It doesn't matter to me which type of car I drive	☐	☐	☐	☐	☐
I don't like driving	☐	☐	☐	☐	☐
Getting good fuel economy out of my car gives me satisfaction	☐	☐	☐	☐	☐
You can tell something about a person by what car he/she has	☐	☐	☐	☐	☐
My car says something about who I am	☐	☐	☐	☐	☐
I like to drive just for the fun of it	☐	☐	☐	☐	☐
I have driven less in the past few years in response to higher fuel prices	☐	☐	☐	☐	☐
I would love to drive in the newest sports car	☐	☐	☐	☐	☐

E. ATTITUDES TOWARDS NEW CARS AND TECHNOLOGY

We would now like to ask you some questions about your attitudes towards new technology and new cars.

E1. How far do you agree or disagree with the following statements?
Please tick one box on each line

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I like to buy new and different technologies	☐	☐	☐	☐	☐
I am not the type of person that needs to be the first to have the newest technology	☐	☐	☐	☐	☐
I generally know more than other people about new technology	☐	☐	☐	☐	☐
I am usually among the first to try new technology	☐	☐	☐	☐	☐
New technology excites me	☐	☐	☐	☐	☐
I often seek out information about new cars	☐	☐	☐	☐	☐
I don't like to be the first to drive cars with the latest technology	☐	☐	☐	☐	☐
I tend to decide on what car to buy by relying on the opinions of friends who have already tried them	☐	☐	☐	☐	☐
When I am choosing a car, I find myself spending a lot of time checking out different models	☐	☐	☐	☐	☐
Prior to buying a new car, I seldom consult my friends/ family	☐	☐	☐	☐	☐
I often influence other people's opinions about cars	☐	☐	☐	☐	☐
When other people are choosing a car to buy, they turn to me for advice	☐	☐	☐	☐	☐
I like magazines / websites about new cars	☐	☐	☐	☐	☐
I am not the sort of person that frequently seeks out new car experiences	☐	☐	☐	☐	☐
I would prefer my car to be fuelled by something other than petrol or diesel	☐	☐	☐	☐	☐

F. YOUR PERSONAL CHARACTERISTICS

You may find this section slightly strange but hopefully fun! Previous research has found there to be a link between a person's personality and their car. We would like to test this out so have included some personality questions here.

F1. How far would you say each of the following is typical or 'characteristic' of you?

Please tick one box on each line

	Very uncharacteristic of me	Moderately uncharacteristic of me	Neither characteristic nor uncharacteristic of me	Moderately characteristic of me	Very characteristic of me
Starting a conversation with a stranger	☐	☐	☐	☐	☐
Making sure others are comfortable and happy	☐	☐	☐	☐	☐
Creating an artwork, piece of writing or music	☐	☐	☐	☐	☐
Preparing for things well in advance	☐	☐	☐	☐	☐
Feeling blue or depressed	☐	☐	☐	☐	☐
Planning social events or parties	☐	☐	☐	☐	☐
Insulting people	☐	☐	☐	☐	☐
Thinking about philosophical or spiritual questions	☐	☐	☐	☐	☐
Letting things get into a mess	☐	☐	☐	☐	☐
Feeling stressed or worried	☐	☐	☐	☐	☐
Using difficult words	☐	☐	☐	☐	☐
Sympathising with others' feelings	☐	☐	☐	☐	☐

INFORMATION ABOUT YOU AND YOUR HOUSEHOLD

There are certain things we need to ask so we can tell whether this survey has been filled out by a broad enough cross-section of the population. You have our word that none of this information will be used to identify you or passed on for any use outside of this project.

G1. Gender: ☐ Male ☐ Female

G2. Year of birth: ___________

G3. Please tell us your highest educational qualification. Start at the top of this list and tick the first one you come to:

- ☐ University Higher Degree (e.g. MSc; PhD)
- ☐ First degree level qualification (e.g. BA; BSc; PGCE)
- ☐ Diploma in higher education; HNC, HND, Nursing or Teaching qualification (excluding PGCE)
- ☐ A Level; AS Level: NVQ Level 3; GNVQ Advanced or equivalent
- ☐ GCSE; CSE, NVQ levels 1&2; GNVQ Foundation & Intermediate or equivalent
- ☐ None of the above

G4. Employment status:

- ☐ Employed ------------------------→ Occupation: _________________
- ☐ Self employed ----------------------→ Occupation: _________________
- ☐ Unemployed and seeking work
- ☐ Looking after family or home/ not seeking work
- ☐ Long term sick or disabled
- ☐ Retired ------------------------→ Previous occupation: _______________
- ☐ In full time education
- ☐ Other

G5. Please tell us your TOTAL HOUSEHOLD annual or weekly income from all sources BEFORE TAX and other deductions:

- ☐ Up to £9,999 per annum (£199 per week)
- ☐ £10,000 to £19,999 per annum (£200 - £389 per week)
- ☐ £20,000 to £29,999 per annum (£390 - £579 per week)
- ☐ £30,000 to £39,999 per annum (£580 - £769 per week)
- ☐ £40,000 to £49,999 per annum (£770 - £969 per week)
- ☐ £50,000 to £74,999 per annum (£970 - £1,449 per week)
- ☐ £75,000 to £99,999 per annum (£1,450 – £1,959 per week)
- ☐ £100,000 to £149,999 per annum (£1,960 - £2939 per week)
- ☐ £150,000 or more per annum (£2,940 or more per week)
- ☐ I would rather not answer

G6. Including you, how many people in the following age groups live in your household?

- Under 2 years old __________
- 2 years – 16 years __________
- 17 years – 64 years __________
- 65 + years __________

G7. Are you:

- ☐ Married/Civil partnership
- ☐ Living with a partner
- ☐ Separated/ Divorced
- ☐ Widowed
- ☐ Living alone
- ☐ Living with parents
- ☐ Other

G8. What is your home postcode (e.g. AB25 3XB)? _______/_______ This is really important data for us because it allows us to plot responses geographically and ensure we capture a good geographical spread. Please be assured that this will ONLY be used for this research, will not be passed on to any third parties and all your responses to this survey will be kept strictly anonymous.

G. KNOWLEDGE ABOUT ELECTRIC CARS

We are about to give you some information to read about cars that get some or all of their power from a battery which is charged by plugging in to an electricity supply ('Plug-in electric cars').

H1. Before we do this, how informed do you already feel about plug-in electric cars?

Totally uninformed	Quite uninformed	Neither informed nor uninformed	Quite informed	Very informed
☐	☐	☐	☐	☐

H2. Please indicate your agreement with the following :

"In the next 5 years, I would choose to have a plug-in hybrid electric car *(i.e. one that works on both a battery that you plug-in and petrol/diesel)"* ***...***

	Not at all likely	Fairly unlikely	Neither likely nor unlikely	Fairly likely	Very likely
... as my main car	☐	☐	☐	☐	☐
... as a second car	☐	☐	☐	☐	☐

H3. Please indicate your agreement with the following:

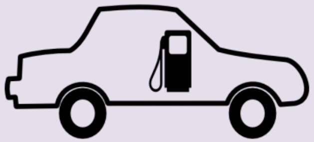
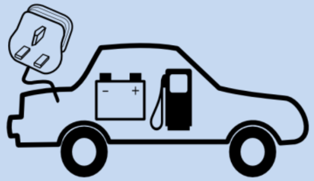
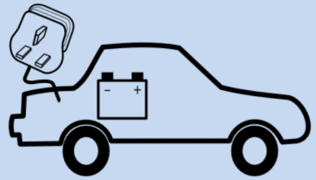
"In the next 5 years, I would choose to have a fully electric car *(i.e. one that works* one that works only on a battery that you plug-in*)"* ***...***

	Not at all likely	Fairly unlikely	Neither likely nor unlikely	Fairly likely	Very likely
...as my main car	☐	☐	☐	☐	☐
... as a second car	☐	☐	☐	☐	☐

H. INFORMATION ABOUT ELECTRIC CARS

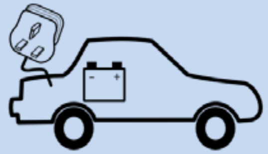
This is the final section for now and does not require you to answer any questions! When you return to complete the second part of this survey, we will be asking you your thoughts on plug-in electric cars. We would really appreciate it if you could read the following information now so that you are clear about the types of cars we are interested in. You will not be tested on your knowledge of this information, but it will be beneficial for you to have read it. It should take about 5 minutes to read this through.

