

Who will adopt electric vehicles?

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Dr Jillian Anable

Centre for Transport Research

University of Aberdeen

j.anable@abdn.ac.uk



Steve Skippon, Shell Global Solutions

Geertje Schuitema, Aarhus University, Denmark

Neale Kinnear, Transport Research Laboratory, UK

Energy Technology Institute: Plug-in Vehicle Programme

Part 1: Research,
analysis and
modelling (£4.5m)

March 2010

Part 2: Testing through extensive
real-world trials with 'mass
market' consumers

June 2011



Charging Technologies,
Electricity Networks and
Integrating Systems

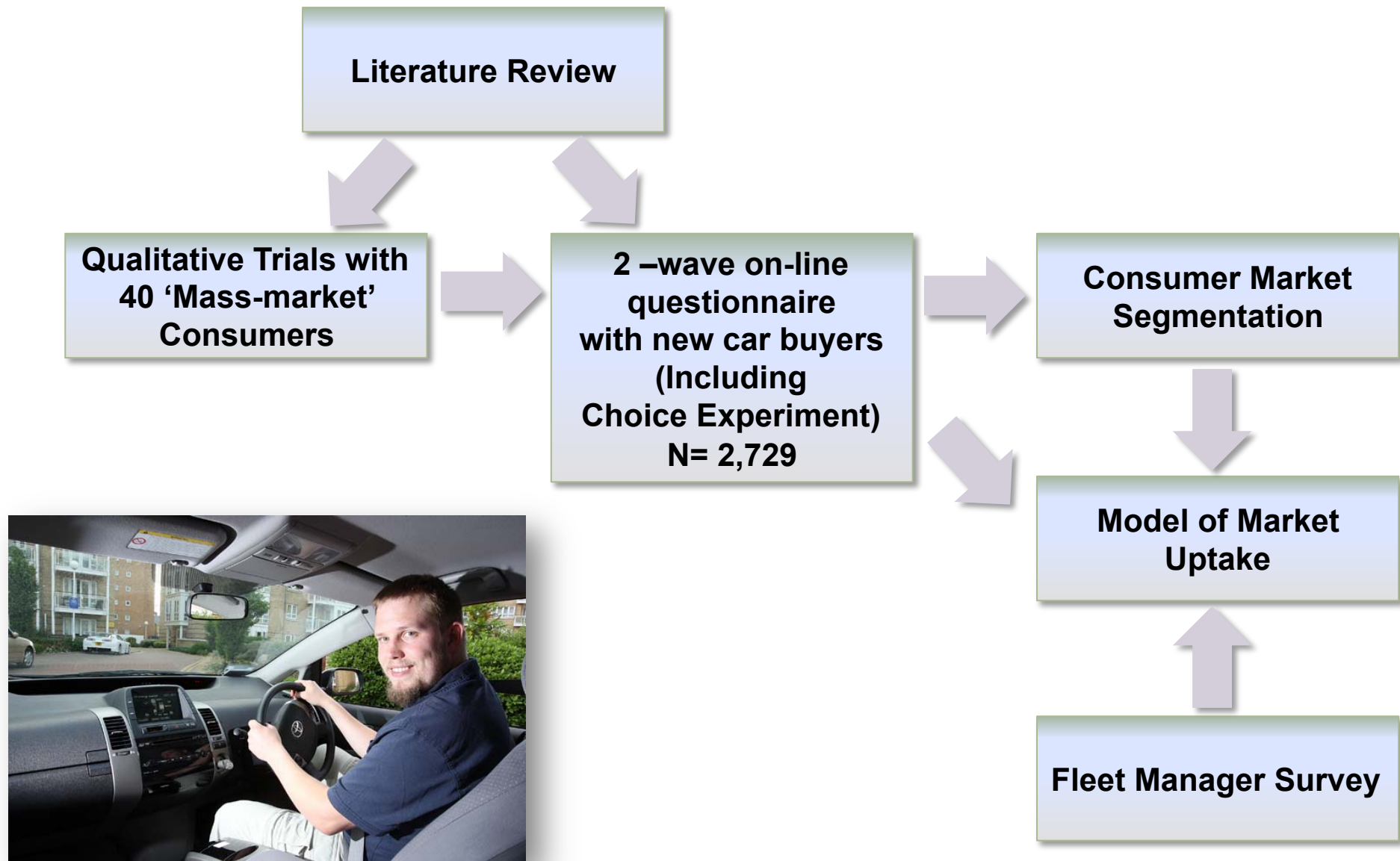
Vehicle Technology,
Performance and
Costs Analysis to 2050

