Programme Area: Energy Storage and Distribution

Project: Consumers, Vehicles and Energy Integration (CVEI)

Title: Fleet Study Report

Abstract:

This report represents Deliverable D6.1, Fleet Study Report. Little is known about the attitudes of Light Duty fleet operators to Plug-in Vehicle (PiV) adoption or PiV use; published research has been very limited. This report is intended to inform appropriate sensitivity analyses to be conducted in the Modelling and System Analysis work package (WP7), based on in-depth qualitative insights into the processes influencing vehicle choice, and likely charging profiles, in those categories of Fleets where PiV uptake could potentially have most impact on the wider energy system. The report summarises the methods employed and the findings from five individual case studies, and provides: a synthesis of insights gained across the case studies considered collectively; answers to the research questions defined in the Fleet Study design; and evidence-based conclusions from the Fleet Study with regard to how the findings have advanced understanding of Fleets, their potential impact on the energy system and integration into it (based on qualitative data), and therefore what the new state-of-the-art understanding of this area is.

Context:

The objective of the Consumers, Vehicles and Energy Integration project is to inform UK Government and European policy and to help shape energy and automotive industry products, propositions and investment strategies. Additionally, it aims to develop an integrated set of analytical tools that models future market scenarios in order to test the impact of future policy, industry and societal choices. The project is made up of two stages:

• Stage 1 aims to characterize market and policy frameworks, business propositions, and the integrated vehicle and energy infrastructure system and technologies best suited to enabling a cost-effective UK energy system for low-carbon vehicles, using the amalgamated analytical toolset.

• Stage 2 aims to fill knowledge gaps and validate assumptions from Stage 1 through scientifically robust research, including real world trials with private vehicle consumers and case studies with business fleets. A mainstream consumer uptake trial will be carried out to measure attitudes to PiVs after direct experience of them, and consumer charging trials will measure mainstream consumer PiV charging behaviours and responses to managed harging options.

PROJECT REPORT

CVEI Stage 2

D6.1 - Fleet Study

Case Studies

Background

The objective of the Consumers. Vehicles and Energy Integration (CVEI) project is to inform UK Government and European policy and to help shape energy and automotive industry products, propositions and investment strategies. In addition to developing new knowledge and understanding, the project aims to develop an integrated set of analytical tools that can be used to model future market scenarios in order to test the impact of future policy, industry and societal choices.

Project scope

The project is made up of two stages: Stage 1 aims to characterize market and policy frameworks, business propositions, and the integrated vehicle and energy infrastructure system and technologies best suited to enabling a cost-effective UK energy system for low-carbon vehicles, using the amalgamated analytical toolset. Stage 2 aims to fill knowledge gaps and validate assumptions from Stage 1 through scientifically robust research, including real world trials with private vehicle consumers and case studies with business fleets.

Purpose and scope of this deliverable

Fleets buy around half the new Light Duty (LD) vehicles sold in the UK and operate around 10% of the present UK LD vehicle parc, accounting for around 17% of total LD Vehicle Kilometres Travelled (VKT), and energy demand, which is a significant share of total energy demand. With fleet vehicles being disposed of into consumer used-vehicle markets after fleet use, the switch to electricity and/or hydrogen vehicles could be significantly influenced by fleets uptake decisions.

Little is known about the attitudes of LD fleet operators to PiV adoption or PiV use; published research has been very limited. This report is intended to inform appropriate sensitivity analyses to be conducted in the Modelling and System Analysis work package (WP7), based on in-depth qualitative insights into the processes influencing vehicle choice, and likely charging profiles, in those categories of Fleets where Plug-in Vehicle (PiV) uptake could potentially have most impact on the wider energy system. The report summarises the methods employed and the findings from five individual case studies, and provides: a synthesis of insights gained across the case studies considered collectively; answers to the research questions defined in the Fleet Study design; and evidence-based conclusions from the Fleet Study with regard to how the findings have advanced understanding of Fleets, their potential impact on the energy system and integration into it (based on qualitative data), and therefore what the new state-of-the-art understanding of this area is.

Two significant knowledge gaps were identified: the factors influencing fleet uptake are not fully understood; and published research into fleet charging profiles is scarce. Information on both topics is required to increase the validity of modelling carried out, and to inform interpretation of modelling analyses.

Method

A qualitative methodology was adopted to enable understanding of fleets' own perspectives on these questions. Five in-depth case studies were carried out, with two Centralised-chooser fleets, two User-chooser fleets, and one Car Club. Each study comprised multiple interviews with managers at strategic and operational levels within the organisation, and, where appropriate, with vehicle users.

Results and Discussion

Knowledge gap 1: factors influencing fleet uptake

It is typically assumed that fleets select their vehicles based on a rational choice between alternatives, determined by operational suitability and total cost of ownership. In all five case studies, this cost-effectiveness perspective was "owned" at the operational level, by Fleet Managers; it was always present, and the most significant influence on fleet choices. This was particularly so in the two Centralised-chooser fleets. However, vehicle choice is subject to other influences, originating at both the strategic and the personal levels.

The findings suggest that modelling uptake of PiVs by those Centralised-chooser fleets where vans are based at user's homes will over-estimate uptake, if based on operational suitability (for duty cycle) and total cost of ownership alone. This is because modelling on that basis neglects the additional operational issue of whether the vans can in fact be charged at users' homes. The evidence from the case studies suggests that in reality, fleets understand that this will be problematic, if not impossible, in many cases, and so will not adopt PiVs even if they are otherwise suitable and cost-effective.

Knowledge Gap 2: PiV charging profiles for fleets

The case studies suggest that charging profiles for Centralised-chooser van fleets whose vehicles are based at users' homes, will be similar to those of private consumers with a pattern of regular daily use of the vehicle. It will therefore be reasonable to use charging profiles generated in the Consumer Charging Trials to model the charging profiles of such fleets.

For User-chooser and Centralised-chooser car fleets, the findings suggest that vehicles are often used for long round trips (e.g. circa 300 miles), but not every day. Fleets do not consider BEVs appropriate for such duty cycles. This suggests the hypothesis that charging profiles of PHEVs will reflect intermittent (non-daily) charging of a fully depleted battery, at home in the evening/overnight. As these drivers are returning from long trips away from home, charge start times may not be as regular as those of consumer drivers in the PHEV charging trial. These charging profiles can be modelled using charging profiles from the consumer charging trial, modified to reflect non-daily use, greater variability of charge start time, and that a full charge is always required.

Charging profiles for car clubs, which become increasingly important where there is greater provision of Mobility as a Service, will include some daytime and evening charging as well as overnight charging. For individual vehicles on individual days, the profiles will consist of short periods of charging between periods when vehicles are in use. Across the fleet these short term fluctuations will tend to average out. It may be appropriate to model them based on the reciprocal of traffic density, assuming that the car club vehicles will tend to be in use at times of day when general traffic density is high, and available for charging at times of day when traffic density is low.

Conclusions

Given the qualitative nature of the research, generalisation from its findings takes the form of hypotheses about PiV uptake and charging behaviour from Centralised-chooser, User-chooser, and Car club fleets. Key hypotheses are summarised:

Uptake of PiVs: Operational suitability and costs of ownership (particularly leasing cost or upfront purchase cost, and depreciation losses) remain the most important vehicle selection considerations for Centralised-chooser, User-chooser, and car club fleets.

Centralised-chooser fleets: The provision of charging facilities at employees' homes is a major barrier to PiV uptake by Centralised-chooser van fleets: many employees live in multiple tenancy accommodation, without access to off-street parking with a power supply where a charging point could be installed.

User-chooser fleets: Vehicle choice is at the personal level, but constrained by criteria imposed by the organisation. The range of vehicle options made available reflects corporate goals that include providing employee benefits.

User-chooser fleets offer "car allowance" schemes as alternatives to company cars, so their company-provided fleets are associated with so-called Grey Fleets of private cars used for company business. The company is likely to impose some basic criteria for eligibility that reflect those used to define its own vehicle list, but users have a wider range of choice.

Car clubs: Typically based in cities, and requiring close relationships with city authorities to operate, they are substantially influenced by city authorities' goals resulting in a strong strategic motivation to adopt PiVs. BEVs are utilised less due to their short range; BEV vehicles may require downtime to recharge during the daytime/evening.

Charging

Centralised-chooser home-based van fleets: Charging profiles are not relevant for fleets whose employees' accommodation precludes home charging.

User-chooser car fleets: Where PiVs are adopted in User-chooser car fleets, charging profiles will be similar to those of consumers: vehicles will largely be charged in the evenings and at night. However there may be greater daily variation in profile where users make long journeys and/or do not use their vehicles daily. Of the models that currently exist, reimbursement for at-home charging costs can most readily be achieved using the system of claiming for business mileage.

Car clubs: will initially seek commercial relationships with existing charge point providers that may be arranged on a localised (city-by-city) basis.

Charging profiles for car club PiVs will include overnight charging (when most vehicles are not in use). Vehicles are in use in the evenings so charging opportunities then will be intermittent.

There will also be a pattern of short-duration "top-up" charging during the daytime and evening, whenever the vehicles are parked in between bookings.

Insights

Centralised-chooser van fleets and User-chooser car fleets have not made significant efforts to carry out systematic comparisons of the costs and benefits of ownership of PiVs and ICE vehicles. Benefit in Kind taxation applied to PiVs acts as a financial deterrent to their adoption by User-choosers. PiV uptake could potentially be increased by reduction or removal of this deterrent.

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Abbreviations

AC	Alternating Current
ACEA	European Automobile Manufacturers' Association
AER	All Electric Range
ALARP	As Low As Reasonably Practicable
ANOVA	Analysis Of Variance
API	Application Programming Interface
BEAMA	British Electrotechnical and Allied Manufacturers' Association
BEV	Battery Electric Vehicle
BIK	Benefit-in-Kind
BIT	Behavioural Insights Team
CAN	Controller Area Network
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CLASS	Customer Load Active System Services
CNG	Compressed Natural Gas
CPAT	Commercial Policy and Accounting Tool
CPMS	Chargepoint Management System
CSM	Charge Station Manager
CSR	Corporate Social Responsibility
CVEI	Consumers, Vehicles and Energy Integration project
DC	Direct Current
Defra	Department for Environment Food and Rural Affairs
DfT	Department for Transport
DM	Demand Management
DNO	Distribution Network Operator
DSR	Demand Side Response
DUoS	Distribution Use of System
DVLA	Driver and Vehicle Licensing Agency
ECCo	Electric Car Consumer
EE	Element Energy
EOBD	European On-Board Diagnostics

ESME	Energy System Modelling Environment
ESOS	Energy Savings Opportunity Scheme
EV	Electric Vehicle (including all plug-in vehicles)
EVSE	Electric Vehicle Supply Equipment
ETI	Energy Technologies Institute
FCV	Fuel Cell Vehicle
FIPS	Federal Information Processing Standard
FTP	File Transfer Protocol
GB	Great Britain
GEE	Generalised Estimating Equations
GPS	Global Positioning System
HAZID	Hazard Identification
HEV	Hybrid Electric Vehicle
IC-CPD	In-Cable Control and Protective Device
ICE	Internal Combustion Engine
ID	Identification
IEC	International Electrotechnical Commission
IEE	Institution of Electrical Engineers
IMS	Integrated Management System
IPIP	International Personality Item Pool
ISO	International Organization for Standardization
LD	Light Duty
LPG	Liquefied Petroleum Gas
MC	Managed Charging
MCAR	Managed Charging Availability Ratio
MCB	Miniature Circuit Breaker
MDSI	Multi-Dimensional Driving Style Inventory
MCPT	Macro Charging Point Tool
MHDT	Macro Hydrogen Distribution Tool
NCAP	New Car Assessment Programme
NICEIC	National Inspection Council for Electrical Installation Contracting
NEDC	New European Driving Cycle
NTS	National Travel Survey

OBD	On-Board Diagnosis
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
ONS	Office for National Statistics
OSGR	Ordnance Survey Grid Reference
PHEV	Plug-in Hybrid Electric Vehicle
PIA	Privacy Impact Assessment
PiV	Plug in Vehicle
PM	Project Manager
RCD	Residual Current Device
RCT	Randomised Controlled Trial
RFQ	Request for Quotation
RPM	Revolutions Per Minute
SMC	Supplier Managed Charging
SMMT	Society of Motor Manufacturers and Traders
SMS	Short Message Service
SOC	State of Charge
SOH	State of Health
SQL	Structured Query Language
SQS	Simple Queue Service
SToU	Static Time of Use
TCO	Total Cost of Ownership
TNUoS	Transmission Network Use of System
TOU	Time of Use
TRL	Transport Research Laboratory
UF	Utility Factors
UK	United Kingdom
ULEV	Ultra Low Emission Vehicle
UMC	User Managed Charging
VAT	Value Added Tax
VDC	Vehicle Data Collector
VGL	Volkswagen Group Leasing
VKT	Vehicle Kilometres Travelled

VW	Volkswagen
VWFS	Volkswagen Financial Services
WP	Work Package

Glossary

Item	Description
Affective attitudes	The emotions and feelings evoked by owning and using a vehicle.
Analytical tools	The quantitative part of the Analytical Framework, used to calculate values for the quantitative Success Metrics.
Analytical framework	Overarching Multi-Criteria Assessment (MCA) framework applied to each narrative to help understand what 'good looks like' for mass market deployment and use of ULEVs and the potential trade-offs, via the assessment of the Success Metrics. This framework comprises the analytical tools which are used to help inform the quantitative assessment as well as a set of supporting qualitative assessment metrics.
Battery Electric Vehicle	A vehicle powered solely by a battery, such battery being charged only by a source of electricity external to and not part of the vehicle itself.
Centralised-chooser fleet	A fleet where vehicles are chosen by the organisation, not by individual users
Consumer	A private, domestic, individual driver who owns or leases his/her own vehicle.
Demand management	The modification of one or more energy consumers' demand for energy through various methods including financial incentives, time of use tariffs and/or education.
Descriptive (or behavioural) norms	Perceptions of what other group members you associate with actually do.
Early adopter	Those who adopt after Innovators and only after awareness, knowledge, and positive attitudes have diffused to them from Innovator. Times to adoption are between one and two standard deviations before the mean time to adopt.
Injunctive norms	Perceptions of what other group members (e.g. family group, friendship group) approve or disapprove of.
Innovators	People high in innovativeness who are first to adopt new technology. They are sources of awareness, knowledge, and positive attitudes towards the innovation whose times to adoption are greater than two standard deviations before the mean time to adopt
Instrumental attitudes	Attitudes towards factors relating to general practical or functional attributes of driving a vehicle.

Mainstream consumer/adopter	All those whose adoption of technology has been influenced by diffusion of awareness, knowledge, and positive attitudes from people who have already adopted the innovation (i.e. everyone except innovators)
Managed charging	Means the management of vehicle charging in such a way as to control the timing and/or extent of energy transfer to provide Demand Management benefits to the energy system and the vehicle user.
Parc	The total number of vehicles considered collectively; the vehicle population.
Personal norms	Perceived obligations to act in a way consistent with personal views.
Plug-in Hybrid Electric Vehicle	A vehicle that is equipped so that it may be powered both by an external electricity source and by liquid fuel.
Provincial norms	The same as injunctive norms but more specifically referring to other people who live under similar conditions such as in the same locality.
Range-extended Electric Vehicle	A vehicle that is equipped so that it may be powered both by an external electricity source and by liquid fuel; similar to a PHEV, except that a RE-EV generally uses the engine solely to charge the battery whereas a PHEV generally uses the engine for direct propulsion).
Self-identity	The perception of oneself including how you see yourself and how one perceives others see them.
Social norms	Similar to injunctive norms but mores specifically referring to the approval or disapproval by close friends/family/colleagues. Informal understandings that influence the behaviour of members of a group, or wider society.
Symbolic meaning/ attitudes	What the vehicle says about its owner/driver in terms of social status, social conscience and personal values
User-chooser fleet	A fleet where individual users are able to choose their own vehicle, from a range of options made available by their organisation

Preface

The purpose of the Consumers, Vehicles and Energy Integration (CVEI) project is to investigate challenges and opportunities involved in transitioning to a secure and sustainable low carbon vehicle fleet. The project explores how the integration of vehicles with the energy supply system can benefit vehicle users, vehicle manufacturers and those involved in the supply of energy.

The objective of the project is to inform UK Government and European policy and to help shape energy and automotive industry products, propositions and investment strategies. In addition to developing new knowledge and understanding, the project aims to develop an integrated set of analytical tools that can be used to model future market scenarios in order to test the impact of future policy, industry and societal choices.

This report details the design, materials and management arrangements for the consumer uptake and charging trials for Stage 2 of the CVEI project.

Stage 2 of the project aims to test, and as far as possible validate, the solutions identified in Stage 1. This will address gaps in knowledge, by conducting scientifically robust research, including real-world trials with private vehicle consumers, and in-depth research with business fleets. The results of the research activities conducted in Stage 2 will be used to update and improve the analytical framework developed in Stage 1. The updated framework will be used to further develop the system analysis and develop prominent policy and industry strategies to enhance energy integration between consumers, vehicles and energy systems in the future.

Stage 2 will consist of four Work Packages (WPs):

- WP5: Consumer Trials
- WP6: Fleet Study
- WP7: Modelling and System Analysis
- WP8: Project Management and DisseminationThis document provides details relating to the WP6 Fleet Study Case Studies and complements the findings of the Stage 1 Fleet Study.

The contents of this document provide full details of the rationale, methodology, design, and results of the Fleet Study.

Executive Summary

This report describes a study comprising five in-depth case studies with organisations that operate Fleets. The aims of the study were to inform appropriate sensitivity analyses in WP7 based on in-depth qualitative insights into the processes influencing vehicle choice, and into likely charging profiles, in those categories of Fleets where ULEV uptake could potentially have the most impact on the wider energy system.

Research focus

Cars operated by User-chooser fleets account for 8% of total car VKT per annum. A further 9% is accounted for by cars operated by Centralised-chooser fleets (of which 80%, or 7.2% of total car VKT per annum, is accumulated by cars based overnight at their users' homes). Thus the VKT, and therefore energy use, of cars operated by fleets is dominated by those based at users' homes.

The majority of new van sales are to fleets, but these are typically disposed into private use after approximately 4 years. As a consequence, around 43% of total van VKT per annum is accumulated by fleet-operated vans. Of that total, 60% is accounted for by vans based overnight at their users' homes.

