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New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon

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DISCLAIMER

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We'd like to thank the households who participated in the research reported here.

We'd like to thank Jamie Davies for his work during the household interviews, Tom Turrentine for managing the initial analysis of the interview data, Matt Favetti for programming the on-line survey, and Dr. Gil Tal for managing survey programming.

REVISION NOTES

1. A new Introduction replaces the former Preamble.
2. A comparative analysis of states and regions is added to the results. As part of this, names of clusters of respondents sharing motivations are streamlined and matched (where appropriate) between the Oregon and Comparative Analyses.
    a. As part of the comparative analysis, Appendix C is added to the document.
    b. As part of the name changes to clusters of respondents in the Oregon analysis, the graphics in sections discussing distinct clusters of motivations are changed to match revisions in other states' reports.
3. Population level estimates of numbers of households with positive PEV valuations are added to the results.
4. Discussion and conclusions are added to reflect these changes.
5. Cleaned up the use of acronyms referring to technology (PHEV, BEV, PEV, and FCEV) and regulatory (ZEV) definitions of vehicle drivetrain types throughout the document.
    a. Acronyms referring to specific drivetrain types, i.e., PHEV, BEV, and FCEV, will be used where a specific technology is being described or respondents' vehicle designs are being described.
        i. The acronym PEV is used to refer to PHEVs and BEVs collectively when the distinction between the two is not essential, but the grouping of vehicles that charge from the grid is germane.
    b. The acronym ZEV is reserved for discussion of policy, whether those discussions are of ZEV policies or the other environmental and energy goals that are the aim of ZEV policies. ZEV will also be used refer to experts—policy, engineering, research, or otherwise—to distinguish their roles from the respondents'.

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INTRODUCTION

Policy goals for vehicles powered (in part or in whole) by electricity or hydrogen include reduced emissions of criteria pollutants and greenhouse gasses from motor vehicles. Battery electric vehicles (BEVs) powered-solely by electricity and hydrogen fuel cell electric vehicles (FCEVs) are zero-emission vehicles (ZEVs). Plug-in hybrid electric vehicles (PHEVs) are powered by both electricity and gasoline. PHEVs and BEVs are collectively known as plug-in electric vehicles (PEVs). New automotive product offerings and energy industry and utility responses to air quality, climate, energy, and ZEV regulatory frameworks mean consumers are confronted with new vehicle technologies and asked to consider new driving and fueling behaviors. Even as PHEVs, BEVs, and FCEVs enter the vehicle market, nascent PEV recharging infrastructure is being deployed and hydrogen fueling infrastructure is being planned and constructed, questions remain as to whether consumers will purchase PEVs and FCEVs.

This research addresses the questions of whether and how households who tend to acquire their vehicles as new value PEVs and FCEVs in comparison to conventional vehicles powered by internal combustion engines (ICEVs) and hybrid electric vehicles (HEVs).[1] This report presents findings regarding new-car buyers' valuations of PEVs and FCEVs as measured by their intentions toward these technologies, describes why people hold these intentions, and characterizes the antecedents to these intentions. Our research seeks to answer the question of how consumers respond to new technology vehicles and new fueling behaviors. Answering these questions was accomplished by measuring consumer awareness, knowledge, engagement, motivations (pro and con), and intentions regarding PEVs and FCEVs.

This study has three objectives:

1. Measure new car buyers' awareness, knowledge, experience, consideration, and valuation of PHEVs, BEVs, and FCEVs;
2. Describe new car buyers' decision making regarding prospective PEV and FCEV purchase decisions; and,
3. Compare new car buyers in California and other states with ZEV sales requirements.

A multi-method research agenda was used to gather data in thirteen states: California, Oregon, Washington, Oregon, Delaware, Maryland, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, and Maine. The survey measured the distribution of consumer knowledge and beliefs about ICEVs, HEVs, PHEVs, BEVs, and FCEVs. Interviews with a subset of survey respondents in California, Oregon, and Washington elaborated on consumer awareness and knowledge of, as well as motivation and intention toward, PEVs and FCEVs. Results include an enumeration of the present responses of new car buyers to the new technologies as well as an understanding of what can be done to transform the positive intentions towards PEVs and FCEVs into purchases and the negative intentions toward PEVs and FCEVs into positive ones.

[1] This focus on households who acquire new vehicles is not a requirement or assumption about who will acquire PEVs and FCEVs in the near future. The requirement that households have purchased a new vehicle within seven model years prior to the survey date assures they had shopped for a vehicle during the period PEVs started to appear in the market and that the respondents' households do buy new (possibly in addition to used) vehicles. Further, PEVs were just starting to appear in small numbers in the used vehicle market at the time of this study.

Regarding the comparative discussion later in the report, the study was conducted as a joint set of state studies. With the exception of California, the Northeast States for Coordinated Air Use Management (NESCAUM) coordinated the participation of all other states. NESCAUM additionally supplied funding for sampling in NESCAUM-member states who did not participate in the study, i.e., Connecticut, Maine, New Hampshire, Rhode Island, and Vermont. This allows for a NESCAUM-wide analysis when these data are combined with those NESCAUM-member states who made the commitment to maximize their state sample so as to produce the best possible estimates for their state: Massachusetts, New Jersey, and New York.[2] Comparisons will be made to the NESCAUM region, as well as California, Oregon, Washington, Delaware, and Maryland.

[2] Sample sizes for Massachusetts, New Jersey, and New York were the largest possible from the sample vendor; sample sizes for all other NESCAUM states were scaled to the New York sample size by relative population.

BACKGROUND

This section provides an overview of the multistate ZEV policy framework and a more specific description of the situation in Oregon as the period of data collection for this study circa December 2014 to January 2016.

A Multistate ZEV Policy Framework

In an attempt to improve local air quality and reduce the emissions that contribute to climate change, Oregon has adopted California's zero emission vehicle (ZEV) mandate requiring manufacturers of passenger cars and light trucks to sell a certain percentage of (ZEVs). In addition to Oregon, the states of Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Rhode Island and Vermont have adopted these standards. ZEVs are any vehicle that releases zero emissions during on-road operation. They include battery electric vehicles (BEVs) and hydrogen fuel cell vehicles (). Other vehicle types, such as plug-in hybrid electric vehicles (PHEVs) can be considered as partial ZEVs.

The California Air Resources Board determines how many credits are required to satisfy its mandate each year. Notably, one credit does not equal one vehicle. For example a BEV earns between one and nine ZEV credits depending on driving range. In an effort to make compliance easier for automakers, credits may be traded between manufacturers and manufacturers can meet their sales requirements with a mix of vehicle technologies, for example, selling a certain number of ZEVs as well as partial zero emission vehicles and neighborhood electric vehicles. Automakers are also allowed to apply ZEV credits earned in one state to their ZEV requirements in other states as long as they sell a minimum number of ZEVs in each participating state.

The 10 ZEV mandate states signed a memorandum of understanding (MOU) that included a ZEV Program Implementation Task Force (Task Force). This Task Force published a ZEV Action Plan (Plan) in May 2014. The plan listed 11 priority actions, including deploying at least 3.3 million ZEVs—roughly 15% of new vehicle sales in the collective region of the signatory states—as well as adequate fueling infrastructure, both by the year 2025.

Oregon ZEVs

Towards these goals and actions, many PHEVs and BEVs are now available for sale in Oregon. BEVs available in Oregon included the Fiat 500e, Chevy Spark BEV, Kia Soul BEV, BMW i3, Ford Focus Electric, Mercedes B-Class Electric, Nissan Leaf, Smart Electric Drive, Tesla Model S, and the Volkswagen E-Golf. Available PHEVs included the Cadillac ELR, Chevy Volt, Ford C-Max Energi and Fusion Energi, Honda Accord Plug-in Hybrid, Porsche Cayenne S E-Hybrid and Panamera S E-Hybrid, and the Toyota Prius Plug-in Hybrid. As of June 2015, 60% of the ZEVs sold or leased in Oregon were BEVs and 40% were PHEVs, compared with the national average of 47% BEVs and 53% PHEVs sold or leased.[3] As of August 2014, Oregon had a PEV adoption rate higher than the national average. [4]

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[3] http://energy.gov/eere/vehicles/fact-877-june-15-2015-which-states-have-more-battery-electric-vehicles-plug-hybrids
[4] http://www.afdc.energy.gov/case/1000

Oregon State ZEV Policy and Incentives

Oregon state ZEV drivers qualify for the federal tax incentive appropriate for their vehicle. Additional state incentives include:

1) The Residential Energy Tax Credits program allows qualified residents to receive a 25 percent tax credit for alternative fuel infrastructure, up to $750[5];
2) An Alternative Fueling Infrastructure Tax Credit for Businesses allows qualified businesses to receive a 35 percent tax credit of eligible costs for alternative fuel infrastructure[6];
3) Exemption from Pollution Control Equipment allows dedicated original equipment manufacturer natural gas and electric vehicles to not be equipped with a certified pollution control system.[7]

Per the Alternative Fuels Data Center, there are 399 electric stations and 944 charging outlets in the state.[8] Oregon is part of the West Coast Green Highway that aims to install DC fast charging stations every 25-50 miles along Interstate 5, running from the Canadian border to the Mexican border.[9] Other major roadways also offer charging stations within a half-mile of the highway where drivers can patronize coffee shops, restaurants, and shopping centers.

Energizing Oregon is a PEV readiness plan written in 2013 aimed at increasing the adoption of PEVs in Oregon. Oregon is focusing on four areas it has deemed hurdles to PEV adoption: 1) Outreach, Education, and Communications, 2) Policy and Inducements, 3) Deployment, and 4) Utilities.[10] The Oregon Department of Transportation, the governor, and Drive Oregon established the Energize Oregon Coalition to implement the plan. Drive Oregon is a nonprofit trade association that offers leadership among industry members throughout the entire supply chain in order to grow a ZEV industry in Oregon.[11]

The Oregon Tourism Commission, vehicle manufacturers, universities, and public agencies collaborated on the Oregon Electric Byways initiative to promote PEV tourism. They provided market research and itineraries to guide the placement of electric vehicle supply equipment (EVSE), i.e., PEV charging infrastructure, throughout Oregon. [12]

The State of Oregon Building Codes Division established a single permit for the installation of EVSE.[13] Oregon was the first state in the US to participate in the Workplace Charging Challenge, created by the US Department of Energy, to increase the number of employers that provide charging at workplaces.[14]

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[5] http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#or
[6] http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#or
[7] http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#or
[8] http://www.afdc.energy.gov/fuels/electricity_locations.html
[9] http://www.westcoastgreenhighway.com/electrichighways.htm
[10] http://www.oregon4biz.com/assets/docs/EVrpt2013.pdf
[11] http://driveoregon.org/about-us/mission/
[12] http://www.afdc.energy.gov/case/1000
[13] http://www.afdc.energy.gov/case/1000
[14] http://www.afdc.energy.gov/case/1000

STUDY DESIGN

The overall study design included an on-line survey (administered in all states) and follow-up interviews with a sub-set of survey respondents in California, Oregon, and Washington. A single survey was designed and implemented in all states. This limited customization to the specific circumstances in each state, e.g., whether and which ZEVs are for sale, state and local policies to support or (intentionally or not) oppose ZEVs. The on-line survey was conducted from December 2014 to January 2015 and the follow-up interviews in January, February, and March 2015. Interview households were drawn from those who indicated strong positive purchase intentions for ZEVs as well as households who indicated no or negative interest toward ZEVs.

The online survey is best suited to questions of "how many?" The interviews are best suited to answer questions of "why?" The survey provides a snapshot of what the population looks like at the time the survey is completed. The interviews position individual respondent's answers to the survey questionnaire within a longer term—both into the past and future—context. In the survey questionnaire the respondents expressed what they know about ZEVs and whether they have a positive or negative valuation toward their purchase of such vehicles. The interviews explore how they came to their state of knowledge and valuation.

Online Survey Instrument Design

ZEV intention and valuation were assessed via vehicle design games in which respondents designed their next new vehicle. These games were administered to the large sample survey and reviewed with households in follow-up interviews. Researchers from the Center have used such games to previously assess new car buyer interest in natural gas, plug-in hybrid and electric vehicles, plug-in hybrid electric vehicles (PHEV) and plug-in hybrid and electric vehicles.

Respondents were asked to design their likely next new vehicle across a variety of conditions. Parameters that respondents manipulated in the game included: 1) drivetrain type (ICEV, HEV, PHEV, BEV, or FCEV), 2) driving range per refueling and/or recharging, 3) home vs. non-home recharging and refueling, 4) and time to recharge or refuel. Further, multiple rounds of designs were created while other variables are added: vehicle body styles/sizes allowed to have all-electric drive and ZEV incentives.

The vehicle design games were customized to each participant. Participants were asked, to the extent that they have considered their next new vehicle, what that vehicle is likely to be. From that point, the design game was a constructive exercise—people put together the vehicle they want. The results of the design games were respondents' prospective designs for the new vehicle they imagined they would buy next. These prospective designs are not forecasts, but indicators of respondents' present positive or negative evaluation of ZEVs compared to more familiar ICEVs. The games, in effect, provided a way for respondents to register whether they are presently willing for their next vehicle to be a ZEV within the boundaries of the game conditions.

Interview Design

Interviews were completed to 1) describe the variety of reasons people have for forming positive or negative purchase intentions toward ZEVs and ZEV-enabling technologies; 2) describe the variety of motivations for different ZEVs and ZEV-enabling technologies; 3) describe the variety of “negative” intentions, e.g., are they grounded in lack of awareness, knowledge, and motivation or actual opposition to ZEVs and ZEV-enabling technology; and 4) characterize the variety of responses to questions too complex to be adequately addressed in the online survey. An example of the latter is whether and how households compare costs across the familiar conventional vehicles and the new technology vehicles.

The interviews improved understanding of decision-making and of whether and how ZEVs and ZEV-enabling technology fit or reshape trajectories of household narratives. The interviews do not represent all households but provide descriptions that are illustrative of how and why some people make the decisions they do. Further, the opportunity for households to frame questions and answer any issues in their own words both better reveals their interpretations and provides language for education and outreach programs, marketing, and subsequent research. Overall, the interviews inform the interpretation and evaluation of the present large sample survey, policy decisions, and future research and policy. In particular the interviews probed for more details and explanations of the items listed under Objective 1, gave the households an opportunity to elaborate on their thoughts during the design games, and probed specifically for the role of body styles on the prospects for ZEV sales.

Samples

Survey

The population from which the samples were drawn was new-car buying households. The Institute of Transportation Studies (ITS-Davis) and Plug-in Hybrid & Electric Vehicle Center (“the Center”) at the University of California, Davis hired a sample management services company. The Center provided the vendor with household selection criteria and the target sample sizes; the firm invited the participation of new car owning households in California, sent reminders to participants, and provided sample weighting to insure the realized sample of completions represents the target population of new-car buying households.

Respondents were invited to the study via email. The email included a link to the questionnaire hosted on a UC Davis computer server. The questionnaire was designed for a wide variety of operating systems for PCs and tablets but not smartphones. Invitees who did not complete the questionnaire were emailed reminders from the vendor. The questionnaire’s URL was active for one month during the period December 2014 to January 2015.

Eligibility to complete the survey, and thus be counted as part of the sample, was confirmed by the market research firm according to criteria supplied by the Center. The screening criteria were as follows:

- How many vehicles does your household currently own, that are driven at least once per week?
  - Eligible participants must have at least one such household vehicle.
- Of these vehicles, how many did your household buy new or lease new in California in the last five years, e.g. model year 2009 or later.
  - Eligible participants must have purchased or leased at least one such new vehicle.

Table 1 shows the target sample sizes for each state, as well as the number of interviews in those states requesting them. State sample sizes were determined largely by the sample provider's ability to assure sample sizes from the population of new-car buying households in each state. The maximum achievable sample size was used; in the case of Oregon, the target sample size was n = 500. Following data cleaning, the final sample size for Oregon is n = 494.

Table 1: Survey sample size, by state

State/Region	Target size	Final sample size	Number of Interviews
California	1,700	1,671	36
Oregon	500	494	16
Washington	500	500	16
Delaware	300	200	-
Maryland	400	396	-
NESCAUM members			
Massachusetts	500	498	-
New Jersey	500	495	-
New York	1,000	997	-
Connecticut	184	180	-
Maine	69	69	-
New Hampshire	68	68	-
Rhode Island	54	54	-
Vermont	32	32	-
All States Total	5,807	5,654	68

Interviews

The overall study design includes follow-up interviews with a sub-sample of survey respondents. These interviews were conducted in Washington, Oregon and California. The sampling procedure produced a stratified sample. The main stratification variables are 1) positive vs. negative valuations of PEVs and FCEVs and 2) a distinction of vehicle body style and size of the households' plausible next new vehicle purchase between those body style/size vehicles that are and are not offered with all-electric operation. That is, larger sedans, vans, SUVs and pickup trucks are not offered as battery electric vehicles or as PHEVs that operate in an all-electric mode.

In Oregon, interviews were conducted in the Portland region in January 2015. In addition to households residing throughout the City of Portland, the interview region spanned east to west from the town of Sandy (east on Highway 26) to Hillsboro (west on Highway 26) and south on Interstate-5 to Wilsonville. Interviews were conducted in respondent's homes or local restaurants.

RESULTS: WHO ARE THE NEW CAR BUYERS IN THE OREGON SAMPLE?

We first present a description of the survey sample according to characteristics of the respondents and their households, vehicles, travel, residences, and awareness, knowledge, and attitudes toward PEVs and FCEVs and the policy goals for ZEVs. The analysis of their PEV and FCEV valuations is presented in the subsequent section. The basic measure of the valuation of PEVs and FCEVs is the vehicle design in the last (of up to three) design games. The rationale for this is explained at the start of the section on Respondents' Valuation of PEVs and FCEVs.

As we move through these descriptions, null hypotheses (H_o) are stated as to how the descriptive variables may relate to respondents' PEV and FCEV valuations, i.e., their vehicle designs in the survey design games. Null hypotheses are typically stated as no effect; the purpose of statistical analyses presented in the Respondents' Valuation of PEVs and FCEVs is to test whether these statements of no effect are probabilistically false.

Socio-economics and demographics

- Overall, there are few differences between the OR sample and the total sample.
    - There is a substantial difference in the gender balance between OR and the total sample: the OR sample has a higher percentage of female respondents (59% compared to 52%).

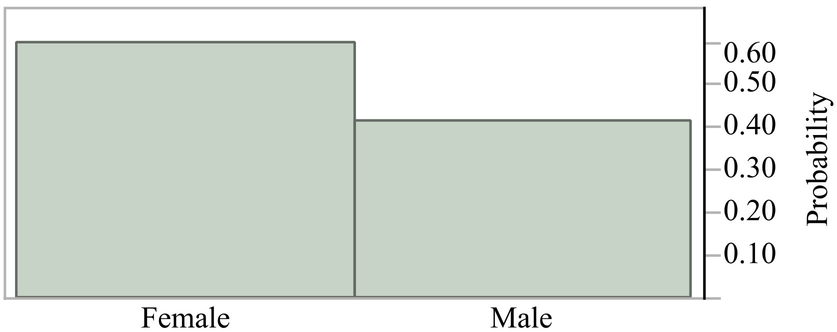
The respondents and their households are described here in terms of socio-economic and demographic variables as background to the subsequent discussion of PEV and FCEV valuation. In part, the reason for this is to understand whether and how readily available data may explain PEV and FCEV valuation, as opposed to custom studies (such as this one). Further, early PEV buyers are predominately male, middle age, higher income, and possess graduate degrees. Understanding how new car buyers who don't fit this characterization think about PEVs and FCEVs will be essential to growing markets. Comparisons are made to the total sample across all states, in lieu of a comparison to other samples of new car buying households in Oregon because no such samples are available to this study.

The OR respondents include many more women than we would expect compared to the total sample (of all the participating states): 59% of the OR respondents were female compared to 52% of the total sample. Evidence from California's Clean Vehicle Rebate program and reports from vehicle manufacturers indicate that early PEV buyers have been disproportionately more likely to be male than female.

H_o: Female and male respondents will not differ in the probability they design their household's next new vehicle to be an ICEV or HEV on the one hand or a PHEV, BEV, or FCEV on the other.

The age distribution of the OR (Figure 2) and total samples are generally similar. (The respondent age distribution shown has been truncated to eliminate a few responses less than 19 years of age. Whether such responses were truthful, mistakes, or spoofs, the sample is intended to exclude respondents younger than 19.)

Figure 1: Respondent gender

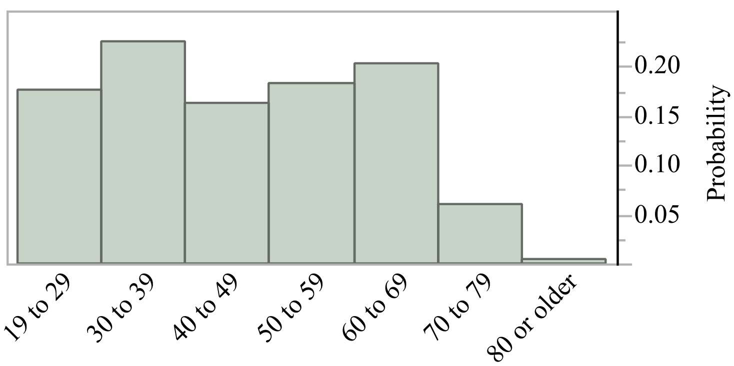


Frequencies

Level	Count	Prob
Female	291	0.59146
Male	201	0.40854
Total	492	1.00000

N Missing 2
2 Levels

Figure 2: Respondent Age



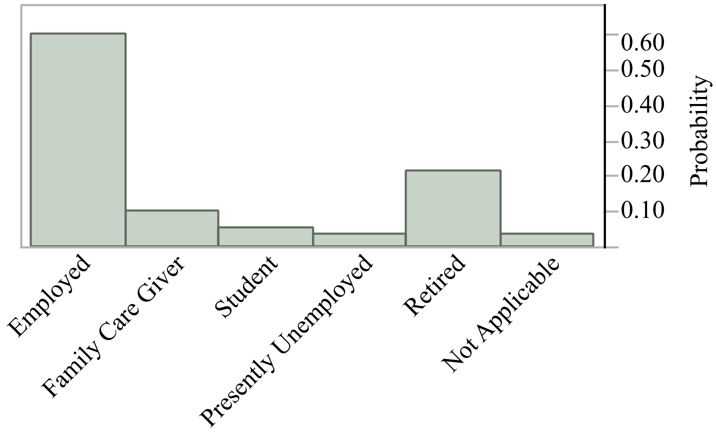
Frequencies

Level	Count	Prob
19 to 29	86	0.17444
30 to 39	110	0.22312
40 to 49	79	0.16024
50 to 59	89	0.18053
60 to 69	99	0.20081
70 to 79	29	0.05882
80 or older	1	0.00203
Total	493	1.00000

N Missing 1
7 Levels

The distribution of respondent's employment status appears similar between OR (Figure 3) and the total sample; across both samples, ~60% are employed in the paid labor force and ~20% are retired. The rest are small percentages each of people who are family caregivers, students, presently unemployed, or otherwise classified as "not applicable." While 21% of individual respondents in OR are retired, 30% of the households they represent contain at least one retired person. At the other end of the age scale, 63% of respondents report no children (persons younger than 19) in the household; those who do report children in the household are evenly split as to whether the youngest reported member is younger than seven years old (18%) or is age seven to 18 (19%). All told, households range in size from one to eight or more members: most (8%) have one to four members (Figure 4).

Figure 3: Respondent Employment Status

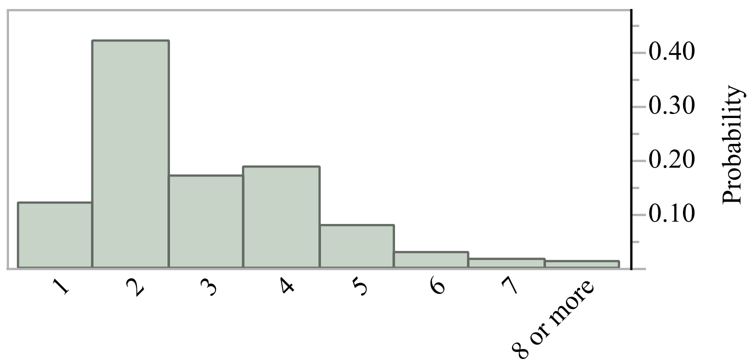


Frequencies

Level	Count	Prob
Employed	289	0.59465
Family Care Giver	45	0.09259
Student	22	0.04527
Presently Unemployed	14	0.02881
Retired	102	0.20988
Not Applicable	14	0.02881
Total	486	1.00000

N Missing 8
6 Levels

Figure 4: Household Size



Frequencies

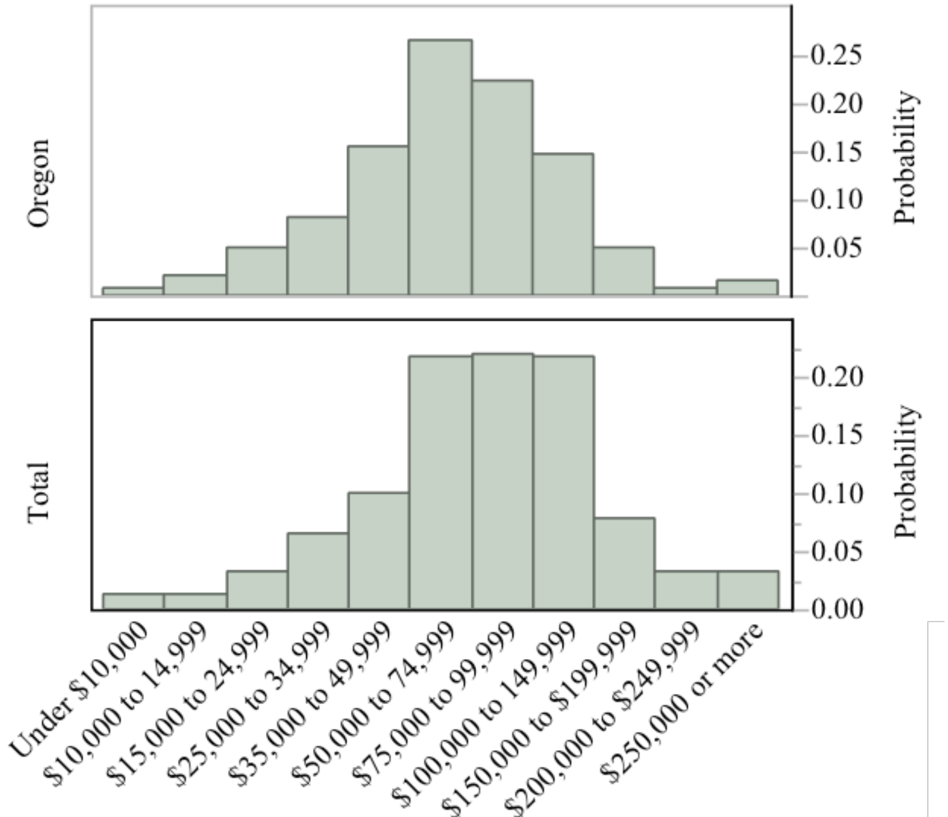
Level	Count	Prob
1	57	0.11538
2	205	0.41498
3	82	0.16599
4	91	0.18421
5	36	0.07287
6	13	0.02632
7	6	0.01215
8 or more	4	0.00810
Total	494	1.00000

N Missing 0
8 Levels

The income distribution for the OR sample is lower overall but more peaked in the middle incomes than the total sample (Figure 5). Despite being a sample of households who had recently purchased a new vehicle, reported annual household incomes includes households in the lowest income categories (as well as the highest). Compared to the total sample, the OR sample is even more concentrated in the middle categories. The mean household income in OR is lower than in the total sample; the difference is statistically significant ($\alpha = 0.05$). Further, the inter-quartile range (the values spanning from the 25th to 75th percentile) for OR is lower ($35,000 to $99,999) than for the total sample ($50,000 to $149,999).

> H_o: Annual household income will not be correlated with drivetrain design.

Figure 5: Annual Household Income, OR and Total Samples



The distributions of respondents' highest education level show little difference: the OR sample is slightly less likely to have some graduate education or a graduate degree. The median educational achievement for both samples is an undergraduate degree: 34% of the OR sample has an undergraduate degree and 24% has some graduate level education or a graduate degree. The corresponding values for the total sample are 36% and 31%.

> H_o: Respondent education will not be correlated with drivetrain design.

To the extent that the policy drivers and social benefits—and therefore respondents' valuations—of PEVs may be politicized, we asked respondents their party affiliation. Political party affiliation in OR sample (Democratic 45%; Republican 27%, Other 6%, and None 22%) is essentially identical to that of the total sample. However, compared to the January 2015 Oregon Secretary of State's voter registration report, the OR sample overstates the electoral advantage of the Democratic Party compared to the Republican Party and reverses the prevalence of those who claim an "other" affiliation vs. no affiliation to a political party (Democratic 38%, Republican 30%, Others 24%, and Non-affiliated 8%).[15]

[15] http://sos.oregon.gov/elections/Documents/registration/jan15.pdf

Prior Awareness, Knowledge, and Valuation of PEVs and FCEVs

Several concepts are possibly related to a respondent's propensity to design—or not—a PEV or FCEV as a plausible next new vehicle for their household. Among those concepts measured in the on-line survey are:

- Likely replacements for gasoline and diesel fuel, in the abstract
- Attitudes toward climate change and air quality
- Prior familiarity with the specific technologies that will be explored in the design games, i.e., HEVs, PHEVs, BEVs, and FCEVs.
- Comparative risks of electricity and gasoline to the environment and human health
- Prior knowledge of the availability of incentives and belief whether the public sector should offer incentives
- General interest in new technology and specific interest in "the technical details of vehicles that run on electricity or hydrogen and how they work."