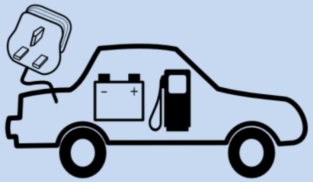
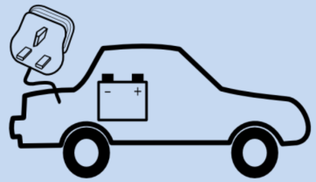
Appendix L Quantitative questionnaire: Pre-read information

		Plug-in cars	
Conventional car	Conventional Hybrid car	Plug-in Hybrid Electric car	Plug-in Fully Electric car
			
Most use petrol/ diesel only. Sometimes we just refer to this as a 'normal' car.	A conventional hybrid electric car, like the Toyota Prius, has a petrol/diesel engine *and* an electric motor powered by a small battery. The battery gets charged when the engine is running. It does not need to be plugged in to an electrical socket to charge the battery. Battery power is mainly used at lower speeds, like when in traffic, which saves fuel.	A plug-in hybrid is like a conventional hybrid electric car with both a petrol/ diesel engine *and* an electric motor. BUT, the battery can be charged by plugging it in to a normal electrical socket (like you have at home) or dedicated charging point as needed. The battery also gets charged when the engine is running. If you run out of charge you can continue driving as long as there is petrol or diesel in the tank. The car will use the electric motor whenever possible to save fuel, but also uses power from the petrol/diesel engine when required.	This is powered ONLY by a battery which is charged by plugging it in to a normal electric socket (like you have at home) or dedicated charging point as needed. No petrol or diesel is therefore required.

Remember that in a 'plug-in hybrid' you can continue to drive it using the petrol/diesel engine after you have used the battery charge. In a 'fully electric car' you must recharge the vehicle when the battery has run out of charge.

Here is some more detailed information just about the two plug-in types of car.

	Plug-in cars	
	Plug-in Hybrid Electric car	Plug-in Fully Electric car
		
	Note that in Part 2 of the survey, we will use the term 'plug-in electric car' to mean both of these types of cars unless we specify otherwise	
Driving	• will use power from the battery whenever possible. • the engine will be used when the battery has run out of charge or when lots of power is needed, for example for overtaking	• has no gears and is therefore similar to driving an automatic car • acceleration is smooth and quiet
Running costs	• lower than a typical car – the electric motors reduce the fuel consumption of the car (the car does more miles per gallon), and electricity is cheaper than petrol/diesel for the same amount of energy	• lower than a typical car because they are more efficient, and electricity costs less than petrol/diesel for the same amount of energy.
Maintenance	• battery capacity may reduce after a few years and need to be replaced	• has an electric motor instead of an engine so has fewer moving parts, meaning expected lower maintenance needs • battery capacity may reduce after a few years
Noise levels	• when using the electric engine there is almost no engine noise	• the electric motor is much quieter than the engine in a normal car
Range	• has the same range as a standard petrol/diesel car, and can also be driven using the electric motor only as long as the battery is charged • will keep on running even when it runs out of charge as long as there is petrol or diesel in the tank • there will be instruments inside the car which tell you how much battery charge and petrol/diesel you have left	• range tends to be lower than a typical car • will stop running once the battery runs out of charge • there will be instruments inside the car which tell you how much battery charge you have left

	Plug-in cars	
	Plug-in Hybrid Electric car	Plug-in Fully Electric car
		
Refuelling and recharging	• requires standard refuelling with petrol/diesel at a service station and recharging by attaching a cable to the car and plugging the other end into a standard household plug socket • it can be charged at home although charging points exist in some public places • a full charge can take up to 6 hours although the battery can be topped up like a mobile phone battery • fast-charging might be available in certain places where the car could be 80% charged in around 15 minutes	• recharged by attaching a cable to the car and plugging the other end into a standard household plug socket • it can be charged at home although charging points exist in some public places • a full charge can take up to 8 hours although the battery can be topped up like a mobile phone battery • fast-charging might be available in certain places where the car could be 80% charged in around 30 minutes
	Note that in Part 2 of the survey, we will use the term 'public places' to capture the idea that charging points may be placed in a variety of places such as public car parks, supermarket car parks, on-street etc.	
Environmental impact	• lower emissions from the exhaust pipe compared to a normal car due to use of the electric motor • some CO_2 is emitted during the production of electricity for the vehicle	• no exhaust pipe so zero emissions from the car itself • some CO_2 is emitted during the production of electricity for the vehicle.
	Note that in Part 2 of the survey, we will use a figure for CO_2 emissions that is equivalent to both the emissions from the burning of the petrol/ diesel + the electricity generation	

Thank you very much indeed and we look forward to getting your response to Part 2 when you fill it out in a day or two.

Appendix M Quantitative questionnaire: Wave 2

PART 2

A. YOUR KNOWLEDGE AND EXPERIENCE OF PLUG-IN CARS

In the first part of the survey, we gave you this information to read ....

	Plug-in cars	
Conventional Hybrid car	**Plug-in Hybrid Electric car**	**Plug-in Fully Electric car**
		
A conventional hybrid electric car, like the Toyota Prius, **has a petrol/diesel engine *and* an electric motor powered by a small battery**. The battery gets charged when the engine is running. **It does not need to be plugged in to an electrical socket to charge the battery**. Battery power is mainly used at lower speeds, like when in traffic, which saves fuel.	A plug-in hybrid is like a conventional hybrid electric car with **both a petrol/ diesel engine *and* an electric motor.** BUT, the battery **can be charged by plugging it in to a normal electrical socket** (like you have at home) or dedicated charging point as needed. The battery also gets charged when the engine is running. **If you run out of charge you can continue driving as long as there is petrol or diesel in the tank.** The car will use the electric motor whenever possible to save fuel, but also provides power from the petrol/diesel engine when required.	This is **powered ONLY by a battery** which is charged by plugging it in to a normal electric socket (like you have at home) or dedicated charging point as needed. **No petrol or diesel is therefore required.**

If you need to refer to the vehicle descriptions at any time, please click this symbol where you see it located on each page:

A1. Since completing Part 1 of our survey, did you read any *other* information on plug-in electric cars in addition to the material we supplied?

Yes

No

Have you ever had any experience of:

A conventional hybrid car (one that you don't need to plug-in):

A2a. As a driver
- ☐ A lot
- ☐ A little
- ☐ None

A2b. As a passenger
- ☐ A lot
- ☐ A little
- ☐ None

A plug-in hybrid electric car (one that you need to plug-in to charge a small battery but it also has a petrol/diesel tank):

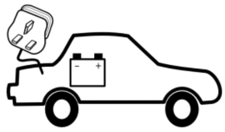
A3a. As a driver
- ☐ A lot
- ☐ A little
- ☐ None

A3b. As a passenger
- ☐ A lot
- ☐ A little
- ☐ None

A plug-in fully electric car (one that only runs on a battery that you have to plug-in):

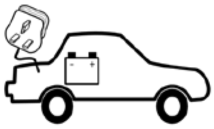
A4a. As a driver
☐ A lot
☐ A little
☐ None

A4b. As a passenger
☐ A lot
☐ A little
☐ None



B. YOUR THOUGHTS ABOUT PLUG-IN CARS IN GENERAL

These few questions are about plug-in hybrid electric cars and plug-in fully electric cars. Please answer these even if you have had no experience of these cars.



B1. Compared to a normal car, plug in cars are generally…: *Please tick one box on each line*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a very exciting new technology	☐	☐	☐	☐	☐
a current fad which will soon disappear	☐	☐	☐	☐	☐
more expensive to buy than normal cars	☐	☐	☐	☐	☐
more expensive to run than normal cars	☐	☐	☐	☐	☐
as safe for the driver and passengers as normal cars	☐	☐	☐	☐	☐
more complicated than a normal car	☐	☐	☐	☐	☐
too new to be reliable	☐	☐	☐	☐	☐

B2. How far do you agree or disagree with the following statements? *Please tick one box on each line*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Finding somewhere at home to park a plug-in car near an electric socket would be difficult for me	☐	☐	☐	☐	☐
The chances of breaking down in a plug-in car are higher than in a normal car	☐	☐	☐	☐	☐
I would only consider a plug-in car if there were plenty to choose from among the main car dealers	☐	☐	☐	☐	☐
I like the idea of being able to refuel at home rather than have to go to petrol stations	☐	☐	☐	☐	☐
I would like to be less dependent on oil companies for fuelling my car	☐	☐	☐	☐	☐

Plug-in cars are a good thing because it makes us less dependent on oil	☐	☐	☐	☐	☐
Driving a plug-in car would give me a 'feel good factor' because of its green credentials	☐	☐	☐	☐	☐
The environmental benefits of plug-in cars have been over exaggerated	☐	☐	☐	☐	☐
I am the type of person who would drive a plug-in car	☐	☐	☐	☐	☐

C. YOUR THOUGHTS ABOUT PLUG-IN HYBRID ELECTRIC CARS

These few questions are only about plug-in hybrid electric cars i.e. those that work on both petrol/diesel *and* a battery that you plug-in. Please answer these even if you have had no experience of these cars.