At present, Car-sharing fleets contribute a very small fraction of total car VKT per annum. However in the City-Led and Transport on Demand Narratives in the Analytical Framework this is predicted to increase substantially.

Therefore the study focussed on:

- User-chooser car fleets
- Centralised-chooser car and van fleets where vehicles are based overnight at users' homes
- Car-sharing fleets

Knowledge gaps addressed

Two significant knowledge gaps were addressed in this research.

First, the factors influencing fleet uptake are not fully understood. The ECCo model used in the CVEI Analytical Framework models User-chooser fleet uptake in a manner analogous to *consumer* uptake, and Centralised-chooser fleet uptake based on operational suitability[1] and total cost of ownership. However this approach results in over-prediction of PiV uptake, so there must be other factors involved.

Second, there has been very little published research into fleet charging profiles.

Further information on both topics is required to increase the validity of Stage 2 modelling carried out with the Analytical Framework, and to inform interpretation of modelling analyses.

[1] Operational suitability refers to the vehicle having sufficient load and passenger capacity for its intended use. In the case of BEVs it also includes whether the AER is sufficient for the intended duty cycle.

Methodology

Given the exploratory nature of the study, a qualitative methodology was adopted, to enable understanding of fleets' own perspectives on these questions. Five in-depth case studies were carried out, with two Centralised-chooser fleets, two User-chooser fleets, and one Car Club. Each study comprised multiple interviews with managers at strategic and operational levels within the organisation, and, where appropriate, with vehicle users.

Conclusions

Generalisation from qualitative case studies is a matter of theoretical extrapolation, having regard to the conditions under which the findings could be applicable to other situations (Patton, 2002). In this study, that means considering the salience (in relation to the research questions) of similarities and differences between the fleets studied and other fleets not included in the study. Qualitative research does not generate statistically representative data, but rather hypotheses whose potential impacts can be explored in modelling. The key hypotheses are summarised here.

Uptake of PiVs

- Operational suitability and costs of ownership (particularly leasing cost or upfront purchase cost, and depreciation losses) remain the most important vehicle selection considerations for Centralised-chooser, User-chooser, and car club fleets.

Centralised-chooser fleets

- The provision of charging facilities at employees' homes is a major barrier to PiV uptake by Centralised-chooser van fleets. They recognise that many of their employees live in multiple tenancy accommodation, without access to off-street parking with a power supply where a chargepoint could be installed (this hypothesis may not apply to fleets whose employees are more highly paid, as they may be able afford housing where off-street charging is possible).
- In the face of this barrier, Centralised-chooser van fleets have not made significant efforts to carry out systematic comparisons of the relative costs and benefits of ownership of PiVs and ICE vehicles.
- Centralised-chooser fleets may include some PiVs in their fleets in response to customer requirements to demonstrate sustainability credentials (e.g. where customers are local or central government).

User-chooser fleets

- In User-chooser fleets, vehicle choice is essentially at the personal level, but is constrained by criteria imposed by the organisation. The range of vehicle options made available reflects corporate goals that include providing employee benefits.

- User-chooser fleet vehicle lists are hierarchically structured, with higher status vehicles for higher status staff; the hierarchical list reflects a corporate view of personal-level symbolic motivations for car choice.
- User-chooser fleets offer "car allowance" schemes as alternatives to company cars, so their company-provided fleets are associated with so-called Grey Fleets of private cars used for company business. The company is likely to impose some basic criteria for eligibility that reflect those used to define its own vehicle list, but users have a wider range of choice.
- User-chooser car fleets have also not made significant efforts to carry out systematic comparisons of the costs and benefits of ownership of PiVs and ICE vehicles.

Car clubs

- Car clubs are typically based in cities, and require close relationships with city authorities to operate. They are thus substantially influenced by city authorities' goals. Most cities have concerns about air quality, so car clubs have a strong strategic motivation to adopt PiVs.
- Present BEVs are problematic for car clubs to operate because their short ranges mean that vehicles may require downtime to recharge during the daytime/evening, adversely affecting their utilisation rates. This dilemma for BEV deployment would eventually be ameliorated by substantial technical improvements to BEV range in the coming decades.In addition, the experience of sporadic recharging of vehicles by car club members when off hiring will continue to present a challenge even when ranges increase.
- PHEVs provide a partial answer, and may be adopted first by car clubs.

Local and central government policies that influence PiV adoption by fleets

- The dependence of the car club business model means there is an opportunity for city governments to influence PiV uptake by car clubs in their cities.
- Local and/or central government departments that procure services externally require suppliers to demonstrate their sustainability credentials. Stronger requirements might lead to more PiV adoption.
- The system of approved framework suppliers that must be used under the 2006 Public Contracts Regulations is currently a deterrent to PiV adoption by organisations that contract under these regulations. PiV adoption by these fleets could be supported by updating this system.
- Benefit in Kind taxation applied to PiVs acts as a financial deterrent to their adoption by User-choosers. PiV uptake could potentially be increased by reduction or removal of this deterrent.

Charging

Centralised-chooser home-based van fleets

- Charging profiles are not relevant for Centralised-chooser van fleets whose employees' accommodation precludes home charging, as these fleets will not adopt PiVs so will have zero charging demand. Such fleets will not consider PiVs as an option, because home charging is not considered viable for their staff.
- Since vehicles are in use in the daytime, charging profiles for those vehicles whose users could charge them at home will tend to be similar to those of consumers (i.e. largely evening and overnight).
- Any daytime charging at public chargepoints will be adventitious, e.g. if the chargepoint is close to the customer premises the van driver is attending.

User-chooser car fleets

- Where PiVs are adopted in User-chooser car fleets, charging profiles will be similar to those of consumers: vehicles will largely be charged in the evenings and at night. However there may be greater daily variation in profile where users make long journeys and/or do not use their vehicles daily.

Reimbursement of charging costs

- Of the models that currently exist, reimbursement for at-home charging costs can most readily be achieved using the system of claiming for business mileage.

Car clubs

- Car clubs will initially seek commercial relationships with existing charge point providers that may be arranged on a localised (city-by-city) basis. These however may not necessarily be at the most appropriate locations to maximise accessibility to vehicles by members.
- In the longer term a car club may also seek to install chargepoints at its own parking bays. This is perceived as a slow and costly process so neither option is a fully satisfactory solution; Zipcar's view is that a sufficient charging infrastructure to operate a substantial PiV fleet is wanting.
- Charging profiles for car club PiVs will include overnight charging (when most vehicles are not in use). Vehicles are in use in the evenings so charging opportunities then will be intermittent.
- There will also be a pattern of short-duration "top-up" charging during the daytime and evening, whenever the vehicles are parked in between bookings.

1. Introduction

Fleets buy around half of the new Light Duty (LD) vehicles sold in the UK and those vehicles are disposed of into consumer used-vehicle markets after fleet use. Thus potentially they could have a substantial influence on the uptake of Plug-in Vehicles (PiVs).

Fleets operate around 10% of the present UK light duty vehicle parc, accounting for around 17% of total LD Vehicle Kilometres Travelled (VKT), and a similar percentage of energy demand (Baringa & Element Energy, 2016). Thus although total LD VKT and energy demand is dominated by private consumers, fleet energy demand represents a significant share. The **fraction** of that energy demand that could potentially switch from liquid hydrocarbon fuels to electricity and/or hydrogen depends on the uptake decisions fleets make: i.e. on what fraction of their vehicles (representing what fraction of VKT) fleets might choose to replace with PiVs, and on their charging demands

However little is known about the attitudes of organisations that operate LD fleets either to PiV adoption or to PiV use; compared with consumer buyers, published research has been very limited. For instance, a comprehensive review of market models for HEV, PHEV, and BEV uptake in the US LD market (Al-Alawi & Bradley, 2013) discussed models of adoption by consumers, but not fleets. A rapid evidence assessment for the UK Department of Transport (Brook Lyndhurst, 2015), on the topic of uptake of ULEVs in the UK, while citing a wide variety of sources for consumer uptake, drew almost exclusively on a single study (Hutchins, Delmonte, Stannard, Evans, & Bussell, 2015) on the role of the Plug-in Car Grant and Plugged-in Places scheme on EV uptake, for its evidence on uptake by fleets.

The main reason for this dearth of useful research literature is that research with fleets is problematic. Fleets are known to use vehicles for a wide variety of purposes, from business operations such as local goods delivery or transporting service staff to work sites, to staff remuneration/rewards in the form of company cars. There is limited quantitative understanding of the structure of the light duty fleet sector, so statistically valid sampling is difficult. In addition, responsibility and decision making regarding fleets in organisations can be shared between staff in different roles and at different levels (see below), so identifying appropriate contacts can be challenging. It can be difficult to access the time of the appropriate people when they work in busy commercial settings. The link between employer-supplied van and car use and personal Benefit in Kind (BiK) taxation introduces an additional level of sensitivity. Finally, organisations are naturally reluctant to engage in research activities such as field trials where they perceive there might be some associated risk to their operations.

Accordingly there are substantial gaps in our knowledge. These relate in particular to the factors that influence vehicle choice and so bear on PiV uptake; and the charging profiles that are likely from “mainstream” fleets (those that are not fleet “Innovators” in diffusion model terms). Modelling of both uptake and energy use was, in Stage 1 (see deliverable D1.3) necessarily based on a series of assumptions rather than grounded in real-world data. The risk in this approach is, of course, that the validity of those assumptions was not known.

This research approached the key knowledge gaps by seeking to discover organisations’ own perspectives on what factors are important in their fleet decision making, using a case study methodology that addressed as far as possible the research challenges outlined above. It consisted of a set of in-depth, particular studies of individual organisations that fell into

categories in whose fleets EV uptake would potentially have the most impact of the UK energy system. This focus on depth aimed to maximise the opportunity to fully understand participating organisations' own perspectives.

Because of the small number of case studies carried out, the research findings cannot be considered statistically representative. Generalisation from the findings of particular case studies is not, therefore, based on the assumption that they accurately represent the perspectives of the UK wider population of fleets, but is rather based on theoretical extrapolation, and thus has a provisional nature. Like all qualitative research outputs, the findings can be considered as *hypotheses* about what may be the perspectives of the wider population, subject to further exploration and/or testing.

Insights from the research will be used to inform interpretation of Stage 2 modelling outputs in WP7, and where appropriate to inform sensitivity analyses that explore the effects of varying the modelling assumptions in ways suggested by the organisational perspectives identified in the field research. The deeper insights generated will also enhance interpretation and discussion of the final CVEI modelling outputs - for instance, limits of validity – and will enable a better informed view of their strengths and limitations.

1.1 Research focus: Fleets where EV uptake would have most potential impact on energy system

In the CVEI Analytical Framework (Baringa & Element Energy, 2016) PiV uptake is modelled in Element Energy's Electric Car Consumer (ECCo) model, initially developed for the ETI. ECCo predicts future alternative fuel vehicle demand by bringing together an understanding of purchase behaviour, the vehicle cost and performance offer, and the policy context. In ECCo, vehicle choosers are categorised into four user categories, three of which represent categories of fleet choosers:

- Private consumers
- User-chooser fleets
- Centralised-chooser fleets
- Car-sharing fleets

1.1.1 Cars operated by fleets:

Cars operated by User-chooser fleets account for 8% of total car VKT per annum (Baringa & Element Energy, 2016). A further 9% is accounted for by cars operated by Centralised-chooser fleets (of which 80%, or 7.2% of total car VKT per annum, is accumulated by cars based overnight at their users' homes). Thus the VKT, and therefore energy use, of cars operated by fleets is dominated by those based at users' homes.

At present, Car-sharing fleets contribute a very small fraction of total car VKT per annum. However in the City-Led and Transport on Demand Narratives in the Analytical Framework this is predicted to increase substantially.

1.1.2 Vans operated by fleets:

The majority of new van sales are to fleets, but these are disposed into private use after circa 4 years. As a consequence, around 43% of total van VKT per annum is accumulated by fleet-operated vans. Of that total, 60% is accounted for by vans based overnight at their users' homes (Baringa & Element Energy, 2016).

1.1.3 Stage 2 research focus

The Stage 1 field research (Deliverable D2.2) was focussed on Centralised-chooser, depot-based fleets, since the vehicle-choice decision-making process in such fleets was considered most likely to differ from the better-understood Personal-level choice processes of consumers.

The Stage 2 case studies focussed on in-depth understanding of those categories of fleets where there is the greatest potential for PiV uptake and use to impact on the wider energy system. As the above discussion indicates, those are:

- **User-chooser car fleets**
- **Centralised-chooser car and van fleets where vehicles are based overnight at users' homes**
- **Car-sharing fleets.**

Of the fleets considered in this study, only one organisation had any depot-based vehicles, and the number of vehicles which were depot-based was a maximum of 10 in a fleet of 450 vehicles (i.e. less than 2%). Accordingly, no further research could be carried out with depot-based fleets in this study.

1.2 Knowledge Gap 1: Potential for PiV uptake in fleets

1.2.1 Vehicle selection: organisational decision making processes

Nesbitt & Sperling (2001), in a mixed-methods study, characterised the decision-making processes used in acquiring new fleet vehicles in the US market as fitting into four categories:

- *Autocratic*: typically common in small fleets (fewer than 10 vehicles). Fleet purchase decisions were found to be very informal and highly centralised. Decisions were usually made by one person (e.g. the CEO or Managing Director). Vehicle choices were shaped by that individual's perceptions and interests, and, as this individual had other responsibilities, fleet purchase decisions could receive relatively little attention.
- *Bureaucratic*: The most common decision-making process, highly formalised and de-centralised, involving multiple staff in different organisational roles. Decision outcomes result from objective, formal evaluations carried out systematically using pre-defined criteria that reflect corporate policies.
- *Hierarchic*: Quite common in medium to large fleets, reflecting characteristics of both Bureaucratic and Autocratic decision-making. Decisions were found to be made by one or two senior managers, but guided by policies, procedures, and evaluations usually carried out by less senior staff.
- *Democratic*: Relatively uncommon, decision-making is highly de-centralised and very informal, involving several individuals at different levels in the organisation and in

different departments, who all influence the outcome, contributing their technical knowledge, management experience, or administrative practice as appropriate.

In these different categories of decision-making processes in larger organisations, influences on vehicle choices can be considered to originate from three organisational levels:

- **Strategic:** ***decisions made by senior corporate executives to implement aspects of corporate strategy.***
    - In the context of potential PiV uptake, these might include, for instance, corporate social responsibility, brand positioning, financial, or staff reward/remuneration strategies. These decisions may be influenced by information flow from operational level (for instance, on costs and operational suitability[2] of PiVs)
- **Operational:** ***decisions made at operational level, to maximise cost-effectiveness of business operations.***
    - In the context of PiV uptake, these are specific choices of vehicles, made at "fleet manager" level, to maximise cost-effectiveness of vehicle-dependent aspects of business operations. These choices may be influenced and/or constrained by strategic-level decisions that determine an overarching framework
- **Personal:** ***decisions made by individual employees, where they have capacity to exercise individual choice.***
    - In the context of PiV uptake, these are specific choices of vehicles to support personal instrumental and symbolic motivations. Those choices may be constrained by operational-level decisions that restrict the range of available choice options in line with the organisation's operational and/or strategic-level goals

1.2.2 Previous ETI research on PiV adoption by fleets

The earlier ETI Plug-in Vehicles project included qualitative research with 20 fleet managers from a diverse range of UK fleets (Hutchins, 2011). At that time, the modern generation of PiVs were relatively new to the UK market, and awareness was found to be patchy. In particular, few fleet managers were aware of PHEVs, which were yet to appear; and there was considerable uncertainty about charging times. Given this lack of knowledge, few of the participating fleets were in an immediate position to evaluate the operational suitability of PiVs for their fleets.

Linked to this low awareness was a general risk-aversion: fleet managers who could see some potential advantages to adopting PiVs were nevertheless reluctant to be among the first to do so, preferring to wait until others had experience of operating such vehicles that they could draw on.

[2] Operational suitability refers here to the vehicle having sufficient load and passenger capacity for its intended use. In the case of BEVs it also includes whether the AER is sufficient for the intended duty cycle.

The decision-making processes described did appear to map onto Nesbitt & Sperling's four categories. Where structured evaluation was used, this typically emphasised operational suitability (i.e. suitability for the vehicles' required duty cycles) and total cost of ownership.

Although the decision-making processes were varied, there appeared to be considerable consensus about what the potential advantages and disadvantages of PiVs would be. Perceived advantages included:

- Helping fleet managers meet CO_2 reduction targets set at corporate level
- Reducing operating costs through lower vehicle running costs (energy & maintenance)
- Potential to differentiate from competitors, particularly as a demonstrable reason to believe that the organisation was innovative and up-to-date with technology
- Potential to contribute to staff well-being through improved driving experience (e.g. quietness) and reduced driver workload (e.g. automatic transmission).

Perceived disadvantages centred around lack of operational suitability, and included:

- Insufficient range for required duty cycles - this was considered to rule out PiVs for many fleets
- Lack of sufficiently comprehensive infrastructure of public chargepoints to compensate for inadequate range
- Negative impact on vehicle availability if it was necessary to recharge them part way through the day
- Home-based drivers not having suitable facilities (off-road parking with an electrical power supply)

Overall, fleet managers' emphases were on the perceived disadvantages and lack of operational suitability. Fleet managers saw themselves as potentially trying out small numbers of PiVs in the next five years (and so benefitting from some ability to demonstrate innovativeness and pro-environmental credentials) but with a strong preference to wait until more capable vehicles become available, and until others had gained sufficient experience to alleviate their uncertainties before investing substantially.

1.2.3 Assessment of the role of the UK Plug-in Car Grant and Plugged-in Places Scheme

Hutchins et al (2013) reviewed the role of the UK Plugged-in Car Grant and Plugged-in Places Scheme in influencing PiV adoption in the early market (all their participants were, in Diffusion model terms, PiV Innovators). At that date, a majority of PiVs purchased had been acquired by fleets; and those fleets were all, in Diffusion model terms, Innovators. The main motivations for PiV acquisition reported by fleet purchasers were, in descending order:

- Savings on the cost of fuel
- Financial benefits/incentives provided by UK Government
- Contribution to meeting organisation's Corporate Social Responsibility targets
- Contribution to meeting organisation's CO_2 emissions reduction targets

In terms of the organisational levels involved in influencing decision-taking, the (dominant) first two of these could be considered Operational-level influences, whilst the second two could be considered Strategic-level influences.