Likely replacements for gasoline and diesel fuel

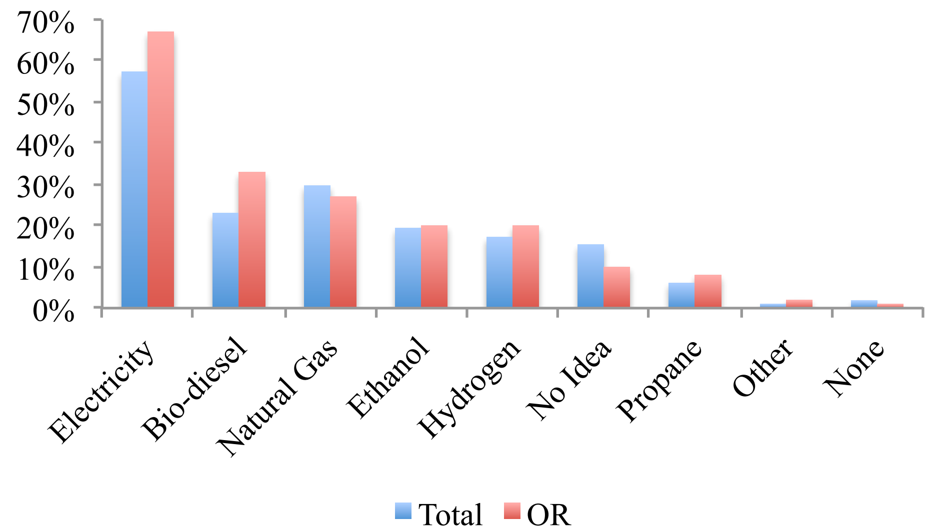
- Electricity wins.

The question was asked, "If for any reason we could no longer use gasoline and diesel to fuel our vehicles, what do you think would likely replace them?" Respondents could choose up to three fuels from the list electricity, hydrogen, natural gas, ethanol, bio-diesel, propane, none, "I have no idea," and other. The response order was randomized across respondents. Most people are willing to stipulate at least one replacement: only 11% of the OR sample and 17% of the total sample answer "None" or "No idea. Electricity was selected by a much larger majority of the OR sample (67%) than in the total sample (57%). Oregonians are also more likely to believe that bio-diesel is a viable replacement, so much more so that the rank order of bio-diesel is higher in the OR sample than in the total sample (Figure 6).

> H_o: Prior belief that electricity (or hydrogen) is thought to be the most likely replacement for gasoline and diesel will not be correlated with drivetrain design.

Given the respondent chose at least one replacement, they are next asked to pick the single most likely replacement and to provide a reason why they believe it is most likely. The relative difference between electricity and the nearest competing replacements increases: the advantage of electricity over bio-diesel is about two-to-one when people choose up to three possible replacements for gasoline and diesel (67% electricity/33% bio-diesel); the advantage is almost four-to-one when a single fuel is chosen (55% electricity/15% bio-diesel). (Compared to when they can choose up to three, the percent of people who select any single fuel must decline when they can choose only one as the total percentage across fuels is now constrained to be 100%). Hydrogen (the fuel for FCEVs) fairs poorly compared to other fuels in the OR sample, selected by only 20% of respondents when they have up to three choices and only eight percent when asked to pick the single most likely replacement. However, when compared to the total sample, Oregonians are slightly more likely to choose hydrogen.

Figure 6: Replacements for Gasoline and Diesel, percent selecting each replacement (up to three selections per respondent), sorted by rank order in Oregon



The reasons why OR respondents think different options are the most likely to replace gasoline and diesel are explored in Table 2. Reasons that distinguish electricity from the other possible replacements are that electricity is more likely to be said to "already [have] been proven to be effective" and "[be] best for the environment." (The "deviations" highlighted in **bold** in Table 2 for these two reasons have large, positive, values compared to the deviations for other reasons to choose electricity.) Conversely, respondents are less likely to say, "[electricity] will require the least amount of change for drivers and fuel providers." That reason (no change required) is disproportionately common for bio-diesel and ethanol. Natural gas is favored because "it is most abundant in the United States."

Attitudes toward a shift from oil, clean air, and climate change

- The OR sample shares a similar level of urgency with the total sample for a need to switch from gasoline.
- The OR sample is less concerned with air quality in their region compared to the total sample, but are as likely to personally worry about air quality and to believe that changes in individual lifestyle make a difference.
- OR respondents are nearly identical to the total sample in their agreement-disagreement with statements about global warming and climate change.
    - While there are those who disagree, by and large this sample believes global warming is real, is caused by humans, can be affected by changes in lifestyle, and that immediate action is required.

As environmental and energy goals are the drivers for government policies requiring and encouraging PEVs and FCEVs, it may be that respondents' attitudes about these goals will be important to their valuation of the vehicles themselves. Several questions were asked regarding these goals; most were asked in a format of agreement/disagreement with a statement. A score of -3 = strongly disagree and 3 = strongly agree; non-responses and "I don't know" were tallied separately. Scores shown here are based only on those on the agree-disagree scale.

Table 2: Reason for Most Likely Replacement By Likely Replacement[1]

Count Deviation[2]	Bio-Diesel	Electricity	Ethanol	Hydrogen	Natural Gas	Total
It doesn't need to be imported from foreign countries	5 -5.73	45 4.82	3 -2.45	7 1.55	11 1.81	71
It has already proven to be effective	13 0.01	**60** **11.33**	6 -0.60	3 -3.60	4 -7.14	86
It is cheapest for drivers	5 -1.95	23 -3.03	6 2.47	4 0.47	8 2.04	46
It is safest for drivers	6 3.13	8 -2.75	1 -0.46	1 -0.46	3 0.54	19
It is the best for the environment	17 -2.34	**81** **8.56**	6 -3.82	12 2.18	12 -4.58	128
It is the most abundant in the United States	3 -1.08	10 -5.28	0 -2.07	4 1.93	**10** **6.50**	27
It will require the least amount of change for drivers and fuel providers	**14** **7.96**	9 -13.64	**10** **6.93**	1 -2.07	6 0.82	40
Total	63	236	32	32	54	417

1. Table 2 excludes the three least mentioned replacements (propane, none, and other) as well as the least mentioned reason (other).

2. Deviations are calculated as the difference between the observed count (the upper number in each cell) and the value expected if there were no differences in the distributions of reasons across likely replacements. Multiplying the row and column totals for each cell and dividing that product by the total sample size calculate expected values. Thus, the expected value for "it doesn't have to be imported from foreign countries: bio-diesel" is (71x63)/417 = 10.73. The deviation is 5 – 10.73= -5.73. Negative deviations indicate fewer people give that reason than expected.

Without stipulating why it might be necessary, respondents were asked whether, "There is an urgent national need to replace gasoline and diesel for our cars and trucks with other sources of energy." On average, the Oregon sample feels about the same urgency as the total sample (mean scores: OR, 0.88; total sample, 0.84. The median values are well above zero (1.2 for OR, 1.1 for total), indicating more than half the respondents

> H_o: Prior belief in the urgency to replace gasoline and diesel will not be correlated with drivetrain design.

agree—to some degree—in the national urgency to replace gasoline and diesel. Both distributions show two distinct peaks (or, modes) in the distributions: the highest (~20% of respondents) at the mid-point on the scale, followed by a slightly lesser peak at the point of strongest agreement in the urgency of a national need to replace gasoline and diesel (~15%).

On average, this sample of new-car buyers in OR is much more likely to disagree with the statement, “Air pollution is a health threat in my region” than is the total sample: the mean score on the scale of -3 (strongly disagree) to 3 (strongly agree) is -0.26 in OR and 0.53 for the total sample. However, the OR sample is similar to the total sample in the distribution of their agreement or disagreement with the statements, “I personally worry about air pollution,” and “Air pollution can be reduced if individuals make changes in their lifestyle.” Both samples are, on average, likely to modestly agree with both statements: mean values for both samples for worry are about 1.0 and for lifestyle, about 1.6. Median values and inter-quartile ranges are also similar between the two samples.

With regard to the topics of global warming and climate change, the distributions of responses for the OR and total samples are nearly identical. Both the OR and total samples are on average more likely to agree “there is solid evidence the average temperature on Earth has been getting warmer over the past several decades”: OR, mean = 1.17 and total sample =1.18. Among those who believe there is evidence for global warming, on average they believe it is caused by human action (3) rather than natural causes (-3): the mean score for OR is1.54; total sample mean = 1.51. Similarly small percentage of the OR and total samples believe “concerns about climate change are unjustified, thus no actions are required to address it.” Further, nearly identical percentages of the two samples believe more research is required before action is taken than is the total sample or that “human caused climate change has been established to be a serious problem and immediate action is necessary” (Table 3).

H_0: Neither prior belief air quality is a regional problem nor personal worry about it is correlated with drivetrain design.

H_0: Beliefs that climate change is real, amenable to human action, and an urgent priority are not correlated to drivetrain design.

Excluding those who think no action re: climate change is required, the rest of the OR sample is, on average, as likely as the total sample to agree that climate change can be affected by changes to individual lifestyle (mean score for OR = 1.40; total sample = 1.48).

Table 3: Urgency to address climate change (choose one), percent[1]

	OR	Total
Human-caused climate change has been established to be a serious problem and immediate action is necessary.	56	57
We don't know enough about climate change or whether humans are causing it; more research is necessary before we decide whether we need to take action and which actions to take.	35	35
Concerns about human caused climate change are unjustified, thus no actions are required to address it.	6	8

1. Totals may sum to more than 100% because of rounding.

Prior awareness, familiarity, and experience with HEVS, PHEVs, BEVs, and

- Overall, awareness of PHEVs, BEVs, and FCEVs is so low that the reasonable assumption is most new car buyers' prior evaluations of these vehicles are based largely on ignorance.
- BEV name recognition is not pervasive across the sample and is limited to two vehicles.
- Lack of familiarity with the distinctions between BEVs, PHEVs, and HEVs is a likely explanation for why respondents name PHEVs when asked for makes and models of BEVs.

Prior awareness and familiarity with HEVs, PEVs and FCEVs was measured in several ways: respondents were asked whether they can name an HEV, BEV, PHEV, and FCEV presently sold in the US, to rate whether they are "familiar enough with these types of vehicles to make a decision about whether one would be right for your household," whether they have seen electric vehicle charging locations in the parking lots and garages they use, how much driving experience they have with HEVs, BEVs, PHEVs, and FCEVs, and a battery of questions about their impressions of PEVs and FCEVs.

The analysis of name recognition is limited to BEVs due to the lengthy time required to clean data and the likeliness the same results apply to PHEVs and especially FCEVs. Overall, name recognition is low and limited to two vehicles. Asked, "Can you name an electric vehicle that is being sold in the US," 39% say "no"; 30% correctly name a BEV, leaving 31% who name a vehicle, but it is not a BEV.[16] Among those who correctly name a BEV, just two vehicles account for 93% of correct responses: Nissan Leaf (55%) and Tesla (39%). The most commonly misidentified vehicle is the Chevrolet Volt: of all the people who offer the make and model of a vehicle that might have plug (whether it is a BEV or not) 20% name this PHEV. In addition to misclassifying the Chevrolet Volt, the Toyota Prius is also frequently named as a BEV (13% of makes and models of vehicles that might have plugs). However, it is not clear people recognize the difference between the Prius (an HEV) and the Plug-in Prius (a PHEV, and never mind that both are incorrect responses to a question about naming BEVs). This distinction between HEVs, PHEVs, and BEVs is one analysts proficient with ZEVs make easily, however the result reported here and those upcoming suggest the public is confused about the concepts of HEVs and PHEVs, perhaps even more so than they are about BEVs.

> Ho: Prior BEV name recognition is not correlated with drivetrain design.

Responses to the question, "Are you familiar enough with these types of vehicles to make a decision about

> H_o: Familiarity with PHEVs, BEVs, and FCEVs will are not correlated with drivetrain designs.

[16] The rules for determining "right" and "wrong" BEV names are subject to disagreement. Three sets of rules were used to test for the effects of such disagreements. As can be inferred from the text, one set of rules allows any correct make and model of a vehicle that as a PEV variant—PHEV or BEV—as a "correct" answer to the question, "Can you name a BEV sold in the US?" Two sets of rules stipulate that if the make and model are correct, they do not have to stipulate the PEV variant when the vehicle is offered as an ICEV and any PEV (PHEV or BEV). However, if they go on to stipulate a PHEV variant, their response is then counted as incorrect in the set of rules that most strictly adheres to the question (Can you name an electric vehicle that is being sold in the US?). For example, if they reply, "BMW i3" they are counted as correct. However, if they go on to stipulate "BMW i3 REx," they are wrong under the most stringent rules. It is, as discussed in the text, the Chevrolet Volt that makes the most difference. If it is allowed as a correct answer, the percentage of Oregonian new car buyers able to name an "BEV" for sale in the US rises from 30% to 42%.

whether one would be right for your household?" were made on a scale from -3 (unfamiliar) to 3 (familiar), with allowance for a distinction between the 0-point of the scale (I'm neither unfamiliar nor familiar) from "I'm unsure." The first distinction between ICEVs, HEVs, PHEVs, BEVs, and FCEVs is the percentage of people who are either unsure or simply decline to answer. As shown in Table 4, few respondents are unsure or unwilling to rate their familiarity with gasoline and diesel fueled ICEVs. However, the combined percentage of those unable or unwilling to do so rises from HEVs, BEVs, to PHEVs, to a maximum of nearly one-third of respondents are unable or unwilling to rate their familiarity with FCEVs.

Given these results, the mean, median and inter-quartile ranges are reported only for those respondents willing to rate their familiarity (Table 4). The differences in the mean values are all significant at $\alpha < 0.001$ (Table 5). Given that a respondent is willing to rate their familiarity with conventional ICEVs, those vehicles have a high familiarity score, the highest familiarity score of the five types of vehicle drivetrains. Familiarity, on average, declines from ICEVs through HEVs, BEVs, PHEVs, to FCEVs. Pairwise, the differences in mean familiarity scores are all statistically significantly different from each other at $\alpha \leq 0.01$; the differences confirm the rank order in Table 5.

Table 4: Respondents Unwillingness to Rate Familiarity with Drivetrain Types, %

	Unsure	Decline to state	Total Unsure plus Decline to state	Mean	Median	Inter-quartile range
ICEVs	3.4	0.6	4.0	2.51	2.85	2.65 to 2.91
HEV	14.6	1.1	15.7	1.52	2.41	0.31 to 2.87
BEVs	17.4	0.8	18.2	1.26	1.96	0.00 to 2.85
PHEVs	20.4	1.9	22.3	0.80	1.35	-0.43 to 2.83
	30.1	4.0	34.1	-0.80	-1.12	-2.89 to 0.59

For comparison, the mean and median scores for self-rated familiarity with BEVs from all states are illustrated in Figure 7. (For the smaller northeast states—CT, NH, RI, VT, and ME—mean scores are based on small numbers of respondents and thus have large uncertainties.) That the mean scores are always lower than the median scores indicates that a group of people rate themselves very lowly—as very unfamiliar with BEVs—is pulling down the mean value. This is illustrated in Figure 8 with data from OR. While approximately one-third of the respondents rate themselves as definitely familiar enough with BEVs to assess whether one is right for their household (score ~ 3), smaller concentrations are found at the dividing line between familiar and unfamiliar (0) and at definitely not familiar enough (-3).

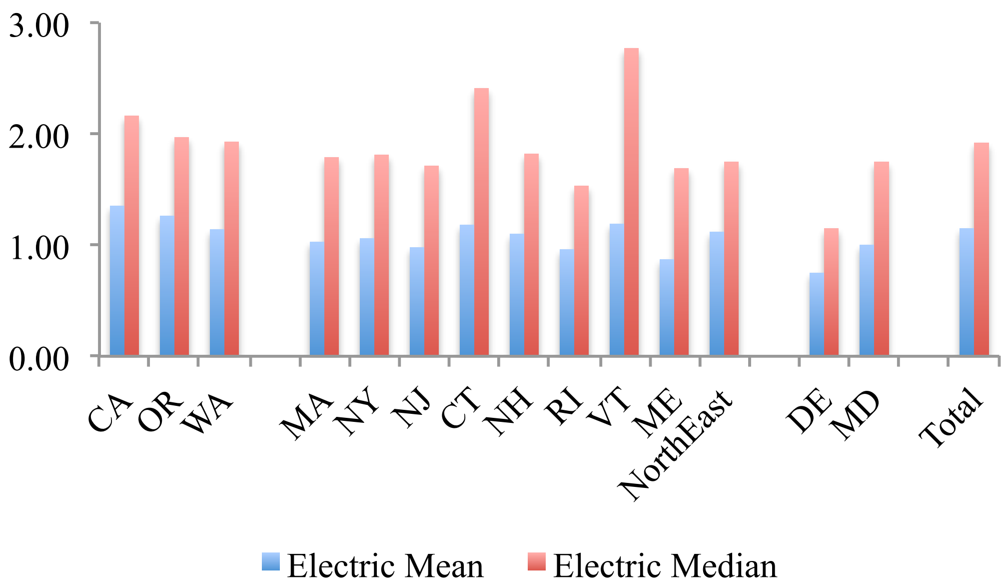
Table 5: Differences in Respondents Ratings of Familiarity between Drivetrain Types, -3 = unfamiliar to 3 = familiar

Vehicle Type	Mean[1]	Mean Difference[2]	
ICEV	2.49		—
HEV	1.29	ICEVs - HEV	-1.21
BEV	1.12	ICEVs - BEVs	-1.37
PHEV	0.73	ICEVs - PHEVs	-1.76
FCEV	-.70	ICEVs -	-3.19

1. Means differ from Table 4 because they are estimated on a smaller (n = 109) set of respondents who provide a valid familiarity score for all five types of vehicles.

2. All differences statistically significant at α<0.01.

Figure 7: Self-rating of familiarity with BEVs, mean and median scores for each state and the total sample, score on scale: -3 = No; 3 = Yes

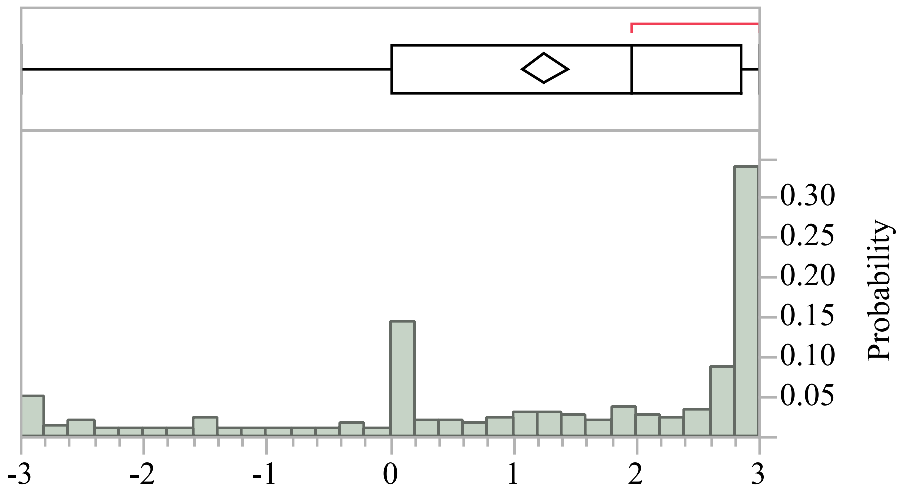


Note: The question is, "Are you familiar enough with electric vehicles to make a decision about whether one would be right for your household?"

If respondents are "familiar enough with [drivetrain type] to make a decision about whether one would be right for [their] household," that familiarity was not gained through actual driving experience with any PHEV, BEV, FCEV, or even HEV. Measured on a similar scale of -3 (none at all) to 3 (extensive driving experience) and excluding those who scored themselves as unsure or declined to answer, the *mean* scores for OR respondents are all negative (HEVs. -1.49; BEVs, -2.37; PHEVs, -2.52; and FCEVs, -2.68) and the median scores for all four vary from -2.80

(HEVs) to -2.98 (). In short, within the realistic accuracy of the on-screen slider used to create the scores in the survey, more than half the sample has *no* driving experience with anything other than ICEVs. This result holds for the total sample, too.

Figure 8: Self-rating of familiarity with BEVs, -3 = no; 3 = yes; %



Prior awareness of vehicle purchase incentives

- Less than half (41%) of this sample of OR new-car buyers are aware of incentives from the federal government.
- Oregon offers a Residential Energy Tax Credit toward PEV charging infrastructure; 17% of the sample says they have heard Oregon offers "incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel."

A buyer of any qualifying PEV anywhere in the country is eligible for a federal tax credit.

> "A tax credit is available for the purchase of a new qualified plug-in electric drive motor vehicle that draws propulsion using a traction battery that has at least five kilowatt hours (kWh) of capacity, uses an external source of energy to recharge the battery, has a gross vehicle weight rating of up to 14,000 pounds, and meets specified emission standards." (http://www.afdc.energy.gov/laws/409).

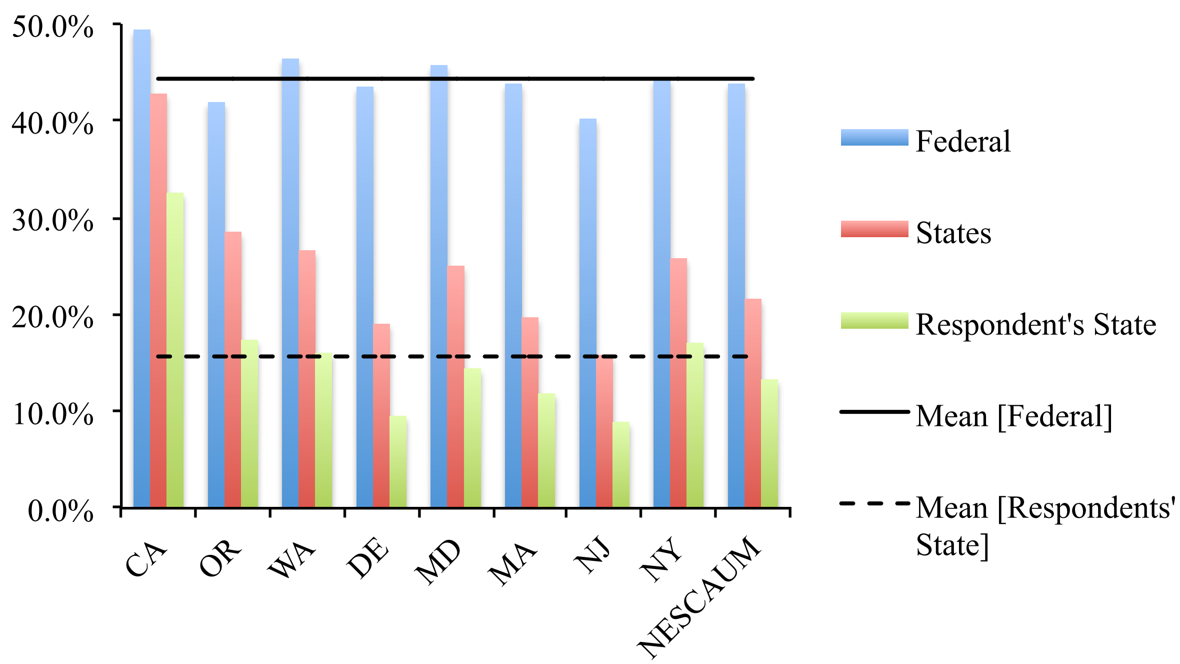
The federal tax credit is $7,500 for all BEVs presently for sale in the US; the credit for PHEVs ranges from $2,500 to $7,500 depending on the size of the traction battery.

The availability of other incentives varies by state as well as by overlapping city, county, and power utility jurisdictions. The variety of these incentives include exemption from state sales tax or vehicle licensing and registration fees, rebates, single occupant vehicle access to high-occupancy vehicle lanes, and reductions or exemptions from road or bridge tolls. In the case of

Oregon, the state offers Residential Energy Tax Credits program to qualified residents of 25 percent tax of the cost of alternative fuel infrastructure, up to a maximum of $750.

The question about awareness of incentives is not specific to presently available incentives, but more generally asks, "As far as you are aware, is each of the following offering incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel?" A dozen types of entities are listed; a yes/no/I'm not sure response is elicited for each. If a respondent replies, "Yes," for states, cities, or electric utilities, a follow-up question is asked regarding "my state," "my city," or "my electric utility.[17] The question is a weak test: a "yes" response may be prompted by an impression of incentives for any alternative, such as bio-fuels or natural gas. That is, observed percentages of positive responses would likely be lower if the question were more specifically crafted to existing incentives for consumer purchase of ZEVs. Further, the variation in incentives across states and localities means that stating one is aware of incentives from a particular entity is not the same as being right or wrong for all respondent-entity combinations—except for the universally available federal incentive. Data from all participating states regarding awareness of federal incentives are shown in the Figure 9.

Figure 9: Awareness of incentives to buy and drive vehicles powered by alternatives to gasoline and diesel? [Federal government, my state], % "Yes"



[17] "Yes" and "No" are not the same as right and wrong for all respondents. A respondent may live in a state that does not offer any purchase incentives for vehicles powered by alternatives to gasoline and diesel. In such states, "No" is the right answer. This extends to cities, electric utilities, and all the other listed entities. However, for all respondents, the right answer to whether the federal government and "my state" offer such incentives is, "Yes."

The percent of OR respondents who are aware of federal incentives (42%) is slightly less than the average across all states (44%). Belief that respondents' home states are offering such incentives is much lower. In OR, barely 17% believe they have heard their state is offering incentives. (This may be regarded as high or low compared to policy goals, depending on how long the state's residential infrastructure tax credit has been offered and how extensively it has been advertised.). Belief that other entities, e.g., cities, utilities, and vehicle makers, are offering incentives are comparable to, or lower than, the percentages for the respondents' own state.

> H_o: Those who are already aware of incentives will not be more likely to design a ZEV.

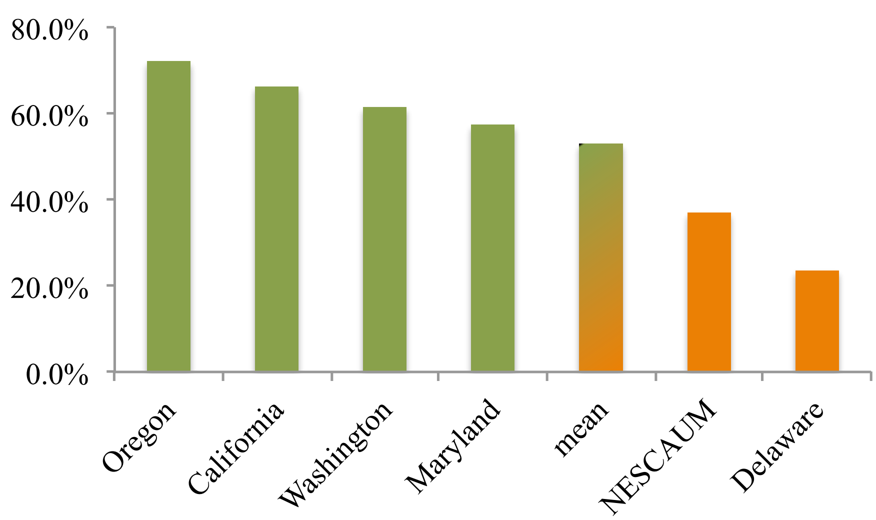
Prior awareness of PEV charging infrastructure

- PEV charging infrastructure may be the most oft recognized sign of PEVs in those states that have had active programs to deploy workplace and/or public charging. In this regard, the OR sample has the highest percentage of respondents claiming to have seen EVSEs: 72%.

The deployment of PEV charging infrastructure at workplaces (where such charging may or may not be open and available to non-employees), retail locations, and public parking garages, lots, and spots is intended to provide charging services to PEV drivers and to provide a visible symbol to all drivers of PEVs. The question is are drivers of non-PEVs noticing? Respondents were asked, "Have you seen any electric vehicle charging spots in the parking garages and lots you use?" Data for all participating states (plus the average value of the Total sample) are shown in the Figure 10: 72% percent of the Oregon sample say they have seen a PEV charger in the places they park—well above the total sample percentage (52%).

> H_o: Those who have already seen PEV charging will not be more or less likely to design a PEV.