Consumer Attitudes,
Behaviours and
Societal Acceptance

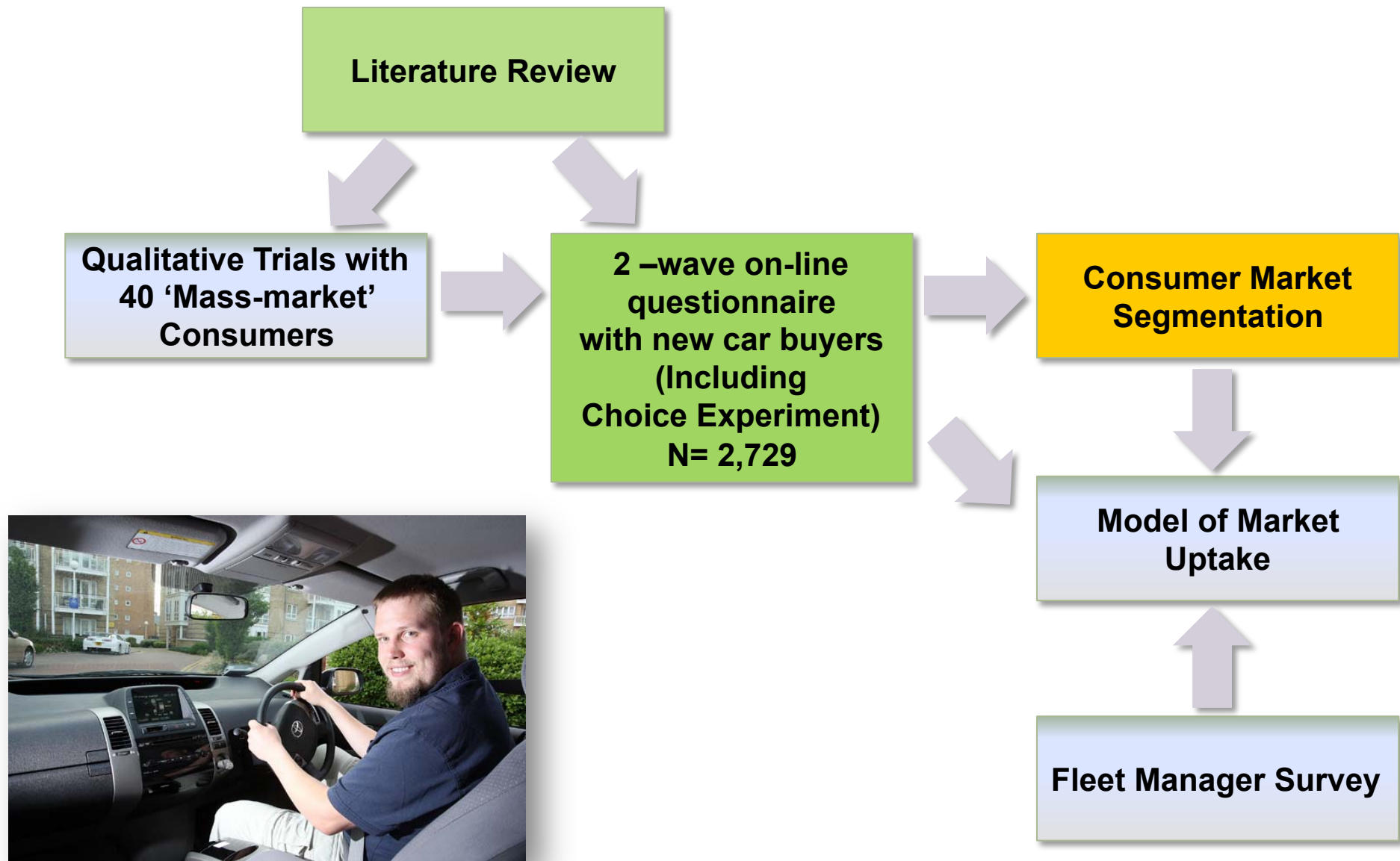
Long-term Economics,
Carbon Offset and Strategic
Options for Market Transition



Project Methodology



Project Methodology



Literature review

- Purchase price
 - Evidence from SP surveys suggests purchase price has the greatest influence on car choice
 - However studies have found a lot of consumer interest in EVs, especially PHEVs
 - Early adopters may be willing to pay more for their purchase
- Fuel economy
 - Conflicting evidence from studies regarding importance as a purchasing factor
 - May have become more important recently
 - However most consumers can not make detailed payback calculations and do not know their vehicle's mpg

Literature focuses on the 'feasibility' of EVs:

- Range/Battery life

- Current (H)EV owners currently have lower mileages than the overall population
- UK National Travel Survey:
 - 50% do not drive more than 25 miles a day
 - 66% of commuting trips are less than 10 miles
 - Assuming a utilised range of 80km, 50% of UK vehicle-km can be undertaken by EVs

- Range anxiety

- Very desirable to have the *option to drive long distance*, despite the fact that longer trips may be rare.
- Users are *over-cautious* when planning journeys, and modify their driving style when battery charge approached 50%.
- One European study found interest in EV ownership *decreased* after a few months of use due to concerns about range

Literature review: Psychological factors

- Conscious choices are systematically related to psychological processes, including attitudes.
- Three 'decision factors' :
 - **Instrumental** – general practical/functional attributes of the vehicle
 - **Affective** – feelings evoked by owning/driving the vehicle
 - Role in EV driving is poorly understood; one study found the majority of participants thought driving an EV gave the same or more pleasure than their conventional vehicle.
 - **Symbolic** – expression of social status or personal identity/values through the vehicle
 - These may take some time to become established as the market matures.
 - Important to understand the role of symbolism as consumers attempt to differentiate EVs from other vehicles.