1.2.4 Information resources for fleet managers: Cenex & Energy Saving Trust

There are a number of decision support resources available to fleets that are considering the potential adoption of PiVs into their fleets. CVEI Stage 1 partners Route Monkey, for instance, offer a fleet evaluation service based on proprietary algorithms that assess the potential cost and CO_2 emission savings that could be made if PiVs were adopted, either in terms of one-for-one vehicle substitutions, or if fleet operations and duty cycles were re-optimised taking the capabilities of PiVs into account.

CVEI partners Cenex, together with the Energy Saving Trust, The Climate Group, Transport for London, and TNT, collaborated to produce guidance for deploying PiVs in fleets (McMorrin, Anderson, Featherstone, & Watson, 2012) that remains current. The guidance includes "practical tools that fleet decision makers need to assess the benefits EVs can deliver". The guidance is based on research and case studies carried out by the contributing organisations (e.g. the Cenex "Smart Move" case studies (Carroll, 2011), and is specific to the UK market. It emphasises four considerations:

- Analysis of the range of operations within the fleet, to identify the optimal operating environment for EVs.
- Adoption of a whole-life costing approach to take into account the large number of cost variables beyond purchase price that impact on the cost-effectiveness of PiV acquisition: vehicle taxes and subsidies, fuel and electricity use, battery lifetime, service, maintenance, & repair, and length of ownership.
- Potential "branding" benefits, arising from the perception of PiVs as a "green" technology, in a context of increasing consumer demand for greener products and services, and preferences for brands with stronger pro-environmental credentials.
- The combination of government grants to support early acquisition of PiVs, together with increasing deployment of public charging infrastructure, to facilitate their use.

The guidance emphasises the first two points: "Combining whole life costs and a duty cycle approach will determine where an EV will be bring value to a fleet" (McMorrin, et al., 2012, p16). This emphasis reflects the findings of the ETI PiV project research (Hutchins, 2011) and that of Hutchins et al (2013), suggesting that, when fleets take a systematic approach to making their vehicle choice decisions, the uptake of PiVs will depend on (1) operational suitability, and (2) total (whole-life) cost of ownership[3].

[3] A somewhat different picture of factors influencing fleet managers' adoption of EVs was reported by Sierzchula (2014) based on research with 14 US and Dutch fleets, all EV Innovators. "Testing new technology" was their primary motivation; secondary factors included reducing environmental impact, accessing government grants, and improving the organisation's public image. It is unclear to what extent these motivations might be present for fleets more generally.

1.2.5 Modelling of vehicle choice processes in ECCo

In ECCo, vehicle choosers are categorised into four user categories, three of which represent categories of fleet choosers:

- Private Consumers: Vehicles are owned privately and choice lies entirely with the driver. The purchase decision is modelled in ECCo based on a weighted sum of six attributes: Purchase cost, Operating cost, Driving range, Access to charging infrastructure (local, workplace, & rapid), Performance of rapid charging, and Availability of preferred model/make. Six consumer segments ("Innovators", "Cost conscious greens", "Pragmatists", "Unmet Needs", "Uninterested rejectors", and "Car-loving rejectors" are modelled, each giving different weights to the different attributes (this segmentation, and the attribute weights, are based on empirical data from a recent choice experiment with UK consumers).
- User-chooser Fleets: Vehicles are registered to a company but chosen by individual employee users who are offered a mix of cash allowances, company cars or employee car ownership arrangements. Vehicle choice is modelled in ECCo on the same basis as Private Consumer choice – i.e. as essentially a free choice among a wide range of alternatives. Fleet User-choosers value a vehicle through the same range of attributes as Private Consumers; though with different weights, specific to the User-chooser fleet segment.
- Centralised-chooser Fleets ("Non User-choosers"): Vehicle choice decisions are modelled as being made centrally by a Fleet Manager rather than by individuals. ECCo assumes that Fleet Managers' choices are "rational", i.e. made to maximise utility based on operational cost-effectiveness. Consistent with the findings of Hutchins (2011) and the guidance of McMorrin et al (2012) such choices are assumed to be based first on operational suitability of vehicles (vehicles must meet duty cycle requirements), and then on total cost of ownership. Thus vehicle choices by Centralised-chooser fleets and User-chooser fleets are modelled using different processes and there is a recognition that this may result in substantially different choices. The separate treatment of these groups is a significant improvement to ECCo, developed in Stage 1, that is expected to improve its validity. Analysis of Route Monkey data was used to disaggregate the Centralised-chooser segment by duty cycle requirements. Further analysis of tax receipts was used to differentiate what proportion of centrally-chosen vehicles are liable to pay BiK tax and are therefore likely to be home-based.
- Fleet Car Sharing: Vehicles are owned by companies that provide access to user-driven transport as a service, involving a degree of asset-sharing (e.g. car clubs and private hire cars). Vehicle choices are modelled in ECCo in the same way as those of other Centralised-chooser Fleets, though with different assumptions about vehicle duty cycles. However vehicle **use** by Car Sharing Fleets is assumed to satisfy a portion of the VKT demand of Private Consumers, effectively replacing a fraction of Private Consumer VKT with a more efficiently utilised fleet.

The modelling assumptions are based on the "rational choice" perspective that dominates econometric modelling: that organisations make choices that maximise their net utility, based on cost-benefit considerations. Although it is now understood that this perspective often fails

to represent individual *consumer* choices adequately (because it over-emphasises instrumental (functional) motivations over symbolic motivations), the assumption is made that symbolic motivations play a less significant role in *organisational* decision making, so that a rational choice perspective is appropriate (noting though, that where organisation decision making is autocratic, symbolic motivations may play a bigger role).

1.2.6 Potential limitations of the current approach

There are two key potential limitations of the approach outlined above, that arise from the lack of in-depth understanding of factors that influence vehicle choices by fleets:

- *Neither Strategic level factors, nor interactions between decisions at Strategic, Operational, and Personal levels are modelled, for either choice process.*

Evidence was found in Stage 1 research with Operational-level decision makers (Fleet Managers) in depot-based Centralised-chooser fleets that their decisions were indeed influenced by Strategic-level concerns. Therefore we might formulate a hypothesis that this can be generalised to other Centralised-chooser fleets. If so, then insight into the extent to which the influence of Strategic-level concerns affects the choices made could usefully inform sensitivity analyses that explore the potential impacts of other choice variables that relate to Strategic-level factors, (and/or interactions between Strategic- and Operational level factors).

In car-sharing fleets, marketing strategy requires that vehicles are chosen that have consumer appeal – so while decisions are made centrally, they are likely to be influenced by consumer preference. Thus vehicle choice in car-sharing fleets in principle may share some of the properties of both choice mechanisms outlined above. Again, insight into this could usefully inform sensitivity analyses that explore its potential impacts.

- *Operational-level modelling in terms of suitability of vehicles for duty cycle plus total cost of ownership is known to over-predict current EV acquisition rates.*

Modelling uptake based on the assumptions discussed above tends to over-estimate the uptake of PiVs (Baringa & Element Energy, 2016). This over-prediction is corrected for in ECCo using a "familiarity penalty", a factor that reduces uptake based on an assumption that choosers in the early market have a bias against choosing PiVs because of their relative unfamiliarity. This effect of this factor is assumed to decrease as the penetration of PiVs in the LD vehicle parc (and therefore their familiarity) increases.

However, there may be other factors influencing operational-level decision making, beyond operational suitability, total cost of ownership, and the strategic-level influences discussed above, that influence those decisions in ways that are not well represented by the familiarity penalty. Such factors might be explicitly known to fleet managers, though not by modellers. For example, the Stage 1 research with Fleet Managers in Centralised-chooser depot-based fleets identified the indirect influence of positive feedback from drivers, and the anticipated higher administrative burden of operating with PiVs (including scheduling of charging, and more complex route scheduling) as having a bearing on some Operational-level vehicle choices. Alternatively they might reflect implicit influences that are outside the immediate awareness of Operational-level decision makers, but indirectly influence their choices (for instance, implicit social signalling within the organisation, by those decision-makers).

Insights into such factors as they relate to Centralised-chooser fleets with home-based vehicles, and to Car-sharing fleets, could usefully inform sensitivity analyses to explore their potential impacts.

1.2.7 Research Questions

To reduce Knowledge Gap 1, the Case Studies addressed five key research questions:

User-chooser fleets:

- How is the range of choice options available for Personal-level choices by User-choosers influenced by Operational and Strategic level decision making?

Centralised-chooser fleets with home-based vehicles:

- How do Strategic-level factors influence uptake decisions (in what ways) and how do these interact with Operational-level decision making?
- What other Operational-level factors (beyond operational suitability and Total Cost of Ownership (TCO)) influence decision making (in what ways)?

Car-sharing fleets:

- How do Strategic-level factors influence uptake decisions (in what ways) and how do these interact with Operational-level decision making?
- How do consumer preferences influence Strategic-level and Operational-level decision making?

1.3 Knowledge Gap 2: Charging profiles

There is even less research evidence to draw on regarding the charging profiles of PiVs in User-chooser fleets, Centralised-chooser fleets with home-based vehicles, or Car-Sharing fleets. The limited evidence that exists for the UK is summarised by Brook Lyndhurst (2015) and Hutchins et al (2013). Broadly, this suggests that charging profiles for home-based vehicles are similar to those of private consumers, while charging profiles of office-based pool cars include both overnight charging and daytime top-up charging after use.

Modelling is necessarily based on plausible assumptions as much as it is grounded in empirical data. The starting assumption for modelling the charging profiles of home-based PiVs, whether in User-chooser or Centralised-chooser fleets, is that they are similar to the charging profiles of private consumers. That is, charging is mainly carried out at home, in the evening and overnight.

However given the paucity of research evidence, this assumption is potentially subject to challenge. For instance, we know that the average VKT by fleet-operated vehicles is higher than the average VKT by private consumers, so on average, daily charging demand from home-based vehicles in both User-chooser and Centralised-chooser fleet categories may be higher, than that of private consumers. This will alter demand-time profiles, by extending the duration of charging periods. Consequently it will limit flexibility of charging times, and potentially therefore suitability for Managed Charging.

There may be other reasons why the charging profiles of real-world User-chooser fleets and Centralised-chooser fleets with home-based vehicles may differ from those predicted under

this starting assumption. To the extent that organisations provide workplace charging, and duty cycles place vehicles at the workplace for substantial intervals, then a shift towards daytime charging is plausible. Fleet PiV users may also have different patterns of access to public charging during daytime than private consumers, e.g. where fleets, for operational reasons, negotiate access to charge point networks.

Car-sharing fleet vehicles are not based at users' homes, but rather are based at distributed locations: near to members' residences, at transport hubs, and near key destination locations in city centres. As suggested in the preceding section, car sharing fleet uptake of PiVs is likely to depend on their ability to provide chargepoints at these locations.

Car-sharing vehicles are typically in use daytime & evening, so their main window of opportunity for charging at their distributed base locations is overnight (late evening to early morning). However car sharing business models depend on vehicles having high utilisation rates while offering members reasonably high availability. To achieve both of these with an EV requires that it have sufficient charge to meet user needs throughout the day and evening, suggesting that car sharing fleet PiVs would need to be recharged whenever returned to a base location. In addition, users on longer hires may seek to recharge vehicles at public chargers during their hire periods.

1.3.1 Research questions

To reduce Knowledge Gap 2, the Case Studies addressed eight research questions:

User-chooser and Centralised-chooser fleets:

- What is the form of home-based charging profiles? What is daily charging demand, what are charging durations? How valid are the assumptions that charging will mainly occur at home during evening and overnight?
- How far would organisations provide workplace charging, and to what extent would they make it attractive for users?
- How far would users have different patterns of access to public charging during daytime than private consumers?
- How would users pay for electricity used by the vehicle (at home, or at public chargers)? How would they reimburse for electricity used for business purposes?

Car sharing fleets:

- How readily can chargers be provided at the appropriate distributed locations?
- What is the pattern of vehicle availability for charging? (Specifically, what fraction of daytime and evening)?
- What fraction of charging would be carried out by users at public charge points, rather than between users at base locations?
- How would car sharing fleets ensure that members leave vehicles connected to chargers at the end of trips?

1.4 Stage 1 research

Stage 1 field research focussed on Centralised-chooser, depot-based fleets, using a semi-structured interview approach at Operational level (with Fleet Managers). This focus was chosen because Centralised-chooser fleets are modelled in ECCo using a choice process that seems plausible but to date lacks empirical support. Depot-based rather than home-based fleets were selected to facilitate discussion of managed charging options. Although not directly relevant to the objectives of the CVEI project, there is interest from Distributed Network Operators (DNOs) concerned with understanding the potential network reinforcement implications of depot-based fleets charging large numbers of PiVs simultaneously at one location.

Participating fleets were recruited largely from the Route Monkey database, supplemented by fleets recruited by Cenex. Most participating fleets either had PiVs already, or were considering them; they could thus be considered as PiV Innovators. The research addressed research questions around attitudes to PiVs, experience with PiVs, charging behaviour, and initial responses to User-managed and Supplier-managed Charging options. As a stimulus to discussion, Route Monkey analysed vehicle utilisation and the potential to replace ICE vehicles with BEVs either on a like-for-like basis or more optimally by adjusting scheduling to maximise opportunities for PiV use; a summary of the analysis was provided to participants in advance, and discussed during the interview.

Key research findings relevant to EV uptake were:

- Strategic-level considerations, particularly around positioning of the organisation as seeking to minimise its carbon footprint, were evident in many participating fleets' accounts of the factors involved in vehicle selection.
- Several other factors were identified in addition to suitability for duty cycle and total cost of ownership as being relevant to vehicle purchase decisions.

The research served as a methodological pilot study, testing the usefulness of individual semi-structured interview research, and the use of the Route Monkey fleet energy management optimisation tool as a means to stimulate discussion of Managed Charging options. In fact neither proved particularly successful. The short duration, long list of research topics to address, and limited time for the development of relational depth meant that there was insufficient time in a 1-hour slot to address any of the research questions in depth. Nor was there sufficient time to discuss and explain the Route Monkey analysis summary.

1.5 Methodology

Given that the existing evidence base is so sparse, there is a need to explore fleets' own perspectives on what factors are important in their decisions about PiV uptake: we do not know these in advance. Research methods that draw on researchers' own knowledge, experience or personal understanding are therefore inappropriate, because they run a high risk of the "Procrustean" error – that is to say, forcing information to fit prior theory, irrespective of its validity. Theory should emerge from and be grounded in the information and data gleaned. For this reason quantitative research methods such as surveys are not suitable; nor are highly structured interview methods.

Rather, to address the research questions discussed above we require an exploratory, qualitative methodology that reflects rather than constraining participants' own ways of construing the issues. Qualitative methods do not generate statistically representative data, but rather hypotheses whose potential impacts can be explored in modelling.

Two qualitative research methods dominate the literature in both transport research and organisational research: the semi-structured individual interview, and the discussion group ("focus" group).

1.5.1 Semi-structured interviews

The semi-structured interview method is the most widely used qualitative research method in both the transport and organisational research fields.

In organisational research, participants are typically individuals in similar roles in different organisations. A sufficient number of interviews is required to achieve "saturation" – a point where adding extra participants does not add further themes in the analysis. If the population being studied is relatively homogeneous in terms of its ways of construing the topics of research interest, then as few as ten interviews may suffice to achieve saturation. Often, the population will be heterogeneous in its ways of construing, so a larger number of interviews may be required. Experience suggests that, across a wide range of domains including transport and organisational research, around 30 interviews will often be sufficient.

In a semi-structured interview, the participant has the opportunity to discuss the research topics from his/her own perspective, in his/her own words. The interview does not take the form of a survey or questionnaire, with the participant being asked to select from a range of researcher-supplied answer options. Instead the researcher asks open questions that invite the participant to talk about their experiences, understandings, feelings and views about the topic. The researcher draws on a discussion or topic guide to provide overall direction and focus, so that the topics of research interest are covered; but it is not necessary to follow the specific order of questions, ask every question, or to use the exact wording for a question as suggested in the guide. Rather, the researcher seeks from the start to develop a comfortable, relaxed rapport with the participant so that he/she feels confident to talk as openly as possible. In a semi-structured interview the researcher is seeking to build a rich picture of the way that the participant relates to the topics – how the participant experiences them, is affected by them, thinks and feels about them, and what influences his/her responses to them.

In organisational research, interviews are typically limited to an hour or less in duration, as it can become more difficult to recruit organisational participants if the research imposes any bigger loss or working time. However this relatively short duration limits the value of the method when the range of topics to be explored is wide, when topics need to be explored in depth, or when rapport between researcher and participant is expected to be critical (for instance where research topics may be commercially or personally sensitive) because even with a skilled researcher it may take some time to develop.

Telephone interviews are the norm, as these can be conducted efficiently at lower cost, and participants are generally comfortable engaging in extended discourse by telephone. However face to face interviewing is preferred when rapport between researcher and participant is expected to be critical.

In scientific qualitative research (in contrast to marketing research) semi-structured interviews are audio recorded, and transcribed. The set of transcripts is then analysed, line by line and transcript by transcript, to identify and describe common themes.

This method was used for the qualitative research with Fleet Managers of depot-based Centralised-chooser fleets in Stage 1. Experience in that study suggested that the limited duration of individual interviews was insufficient to enable in-depth exploration of the wide range of topics involved in exploring PiV uptake and use. In addition, short-duration telephone interviews provided limited opportunity for researcher-participant rapport to develop.

1.5.2 Discussion groups

Discussion or "focus" groups (rather than individual interviews) are also common in both transport and organisational research, mainly for reasons of speed and cost.

In organisational research, participants may either be individuals in similar roles in different organisations, or individuals in different roles within same organisation, depending on the research questions being addressed. Discussion groups are typically of two hours' duration, and to be effective, must be carried out face-to-face. In scientific research, discussion groups are either audio or video recorded (the latter making transcription of multiple voices easier, and enabling observation of social processes enacted through non-verbal means).

However there are often substantial issues of social influence in groups that can lead to distortions in the information gathered; individual semi-structured interviews are often to be preferred when possible. Some exceptions include research where social influence processes are themselves of research interest, and workshop-style sessions where the aim is to make use of social processes to help with, say, ideas generation or concept development.

1.5.3 Case studies

Where research involves the exploration of complex organisational phenomena, particularly those which have an inter-personal dimension, or those which involve multiple organisational goals that may complement each other, compete, or conflict, then neither semi-structured interviews nor discussion groups provide sufficient engagement time, breadth, or depth of exploration. As we have seen, PiV uptake by fleets may involve complex interactions between the decision-making of staff at Strategic, Operational, and Personal levels. We therefore need to listen to the perspectives of staff in a variety of roles that reflect these levels, and understand their interactions. This requires a more complex approach.