Figure 10: Previously seen charging for PEVs in parking garages and lots, % Yes



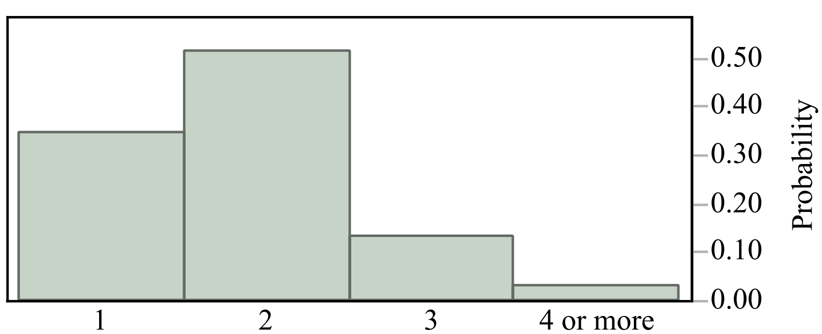
Household Vehicles

- The OR sample owns a similar number of new vehicles, of similar age, as the total sample.
- This sample from Oregon is less likely to have leased vehicles than is the total sample.
- These Oregonians paid ~$1,000 less, on average, for their most recently acquired new vehicle than did the total sample.

The sample is intended to represent households who have purchased a new vehicle within the previous seven years, i.e., since January 2008. The survey instrument collects data on the most recently acquired new vehicle plus the other vehicle in the household (when there is more than one vehicle) that is driven most often. ("Vehicles" are defined in the questionnaire to be "…cars, trucks, vans, minivans, or sport utility vehicles, but…not…motorcycles, recreational vehicles, or motor homes.) Given they must own at least one vehicle to be in the study, 34% of the OR sample owns one and 66% owns two or more. The distribution of number of vehicles owned (Figure 11) is nearly identical to the total sample, though the OR sample is slightly less likely to have acquired more than one new vehicle since 2008. The age distribution of these recently acquired vehicles—measured by the model year or year acquired—are similar for the two samples. Nearly ~43% of both samples' most recently acquired new cars were model year 2013 or newer.

H_0: Number of household vehicles is not correlated with drivetrain designs.

Figure 11: Number of Vehicles per household



Frequencies

Level	Count	Prob
1	167	0.33806
2	251	0.50810
3	63	0.12753
4 or more	13	0.02632
Total	494	1.00000
N Missing	0	

4 Levels

According to data from California's Clean Vehicle Rebate Program, a higher percentage of early PEV acquisitions have been by lease rather than purchase compared to non-ZEVs historically and, based on additional survey and interview work with that population of PEV drivers, compared to their own past vehicle acquisitions. Fewer Oregonians leased their most recently acquired new car (8%), other household vehicle driven most often (4%), or either these vehicles (10%) than did the total sample, for which the corresponding figures are 14%, 9%, and 17%.

H_0: Prior experience leasing vehicles is not correlated with drivetrain designs.

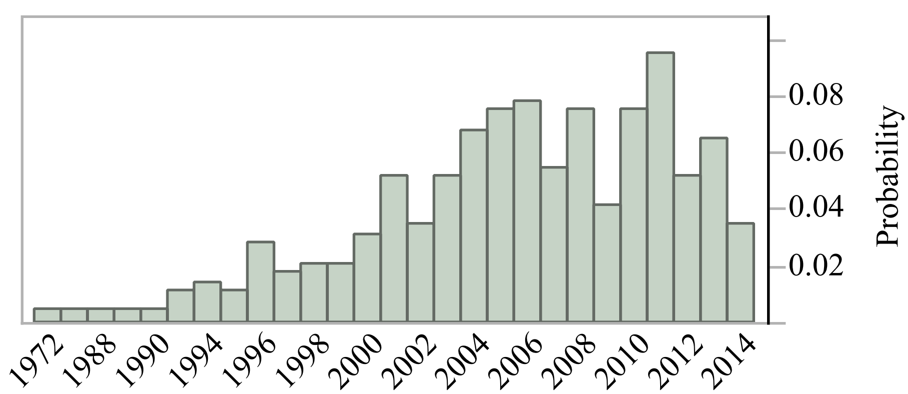
On average, the Oregon sample paid less for their most recently acquired new vehicles than did the total sample. The median of the reported "total price including options, fees, and taxes" for the most recently acquired vehicle is $25,000 in OR—$1,000 less than for the total sample. The mean price in OR was ~$1,100 lower than for the total sample ($27,430 vs. $28,550)—a difference that is significant at $\alpha \leq 0.05$. While we might expect people who spend more on new cars to be more likely (or at least more able) to buy PEVs, this expectation is mediated by 1) spending on new cars is plausibly correlated with household income, but 2) the effect of income is mediated by differing propensities across households to spend differing amounts of their income (or more generally, their income, wealth, and credit) on new (and used) vehicles.

> H_{0-}: Past prices of new vehicle purchases will not be correlated with drivetrain design.
>
> H_0: Household income will not be correlated with drivetrain design.

The vast majority of these most recently acquired vehicles (95% in OR and 96% in the total sample) are fueled by gasoline. The balance in OR is diesel and electricity (a few respondents report they own a BEV).

For respondents with more than one vehicle, the second vehicle for which information was collected had only to be the next most frequently driven vehicle—no stipulation was made as to age or whether it was acquired as a new or used vehicle. Thus, these vehicles show a greater age range: the data for the OR sample are shown in Figure 12. Despite the long tail toward older years (note the x-axis is not linear for years older than 1994), 84% of these "second" vehicles are model year 2001 or newer for both the OR sample; for the total sample, 90% of these other vehicles are model year 2001 or newer. As we don't have data on all vehicles in all households, nor do we ask directly how long households hold their vehicles, we can only suggest the household vehicle fleet may be turning over at a similar rate in OR as in the total sample.

Figure 12: Model Year of Other Frequently Driven Household Vehicle



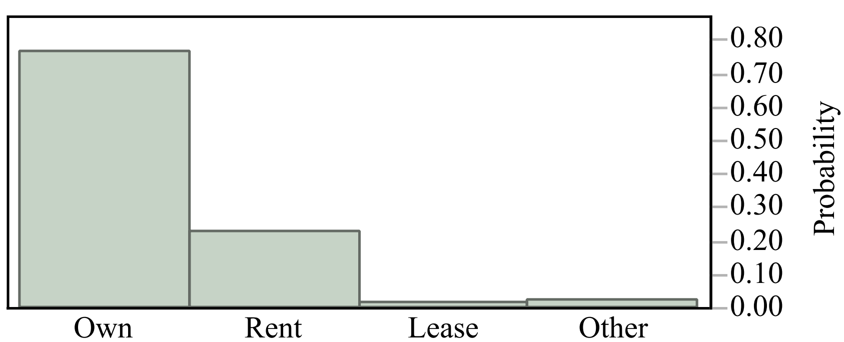
What are the features of their residences, especially those that might affect their valuation of PEVs and FCEVs?

- Based on similar percentages of respondents who own their home, live in a single family residence, have access to electricity at the location they park at least one household vehicle, park in a garage or carport attached to their residence and do not require permission from someone else to install electricity, the OR sample is as likely to be able to charge a PEV at home as the total sample.
- Based on the lower reported incidence of residences with natural gas, the possibility for home hydrogen refueling may be less in OR than in the total sample.
- Homeownership vs. rental and residence type are broadly similar between OR and the total sample.

Turning from the household members and their vehicles to features of their residences that may make the respondent households more or less able to charge a PEV or fuel an FCEV at home, most of the OR sample (76%) report they own their home while 22% rent (Figure 13). These percentages are nearly identical to the total sample. Eight-of-ten respondents report their residence is a single-family home (higher than the total sample at 72%). Fewer OR respondents report they have no access to electricity at the location they park their vehicles at home (18%) than for the total sample (24%). It is also the case that a slightly smaller percentage of the OR sample (29%) would require permission from someone else to install electricity at their home parking location than is the case for the total sample (32%). A nearly identical percentage of the OR sample is able to park a vehicle in a garage or carport attached to their residence (55%) compared to the total sample (56%).

H_0: Neither ownership of one's residence nor type of residence is correlated with drivetrain design.
H_0: Whether the residence has natural gas or solar panels is not correlated to vehicle design.

Figure 13: Own or rent residence, percent



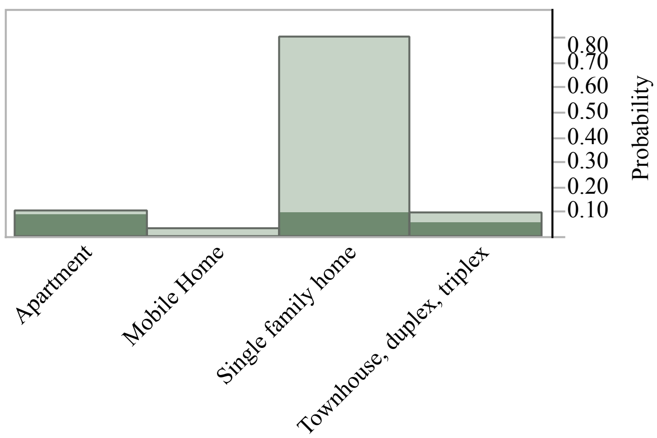
Frequencies

Level	Count	Prob
Own	374	0.75709
Rent	109	0.22065
Lease	5	0.01012
Other	6	0.01215
Total	494	1.00000

N Missing 0
4 Levels

In the Figure 14, respondents who rent their residence are highlighted in a darker shade: most apartments are rented but only a small share of townhouses, duplexes, and triplexes are. Multi-unit dwellings have been problematic for PEVs, as residents of such buildings may not have access to a regular, reserved parking spot and be reluctant—or may lack authority—to install electrical infrastructure to charge a PEV. Among those who rent their residence in OR, 73% indicate they could not make such an installation on their own authority; only 15% of those who own their residence indicate they would need permission from someone else. The group of people who own a single-family home is somewhat higher than in the total sample: 69% of OR respondents reside in a single-family residence they own compared to 65% of the total sample. The percentage of OR respondents and the total sample that report they have solar panels installed at their residence are the same: 13%. Finally in OR, 56% report having natural gas; much lower than the total sample (63%).[18]

Figure 14: Type of Residence, percent



Frequencies

Level	Count	Prob
Apartment	39	0.09750
Mobile Home	10	0.02500
Single family home	317	0.79250
Townhouse, duplex, triplex	34	0.08500
Total	400	1.00000

N Missing 94
4 Levels

[18] The home hydrogen fueling offered to respondents in the vehicle design games is based on reforming natural gas.

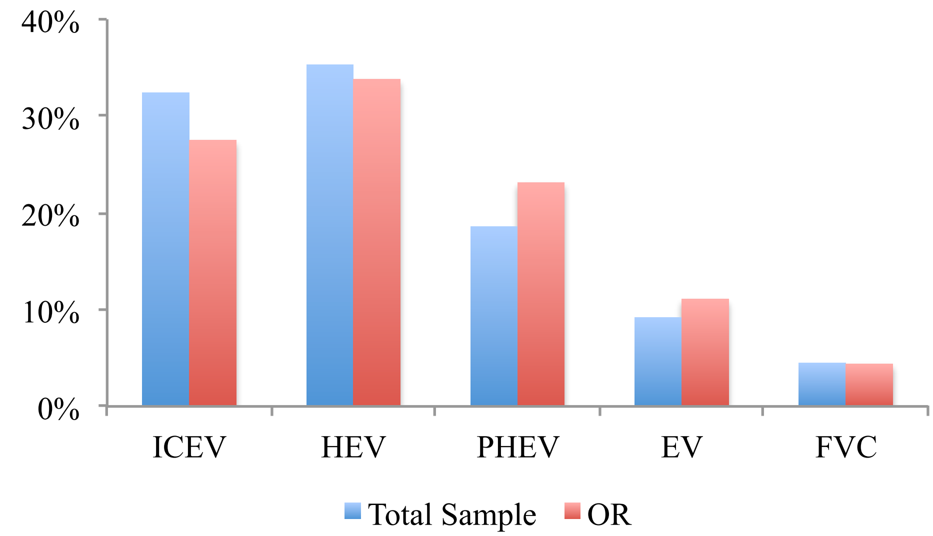
RESULTS: RESPONDENTS' ZEV AND ZEV-ENABLING DESIGNS

How many Respondents design their next new vehicle to be a PEV or FCEV?

PEV and FCEV valuation is determined in the final design game that most corresponds to the present reality—there are no PEVs or FCEVs offered with battery-powered, all-electric drive and full-size body styles however there are federal, state, and local incentives offered for PEVs and FCEVs. The vehicle designs that are disallowed by the body size restriction are PHEVs that run solely on electricity until their batteries are depleted (at which point they switch to run as do present day HEVs) and BEVs; PHEVs that run on both gasoline and electricity until the battery is depleted and FCEVs are allowed (in the design game) as full-size vehicles. The overall smaller sample size for OR warrants caution; the small numbers of people who design vehicles with specific drivetrains might better be regarded as case studies highlighting values and meanings rather than population studies that generalize these.

Ignoring for now differences between vehicles within each drivetrain type, not quite four-in-ten Oregon respondents design their next new vehicle to be a PHEV (23.1%), BEV (11.1%), or FCEV (4.4%) (Figure 15). As HEVs are important for many transportation energy goals related to ZEVs, note they are the most common drivetrain design (33.8%)—far out-distancing the prevalence of HEVs in the actual on-road fleet of vehicles and in new vehicle sales. As illustrated in Figure 15, the distribution of drivetrain types created by the OR sample differs from that of the total sample: broadly speaking, the OR sample is more likely to design their next new vehicle to be a PEV or FCEV. The differences between the distributions are statistically significant at $\alpha = 0.024$.

Figure 15: Oregon and Total Sample Vehicle Drivetrain Designs in Game Three: no full-size all-electric designs but with incentives, percent



Characteristics of Respondents' PHEV, BEV, and FCEV Designs

As described earlier, respondents could customize PEV and FCEV drivetrains for driving range, charging speed both at home and away-from-home, and whether or not an FCEV could be refueled at home. The distributions of these designs are described here. As in the previous section, this discussion details the results of the final game in which no full-size vehicle may be designed with all-electric operation but incentives are offered for PEVs and FCEVs.

PHEV Designs

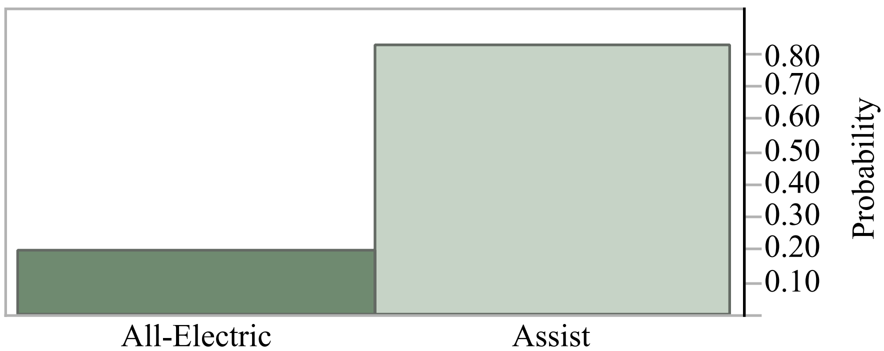
PHEVs may differ in how they use electricity stored from the grid (known technically as "charge-depleting" operation) and their charge-depleting driving range before reverting to operate as conventional HEVs do (known technically as "charge-sustaining" operation). "All-electric" describes a charge-depleting mode that uses only electricity stored from the grid. Such PHEVs require an electric motor capable of providing all power and torque required to drive the vehicle and a battery capable of providing all the power required for high demand situations, such as hard accelerations and climbing hills. Thus, all-electric designs are more expensive than assist designs. "Assist" refers to PHEV designs in which the gasoline engine may be used to help power the vehicle even while the vehicle is in charge-depleting operation. For both types of PHEVs, when the high-voltage battery (where electricity from the grid is stored) reaches some design minimum state-of-charge (SOC), the vehicle reverts to charge-sustaining operation where the gasoline provides more of the power for the vehicle and regenerative braking and the gasoline engine are used to maintain that SOC near the design minimum. A PHEV returns to charge-depleting operation, i.e., powered solely or mostly by electricity from the grid, only after the vehicle is plugged in to recharge the high-voltage battery.

In addition to a choice all-electric or assist capability during charge depleting operation, respondents choose the driving range over which charge depleting operation lasts, the time it takes to fully charge their PHEV design at home (expressed to them in hours), and whether they want access to a limited network of away-from-home quick chargers capable of charging vehicles far more rapidly than can be done at home.

- PHEV designs were by far the most popular of the PEV and FCEV possibilities: 23 percent (n = 114) of Oregon respondents designed a PHEV compared to 11 percent (n = 55) BEVs and four percent (n = 22) FCEVs.
- PHEV designs emphasize longer range driving on electricity and Assist mode during charge depleting operation (such as the Prius Plug-in) over all-electric (such as the BMW i3 with range extender).
- Fast charging at home or at an (initially limited) network of quick chargers is not viewed as necessary by most who design a PHEV; only 25.7% of those who design a PHEV indicate they want the fastest charging offered at home; only 40% incorporate quick-charging capability (away-from-home).

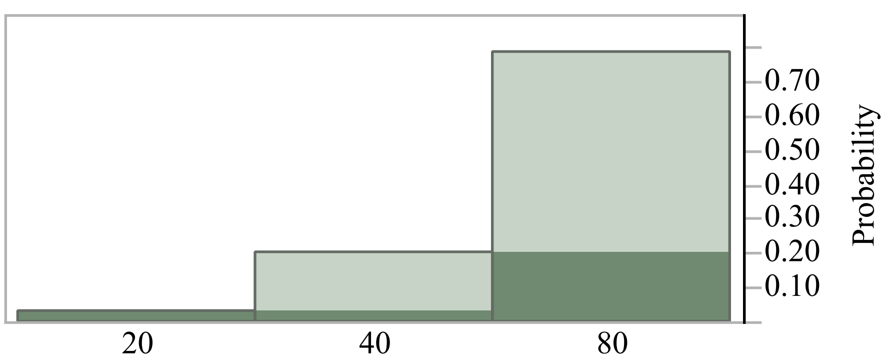
The following figures illustrate the distributions of PHEV designs by charge-depleting modes, charge-depleting driving range, and home charging speed. The dark-shaded region in Figures 16 to 18 highlights those respondents whose PHEV design include all-electric charge-depleting mode. Most of the OR sample (82%) designed a PHEV with Assist charge-depleting operation (Figure 16).[19]

Figure 16: PHEV Charge-depleting operation, n =114



A large majority (78%) of the OR sample designed a PHEV with the maximum offered charge-depleting range, 80 miles (Figure 17). Eighty miles is approximately twice the charge-depleting range of the 2014 Chevrolet Volt, though it approximates that offered by BMW's 2015 i3 with Range Extender. At the low end, a range of 10 miles (incorporated into no OR respondent's PHEV design) approximates that of the 2014 Plug-in Prius.

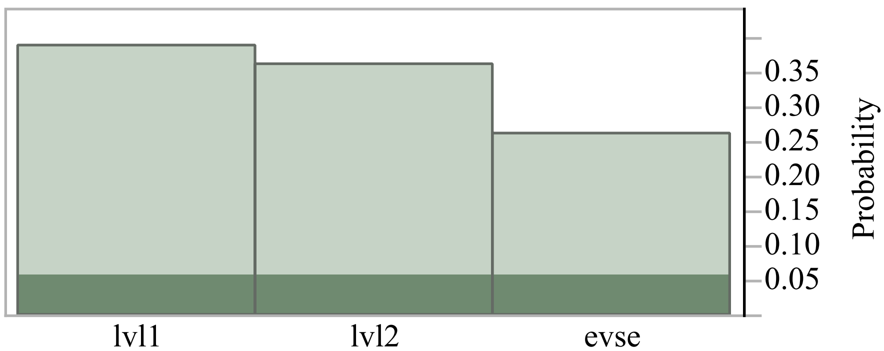
Figure 17: PHEV Charge-depleting driving range (miles) by all-electric vs. assist mode



[19] Feedback during the follow-up interviews in California, Oregon, and Washington suggests the concepts of charge-depleting and charge-sustaining operation as well as all-electric vs. assist modes caused considerable confusion. Much of the confusion crosses from HEVs to PHEVs to BEVs; many respondents were confused about the distinctions between the three.

In Figure 18, home charging speeds are denoted by lvl1, lvl2, and EVSE. These are shorthand for the charging speed offered by a typical home 110-volt outlet (lvl1 ≈ 1.1kW), a higher power 220-volt outlet (lvl2 ≈ 6.6kW), or a higher power, specialty appliance for charging PEVs (EVSE ≈ 9.9kW). Higher power charging costs more in the design games. Most (39%) of those who design PHEVs believe they would be satisfied to charge the vehicle at home at the speeds afforded by a conventional home 110v outlet.[20]

Figure 18: PHEV Home Charging Speed by all-electric vs. assist mode



The capability to quick charge at a network of stations requires the installation of an optional plug on the vehicle (mimicking the decision potential buyers of several PEVs would face). The cost for this was presented as a $500 vehicle option; charging time was stipulated to be 30 minutes. Respondents were given this description of what to expect of a quick charging network:

> "At first, there will only be a few places you can quick charge. Imagine there is one location you can use to accomplish your day-to-day local travel. It is not the most convenient location—it requires you to go a little bit out of your way. Out of town trips may or may not be possible. Imagine that for at least a couple years, there will be some out of town trips during which you can quick charge, and some that you can't."

Given this, 46 of the 114 (40%) Oregonians who designed a PHEV added the quick charge option to their vehicle design. There is not a statistically significant difference in the speed of home charging by either assist vs. all-electric operation, but there may be a slightly greater likeliness that those who design PHEVs with all-electric operation will include quick charging capability (recalling quick charging only occurs away from home). Those who design PHEVs with 80 miles "electric" range are more likely than those who design PHEVs with shorter electric range to incorporate faster home charging as well as quick charging.

---

[20] Respondents were presented with the time it would take to fully charge a vehicle of their design at each power level; they chose charging durations, not power levels. Power levels are shown here. All prices are customized to each respondent based on their charge-depleting mode (all-electric or assist) and range selections. The highest price presented for an EVSE was $2,000. This is an estimate for the price to buy the EVSE and a low-cost installation, i.e., no new construction or wiring is required to accommodate the device.

BEV Designs

- So few respondents design BEVs that the following descriptions should be regarded as case studies.
- BEV designs incorporate driving ranges from across the spectrum of offered options, i.e., 50 to 300 miles; more than half (56%) design BEVs with ranges of 125 miles or less.
    - The distribution of designs is bi-modal with peaks at 100 to 125 miles and at 300 miles
- While the single most frequent charging speed would require the installation of a high-power (6.6kW) EVSE, most households (59%) believe they would be satisfied with a charging speed that could be supplied by existing home 110V or 220V circuits.

For BEV designs, respondents could manipulate driving range, home recharging times, and whether or not their vehicle would be capable of quick-charging away from home. The driving range options were 50, 75, 100, 125, 150, 200, and 300 miles. The longest-range offered is in response to the capabilities of the longest-range Tesla vehicles presently for sale. Home charging and away-from-home quick charging are as described above for PHEVs except that the away-from-home quick-charging duration for BEVs was stipulated to take longer: one hour for BEVs, up from the 30 minutes stipulated for PHEVs. The distributions of the BEV designs on driving range and home recharging duration are shown in Figures 19 and 20. The dark shaded areas in both figures are those people who also opted for their vehicle to be capable of quick-charging.

More than half the BEV designs incorporate ranges that are available in many BEVs presently for sale, that is, less than or equal to 125 miles (Figure 19). Those who design BEVs with longer ranges are more likely to include both the fastest possible home charging (Figure 20) and quick charging capability than are those who design shorter range vehicles. Those who select the fastest home charging are more likely to include quick charging capability.

Figure 19: Distribution of BEV Range by quick charging capability was included, n = 55

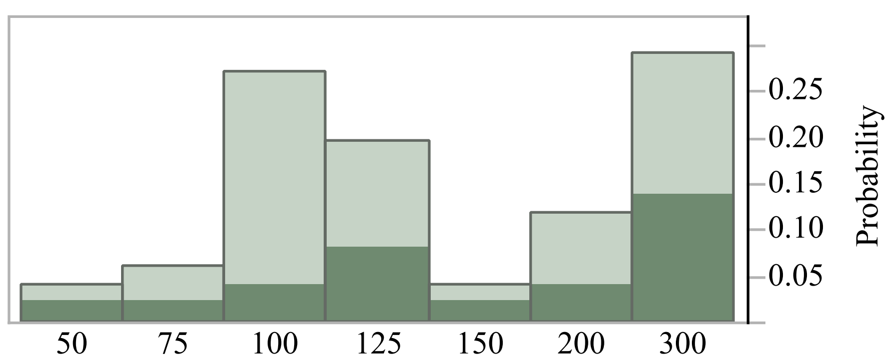
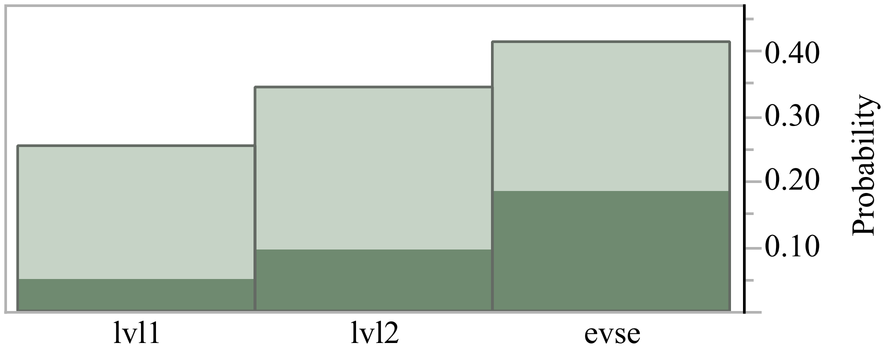


Figure 20: BEV Home Charging Duration by quick charging capability was included



Taken all together, the BEV designs span the range of possibilities. Some respondents choose vehicles that overall have "lower" capabilities, i.e., shorter ranges, longer home recharge times and no access to away-from-home quick charging. Some design vehicles with the longest range, fastest home charging, and access to quick charging. And most every possibility in between appeals to others.

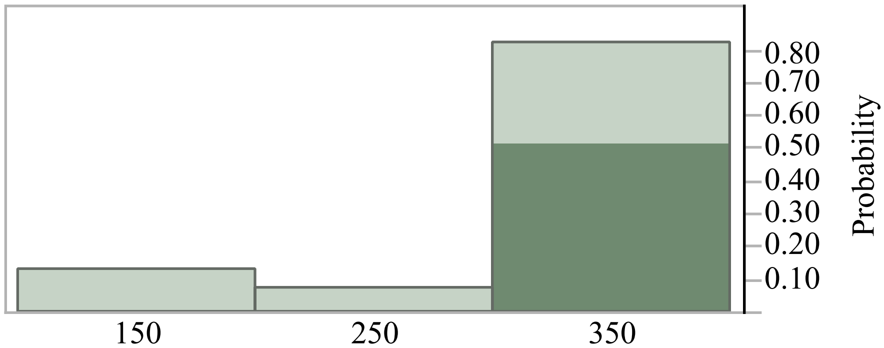
FCEV Designs

- So few respondents design FCEVs that the following descriptions are case studies.
- Range includes all three possible options (150, 250, and 350 miles), but by far the highest percentage opts for the longest range.
- Home H_2 refueling was included in a bit more than half of FCEV designs, and then only by respondents who opted for the longest possible driving range.

Respondents could manipulate driving range (150, 250, or 350 miles) and whether they could refuel with hydrogen at home. The latter was presented at a price of $7,500. The dark shaded area in Figure 21 indicates respondents who included home H_2 refueling. Away-from-home refueling for FCEVs was described this way:

> "5 to 15 minutes to fill tank at a service station. Longer driving range options will take a little longer.
>
> "At first, there will only be a few places you can refuel with hydrogen. Imagine there is one hydrogen station that you can use to accomplish your day-to-day local travel. It is not the most convenient location—it requires you to go a little bit out of your way. Out-of-town trips may or may not be possible. Imagine that for at least a couple years, there will be some out of town trips you can't make in your hydrogen fuel cell vehicle."

Figure 21: Distribution of FCEV driving range by home H_2 fueling, n = 22



RESULTS: RESPONDENT VALUATION OF PEVS AND FCEVS

The description of who does and does not design their next new vehicle to be a PEV or FCEV begins with the search for simple correlations between several descriptors of respondents, their other household members, their vehicles, travel, and residences. Most of these were previewed in the first Results section above describing the sample. The set of possible explanatory variables is summarized in Appendix A. For each potential explanatory variable, i.e., dependent variable, an alternate hypothesis is stated. These hypotheses are alternates to the standard null hypothesis (H_0). In statistical jargon, null hypotheses are stated as no effect, e.g., for the number of vehicles owned by each household, the null hypothesis is that how many vehicles a household already owns has no effect on the type of drivetrain they design. For BEVs with the shortest driving ranges, prior research indicates that households with more vehicles have more options for those instances when a driving range would prevent a BEV from making a trip. Thus the alternate hypothesis can be stated that the more vehicles a household owns, the more likely it is to design its next new vehicle to be a BEV. As many of the null hypotheses have previously been stated, we do not bother to repeat them for each dependent variable in the table. The statistical tests of significance to reject the null hypothesis of no effect is set to $\alpha = 0.05$. The acceptance or rejection of any null or alternative hypothesis in Appendix A is only in regards to the bivariate relationship between each explanatory variable—taken one at a time—and the dependent variable, that is, drivetrain design in the third design game. The results in Appendix A guide the construction of the more complex model reported next.