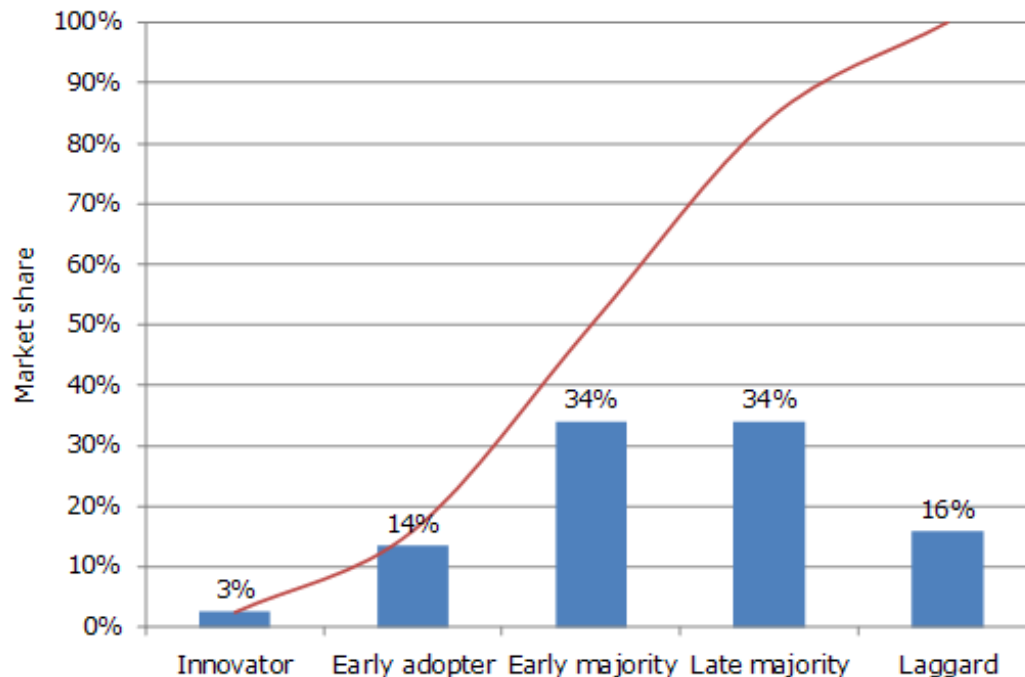
Literature review – Dynamic effects

- Dynamic effects
 - Increased market penetration will alter the way consumers view and choose EVs
 - **Attitudes and norms** will change with exposure to EVs
 - **Travel and car ownership patterns** may change as a result of EV ownership
- Diffusion effects
 - Consumer preferences tend to change as technology becomes more prevalent – known as ‘the neighbour effect’ or ‘**spillover**’
 - Stronger marketing and direct word of mouth are assumed to favour diffusion (as long as feedback is favourable) but **the impact of word of mouth** is likely to be small due to the long lifetime of vehicles causing a lag in new vehicle sales
 - EV drivers will promote EVs in their social networks, and the vehicles often advertise themselves through their appearance
 - The importance placed by consumers on new technology attributes changes as the new technology gains market share

Literature review: Segmentation

- Segmentation

- Rogers, 1962, Diffusion of Innovation: Consumers classified as innovators, early adopters, early majority, late majority and laggards
- Innovators/early adopters are a relatively small group but characterise the uptake of new products



Literature review: who adopts electric vehicles?

Early adopters of electric vehicles are assumed:

- Higher household income and education
- Older
- Urban dwellers, lower average mileage
- BUT – off street parking
- Multi-car households
- Sensitive to running costs, especially fuel costs
- Willing to buy at a higher price premium
- (May) require 'recognition' for being an early adopter
- Desire to signal their commitment to a cleaner environment to others
- Pursue new technology vigorously

BUT

- Is there likely to be more than one early adopter segment?
- The early adopters are unlikely to hold the key to understanding the early majority

Why segment the market?

- Challenge the notion there is one innovator and one early adopter segment
- What are the motivations for a higher willingness to pay?
- How important are environmental beliefs?
- Are some segments more concerned about functional attributes than others?
- How stable are attitudes and segment membership?
- How can messages be targeted?
- What is the potential for EV adoption?

Questionnaire Methodology

- UK-wide, **Online survey** using a panel provider
- **New car buyers only**: people who had bought a new or nearly new car in the past 5 years (including a company car)

BUT

- Assessment of consumers' preferences for **really new products** is **challenging**
- Research in which participants have not experienced EVs may be **subject to large uncertainties**
- Construal level theory (Liberman et al): the more psychologically distant an object, the more it is construed in high level abstract terms rather than low-level, concrete terms
- Unconscious Thought Theory (Dijksterhuis & Nordgren): **consumers make 'better' decisions when information is being non-consciously processed** than when they engage in conscious deliberation

Questionnaire structure

Survey 1 (21 minutes)

- Car owning history + general travel patterns
- Attitudes: owning and driving a car
- Attitudes: new cars and technology
- Knowledge about BEV/PHEVs + likelihood to purchase
- Demographics
- Pre-read information

N = 4240

48 hour break


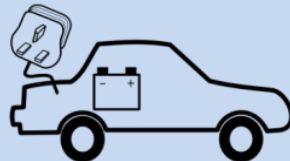
- *Opportunity for non-conscious processing & integration into long term memory*

Survey 2 (23 Minutes)

- Attitudes towards plug-in cars (general)
- Choice experiment
- Attitudes towards PHEVs
- Attitudes towards BEVs
- Likelihood to adopt
- Attitudes towards the environment

N = 2729 (64%)

Pre-read information

	Plug-in cars	
	Plug-in Hybrid Electric car	Plug-in Fully Electric car
		
	<i>Note that in Part 2 of the survey, we will use the term 'plug-in electric car' to mean both of these types of cars unless we specify otherwise</i>	
Driving	<ul style="list-style-type: none"> ∞ will use power from the battery whenever possible. ∞ the engine will be used when the battery has run out of charge or when lots of power is needed, for example for overtaking 	<ul style="list-style-type: none"> ∞ has no gears and is therefore similar to driving an automatic car ∞ acceleration is smooth and quiet
Running costs	∞ lower than a typical car – the electric motors reduce the fuel consumption of the car (the car does more miles per gallon), and electricity is cheaper than petrol/diesel for the same amount of energy	∞ lower than a typical car because they are more efficient, and electricity costs less than petrol/diesel for the same amount of energy.
Maintenance	∞ battery capacity may reduce after a few years and need to be replaced	<ul style="list-style-type: none"> ∞ has an electric motor instead of an engine so has fewer moving parts, meaning expected lower maintenance needs ∞ battery capacity may reduce after a few years
Noise levels	∞ when using the electric engine there is almost no engine noise	∞ the electric motor is much quieter than the engine in a normal car
Range	<ul style="list-style-type: none"> ∞ has the same range as a standard petrol/diesel car, and can also be driven using the electric motor only as long as the battery is charged ∞ will keep on running even when it runs out of charge as long as there is petrol or diesel in the tank ∞ there will be instruments inside the car which tell you how much battery charge and petrol/diesel you have left 	<ul style="list-style-type: none"> ∞ range tends to be lower than a typical car ∞ will stop running once the battery runs out of charge ∞ there will be instruments inside the car which tell you how much battery charge you have left