Case studies are detailed studies of individual cases, aimed at exploring their particularities and complexities in depth (Yin, 2009). Individual case studies are tailored to the individual circumstances of their subject cases, so the specific methods adopted from case to case may differ. However in organisational research they generally share certain characteristics. Case studies typically take place over an extended time interval, providing multiple opportunities to engage and re-engage with the organisation and its staff. In addition, they typically involve engagement with staff in a variety of roles.

Case studies also enable the development of greater relational depth between researchers and participants. Relational depth refers to the development of a relationship of familiarity and trust between participants and researchers, in which participants are facilitated to

disclose more sensitive information, and to access motivations that are at the edge of, or outside awareness. Case study approaches provide the opportunity for relational depth to develop.

To achieve relational depth, researchers need to be able to engage in meaningful contact with all participants. In relation to fleets, this means researchers need experience of engaging appropriately with senior executives as well as with operational level staff such as fleet managers. Researchers also need to be able to engage with, understand, and reflect their understanding of participants' own frames of reference and ways of construing their situations (NOT attempting to fit/interpret participants' contributions using their own frames of reference); they need to be non-judgemental, and convey that to participants; and they need to be genuine, authentic, open, and trustworthy (NOT acting as if concealing something, such as why a particular question is being asked). Working at relational depth requires specific training.

TRL has experience of applying the case study approach to a research programme for Transport for London which aimed to understand why construction vehicles are overrepresented in cyclist fatalities in London (Helman, Delmonte & Stannard, 2013). Researchers identified specific construction sites and engaged in qualitative discussions with a 'network' of key stakeholders (such as clients, principal contractors, subcontractors, and drivers). This level of engagement enabled us to build a detailed picture of perceived relative risk to cyclists represented by construction vehicles as well as examining which features of contractual arrangements, working practices, driver behaviour and vehicle design could contribute to fatal collisions between construction vehicles and cyclists in London.

In conclusion, the more common qualitative research methods are insufficient on their own to enable adequate exploration of the research questions. A flexible case study approach, on the other hand, offered the maximum opportunity to answer the research questions needed to address Knowledge Gaps 1 and 2; this approach was therefore adopted.

2. Method

2.1 Research design

The research consisted of five in-depth case studies, addressing the research questions set out above in relation to Knowledge Gaps 1 and 2, as follows:

2 x case studies of User-chooser fleets

2 x case studies of Centralised-chooser fleets where vehicles are based at users' homes (one of which operates predominantly cars, the other also operates substantial fraction of vans)

1 x case study of a Car sharing fleet

Each case study was an in-depth study of one organisation. The specific methods used for each case study were negotiated and agreed with the participating organisation.

2.2 Recruitment of participating fleets

2.2.1 Recruitment criteria

Participating fleets were recruited against the following criteria:

- The fleet size was required to be greater than 100 vehicles. This ensured that the organisation was of a sufficient scale to exhibit the decision-making complexity outlined above, and also provide a variety of usage profiles and scenarios within each case study.
- Organisations were potential "Early Adopters" (as defined in Rogers' (2003) Diffusion model) of EVs, but not "Innovators" – so willing to consider PiVs in near future, but not currently using them (or only trying out a few).
- Organisations had a track record of successful early adoption of other technological innovations.
- Organisations were successful businesses (measured in both profit & growth), as this may indicate that their strategic thinking is effective

2.2.2 Recruitment channels

To maximise the chances of being able to recruit against the criteria above, initial engagement with potential participating fleets was made via a variety of channels:

1. Engagement via relevant project partners who have established relationships with fleet contacts (e.g. Cenex).
2. Established relationships with key industry facilitators (such as the Freight Transport Association, ACFO, Transport Engineer and Fleet news) who are well-placed to engage with our target participants.
3. Advertisement of the research on the TRL website, Twitter, LinkedIn accounts and other social media channels.

4. Engagement with fleets involved in the ECO Stars Fleet Recognition scheme managed and delivered by TRL which operates in fleets in over 30 different local authority areas across the UK. TRL has established ongoing relationships with the fleet managers associated with this scheme.
5. Engagement with fleets for which we have completed Energy Savings Opportunity Scheme (ESOS) audits.
6. Appropriate contacts from TRL's database.

Once initial contact was made, a strategic engagement plan was developed for each participating fleet, along with bespoke incentives for participation. A key element of the strategic engagement plan was early contact with strategic-level decision makers within the organisation, as their engagement in the research, and support for the organisation's involvement, was considered a critical success factor.

2.3 Participating fleets

A total of five fleets were chosen for Case Studies. They all had over 100 cars and/or vans in their fleet, they represented a variety of UK business sectors, and they were drawn from a variety of locations across the UK. They each had very different ways of managing their fleets, in particular the procurement decision making process, and attitudes to BEVs. This is reflected in the results.

Guinness Property Services is a property owning company who rent and maintain a large housing stock across the UK. Their head office is in Oldham and their fleet management is based in one of their principal depots at Chesterfield. They are a Centralised-chooser van fleet, primarily home based.

Churchill Services are a servicing contracting company with a wide variety of contracts across the UK. These range from a number of major railway operators and office chains, to providing servicing support to small business. Their head officers are based in Harpenden but their business is UK wide. They are a Centralised-chooser fleet.

FCC Environment Limited is a waste management company with their headquarters situated in Northampton. They are owned by their parent company, the Spanish construction and services group, Fomento de Construcciones y Contratas (FCC). They are one of the UK's leading waste and resource management companies. Their fleet is managed from the Doncaster Offices and their vehicle duty cycles include high mileage users. They are a User-chooser fleet.

Arthur McKay & Co Ltd is one of the UKs leading providers of building support services, respected throughout the industry. Their head office and fleet management are based in Edinburgh, but their vehicles are UK wide. Duty cycles tend to be on a regional basis. They are a User-chooser Fleet.

ZipCar (UK) is the UK's largest car sharing network offering availability 24/7 from a number of cities, with the bulk being based in London. There are two types of membership; Roundtrip or one-way and vehicles include both cars and vans. Rental can be by the hour or daily charge and is suitable for personal or business users. Zipcar are the case study which already has BEVs within its fleet in number, rather than a few isolated examples or trials.

2.4 Incentives for participation

Different organisations were likely to be motivated to take part in this research by different incentives, so a range of incentives were designed based on previous successes in engaging with fleets to encourage participation in this research. Potential incentives and the rationale for their selection included:

- The option to take part in an EV demonstration event – these events could be held at either TRL or Cenex and would give fleet managers the opportunity to experience driving the different types of EVs, learning about how to charge them and receiving a briefing about their capabilities.
- Charitable donation – this is a well-established incentive and historically has worked well at encouraging fleets to participate in research. In Stage 1, individual fleet manager participants were offered a £50 donation to one of three charities in exchange for participation in telephone interviews. For the case studies, incentives of £50 per participant, up to a total of £250 per fleet, were offered (i.e. up to £250 to a charity of choice where multiple staff in different organisational roles are involved enabling the organisation to get favourable PR through publicising their corporate citizenship). This incentive was not taken up by any of the participants.
- Positive public relations about being associated with the project – one of the findings from the Stage 1 research was that some fleets operate PiVs in order to signal corporate social responsibility and/or for reasons of brand positioning. Therefore participation in novel research such as this could be used in marketing and promotional activities for participating organisations.
- Enhanced knowledge and understanding of the current status of the PiV market – this would be provided on a consultancy basis with relevant experts from across the project partners. This would enable decision makers at Strategic and Operational levels to have a better understanding on which to base any future decision-making about incorporating EVs into their fleets.

2.5 Case study methods repertoire

The specific methods used in each Case Study were negotiated with each participating fleet. The participating fleets were willing to engage with multiple interviews, but not other methods such as analysis of the organisation's data or activity observations. Given the focus on the particular that is in the nature of Case Study research, there is no disadvantage to variation between Case Studies in the methods employed, provided that they enable adequate exploration of the research questions. Indeed some methods (such as interviews at Personal level) are only relevant for some categories of fleets (in this case, User-choosers).

Each of the Case Studies drew on the following methods:

- Initial desk research conducted prior to engagement with the targeted organisation to identify and contextualise general sector trends and strategic issues
- Multiple interviews with key individuals to build relational depth and cover complex topics in sufficient depth. The roles varied between the organisations, primarily driven

by their size and corporate structure. However all included senior managers involved in the fleet procurement decision making process and included:

  - Fleet Managers – the primary source of information and opinion
  - Procurement and Finance decision makers
  - Operational managers
  - Sustainability/Environmental Managers
  - Vehicle users

- Each organisation was studied over several months' time interval to provide more than a 'snap shot' of opinions and evidence.

2.6 Semi-structured interviews

The primary tool in the repertoire was the semi-structured interview, face-to-face, with an individual member of the organisation's staff. Multiple interviews were carried out with staff in each organisation.

Participants were interviewed in a semi-structured way, in which the participant had the opportunity to discuss the research topics from his/her own perspective, in his/her own words. Interviews did not take the form of a survey or questionnaire, with the participant being asked to select from a range of researcher-supplied answer options. Rather, the researcher asked open questions that invited the participant to talk about their experiences, understandings, feelings, attitudes, and views about the topic. The researcher drew on a discussion guide to provide overall direction and focus, so that the topics of research interest are covered; but did not follow the specific order of questions, ask every question, or to use the exact wording for a question as suggested in the guide. Rather, the researcher sought from the start to develop a comfortable, relaxed rapport with the participant so that he/she felt confident to talk as openly as possible. In these semi-structured interviews the researcher was seeking to build a rich picture of the way that the participant related to the topics – how the participant was experiencing them, was being affected by them, thought and felt about them, and what was influencing his/her responses to them. Information gathered this way was grounded in participants' own experiences, attitudes, and discourses.

2.7 Data recording from semi-structured interviews

In academic qualitative research it is common to make audio recordings of semi-structured interviews for subsequent verbatim transcription and analysis. This has the benefit of removing researcher subjectivity in the recording of data. However in business research the making of audio records can be seriously inhibiting of relational depth, and impact on participants' willingness to disclose information about their experiences, understandings, feelings, attitudes, and views. Since relational depth to facilitate open disclosure was key to this research, audio recordings were not made; rather, the researcher made comprehensive written notes as the interview progressed.

To ensure accurate recording of participants' contributions in researchers' written notes, two interview behaviours were adopted by all researchers. First, researchers engaged in bracketing off: developing awareness of their own ways of seeing the topic and how these

influenced their construals and interpretations; and seeking as far as possible to set these aside in hearing and recording participants' responses. Second, researchers engaged in active listening: avoiding as far as possible attempting to interpret participants' contributions using their own frames of reference; engaging with, understanding, and reflecting their understanding of participants' own frames of reference and ways of construing their situations; and checking this understanding by reflecting back to participants their understanding of what participants have said.

2.8 Thematic analysis of interview data

A thematic analysis was carried out of all interview contents, working from the detailed researcher notes. Thematic analysis involves the identification of all themes within the dataset that are relevant to the research questions. Themes represent the broad constructs that participants draw on in discussing a topic. The analysis process seeks to identify discrete themes that are internally homogeneous (all constructs allocated to a particular theme are closer in meaning to each other than they are to any constructs allocated to different themes) and externally heterogeneous (all constructs allocated to different themes are more different in meaning than any of the constructs within a particular theme.

The analysis was conducted by human analysts rather than using analysis software. Qualitative analysis software enables speedy analysis of large volumes of data, but is inappropriate when addressing research questions adequately requires accurate reflection of nuances and subtleties of meaning.

2.8.1 Themes: pre-determined or emergent?

Thematic analysis can take one of two broad approaches: either assigning content to pre-determined themes (e.g. where researchers are working within a specific theoretical model), or seeking to identify themes that emerge from the content itself. The direction chosen depends on the research questions being addressed. The first runs the risk of making the Procrustean error of constraining participants' responses to a pre-determined conceptual framework that may not adequately reflect their own experiences or ways of construing and expressing them in relation to the research topic: "forcing 'subjects' onto a… bed of Procrustes" (Salmon, 2003, p311-318). The research questions addressed in this study required identification of participants' own experiences or ways of construing and expressing them, so the second approach was more appropriate:

The analysis was approached inductively (Braun & Clarke, 2006), i.e. the structure of themes was allowed to emerge from the data itself. It was conducted at a semantic level (Braun & Clarke, 2006), from the explicit meanings contained in the data, without attempting to draw inferences about underlying meanings, and from an essentialist/realist epistemological stance - assuming that the language used by participants reflected their experience and personal constructions in a straightforward way.

2.8.2 Method of constant comparison

Analysis used the method of constant comparison. Each set of researcher notes was approached in turn, beginning with the first construct used by the participant, which was provisionally assigned to a "code" that reflected the construct's meaning. The next construct

was then considered: if its meaning was similar to the first, it was assimilated within the initial code, the meaning of which was adjusted to reflect that which was common to the meanings of the two included constructs. If its meaning was substantially different than that reflected in the first code, a new code was created, and the construct was assigned to the new code. Analysis proceeded in this way, working successively through all constructs in each set of notes. The meanings reflected by the various codes thus emerged from the data and evolved throughout the process.

The initial coding process produced a “long list” of codes. These were subsequently grouped into broader themes, representing the major aspects of the research topic as construed by the participants. The grouping process proceeded in the same manner as the initial coding, at a higher level of abstraction.

3. Results

Results for each of the five case studies are set out below. They have been written thematically, setting out where one or more of the interviewees has made a statement of fact or expressed an opinion that influences the management and decision making processes. Where a particular statement has been made that supports a salient theme identified in the analysis, they have been shown as Interview Quotes[4].

The results conclude with common themes and some idiosyncratic observations – where analysis has observed a factor individual to one case study. It should be noted that the fifth case study noted – Zipcar – has experience of EVs as a fleet asset and as such provides some significant feedback on their experiences and how this is feeding in to their business strategy for the further roll out of EVs.

3.1 Guinness Properties – Van Centralised Chooser

3.1.1 Background

Guinness Properties are part of Guinness Group of companies. Their fleet supports the main business of property maintenance for 65,000 rented properties across 6 regions in the UK. All of their drivers are employed primarily as tradesmen who use the vehicle as a means of transport for the following purposes:

- To and from their place of employment which varies on a daily basis
- To carry their tools and work related equipment
- To collect up any materials required for buildings maintenance from a network of authorised suppliers

Typically the fleet's drivers work within a 70-80 mile round-trip radius of their home address which is where vehicles are parked overnight. The drivers' tasks fall into 4 categories:

- Major property refurbishments
- Planned property maintenance
- Responsive property repairs
- Preparing empty housing for Guinness Properties to place on the rental market

The fleet has grown from around 300 vans in 2015 to the current fleet of just over 450 vans. It is a mixed fleet of vans, all of which are under 3.5t. The majority are panel vans (known colloquially as Transits) with some car derived variants, and some specialist vehicles such as van chassis based tippers. The fleet includes a recent addition of 50 vehicles from a business acquisition.

Of the fleet of 450, no more than 10 (<2%) are depot-based. These include one Plug in Electric Van (Citroën) on a long term trial for 9 months duration.

[4] Quotes are as recorded in researchers' contemporaneous notes; they are not necessarily strict verbatim but accurately reflect the interview participant's meaning.

The organisation's average annual spend on fuel (diesel) is approximately £1M.

Guinness Property is a relatively large organisation and their fleet procurement is managed through an annual board process.

3.1.2 Fleet Procurement

All of the vehicles are procured on a leased basis. There is a rolling programme to replace the fleet, with around 25% being changed each Financial Year. The current changeover period of every four years is under review and may be extended to every five years. This is a decision based on cost to change.

The annual changeover has to be formally agreed by the company Internal Procurement Group. The process in outline consists of the following stages:

- The Fleet Manager identifies the vehicles that are due for renewal; this is based on age and in some cases where there has been excessive mileage.
- Regional Operational Managers are advised of the proposed vehicle changes and review the requirement from an operational perspective:
    - The Fleet Manager challenges the need to retain a vehicle with the local head of operations to determine whether each vehicle being replaced remains critical or whether an alternative can be utilised, such as spot hire or sharing resources
    - The size and/or variant is also questioned to challenge like for like replacements
- The Fleet Manager reviews the models of vehicle available and makes a recommendation to the Internal Procurement Group
- The Internal Procurement Group reviews the application and makes its decision.

3.1.3 Vehicle Selection Decision Making Influences

The Fleet Manager initiates vehicle selection and draws on the following information:

- The performance of the current fleet, by vehicle type, based on:
    - Cost:
        - Monthly Hire
        - Fuel consumption (mpg)
    - Fitness for purpose - payload
    - Reliability including the cost of down time
    - Safety
    - Security
    - Sustainability & environmental considerations – primarily CO_2 emissions
- Viable alternative vehicles based on like for like costs and performance

- As vehicles are not used privately, personal-level emotive sentiments are not considered to be involved in the process.

Fleet Manager Quote - Cost will always be the primary consideration when pulling together a balanced scorecard for van selection

The balanced scorecard refers to the criteria set out above. Exact details of the scoring system were not shared. However the Fleet Manager, verified by the procurement lead, placed cost as the most highly weighted factor.

The Procurement Department has a major influence on the selection criteria for the company fleet, and a number of key issues at Guinness affect the procurement process:

- The organisation has to comply with a compliance framework when costs exceed £162,000 under the 2006 Public Contracts Regulations. These regulations stipulate that the business uses one of 15 framework suppliers. In Guinness' case *Crown Commercial Services* are used - they are also used by government departments. Neither the current contract with nor any of the other 14 approved framework suppliers recognise EVs or other alternative vehicles and fuels (Frameworks tend to run for 4 years consequently even if policies changed immediately the impact would not be felt until 2021 despite Guinness having an annual fleet budget).
- Currently leasing companies have insufficient evidence of the residual value of EVs and as a result stipulate a premium monthly leasing payment well in excess of petrol and diesel vehicles due to the risk of low residual values. (Contracts are signed primarily based on lease costs -70% on price 30% on other considerations. So even with low fuel cost of EVs compared with diesel or petrol vehicles the higher lease cost more than offsets the saving in fuel)
- Insufficient BEVs are available on the used vehicle market to confidently assess depreciation and future residual values

Procurement Quote - The current low residual values of EVs have considerable impact on EV use for commercial operation

- Changes to Housing Benefit have had a major impact on housing associations and as a result many millions of pounds of government funding originally targeted towards capital investment, including fleet replacement and new more sustainable technology, have been lost. This has had a major impact on the organisation, which has a challenging target of reduction of its carbon emissions by 10% per annum over the next 10 years. Guinness has already a made significant investment in Solar Panels, Heat Pumps and recycled water. In their view the ability to reduce Carbon Footprint for the whole business is more readily achievable at present through the introduction of renewable technologies in buildings than through the van fleet. In addition, the scale of renewables for building is so great as to make it a more significant contributor to CO_2 emissions .

