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How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?

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ABSTRACT

The entry of various plug-in electric vehicles (PEVs) into the passenger vehicle sector provides novel opportunities to learn about the potential for future PEV markets. However, early PEV buyers (or "Pioneers") can substantially differ from present conventional vehicle owners that have interest in purchasing PEVs in the future (or the "Potential Early Mainstream buyers"). To compare the characteristics, preferences, and motivations of Pioneers and Potential Early Mainstream buyers, we draw data from the Canadian Plug-in Electric Vehicle Study, a three-part mixed-mode survey with samples of PEV owners ($n = 94$) and conventional new vehicle buyers ($n = 1754$). We identify several significant differences in household characteristics, including income, education, and recharge access. In terms of preferences, Pioneers express extremely high valuation of PEVs and prefer pure battery electric vehicle (BEV) designs over plug-in hybrid electric (PHEV) designs. In contrast, Potential Early Mainstream respondents prefer PHEVs. Both Pioneer and Potential Early Mainstream respondents are similarly cautious about controlled charging programs, but Pioneers place five times as much value on using electricity generated from renewable sources than the Potential Early Mainstream. Pioneers also tend to have different motivations, including significantly higher levels of environmental concern, and higher engagement in environment- and technology-oriented lifestyles. Policymakers, automakers, and electric utilities that anticipate a transition to electric mobility ought to consider how potential future PEV buyers may differ in their vehicle preferences, usage and motivations relative to current PEV owners.

1. Introduction

Despite much effort and policy support, alternative fueled vehicles have repeatedly failed to displace gasoline and diesel powered passenger vehicles in the vast majority of countries (Melton et al., 2016). In recent years, plug-in electric vehicles (PEVs) have shown promise in several markets, including "pure" battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) that can be powered by gasoline and plugged into recharge. In 2015, PEV sales comprised less than one percent of new light-duty vehicle sales in the U.S. (Pontes, 2015) and Canada (Klippenstein, 2015), although a few regions have achieved much greater sales rates; in Norway, for example, market share was close to 25 percent in 2015, in the Netherlands it was close to 10 percent in 2015 (EAFO, 2016), and in California it was just over three percent in 2015 (Cobb, 2016).

Because increased PEV uptake may be signaling the beginning of a transition to widespread electric mobility, many stakeholders want to better understand PEV buyers, including their preferences, motivations and potential PEV usage patterns.

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Specifically, national and sub-national policymakers have sought to understand how best to incentivize and support further PEV market growth; automakers have sought to understand what PEV designs and attributes will be valued by consumers; and electric utilities have sought to understand how widespread PEV adoption might impact electrical load and how PEV charging might be integrated with intermittent, renewable sources of electricity.

This study explores several aspects of the potential PEV market, focusing on a comparison between current PEV owners (who we refer to as "Pioneers") and "Mainstream" conventional new vehicle buyers. While there may be lessons to learn from current Pioneers, Mainstream buyers, especially those most likely to purchase PEVs in the future (who we refer to as the "Potential Early Mainstream"), are a particularly important target for analysis. Following modeling studies which suggest that plug-in electric or other alternative fuel vehicles must make up a majority of market share by 2040 to meet 2050 greenhouse gas reduction targets (IEA, 2015; Williams et al., 2012), PEV acceptance among Potential Early Mainstream Buyers may be necessary to displace fossil fuels and decarbonize the passenger vehicle sector. While there is little research that directly compares Pioneers and Potential Early Mainstream buyers, initial insights suggest that important demographic and contextual differences exist (Axsen and Kurani, 2013a; Tal and Nicholas, 2013), as well as differences in preferences for both PEVs and renewable electricity programs (Axsen and Kurani, 2013a).

This study uses samples of new vehicle buying households in Canada, with a focus on the Canadian province of British Columbia—a region with some PEV-supportive policy (subsidies and deployment of recharge infrastructure) but low PEV market share (one percent of new vehicle sales in 2014). Through in-depth data collected as part of the Canadian Plug-in Electric Vehicle Study, or CPEVS (Axsen et al., 2015), we compare Pioneers and Potential Early Mainstream respondents according to household demographics and context, PEV awareness and preferences, purchase and use motivations, as well as interest in controlled charging programs that could manage how and when electricity flows from the grid to a PEV (which could, in turn, support the use of intermittent, renewable sources of electricity). We next summarize previous literature on these topics, explain our methods and results, and conclude with implications for policy.

2. Background

2.1. Distinguishing consumers by PEV purchase and intention

Consumers can vary widely in their perceptions, tastes, preferences and motivations. It is therefore useful to identify different groups (or segments) of PEV buyers. Conventional approaches to PEV market segmentation tend to focus on "innovativeness" as the key segmentation parameter (Peters and Dütschke, 2014). One particularly popular framework for segmentation is Rogers' (2003) "diffusion of innovations" model, which separates potential buyers into innovators, early adopters, early majority, late majority, and laggards. Despite its popularity, researchers have criticized Rogers' model for being too limited in its representation of human motives (Axsen and Kurani, 2012a). Others have shown that PEV buyers can be driven by many motives other than technological innovativeness, such as symbolic meanings relating to environment and energy security (Heffner et al., 2007).

In this study we find it useful to segment the current and potential future passenger PEV market according to both actual behavior and stated behavioral intention, specifically the act or likelihood of purchasing a PEV, in contrast to segmenting the market based on a single motivation (e.g., innovativeness) that has not been shown empirically to be a central driver of purchase behavior. We consider three discrete segments of passenger vehicle buyers in this paper. We first divide the total population of new vehicle buyers into those that currently own a PEV ("Pioneers"), and those that do not ("Mainstream"). We then divide the Mainstream into those that state an interest or intention to purchase a PEV in the future ("Potential Early Mainstream") and those that do not ("Potential Late Mainstream"), leading to the following three segments:

1. **"Pioneers"** consumers who own a PEV as of the study date (2015). Here we only consider PEVs commercially available in Canada in the 2000s.
2. **"Potential Early Mainstream"** consumers who currently own conventional gasoline-powered vehicles and have stated an interest in purchasing a PEV (as measured in our survey), and are thus the most likely to buy a PEV in the next 10–15 years.
3. **"Late Mainstream"** (or non-buyers) consumers who currently own conventional vehicles and have not stated an interest in PEVs (as measured in our survey), and are therefore not likely to buy one in the next 10–15 years; substantial changes in policy, costs, technology, and/or cultural norms would be required for these buyers to become interested (if at all) in PEVs.

We expected to observe the greatest differences in preferences and characteristics between the Pioneer segment and the two Mainstream segments, whereas the two Mainstream segments are anticipated to have relatively more similarities.