C1. Compared to a normal car, plug-in hybrid electric cars are: *Please tick one box on each line*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
... similar to a normal car in most respects	☐	☐	☐	☐	☐
... inferior to normal cars in terms of performance	☐	☐	☐	☐	☐
... not suitable for my lifestyle	☐	☐	☐	☐	☐
... good for the environment	☐	☐	☐	☐	☐
... pleasant to drive	☐	☐	☐	☐	☐
... impractical	☐	☐	☐	☐	☐
... a really good idea	☐	☐	☐	☐	☐
... a cheaper option over the longer term	☐	☐	☐	☐	☐

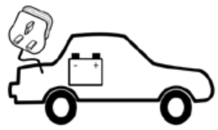
C2. How far do you agree or disagree with the following statements? *Please tick one box on each line*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I would be interested in driving a plug-in hybrid electric car	☐	☐	☐	☐	☐
A plug-in hybrid electric car would suit my daily travel patterns	☐	☐	☐	☐	☐
Having a plug-in hybrid electric car would mean I would have to plan journeys carefully	☐	☐	☐	☐	☐
I would prefer to drive a normal car than a plug-in hybrid electric car	☐	☐	☐	☐	☐
If I had a plug-in hybrid electric car, I would mainly charge it at home or work	☐	☐	☐	☐	☐
Adapting to charging a plug-in hybrid car would be difficult for me	☐	☐	☐	☐	☐

If I had a plug-in hybrid electric car, it would be unlikely to be my main/ only car	☐	☐	☐	☐	☐
I know many people whom I think would be attracted to a plug-in hybrid electric car	☐	☐	☐	☐	☐
I would be prepared to pay more for a plug-in hybrid electric car than a normal car	☐	☐	☐	☐	☐
I would only consider a plug-in hybrid electric car if I knew I had access to a rapid charging point (i.e. somewhere it would charge in less than half an hour)	☐	☐	☐	☐	☐
I would feel embarrassed to drive a plug-in hybrid electric car	☐	☐	☐	☐	☐
When driving a plug-in hybrid electric car, I would always be worried about running out of charge	☐	☐	☐	☐	☐
I would feel proud of having a plug-in hybrid electric car outside my house	☐	☐	☐	☐	☐

D. YOUR THOUGHTS ABOUT PLUG-IN FULLY ELECTRIC CARS

We now repeat these questions but this time ask you about plug-in fully electric cars i.e. those that work only on a battery that you plug-in. Sorry for the repetition! Please answer these even if you have had no experience of these cars.



D1. Compared to a normal car, plug-in fully electric cars are: *Please tick one box on each line*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
... similar to a normal car in most respects	☐	☐	☐	☐	☐
... inferior to normal cars in terms of performance	☐	☐	☐	☐	☐
... not suitable for my lifestyle	☐	☐	☐	☐	☐
... good for the environment	☐	☐	☐	☐	☐
... pleasant to drive	☐	☐	☐	☐	☐
... impractical	☐	☐	☐	☐	☐
... a really good idea	☐	☐	☐	☐	☐
... a cheaper option over the longer term	☐	☐	☐	☐	☐
... a danger to people outside the car because of the lack of engine noise	☐	☐	☐	☐	☐

D2. How far do you agree or disagree with the following statements? *Please tick one box on each line*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I would be interested in driving a plug-in fully electric car	☐	☐	☐	☐	☐
A plug-in fully electric car would suit my daily travel patterns	☐	☐	☐	☐	☐
Having a plug-in fully electric car would mean I would have to plan journeys carefully	☐	☐	☐	☐	☐
I would prefer to drive a normal car than a plug-in fully electric car	☐	☐	☐	☐	☐
If I had a plug-in fully electric car, I would mainly charge it at home or work	☐	☐	☐	☐	☐
Adapting to charging a plug-in fully electric car would be difficult for me	☐	☐	☐	☐	☐
If I had a plug-in fully electric car, it would be unlikely to be my main/ only car	☐	☐	☐	☐	☐
I know many people whom I think would be attracted to a plug-in fully electric car	☐	☐	☐	☐	☐
I would be prepared to pay more for a plug-in fully electric car than a normal car	☐	☐	☐	☐	☐
I would only consider a plug-in fully electric car if I knew I had access to a rapid charging point (i.e. somewhere it would charge in less than half an hour)	☐	☐	☐	☐	☐
I would feel embarrassed to drive a plug-in fully electric car	☐	☐	☐	☐	☐
When driving a plug-in fully electric car, I would always be worried about running out of charge	☐	☐	☐	☐	☐
I would feel proud of having a plug-in fully electric car outside my house	☐	☐	☐	☐	☐

CHOICE EXPERIMENT

E. INCENTIVES TO ENCOURAGE THE ADOPTION OF PLUG-IN CARS

You are very nearly at the end! In this section, we would like to ask you how likely you might be to choose a plug-in car under various circumstances.

Please indicate your agreement with the following :

E1. "In the next 5 years, I would choose to have a plug-in <u>hybrid electric car</u>
*(i.e. one that works on <u>both</u> petrol/diesel and a battery that you plug-in)" **...***

	Not at all likely	Fairly unlikely	Neither likely nor unlikely	Fairly likely	Very likely
... as my main car	☐	☐	☐	☐	☐
... as a second car	☐	☐	☐	☐	☐

E2. "In the next 5 years, I would choose to have a <u>fully electric car</u>
(i.e. one that works one that works <u>only</u> on a battery that you plug-in*)" **...***

	Not at all likely	Fairly unlikely	Neither likely nor unlikely	Fairly likely	Very likely
...as my main car	☐	☐	☐	☐	☐
... as a second car	☐	☐	☐	☐	☐

E3. Compared to your answers above, how much more likely would you be to buy a plug-in car if the following policies were in place? *Please tick one box on each line*

	Much more likely	Somewhat more likely	No more likely
Exemption from road tax (Vehicle Excise Duty) for owners of plug-in cars	☐	☐	☐
Priority lanes (permission to use bus/ taxi lanes)	☐	☐	☐
A Government grant (i.e. money off the purchase of a plug-in car)	☐	☐	☐
Exemption from congestion charges	☐	☐	☐
Exemption from road tolls (e.g. M6 Birmingham Relief Road or Severn Bridge)	☐	☐	☐
Higher fuel costs for petrol and diesel cars	☐	☐	☐
Low interest loans available when buying plug-in cars	☐	☐	☐
Extended warranties for battery performance (e.g. batteries guaranteed for the life of the car)	☐	☐	☐
Reduction in company car tax (<u>leave blank if N/A</u>)	☐	☐	☐

E4. Electricity for plug-in cars may be available at charging points in public places such as supermarkets and car parks. Compared to your answers in E1 and E2, please say how likely you would be to buy a plug-in car if the following were true: *Please tick one box on each line*

	Much less likely	Somewhat less likely	Same	Somewhat more likely	Much more likely
The electricity from public charging points costs the same as the petrol or diesel would to drive the same distance	☐	☐	☐	☐	☐
The electricity from public charging points costs half as much as the petrol or diesel would to drive the same distance	☐	☐	☐	☐	☐
The electricity from public charging points is free	☐	☐	☐	☐	☐

F. ATTITUDES TOWARDS THE ENVIRONMENT

Finally, we would like to ask you how you feel about environmental issues. Please be perfectly honest with us!

F1. How far do you agree or disagree with the following statements? *Please tick one box on each line*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Most people I know do their bit for the environment these days	☐	☐	☐	☐	☐
Being environmentally responsible is an important part of who I am	☐	☐	☐	☐	☐
It's not worth me doing things to help the environment if others don't do the same	☐	☐	☐	☐	☐
I feel a moral obligation to reduce my emission of greenhouse gases	☐	☐	☐	☐	☐
What I do in life doesn't make any real difference to the environment	☐	☐	☐	☐	☐
I am not the type of person to worry about being 'green'	☐	☐	☐	☐	☐
The so called 'environmental crisis' has been greatly exaggerated	☐	☐	☐	☐	☐
Sometimes I feel under pressure to say that I am doing more to help the environment than I am	☐	☐	☐	☐	☐
I am worried that the world is running out of oil	☐	☐	☐	☐	☐
Reducing my car's environmental impact would make me feel good	☐	☐	☐	☐	☐
Reducing my car's environmental impact would be good for society	☐	☐	☐	☐	☐
I would be willing to pay more for a car if I knew it was less harmful to the environment	☐	☐	☐	☐	☐
I would not buy a more efficient car just because it is environmentally friendly	☐	☐	☐	☐	☐
People should be allowed to use their car as much as they like	☐	☐	☐	☐	☐

Thank you so much for completing this survey.
Your answers are very valuable to us.