Procurement Quote- National Government policies in other fields such as housing benefit, impacts on cash available for investment in sustainable measures

2006 Public Contracts Regulations have a major influence on vehicle procurement

- Business needs – EV range is currently insufficient for a large fraction of the emergency repairs carried out the response teams. Careful planning is required, particularly as payload can impact on vehicle range.
- Guinness' perception was that there is currently no hard evidence available for lifetime maintenance costs for EVs

There are corporate sustainability influences on the procurement process, and whilst internal environmental policies would encourage alternative fuels such as the use of EVs (if they were viable to use), the practicalities and restrictions such as compliance conditions can be in conflict with this aspiration as none of the current frameworks that Guinness comply with place any demand on the use of EVs.

Fleet Manager Quote – If an organisation wants to do the right thing environmentally, there are far easier ways to do so than procure and use EVs

3.1.4 Battery Electric Vehicles (BEVs)

At present the organisation has one BEV on a 9 month trial. The vehicle has the same rental cost as a diesel variant (contrary to the view discussed above that lease costs for EVs are higher than for conventional ICE vans, the fleet manager subsequently explained that the lease cost for this vehicle was a special deal to facilitate the trial, that was not expected to be reflected in PiV lease costs more generally). The potential advantage of lower energy cost per mile is the incentive for the trial. This vehicle is depot based as the allocated driver does not have a driveway from which to facilitate an overnight charge. The vehicle was off the road for four weeks due to a mechanical fault; significantly greater downtime than expected for equivalent ICE repairs. The cost to install a rapid charger in the premises is seen as prohibitive. The Fleet Manager decided to take one EV as the profile of depot based vans did not – in his opinion – justify more vehicles being used in the trial.

The business is aware of OLEV grants but the business leases all its vans, so any benefit from the grants has to be reflected in the leasing charges for an end user like Guinness to experience it. Guinness is also aware of grants for rapid chargers, but these are small in comparison to the cost of commercial rapid chargers being installed on site. The trial vehicle is being charged overnight through a standard domestic 240v 3 pin plug – taking 8 hours.

The biggest challenge perceived to the introduction of EVs is the need for home charging. The organisation does not have the real estate to depot base its fleet.

Fleet Manager Quote - Tradesmen are highly likely to live in multiple tenancy buildings and access to a driveway and power will always be uncertain

Due to the short range (around 70 miles) from home that each tradesman works, vehicle range is not seen as a significant issue for switching to EVs for Guinness Properties.

The trial EV is being used to raise awareness of the business environmental culture amongst staff through newsletters, toolbox talks and roadshows. This might suggest that corporate goals to influence internal culture in a pro-environmental direction can be supported without widespread adoption of EVs.

3.1.4.1 Potential charging behaviour

In principle, were this fleet to switch to PiVs, charging profiles would be similar to those of private consumers – vehicles would be charged at user's homes, in the evenings and overnight. However the company had not considered any of the related practicalities such as installation of home charging units or means of paying for the energy used, because the barrier that many of their van users live in multiple tenancy buildings, without access to off-street parking or electrical power, rules out the possibility of switching the fleet to PiVs.

3.1.5 Summary: Main Themes

- The cost of procurement of vans – lease costs and running costs (mostly MPG), will always dominate the decision making process
- EVs are suitable from a range perspective for most of the business demands at the current state of technology
- The operational business model is for vans is 98% home based
- The need to charge EVs at users' homes is a major factor weighing against them – given the nature of many workers' domestic accommodation, home charging is not considered as workable
- The cost of rapid charging infrastructure in the depot is prohibitive and perceived to negate any fuel savings from switching from diesel.
- Regulatory compliance is a further barrier: The 2006 Public Contracts Regulations do not take into account the benefits of PiVs /Alternative Fuelled vehicles
- A key to at least limited adoption of PiVs seems to be cultural change: the sustainability team have made significant progress in this area through various awareness-raising measures across business. However, there is still some way to go in terms of perceptions.

3.2 Churchill Services – car and van Centralised-chooser

3.2.1 Background

Churchill Services Solutions is a trading name of Churchill Contract Services limited. Their fleet supports the main business sectors of:

- Cleaning
- Catering

- Health & Safety Compliance Systems
- Maintenance
- Security
- Specialist Services including grounds maintenance, waste management and pest control

With over 1,000 clients from Scotland to Cornwall, Churchill is the largest independently owned service solution company across the UK. The vehicles within the fleet fall into two categories: Company Cars and Light Commercial Vans. The criteria for a company car are based upon job specification (e.g. a supervisory role, Key Account Manager, Business Development Manager, or Department Manager).

Churchill Services has expanded through acquisition of small businesses and 18 months prior to this report, a Fleet Manager was engaged to manage the growing vehicle assets of the organisation. As Churchill are very much involved in provision of services to government departments and organisations, as well as large private infrastructure suppliers such as train operating companies; they have found it necessary to adopt a more carbon friendly and renewable energy policy in order to enhance their tender competitiveness. Increasingly Churchill is being required to demonstrate their environmental credentials to win new contracts. They have implemented BS EN ISO 14001:2004. Their sustainability statement includes taking environmental performance into account when procuring equipment.

For those eligible for a company car based on business needs, an analysis of mileage used will be undertaken and staff are paid business mileage in accordance with government tax guidelines.

The company offers staff eligible for a company car the alternative of a car allowance scheme in which the employee receives additional salary in lieu of a company car, taxed as PAYE. The employee must then use their own car for company business. To ensure that the vehicles align with Churchill's overall CSR policy and vision, the company has introduced the following criteria for the employee-provided car:

- The vehicle must be less than 4 years old
- The vehicle must be classed as emitting less than 100grams/CO_2 per km
- The user must provide proof of yearly MOT certificate and service

These requirements are included in Churchill's Health & Safety and Driving at Work policy. Whilst some employees choose this option, others prefer to have a company provided vehicle. The percentage of employees choosing a car allowance instead of a company provided vehicle is approximately 35%.

The Light Commercial Vans are used to support the varied service contracts on offer, which can entail carrying equipment from cleaning machines to portable industrial ovens.

The fleet comprises of circa 400 vehicles of which 80% are vans and the remainder are saloon cars. Typical mileages for the vans are 70 to 80 miles each day. Annual mileages for the cars range between 15,000 and 30,000 miles, mostly comprising long journeys, so there are substantial daily variations.

Growth within the cleaning business is generally not organic, but is based more on acquisition. Churchill has acquired small cleaning companies and integrated them into the larger company to increase their portfolio. Historically, those companies have always tended to own their vehicles so, Churchill has inherited a large number of owned vehicles; they currently have around a 50 / 50 mix of owned and contract hire vehicles.

Generally throughout the Group, the contract hire vehicles are on a 4-year contract, with four mileage categories (15,000, 20,000, 25,000 or 30,000 miles per annum), dependent on where the person is employed.

As an example, some-one working in the North or Scotland will generally be put on a 3 or 4 year 30,000 mileage contract. This will be based on historical mileage data.

3.2.2 Fleet Procurement

The Fleet Manager's role encompasses fleet controller, procurement, supplier reviews, negotiating rates with lease/contract companies and fuel providers. Their role is to ensure that Churchill's fleet financial model is suitable and supports the company's future success.

When vehicles are due for renewal:

- Fleet Manager identifies the vehicles that are due for renewal; this is based on age and mileage.
- The Fleet Manager reviews the models of vehicle available and makes a recommendation on a case per case basis for each of the vehicle groups within the limited choice available
- The Fleet Manager agrees the lease contract dependent on company guidelines being met.

3.2.3 Vehicle Selection Decision Making Influences

When the Fleet Manager makes his vehicle selection the following factors are considered:

- The performance of current fleet by vehicle type for:
    - Cost:
        - Monthly hire/lease fee
        - MPG
    - Fitness for purpose - payload
    - Reliability including the cost of down time
    - Safety
    - Security
    - Sustainability & environmental considerations – cap for CO_2 emissions of 100grams/CO_2 per km
- Viable alternative vehicles based on like for like costs and performance.

- Due to the limited range of vehicle models available in the smaller size category used by the fleet, the number of vehicle options is limited. This is further qualified by vehicle price and by the CO_2 emissions of 100grams/CO2 per km cap.

3.2.4 Battery Electric Vehicles (BEVs)

At present the organisation has no BEV cars but has held talks recently with Nissan regarding introducing the Leaf model to the fleet profile. Further work is ongoing regarding cost, public charging infrastructure, employees' capability to charge at home address, and re-imbursement procedure for employee's electric usage. This fits with their CSR policy to green the business – both saving cost in the long term and making the business more environmentally competitive.

The Fleet Manager is aware of OLEV grants and also the grants for rapid chargers and is considering their options having had recent discussions with Nissan.

The biggest challenge at present in introducing BEVs is whether home charging would be feasible. No real work has yet been conducted but this is 'flagged up' as one of the biggest potential obstacles.

Fleet Manager Quote – It is highly unlikely that all employees will have access to a suitable power source in which to re-charge the vehicle whilst at home. However, it shouldn't detract from our efforts into considering introducing some alternate fuel vehicles, where ever possible.

Due to the long range (> 100 miles) from home that some drivers cover, vehicle range is seen at present to be an issue for switching to BEVs. However, HEVs have been introduced as well as LPG fuelled vehicles. These vehicles have been selected to comply with the pro-environmental criteria in customer contracts.

In this organisation there is a clear strategic direction to reduce the carbon footprint of the fleet as a means of securing business with customers who require certain pro-environmental standards from their suppliers. The extent to which PiVs can contribute to this appears to the organisation to be limited because of the potential problems associated with the provision of home charging, an additional and potentially major issue compared with ICE vehicles. At present the fleet manager has begun exploring options, but little evaluation has yet occurred.

3.2.5 Potential charging behaviour

Although Churchill has a strategic interest in adding some PiVs to its fleet, and has begun to consider issues such as whether its vehicles could make use of public chargers, it has not yet arrived at conclusions. The current view was that most vehicles would need to be charged at user's homes, which Churchill considers problematic, as discussed above. In principle, were this fleet to switch to PiVs, charging profiles would likely be similar to those of private consumers – vehicles would be charged at user's homes, in the evenings and overnight. However the company had not yet considered in depth any of the related practicalities such as installation of home charging units or means of paying for the energy used. Again the barrier that many of their van users live in multiple tenancy buildings, without access to off-

street parking or electrical power, may seriously limit the possibility of switching the fleet to PiVs.

If home charging were possible for at least some of their users, Churchill would expect to meet the electricity costs based on recording business mileage and reimbursing staff at a per-mile rate. However, they recognise that this might change in the future if technology were able to provide a solution to identify to the company when and how much a company vehicle was being charged at home. This would include identifying the vehicle, as users might have more than one BEV.

3.2.6 Summary: Main Themes

- The cost of procurement of company cars – lease costs and running costs (mostly MPG), will always dominate the decision making process
- The organisation is required – through the demands of open tendering with government departments and organisations (as well as a number of major private sector companies) – to demonstrate a commitment to the environment and renewable energies. The capping of cars at 100g/km is a first stage, with the introduction of HEVs, LPG fuelled vehicles, and eventually some BEVs to the car fleet beginning to be implemented.
- BEVs are not wholly suitable for the group's fleet due to the range but could be introduced in areas where daily mileage does not exceed 80 – 100 miles per day.
- The vehicle operational business model is that all vehicles are based at user's homes.
- The requirement to charge vehicles at users' homes is not considered as workable for the entire fleet, though the organisation seems committed to introduce some BEV cars where possible, to support its strategic efforts to reduce its carbon footprint.

3.3 FCC Environment – car User-chooser

3.3.1 Background

FCC Environment (FCC) is one of the UK's leading waste and resource management companies. Their approach is to minimise the amount of waste that ends up in landfill by transforming it into valuable resources wherever possible.

They provide a range of services, from collecting business and municipal waste to recycling and processing, and the generation of green energy from waste. This is achieved through a network of vehicles; and over 370 pieces of mobile plant, to collect, move and manage recycling products, supported by an infrastructure of over 200 locations.

Company cars are used mainly to take management staff between offices and business operating locations.

3.3.2 Fleet profile

The fleet comprises of 340 company cars, which are chosen from a predefined but wide range of vehicles set by the company. All vehicles are diesel with the exception of 2 HEVs currently

in use: the current fleet list does not include any other alternative fuel vehicles. FCC had previously operated an Employee Car Ownership Scheme but this has now stopped and all company car users must choose from the car fleet list: there is no Grey Fleet. In 2015 when it was an option for users, 44% chose the Grey Fleet option and 56% chose the company car option.

Fleet vehicles are typically used to make round-trip business journeys of around 300 miles. These are not undertaken every day, so average mileage per day is less than 100 miles.

The fleet list is reviewed regularly and due to the current political discussions around the use of diesel vehicles the company is pre-empting any potential tax penalty for diesel cars by reviewing the car list to include other options to diesel. This review may result in the inclusion of alterative fuelled vehicles, but this has not yet been agreed.

The car fleet list is currently based on:

- Service and support
- Price
- Basic specification - to suit employees' and business needs
- Emissions (less than 130g per km, so that employees benefit from current reduced personal tax liability)

The fleet list is mainly made up of Volkswagen (VW), Ford, Audi and BMW brands. Options are based on a "good" level of standard specifications (including satellite navigation and Bluetooth connectivity but without "unnecessary" extras). The allocation of a company car is described by the organisation's management as a means of transport for employees on company business, not as an employment perk or benefit in kind. That said, company cars do still have an element of prestige associated with them, which is reflected in the allocation of different vehicle choices across four levels of company management.

3.3.3 Fleet procurement

All vehicles are leased from one of three lease companies. Car choices are role specific and the person in the role needs to be to be able to prove that the mileage driven is necessary. Company policy is that the CO_2 emissions levels should not exceed a prescribed level, and options only include models that comply. This requirement has been imposed from a tax perspective, not as a result of an environmental policy.

There are four bandings and staff cannot pay for an upgrade between bands. There are between five and 20 vehicles available in each band for employees to choose from. The total fleet choice is 34 vehicles.

- Band A - Site supervisor
- Band B - Support functions, site management
- Band C - Area manger
- Band D - Director

The implementation of the four bands of categories does indicate that there is a link between company cars and seniority.

3.3.4 Vehicle Selection Decision Making Influences

Vehicles are selected by employees from options available for their employment Band. The cars available in each Band are ultimately determined by the Board of Directors, but much of the decision is delegated to the Fleet Manager (who also manages the organisation's commercial fleet and plant machinery). The car fleet list has been in place for several years and is reviewed regularly, but not "scrutinised" in depth. Thus there are influences from all three organisational levels (strategic, operational, and personal) involved in each choice.

On a day to day basis the main questions about choices of vehicles are emissions (for tax reasons) and the specifications of the vehicles. Given no added extras are provided by the company, what is included as part of the standard specification is important. Personal business circumstances are an important driver, so operational considerations such as the presence of estate options are important; however, the ultimate choice from among the options available is made by the user based on personal preferences and needs.

3.3.5 Battery Electric Vehicles (BEVs)

The organisation does not have any BEVs in its current fleet. There are two HEVs in the fleet at the moment and the management haven't received any negative feedback on these. A variety of reasons were offered for the relative lack of organisational interest in including PiV options on its car list:

- Concerns were expressed about the cost of maintenance, the costs of replacing batteries, the availability of servicing providers and the reliability of electric vehicles given the dampness of the UK environment.
- There is a collective managerial feeling that there is not sufficient charging infrastructure in place to support electric vehicles (availability of chargepoints at hotels where staff stay on company business would help to change this perception). The organisation is aware of the public charging infrastructure that is available locally, but this is considered insufficient for the business' needs.
- There would be a need to provide chargepoints at company premises, and this was not considered as affordable.
- There was also a perception that the speed of charging can be too slow, resulting in vehicle and potentially staff down-time while travelling.
- The short ranges of BEVs are not seen as compatible with high daily mileage patterns. Current business duty cycles mean that the vehicles would need to be charged three times during a working day. Battery technology would need to advance to a stage that a car would run for at least 300 miles without a recharge before inclusion of BEVs on the car list was likely. For this reason a cost appraisal for introducing EVs has not been conducted.
- As most of the company car users are high mileage drivers, there is an attitude that anyone who drives more than 5,000 miles per year will find BEVs unappealing – not just from a range perspective but as the majority are 'micro cars' that are unsuitable for driving longer distances.

- There was a degree of scepticism about government incentives for uptake, which might be withdrawn.

Fleet Manager Quote We are cynical about believing the motives for government incentives. An initial lower price followed by price increases and you are stuck with something that isn't appropriate for your needs.

- Tax incentives for HEVs for the users were a motivation for uptake of that particular technology. However, when tax incentives were removed some company car users reverted to diesel within the fleet.
- The allocation of a company car can be an emotive issue for some employees and BEVs are not seen by the management as being attractive to staff. They would need to made more aesthetically pleasing as a consumer item, or provide more personal financial benefit by offering greater tax incentives for users.

Fleet Manger Quotes - Government are not "selling" the issues of the environment enough to encourage uptake of EVs.

Tax incentives for hybrid (for the users) were a motivation. When the incentive was removed we reverted to diesel, which costs less.

Fleet Manager Quote - There isn't a burning platform for technology providers to move forward. Motor manufacturers drawn into constant cycles of incentivizing into R&D (which is the flavour of the day) then get a change of government or world policy and it changes again.

- Some concerns were raised about safety issues in the event of an accident although there was no evidence to support the assumption. The NCAP rating of vehicles is one of the criteria for inclusion on the fleet selection list.
- From a CSR perspective if the company were to push electric cars it would have to be convinced of the green claims for items such as the life expectancy of the battery and the disposal of the battery. In addition the whole life-cycle environmental cost would need to be taken into account – there is a perceived lack of knowledge as to whether electricity any better than diesel due to the power generation in the UK.