Choosing explanatory variables

Several of the simple correlations between possible explanatory variables and the drivetrain of the vehicle designed in the final survey game (ICEV, HEV, PHEV, BEV, or FCEV) surpass the level of significance set for rejection/non-rejection. However, many of the possible explanatory variables are correlated to each other as well as to the final drivetrain design, e.g., concerns with air quality are correlated with concerns about climate change: people concerned about one are more likely to be concerned about the other. Such correlations between explanatory variables produce difficulties in estimating multivariate models (models containing more than one explanatory variable). As happens here, it isn't possible to estimate a model containing all the potential explanatory variables that passed the test of significance when only one variable is tested at a time.

Further, several questions about a single topic may plausibly be reduced to a smaller number of dimensions. For example, we ask seven questions about respondents' prior evaluation of BEVs: ability to charge one at home, the extent of the away-from-home charging network, time to charge a BEV, driving range, purchase price, cost to charge, safety and reliability compared to gasoline vehicles. It may be the case that these seven questions can be represented by a smaller number of linear combinations, say, one for cost, one for charging, etc. If so, then those factors may be better explanations of ZEV valuation than the original questions.

We review those variables, identify the concepts they represent, and choose potential variables from each concept to represent each concept. Variables are selected for either (or both) substantive interest or statistical strength of the bivariate correlation. The resulting multivariate model is thus only one of many that could be produced. This is not to say that statistical models can be made to say anything, but to construct a model that allows for tests of important concepts.

The description of the "best" model is qualified by the fact that it is the best model built on the absence of interactions between explanatory variables. In short, it is the best model to describe whether each explanatory variable is correlated to the drivetrain design of the survey respondents, controlling for the effects of all the other variables in the model on drivetrain design.

The numerical details of the model are presented in Appendix B. The substantive meaning of the model is discussed next.

Who designs their next new vehicle to be a PHEV, BEV, or FCEV?

For each respondent's combination of values of the explanatory variables, the model estimates a probability for each drivetrain type; the model assigns the drivetrain with the highest estimated probability as that respondent's predicted design. The variables present in the model to explain who does and does not design their next new vehicle to be a PHEV, BEV, or FCEV are the following.

- Respondent (and their household) Socio-economic and Demographics
  - None
- Household travel, characteristics of residence, vehicles, and travel
  - Price paid for most recently purchased vehicle
  - Respondent's monthly fuel spending on the vehicle they drive most
  - Fuel economy of vehicle respondent drives most often
  - Daily flexibility in assigning household vehicles to drivers
  - Whether respondent commutes in a household vehicle
- Attitudes related to policy goals: energy security, air quality, and global warming
  - Pro-social + electricity Factor 4: degree of agreement (or disagreement) that individual lifestyle affects air quality
- Prior PEV and FCEV evaluation and ZEV-specific attitudes
  - Prior belief electricity is a likely replacement for gasoline and diesel
  - Prior PEV Factor 1: a combined assessment as to the relative reliability and safety of PEVs compared to gasoline vehicles
  - Vehicle Familiarity Factor 1: a combined assessment by the respondent of their familiarity with PHEVs, BEVs, and FCEVs
  - Whether they have already considered buying a BEV

These statements are elaborated below.

Household travel, characteristics of residence, vehicles, and travel

Price paid for most recently purchased new vehicle

In general, the effect of how much the respondents paid for their most recently acquired new vehicle is on the probability of designing BEVs vs. HEVs or PHEVs. The further above the median vehicle price, the higher the estimated probability the respondent designed a BEV and the lower of probability they designed an HEV or PHEV. The probabilities assigned by the model to conventional ICEVs do not change much over any differences in purchase price of the most recently acquired vehicle.

Respondent's monthly fuel spending on the vehicle they drive most

Monthly fuel spending most strongly affects the probability the respondent designs an FCEV: as monthly fuel spending increases, the probability of designing an FCEV increases while the probabilities of all other drivetrain types decline. The effect is only strong at very high fuel spending.

Fuel economy of vehicle respondent drives most often

Higher fuel economy of the vehicle the respondent drives most often is primarily associated with the probability they design an ICEV or HEV: higher fuel economy is associated with a higher probability of designing an HEV.

Daily flexibility in assigning household vehicles to drivers

Daily flexibility in assigning household vehicles to different drivers has been observed in other research to affect household adaptability to BEVs. The variable for daily flexibility is associated with the likeliness of designing vehicle drivetrain types, but it is not straightforward. In general the variable is associated most strongly with differences in the probabilities of designing ICEVs or HEVs. Only in moving to the highest level of flexibility—households determine daily who will drive which vehicle—does the variable have the effect of slightly increasing the probability the respondent designs a BEV.

Whether respondent commutes to work in a household vehicle

As with the other measures of the vehicles respondents already own and drive (except the price they paid for their most recently acquired new vehicle), whether the respondent commutes to work in a household vehicle appears to be most associated with changes in the probabilities of designing ICEVs and HEVs.

Attitudes toward policy goals

A factor analysis on eight questions pertaining to the policy goals of energy security, air quality, global warming and whether electricity represents a higher or lower environmental and health risk than gasoline in the respondents region indicates these eight questions can be reduced to a set of four factors which may capture some underlying beliefs or constructs. The four factors are:

1) Whether the respondent strongly disagrees (-3) to strongly agrees (3) he or she "personally worries about air pollution";
2) Whether electricity poses lesser (-3) to greater (3) environmental and health risks vs. gasoline where the respondent lives;
3) Strength of their disagreement-agreement (on a scale from -3 to 3) there is evidence average temperatures on the planet are rising, i.e., global warming, and that individual lifestyles affect climate change; and,

4) Strength of their disagreement-agreement (on a scale from -3 to 3) that individual lifestyle affect air pollution.

Individual lifestyle and air pollution

Of the four factors, only the fourth—pertaining to whether individual lifestyles affect air pollution—is associated with the probability respondents design vehicles with particular drivetrain types. Over most of the range of the factor scores, it is associated mostly with changes in the relative probabilities of designing ICEVs and HEVs: increasing factor scores (which are determined mostly by the strength of agreement that individual lifestyle does affect air pollution) increases the probability the respondent designs an HEV and reduces the probability they design an ICEV. Only at the highest factor scores do the probabilities of designing PHEVs, BEVs, and FCEVs increase.

Prior ZEV evaluation and ZEV-specific attitudes

Four variables related to prior, that is, prior to completing the design games in the survey, consideration of PEVs and FCEVs. One is whether they already hold the belief that, "If for any reason we could no longer use gasoline and diesel to fuel our vehicles," electricity is a likely replacement. Another is their prior conception of the relative safety and reliability of PEVs compared to ICEVs. Still another is their answer to this question about their familiarity with different types of drivetrains for motor vehicles: "Are you familiar enough with these types of vehicles to make a decision about whether one would be right for your household?" Finally, there is the question of whether they have already considered buying a PHEV, BEV, or FCEV for their household.

Prior belief electricity is a likely replacement for gasoline and diesel

Those respondents who choose electricity as a likely replacement for gasoline and diesel fuel are estimated to be more likely to design their next new vehicle as a PHEV or BEV (and less likely to design it as an ICEV or HEV).

Prior PEV Factor 1: a combined assessment as to the relative reliability and safety of PEVs compared to gasoline vehicles

Respondents were asked to rate their agreement/disagreement with seven statements:

1. My household would be able to plug in a vehicle to charge at home
2. There are enough places (other than home) to charge electric vehicles
3. It takes too long to charge electric vehicles
4. Electric vehicles do not travel far enough before needing to be charged
5. Electric vehicles cost more to buy than gasoline vehicles.
6. Gasoline powered cars are safer than electric vehicles.
7. Gasoline powered cars are more reliable than electric vehicles.

Their answers are on a scale from strongly disagree (-3) to strongly agree (3). A factor analysis determined these seven could be reduced to four factors largely identified with these concepts:

1. Prior PEV Factor 1: safety and reliability
2. Prior PEV Factor 2: charging time and driving range

3. Prior PEV Factor 3: enough places (other than home) to charge electric vehicles
4. Prior PEV Factor 4: household can charge at home

Note that the original question related to PEV purchase price does not load onto any of these four factors. In effect, taking into account the other six original items as rotated through an imaginary space to arrive at the four factors, we expect differences in respondents' assessment of PEV purchase prices to have little explanatory power.

Ultimately, only one of these factors enters the final model of respondents' drivetrain designs as a statistically significant explanatory variable—the first factor, which is most strongly associated with respondents' prior conception of PEVs as less or more safe and reliable than conventional ICEVs. The more strongly respondents believe PEVs are more reliable and safer than ICEVs, the more likely they are to design HEVs, PHEVs, and BEVs.

Familiarity Factor 1: a combined assessment by the respondent of their familiarity with PHEVs, BEVs, or FCEVs

Respondents are asked to rate whether or not they are familiar with each of the major drivetrain types they will see in the design game: gasoline (ICEVs), BEVs, HEVs, PHEVs, and FCEVs. Their answers are on a scale from strongly no (-3) to strongly yes (3). A factor analysis revealed these five items could be reduced to two: one for HEVs, PHEVs, BEVs, and FCEVs and a second for ICEVs. Only the first enters the model of respondents' drivetrain designs as a statistically significant explanatory variable. The higher respondents' scores on the first factor—which in a sense summarizes their experience driving all drivetrain types other than conventional ICEVs—the more likely they are to design something other than an ICEV.

Whether they have already considered buying a PEV

The original variable offered six answers along a scale from a lack of prior consideration (reinforced by actual opposition to plug-in vehicles) to people who already own a vehicle that is powered by electricity. The very few people who respond they already own a vehicle the runs on electricity are excluded from this analysis. (The mathematics of the statistical analysis breaks down when there are too few respondents giving any particular answer.) The other five categories are grouped into two: one for those who have not considered PEVs at all and another who have to varying degrees. Those who have already considered PEVs are estimated to be more likely than those who have not to design their next new vehicle to be a PHEV or BEV. The effect is relative, even those who have already considered a PEV are generally more likely to be estimated to design an ICEV or HEV.

Overall model performance

A summary view of how well the model performs is provided in Table 6 where the actual drivetrain design (created by each of the 361 respondents used to estimate the model) is cross-classified by the drivetrain "predicted" by the model. The model predictions are created by assigning a probability that each respondent creates one of the five possible designs then picks the drivetrain design with the highest probability.

Table 6: Actual and predicted drivetrain designs

Actual Game Design No trucks, plus incentives: drivetrain design	Predicted Design ICEV	 HEV	 PHEV	 BEV	 FCEV	Observed Game Total
ICEV	55	27	11	1	2	96
HEV	20	72	31	1	2	126
PHEV	10	26	43	2	3	84
BEV	3	15	12	6	0	36
FCEV	3	2	7	2	5	19
Predicted Total	91	142	104	12	12	361

The model does a relatively poor job predicting who will design PHEVs, BEVs, or FCEVs. Of 84 respondents who actually designed a PHEV (the sum of the PHEV row), the model correctly assigns a PHEV design to a bit more than half (43) while misestimating another 71 people design a PHEV (for total of 104). The model does a poor job distinguishing who designs a BEV (6 of 36) or an FCEV 5 of 19). The question of how the model informs decisions for the real world will be taken up in the Discussion section.

Table 7a summarizes the values of the explanatory variables used for a baseline estimate of the likeliness of respondents' drivetrain designs. The estimation algorithm selects values of each explanatory variable to produce a baseline estimate. Since the algorithm estimates the baseline using no information about the substantively interesting values of explanatory variables, the baseline is merely a point to start a conversation about the effects of the explanatory variables.

Table 7a Values of explanatory variables for baseline estimates of the probability of respondents' drivetrain designs

Values of explanatory variables for baseline estimation
Respondent's own car fuel spending: *$138 per month* Price paid for most recently acquired new vehicle: *$26,500* Daily flexibility assigning drivers to vehicles: *No flexibility*[1] Respondent commute by car: *No* Fuel economy of vehicle respondent drives most: *26.1 mpg*
Prior Familiarity Factor 1: HEVs, PHEVs, BEVs and FCEVs: *0.03* Prior BEV Factor 1: safety-reliability: *0.01* Prior Consideration of a BEV: *No*
Electricity is a likely replacement for gasoline: *No*
Pro-social + electricity Factor 4 (Individual lifestyle affects air quality): *0.01*

The baseline probability estimates are shown at the top of Table 7b, followed by estimates based on the changes to the explanatory variables described in each row of the table. The highest probability in each row is highlighted in **bold**: this is the drivetrain the algorithm assigns to respondents with the combination of values in that row. In general, HEV designs have the highest probability across many values of many explanatory variables; this is as expected from Table 6. Increasing familiarity (with HEVs, PHEVs, BEVs, and FCEVs), more favorable perceptions of the safety and reliability of PEVs, and stronger agreement that individual lifestyle affects air quality all shift probabilities away from ICEVs, but not strongly enough toward PEVs and FCEVs that their probabilities exceed those of HEVs. To observe probabilities that favor PEVs requires changing variables related to household vehicles and travel, not merely perceptions of and attitudes towards PEVs and FCEVs. For example, households with greater degree of flexibility in assigning vehicles to drivers are estimated to be more likely to design a PHEV—if they commute to work in a household vehicle, have previously considered a PEV for their household, have a high (75th percentile) strength of agreement that individual lifestyle affects air pollution, have a strongly favorable (25th percentile) impression of the safety and reliability of PEVs, have a high familiarity (75th percentile) with HEVs, PHEVs, BEVs, and FCEVs, and believe electricity is a likely replacement for gasoline and diesel. To reach probabilities that favor BEVs, we must also look at people who spent more (75th percentile) for their recently acquired new vehicle.[21]

What Incentives do People Choose?

- Upfront financial incentives are overwhelmingly selected respondents (94.6%).
  - Lack of interest in HOV lane access reflects very low lane-miles of HOV lanes in Oregon (one lane on I-5 north from Portland to the Columbia River)
  - Similarly, Oregon has little transportation infrastructure with tolls, mostly obviating the value of reduced tolls as an incentive for PEVs and FCEVs.
- Despite the dollar value of the vehicle and charger incentives being identical, among those who choose a direct financial incentive, they split about five-to-four as to whether they want an incentive for the purchase of the vehicle or home charging/fueling.

In the final game, PHEVs, BEVs, and FCEVs are eligible for federal tax credit (keeping in mind that full-size vehicles are not offered as BEVs or PHEVs that operate in all-electric mode). The amounts offered are customized for each design based on the present federal schedule. In addition, designers of qualifying vehicles choose one of the following:

- A vehicle purchase incentive from their state equal to CA's CVR at the time of the study;
- A home PEV charger or H_2 fueling appliance purchase incentive from their state (PHEV/BEV charger incentive equal to the state purchase vehicle incentive above; the H2 fueling appliance incentive was $7,500);
- Single occupant access to high-occupancy vehicle HOV lanes (until Jan. 2019);
- Reduced bridge and road tolls (until Jan. 2019); or,
- If workplace charging isn't available to them, imagine it is (except for FCEVs).

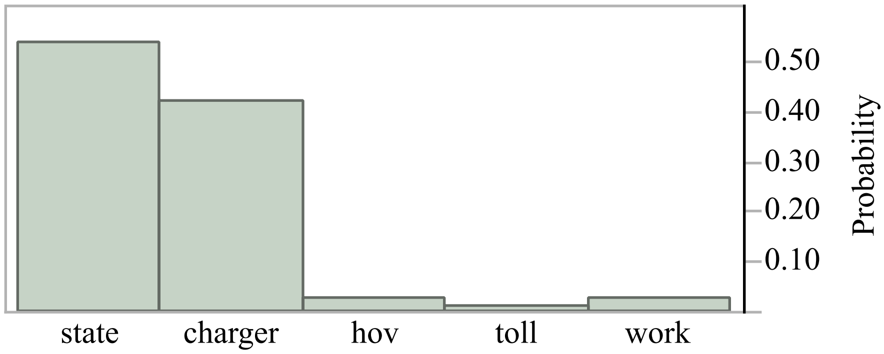
[21] Other combinations of values of explanatory variables will produce probabilities that assign PHEVs, BEVs, and FCEVs to respondents. The values in Table 7b are simply examples.

Table 7b Probability distribution of drivetrain designs for profiles of values of the explanatory variables, percent

Drivetrain type:	ICEV	HEV	PHEV	BEV	FCEV
Base probability estimates, %	36.9	**55.9**	4.0	3.2	0
Changes to base values of explanatory variables	**Resulting Probabilities, %**				
Set these three to the sample median values: • Respondent's own fuel spending • Price of most recently acquired new vehicle • Fuel economy of vehicle respondent drives most	37.1	**55.5**	4.4	2.9	0.1
Plus, Electricity is a likely replacement: *No to Yes*	32.9	**49.6**	12.4	4.6	0.5
Plus, Prior Familiarity Factor 1 to 75th percentile, i.e., higher familiarity with PHEVs, BEVs, and	25.0	**54.4**	13.5	6.5	0.6
Plus, change Prior BEV Factor 1 to 25th percentile, i.e., a better perception of PEV safety and reliability	20.0	**58.4**	14.0	7.2	0.4
Plus, change Pro-social + electricity Factor 1 to 75th percentile, i.e., higher strength of agreement that individual lifestyle affects air quality	17.4	**60.4**	14.7	6.6	0.9
Plus, change Consider a BEV: *No to Yes*	8.5	**38.0**	27.4	13.5	12.6
Plus, switch Commute: *No to Yes*	6.2	**38.4**	37.9	13.9	3.6
Plus, higher Daily flexibility to assign vehicles to drivers (from none to weekly switching or swapping)	6.2	32.0	**49.1**	11.5	1.2
Base values for these variables (see Table 7a): • Respondent's own fuel spending • Fuel economy of vehicle respondent drives most • Prior BEV Factor 1 (safety-reliability) • Commute by household vehicle • Pro-social plus electricity Factor 4 (AQ-lifestyle) Change values for these variables: • Consider a BEV: *No to Yes* • Electricity is a likely replacement: *No to Yes* • Vehicle Purchase Price to 75th percentile • Prior Familiarity Factor 1 to 90th percentile • Highest flexibility in day-to-day assignment of vehicles to drivers	14.2	25.6	20.5	**25.7**	13.9

1. These are households who either 1) have more than one vehicle and driver and say each driver has their own vehicle and they don't switch or swap or 2) households with only one driver and one vehicle.

Figure 22: Incentives selected in addition to a federal tax credit, n = 169, percent



Why do people design PEVs and FCEVs?

- Highly rated motivations to design a PEV or FCEV are a mix of private and pro-social.
    - Private: Savings on (fuel) costs, interest in new technology, convenient to charge at home.
    - Pro-social: Reducing personal effects on climate change, air pollution, oil imports, payments to oil producers
- Little acknowledgement that incentives were important to their vehicle design

Motivations for designing PEVs and FCEVs were assessed on a scale from 0 = not at all important to 5 = very important. Respondents were presented with a list of 17 possible motivations derived from prior research. However, respondents were restricted to spend a maximum of 30 points summed across all 17 items. Because not all respondents spent the maximum number of points, an "average" score for any individual item is the total number of points spent by all respondents, divided by the number of respondents, and divided again by the number of items. The resulting "mean" score for the Oregon sample is 1.43. Any item scoring higher than this is interpreted as having a "high" score. The possible motivations are listed in Table 8, sorted from high to low by their mean score; the percent of respondents assigning maximum importance, i.e., five points, is shown, too.

The top seven motivations have mean scores higher than the mean (Table 8). The top motivations are a mix of private and pro-social benefits. Saving money (in this case, restricted to fuel cost savings) is not often at the top of the list of ZEV discussions in academic papers, policy discussions, and market analyses that tend to emphasize the higher upfront purchase prices. However, more than half (52.4 percent) of respondents who design a PEV or FCEV give the maximum number of possible points to saving money on fuel costs (and 78% assign two or more)—possibly revealing a "partial rationality" that apportions costs to different categories and treats them separately from —and possibly even differently than—vehicle purchase costs. The idea that saving money on fuel costs would be an important motivation is signaled by the presence of the explanatory variables in the model of the design game results for monthly fuel spending and fuel economy of the respondent's most often driven vehicle.

Table 8: Motivations for Designing a ZEV, high to low mean score

Motivation	Mean	% = 5
To save money on gasoline or diesel fuel	3.49	52.4
I'm interested in the new technology	2.28	23.6
It will reduce the effect on climate change of my driving	2.19	29.8
It will reduce the effect on air quality of my driving	2.17	25.1
It will reduce the amount of oil that is imported to the United States	1.91	20.9
I'll pay less money to oil companies or foreign oil producing nations	1.79	19.4
Charging the vehicle at home will be a convenience	1.64	18.3
Mean points per person per item	1.43	
It will be fun to drive	1.30	10.5
It will be safer than gasoline or diesel vehicles	1.16	9.9
It fits my lifestyle/activities	1.16	11.0
I'll save on the cost of maintenance and upkeep	1.15	13.1
I like how it looks	0.98	8.9
I'll save on the cost of vehicle purchase	0.88	6.8
The incentives made it too attractive to pass up	0.79	7.9
I think it makes the right impression for family, friends, and others	0.72	4.7
It will be more comfortable	0.64	4.2
Another motivation[1]	0.01	0.0

1. Only one respondent listed "another" motivation.

The importance of attraction to ZEV technology is underscored by the fact this motivation has the second highest mean score. A personal interest in the new technology is given the highest possible score by almost one-fourth of those who design a ZEV and 55% give it two or more points. This motivation may be signaled by whether the respondent had considered a PEV for their household prior to completing the survey, but the most direct statements of interest in ZEV technology do not enter the multivariate model discussed in the previous section.

The four motivations related to policy goals of climate change, energy security, and air quality all score above average, but only the personal effect on air quality directly enters the model of drivetrain designs. It seems that these pro-social motivations are more likely to appear as "after the fact" explanations for PEV and FCEV designs. "Charging the vehicle at home will be a convenience" also appears as part of this less differentiated set of motivations. This is reflected in the model in the variable assessing whether the respondent parks a vehicle at home at a location with electric service.

As to the importance of incentives, few people acknowledge that the incentives were important to the design of their vehicle in the final game. The mean points assigned to incentives rank well below the mean and only 7.9 percent scored it as high as possible. In the 1st game (no incentives offered, but full-size vehicles with all-electric operation allowed), 163 people designed PEVs or FCEVs. In the third game (incentives offered, but full-size BEVs and full-size PHEVs with all-electric operation are not allowed), this increased to 191 respondents. This increase in the number of ZEV designs despite no full-size ZEVs would be consistent with a greater importance of incentives on respondents' vehicle designs. As with the case for attitudes toward climate change, energy security, and clean air, there is some distinction to be made between the effects expressed while playing the design games and those expressed in post-hoc explanation by the respondent of why they did what they did in the design game.

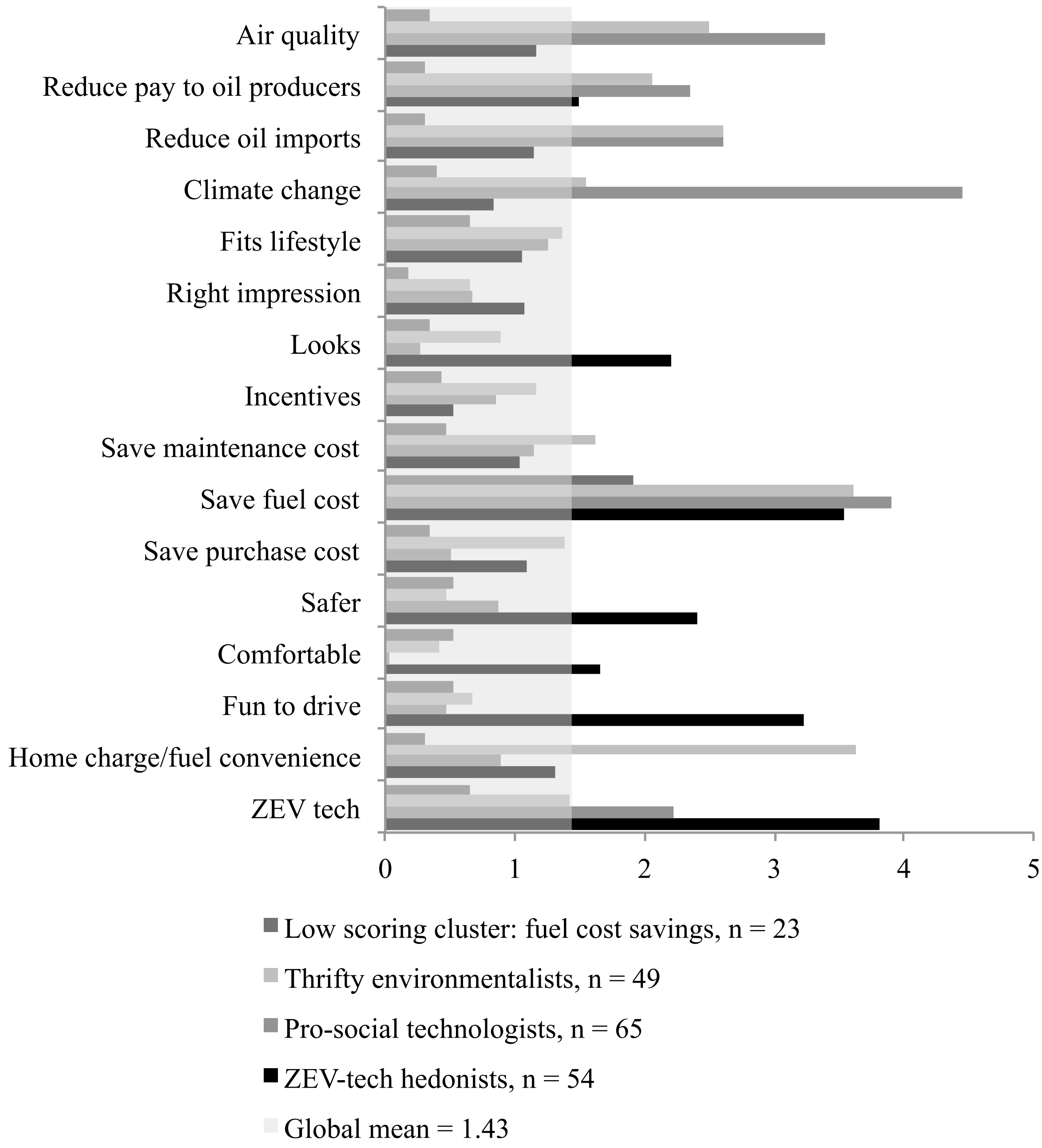
Distinct motivational groups among those who design PEVs or FCEVs

The motivation scores and rankings in Table 8 indicate possible appeals to Oregonians similar to the survey respondents who design PEVs or FCEVs. Motivations are analyzed using cluster analysis to discover distinct clusters of respondents who share patterns of motivations. This extends and refines the explanations of who is interested in PEVs or FCEVs and why they are interested. One output of cluster analysis is the mean motivation scores within clusters of respondents who share similar motivations. In Figure 23 the mean motivation scores for a three-cluster solution are plotted along with a band demarcating the global mean score for all motivations. The final stage of cluster analysis rests on the analyst and the reader to decide whether any observed patterns offer interpretable and actionable information; the group labels shown in Figure 23 are the authors' interpretation. Before reading the authors' rationale below, readers are encouraged to test whether they would have named these groups differently based on the highly scored motivations they share.

All four clusters share a single motivation with a high cluster average score: fuel cost savings. For one cluster, this is the only mean score that is above the global mean average. The occurrence of this singular motivation is because in comparison to the three other clusters this "low scoring: fuel cost savings" cluster used an average of less than nine of the up to 30 points available to them in the motivation exercise. The other three clusters used an average of 26 to 27 of the 30 points. In effect, what makes the respondents in the low-scoring cluster alike is they tended to assign points to only one or two motivations. Respondents in the other clusters have six or seven highly scored motivations.

"Thrifty environmentalists" and "Pro-social technologists" share high mean scores for all pro-social motivations: climate, air quality, and energy supply and security. As with all the other clusters (except the low-scoring cluster) they also score fuel cost savings highly. What distinguishes the two from each other is the thrifty environmentalists score both fuel cost and maintenance savings highly while the pro-social technologists other highly scored motivation is interest in ZEV technology.

Figure 23: Mean motivation scores for four clusters who design PEVs or FCEVs.



The “ZEV-tech hedonists” have no highly scored pro-social motivations except controlling what they pay to oil producers. Rather they appear motivated by the idea that ZEV technology will produce fun, comfortable, safe vehicles that will save money on fuel and be good looking.

Four motivations are highly scored by more than one cluster: interest in ZEV technology, fuel cost savings, climate change, and air quality. These suggest messages and media for crosscutting social networks to support market development—even ZEV-tech hedonists and the most pro-social groups share the motivations of ZEV technology and fuel cost savings.

Why DON’T people design PEVs or FCEVs?

- The highest scoring motivations against designing PEVs or FCEVs have to do with their inherent newness: limited charging and fueling networks, unfamiliarity with the technology, waiting for the technology to be proved reliable, and high initial purchase price.
    - High purchase prices, maintenance and fueling costs were highly rated concerns.
- Immediate, practical limits on the ability to charge a PEV at home as well as concerns about the overall reliability of electricity supply were highly rated motivations against PEVs.
- Concerns about driving range of BEVs and FCEVs, as well as the time required to charge PEVs, scored highly as reasons to not design a PEV or FCEV.
- Few acknowledged that greater incentives (of the kind offered in the game) would have changed their minds.