Appendix N Factor analysis details

N.1 Factor Analysis methodology and results

- Principal components + varimax rotation
- The factor analysis was an iterative process. Several factor analyses were run in order to arrive at the final solution.
- The nature of each factor is inferred from the variables that load most heavily on it. Firstly, however, the loadings were inspected in order to ensure that each item loaded principally on one factor only. The threshold for factor loadings was set at 0.40 on the principal factor and a difference of at least 0.50 between subsequent loadings. Some items failed these loading criteria and were discarded and the extraction carried out once more.
- Reliability analysis using Cronbach's Alpha (α) was another cause of the elimination of variables and repetition of the analysis. A scale is internally consistent to the extent that items are correlated. Cronbach's Alpha provides a summary statistic to this effect. Alpha coefficients range from 0 to 1 and may be used to describe the reliability of each factor. Consistent with the literature, 0.6 was considered to be an acceptable reliability coefficient. In each case, items which did not appear to be measuring the same construct thereby causing a lower alpha value were deleted.

	Factor Loading	Cronbach's Alpha	Interpretation
Environmental Identity			
Qf1f. I am not the type of person to worry about being `green` (REVERSE CODED)	.796	0.88	Concern for and identity with environmental issues
Qf1b. Being environmentally responsible is an important part of who I am	.736		
Qf1e. What I do in life doesn`t make any real difference to the environment (REVERSE CODED)	.710		
Qf1d. I feel a moral obligation to reduce my emission of greenhouse gases	.707		
Qf1g. The so called `environmental crisis` has been greatly exaggerated (REVERSE CODED)	.695		
Qf1j. Reducing my car`s environmental impact would make me feel good	.644		
Qf1k. Reducing my car`s environmental impact would be good for society	.621		
Qf1c. It`s not worth me doing things to help the environment if others don`t do the same (REVERSE CODED)	.591		
Qf1m. I would not buy a more efficient car just because it is environmentally friendly (REVERSE CODED)	.498		
EV Positives			
Qc1d. Compared to a normal car, PHEVss are: ... good for the environment	.701	0.85	Belief in environmental and general benefits of BEVs/PHEVs
Qd1d. Compared to a normal car, BEVs are: ... good for the environment	.696		
Qc1h. Compared to a normal car, PHEVss are: ... a cheaper option over the longer term	.691		
Qd1h. Compared to a normal car, BEVs are: ... a cheaper option over the longer term	.652		
Qc1g. Compared to a normal car, PHEVs are: ... a really good idea	.543		
Qb2h. The environmental benefits of plug-in cars have been over exaggerated (REVERSE CODED)	.475		
Qd1g. Compared to a normal car, BEVs are: ... a really good idea	.471		

BEV Anxieties			
Qd2h. If I had a plug-in fully electric car, it would be unlikely to be my main/ only car (REVERSE CODED)	.717	0.82	Concern about some of the practical aspects of BEVs
Qd2m. When driving a plug-in fully electric car, I would always be worried about running out of charge (REVERSE CODED)	.652		
Qd2b. A plug-in fully electric car would suit my daily travel patterns	.637		
Qd2c. Having a plug-in fully electric car would mean I would have to plan journeys carefully (REVERSE CODED)	.635		
Qd2g. Adapting to charging a plug-in fully electric car would be difficult for me (REVERSE CODED)	.612		
Qd1f. Compared to a normal car, BEVs are: ... impractical (REVERSE CODED)	.593		
EV Openness			
Qb2e. I would like to be less dependent on oil companies for fuelling my car	.793	0.87	Desire for oil independence & excitement about EV technology
Qb2d. I like the idea of being able to refuel at home rather than have to go to petrol stations	.742		
Qb2f. Plug-in cars are a good thing because it makes us less dependent on oil	.701		
Qb2g. Driving a plug-in car would give me a `feel good factor` because of its green credentials	.530		
Qb2i. I am the type of person who would drive a plug-in car	.507		
Qb1a. Compared to a normal car, plug in cars are generally: ...: a very exciting new technology	.415		
PHEV Anxieties			
Qc2c. Having a plug-in hybrid electric car would mean I would have to plan journeys carefully (REVERSE CODED)	.670	0.80	Concern about some of the practical aspects of PHEVs
Qc2l. When driving a plug-in hybrid electric car, I would always be worried about running out of charge (REVERSE CODED)	.633		
Qc2g. If I had a plug-in hybrid electric car, it would be unlikely to be my main/ only car (REVERSE CODED)	.614		
Qc2f. Adapting to charging a plug-in hybrid car would be difficult for me (REVERSE CODED)	.565		
Qc1f. Compared to a normal car, PHEVs are: ... impractical (REVERSE CODED)	.555		
Qc2b. A plug-in hybrid electric car would suit my daily travel patterns	.547		
Innovativeness			
E1d. I am usually among the first to try new technology	.820	0.89	A desire to own and be seen with the latest technology
E1e. New technology excites me	.800		
E1a. I like to buy new and different technologies	.799		
E1c. I generally know more than other people about new technology	.791		
Car Authority			
E1l. When other people are choosing a car to buy, they turn to me for advice	.800	0.84	General car enthusiasm/ self proclaimed knowledge about cars
E1k. I often influence other people`s opinions about cars	.769		
E1m. I like magazines / websites about new cars	.730		
E1f. I often seek out information about new cars	.711		
EV Instrumental			
Qb1g. Compared to a normal car, plug in cars are generally: ...: too new to be reliable (REVERSE CODED)	.650	0.69	Belief in reliability and economy compared to ‘normal’ cars
Qb2b. The chances of breaking down in a plug-in car are higher than in a normal car (REVERSE CODED)	.591		
Qb1f. Compared to a normal car, plug in cars are generally: ...: more complicated than a normal car (REVERSE CODED)	.582		
Qb1d. Compared to a normal car, plug in cars are generally: ...: more expensive to run than normal	.521		

cars (REVERSE CODED)			
Qb1b. Compared to a normal car, plug in cars are generally: ...: a current fad which will soon disappear (REVERSE CODED)	.465		
EV Symbolic			
Qd2l. I would feel embarrassed to drive a plug-in fully electric car (REVERSE CODED)	.673	0.82	Embarrassment/ pride in owning and driving an EV
Qc2k. I would feel embarrassed to drive a plug-in hybrid electric car (REVERSE CODED)	.645		
Qd2n. I would feel proud of having a plug-in fully electric car outside my house	.474		
Qc2m. I would feel proud of having a plug-in hybrid electric car outside my house	.404		
Car Symbolism			
D1n. You can tell something about a person by what car he/she has	.869	0.82	Belief that cars are an expression of personality and status
D1o. My car says something about who I am	.861		
D1i. A car provides status and prestige	.685		
EV Willingness to pay			
Qc2i. I would be prepared to pay more for a plug-in hybrid electric car than a normal car	.746	0.82	Willingness to pay more for EVs and environmental benefits
Qd2j. I would be prepared to pay more for a plug-in fully electric car than a normal car	.706		
Qf1l. I would be willing to pay more for a car if I knew it was less harmful to the environment	.645		
Driving affect			
D1l. I don`t like driving (REVERSE CODED)	.801	0.75	General enjoyment of driving and emotional aspects
D1j. I enjoy driving on my own	.775		
D1p. I like to drive just for the fun of it	.742		
D1f. Driving gives me a chance to express myself	.533		
EV Affect			
Qc1b. Compared to a normal car, PHEVs are: ... inferior to normal cars in terms of performance (REVERSE CODED)	.539	0.70	eliefs about performance and driving experience of EVs
Qc1a. Compared to a normal car, PHEVs are: ... similar to a normal car in most respects	.530		
Qc1e. Compared to a normal car, PHEVs are: ... pleasant to drive	.520		
Qd1b. Compared to a normal car, BEVs are: ... inferior to normal cars in terms of performance (REVERSE CODED)	.500		
Qd1a. Compared to a normal car, BEVs are: ... similar to a normal car in most respects	.468		
Qd1e. Compared to a normal car, BEVs are: ... pleasant to drive	.456		
Qb1e. Compared to a normal car, plug in cars are generally: ...: as safe for the driver and passengers as normal cars	.335		
EV Infrastructure			
Qd2k. I would only consider a plug-in fully electric car if I knew I had access to a rapid charging point (i.e. somewhere it would charge in less than half an hour) (REVERSE CODED)	.785	0.69	Desire to wait for rapid charging infrastructure
Qc2j. I would only consider a plug-in hybrid electric car if I knew I had access to a rapid charging point (i.e. somewhere it would charge in less than half an hour) (REVERSE CODED)	.751		
Car Loyalty			
D1e. I tend to stick to the same brand of car (e.g. Ford, Toyota, Nissan) (Reverse coded)	.842	0.59	Tendency to stick to the same brand and size/type of car
D1d. I tend to buy the same type/ size of car (e.g. small car, family estate) (REVERSE CODED)	.813		