CSR Quote - Is it flavour of the month? Trusting the evidence is difficult given the recent issues with diesel. Petrol was bad, then diesel was good and now it's not. Who's to say that it is the same with electric?

User Quote - Environment considerations are part of it although electricity generation still uses fossil fuels. I'm a trained mechanic and so picked up environmental issues and air pollution.

3.3.6 Potential charging behaviour

Consideration of potential charging behaviour was moot, given the lack of appetite for considering PiVs for the car list. If BEVs were included at some stage, then charging profiles might well include some daytime charging due to the high daily mileages of staff on company

business. There would also be significant evening and overnight charging, both at users' homes and potentially at hotels where staff stay overnight on company business.

3.3.7 Summary: Main Themes

- Individual users choose from a list selected by the Fleet Manager: choices are influenced by all three levels, strategic and operational (to determine the list) and personal (to determine choice within the list)
- The list is in principle based on business need rather than vehicles serving as employment perks. Nevertheless, the banded structure of the car list suggests that a degree of symbolic motivation is present – cars can act as signals of position and status within the company.
- There was an extensive list of operational reasons offered for not including PiVs on the car list. These included perceptions of insufficient public charging infrastructure, high cost of installation of workplace charging, down-time while charging, short range not adequate for daily mileage requirements, and lack of confidence in the current state of EV battery technology.
- As a consequence of these perceptions, no comparative assessment of total cost of ownership had been carried out, nor was there any appetite to do so.
- There was collective corporate cynicism of Government incentive schemes.

3.4 Arthur McKay – car User-chooser

3.4.1 Background

Arthur McKay is a UK-based building support services provider, with depots in Edinburgh, Glasgow, Carlisle, Halifax and London. The three main departments are Mechanical & Electrical, Facilities Management and Networks.

The company has a turnover of £112 million and was established in 1958. The company was recently acquired by a global company based in South Africa, Servest Group Pty.

Company car drivers use vehicles for the following:

- To and from their daily place of employment, which varies
- To carry work related equipment
- To move colleagues to different sites

All drivers start their working day from their own home and do not have to go to a depot at the start or end of the day. Average mileage is 20,000 per annum, and vehicles are typically used every weekday.

The company car fleet consists of 121 cars, drawn from 12 manufacturers. The vast majority of cars in the fleet are diesel with only four being petrol, one a gasoline HEV, and one a gasoline PHEV.

The vehicle list from which users can choose is currently being updated; in updated form it will only list diesel ICE vehicles, with the exception of the Toyota Prius PHEV[5].

Staff entitlement to a company car falls into two categories:

- Essential user, i.e. a car is essential to carry out the employee's role
- Status user, i.e. the employee's role is at a level where market practice dictates that a car should be provided as part of a competitive benefits package

Only 46% of the staff who are entitled to a company vehicle "opt in". The remaining 54% "opt out", in favour of a car allowance, and are then required to use their own vehicle for company business (thus forming the organisation's Grey Fleet). All Grey Fleet drivers must provide the following documentation to the fleet manager for approval:

- Proof of ownership
- MOT (if over 3 years old)
- Insurance
- Service history

From the above information the Fleet Manager makes a decision on whether the vehicle is suitable for business use. At present there are no PiVs in the Grey Fleet.

3.4.2 Fleet Procurement

All of the vehicles are all procured on a leased basis. Vehicles are leased for four years, from one of two leasing companies; there is no cap on mileage within the leasing agreement.

The fleet manager and the company directors meet on a weekly basis and discuss the vehicles on short term hire, which vehicles are due for renewal and which new starters (staff) require a vehicle. The weekly fuel report is also discussed.

In the last six years outright purchase verse leasing has been investigated on two separate occasions and both occasions leasing was perceived as the best choice.

There is no formal cap on CO_2 emissions for any vehicle within the fleet; this is at the discretion of the fleet manager. Feedback from one of the lease providers is that Arthur McKay is below the national average for CO_2 emissions for the vehicles on lease.

The selection of vehicles available on the car list is made by the fleet manager, and is revised every 12-15 months. There are three staff grades, with access to different sets of vehicles:

- Junior Engineer
- Project manager
- Directors

Junior Engineers have a choice of three vehicles: at present all are diesel.

[5] This is conditional on the approval of the OLEV Plug-in Car Grant.

Project Managers have a choice from 24 vehicles that include premium brands such as Audi and BMW.

Directors submit a request to the fleet manager who will assess the request. Vehicles must be in keeping with the business and must comply with the following:

- No convertibles
- Minimum 4 doors
- "Sensible" CO_2 (Fleet managers discretion)
- Appropriate leasing cost

3.4.3 Vehicle Selection Decision Making Influences

When the Fleet Manager makes his vehicle selection he draws on the following information:

- The performance of current fleet by vehicle type for:
    - Cost:
        - Monthly hire
        - MPG
    - Fitness for purpose – payload
    - Reliability including the cost of down time
    - Safety
    - Security
    - Sustainability & environmental considerations – primarily CO_2, (influenced also by BIK considerations)
- Viable alternative vehicles are based on like for like costs and performance
- The head of procurement is not involved in the fleet decision making process, neither is the head of sustainability

3.4.4 Plug in vehicles

The fleet has one Toyota Prius HEV and one Mitsubishi Outlander PHEV. The latter was acquired at an employee's request; the former was acquired as a requirement of contract. There are no plans to expand the number of PiVs in the fleet.

Fleet Manage Quote - the MPG of the hybrid [PHEV] we have is pie in the sky and it's just a tax benefit to the driver

- The organisation is aware of the benefits and grants available to support PiV uptake, but at operational level, this was regarded as secondary since BEVs in particular were not considered suitable for operational needs.
- Engineers drive an average of around 35,000 miles a year and their work pattern is often responsive. BEVs are not considered to be suitable for this pattern of use, given

their perceived short range. There are also concerns about availability of chargepoints in the vicinity of destinations.

- Engineers also carry a range of tools, so that a larger hatchback or estate car is more suitable: there was a perception that PiVs tend to be smaller vehicles.
- Despite the inclusion of one Outlander PHEV in the fleet, consideration of the operational suitability PiVs seems to have been limited to BEVs.
- In addition, the organisation was sceptical that a solution could be found for the problem of charging company vehicles at employee's homes; though this had not been explored in any depth.
- If a particular contract required that the organisation made use of ULEVs then the company would be prepared to make an operational decision, provided the contract value justified this. For example one recent bid required the contractor to demonstrate "green" credentials and operate ULEVs; the company won the bid, and chose to provide the manager who oversees the contract with a Toyota Prius HEV.

3.4.5 Potential charging behaviours

The company had given little thought to the ways PiVs might be charged, since it did not consider them suitable for its operational needs. Plausibly the company might at some stage include PHEVs in its vehicle list (though inclusion of BEVs seems unlikely). If so, charging profiles would be similar to those of private consumers – vehicles would be charged at user's homes, in the evenings and overnight; there might also be occasional ad-hoc daytime charging at public chargepoints if located close to customer premises. However, again the company had not yet considered in depth any of the related practicalities such as installation of home charging units or means of paying for the energy used. When prompted, they argued that they would look at either repayment on a mileage basis or some form of domestic metering.

3.4.6 Summary: Main Themes

- Individual users choose from a car list populated by the Fleet Manager. The list has three levels, with a wider range of higher-cost models in the higher levels. Vehicle choice is influenced therefore by a combination of operational and personal level factors. The status related structure of the car list suggests that personal-level symbolic motivations are a salient factor.
- BEVs were not considered operationally suitable, largely as a consequence of perceptions that their range was too short to meet operational requirements. This deficiency cannot be compensated for by using public chargepoints, as the network is too sparse to be relied on.
- Although the fleet contained one PHEV (acquired at user request), and so had some awareness of PHEVs, little consideration appeared to have been given to PHEV adoption.

- Experience of the fuel economy of the fleet's sole Toyota Prius HEV has led to a cynical view of the performance of ULEVs, which appears to have been generalised to BEVs too.
- The vehicle choice decision making process was largely under Operational-level control – it does not include substantial influence from either the Procurement or the Sustainability departments.

3.5 Benefit in Kind

Both User-chooser fleets gave similar responses in respect of the influence of Benefit in Kind (BiK) taxation. BiK influences user's choices between having a company car versus taking up a car allowance (Grey Fleet) option. BiK was seen by both fleets to act as a disincentive for those of their staff who have limited business mileage to take a company car – these users tended to prefer to take the Grey Fleet car allowance option. BiK was also seen as acting as a disincentive for company car users wanting to use the vehicle for private mileage, as this would incur BiK taxation. Thus BiK is a factor influencing user-choosers in favour of Grey Fleet options.

BiK is taken into account when the list(s) of cars available to company car drivers is drawn up, in particular the CO_2 emissions and the benefit reported on employees' P11D tax forms, both of which have the greatest contribution to the determination of the HMRC taxation level applied to each car. Fleet managers are aware that vehicle models that attract high rates of BiK taxation will tend not to be chosen by users, so they are not included in the vehicle choice sets.

The recent introduction of a BiK taxation for all PiVs, from April 2015, and yearly increments thereafter, has, from these fleet's perspectives, led to fleets not including them in the choice sets available for users, and acted as a disincentive to users choosing them.

3.6 Zipcar – Car Sharing (Car Club)

3.6.1 Background

Zipcar is a car club that has a UK turnover about £30m per annum. About 98% of the car club business is in London, while the remaining 2% is split between Bristol, Cambridge, Oxford and the airports in Scotland.

Zipcar's fleet is made up of 80% cars, 20% vans. The cars are petrol ICE vehicles, with the exception of 50 PHEVs that are part of the 200 car fleet available in Westminster, central London. The vans are all diesel, though Zipcar are currently trialling VW petrol vans because of their lower regulated emissions, especially particulates which are an urban air quality concern (there are few petrol vans available on the market with the appropriate payload). Zipcar operates a total of around 1,600 vehicles for round trip usage by club members; round trip being pick-up and drop off at the same location. It also has vehicles that can be hired on a "Flex" basis for one-way trips.

The Zipcar fleet has an average age of 12 to 14 months; members have, therefore, access to the newest cars with the latest technology. The class mix is:

- Small vehicles, roughly 20% of the fleet (this year only the Ford Fiesta because of the manufacturer's price deals available in that vehicle class).
- Medium sized vehicles are the bulk of the car fleet (70%). These are VW Golf, Ford Focus, Hyundai i30, Golf GTE.
- Premium vehicles, 10% of the fleet (Audi A3).

In June 2016 Zipcar and the City of Westminster launched a joint initiative to place 50 VW Golf PHEVs in the Westminster council area. The vehicles, which fit into the Medium sized vehicle class, are hired at the same hourly rate as ICE equivalents.

An increasing number of automotive manufacturers are showing interest in car sharing business models, since they understand that car sharing may become increasingly part of urban mobility. Some are developing their own car club schemes (e.g. BMW) and are thus competitors to car clubs such as Zipcar, as well as potential vehicle suppliers; while others wish to be involved in partnerships.

Conventional car hire companies have also begun to enter the car club sector, for similar reasons. Zipcar was acquired by Avis as a reflection of a strategy to develop towards being a major Mobility-as-a-Service (MaaS) provider.

3.6.2 Fleet Procurement

Flex vehicles are leased by Zipcar for one year. Round trip vehicles are a mixture of "on-risk" vehicles that are purchased through Avis, then resold at the end of their Zipcar life; and cars acquired on buy-back deals (Zipcar keeps them for a certain period of time, for example three years, and within a certain mileage, at the end of which the cars are resold to the manufacturer at a previously agreed price). Zipcar needs to manage these vehicles' lifetime mileages carefully, deploying them based on mileage to date.

3.6.3 Vehicle Selection Decision Making Influences

Zipcar's vehicle selection process involves both Strategic- and Operational-level factors, and is also influenced by the company's understanding of the vehicle preferences of its customers (i.e. Personal-level factors). Operationally, cost-effectiveness is very important, and purchase or lease cost is a major factor, indeed the starting point. Running costs, including fuel economy, are also important. It must also be technically feasible to equip the vehicles with the smart-card technology that Zipcar uses to provide customers with access to the vehicles.

The car club sector is "hyper-local" in the sense that it is city-based, and needs to adapt to the particular needs of the city in which it operates. For example, London has a major priority of moving away from diesel and towards electric, reflecting the Mayor's Transport Strategy. Zipcar's UK fleet, dominated by its London-based vehicles, is therefore largely petrol fuelled, and it is trialling petrol PHEVs.

Customer preference is a key aspect. This is reflected both in the overall class mix outlined above and in the choice of vehicles within each class. Vehicles are chosen such that customers will enjoy driving them, and find them practical, straightforward and intuitive to use; and they must have a brand image that is seen to be congruent with Zipcar's own. In addition, a certain fraction of the fleet needs to be equipped with automatic transmissions, as some customers

are only licenced to drive these. Whilst driving a low carbon, "green" vehicle is positively evaluated by customers, it is a lower priority consideration for them.

UK General Manager Quote - If you are to persuade people into car sharing then they have to feel like they're not making a compromise; they've got to feel like they're driving good quality vehicles that can do any kind of trip they want

A key point considered is that having one brand only is a business risk (for example, in case of a recall, or if there is an issue with the manufacturer), therefore the car club aims to have a relatively even split between at least two brands in each class. On the other hand, the overall mix is kept simple, i.e. with few models, to avoid excessive administrative and logistics costs.

The vehicle mix also needs to balance types with higher and lower utilisation rates; this is critical to the business model, and utilisation rate in a car club needs to be traded off with availability to customers (a vehicle in use is not available to be booked by the next customer; but having too many vehicles available means lost revenue).

Members' response to plug-in vehicles has been very positive; however, the car club recognises that members do not wish to pay more, even if the vehicle is more expensive to purchase than any other compatible ICE model. The current partnership with VW allows Zipcar to have premium products and therefore they can afford not to charge more for the plug-ins.

3.6.4 Users (Customers)

The most active private customer members use the car sharing service instead of owning their own vehicle. Among these, utilisation is fairly balanced across weekdays and weekend days. However a significant number of members use Zipcar vehicles instead of owning a second household car; their utilisation is skewed towards weekends. In order to keep a balanced utilisation Zipcar has a keen focus on developing the business segment, since this needs access to the vehicles during working days.

Over 10,000 businesses have active accounts with Zipcar. Small-to-medium enterprises (SMEs) are interested in the service (particularly in the baseline product). These are those businesses for which it would be uneconomic to invest in their own fleet or their own transport. Zipcar's view is that London, with many start-ups and infant businesses, has a substantial business-to-business market for services which give access to cars and vans on demand.

3.6.5 Plug In Hybrid Electric Vehicles (PHEVs)

Zipcar is the only fleet among the case studies that has PHEVs in any substantial numbers. London is currently the only location in the business where PHEVs are deployed. This reflects, as mentioned above, Zipcar's efforts to position themselves as consistent with the Mayor's Transport Strategy, which includes a push for electrification of powertrains.

Zipcar's experience to date with its VW Golf PHEVs is that they offer lower fuel costs, which potentially makes them more profitable to operate. However repair and maintenance have proved more expensive. Although a suitable deal has been negotiated for the initial 50 vehicles, in general the small production volumes for PHEVs (indeed, for PiVs in general) means that purchase discounts to bulk buyers are less readily negotiated. In addition there is uncertainty over residual prices. All these considerations mean that there is overall

uncertainty over the total cost of ownership of these vehicles. They are seen, however, as strategically important, as facilitative relationships with city governments are critical to car club success.

Customer feedback on their experience with the PHEVs has been extremely positive. Net Promoter Scores (how likely it is that a customer would recommend the car to friends, family or colleagues) for the PHEVs were higher than for any other vehicle, suggesting high customer appeal and satisfaction. In addition, a large majority of survey respondents were in favour for Zipcar having more vehicles of this type.

Zipcar charges the same for a Golf PHEV as for the petrol ICE Golf, although the value of the car is comparable to that of a vehicle in the luxury segment (such as their Audi A3s); the running costs, however, may be lower, and these savings are not passed on to the customer.

Around 25% of reservations for the PHEVs have come from businesses (perhaps even higher in certain areas, such as Westminster).

Installing charging stations has been the biggest challenge, involving multiple overlapping negotiations with the vehicle suppliers, VW, London Boroughs, the electricity suppliers, the charge point suppliers and installers, the installation project management company appointed by the Borough; inexperience within all of these organisations; and timescales stretching much longer than anticipated.

3.6.5.1 Operational issues with PHEVs

Current operational issues with PHEVs in the fleet in Westminster are:

- Visibility of the state of charge data – they had to work with VW to provide a way of obtaining visibility of vehicle states of charge.
- Information from chargepoints: Zipcar need to know if a vehicle is charging; but if the chargepoint is an open-access one, they do not want people to see this information.
- The PHEVs were originally acquired on a 12 month buy-back basis. However Zipcar had to retain them for longer as VW did not have the supply in place to replace them. This has led to longer than planned lifetime in the fleet, which meant they were more vulnerable to damage / extra costs.
- Experience with its PHEVs suggests that the plug-in rate after the reservation is an issue, so that it is necessary to have fleet teams to patrol the Westminster area and plug the vehicles into charging facilities after they have been left. The plugging-in process is considered not as simple as it could be. However Zipcar have observed that if the car was plugged in at the start of the reservation, the plug-in rate increases to around 80%, so it may be that an educational strategy can affect the necessary behaviour change among customers.
- Costs for fuel are less, but not as much as they anticipated, partly because of users failing to plug the vehicles in on return, which means that utility factors (the ratio of electric energy use to total energy use) are lower than expected.
- Member interaction – Zipcar receives more calls per car from customers unfamiliar with the vehicles.

- The cost of BEVs. These are significantly more expensive to buy, but the car club doesn't charge members any more to use them, because they want them to use the vehicles.

3.6.6 Battery Electric Vehicles

Zipcar does not consider BEVs, at present, to be operationally suitable, particularly given the highly variable usage patterns of their vehicles. BEVs potentially can be charged overnight, when utilisation is low; but at times when higher utilisation is possible, the need for BEVs to be recharged potentially leads to downtime when vehicles are neither available nor being used – anathema to the car club business model. This contrasts with PHEVs, which require less charging time, and can in any case be used even if the battery is depleted.

Zipcar is aware that electric vans have been developed (for example, Nissan E-NV) but considers it problematic to operate them, citing, for instance, the absence of an IT application capable of managing aggregated data about the condition of batteries in a fleet of vans.