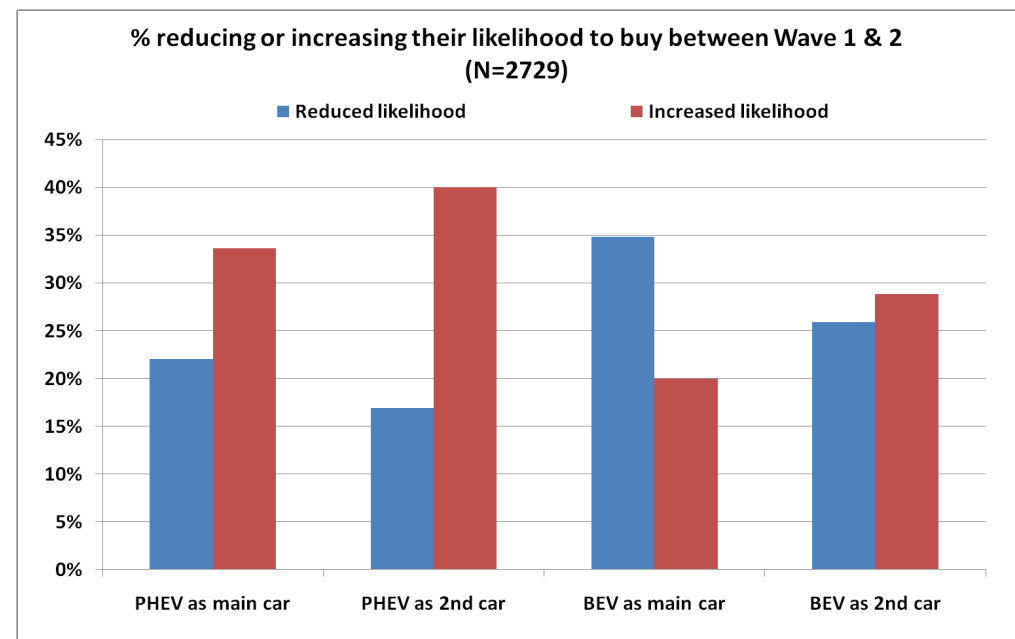
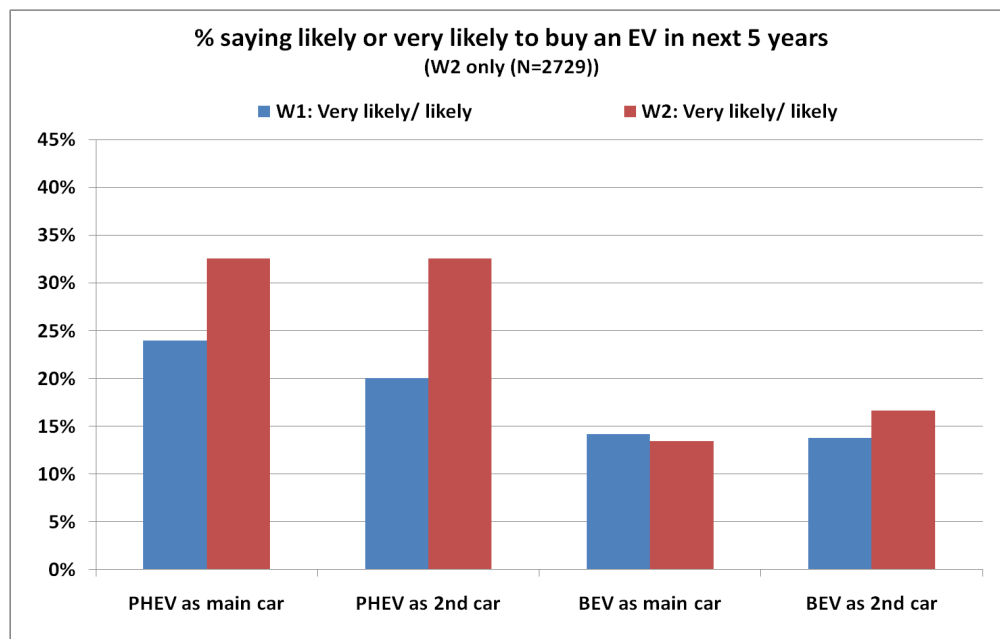
Likelihood to choose a PHEV or BEV

“In the next 5 years, I would choose to have a plug-in hybrid electric car (i.e. one that works on both a battery that you plug-in and petrol/diesel)” ...