Appendix O Cluster analysis methodology

The selection of appropriate clustering algorithms (i.e. the rules or procedures followed to sort observations) is critical to the effective use of cluster analysis (Punj & Stewart, 1983; Ketchen & Shook, 1996). A variety of procedures for forming clusters have been developed. Most of the commonly used algorithms can be classified into two general types: (i) agglomerative/hierarchical and (ii) iterative/non-hierarchical methods, each representing a unique perspective on the creation of groups. However, different results can be obtained when different methods are applied to the same data (Aldenderfelder & Blashfield, 1984) and each method has different strengths and weaknesses.

A combination of the two types of method has been used in this analysis. A hierarchical method is used first in an exploratory 'structure-seeking' phase, followed by the iterative partitioning method (K-means) to 'fine tune' the analysis (Hair et al., 1998) .

Non-hierarchical procedures have become dominant for segmenting the large data sets typically encountered in marketing. This method requires the number of clusters to be specified at the outset. K-means is used as it performs better than any other clustering algorithm so long as a non-random starting point is specified. However, segmentation analysis usually begins 'blind' without exact prior knowledge of how many groups are present or even whether there are any clusters in the data. As a result, a two stage procedure was used:

1. Exploratory structure seeking phase: agglomerative cluster analysis to create solutions and cluster centres.
2. Replication of the exploratory results using the centroids as starting points in K-means and a series of 'tests' to choose the optimum number of clusters.

Whilst being more time consuming, research has shown that this two stage approach increases the validity of solutions (Punj & Stewart, 1983).

O.1 Agglomerative clustering

The objective of this phase was to reveal the number and structure of the clusters that represent the data most effectively. Hierarchical algorithms progress in a stepwise fashion through the data producing a series of solutions ranging from n clusters (where n is the number of objects in the data set) to a solution with only one cluster present. A variety of methods are available and equally numerous are the number of 'stopping' rules developed to identify the appropriate number of clusters. Different algorithms use different mathematical procedures to calculate the distance between the clusters. All the algorithms, however, suffer from a number of problems. Firstly, rarely is the underlying structure of a sample known in advance, making it difficult to select the correct algorithm. Secondly, these algorithms make only one pass through the data and therefore poor clustering assignments cannot be modified (Hair et al., 1998). Nevertheless, agglomerative cluster analysis is useful for establishing a range of possible cluster solutions and producing initial cluster seeds which can then be used in K-means analysis.

Most hierarchical clustering procedures can handle only a small number of cases and do not consistently produce clusters that are clearly homogenous and well balanced. Consequently, Ward's method of hierarchical cluster analysis is used here as a starting point[39].

As a result of the exploratory factor and regression analysis, the following set of 16 variables was subjected to Ward's method:

Factor scores

1. PHEV Anxieties
2. BEV Anxieties
3. EV Symbolic
4. EV Openness
5. EV Instrumental
6. EV Positives
7. EV Willingness to pay
8. EV Affect
9. Environmental Identity
10. Innovativeness
11. EV Infrastructure
12. Car Authority

Z scores based on single item statements

13. BEV Identity
14. PHEV Identity
15. Parking Difficulty
16. WTP Fuel savings

As indicated by the Dendrogram[40] (Figure 93), there is no definitive way of choosing the number of clusters. This diagram indicates that anywhere between four and nine clusters could be taken forward for analysis. Circles have been placed on this diagram to indicate a possible six cluster solution, but other solutions can also be spotted. In addition to this method, therefore, time was spent at this stage profiling different cluster solutions (from four to nine segments) on the basis of key characteristics such as the likelihood to adopt a PHEV or BEV. The four cluster solution was found to not show enough variation or differentiation between the clusters and the eight and nine cluster solution was found to derive segments with very similar levels of likelihood or simply taking on the average sample characteristics. Therefore, five, six and seven cluster solutions were taken forward to the next step.

[39] Ward's method was used to maximise within-cluster homogeneity because it is a frequently used clustering algorithm known to produce stable and interpretable results (Punj & Stewart 1983). This method is designed to minimize the variance within the clusters as opposed to the variance between the clusters. The distance between two clusters (Squared Euclidean Distance) is the sum of squares between two clusters summed over all variables. In addition, this method was found to produce the best cluster solution in this study when compared to other algorithms. 'Best' in this case means the identification of the most meaningful, interpretable and distinguishable segments.

[40] In agglomerative clustering, each individual starts out as its own cluster. In subsequent steps, the two closest individuals are combined into a new cluster, thus reducing the number of clusters by one in each step. In some steps, groups of individuals formed at an earlier stage may join together in a new cluster. Eventually, all individuals are grouped into one large cluster. Because the results at the earlier stages are always nested within the results at a later stage, this can be represented visually as a 'tree' graph or dendrogram. The dendrogram is read from left to right. Vertical lines show joined clusters. The position of the line on the scale indicates the distance at which clusters are joined. The observed distances are rescaled to fall into the range of 1 to 25, so you do not see the actual distances; however, the ratio of the rescaled distances within the dendrogram is the same as the ratio of the original distances. In the last few steps, fairly dissimilar clusters are combined. As explained, cluster analysis works upwards to place every case into a single cluster. Therefore, we end up with a single fork that subdivides at lower levels of similarity.