3.6.7 Charging infrastructure

Zipcar has contracted the use of some charge bays around London. These are owned by the local authority, which is responsible for their functionality. Charging at these was initially free, but this is changing; the business model behind it is not yet determined. Location of, and access to, parking spaces for its vehicles is critical to the success of a car club, and the need for parking spaces to also be equipped for PiV charging adds a further complication. A car club can either seek to use available public chargepoints, or install chargepoints at its own parking bays. The desired objective is enough chargepoints around London so that members can leave the vehicles in charge anytime and anywhere. Neither option is a fully satisfactory solution; Zipcar's view is that a sufficient charging infrastructure to operate a substantial PiV fleet is wanting.

UK General Manager Quote- No-one ultimately has found a commercial model they are comfortable with for the provision of infrastructure.

UK General Manager Quote - people get used to the charging technology, they get used to electric but they don't have any of the downside of it. […] if you think of the kind of trips that our members do, trips around town, they will be almost entirely on electric mode. But if they want to get out of town, and as soon as they get out of town, they'll be on petrol networks.

3.6.8 Charging behaviour

Zipcar customers are encouraged to plug the PHEVs in on return to the parking space at the end of their booking. This means that, in principle, the vehicles can be on charge at any time of day. Assuming that utilisation rates are reasonably high, charging periods are typically short, and batteries are discharged during the next period of use. Batteries will not necessarily be fully charged or fully discharged during the day. Vehicles are available for use during the evening, so the same charge-discharge pattern applies. Vehicles are not generally in use

overnight, so they are then plugged in for an extended period, leaving them fully charged in the morning.

As observed above, Zipcar has experienced some difficulty with customers failing to plug vehicles in at the end of their bookings.

3.6.9 Future Plans

Zipcar plans to increase the proportion of PHEVs in its fleet, potentially doubling the number in the next year. It may also introduce some BEVs, for short trips only.

The company would in the longer term prefer to switch to a fully electric (BEV) fleet for strategic reasons (including congruence with the city's strategic transport goals, which emphasise air quality; and congruence between the car club MaaS concept, and decarbonisation, both seen as parts of the future of mobility). However this would be dependent on improvements to range to increase their operational suitability. The company recognises that there is a great deal to consider before any large scale switch towards a BEV fleet.

Potential issues include the need to update its systems to accommodate managing the state of charge of its vehicles and integrating SOC information into its booking systems; better ways of ensuring that vehicles are plugged in after use (which is even more critical for BEVs than PHEVs); and rapid deployment of vehicle recovery services if vehicles run out of charge en route (to ensure a high quality customer experience). Resolving these various issues is likely to make the process of fleet electrification a slow one.

Zipcar Flex is logically the best fit with BEV deployment, since trips are shorter and utilisation is lower, so vehicles would need less downtime for charging during the day. However this would require chargepoints in place across different London Boroughs, which will add substantially to the deployment time. Initially, therefore, BEVs are likely to be deployed in Zipcar's Roundtrip service, since the deployment of the necessary charging infrastructure can proceed one Borough at a time. Zipcar are planning to research how they can charge the vehicles themselves in the meanwhile.

Commercial Quotes - The car club would like that the local authorities installed and maintained 7kW charging posts. Streets and car parks are the desired location for the dedicated bays.

Talks with all the Boroughs about how to proceed towards the electrification of the Zipcar Roundtrip service are in progress. The starting plan is to have between 2 and 10 BEVs in each borough by the beginning of next year. Boroughs show interest in electric vehicles, and there hasn't been much resistance.

Marketing Quote - A strategy is to make people realise the advantages of EVs in the everyday life, for example if you have an EV charge in your garage, you charge it overnight and you don't have to waste time going to the petrol garage

Looking further into the future: Zipcar will be looking at deploying Fuel Cell Vehicles when both vehicles and refuelling infrastructure are available. They see the introduction of Autonomous Vehicles (AVs) as a "game-changer" for Mobility as a Service, and for the integration of PiVs within it – vehicles being able, for instance, to take themselves to chargepoints. This capability in itself would greatly simplify the issue of needing both parking bays and chargepoints in locations that meet customer needs. Eventually, though, AVs should offer a pick-up capability that dispenses with the need for localised parking bays; charging station locations could then be uncoupled from parking locations.

Head of UK Marketing Quote - Every Roundtrip Zipcar needs its dedicated bay but there are other solutions we are open to exploring like […] floating car-sharing […] through rapid charger stations

3.6.10 Summary: Main themes

- Zipcar's current vehicle choice process involves Operational-level influences (particularly, operational suitability and costs; Personal-level influences in the form of customer preferences; and Strategic-level influences, including a strategy of moving towards full electrification in the longer term.
- Successful operation of a car club requires co-operation with the local authority in each city where the business operates, because access to parking spaces is a critical factor. In London, where the major part of Zipcar's UK operation is based, this means operating a fleet that is consistent with the goals of the Mayor's Transport Strategy, particularly in relation to air quality. Accordingly Zipcar is seeking to remove diesel vehicles from its fleet, and has begun experimenting with petrol-fuelled vans. In the longer run, Zipcar aims to move towards a zero emission fleet through further uptake of PHEVs, and the eventual introduction of BEVs.
- Zipcar presently operates 50 VW Golf PHEVs in London, and expects to expand this in the coming year.
- Its PHEVs are parked in bays that have charging posts (provided by the local authority). Vehicles are charged at any time during the day, between bookings, provided that customers plug them in after use. They are also charged at night when utilisation rates are low.
- Provision of sufficient chargepoints is a limiting factor for PiV uptake. The car club business model depends on access to parking spaces in locations that serve substantial numbers of customers (the distance customers are prepared to walk to pick up a vehicle is limited); electrification of the fleet depends on provision of chargepoints at these locations, which in turn depends on complex, slow negotiations with multiple organisations, including local authorities.

4. Discussion

Generalisation from qualitative case studies is a matter of theoretical extrapolation, having regard to the conditions under which the findings could be applicable to other situations (Patton, 2002). In this study, that means considering the salience (in relation to the research

questions) of similarities and differences between the fleets studied and others. Qualitative research does not generate statistically representative data, but rather hypotheses whose potential impacts can be explored in modelling.

4.1 Knowledge Gap 1: Factors influencing vehicle choice

It is typically assumed that fleets select their vehicles based on a rational choice between alternatives, determined by operational suitability and total cost of ownership. This is reflected in the way choice in Centralised-chooser fleets is modelled in ECCo (Baringa & Element Energy, 2016). In all five of these case studies, this cost-effectiveness perspective was "owned" at the operational level, by Fleet Managers; it was always present, and the most significant influence on fleet choices. This was particularly so in the two Centralised-chooser fleets.

However the case studies show that vehicle choice is also subject to other influences, originating at both the strategic and the personal levels.

4.1.1 Centralised-chooser fleets

The study aimed to address two research questions in relation to factors influencing vehicle choice by Centralised-chooser fleets:

- How do Strategic-level factors influence uptake decisions (in what ways) and how do these interact with Operational-level decision making?
- What other Operational-level factors (beyond operational suitability and Total Cost of Ownership (TCO)) influence decision making (in what ways)?

4.1.1.1 Strategic-level factors influencing uptake decisions

The procurement process at Guinness Properties might be characterised as bureaucratic in Nesbitt and Sperling's (2001) taxonomy of fleet vehicle procurement processes. Within this process, Strategic-level factors are considered alongside with Operational-level factors. Reduction of the organisation's carbon footprint is considered a Strategic-level goal, and in principle this could influence vehicle choices in favour of PiVs. So far, however, it has not. The organisation considers that it had other means of reducing its carbon footprint that are more cost-effective than PiV procurement, particularly given the perceived Operational-level difficulties with using PiVs that are outlined below. Thus in the case of Guinness Properties, a potential Strategic-level influence on vehicle choice is outweighed by Operational-level considerations.

The other Centralised-chooser fleet, Churchill, also has a Strategic-level goal to manage its carbon footprint, explicitly linked to its marketing strategy: much of its business is with public-sector customers that require contractors to demonstrate sustainability in their operations. However this requirement can apparently be met by stipulating that both company-owned vehicles and Grey Fleet vehicles (employees' own vehicles being used on company business) emit less than 100g/km. Since this criterion can be met with ICE vehicles, the customer requirement does not in practice act as a strong influence towards PiV uptake.

Considering both case studies together, vehicle procurement in principle could be influenced in the direction of PiV uptake by commercial pressures, were public-sector customers to

become more demanding in terms of the sustainability requirements they specify for contractors. At present their influence does not seem strong enough to drive much PiV uptake, particularly given the Operational-level barriers to such uptake that are discussed in the next section.

Although Churchill did not express this explicitly, the banded structure of their company car scheme suggests a second Strategic-level influence on vehicle procurement: using the type of company vehicle available to employees as part of its remuneration policy – more senior staff being able to have more expensive, higher-status vehicles. This suggests that there are symbolic motivations at play in determining the models available in each band (see Section 4.1.2 for further discussion of symbolic motivations). It does not appear, however, that this influence had led to any substantial inclusion of PiVs in its car fleet.

4.1.1.2 Other Operational-level factors influencing decision making

For one of the Centralised-chooser fleets, Guinness Properties, which operates vans based at workers' homes, daily mileages (stated to be typically 70-80 miles; circa 110-130 km) are sufficiently short that in principle, BEV vans could be suitable for operational needs, and in principle might make cost-effective one-to-one substitutes for at least some of the fleet. However this has not happened to date, even though such a development would be consistent with the organisation's strategic corporate sustainability goals.

Three major reasons for this emerged. First, the nature of the company's property maintenance business imposes commercial constraints on vehicle choice. As many of its customers are in the public sector, to contract with them it is required to comply with the 2006 Public Contracts Regulations, which stipulate that the business uses one of 15 framework suppliers. None of these framework suppliers includes PiVs in the range of vehicles that can be procured from them. Operation of PiVs acquired through other procurement routes would not be compliant with the regulations, and this would exclude the company from bidding for major public sector contracts.

Second, leasing companies at present have insufficient evidence of the residual value of PiVs and as a result charge a premium on monthly leasing payments compared to those for petrol and diesel vehicles (due to the risk of low residual values). This mitigates against any cost savings that might otherwise accrue due, for instance, to lower energy costs.

Third, many of the company's employees tend to live in multiple tenancy properties without access to off-road parking or power sources for PiV charging. The company's view was that this was a major barrier: it would be unable to provide home charging units to many of its vehicle users.

This latter constraint was also apparent in the vehicle choices made by the second Centralised-chooser fleet, Churchill. A requirement to charge vehicles at users' homes is not considered as workable for the entire fleet, for similar reasons – employees' dwellings do not necessarily feature off-road parking or access to electrical power outlets close to where vehicles are parked overnight.

In this fleet, however, other factors supported at least limited introduction of PiVs into the fleets. The organisation has a strategic goal to reduce the carbon footprint of its fleet, as a means of securing business with customers who require certain pro-environmental standards

from their suppliers. It seems committed to introduce some BEV cars where possible in support of this goal.

4.1.2 User-chooser fleets

The study aimed to address one research question in relation to factors influencing vehicle choice by User-chooser fleets:

- How is the range of choice options available for Personal-level choices by User-choosers influenced by Operational and Strategic level decision making?

In both of the User-chooser fleets, employees choose vehicles from a list determined by the fleet manager. Although one of the organisations argued that its company cars are seen as a means of transport rather than an employment perk, both lists are banded, with more expensive models for more senior staff, and one fleet manager described vehicle choice as an "emotive" issue for users. This suggests one strategic-level influence on vehicle procurement: using the type of company vehicle available to employees as part of its remuneration policy. It seems clear therefore that there is a degree of symbolic motivation in users' choices, and this is reflected in the banding structures.

This is significant in relation to BEV uptake in such fleets. Symbolic motivations to choose particular vehicles depend on self-congruity, the degree to which the symbolic meaning of a car is congruent with the personal identity of the chooser (Sirgy, 1982, 1985; Skippon, 2014). BEVs have been shown in two studies (Skippon & Garwood, 2011; Skippon, Kinnear, Lloyd, & Stannard, 2016) to have a specific symbolic meaning: they signal that the user is above average in the personality traits openness, conscientiousness, and agreeableness. Employees whose personal identity is congruent with this profile are more likely to be motivated to choose BEVs; those whose personal identities are less congruent are motivated to choose other vehicles with different symbolic meanings. Note that the symbolic meanings of "high-status" conventional ICE cars (executive saloons, SUVs, sports cars) typically signal low trait agreeableness (Skippon, 2014). It is reasonable to infer that in User-chooser fleets where signalling of status is important to users, BEVs are relatively disadvantaged, whatever their operational suitability and total cost of ownership.

In both of the User-chooser fleets the list of vehicles from which users could choose was constrained by various criteria set by the organisation, including a cap on CO_2 emissions that reflects Strategic-level concerns, though these relate to taxation rather than pro-environmental strategic concerns. One of the two organisations appeared to have a rather cynical corporate view of government incentives for PiVs; the origin of this negativity was not disclosed, but it seems unlikely that PiVs would be considered by this organisation for inclusion on its car list.

Both organisations offer those eligible for a company car the alternative of a cash "car allowance" in lieu of a car. Employees who opt for this must then use their own car for company business. In each case the organisation imposed some constraints and suitability criteria that apply to users' own vehicles; nevertheless those employees who opt for the car allowance have a much wider choice of vehicles. Essentially the choice process for these "Grey Fleet" vehicles is analogous to that of private consumers.

The potential issues associated with employees charging a company PiV at home were seen as barriers to PiV use to some extent by both fleets. Neither appeared to have given these issues any detailed consideration.

4.1.3 Car sharing fleet

The study aimed to address two research questions in relation to factors influencing vehicle choice by Car sharing fleets:

- How do Strategic-level factors influence uptake decisions (in what ways) and how do these interact with Operational-level decision making?
- How do consumer preferences influence Strategic-level and Operational-level decision making?

4.1.3.1 Influence of Strategic-level factors on vehicle choices

The car club, Zipcar, was the only fleet among the case studies that was actively engaged in operating PiVs, with an intention to progressively convert its fleet.

The key driver behind this is that the car club business model is essentially city-based. It relies on access to large numbers of potential customers living in close proximity to the distributed locations where its vehicles can be based, and needing to make generally quite short trips, with vehicle rentals lasting hours rather than days. Zipcar described its business as “hyper-local” – it is highly dependent on business conditions in the cities in which it operates, and it needs to develop working relationships (commercial contracts and strategic partnerships) with key city stakeholders, particularly local authorities/councils. These relationships are the key to providing the car club with the access to parking spaces in appropriate locations that is critical to success. It follows that local authorities can have a great deal of influence. City authorities tend to be concerned with local air quality, both because of the adverse health effects of air pollution on its population, and because of the potential negative impacts of air pollution on economic development. London, for instance, operates a congestion charging scheme, and the Mayor’s Transport Strategy supports replacement of diesel-fuelled vehicles, and introduction of PiVs, to this end. Zipcar’s strategy of moving towards electrification of its fleet’s powertrains is a direct consequence of the need to align with city goals.

Having said that, the use of BEVs is problematic within the car club model, particularly when their range between recharges is lower than the typical daily mileage of a car club vehicle. When this is the case, BEVs must, at some point in the day, spend downtime charging, neither in use nor available for use; and that impacts negatively on their utilisation rates. Given these constraints, it is unsurprising that Zipcar has begun trialling PHEVs rather than BEVs. These vehicles support the strategic aim of demonstrating commitment to decarbonisation to the city authorities, while not compromising vehicle availability or utilisation rates.

The other major strategic barrier to PiV introduction is the provision of chargepoints. As discussed in section 4.2.2.1, initially car clubs are likely to rely on commercial deals with existing networks, so the extent of PiV uptake is likely to be restricted by charge point availability and the ability to strike appropriate deals. A car club might choose to develop its own network of chargepoints where suitable deals are not available; again the rate at which that could proceed would limit the rate of uptake of PiVs.

Zipcar's short term strategy in London is to grow the PHEV fraction of its fleet in London, relying at this stage on negotiated access to existing charge points. In the longer term it intends to introduce and eventually switch completely to BEVs. However this seems a long term project, suggesting that the company sees the utilisation dilemma being addressed by waiting until the range of BEVs has improved to the point where an overnight charge will suffice for all trips the next day.

4.1.3.2 Influence of Personal-level factors on vehicle choices

Personal-level factors have considerable influence on Zipcar's vehicle selections. Individual customers do not have direct influence over choices in the same way that User-choosers do, but in order to sustain its business Zipcar needs to reflect its customers' vehicle preferences in its fleet procurement. Four Personal-level factors appear to influence the mix of vehicles Zipcar makes available for its customers:

- Vehicles must be "fun" to drive
- Vehicles must be straightforward, practical, and intuitive to use (customers may not have previous experience of a particular Zipcar vehicle, but this must not act as a deterrent)
- The brand image of the supplier must be congruent with Zipcar's own
- A certain proportion of the fleet must have automatic transmission, as some customers are only licenced to drive these.

Although moving towards a more sustainable fleet for Strategic (commercial) reasons, Zipcar's vehicle choices are ultimately dependent on its understanding of customer needs. While decarbonising its fleet is a Strategic goal (for commercial reasons), and driving a PiV is positively evaluated by customers, Zipcar's view is that the sustainability of its cars is a low priority consideration for its customers.

4.1.4 What about PHEVs?

Considering the Centralised-chooser and User-chooser fleets together, it seems clear that, when discussing PiVs, the focus is on BEVs rather than PHEVs. This was the case even in the fleet that had a PHEV. In the case of van fleets, this can be explained by the lack of availability of PHEV vans in the present UK market. However it also suggests that awareness of PHEV cars, which are available in the UK, remains low, which perhaps results from their later introduction into the UK market.

4.1.5 Influence of local and central governments

As discussed in section 4.1.3, the "hyper-local" nature of the car club business means that a strong working relationship with the local city authority is a critical success factor. Zipcar has developed a strategic goal to decarbonise its London fleet for this reason – in order to demonstrate consistency with the Mayor's Transport Strategy. This suggests that there is an opportunity for city governments to influence PiV uptake by car clubs in their cities.

Other fleets that had local or central government as direct customers were influenced by contracting and procurement requirements to demonstrate their sustainability credentials.

None of them had responded with substantial PiV uptake; they saw it as sufficient to limit the carbon emissions of their ICE vehicles to circa 100-120 g/km, or in one case preferring to reduce their carbon footprints in other, non-transport ways. Stronger contractor sustainability requirements on the part of local and central governments might, however, lead to some PiV adoption.