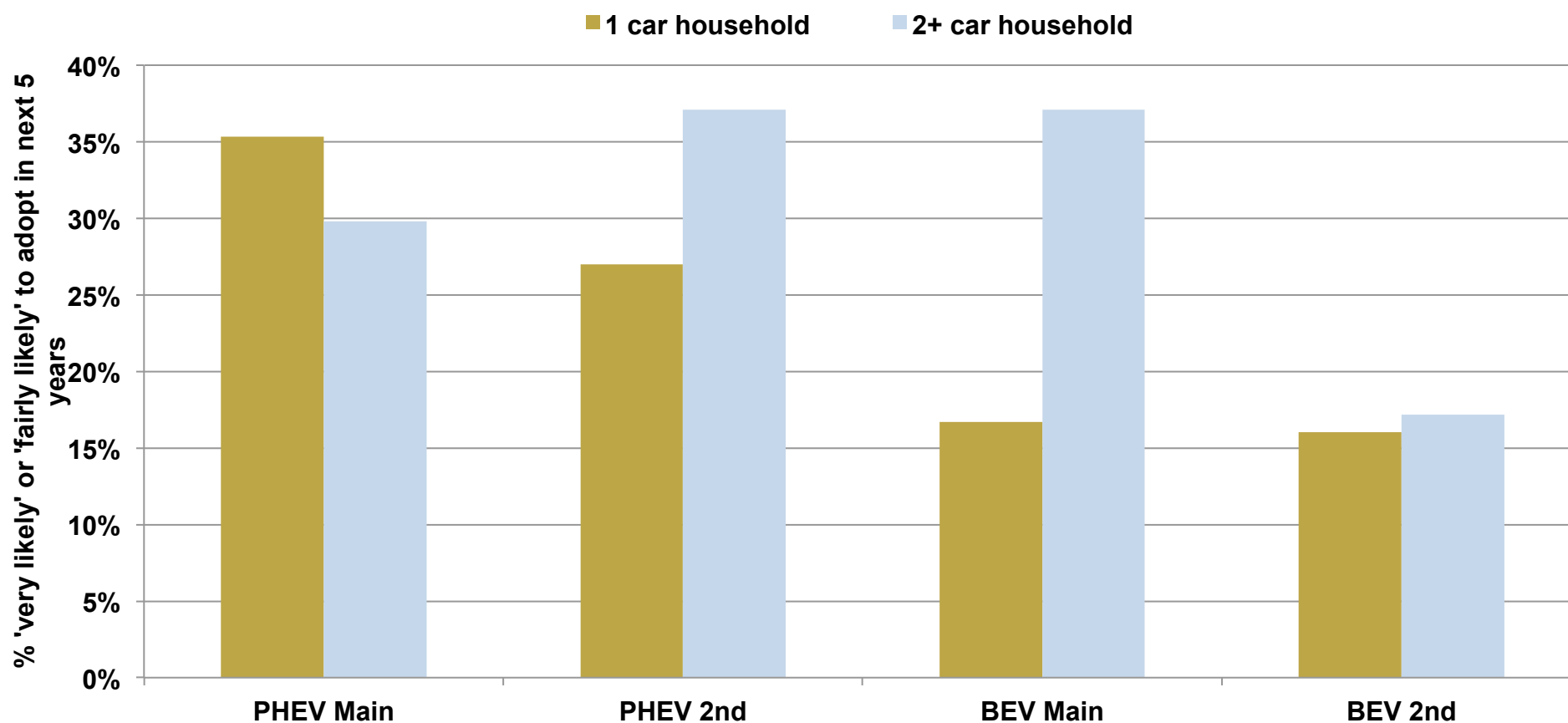
	Not at all likely	Fairly unlikely	Neither likely nor unlikely	Fairly likely	Very likely
... as my main car	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... as a second car	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

[NB repeated for BEV and asked in W1 and w2]

- **W2: 33% say they are likely to choose a PHEV & 13% a BEV as a main car in the next 5 years**
- **Likelihood increased in W2 for PHEV (main and 2nd car) and BEV (2nd car), but *reduced* for BEV as a main car (*paired T-test)**

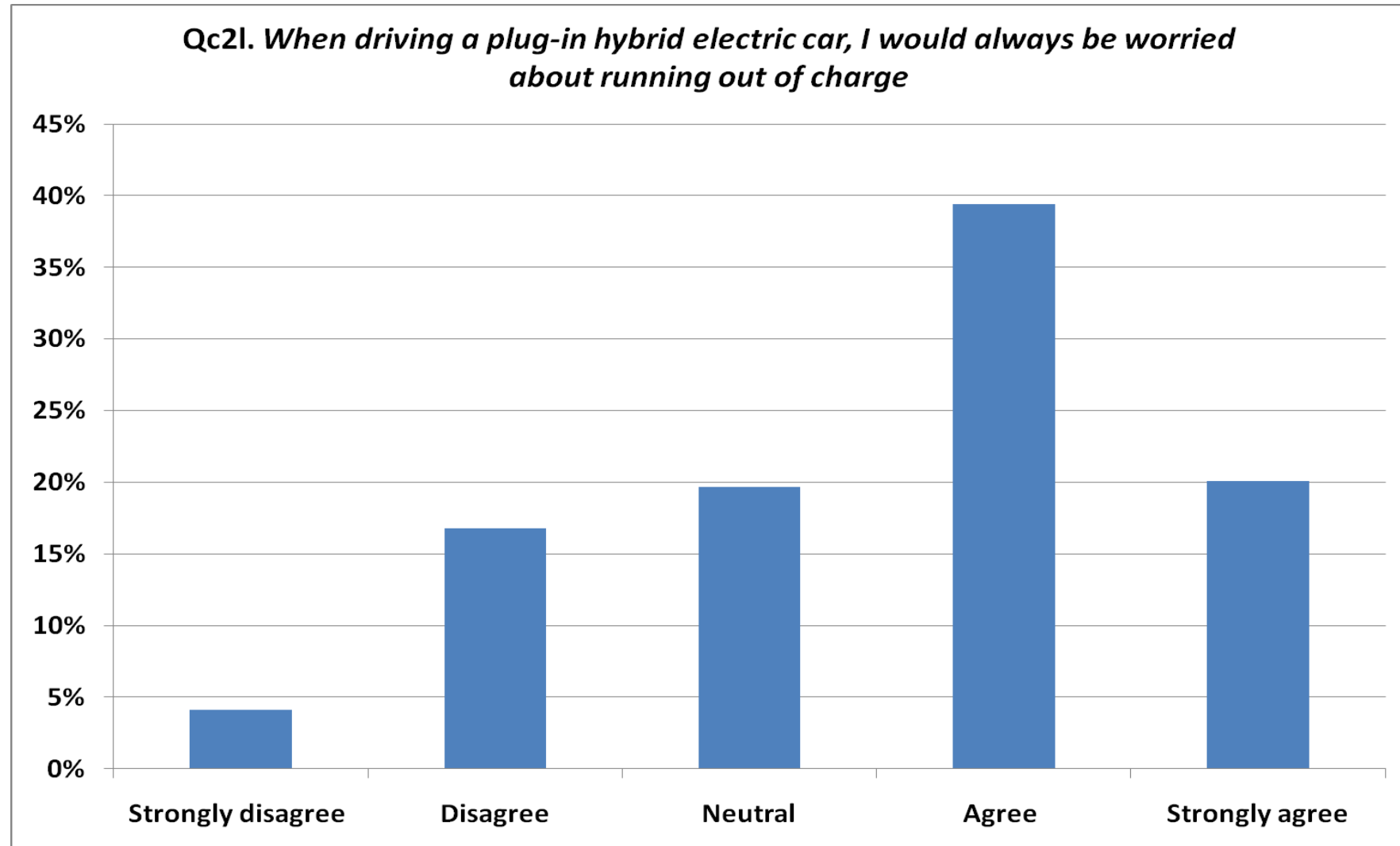


Likelihood to adopt by number of cars in household



(N=2,729)

Level of understanding?