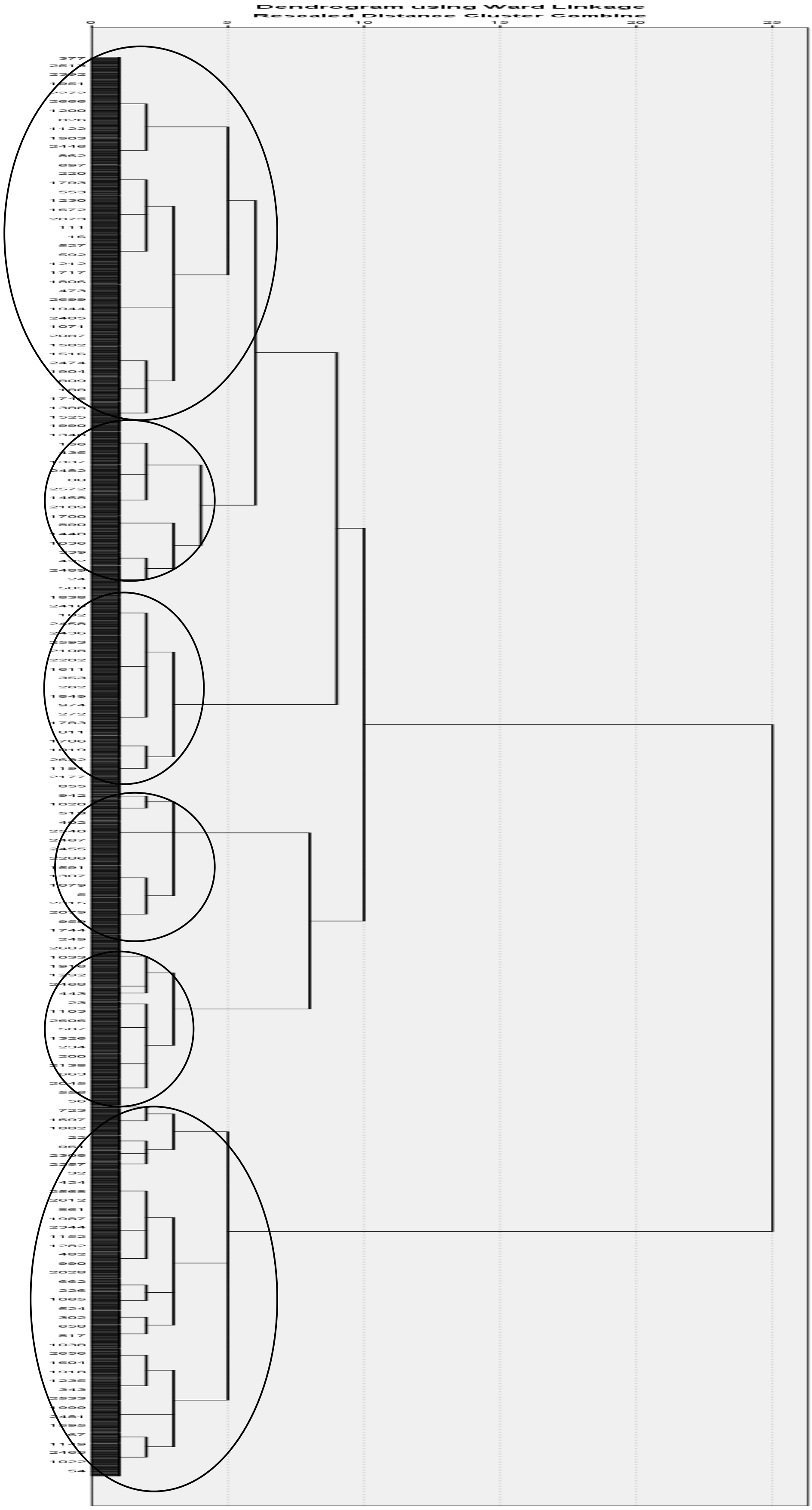


Figure 93: Dendrogram to aid cluster identification (N=2,729)

O.2 K-means cluster analysis and choosing the best clustering solution

Once a range of likely cluster solutions and cluster 'centres' has been established by the agglomerative method, K-means cluster analysis can be used. The cluster means from the agglomerative procedure are used as starting points for a K-means analysis[41]. The number of clusters was specified at five, six and seven. Given these cluster centres, each subject is assigned to the group with the closest centre. The analysis proceeds to re-compute the centre and reassign subjects iteratively to the newly formed clusters with the goal of minimising the variability within clusters whilst maximising the variability between clusters[42]. During each iteration cycle, cases are 'passed' from one cluster to another improving the homogeneity of the clusters.

As with factor analysis, cluster analysis presents the problem of choosing the number of clusters to be used to describe the data structure. However, no standard objective criterion exists to determine the number of clusters. The selection criterion suggested in the literature range from highly subjective to complex mathematical procedures.

A combination of statistical and intuitive evaluation methods has been used here.

ANOVA

Using the 12 factor and four z-scores, a one way ANOVA was performed for the different cluster solutions (five, six and seven). This measures the degree of discreteness of the clusters for each of the solutions. The best solution is one where the centres of each cluster (mean (factor) scores on the clustering variables) should be as distant from one another as possible and the cloud of data points surrounding each cluster centre should be as concentrated as possible. Moreover, the differences in mean values of the variables at each cluster centre should be statistically significant.

The ANOVA procedure examines the variability of the observations within each cluster as well as the variability between group means (producing the 'F' ratio). Based on these two estimates of variability, conclusions as to the significance of the differences in the means can be drawn. The higher the 'F' ratio, the more there is variability between groups compared to within them and the more discrete and concentrated are the clusters. Accordingly, an F ratio was calculated for each variable for each of the cluster solutions, as shown in the following table. This procedure indicates that the six cluster solution may be marginally better than five clusters. As a result, subjective criteria were used to finally decide upon the solution to use.

[41] Iterative partitioning methods make more than one pass through the data set, eliminating problems of undesirable early combinations that are common in hierarchical procedures. By using the cluster centres generated by the prior hierarchical clustering procedure, problems of the cluster results being biased by the order of the observations are alleviated.

[42] The iterative clustering procedure places observations in the clustering groups by minimising the sum of the squared distances from cluster group means. The initial seeds are then replaced by the means of the clusters and the process is repeated until no more changes are made in the clusters (Hair et al., 1998).

Table 68: F Ratio scores for each of the post-hoc cluster solutions

	5 Clusters	6 Clusters	7 Clusters
Environmental Identity	16.237	46.427	38.981
BEV Anxieties	260.274	252.761	228.918
EV Positives	41.851	39.623	114.953
PHEV Anxieties	237.63	222.651	199.400
EV Openness	43.133	37.189	50.191
Innovativeness	14.555	62.461	42.706
Car Authority	19.409	20.235	32.823
EV Instrumental	49.059	42.925	41.448
EV Willingness to pay	71.873	136.517	152.913
EV Symbolic	61.131	67.369	55.249
EV Affect	5.93	6.824	8.245
EV Infrastructure	36.114	38.976	44.955
BEV Identity	509.391	512.795	411.349
PHEV Identity	567.766	570.435	471.972
WTP	119.441	111.809	99.841
Parking	380.64	284.833	199.499
Total ANOVA	**2434.434**	**2453.83**	**2193.443**

Subjective criterion

In selecting the appropriate number of clusters, two conflicting considerations have to be balanced. On the one hand, if too few clusters are used, information is lost by merging distinct clusters and the groups will tend to be homogeneous and difficult to interpret. On the other hand, if there are too many clusters, one or more may be too small to be meaningful and the benefit of the clustering is diminished. Although statistical considerations described above have been used in this case, the primary criterion for selecting the number of groups was the interpretability of the various solutions, supported by the principle advocated by Späth (1980):

> *"Cluster analysis … can be regarded as successful… if a data matrix contains a structure which is made clear and meaningful through interpretation of the clustering produced. Primarily, what makes an application of cluster analysis successful is the significant practical application of the clusters it produces." (p.12)*

Mean values of the variables used to create the clusters (e.g. mean scores on all the sets of variables in Table 68) and other selected background variables were compared across clusters and substantive judgements were made regarding the meaningfulness of the groups. Comparisons were made as to the 'separability' of the groups. On balance, the six cluster results produced the clearest distinguishable segments. In particular, the six cluster solution provided greater delineation between what became the 'Aspirers, Followers and Sceptics' as compared to the five cluster solution. Thus the six cluster solution was selected as the appropriate solution to be examined in more detail, combined with the two a-priori segments (Plug-in Pioneers and Company Car Drivers).

O.3 Profiling on the cluster variables

Table 35 on page 242 ranks each variable according to which constructs vary the most between groups and therefore will be the most important to understanding group differences[43]. All ANOVAs were significant as expected due to these variables having been used to create the clusters. However, a statistically significant F-ratio tells you only that all population means are unequal, not which groups are significantly different from each other. Post-hoc tests look for differences among all possible combinations of groups (using stricter confidence levels to account for the larger number of comparisons being made causing a greater chance of a Type 1 error (in which it is believed that a difference exists or is observed, when in fact there is none)). The Scheffé test was used here as it is the most conservative with respect to Type 1 errors (Hair *et al*., 1998).

Table 69 (below) calculates the mean score on each of the factor constructs or clustering variables and shows which groups are different from which other groups on each variable. The numbers in superscript relate to the Scheffé post-hoc tests, which show the differences among all possible combinations of groups. So, for instance, the Plug-in Pioneers are significantly different from groups three to eight on the variable 'Environmental Identity' and the Zealous Optimists are different from groups five to eight on this same variable and so on.

The post-hoc analysis is a vital part of interpreting the differences between the clusters. One key finding here, for example, is that the Plug-in Pioneers and the Zealous Optimists are only significantly different from each other with respect to the Willingness to Pay variables and perceptions about parking availability at home. The Rejecters are significantly different from all other segments on a large number of these variables. This analysis has been used to aid the profiling of the segments in the main report.

The differences between the groups on their mean scores on the clustering variables can also be displayed visually to see where the greatest differences lie between groups. Figure 95 shows the mean scores on the clustering variables by each segment ordered left to right according to which constructs vary the most between groups.

[43] This is done by ordering the variables on their F-ratio (the ratio of the variance between groups to the variance within the groups) calculated using ANOVA.