Because more new-car buyers in OR appear to not be interested in PEVs or FCEVs (at least at this point in time), why they are not interested is as, if not more, important than why a smaller number are interested. Respondents assigned points from 0 = not at all important to 5 = very important to 19 possible motivations derived from prior research. The global mean score for all motivations was 1.03. Any item scoring higher than this is interpreted as having a “high” score. Results are in Table 9, sorted from high to low by their mean score.

The mean score assigned to eleven motivations against designing a PEV or FCEV are higher than the global mean score. Almost all the highest ranked motivations are related to the inherent newness of the vehicles: limited away-from-home fueling, respondent’s unfamiliarity with new technology, waiting for technology to become more reliable, and the high initial purchase price (as first generation technology). Arguably distance per charge or fueling also belongs to this category of “teething problems of new technology.” This is not to dismiss the importance of these concerns in the here and now, but to note that all may improve with new generations of technology, with continued market growth and infrastructure deployment, and with continued accumulation of experience and information by consumers.

The interpretation of the (lack of) effect of incentives is somewhat different than for those respondents who did design a PEV or FCEV. For those who did not design one, few were willing to state that higher incentives would have changed their minds: the mean score for “higher incentives would have convinced me” is 0.39 and less than three percent of those who did not design a PEV or FCEV assign the maximum number of points. In effect, despite the importance of high vehicle purchase price as a motive against designing a PEV or FCEV, simply offering more money (in the form of vehicle, charger, or home fueling rebates or reduced tolls) doesn’t solve enough other problems—real or perceptual.

Table 9: Motivations against Designing a ZEV, high to low mean score

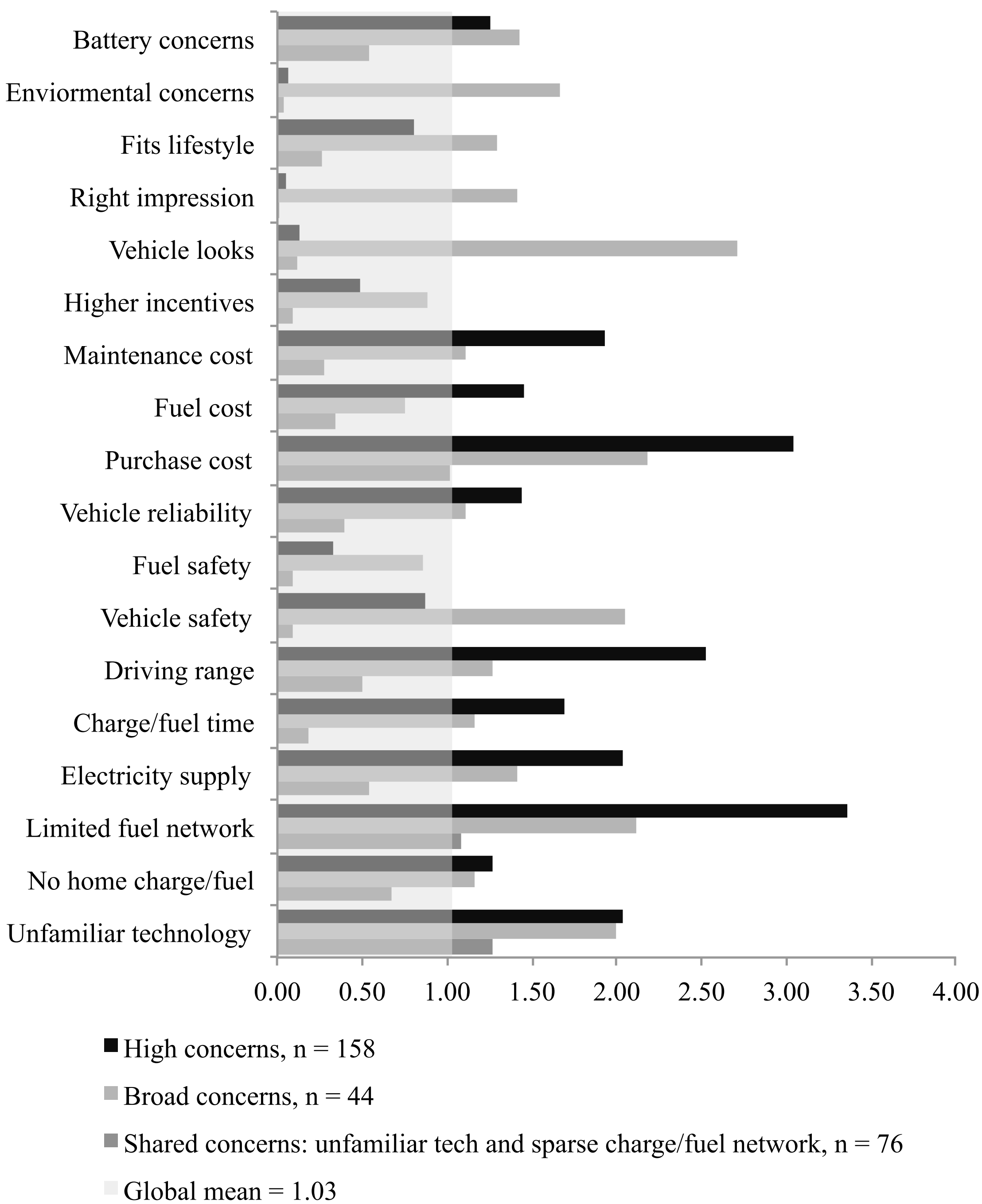
Motivation	Mean	% = 5
Limited number of places to charge or fuel away from home	2.54	36.0
Cost of vehicle purchase	2.35	33.5
I'm unfamiliar with the vehicle technologies	1.82	22.7
Distance on a battery charge or tank of natural gas is too limited	1.77	21.9
Concern about unreliable electricity, e.g. blackouts and overall supply	1.53	17.3
Cost of maintenance and upkeep	1.35	15.5
Concern about time needed to charge or fuel vehicle	1.20	12.2
I'm waiting for technology to become more reliable	1.10	13.7
I can't charge vehicle with electricity or fuel one with hydrogen at home	1.09	13.3
Concerns about batteries	1.09	11.2
Cost to charge or fuel	1.04	13.3
Global mean points per person per item	1.03	
Concern about vehicle safety	0.84	11.2
Doesn't fit my lifestyle/ activities	0.73	8.6
I don't like how they look	0.54	6.1
I was tempted; higher incentives would have convinced me.	0.44	4.7
Concern about safety of electricity or natural gas	0.35	2.5
Environmental concerns	0.31	3.2
I don't think they make the right impression	0.26	2.2
Another motivation, please specify	0.20	2.2

1. Only 16 respondents listed an "another" motivation; only six assigned 5 points to their specified motivation.

Distinct motivational groups among those who do not design PEVs or FCEVs

As was done for the respondents favorably disposed toward PEVs or FCEVs, here the motivations (or perhaps, concerns) of those who did not design a ZEV are examined. Results of a five-cluster solution are illustrated in Figure 24. In comparison to the cluster analysis for those who did design PEVs or FCEVs, the cluster analysis of the motivations of those who did not appears more singular in its conclusion: these respondents simply don't know what PEVs and FCEVs are. One cluster ("Broad concerns") scores almost every motivation (15 of 19 possible) above the global mean. Another ("High concerns") scores fewer motivations highly—11 of 19—but scores ten of those eleven higher than the previous cluster. The third cluster is distinguished primarily by its comparative lack of concern, yet the two the do score highly are shared with the other clusters and includes the basic idea that these respondents are simply unfamiliar with ZEV technology.

Figure 24: Mean motivation scores for three clusters who do not design PEVs or FCEVs.



ELABORATING ON THE PROS AND CONS OF PEVS AND FCEVS: INTERVIEWS OF SURVEY RESPONDENTS

Results from the follow-up interviews with survey respondents in Oregon are discussed here. Sampling for the interviews was not intended to produce a representative sample in any single state or across all three states in which interviews were conducted. Rather, the interviews elaborate on respondent awareness, knowledge, and consideration of PEVs and FCEVs across a range of awareness, knowledge, and consideration. As described in the Methods section, interviewees were sampled based on their vehicle designs from the on-line survey. Households that did, and households that did not, design a PEV or FCEV were interviewed. The interviews are summarized within these five main sections: 1) those who can imagine owning a PEV, 2) those who cannot imagine owning a PEV, 3) the lure and lore of Tesla, 4) frequently asked questions, and 5) the future of cars. In general, there are few surprises in the interviews (compared to their survey results), but there are deeper insights into some results.

Those Who Can Imagine Owning a PEV or FCEV

Some interviewees could imagine owning a PEV. They discussed what they know about PEVs, including types of vehicles available, the technology, charging and fueling options, and incentives. Motivations for a PEV purchase, such as saving money and being environmentally friendly, were discussed, as were barriers to and motivations against a PEV purchase. This section concludes with details on how they ultimately chose a PEV in their design game.

What do they know about PEVs or FCEVs

Types and Technology

The interviewees' knowledge of different types of PEVs varied considerably. Only one interviewee, a retired vehicle manufacturer employee, had a sophisticated understanding of the different technologies. The rest varied in their knowledge from not knowing anything specific to recalling they had seen PEVs at a dealership or recounting driving a friends'. A few could name at least one BEV, usually the Nissan Leaf or Tesla. Many said they were familiar with the idea of PEVs but didn't know specifics. Underscoring inferences from the survey results, it was clear from the interviews there was a lot of confusion about the difference between HEVs and PHEVs; interviewees tended to call both "hybrids" without demonstrating an understanding these are two different vehicle types—in particular the distinction between being fueled by gasoline only or by either or both gasoline and electricity. They were not at all familiar with FCEVs.

Recharging/Refueling Locations

Nearly every interviewee was aware of PEV charging at a superstore chain. Some believed finding a public charger would be easy because they perceived broad availability in their area. One interviewee said, "It just seems like we see them everywhere…I just take them for granted, I mean, I've been seeing chargers around for years" (5296). This interviewee gained confidence in the number of chargers available from speaking with a friend who owns a Nissan Leaf and showed them charging location apps. Conversely, some knew of dedicated parking spots for charging and were either frustrated they could not park (their conventional vehicle) there or stated those spots was usually empty.

Those living in apartments and condominiums discussed the difficulties of charging a PEV at a multi-unit dwelling. While the issues include the basics of electricity availability (or not) and whether residents have assigned parking, the issues are also institutional. One interviewee lived in a condominium community that did not have charging for residents. A proposal was made to install a charging station for residents—at the cost of all residents in the community. This interviewee voted against it, explaining, “I’m not going to pay for your electric car if I don’t have one” (7463).

The interviewees were largely unfamiliar with the specifics of the time required to charge, cost of charging, and range of PEVs (or even that these might vary across types of PEVs). One was concerned about forgetting to charge and then being stranded at home. Another interviewee was interested in a hydrogen fueling station but would want it as close as possible to her house so she didn’t burn through fuel to get to the station.

Incentives

Knowledge of actual incentives was minimal; response to the idea of incentive was mixed, ranging from positive interest, to indifference, to opposition. Some liked the idea of an incentive to reduce the cost of PEVs and FCEVs, while others liked a tax credit or found HOV lane access interesting. One interviewee explained, “If you can equate the amount of incentive you’re going to get back to how much you paid for the vehicle and it brings the overall price down to what you would call a normal car price, yeah, absolutely it would pique my interest in a heart beat” (3510). One interviewee preferred an incentive that came from a corporation rather than the government.

Aside from an explicit financial incentive from either a government or corporation, another said the environmental benefits were incentive enough, explaining, “It should be just knowing that it’s better for the environment…that should just be somebody’s incentive in wanting to get something like that kind of car” (7382).

One interviewee was conflicted about incentives to purchase PEVs vs. a proposal to institute new fees on PEVs to offset the fact that no road tax is paid on electricity. They feared they would end up being taxed more if they bought a PEV; “So they’re going to pay me an incentive to get an electric car and then double charge me because I’m not paying any gas tax” (7463).

Motivations for PEV purchase

As expressed in the interviews, the primary motivation for interviewees who could imagine owning a PEV was the idea that PEVs and FCEVs are better for the environment. As one interviewee explained, “When you get down to it, you’re kind of doing the right thing. It’s not putting out emissions” (5296). They also liked the convenience they imagined would come with a home charger, as one interviewee said, “Having a gas station in my backyard…would be wonderful” (7423). Interviewees like the idea of not going to the gas station and not paying for gas; they thought a PEV would save them money on fuel. Another motivating factor was the idea of the car being cool from a technology perspective. One interviewee said, “They are like the Apple of cars” (5296) and another imagined, “If I had a car like that you’d have to work to get my head through the door” (7423).

The interviewees spoke about BEVs mostly, although one was motivated by a PHEV because he thought it was "the best of both worlds" in that he could drive around town on electricity and still be able to take the car on long trips. He explained, "It would reduce our use of gasoline by about 70% because most of the stuff is short enough that a plug-in hybrid would handle it, and yet you'd have the ability to go across country" (3510). Another was motivated to get a FCEV because he imagined it to be practical, stylish, and fun, saying "For me it has to be fun to drive…if it sucks I'll park it in the garage and leave it there" (7423).

Barriers and motivations against PEV and FCEV purchase

Despite being able to imagine owning a PEV, these interviewees also perceived barriers. Some cited a lack of knowledge; one interviewee summed it up, "I don't even know anything about those cars" (7555). For many, they thought the purchase price of a PEV or FCEV was too much and would require analysis to determine if such vehicles would save them money. One interviewee explained, "You have to sit down and do the math. You really do, you have to look at how you drive, what it is you wish to do with that vehicle, and will it do it. And is the price reasonable enough to purchase it" (3510). Some were concerned about running out of "fuel" and being stuck on the side of the road, especially with children in the car. There was fear that the range would not meet their daily driving needs and would therefore require them to have a second car. Forgetting to charge was another concern for these interviewees, as was the frequency of charging. One interviewee explained, "If I have to go out everyday and charge a car…I don't want to do that…my wife, she can't put gas in a car, let alone charge it everyday" (7423). Some didn't want to have to plan charging while on long trips, as this interviewee said, "The one problem with electric vehicles is that you have to figure out where you're going to be" (4653). One interviewee would be interested in a PEV if it was available as an SUV and if they moved residence as they are currently unable to charge or install charging at their condominium, "There would be…misgivings you might have about 'where's my next fill up' but the other thing is, I park in a communal garage. I have an assigned parking space but there's no way to charge" (7463). There were also concerns about not being able to fit passengers and cargo.

Specific to FCEVs, interviewees worried about safety and availability of hydrogen. One said FCEVs were still "too exotic" and worried that he would have to travel far to refuel, "You have to go somewhere and where is that, who knows? There won't be one in [my town]" (4653).

Vehicle Designs

The variety of the vehicles these respondents designed in their survey responses included BEVs and PHEVs, but no FCEVs. Two drivers chose a BEV. Interviewee 5296 wanted a BEV with100 miles of range; this would enable them to get to the Pacific Coast and Mt. Hood, two locations they travel to frequently. Interviewee 4653 elaborated on his BEV design from the survey—what he wanted was the Tesla Model S.

Three interviewees designed a PHEV. Their descriptions of their vehicle designs reveal the existence of trips that serve as important markers of the practicality and value of a PHEV. The decision to select a PHEV over a BEV itself is a marker of how to make electric drive practical for some households: the idea the car always has the "backup" of gasoline quiets concerns about being stranded and extends the range of the vehicle to include long-distance travel.

Interviewee 3510 wanted their vehicles to have all-electric capability for the first 80 miles and quick charging. Their longest routine trip is 60 miles round trip so they knew an 80 miles range would allow them "as much gasoline free driving as possible." Interviewee 7382 wanted a PHEV because they weren't confident they would be able to find a charger on a long trip and they travel a lot for work. They chose a PHEV with 40 miles of all electric range and quick charging. Another chose a PHEV because they were more comfortable with a gasoline back up, "I feel more comfortable with it and that's what I'm familiar with. Having children and everything I'd like to have that safety blanket" (7423).

Two other interviewees opted for HEVs in the game, mostly for environmental reasons and cost savings. The interviews allow for households who might be interested in some vehicle in the household being a PEV or FCEV even if it is not the next likely vehicle.[22] For example, interviewee 7215 chose an ICE truck in the game because they were worried about an HEV or BEV not having enough power to tow. They were open to a PEV or FCEV if it were to replace another vehicle in their household, but in the game they chose to replace their oldest vehicle whose main job was to tow.

Those Who Cannot Imagine Owning a PEV or FCEV

Some drivers were unable to imagine, uninterested in imagining, or unconvinced by their imagination of owning a PEV or FCEV; they were certain that such a vehicle was not for them or their household. They discussed what they know or don't know about PEVs and FCEVs, including vehicles available, the technology itself, refueling options, and available incentives. Motivations against a PEV or FCEV purchase, such as driving range and safety concerns, were discussed, as were motivations that other people may have to purchase such a vehicle. This section concludes with details on how they ultimately did not choose a PEV or FCEV in the game scenario.

What do they know about PEVs and FCEVs

Types and Technology

There were two drivers who could not imagine owning a PEV or FCEV: they had limited knowledge of PEVs and FCEVs, but were aware of HEVs. They were both aware of Tesla although were uncertain if it is a BEV. One interviewee had been told FCEVs were better for the environment than BEVs; she thinks BEVs have the same range as an ICEV. She admits she doesn't know much about these vehicles, but says, "I think [ZEVs are] getting less new now" (6989).

Refueling

The primary concerns of these interviewees regarding refueling focused on finding, or having to find, public chargers for PEVs. Interviewee 2856 had seen a charger near their house and was frustrated by priority parking for PEVs throughout the area. Despite seeing chargers at Portland

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[22] To increase the verisimilitude of the design games they are posed around the design of the next vehicle the household will acquire as a new vehicle. The point is to attempt to ground the respondents' vehicle designs in the games in the possibilities of the next few years rather than to allow for a future fantasy.

State University, interviewee 6989 was convinced she would have to move to the suburbs in order to have access to charging and was unwilling to give up her urban lifestyle.

Incentives

Interviewee 6989 didn't know anything specific about ZEV incentives but thought the State of Oregon may offer something; purchase cost was still an issue for her even with incentives. Interviewee 2856 was concerned that there were BEV taxes that would balance out not having to pay a gas tax. He was also concerned that incentives wouldn't benefit him because he is retired and doesn't pay enough in taxes to take full advantage of tax credits.

Barriers and motivations against PEV and FCEV purchase

Interviewee 6989 was concerned about not knowing enough about the vehicle technology to maintain it, saying, "We wouldn't even know where to start if something went wrong." She was also worried about the purchase price being too high and the cost of electricity driving up her electric bill. She wondered if increased electricity production balanced out to be better for the environment compared to gasoline. Her main barrier, however, was her idea that she would have to move to the suburbs in order to have access to chargers. In terms of FCEVs, she wants to know what can go wrong, how much it costs to fuel, and where to fuel. Interviewee 2856 said a PEV doesn't meet their needs in terms of size or range. His household has many cars and he worried about the inconvenience of having to dedicate one parking spot to a PEV so it could reach a charger. He is also only interested in purchasing a Subaru and did not think they offered a ZEV. This interviewee said he didn't understand the difference between an HEV and a PHEV and was very concerned about driving range in any ZEV.

Motivations for PEV or FCEV purchase

Two interviews offered positive motivations to purchase a PEV; neither had any motivations for a FCEV purchase. They both would be open to looking at a PEV if a specific vehicle make to whom they were loyal offered one and liked the ideas of not having to look at gas prices, saving money on fuel, and driving a car that was good for the environment in terms of emissions.

Vehicle Designs

Interviewee 2856 chose an ICEV in the vehicle design game; their perceived barriers to PEVs and FCEVs were too high and their attachment to a specific manufacturer (not offering any PEVs or FCEVs at the time of their interview) was too strong to allow them to consider anything else—including an HEV. Interviewee 6989 did design an HEV in her survey. She did not choose a PEV or FCEV because she felt she didn't know enough about and there aren't any places to charge a BEV. She liked the idea of a PHEV because she would have a gasoline back up that would allow her to drive to find an "electric docking stations."

The Lure and Lore of Tesla

Most of the interviewees—both those who could and those who could not imagine owning a PEV—talked about Tesla without being directly asked. Familiarity with the brand ranged from having heard of it to having visited a showroom. Interviewees who were more familiar with

Tesla vehicles expressed an interest in purchasing one but all said the purchase price was prohibitively high. One interviewee (4653) made ritual visits to the Tesla showroom. He admits, "“Every time I walk through Washington Square, they have a Tesla showroom area and I have to walk in, walk around it, and walk out…because of the price."

For some, the appeal of a Tesla BEV was the long driving range and short charging time; "If you could get an [affordable] electric car that could do 200 miles on a pop and recharge in 20 minutes I'd probably get one" (3510). For others it was the luxury status they associated with the car. Many of these interviewees who discussed the symbolic allure of the Tesla did so in terms of high technology—positioning Tesla as a "tech" company maybe more than as an "auto" company. One described Tesla as "the Apple of cars." Another discussed how Tesla had "…just released all of their patents into the open source which is really good because they've really got it going." For one interviewee (6989) the brand was strongly connected to founder Elon Musk. She explained how her husband had developed an interest in the Nissan Leaf, which led him to the Tesla and began an infatuation with Elon Musk. It was this infatuation that motivated him to actively research how to incorporate a Tesla into their lives.

Frequently Asked Questions

Many of the interviewees shared the same questions regarding PEVs and FCEVs. For FCEVs they tended to ask about the safety of fueling with hydrogen and fuel availability: "So I guess the hydrogen wouldn't make me think it was going to run out as much but I don't know where I'd get hydrogen" (2270). For BEVs, interviewees generally asked questions about range, purchase price of the vehicle, charging times, and if it really was better for the environment compared to internal combustion cars. They had concerns about the environmental impact of energy production for fueling vehicles and the recycling of batteries. Interviewees wanted to know about away-from-home charging infrastructure, the mechanics of charging, and the cost of electricity.

Interviewees asked questions about the long-term upkeep of PEVs and FCEVs and the cost of purchasing and maintaining such cars. Many expressed their lack of knowledge regarding the operating and maintenance costs of a PEVs and FCEVs as opposed their familiarity with these costs for a gasoline car. For example, one interviewee (6989) suggested, "if something were to go wrong with the car and we didn't have enough knowledge and it hasn't been proven… we wouldn't even know where to start if something went wrong."

A common idea among the interviewees was that existing PEV owners offered the best source of information. Interviewees believed that speaking with PEV drivers could dispel a lot of their concerns and questions. In particular several expressed a desire to wait and speak with PEV drivers in the future about the longevity of PEVs both in the sense of their permanence in the market and the durability and longevity of the vehicles themselves. One interviewee (7555) explained, "It would just be kind of one of those things I would like to know. 'Well am I only going to get 3-5 years out of it? Can I rely on it for 10 years?' Something like that. And that's the kind of stuff you would want to ask someone who had the car for a while and can tell you honestly." The interviewees imagined these hypothetical future ZEV drivers could reliably and honestly answer questions about their cars.

Are ZEVs the Future?

For some interviewees ZEVs represented the future in that their production and adoption demonstrated a conscious action to address future environmental issues in the present. One interviewee (5296) stated, “It’s a progressive decision, it’s something future thinking, forward thinking.” Another interviewee (3510) talking about the sustainability of oil and the environmental effects of emissions asserted, “It’s about time we really got serious about alternative forms of energy for transportation.” He declared his enthusiasm for the FCEV stating, “A hydrogen fuel cell would be awesome…because you’ve got the best of both worlds. You’ve got a renewable resource and nothing comes out of it but water.”

Many of the interviewees expressed a belief that ZEV technology would continue to improve and progress. None of the interviewees talked about the possibility that ZEV technology would stall or that the market would not develop. Instead they spoke of waiting for the next generation or talked about revisiting the idea of purchasing a ZEV once the technology was proven, or had been tested. One interviewee (6989) explained his lack of interest in the first generation vehicles: “There isn’t enough proof that [ZEVs] work and there isn’t enough people saying, ‘Oh we’ve done it. We would never go back….” However, he continued saying he would be willing to “inch his way into it” once the technology had been proven by others. The expectations of future development extended to charging infrastructure as well. For example, one interviewee said, “I think in 10 years. I think they will have progressed to where the charging is a little faster, to where there are more charging options” (7463).

RESULTS: COMPARISON OF STATE RESULTS

State and region results are compared in this section. There are multiple geographies in this study. The geography of air quality standards is fairly uniform: all the states except New Hampshire share California's air quality standards because under Section 177 of the federal Clean Air Act they have adopted California's standards. All the states except Delaware, New Hampshire, and Washington have also adopted California's PHEV, BEV, or FCEV sales requirements. While NESCAUM is not a policy-making or regulatory body itself, it does serve as a forum for its member states to coordinate information, analysis, and actions across a variety of environmental policy areas. The geography of the market varies between the states and regions as more types of PEVs have been offered for sale for longer in the three western states than in the eastern states. Beyond these, there are many differences in other state policies, e.g., whether states offer incentives for consumer purchase of PEVs and FCEVs and if so what incentives.

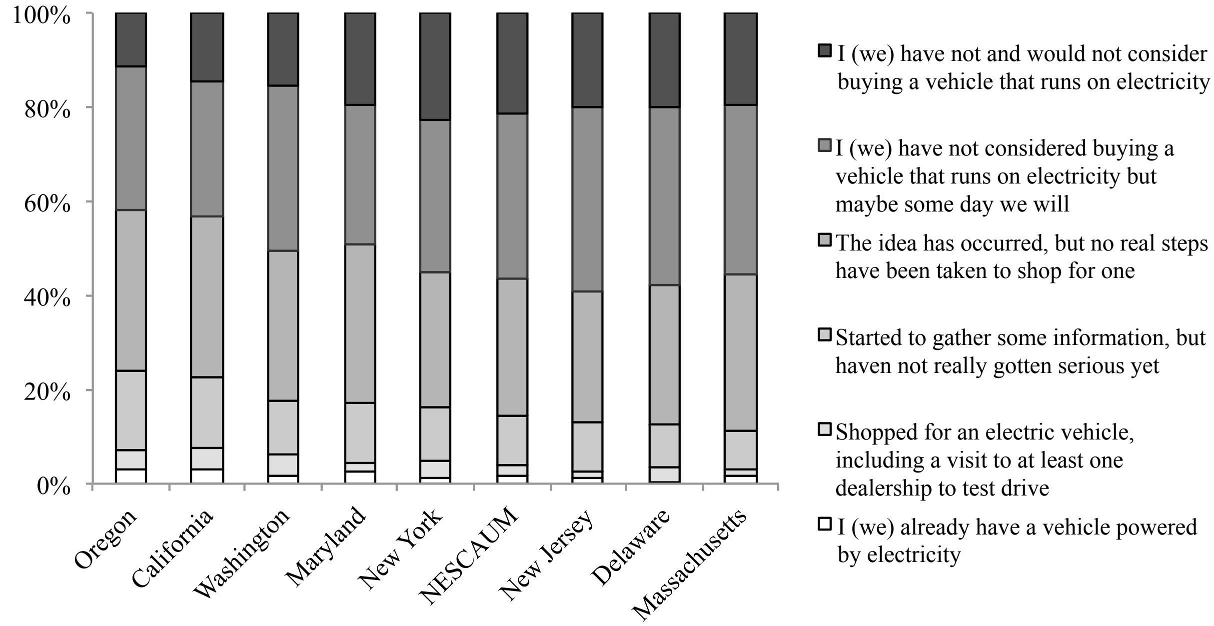
The intent is to explore both general concepts and specific measures indicating whether the multiple state and regional analyses are mutually reinforcing and unifying across the multiple policy and market geographies vs. the extent to which they present idiosyncratic findings for states or NESCAUM. This discussion starts with the measures of prior PEV or FCEV consideration. Then, distributions of drivetrain designs are compared across the state and regional analyses. This will compare both respondents' designs and the multivariate models to explore the explanatory variables in the models of those distributions. Finally, motivations of both those who designed a PEV or FCEV and those who designed an ICEV or HEV will be compared. Because their data has only been used in the aggregate NESCAUM regional study, the reader is reminded data was collected from samples of new car buying households in all NESCAUM states, including Connecticut, Rhode Island, Vermont, New Hampshire and Maine.

PEV and FCEV Consideration

- Levels of prior consideration of PEVs and FCEVs are low among new car buyers across all the study states and the NESCAUM region.
- Respondents are more likely to have higher levels of prior consideration of PEVs in western states than eastern.
    - Oregonians have the highest level of prior consideration of PEVs.
- Prior consideration is higher for PEVs than FCEVs across all states, as one might expect given the tiny number of FCEVs that have been leased and the strictly proscribed regions in which those leases are available at the time of this study (limited largely to small regions within the greater Los Angeles, CA region).
    - In contrast to PEVs, Oregonians had lower levels of prior consideration of FCEVs.