Segmentation analysis methodology

Step1:

Exploratory analysis: What are the strongest predictors of likely adoption of EVs? (**Factor analysis, regression**)

Step 2:

Extract company car drivers

Step 3:

Cluster analysis using most discriminating factor scores (Hierarchical clustering + use cluster centres as input to K-means; validation and iteration)

Step 4:

Profiling

Attitudinal constructs

Original sets of attitude statements	#	15 'Factors'	Interpretation
Attitudes towards owning/driving a car	18	Environmental Identity	Concern for and identity with environmental issues
Innovativeness	15	EV Positives	Belief in environmental and general benefits of BEVs/PHEVs
Environmental values	14	BEV Anxieties	Concern about some of the practical aspects of BEVs
Beliefs about Plug-in cars in general	16	PHEV Anxieties	Concern about some of the practical aspects of PHEVs
Beliefs about PHEVs	21	EV Openness	Desire for oil independence & excitement about EV technology
Beliefs about BEVs	22	EV Infrastructure	Desire to wait for rapid charging infrastructure
		EV Instrumental	Belief in reliability and economy compared to 'normal' cars
		EV Symbolic	Embarrassment/ pride in owning and driving an EV
		EV Affect	Beliefs about performance and driving experience of EVs
		EV Willingness-to-pay	Willingness to pay more for EVs and environmental benefits
		Innovativeness	A desire to own and be seen with the latest technology
		Car Symbolism	Belief that cars are an expression of personality and status
		Driving Affect	General enjoyment of driving and emotional aspects
		Car Authority	General car enthusiasm/ self proclaimed knowledge about cars
		Car Loyalty	Tendency to stick to the same brand and size/type of car
		<i>Additional single statements</i>	<ul style="list-style-type: none"> ▪ I would pay more for a car with lower running costs ▪ Finding somewhere at home to park near a plug in socket would be difficult ▪ Compared to a normal car, plug-in fully electric cars are a danger to people outside the car because of the lack of engine noise ▪ I know many people who would be attracted to a plug-in hybrid car (PHEV Identity) ▪ I know many people who would be attracted to a fully electric car (BEV Identity)

Factor analysis was used to reduce the 106 attitudinal statements into 15 overarching, psychologically meaningful constructs

A few other attitude statements did not join any factors but stand alone as single item constructs

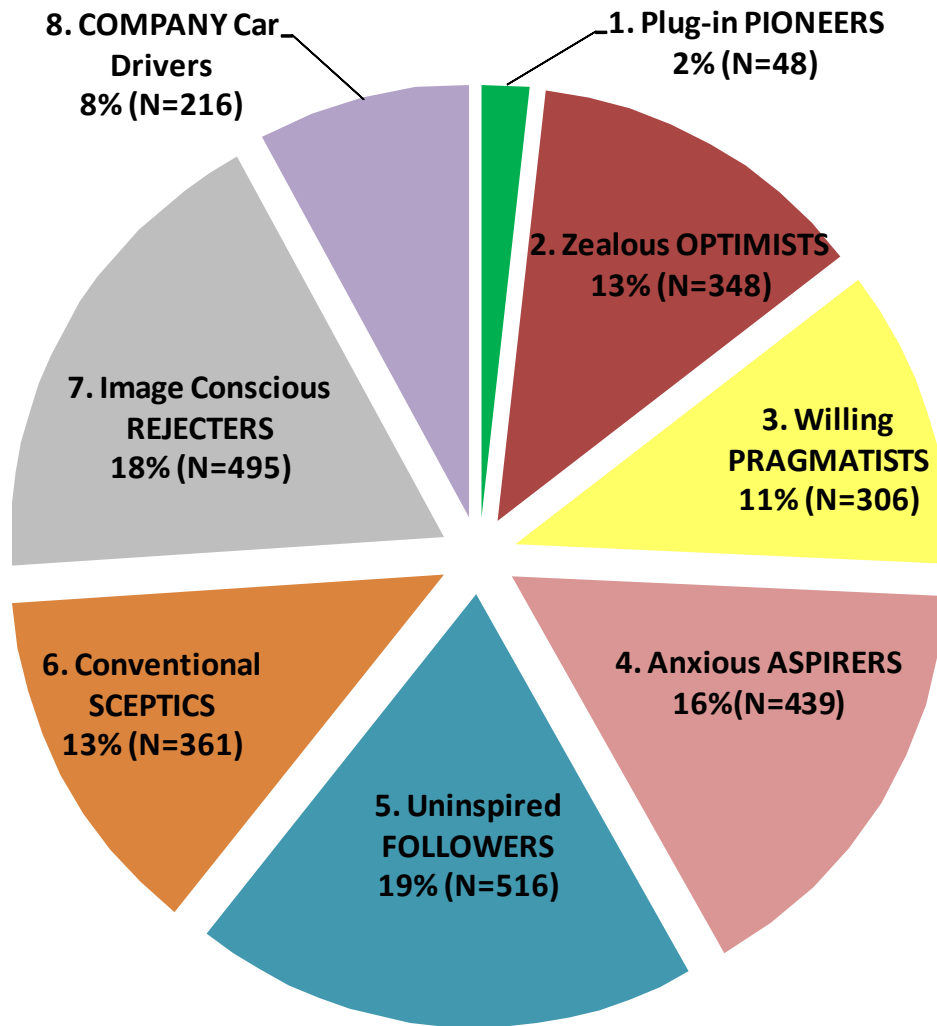
Explaining the likelihood to adopt

- Explanatory depend on whether PHEV or BEV and Main or 2nd car
- Demographic factors are less important than most psychological constructs
- Identity, anxiety, willingness to pay lower running costs or environmental benefits
- Symbolism is particularly important for BEV ownership
- Innovativeness less important than other factors
- Income not significant