2.2. Previous literature on Pioneers versus the Mainstream

To the best of our knowledge, only three previous studies have directly compared Pioneers and Mainstream buyers. While these studies do not necessarily use the same terminology as that presented in our three-segment framework, they do

compare similarly distinguished segments; that is, respondents that bought a PEV ("Pioneers") versus conventional buyers in general ("Mainstream") or those who stated intention in buying one in the future (what we are calling Potential Early Mainstream). Specifically, these comparative studies include a survey of 1502 Mainstream and Pioneer buyers in the U.S. (Axsen and Kurani, 2013a), a comparison of Pioneer (n = 3201) and Mainstream (n = 9600) survey respondents in California (Tal and Nicholas, 2013), and an online survey of 1196 Pioneers and Mainstream buyers in Germany (Peters and Dütschke, 2014; Plötz et al., 2014). In contrast, other PEV market literature focuses exclusively on either Pioneers (California Center for Sustainable Energy, 2014; Pierre et al., 2011; Tal et al., 2013) or Mainstream buyers (Axsen and Kurani, 2009; Jensen et al., 2013).

As a starting point of comparison, studies consistently find that Pioneers and Mainstream car buyers have demographic distributions that are significantly distinct from Mainstream car buyers. In particular, Pioneers tend to be older (California Center for Sustainable Energy, 2014; Peters and Dütschke, 2014; US Department of Energy, 2013) and to have significantly higher income and education levels than Mainstream buyers (Axsen and Kurani, 2013a; Plötz et al., 2014; Tal and Nicholas, 2013). Pioneers also tend to be male (California Center for Sustainable Energy, 2014; US Department of Energy, 2013), accounting for up to 95% of the Pioneer sample in one study (Plötz et al., 2014). In terms of household characteristics, Pioneers are more likely to live in multi-car households (Peters and Dütschke, 2014; Tal and Nicholas, 2013), and in detached homes (Axsen and Kurani, 2013a; California Center for Sustainable Energy, 2014). While about half of U.S. Mainstream buyers have access to Level 1 charging (110/120 V) at home (Axsen and Kurani, 2012b), almost all U.S. Pioneers have access to at least Level 1 home charging (US Department of Energy, 2013). About 28% of Mainstream respondents in San Diego reported having relatively easy Level 2 (220/240 V) home charging potential, and a further 45% indicated the ability to install Level 2 charging at a higher cost (Axsen and Kurani, 2012b). As a point of reference, over 60% of Pioneers in California have installed Level 2 home chargers (California Center for Sustainable Energy, 2014), and this is about twice as common among BEV owners relative to PHEV owners (Tal and Nicholas, 2013).

In terms of PEV perceptions, there is evidence that U.S. Mainstream buyers have lower levels of PEV familiarity and awareness, and are particularly confused about the idea of a PHEV and how to refuel it (Axsen and Kurani, 2008; Caperello and Kurani, 2012). Pioneers and Mainstream buyers also differ in their preferences for PEVs, where U.S. Pioneers are up to three times more likely to express an intention to purchase a PEV as their next vehicle (Axsen and Kurani, 2013a), and German Pioneers are willing to pay up to twice as much for a PEV design (Peters and Dütschke, 2014). Further, these segments differ in the type of PEV they want. In particular, once the concept of PHEVs and BEVs is explained, U.S. Mainstream buyers tend to express more interest in PHEVs (Axsen and Kurani, 2013a; Carley et al., 2013), while most Pioneers express more interest in BEVs (Axsen and Kurani, 2013a; Turrentine et al., 2011). Other research suggests that Mainstream consumers' general perception of PEVs may change substantially following direct experience with these vehicles. For instance, valuation of particular PEV attributes may increase (Bühler et al., 2014; Jensen et al., 2013; Rezvani et al., 2015), so it is possible that the stated preferences of Mainstream buyers could change in a world with higher PEV market share (and thus more access to PEV experience).

Relatively less research has examined Pioneer and Mainstream preferences for renewable electricity and controlled charging programs related to PEVs. Exploratory research suggests that U.S. Pioneers are almost three times as likely to be willing to pay extra to power their PEV with some form of "green," or renewable, electricity (Axsen and Kurani, 2013a; Turrentine et al., 2011). Pioneers are also more likely to have installed home solar panels, accounting for more than one-third of California Pioneers compared to less than 1% of the general California population (California Center for Sustainable Energy, 2014; Tal et al., 2013). Additional exploratory research on demand for controlled charging and vehicle-to-grid (V2G) programs suggests that many U.S. Mainstream buyers may be reluctant to enroll in such a program due to inconvenience (Parsons et al., 2014), though no comparison to Pioneers has been conducted yet.

Previous studies have not directly compared the motivations that Pioneers and Mainstream consumer associate with PEV interest. More generally, many studies find that consumer motivations for interest in PEVs and renewable electricity is associated with concern for the environment, and pro-environmental attitudes and lifestyles (Axsen and Kurani, 2013a; Carley et al., 2013; Egbue and Long, 2012; Jensen et al., 2013; Plötz et al., 2014; Rezvani et al., 2015). Other studies find that PEV interest is also associated with technology interest and/or engagement in a technology-oriented lifestyle (Axsen and Kurani, 2013a; Pierre et al., 2011; Plötz et al., 2014). Lastly, several studies find a connection between financial savings and PEV interest (Krupa et al., 2014; Pierre et al., 2011).

3. Methods

3.1. Data collection and survey design

Data were collected as part of the Canadian Plug-in Electric Vehicle Study (CPEVS), which is described in full elsewhere (Axsen et al., 2015). CPEVS collected data from two multi-phased surveys: the British Columbia Pioneer survey and the Canadian Mainstream survey. We presently focus on respondents from the province of British Columbia as a case study. The target population for the Mainstream survey was new vehicle buying households in English-speaking Canada (Quebec was omitted due to a lack of budget for language translation). The web-based survey recruited a representative sample of 1754 households in 2013 and included an oversample of respondents from British Columbia (n = 538) to permit regional

analysis. Our Pioneer survey targeted PEV owners in British Columbia – specifically, households that had purchased or leased a commercially-available PEV. Participants were recruited from 2014 to early 2015 via invitations sent to three lists: recipients of PEV purchase or home charging installation rebates from the British Columbia Government's Clean Energy Vehicle Program, members of the Vancouver Electric Vehicle Association (VEVA) and subscribers to a PEV promotional campaign in British Columbia (called "Emotive BC"). In total, 97 respondents completed the entire Pioneer survey, with 157 completing the initial phase of the survey (we use this larger sample for the depiction of some results for greater representation of BC's Pioneer population).

CPEVS implemented similar instruments in a three-part survey for both the Pioneer and Mainstream samples. Part 1 of each survey was a web-based questionnaire that collected background details on each respondent's vehicle fleet, energy usage, and PEV-related knowledge and perceptions. Part 2 was a mail-out and web-based survey package that included a technology primer with basic information on the vehicle technologies and charging scenarios to be discussed in Part 3, as well as a driving diary and charging assessment. Mainstream respondents were asked to complete a 3-day driving diary and indicate charging opportunities (in part to proxy potential charging activity) at home and other parking locations, while Pioneer respondents were asked to complete a 5-day driving diary and provide a log of charging activity. Pioneers were assigned 5-days to get sufficient coverage of weekdays and weekends with a smaller sample, and we assumed that given the enthusiasm demonstrated by Pioneers, such respondents would be more willing than Mainstream respondents to undergo the burden of completing a 5-day diary. Part 3 was a web-based survey that elicited respondents' interests and preferences for PEV technology and controlled charging programs via stated choice experiments and design space exercises (described in Sections 3.2 and 3.3).