Respondents' consideration of PEVs and FCEVs prior to completing the on-line survey is plotted in Figures 25 (PEVs) and 26 (FCEVs). The order from left to right in each figure is by the sum of the three highest or most active levels of consideration: own a PEV (or FCEV), shopped for one including at least one visit to a dealership, and started to gather some information but not yet serious. Though the differences are small, these higher levels of consideration of PEVs are more common among the respondents of all three western states than of any of the eastern states and the NESCAUM region. Some degree of resistance to PEVs and FCEVs is more common in the eastern states.

Figure 25: Comparison of Consideration of PEVs by state and region



For FCEVs (Figure 26), the highest levels of consideration have been consolidated into a single category as opportunities to lease an FCEV or even test drive one are strictly proscribed to only a few locations in southern California. Using the same principle of ordering the states from left to right by the decreasing incidence of the percentage of respondents at the highest level of consideration, the states are not listed in the same order in both figures. In general, levels of prior consideration of PEVs are higher in every state and region than of FCEVs.

Cross-classifying the distributions of PEV and FCEV consideration by state/region confirms the distributions are statistically significantly different. The data are shown in Tables 11 (PEVs) and 12 (FCEVs).[23] The test is whether the state/region (row) distributions of row probabilities are the same. The very small probability of getting a larger chi-square value indicates we can be quite confident the row probabilities are different. To illustrate the differences, values for each state have been highlighted in **bold** for each level of consideration where there are more people than expected if the row probabilities were the same. The states and regions have then been ordered top to bottom in the table from those states with more people at the higher levels of consideration to those with lower levels. The general flow of **bold** cells from upper left to lower right in both tables illustrates a flow from higher to lower levels of consideration. The western states are highest in consideration for both PEVs and FCEVs—though the ordering is different.

[23] Massachusetts, New Jersey, and New York are not shown separately in Tables 11 and 12 because to do so would double count their data in the statistical tests.

Figure 26: Comparison of Consideration of FCEVs by state and region

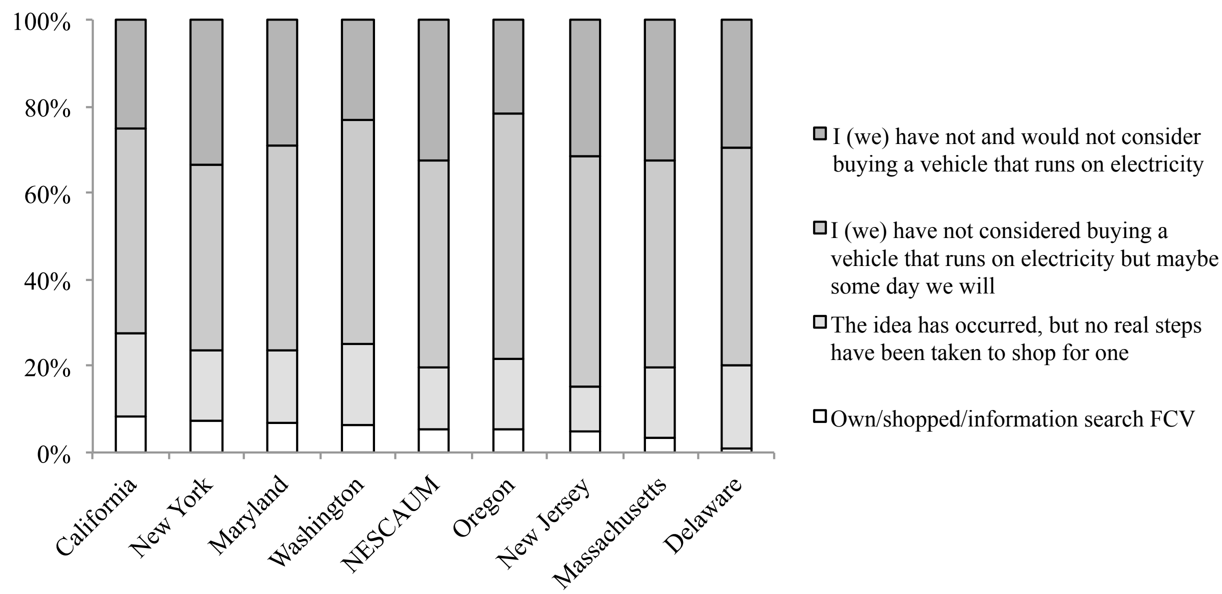


Table 10: State/Region by Consider PEV

Count Row %	I (we) already have a vehicle powered by electricity	Shopped for an electric vehicle, including a visit to at least one dealership to test drive	Started to gather some information, but haven not really gotten serious yet	The idea has occurred, but no real steps have been taken to shop for one	Have not considered buying a vehicle that runs on electricity but maybe some-day we will	Have not and would not consider buying a vehicle that runs on electricity	Total
California	**51** **3.05**	**78** **4.67**	**249** **14.90**	**568** **33.99**	480 28.73	245 14.66	1671
Oregon	**15** **3.04**	**20** **4.05**	**84** **17.00**	**167** **33.81**	151 30.57	57 11.54	494
Washington	8 1.60	**22** **4.40**	59 11.80	**159** **31.80**	**174** **34.80**	78 15.60	500
Maryland	**10** **2.53**	8 2.02	50 12.63	**134** **33.84**	117 29.55	**77** **19.44**	396
NESCAUM	35 1.46	57 2.38	255 10.66	698 29.17	**833** **34.81**	**515** **21.52**	2393
Delaware	1 0.50	6 3.00	18 9.00	59 29.50	**76** **38.00**	**40** **20.00**	200
Total	120	191	715	1785	1831	1012	5654

Note:

Test	**ChiSquare**	**Prob>ChiSq**
Pearson	126.573	<0.0001

Table 11: State/Region By Consider FCEV

Count Row %	Own/shop/ information search	The idea has occurred, but no real steps have been taken to shop for one	Have not considered buying a vehicle that runs on hydrogen but maybe someday we will	Have not and would not consider buying a vehicle that runs on hydrogen	Total
California	**141** **8.44**	**316** **18.91**	793 47.46	421 25.19	1671
Washington	31 6.20	**94** **18.80**	**259** **51.80**	116 23.20	500
Oregon	27 5.47	81 16.40	**278** **56.28**	108 21.86	494
Maryland	**27** **6.82**	**67** **16.92**	186 46.97	**116** **29.29**	396
Delaware	2 1.00	**38** **19.00**	**101** **50.50**	**59** **29.50**	200
NESCAUM	132 5.52	343 14.33	1144 47.81	**774** **32.34**	2393
Total	360	939	2761	1594	5654

Note:

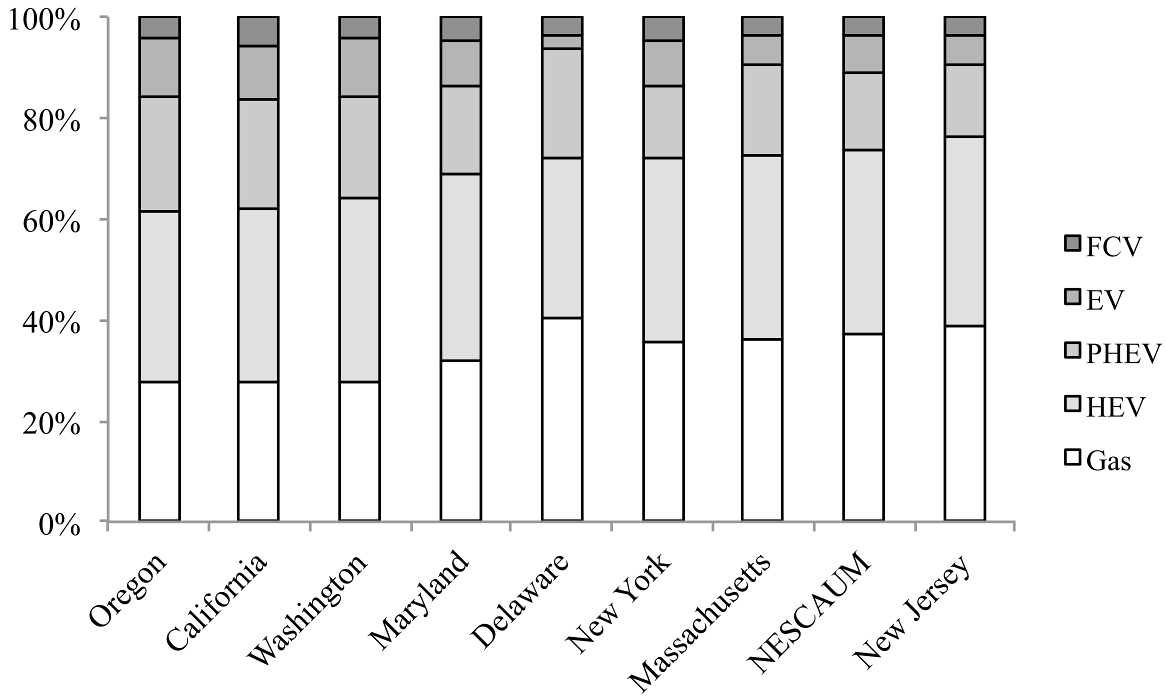
Test	**ChiSquare**	**Prob>ChiSq**
Pearson	78.524	<0.0001

PEV and FCEV Valuation: Drivetrain designs

- In every state and region, fewer respondents design a next new vehicle for their household to be a PHEV, BEV, or FCEV than design them to be ICEVs or HEVs.
- Still, between one-fourth and two-fifths of new car buyers appear ready to consider a PEV or FCEV for their household, i.e., they design such vehicle in the design games.
- The differences between states in drivetrain designs—and in particular between western and eastern states—is greater than the differences in prior consideration.
- The states and NESCAUM region range from a high of 39 percent in Oregon to a low of 27 across the NESCAUM region that designs a PHEV, BEV or FCEV.

The distributions of drivetrain designs are compared in Figure 27. The results are much the same as for prior consideration: higher percentages of respondents in the western states create vehicle designs with PHEV, BEV or FCEV drivetrains than do in any eastern state. The NESCAUM member states have the lowest percentage of PEV and FCEV drivetrains. Still, approximately one-in-four respondents throughout the NESCAUM region do design a PHEV, BEV, or FCEV: nearly four-in-ten do Oregon, California, and Washington.

Figure 27: Drivetrain Types from Game 3, ordered left to right from high to low of the total percent of PHEV, BEV, and FCEV designs



Cross-tabulating the distribution of drivetrain designs by state and region samples allows testing whether the drivetrain probability distributions are statistically significantly different.[24] The cross-tabulation is illustrated in Figure 28 and provided in Table 13. The vehicle design distributions in Figure 28 have been ordered by the total of the percent of respondents who design a PHEV, BEV, or FCEV. The mosaic plot in Figure 29 highlights both the differences between western and eastern states (the vertical axis) and the different sample sizes (the width of each column is proportional to sample size).

The order from top to bottom in Table 13 preserves the rank order of the total percent of PEV and FCEV designs. The chi-square test indicates the row (drivetrain design) distributions are not independent of the state/region from which they were drawn. The cells shown in bold are those in which there are more respondents than would be expected if all the state/region drivetrain distributions were the same. The general pattern of a diagonal of **bold** cells from upper right to lower left indicates the difference is caused by a higher proportion of PEV and FCEV designs in the west and lower in the east (and thus higher gasoline ICEV and HEV designs in the east than the west).

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[24] These tests require that Massachusetts, New Jersey, and New York be treated either as individual states or as part of the NESCAUM to avoid double counting. Here, they are aggregated with the other member states into a single regional entity.

Figure 28: Mosaic Plot of Drivetrain Types from Game 3 by state/region, ordered left to right as high to low by total percent of PEV and FCEV designs

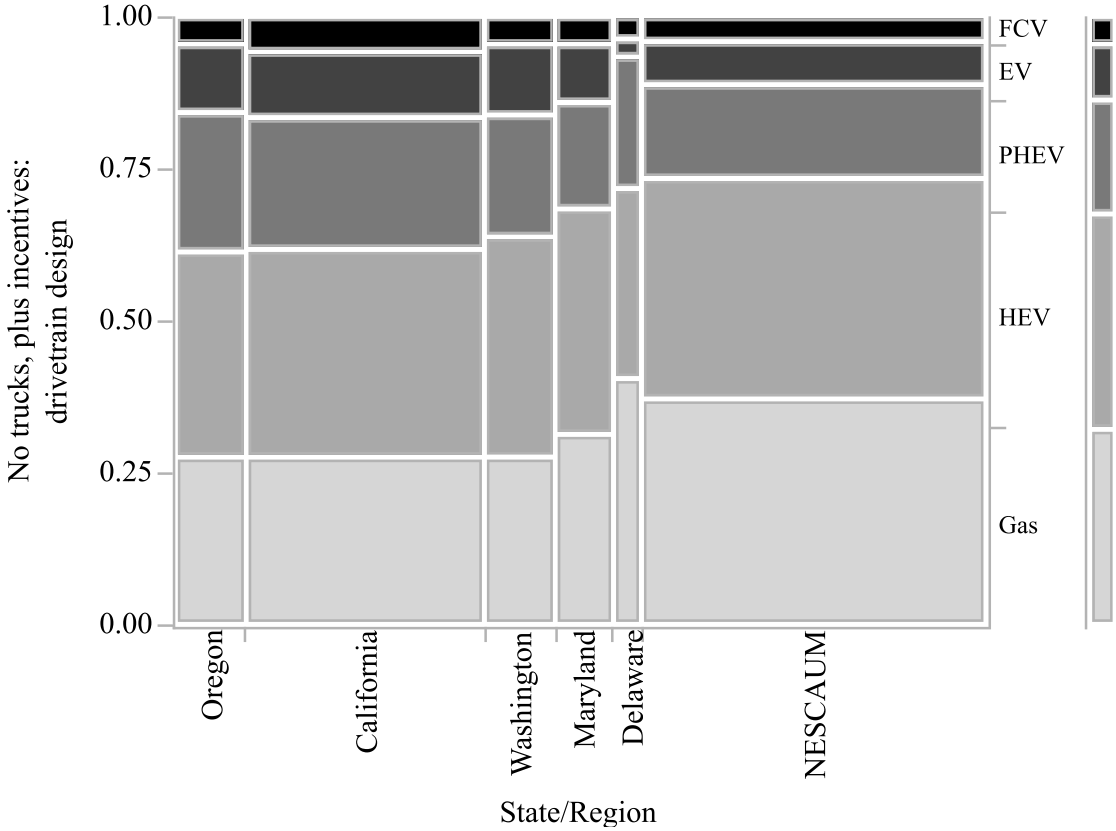


Table 12: State/Region Drivetrain Designs, Game 3

Count Row %	Gas	HEV	PHEV	BEV	FCEV	Total
Oregon	136 27.53	167 33.81	**114** **23.08**	**55** **11.13**	22 4.45	494
California	459 27.52	574 34.41	**358** **21.46**	**184** **11.03**	**93** **5.58**	1668
Washington	138 27.71	**181** **36.35**	**99** **19.88**	**58** **11.65**	22 4.42	498
Maryland	125 31.65	**146** **36.96**	69 17.47	**37** **9.37**	**18** **4.56**	395
Delaware	**81** **40.50**	63 31.50	**43** **21.50**	6 3.00	7 3.50	200
NESCAUM	**890** **37.30**	**861** **36.09**	367 15.38	177 7.42	91 3.81	2386
Total	1829	1992	1050	517	253	5641

Note:

Test	**ChiSquare**	**Prob>ChiSq**
Pearson	106.270	<0.0001

PEV and FCEV Valuation: Who designs their next new vehicle to be a PHEV, BEV, or FCEV?

Logistic regression models of the respondents' drivetrain designs, i.e., the primary measure of which respondents have a sufficiently positive valuation of PEVs or FCEVs to seriously consider one for their household, were created for each state and the NESCAUM region. The explanatory variables from those models are summarized in these categories:

1. Socio-economic, demographic, and political descriptors of the respondents and their households;
2. Characteristics of household vehicles, travel, and residences;
3. Attitudes regarding the policy goals of PEVs and FCEVs: air quality, climate change, and energy supply and security; and,
4. Measures of awareness, knowledge, and experience as well as prior assessments of PEVs and FCEVs and of electricity and hydrogen as replacements for gasoline and diesel.

The question addressed in this section is not what are the most influential variables, i.e., the variables that have the highest correlation with the distribution of respondents' vehicle designs. Rather, the question addressed here is which explanatory variables are particular to one or a few states and which are pervasive across states and the different "geographies" of policies and markets they represent.

- Almost no measures of socio-economics, demographics and political affiliations appear in any model of respondents' drivetrain designs, i.e., given the other variables that do appear in the models, these measures offer no real explanation for who presently has a high enough valuation of PEVs or FCEVs to seriously consider one for their household.
- The contextual measures appearing across the largest number of state and regional models pertain to whether respondents are likely to be able to charge a PEV at home.
- The measure of vehicle travel that appears in a few models is whether or not the respondent commutes (at least part way) to work in a household vehicle.
  - The model for Oregon is quite different from any other in that several measures pertaining to the households existing vehicles and vehicle travel are included as statistically significant explanatory variables of respondents' PEV and FCEV valuations.
- Of the measures pertaining to policy goals and instruments, those measuring attitudes about air quality are the most common across states and regions.
  - In a few states, whether respondents are aware of federal incentives for alternatives to gasoline and diesel or support the idea of government incentives enter the models of respondents' vehicle designs as statistically significant.
- The conceptual category that provides the most measures of respondents' drivetrain designs is the category containing measures specific to PEVs, FCEVs, electricity, and hydrogen.
  - Whether electricity and/or hydrogen is already believed to be a likely replacement for gasoline and diesel;
  - Personal interest in ZEV technology;
  - Familiarity with all vehicle drivetrain types included in the design games: ICEVs, HEVs, PHEVs, BEVs, and FCEVs;

- Prior assessments of PEVs and FCEVs on six dimensions: charging/fueling, purchase price, safety, and reliability;
- Experience driving vehicles of the different drivetrain types;
- Whether respondents have already seen PEV charging in the parking facilities they use; and,
- Extent to which respondents have already considered acquiring a PEV or FCEV.

Socio-economic, demographic, and political measures

Socio-economic and demographic measures test for whether the profile of the early applicants for California's Clean Vehicle Rebates (CVR) defines some sort of boundaries on who might be expected—at least at present—to be interested in PEVs and FCEVs. The socio-economic and demographic profile of those early PEV buyers and lessors in CA is that they are much more likely to be male, upper-middle age, very high-income men with several years of formal education. They are much more likely to own their residence and for that residence to be a single-family home. Political measures are added to help explain whether differences in valuation of PEVs and FCEVs are shaped by political party affiliation or beliefs about the role of government specifically to incentivize vehicles powered by electricity and/or hydrogen.

Appendix C shows that in general socio-economic, demographic, and political measures are not retained as statistically significant explanatory variables in the final models of respondents' drivetrain designs. New York is the only state for which the variable for respondent gender is retained. That New York is a large part of the NESCAUM data may explain why gender also appears in the NESCAUM model. Education is also retained in the NESCAUM model. The effect of respondent gender in New York is contrary to the profile of early applicants for California's CVR—holding all other variables constant at their baseline values, women are more likely than men to design anything but an ICEV. On the other hand, the effect of the education variable in the NESCAUM region is in keeping with that profile of early PEV drivers: more years of education are associated with a higher probability of designing anything but an ICEV. Still, the overall conclusion is that when measures in the other conceptual categories are accounted for (by their inclusion in the model), measures of socio-economics, demographics, and political affiliation do not explain differences in interest in drivetrain types.

Contextual measures: existing vehicles and their use; residences

Respondents' existing vehicles, travel, and residences establish context for their adaptation to vehicles with different operating characteristics such as the limited range per charge combined with home charging of PEVs. In all the state and regional models except Maryland, at least one of these measures is a statistically significant explanatory variable in the state or regional model of drivetrain designs. Though more measures of these contextual factors appear in more state and regional models than do socio-economic, demographic and political measures, it is still the case that comparatively few measures of existing vehicles, travel, and residences have much explanatory power when measures from the other categories are included.

Measures of existing vehicles and their use appear in the models for Oregon, New Jersey, New York, and NESCAUM. Oregon is unique in the emphasis of existing vehicles and their use on the distribution of drivetrain design—five variables pertaining to cost (vehicle price, fuel spending, and fuel economy), use (commuting), and the flexibility within the household for different drivers to use different vehicles. Of these, only the measure for whether the respondent commutes (at least part way) to work in a household vehicle is found in the models for New Jersey and NESCAUM. The model for New York is singular for its inclusion of the measure of how many miles the respondent drives.

A common measure for the ability of the respondent to charge a PEV at home appears in the models for California, Washington, Delaware, and Massachusetts; a different measure appears in the NESCAM model. The measure found in multiple state models has to do with whether electrical service is available at the location they park at home; for NESCAUM the variable simply assesses whether at least one household vehicle is parked in a garage or carport attached to the residence. For Massachusetts, an additional variable distinguishes whether the respondent could install a new electrical outlet near where they park at least one vehicle at home on their own authority or would require permission from some other person or group.

Attitudes related to policy goals: energy security, air quality, and global warming

Relative support for pro-social goals may explain differences in respondent valuation of different drivetrain types. Six of the nine state and regional models include some measure related to air quality that is associated with differences in drivetrain designs. One state model includes measures specific to incentives for alternatives to gasoline and diesel fuel. The NESCAUM model includes both a variable related to whether there is an urgent need for a national transition to alternatives—without specifying why such a transition is needed. It also contains a factor related to respondents' assessments of whether electricity or gasoline poses greater environmental and human health risks in their region—again though without specifying what aspects of the environment or human health are at risk. No models contain measures related to climate change.

Respondents' assessments of air quality includes whether they view air pollution as a "health threat in their region," a "personal worry," and subject to lifestyle choices of individuals. In California, Maryland, and Massachusetts a factor that combines regional threat and personal worry is associated with differences in drivetrain designs. In New York and Washington, the emphasis is on the personal risk aspect of air pollution. Finally, in Oregon the element of personal lifestyle affecting air quality is the measure associated with drivetrain designs.

In California, Delaware and New Jersey variables measuring awareness of and support for government-provided incentives to consumers are associated with valuation of PEVs and FCEVs.[25] In New Jersey both the variable measuring awareness of federal incentives and another assessing whether governments should offer incentives (or leave the matter to "markets") are associated with drivetrain designs. Note the presence of the variable in the model for New Jersey does not mean that new car buyers in the Garden State are more likely to have heard of the federal tax credit than respondents from other states. It simply means that of all states, only in

[25] For purposes of modeling PEV and FCEV valuation, the measure of incentive awareness was limited to the federal tax credit as it is the only incentive available to all respondents in every state. That is, interpreting the answers to the question about whether respondents have heard whether their state is offering incentives depends on whether their state is offering incentives, what those incentives are, how long they have been offered, whether they are offered (or of value) to residents throughout the state, and how vigorously they have been promoted.

New Jersey is whether they have heard of the federal incentive associated with their likeliness they incorporate different drivetrains in their vehicle designs. This same variable on the role of government in providing incentives is statistically significant in California. The variable measuring awareness of federal incentives is also retained in Delaware's model.

Prior PEV and FCEV Evaluation and Experience; PEV and FCEV-specific attitudes

The final category of variables includes those most specific to PEVs and FCEVs: drivers prior awareness, consideration, and assessment of the vehicles as well as their "fuels," electricity and hydrogen. Whether a respondent believes electricity or hydrogen is a likely replacement for gasoline and diesel fuels is associated with whether she or he designs a PEV or FCEV. Only in California is their belief about both electricity and hydrogen associated with drivetrain design; in the other five states and the NESCAUM region it is only one or the other (and hydrogen may matter in the NESCAUM region because it matters in both Massachusetts and New Jersey).

Whether the respondent has a specific interest in ZEV technology or more generally whether there is someone in their household, "friends and extended family would describe as being very interested in new technology," are statistically significant variables in five state models and the NESCAUM model. The personal interest of the respondent may be significant in the NESCAUM model because it is the New Jersey and New York models.

Questions about respondents' familiarity with the types of vehicles they would be asked to design later in the questionnaire were framed in terms of whether the respondents believed they are familiar enough "to make a decision whether one would be right" for their household. Questions addressed each of the five main drivetrain types in the study: ICEVs, HEVs, PHEVs, BEVs, and FCEVs. Broadly, differences in familiarity with different drivetrain types are associated with differences in drivetrain designs, i.e., PEV and FCEV valuation, in four of the state models and the NESCAUM model. California is notable in that familiarity with all five types is associated with resulting designs. In general, higher self-rated familiarity with HEVs, PHEVs, BEVs, and/or FCEVs is associated with a higher likeliness to design one as a plausible next new vehicle for the household.

Respondents may have had preconceptions or prior evaluations of PEVs and FCEVs before they started their questionnaire—or as seems likely given the analysis of the survey and interview data, may have constructed some initial evaluation during the course of completing their questionnaires. They were presented a series of statements on PEVs and another on FCEVs and asked to rate the strength of their agreement or disagreement. The items included their ability to charge a PEV at home, whether they think there are enough places for PEV charging or FCEV fueling, how long it takes to charge a PEV or fuel an FCEV, whether PEVs and FCEVs travel far enough, and how PEVs and FCEVs compare to gasoline powered cars on purchase price, safety, and reliability. Whether tested as individual items for each statement or as a smaller number of factors that combine statements, some variables measuring respondents' prior evaluations of BEVs and FCEVs are associated with their vehicle designs in every state (and the NESCAUM region) except New York and Delaware. Among these measures, those related to PEVs are much more likely to appear as significant explanatory variables than are those for FCEVs: only in California, and only for driving range and fueling time, are prior evaluations of FCEVs associated with respondents' drivetrain designs. The most commonly occurring measure of

BEVs is a factor combining respondents' assessments of the relative safety and reliability of BEVs compared to vehicles powered by gasoline. This indicates an additional dimension to the discussion of PEVs and FCEVs beyond the widely assumed importance of purchase price, driving range, and charging networks.

Actual driving experience was measured through self-ratings on a scale from "none at all" to "extensive driving experience" with each of ICEVs, HEVs, PHEVs, BEVs, and FCEVs. Some of these measures are associated with respondents' vehicle designs in the models for California, New Jersey, and NESCAUM. In all cases, higher experience with HEVS, PHEVs, BEVs, or FCEVs, is associated with higher likeliness of designing such vehicles.

Whether respondents recall seeing charging for PEVs in the parking garages and lots they use is associated with the vehicles they design in the models for six states plus the NESCAUM region. The latter is certainly the case because it is true for the models for Massachusetts, New Jersey, and New York.

The last set of variables is the extent to which respondents have already considered a PEV or FCEV for their household. The measure of prior consideration of a PEV appears in the models for every state and the NESCAUM region, except Washington. Prior consideration of an FCEV does appear in the model for Washington, as well as those for California, Massachusetts, New York, and NESCAUM.

Post-Game Motivations: Why *do* respondents design PHEVs, BEVs, and FCEVs?

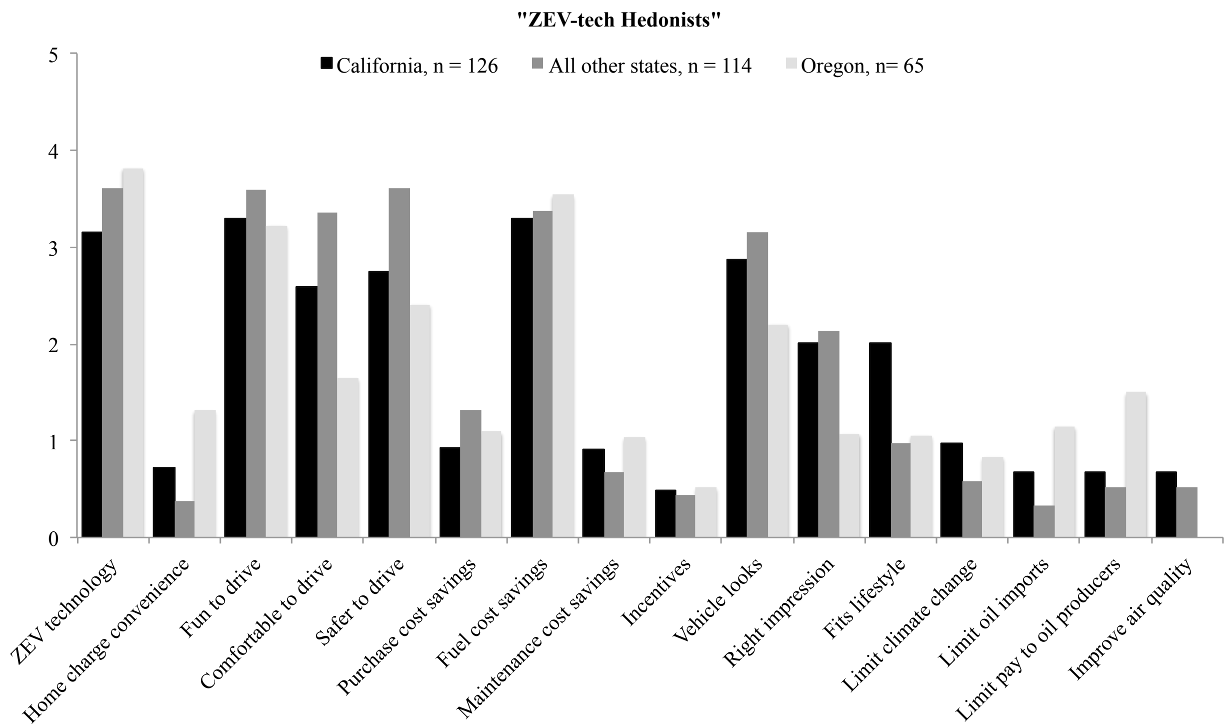
- Clusters of respondents who share similar motivations are identified across states and the NESCAUM region.
- Interest in PHEV, BEV, or FCEV technology and saving on fuel costs are nearly universal motivations across these clusters.
- The clusters are distinguished largely by whether they share pro-social motivations such as air quality, climate change, and energy supply and security, cost motivations, or private benefits such as seeking fun, safe vehicles and private cost savings.