Table 69: Differences between the segments with respect to their mean score on the clustering variables including post-hoc comparison

	1 (Pioneers)	2 (Optimists)	3 (Pragmatists)	4 (Aspirers)	5 (Followers)	6 (Sceptics)	7 (Rejecters)	8 (Company)	*Sample Average*
Environmental Identity	3.94 (3,4,5,6,7,8)	3.68(5,6,7,8)	3.55(1,6,7)	3.57 (1,6,7,8)	3.49 (1,2,6,7)	2.99 (1,2,3,4,5,8)	3.06 (1,2,3,4,5,8)	3.40 (1,2,4,6,7)	*3.39*
EV Positives	3.14 (3,4,5,6,7,8)	2.97 (3,5,6,7,8)	1.92 (1,2,4,7)	2.32 (1,3,5,6,7,8)	2.70 (1,2,4,7)	2.46 (1,2,4,7)	1.74 (ALL)	2.28 (1,2,4,7)	*2.35*
BEV Anxieties	4.26 (3,4,5,6,7,8)	4.00 (3,4,5,6,7,8)	3.55 (ALL)	3.87 (1,2,3,5,7)	3.54 (ALL)	3.50 (1,2,3,5,7)	3.22 (ALL)	3.55 (1,2,,5,7)	*3.60*
EV Openness	3.56 (3,4,5,6,7,8)	3.37 (3,4,5,6,7,8)	3.55 (1,2,7)	2.68 (1,2,5,6,7,8)	2.88 (1,2,4,7)	2.90 (1,2,4,7)	2.18 (ALL)	2.79 (1,2,4,7)	*2.86*
PHEV Anxieties	4.59 (4,5,6,7,8)	4.26 (3,4,5,6,7,8)	3.83 (2,4,5,6,7,8)	3.96 (1,2,3,5,6,7)	3.71 (1,2,3,4,7)	3.66 (1,2,3,4,7)	3.17 (ALL)	3.76 (1,2,3,7)	*3.75*
Innovativeness	3.72 (3,5,6,7)	3.34 (3,5,7)	3.04 (ALL)	3.34 (3,5,7)	2.50 (ALL)	3.23 (1,5,7)	2.77 (ALL)	3.43 (3,5,7)	*3.04*
Car Authority	3.35 (3,5,6,7)	2.93 (1,5,6,7)	2.75 (1,4,5,7,8)	2.97 (3,5,6,7)	2.39 (1,2,3,4,6,8)	2.60 (1,2,4,5,8)	2.45 (1,2,3,4,8)	3.01 (3,56,7)	*2.70*
EV Instrumental	3.43 (4,6,7,8)	3.53 (3,4,5,6,7,8)	3.24 (2,4,6,7)	2.94 (1,2,3,5,7)	3.14 (2,4,7)	3.01 (1,2,3,7)	2.69 (ALL)	3.10 (1,2,7)	*3.07*
EV Symbolic	4.24 (3,4,5,6,7,8)	4.01 (3,4,5,6,7,8)	3.47 (1,2,5,7)	3.45 (1,2,5,7)	3.27(1,2,34,7)	3.38 (1,2,7)	2.76 (ALL)	3.31 (1,2,7)	*3.36*
EV Willingness to pay	3.71 (ALL)	3.03 (1,3,5,6,7,8)	2.54 (1,2,4,5,6,7)	2.93 (1,3,6,7,8)	2.78 (ALL)	1.89 (1,2,3,4,5,8)	1.88 (1,2,3,4,5,8)	2.60 (1,2,4,5,6,7)	*2.53*
EV Affect	3.69 (3,4,5,6,7,8)	3.58 (3,4,5,6,7,8)	3.18 (1,2,7)	3.25 (1,2,7)	3.20 (1,2,7)	3.21 (1,2,,7)	2.87 (ALL)	3.18 (1,2,7)	*3.20*
EV Infrastructure	2.32 (NONE)	2.62 (4,6,7,8)	2.44 (2,4,6)	1.96 (2,3,5,7,8)	2.51 (4,6,7,8)	2.12 (2,3,5,7)	2.30 (2,3,4,5,6)	2.31 (2,4,5)	*2.32*
PHEV Identity	3.81 (3,5,6,7,8)	3.88 (3,4,5,6,7,8)	3.18 (1,2,4,5,6,7)	3.54 (2,3,5,6,7,8)	2.87(1,2,34,7)	2.87 (1,2,3,4,7)	1.84 (ALL)	3.02 (1,2,4,7)	*2.98*
BEV Identity	3.81 (3,4,5,6,7,8)	3.75 (3,4,5,6,7,8)	2.26 (ALL)	3.26 (ALL)	2.79(1,2,34,7)	2.69 (1,2,3,4,7)	1.59 (ALL)	2.79 (1,2,3,4,7)	*2.72*
WTP	3.48 (2,4,7,8)	4.12 (ALL)	3.74 (2,4,5,6,7,8)	1.68 (ALL)	3.24 (2,3,4,7,8)	3.07 (2,3,4,7)	2.08 (ALL)	2.76 (1,2,4,5,7)	*2.89*
Parking	4.42 (ALL)	3.71 (1,3,5,6,7,8)	3.52 (1,2,4,5,6,7)	3.78 (1,3,5,6,7,8)	3.32 (1,2,3,4,6,7)	2.73 (ALL)	3.03 (ALL)	3.31 (1,2,4,6,7)	*3.35*

Note: The numbers in superscript relate to the Scheffé post-hoc tests, which show the differences among all possible combinations of groups. So, for instance, the Plug-in Pioneers are significantly different from groups 3, 4, 5,6,7 and 8 on the variable 'Environmental Identity' and the Zealous Optimists are different from groups 5,6,7,8 on this same variable and so on.

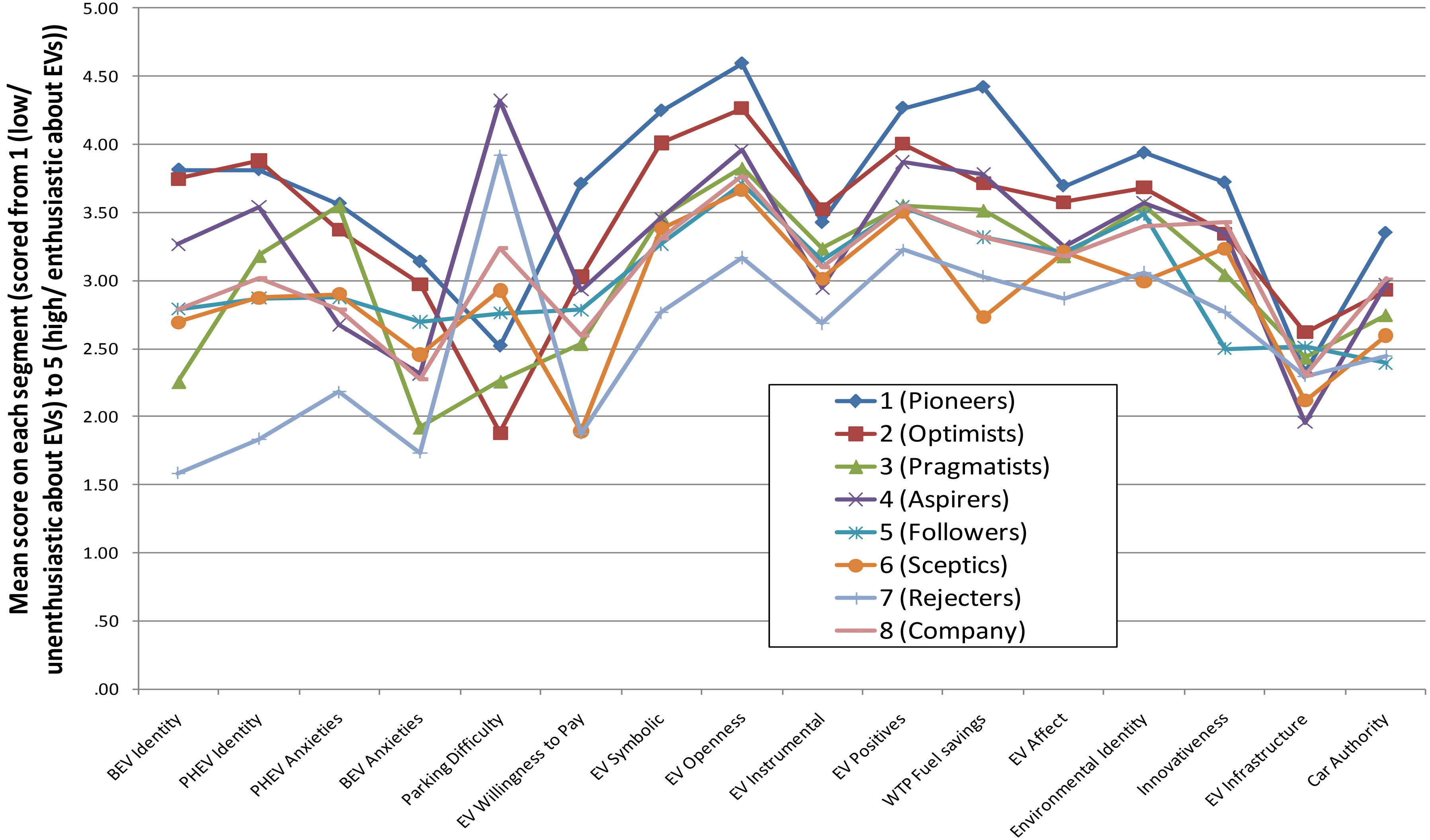


Figure 94: Mean scores on the clustering variables by each segment (ordered left to right according to which constructs vary the most between groups) (N=2,729)

Appendix P Tests used to aid profiling of the clusters

In order to understand whether the apparent differences between the segments on any given variable were statistically significant, analyses of variance (ANOVAs), Chi Square tests or the contingency coefficient were calculated as appropriate. In addition, as detailed in Appendix N, post-hoc comparisons were carried out in order to understand which segments were different from which other segments.