3.2. PEV design space exercises

The CPEVS survey used design space exercises to elicit respondent interest in PEVs. These exercises provided respondents with a "space" or design envelope—a series of design options that respondents could select from to create their preferred vehicle design given a particular context. This approach has been applied to surveys of PEV demand in previous research (Axsen and Kurani, 2009, 2013b; Kurani et al., 1994, 1996). The PEV design space exercise was nearly identical for Pioneer and Mainstream respondents. Each respondent first selected a currently available "base" vehicle that represented the body type, price, and fuel economy of the vehicle they would buy next if they were limited to a conventional gasoline vehicle. Respondents then selected from four drivetrain options: (i) conventional vehicle (the base vehicle); (ii) a hybrid version of their base vehicle (with 33% improved fuel economy over the base); (iii) a PHEV version of their base vehicle powered with electricity for the first 16, 32, or 64 km (achieving the same 33% increase in fuel economy when using gasoline); and (iv) an BEV version of their base vehicle powered only by electricity for 80, 120, 160, 200, or 240 km of range.

The Pioneer version of the design game was identical to that of the Mainstream, except that it included a 320 km option for the BEV design. The reason for the additional option was perceptual; our Pioneers sample included a number of Tesla Model S owners with longer range batteries (~400 km), and we anticipated that the remainder were aware of the existence of such longer-range BEV models. Initial pre-testing indicated that some Pioneer respondents wanted to see a longer-range BEV option in the design game to reflect the reality of the market at that time. However, this inconsistency in the design space exercises between the two segments could impact the results; literature suggests that varying attribute ranges may impact the choices elicited from survey respondents, depending on the magnitude of the differences (Hensher, 2006; Rose and Bliemer, 2009). Thus, interpretation of observed differences in design space results between the two samples should be cautious, including the difference in overall preference for PHEV versus BEV designs. However, the subsequently-described stated choice experiment (which informs the discrete choice models) provides an additional point of comparison with identical experimental designs for both samples.

Respondents completed "higher price" and "lower price" scenarios for the vehicle design exercises, with incremental prices based on a simple battery cost model constructed by Axsen and Kurani (2013b), and summarized in Table 1. We classify the 40% of Mainstream respondents who selected a PEV design (BEV or PHEV) in the lower price scenario as the "Potential Early Mainstream."

3.3. Stated choice experiments

In addition to design space exercises, respondent PEV interest was also assessed via two stated choice experiments in Part 3 of the CPEVS, which were used to estimate discrete choice models for vehicle preference and controlled charging. Discrete choice models quantify consumer preferences and are frequently utilized to model consumer demand for alternative-fuel vehicles (Bunch et al., 1993; Hidrue et al., 2011; Potoglou and Kanaroglou, 2007). Consumer utility is represented by a vector of coefficients weighted to the specified attributes of the product in question (e.g. purchase price and fuel costs for a PEV). The alternative specific constant represents the observable utility of each choice that is not captured by attributes specified in the model, and represents intangible vehicle benefits or drawbacks such as symbolic values, safety concerns, or perceived inconveniences. In addition to estimating utility coefficients, we can also calculate the average "willingness-to-pay" for attributes by calculating the ratio between each attribute coefficient and that estimated for purchase price.

In the choice exercise, respondents selected between pre-defined "packages" of vehicle attributes in each choice set, in contrast to the design space exercises where respondents customized vehicle attribute options (Section 3.2). Base vehicle

Table 1
PEV design space exercise options and prices (prices incremental to respondents' next anticipated conventional vehicle).

Vehicle type	Higher price scenario				Lower price scenario			
	Compact	Sedan	Mid-SUV	Full-SUV	Compact	Sedan	Mid-SUV	Full-SUV
HEV	$1380	$1740	$2050	$2470	$930	$1070	$1200	$1370
PHEV-16	$2230	$2720	$3130	$3690	$1690	$1910	$2100	$2360
PHEV-32	$2680	$3230	$3810	$4500	$1910	$2170	$2440	$2770
PHEV-64	$3560	$4260	$5190	$6120	$2350	$2680	$3130	$3580
BEV-80	$6500	$7880	$10150	$12150	$3220	$3620	$4600	$5300
BEV-120	$8940	$10690	$13930	$16600	$4440	$5030	$6490	$7520
BEV-160	$11380	$13500	$17710	$21050	$5660	$6440	$8380	$9750
BEV-200	$13820	$16310	$21490	$25500	$6880	$7840	$10270	$11970
BEV-240	$16260	$19130	$25260	$29940	$8100	$9250	$12160	$14200
Pioneer survey (only)								
BEV-320	$21140	$24770	$32800	$38820	$10540	$12070	$15940	$18660

Note: HEV = hybrid electric, PHEV = plug-in hybrid electric, BEV = pure battery electric.

data (i.e. make, model, purchase price, fuel costs) from the design exercise were used to present six customized choice sets to each respondent, where each set presented four different vehicle options: a conventional vehicle (respondent's base vehicle), as well as a hybrid, plug-in hybrid and pure battery electric version of that vehicle. Respondents were then asked to select one of the four vehicle options in each choice set. Table 2 depicts the experimental design for the choice sets, which included incremental purchase price premiums, fuel cost differences, and electric-powered driving ranges as well as access to slower (Level 1) or faster (Level 2) home charging. Experimental designs were identical in the Pioneer and Mainstream versions of the survey.

We also used a choice experiment to assess respondent interest in controlled charging—a suite of technologies and strategies that could be used to balance electrical loads or to facilitate the integration of intermittent renewable sources of electricity into the grid, e.g. vehicle-to-grid (V2G) or timed charging programs (Kempton and Tomić, 2005). The choice experiment is explained in detail in Bailey and Axsen (2015). In the technology primer in Part 2 of each survey, controlled charging was described as a program where "your electric utility may want to take electricity from a battery in your vehicle when it is plugged in. They may take this electricity to help manage your local power supply or to help increase the use of renewable energy in your region." In the discrete choice experiment portion of the surveys, controlled charging was again described as a particular program that could potentially manage the charging of the respondent's PEV when plugged in for charging overnight.

We used four attributes to represent controlled charging in the choice exercises: household electricity costs (monthly bill), "guaranteed minimum charge" (GMC) of the PEV in the morning (after a night of controlled charging), percentage of electricity provided to the PEV derived from renewable electricity, and source of renewable electricity (wind, solar, small hydro or "mixed"). Renewable electricity was described as provided via the electricity grid (e.g. via wind farms or solar

Table 2
PEV stated choice experimental design (6 choice sets per respondent).