None of the 14 approved framework suppliers that must be used under the 2006 Public Contracts Regulations recognises PiVs, thus limiting their use by organisations that must contract under the regulations. PiV adoption by these fleets could be supported by updating this system.

User chooser fleets saw BiK taxation applied to PiVs as a financial deterrent to their adoption by User-choosers. PiV uptake could potentially be increased by reduction or removal of this deterrent.

4.2 Knowledge Gap 2: PiV charging profiles for fleets

4.2.1 Centralised-chooser and User-chooser fleets

The study aimed to address four research questions in relation to potential PiV charging profiles for Centralised-chooser and User-chooser fleets:

- What is the form of home-based charging profiles? What is daily charging demand, what are charging durations? How valid are the assumptions that charging will mainly occur at home during evening and overnight?
- How far would organisations provide workplace charging, and to what extent would they make it attractive for users?
- How far would users have different patterns of access to public charging during daytime compared to private consumers?
- How would users pay for electricity used by the vehicle (at home, or at public chargers)? How would they be reimbursed for electricity used for business purposes?

4.2.1.1 Home-based charging profiles

Neither the Centralised-chooser fleets nor the User-chooser fleets were operating significant numbers of PiVs, because of the barriers of lack of operational suitability and problems associated with charging of company vehicles at employees' homes. As a consequence, they had little or no experience to draw on in relation to charging profiles, and have given the issue little if any thought. What follows in this section, therefore, necessarily goes beyond the case study data, and is based partly on theoretical extrapolation and partly on plausible speculation. What is clear, however, is that, for both types of fleets, the charging profiles of PiVs based at users' homes will have the same general pattern as those of consumers: vehicles (both cars and vans) are in use on company business during the day, and would largely be charged in the evenings and overnight, when the user is at home. This might be supplemented by ad hoc use of public chargepoints where range was insufficient for the day's mileage needs; but if this were routinely the case, BEVs at least are unlikely to be chosen for the fleet in the first place.

The question of charging profiles is not relevant to home-based van fleets where the users live in accommodation not suited to the installation of home chargepoints. Since this was seen as a major barrier to PiV adoption, it is reasonable to assume there will be no charging demand from such fleets.

This argument does not necessarily apply to all van fleets, however. In those fleets whose typical vehicle users are able to afford to live in individual accommodation (e.g. houses rather than apartment blocks), users may well be able to charge at home. The two case studies can still tell us something useful about charging profiles in some such cases: those fleets, like the case studies, where vans are used primarily to transport staff (such as technicians) and their equipment to distributed working locations. In both of the van fleets studied, average daily mileages were around 70-80 miles. This represents up to around two hours' driving time, and it seems plausible that such distances and travel times are typical for van fleets used primarily to transport staff and equipment, since longer daily mileages would reduce working time at those locations. Home-based BEV vans with similar daily mileages would require around 5-6 hours of charging time using a 3kW charger. Assuming the vehicles are plugged in on return to home (early evening) and charging is unmanaged, most of this charging demand would fall in the evening. However there seems a reasonable potential for time-shifting this demand to late evening/overnight using Managed Charging.

Average daily mileages were higher in the car fleets, and indeed the annual mileage of U.K. company car users is substantially higher than that of private consumers. To the extent that BEVs are taken up by such fleets, their charging demand per charging event is likely be higher, the duration of home charging events will therefore likely be longer, and so the flexibility to manage their charging may be reduced. One of the car fleets indicated that the average daily mileage figure is misleading on its own in that day-to-day variations in mileage can be substantial. This suggests that present (2017 model) BEVs might have insufficient range for the longer journeys undertaken, even if BEV range exceeded *average* daily mileage, so they might therefore be considered operationally unsuitable. As BEV ranges increase, they will become more and more suitable for longer journeys and thus more likely to be adopted.

Since these vehicles are based at users' homes, and users are generally working during weekday daytimes, it is reasonable to assume that they will be charged in the evenings/overnight, starting on the user's return home. Also, since average mileages are higher, charging demand will be higher than in the case of the van fleets. However the day-to-day variability of trips means that daily mileages, charging demand, charging duration, plug-in, and plug-out times are likely to have wider variability than was the case for the van fleets studied.

Over the time interval to 2050, as the range of BEVs increases, it becomes more likely that 7kW home chargepoints will be installed rather than 3kW points. This will increasingly have an impact on charging profiles, reducing charging durations while increasing charging currents. In the case of company car fleets, it seems plausible that greater BEV ranges will enable substitution of a greater proportion of ICE vehicles by BEVs that are capable of being used for longer journeys. These vehicles will tend to have greater annual mileages and therefore greater overall charging demands, so charging durations with 7kW chargers may still extend to many hours when the longest journeys have been completed or are planned for the following day.

There were very few depot-based vehicles in use in the fleets studied so we are able to say little that can be generalised about charging of depot-based fleets, except for the already obvious, that vehicles are likely to be charged overnight, with some daytime charging where mileage requirements exceed range. However, as with home-based vehicles, if this is routinely the case, fleets are unlikely to consider them operationally suitable, and BEVs at least are unlikely to be chosen for the fleet in the first place.

4.2.1.2 Workplace charging

The participating fleets had little to say about the possibility of workplace charging. The "workplace" for the home-based vans in the case studies is not a central company depot or office, but rather a distributed set of locations owned and operated not by the fleet organisation, but by its customers. As such, the opportunity to provide workplace charging is minimal. There might be more opportunity to provide workplace charging for company cars, but since none of the four organisations had significant numbers of PiVs in their fleets, they had not given the issue any consideration.

4.2.1.3 Daytime public charging

Of the two Centralised-chooser fleets, only Churchill had given the possibility of daytime charging at public chargers any consideration, as it has a strategic motivation to introduce some PiVs into its car fleet at some stage. However it had not arrived at a firm conclusion on its feasibility, and in any case took the view that most charging would be in the evenings and overnight, at user's homes.

In both Centralised-chooser fleets, home charging potentially might be supplemented by ad-hoc use of public chargepoints when range was insufficient for the day's mileage needs; but if this were routinely the case, BEVs at least are unlikely to be chosen for the fleet in the first place.

Of the two User-chooser fleets, FCC Environment appeared to have a rather sceptical corporate view of PiVs, took the view that they did not meet its operational needs, has no plans to include them in its vehicle list, and appeared to have given all aspects of charging little consideration, including the use of public chargers. Their staff spend significant time away from home staying in hotels, so if they were to introduce PiVs (most likely PHEVs) onto their vehicle list and these were chosen by users, there might be some evening and overnight charging demand at chargers located at hotels.

4.2.1.4 Paying for electricity

In the User-chooser car fleets there were three different methods being used to pay for fuel used on company business:

- User reclaiming cost based on business mileage; no fuel card
- Fuel Card provided (billed directly to company) with private mileage declared, and cost recovered by company through payroll
- Fuel Card with 100% paid by employer and driver taxed as additional BIK (an infrequently used option)

Again the fleets had given the issue of paying for PiV electricity little consideration. The option of reimbursing for business mileage is readily adaptable for the case of a home-based PiV that is used both for business and private mileage, and where the electricity is paid for by the user. Such an option would potentially enable users to take up Managed Charging offers on an individual basis.

The issue has not been considered by the Centralised-chooser van fleets, since they do not view home charging as feasible for their workforces.

4.2.2 Car sharing fleets

The study aimed to address four research questions in relation to charging by Car sharing fleets:

- How readily can chargers be provided at the appropriately distributed locations?
- What is the pattern of vehicle availability for charging? (Specifically, what fraction of daytime and evening)?
- What fraction of charging would be carried out by users at public charge points, rather than between users at base locations?
- How would car sharing fleets ensure that members leave vehicles connected to chargers at the end of trips?

4.2.2.1 Chargers at distributed locations

For Zipcar this is an unresolved question that it is still exploring. In principle, a car club could strike a commercial deal with a charge point infrastructure provider, as Zipcar has done in Westminster, allowing its pilot fleet of PHEVs access to an existing network of charge points. However this approach has limitations: in particular, there might be substantial mismatch between existing chargepoint locations and the optimum distributed locations at which to base car club vehicles. In addition, reliance on existing charge point networks acts to limit potential growth of the car club business. The alternative is for the car club to develop its own network, either alone or via partnerships. Zipcar's experience shows this to be difficult to implement in public locations, such as the roadside, involving complex negotiations with multiple parties. Neither option is a fully satisfactory solution; Zipcar's view is that a sufficient charging infrastructure to operate a substantial PiV fleet is wanting.

In principle the utilisation dilemma for BEVs could be addressed by the provision of rapid chargepoints. Where a car club relies on access to existing networks, this option is clearly constrained by the types of chargepoints in the networks concerned; these are, at present, dominated by "slow" charging. Investment in a widespread new network of rapid chargepoints would clearly be an expensive route, and might be uneconomic.

Use of rapid chargepoints is also limited by compatibility of vehicles. The Golf PHEVs that Zipcar is currently using, for instance, are not compatible with rapid charging.

4.2.2.2 Vehicle availability for charging

Charging profiles of car club vehicles will likely include daytime and evening charging, in the intervals when vehicles are not in use. These short duration charging events are likely to be

scattered through the day, though in particular cities they may occur preferentially at times when traffic density is low (i.e. when demand for road travel is lower). The lowest utilisation of car club vehicles is overnight, so it is to be expected that all car club PiVs will be charged at night to bring them up to 100% SOC before usage begins again the next morning.

4.2.2.3 Fraction of charging at public charge points

Trip mileages tend to be short (mostly intra-urban journeys) so charging tends to happen in the intervals between hires, rather than the vehicle being charged by the customer in mid-hire. At present all Zipcar's charging is done at public chargepoints. Where a sufficient network already exists, commercial deals with existing public chargepoint networks seem likely to be a preferred option, at least in the initial introduction of PiVs to a car club fleet. In cities where there is only a sparse existing network, or none, the complexities and capital cost of deploying its own network may deter a car club from introducing PiVs; though the problem of mismatch between locations means that this solution might eventually be adopted to some extent. Ultimately the fraction of charging at public chargepoints will vary from city to city, dependent on local circumstances, in keeping with the "hyper-local" nature of the business.

4.2.2.4 Ensuring that customers leave vehicles plugged in

This is an operational problem that Zipcar has encountered but not resolved. For its pilot fleet, it uses a mobile patrol that visits returned vehicles to plug them in.

4.3 Implications for CVEI analysis

The case studies have two direct implications for the Analytical Framework.

4.3.1 Uptake of PiVs by fleets

The findings suggest that modelling uptake of PiVs by those Centralised-chooser fleets where vans are based at user's homes will over-estimate uptake, if based on operational suitability (for duty cycle) and total cost of ownership alone. This is because modelling on that basis neglects the additional operational issue of whether the vans can in fact be recharged at users' homes. The evidence from the case studies suggests that in reality, fleets understand that this will be problematic, if not impossible, in many cases, and so will not adopt PiVs even if they are otherwise suitable and cost-effective.

ECCo accounts for the present discrepancy between predicted and actual uptake by fleets using a "familiarity penalty", a factor that reduces uptake based on an assumption that choosers in the early market have a bias against choosing PiVs because of their relative unfamiliarity. The effect of this factor is assumed to decrease as the penetration of PiVs in the LD vehicle parc (and therefore their familiarity) increases.

The case studies suggest a further penalty factor that reflects the fraction of such vehicles that cannot be charged at home for the various reasons outlined above. Unlike the familiarity penalty, this is unlikely to decrease with time. At present it is difficult to quantify the magnitude of the penalty that might be applied.

At present the operation of such a further penalty is a hypothesis, as is all generalisation from qualitative research. It is not therefore appropriate to consider making changes to ECCo at

this stage. However the hypothesis will be tested by running sensitivity analyses with the Analytical Framework, assuming a range of levels of reduced uptake of PiVs by such fleets. The analysis should consider the range from zero up to the level of uptake predicted by operational suitability and total of cost of ownership. Lower values in this range reflect the hypothesis that other fleets with similar workforces will not adopt PiVs because their employees cannot charge them at home. Higher values reflect the possibility that this situation might change, or not apply to all such fleets. At present we do not have adequate knowledge of the fraction of home-based Centralised-chooser van fleets whose workforces could not charge at home; this could be the topic of future research.

4.3.2 Charging profiles

The case studies suggest that charging profiles for Centralised-chooser van fleets whose vehicles are based at users' homes, will be similar to those of private consumers with a pattern of regular daily use of the vehicle. It will therefore be reasonable to use charging profiles generated in the Consumer Charging Trials to model the charging profiles of such fleets.

For User-chooser and Centralised-chooser car fleets, the findings suggest that vehicles are often used for long round trips (e.g. circa 300 miles), but not every day. Fleets do not consider BEVs appropriate for such duty cycles. This suggests the hypothesis that charging profiles of PHEVs will reflect intermittent (non-daily) charging of a fully depleted battery, at home in the evening/overnight. As these drivers are returning from long trips away from home, charge start times may not be as regular as those of consumer drivers in the PHEV Charging Trial (WP5). These charging profiles can be modelled using data from the Consumer Charging Trials, modified to reflect non-daily use, greater variability of charge start time, and that a full charge is always required.

Charging profiles for car clubs, which become increasingly important in those Narratives where there is greater provision of Mobility as a Service, will include some daytime and evening charging as well as overnight charging. For individual vehicles on individual days, the profiles will consist of short periods of charging between periods when vehicles are in use. Across the fleet these short term fluctuations will tend to average out. It may be appropriate to model them based on the reciprocal of traffic density, assuming that the car club vehicles will tend to be in use at times of day when general traffic density is high, and available for charging at times of day when traffic density is low.

4.3.3 Interpretation of modelling outputs

In addition to these direct implications for WP7 modelling, the wider findings of the case studies will be used in interpreting the outputs of whole-system modelling using the Analytical Framework.

5. Conclusions

Given the qualitative nature of the research, generalisation from its findings takes the form of hypotheses about PiV uptake and charging behaviour from Centralised-chooser, User-chooser, and Car club fleets. The key hypotheses are summarised here. The validity of these hypotheses will depend on salient similarity with the participating fleets.

5.1 Uptake of PiVs

- Operational suitability and costs of ownership (particularly leasing cost or upfront purchase cost, and depreciation losses) remain the most important vehicle selection considerations for Centralised-chooser, User-chooser, and car club fleets.

5.1.1 Centralised-chooser fleets

- The provision of charging facilities at employees' homes is a major barrier to PiV uptake by Centralised-chooser van fleets. They recognise that many of their employees live in multiple tenancy accommodation, without access to off-street parking with a power supply where a chargepoint could be installed (*this hypothesis may not apply to fleets whose employees are more highly paid, as they may be able to afford housing where off-street charging is possible*).
- In the face of this barrier, Centralised-chooser van fleets have not made significant efforts to carry out systematic comparisons of the costs and benefits of ownership of PiVs and ICE vehicles.
- Centralised-chooser fleets may include some PiVs in their fleets in response to customer requirements to demonstrate sustainability credentials (e.g. where customers are local or central government).

5.1.2 User-chooser fleets

- In User-chooser fleets, vehicle choice is essentially at the personal level, but is constrained by criteria imposed by the organisation. The range of vehicle options made available reflects corporate goals that include providing employee benefits.
- User-chooser fleet vehicle lists are hierarchically structured, with higher status vehicles for higher status staff; the hierarchical list reflects a corporate view of personal-level symbolic motivations for car choice.
- User-chooser fleets offer "car allowance" schemes as alternatives to company cars, so their company-provided fleets are associated with so-called "grey" fleets of private cars used for company business. The company is likely to impose some basic criteria for eligibility that reflect those used to define its own vehicle list, but users have a wider range of choice.
- User-chooser car fleets have also not made significant efforts to carry out systematic comparisons of the costs and benefits of ownership of PiVs and ICE vehicles.

5.1.3 Car clubs

- Car clubs are typically based in cities, and require close relationships with city authorities to operate. They are thus substantially influenced by city authorities' goals. Most cities have concerns about air quality, so car clubs have a strong strategic motivation to adopt PiVs.
- Present BEVs are problematic for car clubs to operate because their short ranges mean that vehicles may require downtime to recharge during the daytime/evening, adversely affecting their utilisation rates. This dilemma for BEV deployment would eventually be ameliorated by substantial technical improvements to BEV range in the coming decades.
- PHEVs provide a partial answer, and may be adopted first by car clubs.

5.1.4 Local and central government policies that influence PiV adoption by fleets

- The dependence of the car club business model means there is an opportunity for city governments to influence PiV uptake by car clubs in their cities.
- Local and/or central government departments that procure services externally require suppliers to demonstrate their sustainability credentials. Stronger requirements might lead to more PiV adoption.
- The system of approved framework suppliers that must be used under the 2006 Public Contracts Regulations is currently a deterrent to PiV adoption by organisations that contract under these regulations. PiV adoption by these fleets could be supported by updating this system.
- BiK taxation applied to PiVs acts as a financial deterrent to their adoption by User-choosers. PiV uptake could potentially be increased by reduction or removal of this deterrent.

5.2 Charging

5.2.1 Centralised-chooser home-based van fleets

- Charging profiles are not relevant for Centralised-chooser van fleets whose employees' accommodation precludes home charging.
- Since vehicles are in use in the daytime, charging profiles for those vehicles whose users could charge them at home will tend to be similar to those of consumers (i.e. largely evening and overnight).
- Any daytime charging at public chargepoints will be adventitious, e.g. if the chargepoint is close to the customer premises the van driver is attending.

5.2.2 User-chooser car fleets

- Where PiVs are adopted in User-chooser car fleets, charging profiles will be similar to those of consumers: vehicles will largely be charged in the evenings and at night.

However there may be greater daily variation in profiles where users make long journeys and/or do not use their vehicles daily.

5.2.3 Reimbursement of charging costs

- Of the models that currently exist, reimbursement for at-home charging costs can most readily be achieved using the system of claiming for business mileage.

5.2.4 Car clubs

- Car clubs will initially seek commercial relationships with existing charge point providers that may be arranged on a localised (city-by-city) basis.
- Charging profiles for car club PiVs will include overnight charging (when most vehicles are not in use). Vehicles are in use in the evenings so charging opportunities then will be intermittent.
- There will also be a pattern of short-duration “top-up” charging during the daytime and evening, whenever the vehicles are parked in between bookings.

6. References

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D6.1 - Fleet Study

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