The same analysis of post-game motivations was performed for the other participating states. The comparison here is of Oregon to California and the aggregate of all states other than California. Figure 29 through 32 illustrates the results of a four-cluster solution from the cluster analysis of California compared to the four-cluster solution for the aggregate of the other states. The question these figures address is whether the same four clusters of motivations exist for designing PEVs and FCEVs. The answer is generally, yes. Though there is no specific statistical test, the figures illustrate that at least for three of the four clusters identified for California, it is possible to match them to clusters of similar motivations for designing PEVs and FCEVs for New York and the aggregate of all states except California.

There is little difference in the mean motivations scores in Figure 29 between CA and all the other states for the cluster identified in California as "ZEV-tech Hedonists": people who on average have no highly scored pro-social motivation but appear to think a vehicle powered by an electric motor will simply be the best car: a fun, comfortable car that is safe to drive, good looking, makes a good impression on family and friends, and is fuel economical. This cluster for

Oregon does not score as highly on some of the social impression and lifestyle motivations, but does share high interest in ZEV technology they believe will produce cars that are fun to drive and will save on fuel costs.

Figure 29: Mean motivation scores for "ZEV tech hedonists"



A close mapping is also possible for clusters identified as "Pro-social" (Figure 31), though in Oregon, the ancillary related motivation appears to be more fuel cost savings than interest in ZEV technology. On average, respondents in this cluster score highly all pro-social motivations: climate change, energy supply and security, and air quality. In naming this cluster, emphasis was given to interest in technology over fuel cost savings in CA and the aggregate of all other states because the convenience of home charging follows directly from the new technology. The cluster for Oregon does not, on average, highly score home charging as a motivation.

The analyses produce "generalist" clusters (Figure 31) though these are not as similar as those in Figures 29 and 30. In California and the aggregate of all other states, these clusters draw from across all categories of motivations: ZEV technology, driving performance, costs, and pro-social motives. The "CA Thrifty environmentalists" differ from the generalists for the aggregate of all other states in that they place less emphasis on most all the vehicle performance and personal and social impression motivations, e.g., fun, comfort, looks, making a good impression and lifestyle. The "CA thrifty environmentalists place more emphasis on than the other generalists on purchase cost savings. For Oregon, this cluster has lower concerns for climate change than the pro-social cluster, but puts a very high mean score on home charging convenience.

Figure 30: Mean motivation scores for “Pro-social” clusters

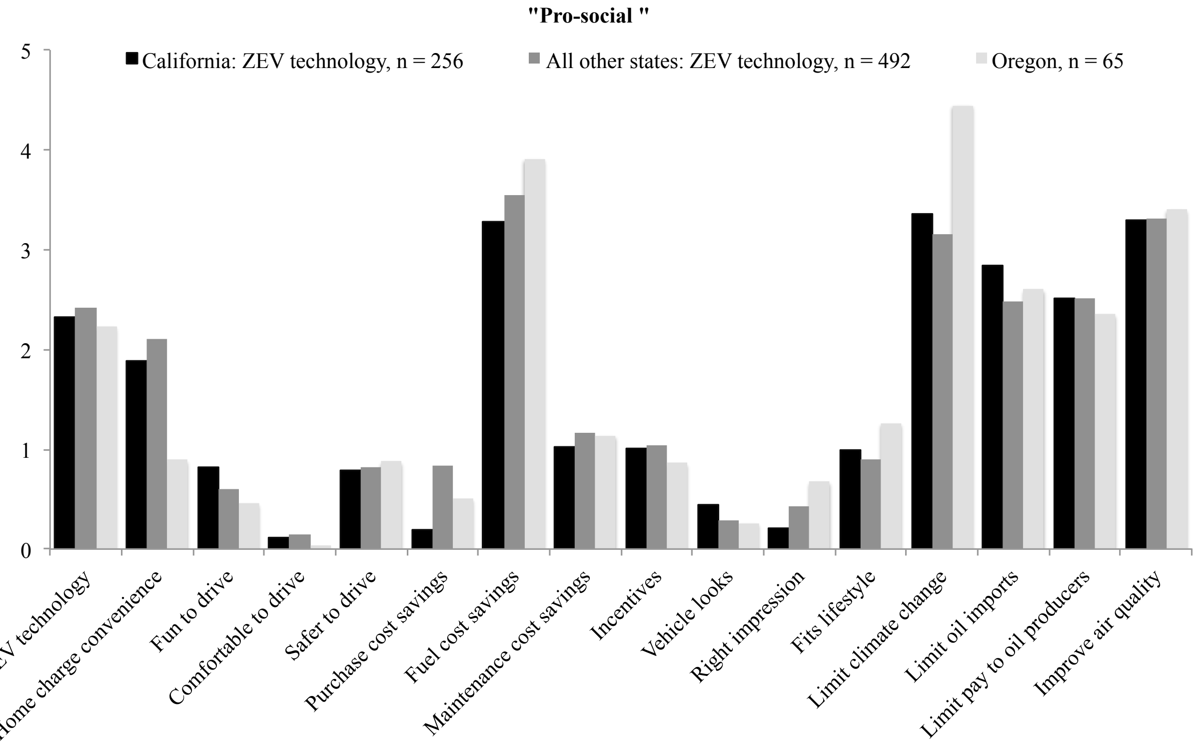
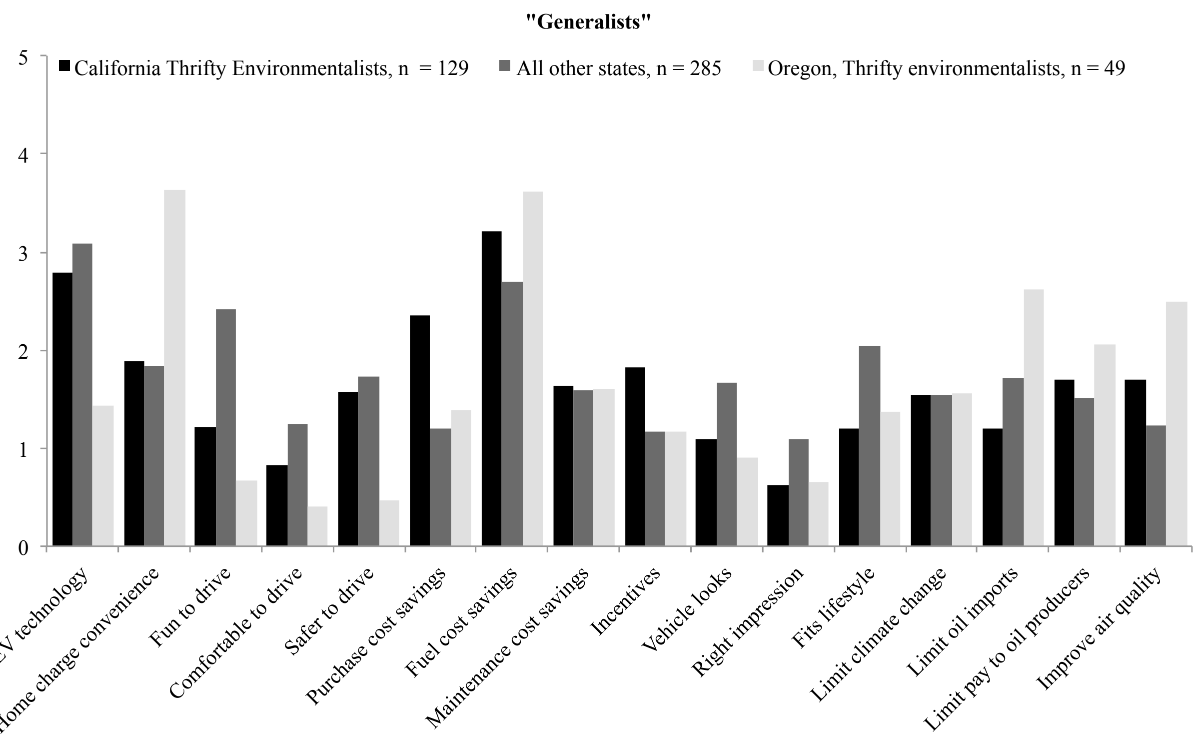
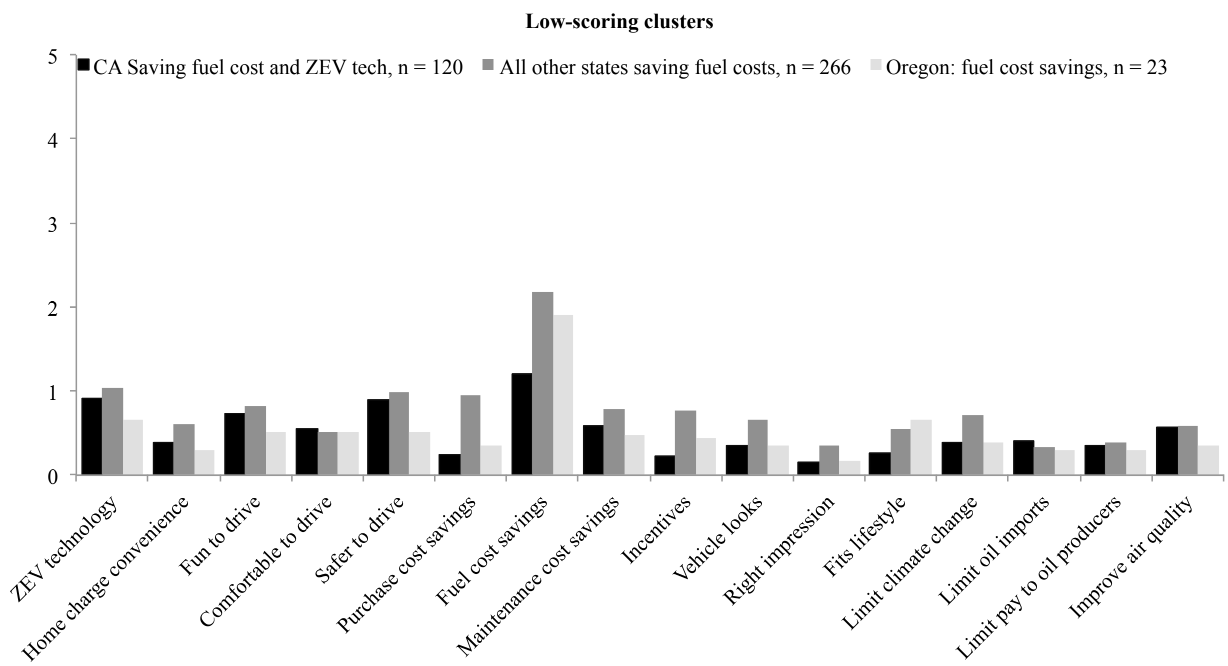


Figure 31: Mean motivation scores for “Generalists” clusters



Finally, all three analyses reveal that the attribute around which some respondents cluster is that they spent far fewer points in the motivation exercise than the other clusters in their analysis. These three clusters are shown in Figure 32. Even here though, the pervasive importance of interest in ZEV technology and an expectation of fuel costs savings can be seen. First, the "All other states" and Oregon clusters emphasize fuel cost savings. While no cluster mean for the low-scoring California cluster is above the global average for California, a review of the individual score distributions for these respondents indicates a plurality highly score either “ZEV technology” or “Fuel cost costs.”

Figure 32: Mean motivation scores for low scoring clusters.

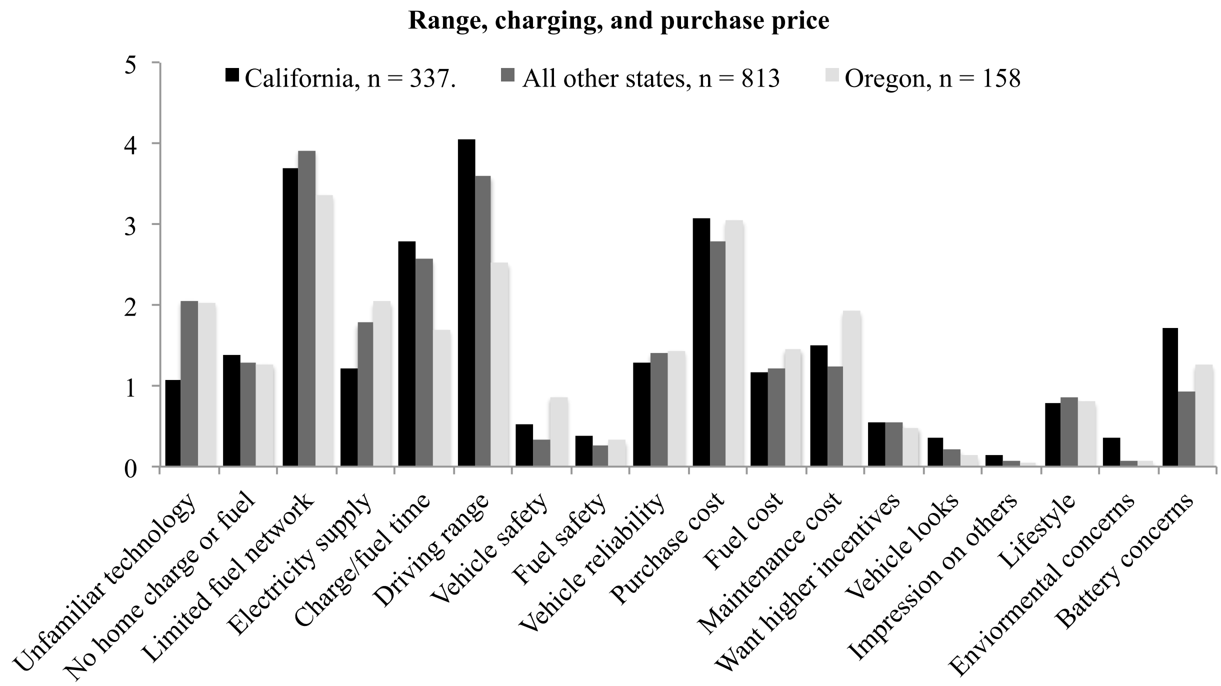


Post-Game Motivations: Why *don’t* respondents design PHEVs, BEVs, and FCEVs?

Motivations of those who design ICEVs and HEVs for not designing a PEV or FCEV are compared here. Clusters of respondents appear broadly similar between California, the aggregate of other participating states, and Oregon. Cluster mean scores are shown in Figures 33 through 35 for a three-cluster solution for California, the aggregate of all other states and the three-cluster solution for Oregon presented earlier.

Figure 33 illustrates a cluster from all three analyses that had several highly scored motivations for not designing a PEV or FCEV, especially concerns about driving range, away-from-home charging/fueling networks, and vehicle purchase prices. For Oregon, this is the cluster identified as "broad concerns" in the state specific analysis presented above. Though the order differs for each analysis, the top three concerns are the same.

Figure 33: Mean motivation scores for "Range, away from home charging, purchase price."



In Oregon and for the aggregate of all states other than California, there is a cluster with high mean motivation scores across several categories: technology, charging, vehicle performance and safety, and concerns about batteries (Figure 34).

There is no such broadly (and highly) concerned cluster in California. The highly scored motivations against buying a PEV or FCEV in the final cluster for California center on an inability to charge a PEV at home, concern for sparse networks of away-from-home charging/fueling, the impacts of charging on electricity supply, and the unfamiliar technology.

As seen in the state-specific analysis for Oregon, examination of the individual motivation scores for respondents in the low-scoring clusters (Figure 35) reveals the ubiquity of concern for unfamiliar technology across the states and region of this analysis. Other concerns may be seen to amplify or elaborate on this basic motivation against designing a PEV or FCEV

Figure 34: Mean motivation scores for clusters with concerns across all categories

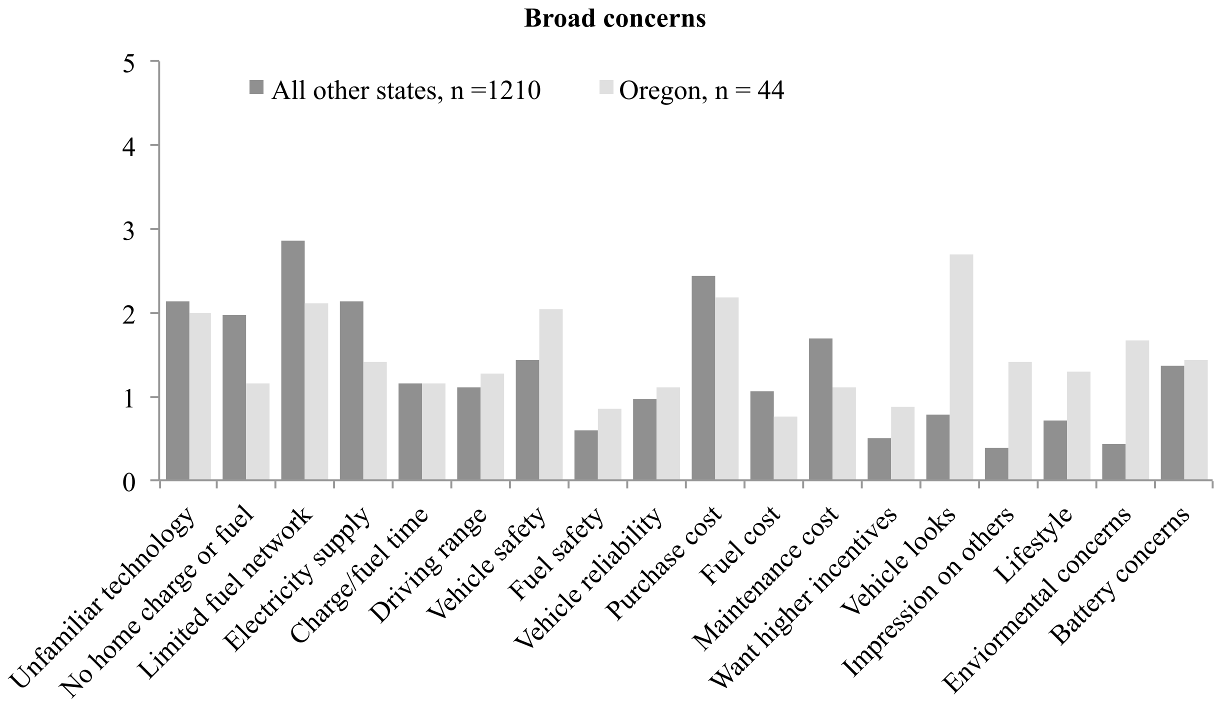
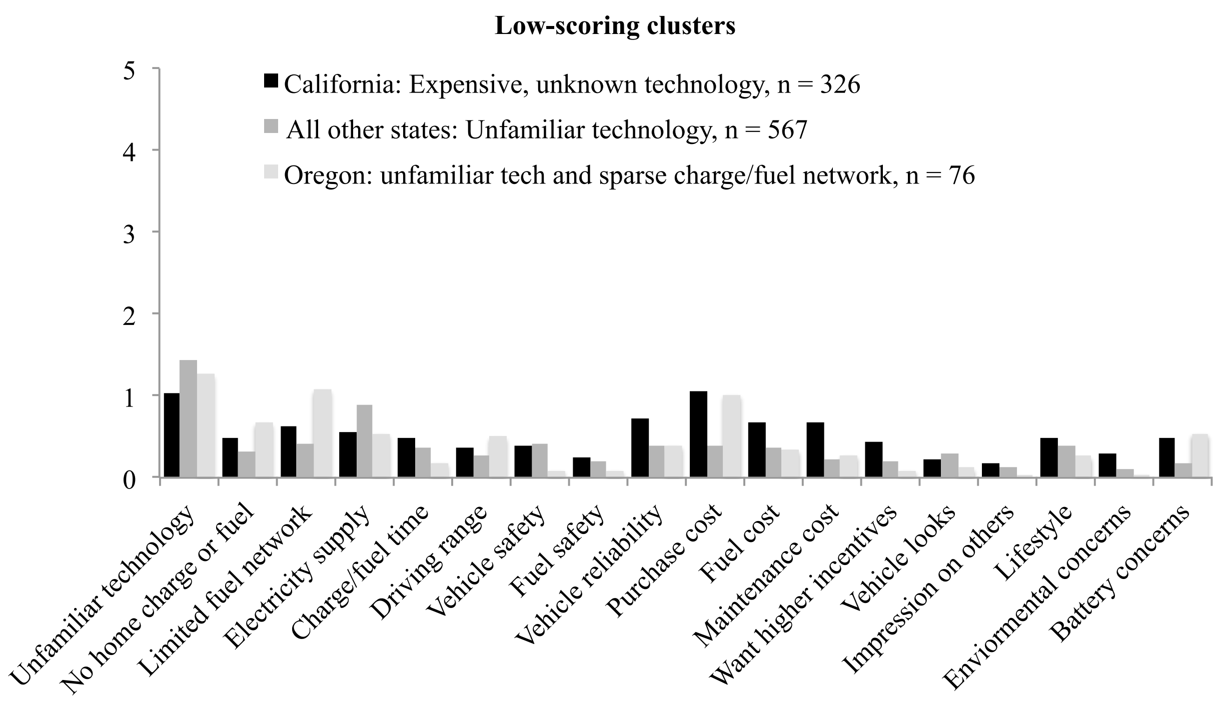


Figure 35: Mean motivation scores for low-scoring clusters



RESULTS: POPULATION-LEVEL ESTIMATES OF NEW-CAR BUYING HOUSEHOLDS WITH POSITIVE PHEV, BEV, OR FCEV VALUATIONS

Combining data from several sources allows an estimate of the total number of households that are represented by the survey respondents who designed a PHEV, BEV, or FCEV in the final design game. These calculations are summarized in Table 13. The second through fourth columns estimate the number of households that meet the definition of "households who acquire new vehicles" used in this study: households who have acquired a new vehicle in the seven years prior to fielding the on-line survey in December 2014. The fourth column—Buy new vehicles, %—is an estimate based on data for California only, thus the estimates for all other states and regions depends on the assumption this percentage in other states is similar. Taking the product across each row produces the Population Estimate in the sixth column. The result is that something like three million households—who already spend the income, wealth, or credit it takes to buy new cars—sufficiently value the idea of a vehicle that runs on electricity (in part or in whole) or hydrogen to design one as their household's next new vehicle.

Table 13: Population-level estimates of new-car buying households with positive PHEV, BEV, or FCEV Valuations

	Households, 1,000s[1]	Vehicle available[2]	Buy new vehicles, %[3]	Design PEV or FCEV in Game 3	Estimated Households with Pro-PEV or FCEV Valuations, 1,000s
Oregon	1,523	92%	33%	38.7%	181
California	12,617	92%	33%	38.1%	1,476
Washington	2,645	93%	33%	35.9%	295
Maryland	2,156	91%	33%	31.4%	204
Delaware	339	94%	33%	28.0%	30
New York	7,256	70%	33%	27.9%	474
Massachusetts	2,538	87%	33%	27.7%	205
New Jersey	3,188	88%	33%	23.7%	222
NESCAUM[4]	16,078	81%	33%	26.6%	1,151
Total[3]					3,337

1. US Census http://www.census.gov/quickfacts/table/HSG010214/00

2. American Community Survey. Figures are as of July 1, 2014.

3. Based on a survey in November 2014 by UCD of all car-owning households in California the subset estimated to meet the definition of new car buyers used in this study.

4. Does not double count Massachusetts, New York, and New Jersey as part of NESCAUM.

DISCUSSION

Part of the overall framework for this study was to trace consumers through awareness, knowledge, and valuation of ZEVs. A valuation—does the respondent think there is a ZEV they would buy for their household in the near-term—does not have to be based solely on knowledge of ZEVs, their technology, supporting infrastructures, social goals, and private performance attributes. A valuation does not have to be based on accurate knowledge, but can be based on what the respondent thinks they know, whether that "knowledge" matches that of other consumers, ZEV engineers and designers, policy makers or other experts. A valuation likely does depend on awareness—consumers are unlikely to form valuations of things of which they are entirely unaware. Following from this, the vehicle design games are not an attempt to estimate markets but to explore new car buyers' present valuations of ZEVs—no matter how imperfectly formed—and to understand whether and how those present valuations can be affected.

Lack of awareness, knowledge, and experience

In Oregon—where PEVs are presently offered for sale—the results of this research indicate a lack of general consumer awareness of this basic availability is the first problem to be overcome to expand ZEV markets, followed immediately by aiding consumers to learn what it is they don't know (or to unlearn what they think they know but is incorrect) about ZEVs.

Name recognition of the available BEVs is low. Barely three-of-ten respondents in this sample of new-car buyers could name a BEV sold in the US at the time of the survey—and more than nine-of-ten of those respondents name one of only two BEVs. At this early stage of introducing PEVs, it may seem picky to disallow valid names of PHEVs as answers to the question of naming a BEV, but the inability of consumers to distinguish BEVs from PHEVs—and PHEVs from HEVs—speaks to the core problems measuring familiarity and distinguishing what people know from what they think they know about PEVs and FCEVs. The distinction between charge-depleting modes of PHEVs—all-electric operation (for example, BMW's i3 with range extender) vs. assist (for example, Toyota's Prius Plug-in)—is another source of profound confusion. While this confusion can be inferred from the survey data, the follow-up interviews add supporting insights. Interviewees were routinely confused by the differences in operating modes of PHEVs; some had avoided "all-electric" operating modes in PHEVs because they believed they would be stranded when the battery discharged.

Misunderstandings about HEVs, PHEVs, and BEVs provides a partial explanation for why so many more people design HEVs in the survey than buy them in the real world, but also provides encouragement that some consumers would more highly value PHEVs—especially those with all-electric charge-depleting operation—if those people understood how the different vehicles operate.

If many people don't understand the distinctions between HEVs and PHEVs in particular, why do nearly four-in-ten survey respondents design a PEV or FCEV for their next new vehicle, especially compared to existing sales (leaving aside that FCEVs were not for sale in Oregon)? Again, the survey is not intended to estimate market share, but to assess whether (and which) consumers are forming positive or negative valuations of ZEVs. Differences between the "game world" and the real world illustrate this. On the supply side in the real world, not all manufacturers have offered PEVs since sales started (nor do all offer at least one, now). Nor do all dealerships carry PEVs, even if the manufacturer(s) they represent make them. On the demand side in the game world, we have allowed respondents to start their design with any make/model vehicle they want, so that many issues of brand, body style/size, performance, and any other idiosyncratic feature of a vehicle they want is available to them in the game world that aren't available in the real world.

In general, the assertion that respondents are unfamiliar with ZEVs is supported by self-ratings of their familiarity with ICEVs, HEVs, BEVs, PHEVs, and FCEVs. Not only do familiarity scores drop on average as we move from start to finish of this list, but the percentage of people even willing to offer an answer declines, too. The assertion is further supported by respondents' limited or absent driving experience with HEVs, PHEVs, BEVs, and FCEVs. Finally, the assertion is further supported by respondents' answers to whether they had already considered buying a BEV or FCEV prior to completing their on-line survey: 7% of new car-buyers in Oregon indicate they have made a real effort to consider PEVs; for FCEVs, the figure is 1%.

Prior PEV-related Evaluations

Despite the lack of name recognition, the mistaken concepts about how different PEVs operate, the admitted low familiarity and experience, as well as the limited opportunity to buy PEVs because of their recent and partial introduction to retail markets, a small percentage of respondents claim to have searched for any information (17%), perhaps already visiting a dealership for a test drive (4%), or even acquiring one for their household (3%) for PEVs; for FCEVs, 5% have started to gather information.[26] Despite these claims, the Oregon sample has slightly lower incidence of awareness of federal incentives (42%) than the average across the study states. Awareness of OR state incentives for consumers to purchase vehicles fueled by alternatives to gasoline and diesel is low (17%) in comparison to awareness of federal incentives. In contrast, the Oregon respondents are the most likely in any state to indicate they have seen PEV charging in the parking lots and garages they use. Other concepts that appear as important to their PEV and FCEV valuations include whether they believe electricity is a likely replacement for gasoline and diesel and whether they personally have an interest in ZEV technologies.

It turns out though that awareness of neither incentives nor PEV charging infrastructure is associated with the vehicle designs created by the Oregon sample. While there are distributions across the Oregon respondents on both these measures of policy and infrastructure deployment, these differences s are not correlated with differences in their vehicle designs.

Four other measures of the respondents' consideration of ZEVs prior to their completing the on-line survey do enter into a multivariate model of respondent valuation of ZEVs, i.e., respondents' drivetrain designs in the third vehicle design game.