Attributes	Next anticipated conventional vehicle (base)	Hybrid vehicle version	Plug-in hybrid vehicle version	Battery electric vehicle version
Purchase price premium	Selected by respondent	Conventional price 10% more 20% more 40% more	Conventional price 10% more 20% more 40% more	Conventional price 10% more 20% more 40% more
Weekly fuel cost	Selected by respondent	40% less 30% less 20% less 10% less	80% less 60% less 40% less 20% less	80% less 60% less 40% less 20% less
Electric-driving range	n/a	n/a	16 km 32 km 64 km	120 km 160 km 200 km 240 km
Home recharge access	n/a	n/a	Level 1 (1 kW) Level 2 (6 kW)	Level 1 (1 kW) Level 2 (6 kW)
Recharge time[a]	n/a	n/a	Calculated	Calculated

[a] The discrete choice experiment showed "recharge time" to respondents to help them understand the recharging needs of the PHEV or BEV. Recharge time was calculated as the time required for the respondent to fully recharge a depleted battery using their home charger. This time is a function of the vehicle's electric driving range, the base vehicle type (where larger vehicle bodies are assumed to require more electricity consumption or have a higher kWh/km), and the speed of the home charger (Level 1 or Level 2).

Table 3
Controlled charging stated choice experiment design (6 choice sets per respondent).

Attributes	Electricity system powering respondent home and vehicle		
	Status quo	Alternate design 1	Alternate design 2
Percentage of renewable electricity (powering the respondents' home and vehicle)	Current renewable electricity%	25% 50% 75% 100%	25% 50% 75% 100%
Source of renewable electricity	Existing grid supply mix	Wind Solar Small hydro Mixed	Wind Solar Small hydro Mixed
Guaranteed minimum charge (GMC) (displayed as both percentage charge and electric range in km)	100% charge	50% charged 70% charged 90% charged 100% charged	50% charged 70% charged 90% charged 100% charged
Monthly electricity bill	Current bill provided by respondent	60% of current bill 80% of current bill 100% of current bill 110% of current bill	60% of current bill 80% of current bill 100% of current bill 110% of current bill

farms) as opposed to an energy source that was directly connected to the PEV only (e.g. rooftop solar photovoltaics). Each attribute was assigned four levels that varied between the alternatives depicted in each choice set (Table 3). To represent the potential inconvenience associated with controlled charging we use the attribute GMC, which we described as: "the minimum level of charge that your battery would have after a night of being plugged-in." We represented this GMC as a percentage of charge (e.g. 90% charged) as well as a resulting electric driving range in kilometres (depending on the PEV type). Respondents completed a series of six choice sets, customized to their current home charging access and electricity costs. For each choice set, respondents selected their preferred charging scenario from three options: the status quo (current electricity supply and no controlled charging) and two alternative designs with controlled charging (with varying amounts of GMC, renewable electricity and renewable electricity sources). Screenshots of the choice experiment are available in the CPEVS report (Axsen et al., 2015).

Pioneer respondents completed the choice experiment for the PEV design that they currently own. Mainstream respondents completed up to two scenarios: (i) with the PEV they selected in the design exercise (if they selected one) and (ii) with a BEV-240 km version of their base vehicle. We know from previous consumer research that Potential Early Mainstream respondents tend to prefer smaller-battery PHEV designs (Axsen and Kurani, 2013b). Because we anticipated that controlled charging preferences could differ between a PHEV and BEV, we had Mainstream respondents complete the experiment with a BEV-240 km also.

To quantify respondent preferences and willingness-to-pay for both the PEV and controlled charging choice experiments, we estimate multinomial logit (MNL) and latent-class (LCM) models using Latent Gold 5.0 (Vermunt and Magidson, 2013) for Pioneer and Mainstream respondents. The MNL assumes homogeneity in preference and represents the entire sample as one group (estimating one set of coefficients for that group). In contrast, a LCM quantifies heterogeneity in consumer preferences by assigning the sample into classes (or segments), estimating different coefficients for each class, and describing the probability of membership in each class according to respondent variables such as socio-demographic characteristics, values and lifestyles (see the next section on motivations). We consider several criteria when selecting the number of classes in each LCM, including interpreting the solution clearly, avoiding solutions with proportionally large classes (e.g. greater than 50% of sample) or very small classes (e.g. less than 5% of sample), avoiding solutions where two or more classes are essentially identical, and maximizing statistical measures of quality and parsimony.

3.4. Respondent motivations

We assess motivations of both Pioneer and Mainstream respondents through several scales included in Part 1 of the surveys. Specifically, engagement in an environment- or technology-oriented lifestyle was assessed via questions of respondent engagement in 10 activities with five-point response categories ranging from "*never*" to "*very frequently*," similar to Axsen et al. (2012). The five environment-oriented activities included statements such as "engaging in environmental conservation activities," "attending environmental meetings," and "promoting environmental conservation (talking to people about the environment)". The five technology-oriented activities included statements such as "researching new technology," "shopping for a new technology," and "working on or tinkering with technology." For each lifestyle category, we create a single composite score by summing responses to the five questions. We also assessed respondent openness to change (or liminality) via a nine-question scale, which has previously been associated with PEV interest (Axsen et al., 2012). CPEVS also included a measure of environmental concern using a "brief," eight-item version of the New Environmental Paradigm

(NEP) scale (Cordano et al., 2003). Finally, the surveys included a 12-item scale that assessed respondent motivation according to biospheric, altruistic, egoistic and traditional values (Stern et al., 1998).

4. Results

4.1. Household characteristics and context

Table 4 summarizes household demographic and context data from our Pioneer and Mainstream respondent samples residing specifically in British Columbia and our Mainstream respondent sample residing in Canada, as well as census data for both British Columbian and the Canadian general populations. Overall, our sample of Mainstream vehicle buyers seems to be largely representative of new vehicle-buying households, in that respondents tend to have higher income and education levels than the general population, as also found in previous studies (Axsen and Kurani, 2010; Busse et al., 2013; Harris-Decima, 2013). It is more difficult to determine the representativeness of the Pioneer sample as we do not have data on the full population of PEV owners, and that population is changing as the PEV market develops.

All differences in demographic and household characteristics between the three segments of British Columbian respondents are significant at a 99% confidence level. Overall, Pioneer respondents report significantly higher household incomes (being five times more likely to earn over $125kCAD/year), and education (being about three times more likely to have a graduate degree) than the Mainstream respondents. Pioneers are also more likely to be male (82% of sample), and be in the 45–64 age range (55% of sample) compared to Mainstream respondents (38–42% of sample). Pioneers are also significantly more likely to own their homes, and to live in single-family detached homes. Further, 97% of Pioneer respondents reported having home charging access, compared to 66% of Mainstream respondents who reported Level 1 charging access

Table 4
Comparing Pioneer and Mainstream Demographics in British Columbia and Canada.