Ranking of main attitudinal and demographic factors explaining likelihood to purchase

PHEV (Main)	PHEV (2 nd)	BEV (Main)	BEV (2 nd)
<ol style="list-style-type: none"> 1. PHEV Identity 2. PHEV Anxiety 3. Willingness to pay for lower running costs 4. EV Openness 5. EV Positives 6. Environmental identity 7. EV Willingness to pay 8. EV Symbolism 9. EV Affect 10. EV Infrastructure 11. Innovativeness 12. Car Authority 13. Capacity to charge at home 	<ol style="list-style-type: none"> 1. PHEV Identity 2. Capacity to charge at home 3. PHEV/BEV Positives 4. EV Affect 5. EV Openness 6. PHEV Anxieties 7. EV Willingness to pay 8. Car Authority 9. Environmental identity 10. Innovativeness 11. EV Symbolism 12. EV Affect 13. Total cars in household 14. EV Infrastructure 15. Car Symbolism 16. Employment status 	<ol style="list-style-type: none"> 1. BEV Anxiety 2. BEV Identity 3. EV Willingness to pay 4. EV Openness 5. EV Symbolism 6. PHEV/BEV Positives 7. Environmental Identity 8. Car Authority 9. Innovativeness 10. EV Affect 11. Driving Affect 12. Gender (Men more likely) 13. Willingness to pay for lower running cost 	<ol style="list-style-type: none"> 1. BEV Anxiety 2. EV Willingness to pay 3. EV Symbolism 4. EV Openness 5. EV Positives 6. Car Authority 7. Environmental Identity 8. Capacity to charge at home 9. Innovativeness 10. EV Affect 11. EV Instrumental 12. Car Symbolism 13. Total cars in household 14. Satisfaction with current mpg 15. EV Infrastructure

Who is interested in buying 'plug-in' vehicles.....?



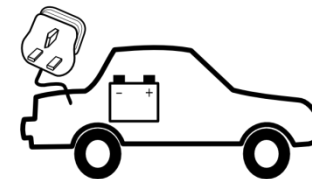
Conventional Vehicles



Conventional Hybrid Vehicles

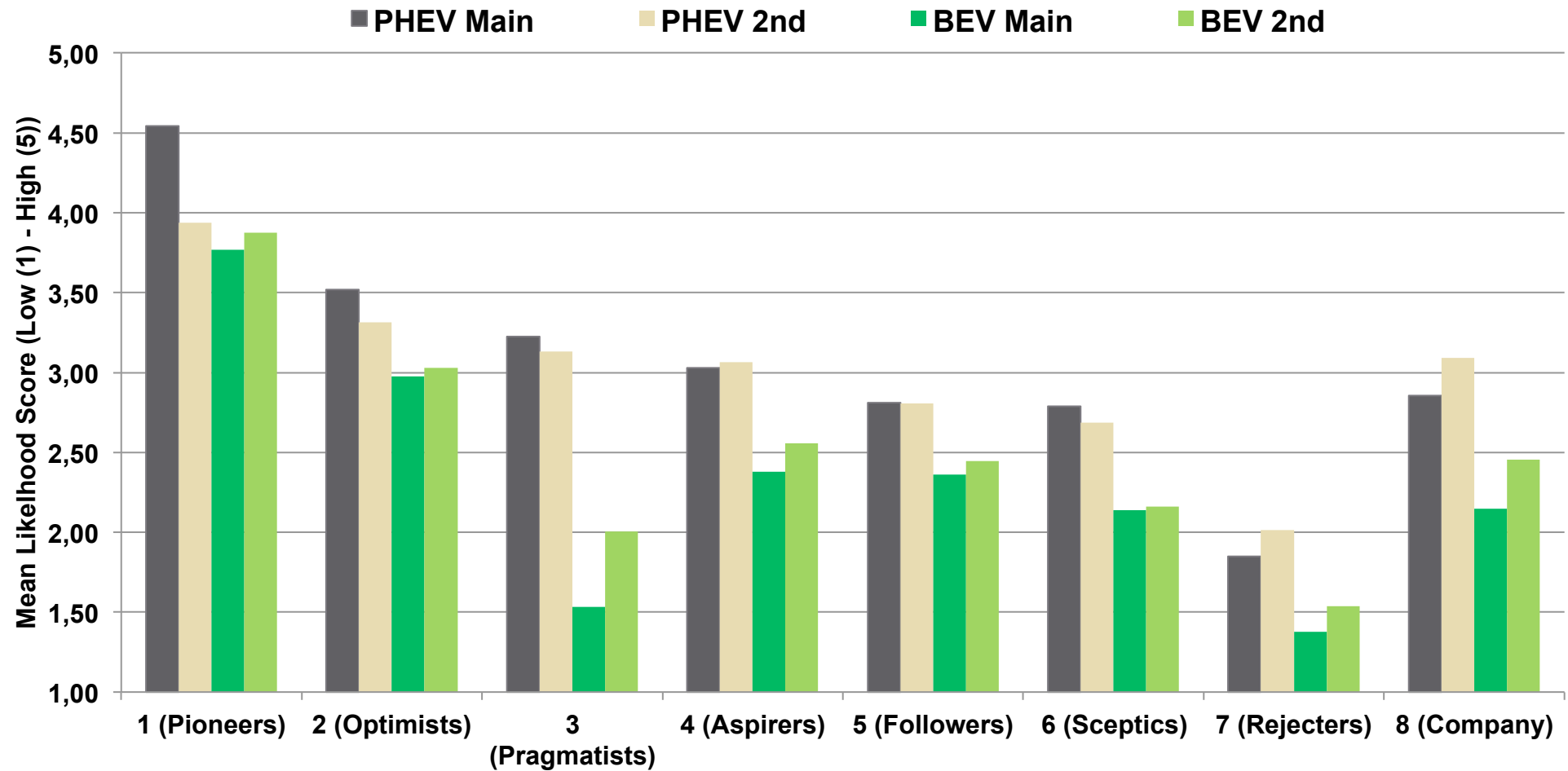


Plug-in Hybrid / Range Extended Electric Vehicles (PHEV / RE-EV)