These tests were carried out for well over 100 variables on which the segments were profiled. In addition, the tests were routinely carried out twice: once to test that there was an overall significant difference between the six post-hoc segments only and secondly in order to test the overall difference across the whole set of eight segments. This comparison was necessary in order to ensure that the overall difference was not simply down to the fact that the Plug-in Pioneers and the Company Car drivers have distinctive characteristics and to understand whether the six segments actually differed from each other. This comparison was particularly necessary in the case of categorical data where post-hoc comparisons cannot be undertaken.

There is insufficient space in this report to detail the result of each test carried out. Suffice to say that in the main report, as explained in the introduction, differences between segments are only remarked upon where the differences were found to be statistically significant.

In this annex we detail two of the key comparisons undertaken between the segments: the differences between the groups on likelihood and the differences between the groups on the Mosaic and urbanity indices.

Table 70 details the statistical tests used to present the results in this Appendix.

Table 70: Statistical tests used to compare segments on different variables

ANOVA	F	Analysis of Variance: a test of statistical significance of the overall differences among mean scores of two or more groups on one or more variables. (It is an extension of the t-test which can handle only two groups or two conditions.) Involves computing the F-ratio of the variance between groups to the variance within the groups.
Chi Square	X^2	For most cross-tabulations / categorical data the test statistic is the traditional Chi Square. The larger the observed frequency is in comparison with expected frequency, the larger the Chi Square statistic and the more likely it is that the difference between the expected and observed frequencies is statistically significant.
Post-hoc tests		The Chi Square and ANOVA tests tell you whether at least one group differs from at least one other group. However, if there are more than two groups, the Chi Square and ANOVA tests do not pinpoint where the significant differences lie i.e. between which specific group(s) and which other group(s). For Chi Square tests, where categorical data cannot be turned into interval data (e.g. education levels, types of car ownership) it is only possible to say whether there is significant difference between observed and expected values, and not precisely how this difference manifests. For ANOVA tests, it is possible to carry out a 'test of multiple post-hoc comparison' in order to detect whether all the groups differ from one another or whether there is simply an 'odd one out'. The Scheffé test was used here as it is the most conservative with respect to Type 1 errors (Hair et al, 1998).
Contingency Coefficient		The Chi Square test is sensitive to the sample size. If the sample size is too small, the Chi Square value is overestimated; if it is too large, the Chi Square value is underestimated. To overcome this problem, Phi–square, Cramer's V and Contingency Coefficient all modify the Chi Square statistic to take account of the sample size. Here we have used the Contingency Coefficient. The coefficient of contingency restricts the range of the test statistic to between 0 and 1, making it similar to a correlation coefficient (the closer to 1, the stronger the relationship).
Statistical Significance	*p* NS	Tells how significant the relationship in the model is – if less than 0.05 ($p<0.05$), the relationship is considered to be significant at the 95% confidence level, and if it is less than 0.01($p<0.01$) it is considered significant at the 99% level.

Likelihood of adoption – tests of statistical significant differences between the groups

Table 71 shows the mean likelihood scores on each of the four measures of likelihood. Scores are mean scores where '1' was 'very unlikely' and '5' was 'very likely' to adopt a PHEV/BEV in the next five years. The numbers in superscript relate to the Scheffé Post Hoc tests, which show the differences among all possible combinations of groups. So, for instance, the Plug-in Pioneers are significantly different from ALL groups on all four likelihood variables and the Zealous Optimists are different from groups 1,4,5,6,7,and 8 (i.e. all but group 3) on PHEV Main, and so on.

Table 71: Mean likelihood scores for each segment and post-hoc comparisons

	PHEV main	PHEV second	BEV main	BEV second
1 (Pioneers)	4.54 (ALL)	3.94 (ALL)	3.77 (ALL)	3.88 (ALL)
2 (Optimists)	3.52 (1,4,5,6,7,8)	3.32 (1,5,6,7)	2.97 (ALL)	3.03 (ALL)
3 (Pragmatists)	3.23 (1,5,6,7,8)	3.13 (1,5,6,7)	1.53 (1,2,4,5,7,8,)	2.00 (1,2,4,5,7,8)
4 (Aspirers)	3.03 (1,2,7)	3.07 (1,6,7)	2.38 (1,2,3,7)	2.56 (1,2,3,6,7)
5 (Followers)	2.81 (1,2,3,7)	2.81 (1,2,3,7)	2.36 (1,2,3,7)	2.45 (1,2,3,6,7)
6 (Sceptics)	2.79 (1,2,3,7)	2.69 (1,2,3,4,7,8)	2.14 (1,2,3,7)	2.16 (1,2,4,5,7)
7 (Rejecters)	1.85 (ALL)	2.02 (ALL)	1.38 (1,2,4,5,6,8)	1.54 (ALL)
8 (Company)	2.86 (1,2,3,7)	3.09 (1,6,7)	2.15 (1,2,3,7)	2.45 (1,2,3,7)
Total	*2.84*	*2.83*	*2.15*	*2.31*
Between all 8 segments F(df) p-value	F=122.411 (7,2721) p=0.000	F=68.532 (7,2721) p=0.000	F=128.676 (7,2721) p=0.000	F=92.913 (7,2721) p=0.000
Between 6 post-hoc segments F(df) p-value	F=145.586 (5,2459) p=0.000	F=83.102 (5,2459) p=0.000	F=159.683 (5,2459) p=0.000	F=108.286 (5,2459) p=0.000

Note: Scores are mean scores where '1' was 'very unlikely' and '5' was 'very likely' to adopt a PHEV/BEV in the next five years. The numbers in superscript relate to the Scheffé Post Hoc tests, which show the differences among all possible combinations of groups. So, for instance, the Plug-in Pioneers are significantly different from ALL groups on all the likelihood variables and the Zealous Optimists are different from groups 1,4,5,6,7,and 8 (i.e. all but group 3) on PHEV Main, and so on.

Tests of statistical significance in relation to Mosaic groups and the urbanity index

Tests were undertaken to understand the strength of the association between our consumer segments and the Mosaic Groups and the Urbanity Classification. The analysis revealed a statistically significant association between the segments and both indices as shown by the tests below. The contingency coefficient has been used instead of the Chi Square as this is more robust in larger samples.

I. SPSS output of Segments versus Mosaic Group.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	241.016[a]	98	.000
Likelihood Ratio	238.198	98	.000
Linear-by-Linear Association	2.253	1	.133
N of Valid Cases	2711		

a. 13 cells (10.8%) have expected count less than 5. The minimum expected count is .83.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Contingency Coefficient	**.286**	**.000**
N of Valid Cases		2711	

II. SPSS output of Segments versus Rural/Urban Class.

Chi-Square Tests

	Value	df	Asymp. Sig.
Pearson Chi-Square	168.248[a]	56	.000
Likelihood Ratio	143.280	56	.000
Linear-by-Linear Assoc.	1.543	1	.214
N of Valid Cases	2666		

a. 8 cells (11.1%) have expected count less than 5. The minimum expected count is 1.00.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Contingency Coefficient	**.244**	**.000**
N of Valid Cases		2666	

Appendix Q Mosaic Rural / Urban data sources

Experian developed a classification of eleven types of urbanity in 2004, with the last update released in May 2010. Each of the eleven rural/urban types is derived from a combination of postal sector and output area data. The data used to create the classification is derived from a combination of the following sources:

- Census population density.
- Census household density.
- Census working population density.
- Experian population density estimate.
- Experian household density estimate.
- Experian daytime population density estimate.
- Generalised Rurality Measure (Capped).
- Generalised Urbanity Measure.
- Sector Area (km2).
- Census % Agriculture.
- Census % Occupancy rating 2 or more.
- Census % Occupancy rating 1.
- Census % Occupancy rating 0.
- Census % Occupancy rating –1.
- Census % Occupancy rating –2 or less.
- Census % Lowest floor 3 or 4.
- Census % Lowest floor 5 or above.
- % Agriculture, Hunting and Forestry (of number of sites).
- Postal district Population density.
- Postal district Household density.
- Postal district Daytime population density.
- Daytime to Resident population ratio.