Demographics and context	British Columbia samples				Canada sample	
	Pioneer	Mainstream		Census	Mainstream[a]	Census
		Potential Early	Potential Late			
Sample size	157	215	323	4,400,057	1754	33,476,688
Female (respondent)***	18%	64%	59%	51%	58%	51%
*Age (respondent)****						
15–34	11%	30%	23%	30%	30%	31%
35–44	24%	20%	18%	18%	18%	16%
45–54	26%	20%	21%	20%	20%	19%
55–64	29%	18%	21%	19%	19%	16%
65+	10%	12%	18%	13%	13%	18%
*Household income (pre-tax)****						
Less than $90,000	24%	66%	68%	69%	63%	69%
$90,000 to $124,999	28%	23%	23%	17%	25%	17%
Greater than $125,000	49%	11%	9%	14%	12%	15%
*Education (respondent)****						
Other	20%	24%	32%	59%	25%	60%
Diploma or some university	22%	34%	34%	22%	37%	22%
University degree (Bachelor)	28%	30%	24%	14%	26%	14%
Graduate or professional degree	30%	12%	10%	5%	12%	5%
*Residence type****						
Detached House	79%	65%	59%	54%	67%	62%
Attached House	12%	16%	14%	23%	15%	17%
Apartment	8%	17%	24%	21%	16%	20%
Mobile Home	1%	2%	2%	2%	2%	1%
Own residence***	92%	78%	74%	70%	78%	69%
*Vehicle ownership****						
1	14%	43%	51%	N/A	N/A	N/A
2	61%	45%	41%	N/A	N/A	N/A
3 or more	25%	13%	8%	N/A	N/A	N/A
Level 1 or 2 home charging access***	97%	66%		N/A	N/A	N/A

Note: Data on household size, sex, age, and residence type are from the 2011 Canada Census. Data on work status, education, and income are from the 2006 Canada Census. Data on home ownership are from the Canadian Mortgage and Housing Corporation: http://www.cmhcschl.gc.ca/odpub/esub/64693/64693_2013_A01.pdf?fr=1374042362378.

[a] Overall Canada sample is unweighted. Survey data includes only English-speaking Canada – Quebec was excluded due to language translation costs. Census data includes Quebec.

*** Differences indicated between Pioneers, Potential Early Mainstream and Late Mainstream British Columbia samples using chi-squared analysis at 99% confidence level.

(access to a 110/120 V outlet near their vehicle). Pioneers are also more likely to be multi-vehicle households (86%), compared to Mainstream respondents (49–57%). In contrast, the Potential Early and Late Mainstream samples do not differ substantially from one another, given that age, income, education, gender and household type are not significantly different at a 90% confidence level.

4.2. PEV awareness

Mainstream respondents have less PEV familiarity and awareness than Pioneer respondents (Fig. 1). Only a minority of Potential Early Mainstream respondents reported that they were either "familiar" or "very familiar" with the Nissan Leaf (17%), Chevrolet Volt (20%) and Toyota Prius (34%), while most Pioneer respondents reported a high degree of familiarity across all three models (77–84%). The majority of Potential Early Mainstream respondents also demonstrated confusion with the operation of each of the three vehicle models. In Part 1 of the CPEV survey, respondents were asked about how the Toyota Prius (non-plug in hybrid), Nissan Leaf, and Chevrolet Volt were fueled (either gasoline only, gasoline and electricity, or electricity only). Only 20% of Mainstream respondents successfully indicated that the Toyota Prius is fueled only by gasoline, and one-third successfully identified the correct fueling method for the Chevrolet Volt (gasoline and electricity) and the Nissan Leaf (electricity only). In contrast, the vast majority of Pioneer respondents (90–99%) were able to identify the correct fuelling method for the Nissan Leaf and Chevrolet Volt. Potential Early and Late Mainstream respondents demonstrated very similar levels of familiarity and awareness (see blue bars in Fig. 1).

4.3. Preferences for PEV designs (design space and choice exercises)

Findings from both the design space exercises and choice experiments indicate that most Pioneer respondents tend to prefer BEV designs, while Potential Early Mainstream respondents tend to prefer PHEV designs. Across the higher and lower price design scenarios, over one-third of Mainstream respondents selected a PEV, with 28–36% selecting a PHEV and only 2–4% selecting a BEV (Fig. 2). In contrast, Pioneer respondents stated a high degree of interest in PEVs, with almost all respondents selecting some type of PEV in both price scenarios (96–100%). Pioneers were almost evenly split between BEV and PHEV designs in the higher price scenario, but more than two-thirds selected a BEV in the lower price scenario. However, we must be careful in comparing the results of the Pioneer and Mainstream respondents because the Pioneer version of the design space exercise included one additional BEV option (with 320 km of range). That said, it seems clear that BEV interest is much higher among Pioneer respondents even when ignoring the BEV-320 (i.e. even with the conservative assumption that if the BEV-320 km were available, all respondents selecting this design would have instead selected a PHEV, or no PEV at all).

The multinomial logit model (MNL) (i.e. a single class model) estimated from the PEV choice experiment revealed similar results as the design exercise (Table 5). Note that the Mainstream model is estimated from the full Canadian sample (not just British Columbia respondents), as this larger sample provides a better statistical model (with no apparent differences in comparison to the British Columbia-only model). For Mainstream respondents, the alternative-specific constants indicate that compared to a conventional vehicle, the hybrid is the most desirable drivetrain followed by the PHEV, while the BEV is the least desirable. Interestingly, valuation of BEV and PHEV range was not statistically significant in this sample. As shown in Table 5, Mainstream respondents would be willing to pay, on average, an additional $744 for a PHEV (of any electric range, as the range coefficient is not significant), and would have to be compensated over $10,000 to purchase a BEV of any range. With Level 2 (220/240 V) home charging access, however, both vehicle designs are more valuable to Mainstream respon-

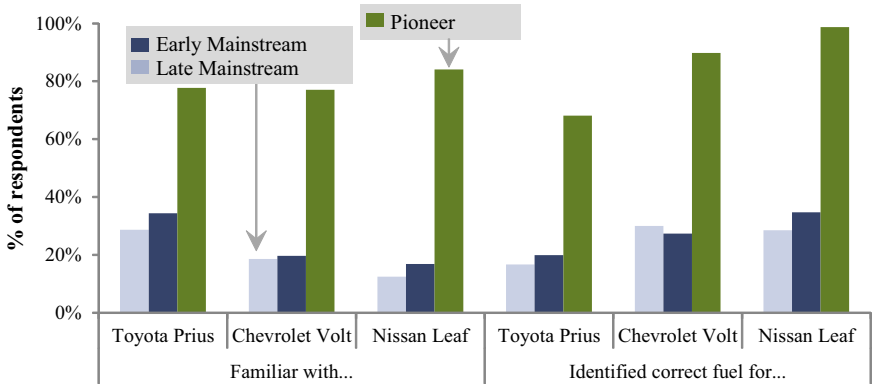

Fig. 1. Comparison of PEV familiarity and refuelling between Mainstream respondents (n = 538, blue bars) and Pioneer respondents (initial survey component, n = 157, green bars) from the British Columbia samples. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