Battery Electric Vehicles (BEV)

Mean likelihood score by segment



(N=2,729)

Group 1: Plug in PIONEERS

1. Plug-in PIONEERS
2% (N=48)

*It's about time!
Why wouldn't
you?*

PHEV interest	Very High
BEV interest	Very High
Innovativeness	Very High
Greenness	Very High

- **Buy** brand new, relatively expensive **cars**
- High mileage, **but leisure as important as commute**; **high** bias toward in-town **mileage**
- **Image conscious**; very proud to own
- Motivated more by running cost **than price**
- **Very high willingness to** pay for fuel economy and environment **benefits**
- **Faith they will** rely on home/work charging
- **Want** 'comfort' of rapid recharging **available**

Group 2. Zealous OPTIMISTS

2. Zealous OPTIMISTS
13% (N=348)

***Yes please.
It would save me how
much fuel?***

PHEV interest	High
BEV interest	High
Innovativeness	High
Greenness	High

- **Buy** small cars with low fuel consumption
- Above average mileage, **with high commuting by car**
- **High willingness to** pay for fuel economy
- **Some willingness to** pay for environment
- **Strong belief pure electric vehicle (BEV) would fit social identity**
- **Curious to learn more; opinion still forming**

Group 3. Willing PRAGMATISTS

*Yes please, but
make it a plug-in hybrid
for now, thanks.*

3. Willing
PRAGMATISTS
11% (N=306)

PHEV interest	High/Medium
BEV interest	Low
Innovativeness	Medium
Greenness	Very High

- Buy medium/large cars, but with average fuel consumption
- Medium mileage; high car commuting with longer distances; high motorway mileage
- Motivated more by 'functional' attributes than 'symbolic' factors
- High willingness to pay for fuel economy but not for environment benefits
- Optimistic about PHEVs/RE-EVs
- Embarrassed to own a BEV

Group 4. Anxious ASPIRERS

*Great, but not
sure where I
would charge it.*

PHEV interest	Medium
BEV interest	Medium/Low
Innovativeness	High
Greenness	High

4. Anxious ASPIRERS
16%(N=439)

- **Tendency toward second-hand, older, smaller, cheaper cars with low consumption**
- **Quite high mileage; low commuting by car**
- **High in town driving and low motorway**
- **High willingness to pay for fuel economy and some for environment benefits**
- **Concerned about the image**
- **Very low perceived ease of home charging**
- **Very high range anxiety**
- **Curious to learn more**

Group 5. Uninspired FOLLOWERS

*If everyone
else is, then,
maybe...*

PHEV interest	Medium/Low
BEV interest	Medium/Low
Innovativeness	Very Low
Greenness	High

- **Tendency to** smaller, cheaper, average fuel consumption **cars**
- **Avg. mileage; short commutes with lower car dependence;** shop/commute equal
- **Least likely to say they enjoy driving**
- **Low willingness to pay for fuel economy or environment benefits**
- **Some embarrassment to own; sceptical of 'green credentials'**
- **Low perceived ease of charging at home**

5. Uninspired
FOLLOWERS
19% (N=516)

Group 6. Conventional SCEPTICS

*Will they save
the planet?
Don't think so.*

6. Conventional
SCEPTICS
13% (N=361)

PHEV interest	Medium/Low
BEV interest	Low
Innovativeness	High
Greenness	Very low

- **Tendency to brand new**, medium sized and priced **cars**, but not particularly efficient
- **Low mileage**, including commuting
- **Low use of the motorway**
- **Not willing to pay for fuel economy and strongly against paying for environment benefits; believe running costs higher**
- **Some acknowledgement of suitability for trip patterns; but pessimistic and high range anxiety**
- **Desire for equivalent refuelling experience**

Group 7: Image-conscious REJECTERS

7. Image Conscious
REJECTERS
18% (N=495)

*I'd never be
seen in one
of those!*

PHEV interest	Very Low
BEV interest	Very Low
Innovativeness	Low
Greenness	Low

- **Tendency to medium sized and priced cars, but not particularly fuel efficient**
- **Above avg. mileage; car use is dominated by the commute; high motorway use**
- **Style and performance driven**
- **Place brand higher than running cost**
- **Not willing to pay for reduced running costs and strongly against paying for environment benefits**
- **Embarrassed to own; extreme pessimism**
- **Very entrenched views**

Group 8. COMPANY Car Drivers

8. COMPANY Car
Drivers
8% (N=216)



**With my
mileage?
Convince me.**

PHEV interest	Medium
BEV interest	Medium
Innovativeness	Very High
Greenness	Medium

- High ownership of multiple cars; **newest, largest, most efficient, most expensive cars**
- **Very high mileage; very high motorway use**
- Motivated more by size/practicality, **running cost and performance than purchase price**
- **Desire for oil independence, but low willingness to pay for environment benefits**
- Concerns about image, range, performance and reliability
- **Relatively optimistic about suitability**

Summary

- There is more than one early adopter group
- Most important distinguishing factors are symbolic motives, willingness to pay and innovativeness – not demographics
- Symbolic motivations play as strong a role as economic or functional attributes for some segments
- Innovation is a complex construct and does not predict adoption on its own
- Opinions and meanings are still being shaped – it is likely that the segmentation ‘landscape’ will be highly fluid in the near term
- Company car owners also show potential to adopt EVs, particularly as second cars
- Even the most enthusiastic adopters make pessimistic assumptions about their range and charging options and want to wait for rapid charging and more choice in the market