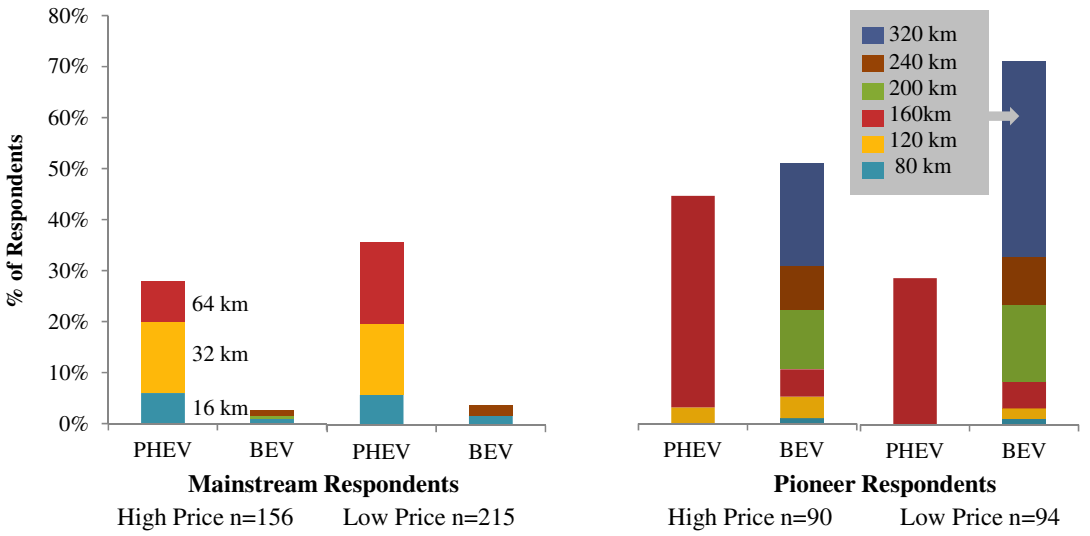

Fig. 2. Comparing PEV designs among Pioneer and Mainstream respondents (higher and lower price scenarios).

dents, increasing willingness-to-pay by $1295 for PHEVs, and by $3311 for BEVs. Our latent class model (LCM) identifies heterogeneity in Mainstream respondents' PEV preferences (middle five columns of Table 5). We selected the five-class solution as the most interpretable (while meeting our other objectives as summarized in Section 3.3). The first two classes represent about one-third of the total sample, and express particularly high interest in and valuation of PEVs: (1) a small class of "PEV enthusiast" Mainstream respondents (8%) willing to pay an incremental price of over $100k for both BEVs and PHEVs and (2) a larger group (25%) of "PHEV-oriented" Mainstream respondents willing to pay $15,300 for PHEVs. The class membership model indicates that respondents in these two PEV-interested classes are more likely to engage in environmentally-oriented and technology-oriented lifestyles, as well as to have higher levels of environmental concern. The remaining three Mainstream classes (65%) express low or negative valuation of PEVs and their attributes.

The MNL model for Pioneer respondents demonstrates high valuation of PEVs, with these individuals expressing almost equally high willingness-to-pay values for PHEVs and BEVs (consistent with the design space results). The electric driving range coefficients, which were significant and positive, translate into an average incremental willingness-to-pay of $69,738 for a PHEV-64, and over $80k for a BEV-240, increasing by just over $11k and $23k, respectively, if residential Level 2 access is available for the PHEV or BEV. While these willingness-to-pay values are perhaps too extreme to be taken literally, they demonstrate that Pioneers are highly enthusiastic for both PHEV and BEV designs; these willingness-to-pay values are fairly consistent with those estimated for the "PEV-enthusiast" class of Mainstream respondents. Finally, Pioneer respondents place a much higher value on fuel cost savings relative to Mainstream respondents, though it is not clear if this is motivated by financial motivations, or other motivations associated with fuel savings, such as reduced fuel or energy consumption or reduced environmental impacts. We did not successfully estimate a LCM for the Pioneer sample, as the software could not find an appropriate multi-class solution. This result indicates that preferences within this Pioneer sample are relatively homogenous and thus the "single class" MNL is appropriate to represent the preferences of the entire sample–or alternatively that the Pioneer sample size was too small to estimate a model with multiple classes.

4.4. Preferences for controlled charging

Table 6 presents MNL and LCM models based on responses of the Potential Early Mainstream and Pioneer samples to the controlled charging stated choice experiment. The majority of coefficients in the MNL are significant at a 95–99% confidence level. Comparing the MNL models of the Pioneer and Potential Early Mainstream samples we observe two important differences. First, Pioneer respondents perceive controlled charging as a greater inconvenience than Potential Early Mainstream respondents, where willingness-to-pay calculations indicate that Pioneers, on average, have to be compensated more to adopt controlled charging and are willing to pay higher premiums for more guaranteed charge each morning (i.e. more battery charge after a night of charging or more GMC). On average, with all other attributes being identical, Pioneers would have to be compensated $18–24 per month to adopt controlled charging, while the Potential Early Mainstream would only need to be compensated $7 per month (to adopt with a PHEV design). Pioneers are also more sensitive to changes in the minimum amount of charge guaranteed each morning (i.e. GMC), and are willing to pay $9–25 per month for a 10% increase in GMC, while the Potential Early Mainstream is willing to pay $6–8 per month; both samples, however, are more sensitive to increases in GMC for a PHEV design relative to a BEV design. One potential explanation for these differences is that Pioneers have more experience with driving and recharging PEVs and thus have a better sense of the impacts of participating in such a

Table 5
PEV MNL for Pioneers and Mainstream sample, and latent class model for Mainstream sample.

Model coefficients	Mainstream						Pioneer
	MNL	Latent Class					MNL
		PEV-Enthusiast	PHEV-Oriented	HEV-oriented	HEV-leaning	CV-oriented	
Constants							
HEV constant	0.205***	0.552*	2.279***	2.6286***	0.9017***	−2.9287***	−0.244
PHEV constant	0.126**	1.999***	3.212***	−1.3927***	−0.1169	−4.5195***	1.069***
BEV constant	−1.850***	2.044***	−1.235*	−5.3855	−3.1671***	−1.9695	0.891**
Model attributes							
Vehicle price (CAD$)	−0.0002***	−0.00002***	−0.0002***	−0.0002***	−0.0006***	−0.0003***	−0.00003***
Fuel cost (CAD$/week)	−0.008***	0.0002	−0.042***	−0.0083**	−0.0396***	−0.0194***	−0.009**
PHEV range (km)	−0.0001	−0.0026	−0.0036	0.0125*	0.0063*	0.002	0.018***
BEV range (km)	0.0009	−0.0016	0.0038	0.0001	0.0059*	−0.0205	0.007***
PHEV × Level2 home charger	0.219***	0.1245	0.5016***	1.0248***	0.5288***	−0.294	0.366**
BEV × Level2 home charger	0.559***	0.6158***	1.2272***	3.9885	0.2863	−1.0897	0.734***
Class membership probability model (HEV-Leaning = base)							
Constant		−4.6***	−1.908***	−0.9658	[base]	0.8747*	
Demographics							
Dummy – 1 if income > 100k/yr. (>90k for PEVOS)		−0.206	−0.04	−0.2876		−0.1476	
Dummy – 1 if Bachelors or higher.		0.299	0.0666	−0.3625*		−0.6289***	
Lifestyle & Attitudes							
Technologically oriented lifestyle: Scale (0–25)		0.086***	0.0113	−0.0109		−0.0288	
Environmentally oriented lifestyle s: Relative scale (0–25)		0.086***	0.083***	0.0285		−0.0059	
Biospheric values: Relative scale (0−12)		0.146*	0.0741	0.0276		0.0532	
Altruistic values: Relative scale (0−12)		−0.03	−0.004	0.0328		−0.0771	
Implied willingness-to-pay (CAD)[a]							
HEV	$1215	$35,190	$10,856	$11,695	$1499	−$8870	
PHEV	$744	$127,502	$15,300	−$6196		−$13,688	$33,770
BEV	−$10,956	$130,344	−$5884		−$5267		$28,111
Saving $1000/year in fuel	$769		$4038	$798	$1270	$1244	$5769
1 km Of PHEV range				$55	$10		$562
1 km Of BEV range					$10		$234
PHEV with Level 2 charging	$1295		$2389	$4559	$879		$11,542
BEV with Level 2 charging	$3311	$39,272	$5845				$23,178
PHEV-64				−$2676			$69,738
BEV-320					−$2867		$84,271
Class Membership Probabilities		0.08	0.25	0.16	0.27	0.22	
Log Likelihood	−12,425	−8839					−507
Overall Pseudo R^2	0.148	0.59					0.368

Note: HEV = conventional hybrid vehicle, CV = conventional gasoline or diesel vehicle.
*** Significant at a 99% confidence level.
** Significant at a 95% confidence level.
* Significant at a 90% confidence level.
[a] We only depict willingness-to-pay calculations where the coefficient estimates are significant at a 90% confidence level or greater.

Table 6
Controlled charging MNL and Latent Class Model for Potential Early Mainstream and Pioneer samples.

Model coefficients	Early Mainstream					Pioneers			
	MNL	Latent Class				MNL	Latent Class		
	N/A	Charge Focused	Cost Motivated	Renewable Focused	Anti-CC	*N/A*	Cost Motivated	Renewable Focused	Anti-CC
Constants									
Controlled charging with a PHEV	−0.203***	0.239	0.975***	1.212***	−2.621***	−0.6**	−0.341	1.687	−0.9*
Controlled charging with a BEV	0.149	0.11	0.365	1.836***	−0.729	−0.446**	0.376	0.505	−0.975**
Model attributes									
Monthly electric bill (CAD)	−0.03***	−0.059***	−0.233***	−0.019***	−0.016***	−0.025***	−0.12***	−0.022***	−0.017***
Guaranteed minimum charge with a PHEV (%)	0.023***	0.06***	0.036***	0.017***	0.013**	0.062***	0.187***	0.065***	0.235**
Guaranteed minimum charge with a BEV (%)	0.017***	0.027**	0.018	0.01	0.099***	0.022***	0.017*	0.003	0.061***
Percentage of renewable electricity (%)	0.004***	−0.003	0.013***	0.015***	−0.011***	0.016***	0.011**	0.044***	0.011**
Type of renewable electricity (base = "mixed sources")									
Dummy – 1 if wind	−0.325***	−0.309**	−0.089	−0.528***	0.228	0.001	−0.136	0.357	0.427
Dummy – 1 if small hydro	0.00	0.232	0.144	−0.254*	0.095	0.525***	1.218***	0.798**	0.382
Dummy – 1 if solar	−0.098*	−0.11	0.286	−0.429**	0.495*	0.073	0.2	0.092	0.075
Class membership probability model (with Class 1 as the base)									
Intercept			−1.456**	−4.804***	−2.33***			−1.538	1.645
Demographics									
Age: Continuous			−0.001	−0.015*	0.019***			0.031	0.045**
Dummy – 1 if Bachelors or higher			0.412*	0.991***	−0.751***			0.66	0.779
Dummy – 1 if income > 80k/yr			0.333	0.069	0.153			1.431*	−0.156
Lifestyle & attitudes									
Technologically oriented lifestyle: Scale (0–25)			0.071***	0.04	0.045*			−0.065	−0.122**
Biospheric values: Relative scale (0–12)			0.142**	0.464***	0.055			0.273	0.017
Altruistic values: Relative scale (0–12)			−0.124*	−0.059	0.007			−0.322*	−0.231*
Implied willingness-to-pay (CAD)									
10% increase in PHEV Guaranteed minimum charge/month	$8	$61	$10	$9	$8	$25	$16	$29	$135
10% increase in BEV Guaranteed minimum charge/month	$6	$5			$61	$9	$1		$35
For a 10% increase in% of renewables/month	$1		$1	$8	−$7	$7	$1	$20	$6
To adopt controlled charging with a PHEV/month	−$7		$4	$66	−$161	−$24			−$52
To adopt controlled charging with an BEV/month				$99		−$18			−$56
Class Membership Probabilities		0.32	0.28	0.19	0.21		0.40	0.28	0.32
Log Likelihood	−5974.63	−4493.24				−976.929	−747.562		
Overall Pseudo R^2	0.1565	0.5623				0.2173	0.5508		

*** Significant to 99%.
** Significant to 95%.
* Significant to 90%.

Table 7
Lifestyles, attitudes and values for Pioneers, Potential Early Mainstream and Late Mainstream (British Columbia samples, average scores for each question scale).

Sample	Pioneer	Early Mainstream	Late Mainstream
Sample size	157	215	323
Lifestyle engagement			
Technology orientation (0–25)***	17.0	13.8	12.9
Environmental orientation (0–25) ***	15.4	13.2	11.8
Attitudes			
Liminality/openness (−18 to +18)(ns)	0.8	1.1	0.9
Environmental concern (−16 to +16) ***	8.0	6.5	5.4
Values			
Traditional values (0–12) ***	9.7	10.2	10.3
Egoist values (0–12) ***	5.5	6.9	6.9
Biospheric values (0–12) *	9.5	9.4	9.1
Altruistic values (0–12)(ns)	9.9	10.1	10.0

Note: Differences indicated between BC Pioneers, Potential Early Mainstream and Late Mainstream samples using ANOVA analysis:
ns not significant.
* Significant at 90% confidence level.
** Significant at 95% confidence level.
*** Significant at 99% confidence level.

controlled charging program. A second key difference is that Pioneers more highly value renewable electricity from the grid, placing almost five times more value on connecting renewable electricity to their PEV than Potential Early Mainstream respondents ($6.50/month v. $1.33/month, respectively).

As with our vehicle choice model, we estimate LCMs to identify heterogeneity in each sample – we selected the four-class solution for Mainstream respondents and the three-class solution for Pioneer respondents (indicating that both samples have heterogeneity that can be represented through multiple classes). In each sample we identify one class that is anti-controlled charging (“Anti-CC”), consisting of respondents who require relatively high levels of compensation to adopt a controlled charging program—up to $161 per month among Potential Early Mainstream respondents and just over $50 per month with the Pioneer sample. We also identified a “Renewable-focused” class in each sample, consisting of respondents with relatively high willingness-to-pay for a 10% increase in renewable electricity–$20/month for the Pioneer version (representing 28% of Pioneer respondents) and $8/month for the Mainstream version (representing 19% of Potential Early Mainstream respondents). Members of the “Renewable-focused” class in the Potential Early Mainstream sample are significantly more likely to engage in technology-oriented lifestyles and to have biospheric values than members of other classes. In contrast, the Pioneer version of this “Renewable focused” segment was not more likely to have biospheric values. Lifestyle factors were not shown to be related to Renewable-focused Pioneers to any significant degree; however, we do know that in general Pioneers have higher levels of environmental concern and environment-oriented lifestyle engagement. The remaining classes express higher valuation for the functional attributes of controlled charging, including cost savings (“Cost-motivated” in both samples) and increased GMC (“Charge-focused” in the Potential Early Mainstream sample only).

4.5. Respondent motivations

As a final comparison, we identify significant differences between Pioneer and Mainstream respondents’ motivations, as measured in terms of lifestyle engagement, attitudes and values (Table 7). Pioneer respondents have higher levels of environmental concern and engagement in both technology- and environment-oriented lifestyles, in addition to lower levels of traditional values and egoistic values (all at a 99% confidence level). Overall, the Potential Early and Late Mainstream samples are more similar to each other than to Pioneers. Between the two Mainstream samples, the Potential Early Mainstream is more likely to have higher engagement in environment-oriented lifestyles (99% confidence level) and technology-oriented lifestyles (95% confidence level), and a higher level of environmental concern (95% confidence level). Assessment of respondents’ openness to change (or liminality) and values are nearly identical between Potential Early and Late Mainstream respondents.

5. Discussion and conclusion

To anticipate how the potential future PEV market may differ from the present one, we use in-depth survey data collected in British Columbia, Canada to provide a comprehensive characterization of three segments of new-vehicle buying households: Pioneers (current PEV buyers), Potential Early Mainstream buyers (conventional new vehicle buyers who stated interest in purchasing a PEV) and Potential Late Mainstream buyers (conventional new vehicle buyers who did not state interest in purchasing a PEV). Many of our results are consistent with previous research from the U.S. and Germany, indicating that

relative to the Mainstream buyers, Pioneers are more likely to have higher income and education (Axsen and Kurani, 2013a; Plötz et al., 2014; Tal and Nicholas, 2013), more likely to be middle-aged and much more likely to be male (Plötz et al., 2014). We also find that Pioneers are more likely to be multi-vehicle households which can allow PEV buyers to adapt to limited range BEVs (Kurani et al., 1996). Canadian Pioneers are also more likely to have charging access (especially Level 2) at home, which is consistent with U.S. data (Axsen and Kurani, 2012b; US Department of Energy, 2013). While previous comparisons tend to focus solely on demographic and household context—often as proxy measures of consumer preferences or motivations—we directly assessed preferences via an in-depth questionnaire that included PEV design exercises and stated choice experiments.

As a starting point, we find that Mainstream respondents' awareness of PEV technology is very low, particularly regarding PHEVs and how they can be refueled—which is consistent with early U.S. market research on potential PHEV demand (Axsen and Kurani, 2008; Caperello and Kurani, 2012). Thus, it seems unlikely that most Mainstream buyers have clear or stable preferences for PEVs if they are not yet aware of the basic functions of PEVs (i.e. how they are refueled). Once the idea of a PHEV and BEV was explained to respondents in the survey, both the design space and choice experiment results indicate that Potential Early Mainstream respondents are substantially more likely to prefer a PHEV over a BEV design, as has been found in samples drawn from San Diego, California (Axsen and Kurani, 2013a) and the U.S. (Carley et al., 2013). In contrast, Pioneers tend to prefer BEV designs, which also has been found in previous literature (Axsen and Kurani, 2013a).

This study is the first that we know of that directly compares Pioneer and Potential Early Mainstream respondents in terms of environmental concern and lifestyle engagement. As hypothesized, we find that Pioneers are significantly more likely (at a 99% confidence level) to have high concern about environmental impacts, and to engage in technology-oriented and environment-oriented lifestyles. When comparing Potential Early Mainstream respondents to Potential Late Mainstream respondents, we see similar differences but to a lesser degree. Pioneers and Potential Early Mainstream respondents have similar scores for biospheric values. In other words, the Potential Early Mainstream and Potential Late Mainstream are significantly more different from Pioneers than to each other.

Given that, by definition, Potential Early Mainstream buyers represent the broad segment of new vehicle buyers most likely to buy PEVs in the future (if such vehicles become widely available), their current perceptions and preferences hold important implications for a number of stakeholders. Policymakers seeking to support PEV adoption and automakers seeking to sell PEVs (or to comply with PEV supportive policies) should be aware of the unique qualities of the Potential Early Mainstream. For one, these potential future buyers are more likely to be interested in PHEVs designs than BEV designs. It therefore seems important for automakers to produce a wide range of PHEVs and for policy makers to implement policies that support both PHEVs and BEVs; for example providing PHEV subsidies or providing credits for PHEVs as part of a Zero-Emissions Vehicle mandate. Although it should be acknowledged that Mainstream buyers may have relatively unstable preferences, which could change with future exposure to PEVs (Bühler et al., 2014; Jensen et al., 2013), it seems that PHEVs present an opportunity for that exposure. Second, given the observed confusion among Potential Early Mainstream respondents regarding how PEVs work, it is important for future information or marketing campaigns to focus on clarifying the differences between PHEVs and BEVs.

Results also suggest that Potential Early Mainstream buyers and Pioneers may have different patterns and preferences for charging. In terms of general charging patterns, the fact that Potential Early Mainstream buyers prefer different types of PEVs (notably PHEVs) and tend to have different levels of home charging access, indicates that overall time of day recharge (or electricity demand) profiles could differ significantly from those of Pioneers. When specifically looking at the potential enrollment in a controlled charging program, Pioneers are more sensitive to the guaranteed minimum charge of the program, but place five times more value on supporting renewable energy than Potential Early Mainstream buyers, as has also been found in U.S. research (Axsen and Kurani, 2013a; Turrentine et al., 2011). Pioneers are also less likely to express interest in controlled charging programs, which could, in part, be explained by the fact that Pioneers have significant experience with PEV charging and have a better understanding of their daily need for electric range. Mainstream buyers, on the other hand, have little to no experience to draw on when expressing preferences about controlled charging, which may partly account for why Potential Early Mainstream respondents were slightly more accepting of controlled charging in this study. However, there is heterogeneity among Pioneers' and Potential Early Mainstream's preferences in relation to controlled charging. Thus, electric utilities seeking to recruit future PEV buyers to enroll in controlled charging programs might want to offer a range of incentives, potentially offering cost savings, renewable electricity access, and higher levels of guaranteed charge (where Pioneers might be particularly motivated by renewable electricity).

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