1. It matters whether respondents already believe electricity is a likely replacement, "if for any reason we could no longer use gasoline and diesel to fuel our vehicles." Those who

[26] Given these low percentages, we use this opportunity to remind the reader that small percentages compound the problems of drawing precise conclusions about the incidence of behaviors in the population of all new-car buying households in Oregon. Given the results reported here, we are confident very few new car-buyers in Oregon have purchased a PEV, however 3% is not a defensible estimate of how many have.

choose electricity as a likely replacement are estimated to be more likely to design their next new vehicle as a PHEV or BEV (and less likely to design it as an ICEV or HEV).

2. Respondents' prior assessment of the comparative safety and reliability of PEVs and ICEVs is associated with their valuation of ZEVs. The more strongly respondents believe PEVs are more reliable and safer than ICEVs, the more likely they are to design HEVs, PHEVs, and BEVs.
3. Regardless of whether respondents' self-scored familiarity with ZEV technology is based on a solid factual understanding, those familiarity scores are associated with the vehicle designs respondents create. Those who claim a higher familiarity with HEVs, PHEVs, BEVs, or FCEVs are more likely to design something other than an ICEV.
4. Those who have already given any consideration to the question of buying a PEV are estimated to be more likely than those who have not designed their next new vehicle to be a PHEV or BEV.

That these measures of whether respondents have already considered PEVs enter the model of respondents' valuations of PEVs and FCEVs—and that those respondents who have a more favorable evaluation of PEVs claim a higher level of familiarity with HEVs and ZEV technology—support the importance of initiating and shaping such consideration, but are vague as to how exactly to do so. If measures of more specific PEV and FCEV attributes entered the model (and as shown in Appendix Table A, many candidate variables that were tested) those measures would have spotlighted areas for education and information, incentive deployment, infrastructure development, product availability or any of a number of possible specific actions. In the absence of these measures of specific dimensions of PEVs and FCEVs, other aspects of this analysis must inform conclusions and next steps—including other variables that are in the multivariate model.

One of these other variables is the measure of whether lifestyles of individuals affect air quality. On average, Oregonians are less likely than the total sample to believe air pollution is a problem in their region, but are as likely to believe individual lifestyles affect air quality. Inside of those averages are distributions of people who differ in their strength of agreement or disagreement. Whether it is good public policy to convince those Oregonians who are not worried about air pollution in their region to worry is a question for state and regional air pollution regulators, air quality scientists, and public health professionals. Regardless, that those in the Oregon sample who believe the lifestyles of individuals matter to air quality are more likely to design a plausible next new vehicle for their household as a PEV or FCEV suggests a public policy approach to marketing ZEVs.[27]

Motivations for PEVs and FCEVs

What we have called motivations for and against PEVs and FCEVs are different from other variables affecting the likeliness a household designs such a vehicle in that motivations are assessed after the respondents have designed their next new vehicle. In this sense, the questions about motivations are less about inferring what matters to respondents through the exploration of statistical correlation than they are a challenge to the respondent to explain themselves.

[27] The "air quality" community is not monolithic in its acceptance of "clean vehicles"; many in it believe the key to improved air quality is not cleaner cars, but no cars.

Motivations for designing a PEV or FCEV that scored highly across the sub-sample of people who designed one or the other include these:

- To save money on gasoline or diesel fuel;
- I'm interested in the new technology;
- It will reduce the effect on climate change of my driving;
- It will reduce the effect on air quality of my driving;
- It will reduce the amount of oil that is imported to the United States;
- I'll pay less money to oil companies or foreign oil producing nations; and,
- Charging the vehicle at home will be a convenience

Of these, only the link to personal effect on air quality is directly reflected in the modeling results. Still, these after-the-fact explanations indicate personal and social goals ancillary to ZEV-related policy motivate some consumers. For example, some consumers would switch from gasoline to electricity to take control over specific types of spending. Gasoline costs—being ongoing and uncertain—may be accounted for differently than vehicle purchase costs that are more fixed.

Additional insights are gained by examining subsets of respondents who share similar motivations. The most striking finding is a distinction between a group of people who say they were strongly motivated to design a ZEV by all the major public policy issues associated with ZEVs: air quality, climate change, and energy security (the "Pro-social technologists" in Figure 23) and another group who claimed very little motivation by any of these (ZEV-tech hedonists). Pro-social and fuel cost saving motives might not be a surprise, but that a group of respondents would score highly only on motivations of private cost (expecting fuel and maintenance cost savings), a personal interest ZEV technology, and a belief a ZEV can be a fun, comfortable, safe, good looking car that make the right impression on family and friends likely is a surprise. The third group ("Thrifty environmentalists") are motivated by pro-social issues—but only those typically characterized as environmental issues, i.e., climate change and air quality—and fuel and maintenance cost savings. They are the only group who characterizes ZEVs as fitting their lifestyle.

In closing this discussion of groups sharing similar motivations it is worth noting that cluster analysis assigns respondents to clusters probabilistically. That is, there is a less clear-cut distinction between clusters than this discussion may imply. In this instance, it turns out all three clusters contain about the same number of respondents. Hypothetically then, appeals to fuel cost savings (the only motivation scored highly by respondents in all three clusters) and public policy goals should appeal to about two-thirds of those with a positive ZEV valuation. More conventional automotive marketing media may reach the cluster we have labeled "ZEV-tech Hedonists."

Motivations against PEVs and FCEVs: lack of awareness, knowledge, and motivation

Aside from the lack of awareness discussed above, understanding why more people do not have positive valuations of PEV or FCEVs—at least not positive enough to cause them to design one as a plausible next new vehicle for their household—may be more important to understand. Recall these are the top-scoring motivations for not designing a PEV or FCEV:

- Limited number of places to charge or fuel away from home
- Cost of vehicle purchase
- I'm unfamiliar with the vehicle technologies
- Distance on a battery charge or tank of natural gas is too limited
- Concern about unreliable electricity, e.g. blackouts and overall supply
- Cost of maintenance and upkeep
- Concern about time needed to charge or fuel vehicle
- I'm waiting for technology to become more reliable
- I can't charge vehicle with electricity or fuel one with hydrogen at home
- Concerns about batteries
- Cost to charge or fuel

Taken as a whole, this list illustrates that for many people it is the sheer number of questions, uncertainties, and doubts they have that add up to their negative (or at least, not sufficiently positive) valuation of PEVs or FCEVs. Those who do not design a PEV or FCEV echo the argument about low familiarity; the third highest rated motivation for designing an ICEV or HEV is simply "I am unfamiliar with [ZEV] technology."

This leads to the possibility that the list of concerns is a rationalization—a way of explaining in a seemingly reasoned way opposition to something that is simply unknown. The list indicates important barriers to considering PEVs or FCEVs include charging/fueling (away from home networks, fuel/charge at home, time to charge/fuel), costs (purchase, maintenance, and fueling). Solutions to charging at home are likely to be idiosyncratic and specific to each household—but amenable to general actions on codes, standards, and designs for EVSE installations. Beyond some initial threshold of away-from-home charging and fueling locations, addressing concerns about availability of away from home charging is as much about the perception of an extensive fueling network, that is, about developing and disseminating images and information about such networks.

Costs are also amenable to both changes in present costs as well as better information about present costs and trajectories of costs into the future. Purchase costs are susceptible to reduction through incentives such as those offered in the survey (modeled on those actually offered by the federal government and different states and localities) as well as cost/price reductions by vehicle manufacturers over multiple vehicle generations.

Maintenance and fuel costs are discoverable by drivers only over time. Other barriers that share this are concerns about reliability of electricity supply, the ability of an away-from-home network to provide adequate charging/fueling, and coupled with this, the suitability of any particular driving range charge/fueling. While experience might be the best teacher, the problem discussed here is people who aren't interested in accumulating the relevant experience in a PEV or FCEV. Images that make PEVs and FCEVs "normal" can help; the experiences of PEV drivers as related in on-line forums have been important sources of information—to those already inclined to seek them out.

The argument that the greatest barrier to growth of the ZEV market to include these households who, at present, demonstrate a negative valuation of PEVs and FCEVs is their long list of questions and concerns (more than any single question or concern), is borne out by the cluster analysis done on these respondents' motivations. Despite increasing the number of clusters to five (from three for those who did design a PEV or FCEV) in an effort to see whether other top-level ideas would start to distinguish between groups, the main distinction is between one cluster who appears comparatively unconcerned (scoring only slightly above average on two motivations, "unfamiliar ZEV technology" and "limited fuel networks") and two other clusters who have long lists of highly scored concerns: these two clusters score ten and fifteen (of nineteen possible) different dis-motivations well above average. Their shared concerns include "unfamiliar ZEV technology" and "limited fuel networks" (these are the only two highly scored by all three clusters) as well as "vehicle purchase cost." The litany of concerns can be read in Figure 24.

Pro- or Con-ZEV, few are willing to say incentives are important

Financial incentives alone do not overcome the barriers and "dis-motivations" of the people who do not already have a favorable valuation of PEVs or FCEVs. Only 5% of those who did not design a PEV or FCEV strongly indicated that larger incentives would have changed their minds. Simply making the vehicles less expensive doesn't address the litanies of concerns and barriers, perceptual and real. Even for those who did design PEVs or FCEVs, only 8% assigned the maximum value to the statement, "incentives made [a ZEV] too attractive to pass up." Neither did awareness of federal incentives appear in the model of respondents' vehicle designs. The one sign of a positive effect of incentives comes from the difference between the first and third design games: 18% more people designed a PEV or FCEV in the third game (in which incentives were offered, but respondents could not design full-size vehicles with all-electric drive) than in the first game (in which no incentives were offered and thus prices were much higher, but full-size vehicles could have all-electric drive). Keeping in mind that the vast majority of respondents in Oregon choose the optional additional financial incentive (splitting on whether that incentive was for the vehicle or home charging/fueling), the primary effect on the Oregon respondents is for incentives to reduce the upfront costs of acquiring a PEV or FCEV. It is not possible to know from this survey design the effect of the federal incentive alone; ostensibly in the absence of any greater incentive than the equivalent of the federal tax credit, the increase in the percentage of respondents willing to design a PEV or FCEV in the third game would have increased less than 18% from the first game.

Measuring access to PEV home charging

Lack of access to PEV charging at home is one of the motivations against designing a ZEV that earns a higher score than average. Nearly 25 percent of this sample doubt they would be able charge a PEV at home; 13% of those who don't design a PEV or FCEV assign the maximum score to the statement, "I can't charge a vehicle with electricity or fuel one with hydrogen at home." Yet, these measures do not enter the multivariate model, i.e., other variables appear to provide more power to explain respondents' vehicle designs than does access to PEV charging at home.

Since data on self-assessments of whether people have access to electricity at their home parking location are not common, such data would be difficult and expensive to use for home PEV infrastructure and PEV market development. Other, perhaps statistically less powerful but more available data serves the purpose of identifying households who are more or less likely to already have access to electricity at their home parking and to be able to make it available if desired. However, these other variables change our focus from the respondent (their self-evaluation of access) to their physical residential context (ownership, building type). The hazard is that by focusing now on, for example, owners of single family homes because they are most likely to be able to charge PEVs at home, we miss the renter, the apartment dweller, or even the condominium owner who is favorably disposed toward PEVs.

Descriptions of household vehicles and use

The other variables associated with differences in respondents' vehicle designs are descriptors of household vehicles and usage. Three of these variables describe the vehicle most recently acquired as new by the household (total price paid), the vehicle the respondent drives most often (fuel economy of the vehicle and monthly spending on fuel for that vehicle). The other two are related to the households travel routines and (whether the respondent commutes to a workplace) and flexibility (on a scale ranging from exclusive assignments of vehicles to a single driver to deciding everyday which drivers will use which vehicles).

All these are associated with a lower probability of designing an ICEV (and thus a higher probability of designing an HEV, PHEV, BEV, or FCEV):

- Higher price paid for the most recently acquired new vehicle;
- Higher fuel economy of that vehicle;
- Higher spending on fuel for the respondent's most frequently driven vehicle;
- Being a commuter to a workplace; and,
- Greater flexibility within the household to reassign vehicles to drivers.

What is not in the multivariate model?

Socio-economic and demographic descriptors of respondents

Home ownership may be an inexpensive and readily available proxy measure for the probability the resident could charge a PEV at home, but we can't say there are widely available proxy measures for people who are interested in PEVs or FCEVs. That is, measures such as income, age, education, and gender may not be reliable indicators of interest in PEVs or FCEVs—even if there exists at present a specific socio-economic and demographic profile of the earliest PEV buyers. The absence of measures such as age, income, education, and gender from the model of drivetrain designs may have two explanations. First, the sample is limited to new-car buyers. So while not strictly a high-income sample, it is a sample of people who spend a sufficient portion of their income (or credit or accumulated wealth) to buy new cars. Second, the survey data are from a simulation, not actual vehicle sales, and multivariate models control only the effects of variables in the model. This means that in the abstract world of the survey and model, once we have accounted for "constraints" on buying and driving a PEV or FCEV, direct assessments of such vehicles and ZEV policy goals, most general descriptors of people are not important to explaining pro- and con-PEV and FCEV valuations.

CONCLUSIONS

Who is in the Oregon Sample of New Car Buyers? What are Their Prior Notions about ZEVs?

On socio-economic and demographic measures including respondent age, education, employment status as well as home ownership, number of people in the household, and household income, the Oregon sample looks very similar to the total sample from all states. The largest difference between the Oregon sample and the total sample of survey respondents is the gender split; there are far more women in the Oregon sample than in the total sample (or in the Oregon population). However, gender does not enter as an important explanatory concept in the valuation of PEVs or FCEVs in the OR sample.

In general, several concepts may be related to a respondent's valuation of a PEV or FCEV as a plausible next new vehicle for their household:

- Likely replacements for gasoline and diesel fuel;
- Attitudes toward energy security, air quality, and climate change;
- Prior familiarity with the specific technologies that will be explored in the design games, i.e., HEVs, PHEVs, BEVs, and FCEVs;
- Assessment of the comparative risks of electricity and gasoline to the environment and human health in the respondent's region;
- Prior knowledge of the availability of incentives and belief whether the public sector should offer incentives; and,
- General interest in new technology and specific interest in the technical details of vehicles that run on electricity or hydrogen and how they work.

In Oregon specifically, a substantial majority—greater than the majority for the total sample—selects electricity as a likely replacement for gasoline and diesel. Reasons given include it has "already been proven to be effective" and "it is best for the environment." Concerns for air quality and climate differ slightly between the Oregon and total samples: respondents from Oregon on average are less likely to agree that air quality represents a health threat in their region but are as likely as the total sample to agree that they personally worry about air quality and that changes in individual lifestyle affect air quality. The percentage of Oregon respondents (56%) who believe, "Human-caused climate change has been established to be a serious problem and immediate action is necessary" is virtually the same as for the total sample (57%).

Overall, prior awareness and experience—measured in the survey before valuation is assessed—of HEVs, PHEVs, BEVs, and FCEVs is so low that the reasonable assumption is most new car buyers' prior evaluations of these vehicle types are based largely on ignorance. PEV name recognition is comparable in Oregon to other states for which this analysis has been completed: 31% of the sample provides a correct make-model name of a vehicle that is a BEV or comes in a BEV variant. However, Oregon is also comparable to those other states in the extent to which correct responses are dominated by only two vehicles: 95% of all correct names are either Nissan

Leaf or Tesla. Asked to rate their familiarity with HEVs, PHEVs, BEVs, and FCEVs, 15.7% (HEVs) to 34.1% (FCEVs) of respondents say they are unsure or decline to answer. Of those who do respond, the mean familiarity scores are low: compared to a mean score (on a scale from -3 to 3) of 2.54 for conventional vehicles, mean familiarity scores range from 1.52 (HEVs) to -0.80 (FCEVs).

The percentage of the new car buyers in Oregon who have heard the federal government "is offering incentives for consumers to buy vehicles that are powered by alternatives to gasoline and diesel" (42%) is slightly lower than in the total sample (44%). The percentages of those who claim to be aware other entities are offering incentives are far lower for those entities including states, cities, electric utilities, and automotive manufacturers.

If respondents are "familiar enough with these types of vehicles to make a decision about whether one would be right for [their] household," that familiarity was not gained through actual experience with any PHEV, BEV, FCEV, or even HEV. Measured on a similar scale of -3 (none at all) to 3 (extensive driving experience) and excluding those who scored themselves as unsure or declined to answer, the *mean* scores for OR respondents are all increasingly negative across HEVs, PHEVs, BEVs, and FCEVs. The median scores for all four types vary from -2.80 (HEVs) to -2.98 (FCEVs). In short, more than half the sample has *no* driving experience with anything other than ICEVs. This result holds for the total sample, too.

Sightings of PEV charging infrastructure may be the most oft recognized sign of PEVs in those states that have had active programs to deploy workplace and/or public charging. On this measure, Oregon is ahead of all the states in this study: 72% of respondents claim to have seen a PEV charger in a parking garage or lot they use compared to the next highest state (CA, 66%) and the total sample (53%).

Half of Oregon respondents (51%) own two vehicles and 64% own two or more; these figures are similar to the total sample (48% two vehicles; 63% two or more). The "age" distributions of these recently acquired vehicles—whether measured by the model year or year acquired—are similar between Oregon and the total sample. The distributions of self-reported vehicle purchase prices are lower in the Oregon sample compared to the total sample: the median difference is ~$1,000. The vast majority of these vehicles (OR, 95%; total sample, 96%) are fueled by gasoline.

Three-fourths of the Oregon sample (76%) report they own their home, 22% rent, and approximately 2% lease or have some other arrangement. These match the total sample percentages. 80 percent of OR respondents report their residence is a single-family home. Taking ownership and building type together, 68% of all OR respondents reside in a single-family residence they own. Most apartments are rented, as are about one-half of townhouses, duplexes, and triplexes. These multi-unit dwellings have been problematic markets for PEVs as residences of such buildings may not have access to a regular, reserved parking spot and be reluctant—or may lack authority—to install electrical infrastructure to charge a plug-in vehicle.

PEV and FCEV Designs

Respondents' valuations of PEVs and FCEVs are determined in the final design game in which no vehicles are offered with both battery-powered, all-electric drive and full-size body styles however there are incentives offered for PEVs and FCEVs. The vehicle designs that are disallowed by the body size restriction are PHEVs that run solely on electricity until their batteries are depleted (at which point they switch to run as do present day HEVs and any other PHEV) and BEVs; PHEVs that run on both gasoline and electricity until the battery is depleted and FCEVs are allowed as full-size vehicles.

Ignoring for now differences between vehicles within each drivetrain type, e.g., ignoring differences in driving range across the BEV designs created by respondents, 39% of the Oregon respondents design their next new vehicle to be a PHEV (23.1%), BEV (11.1%), or FCEV (4.4%). (As it is important for other policy goals, the single most common drivetrain design is HEV (33.8%)—far out-distancing the prevalence of HEVs in the actual on-road fleet of vehicles and in new vehicle sales.)

PHEV Designs

- PHEV designs were by far the most popular of the PEV or FCEV possibilities: 114 respondents designed a PHEV compared to 55 BEVs and 22 FCEVs.
- PHEV designs emphasize longer range driving on electricity, but a mode in which more gasoline is used, i.e., "Assist" designs (such as the Prius Plug-in) rather than all-electric (such as the BMW i3 with range extender).
- Fast charging at home or at an (initially limited) network of quick chargers is not viewed as necessary by most who design a PHEV; only 25.7% of those who design a PHEV indicate they want the fastest charging offered at home; only 40% incorporate quick-charging capability (away-from-home).

BEV Designs

- So few respondents design BEVs that the following should be regarded as case studies.
- BEV designs incorporate driving ranges from across the spectrum of offered options, i.e., 50 to 300 miles; more than half (56%) design BEVs with ranges of 125 miles or less.
    - The distribution of designs is two peaks at 100 to 125 miles and 300 miles.
- While the single most frequent charging speed would require the installation of a high-power (6.6kW) EVSE, most households (53%) believe they would be satisfied with a charging speed that could be supplied by existing home 110V or 220V circuits

FCEV Designs

- Again, so few respondents design FCEVs that the following are case studies.
- While the driving ranges incorporated in FCEV designs span the options, the longest range offering (350 miles) is favored by most (81%).
- Home H_2 refueling was included in less than half of FCEV designs.

Who Designs Their Next New Vehicle to be a ZEV?

The following are all associated with a higher likeliness of designing the household's next new vehicle to be a PEV:

- Household travel, characteristics of residence, vehicles, and travel
    - Higher purchase price for the most recently acquired new vehicle
    - Higher fuel spending for the vehicle the respondent drives most often
    - Higher fuel economy for the vehicle the respondent drives most often
    - Greater daily flexibility assigning vehicles to drivers
    - Being a commuter to a workplace in a household vehicle
- Attitudes related to policy goals: energy security, air quality, and global warming
    - Stronger agreement that individual lifestyle affects air quality
- Prior PEV and FCEV evaluations and ZEV-related attitudes
    - Prior belief electricity is a likely replacement for gasoline and diesel
    - Stronger agreement that BEVs are safer and more reliable than ICEVs
    - Higher self-rated familiarity with PHEVs, BEVs, or FCEVs
    - Already having considered buying a BEV, including at least an initial search for information

Why do people design PEVs or FCEVs?

- Highly rated motivations to design a PEV or FCEV are a mix of private and pro-social
    - Private: Savings on (fuel) costs, interest in new technology, safer than gasoline or diesel vehicles, convenient to charge at home, and fun to drive.
    - Pro-social: Reducing personal contribution to climate change, oil imports, and air pollution as well as payments to oil producers.

In about equal proportions in this sample there appear to be three groups of respondents who share similar motivations. One group is motivated almost solely by private wants and desires; they score below average on all pro-social motivations, but believe vehicles with electric drivetrains will be fun, good looking, comfortable, safe cars that make the right impression on family and friends. Another group scores highly on all the pro-social issues (energy security, climate change, and air quality), as well as being very highly motivated to save on "fuel" and (to a lesser degree) maintenance costs. The third group is also highly motivated by pro-social issues—but only those typically characterized as environmental issues, i.e., climate change and air quality. They are the only group who characterizes ZEVs as "fits my lifestyle."

Why don't people design PEVs or FCEVs?

- The highest scoring motivations against designing a PEV or FCEV have to do with their inherent newness: limited charging and fueling networks, unfamiliarity with the technology, waiting for the technology to be proved reliable, and high initial purchase price.
    - In addition to high initial purchase prices, maintenance and fueling costs were highly rated concerns.
- Immediate, practical limits on the ability to charge a PEV at home as well as concerns about the overall reliability of electricity supply were highly rated motivations against PEVs.

- Concerns about driving range of BEVs and FCEVS, as well as the time required to charge PEVs, scored highly as reasons to not design a PEV or FCEV.
- Few acknowledged that greater incentives (of the kind offered in the game) would have changed their minds.

As with those who do design PEVs or FCEVs, there appear to be sub-sets of those who do not design them who share motivations. The highest level distinction is between a relatively smaller number of people who are—at least judged by this survey—not particularly concerned about much else other than the fact they are unfamiliar with ZEV technology and all others who have long lists of highly scored motivations against designing their next new vehicle to be a ZEV. These latter groups can be further distinguished from each other by their highest scoring concerns—fuel networks, driving range, and costs vs. inability to charge/fuel at home vs. questioning whether PEVs really are good for the environment vs. concern that ZEVs aren't fun, good looking, comfortable, safe cars that make the right impression on family and friends.

The Role of Government Incentives

While most of those who do not design a PEV or FCEV may be overwhelmed with a long list of concerns, fewer seem outright opposed. When asked about whether they have already considered ZEVs, only 12% of the Oregon sample replies they have not and *would not* consider buying a BEV, 22% an FCEV, and 10% neither one. If an actual opposition (at present) to PEVs and FCEVs seems a small portion of new-car buyers, financial incentives play an unacknowledged role in positive valuations or may not address the first problems of those with negative valuations. We start by observing that prior to the introduction of incentives in the final design game (modeled on incentives offered in the real world) in the design games, few respondents were aware such incentives exist. Offered financial purchase incentives and use incentives, respondents were far more likely to choose financial incentives.[28] In Oregon, this may be largely explained by the relative absence of HOV lanes and tolled road and bridge facilities. Further, despite the dollar value being identical for both the vehicle and home charging, among those who choose a direct financial incentive, respondents split about four-to-three as to which they want.

There appears to be an unwillingness (among those who do design a PEV or FCEV) to credit to the introduction of incentives in the third game to their design of a ZEV despite an 18% increase in the number of respondents designing a PEV or FCEV. Most of those who committed to a PEV or FCEV design did so without incentives. There are few among those unwilling to design a PEV or FCEV who indicate that higher incentives would have changed their minds.

This doesn't mean incentives can be terminated in the real world. Incentives are an important part of the "saving money" motivations some give for PEVs and FCEVs. Incentives are routinely reported to be instrumental to explain differences in PEV sales between states: high in those with high incentives, lower otherwise. Whether or not individual survey respondents are willing to say

[28] Anyone designing a qualifying ZEV was offered the equivalent of the existing federal tax credit and the choice of one other incentive. The other financial incentives were a vehicle purchase incentive (the value was taken from California's present vehicle purchase rebate schedule) or an equivalent incentive for a home EVSE or $7,500 for home H_2 refueling. Use incentives included single-occupant vehicle access to high occupancy vehicle lanes, reduced road and bridge tolls, or workplace charging.

incentives are affecting their choices, incentives have become part of the public discussion of ZEVs, taking them away now erodes part of the "saving money" rationale.

What are the biggest problems for those who don't value PEVs or FCEVs?

Even if a financial hurdle in the form of high purchase prices—which incentives can help push them over—is an important problem, what are the other problems?

1) Lack of awareness that PEVs are for sale. The result is people don't even formulate the question of whether a PEV (or FCEV) is right for their household. The results of this study indicate that despite the availability of PEVs for retail sale, many new-car buyers—people who have been on new car lots in the last few years, shopping for, and buying new cars—don't know PEVs are for sale. This is clear in the difference between answers to questions about familiarity vs. experience, from the lack of BEV name recognition, from the low percentage of people in the sample who already own a PEV that the vast majority of respondents were constructing their valuation of PEVs and FCEVs for the first time while completing the survey.

2) Lack of knowledge and experience. The litany of questions and concerns that most respondents have about PEVs and FCEVs is itself a barrier. Many people simply have too many questions, certainly too many for financial incentives alone to overcome. Answering their questions is an opportunity to build coalitions both on the supply side with vehicle, EVSE, and electricity providers and with communities of interest among potential consumers.

Building a market

Despite being an early market for PEVs, the Oregon sample shows a similar lack of general awareness and knowledge of PEVs and FCEVs. PEV charging infrastructure is one area in which Oregon distinguishes itself—a much higher percent of the Oregon sample claims to have seen PEV charging in the parking facilities they use than in any other state. This does not appear however to have resulted in greater substantive engagement by new car buyers in Oregon with the question of whether a PEV is the right vehicle for them? (Or maybe better phrased as, which PEV would be the right vehicle?)

How do we use these results to build markets for ZEVs? One conceptual model is to view markets as built up from (sometimes overlapping) segments of consumers. Attitudes and beliefs regarding the environment and energy offer some ideas, as do respondents' motivations for—and against—PEVs and FCEVs.

The attachment of pro-social goals such as reduced threats from energy insecurity, climate change, and air pollution to PEVs and FCEVs by the survey respondents points to interest groups around those issues who may be enlisted in a broader campaign to market the idea of ZEVs—as much or more than any specific make and model of vehicle (the latter being the purview of that vehicle manufacturers). Taking another tack, the constituency represented by the automotive enthusiast and consumer press was slow to see the consumer value of HEVs. Automotive reviews contemporaneous with the writing of this report indicate the potential for vehicles powered by electric motors to simply be the best available cars on many metrics including performance and other kinesthetic and aesthetic criteria.[29]

It seems clear from these results that the initial valuations people will form of ZEVs are still to be formed and are therefore subject to shaping through social marketing campaigns including education, outreach, and opportunities for direct experience driving ZEVs. The social marketing of ZEVs could be both broader and more focused: broader in the sense of appealing to all the reasons people have for forming positive valuations, more focused in the sense of crafting messages to appeal to positive motivations and address the concerns of those who do not have positive valuations. As an example of the latter, other work on consumers, PEVs, and green electricity indicates that explicitly co-marketing PEVs and green electricity builds market share for both. For those with positive valuations of PEVs built on energy security, climate change, or air quality, the package of a PEV and green electricity assures the vehicle addresses their motivations. For those who lack a positive valuation of PEVs because they question whether electricity is really cleaner than gasoline and are worried about the effect of many PEVs on electricity supply, tying PEVs to new sources of renewable electricity quiets these concerns.

[29] http://www.npr.org/sections/thetwo-way/2015/08/27/435325951/new-tesla-breaks-consumer-reports-ratings-scale-bolsters-companys-stock

APPENDIX A: POTENTIAL EXPLANATORY VARIABLES

The table summarizes statistical associations between the dependent variable, i.e., the design of the drivetrain in the third design game, and several possible independent variables previewed in the previous section. In general, a threshold of α = 0.05 is used to establish statistical significance.

Table A1: Potential Explanatory Variables, Alternate Hypotheses, and Bivariate Result

Independent (Explanatory) Variable	**Alternate Hypothesis (Rationale)**	**Bivariate Statistical Relationship to Dependent Variable: Drivetrain design**
Number of vehicles	H_a: Households with more vehicles are more likely to design a PHEV, BEV, or FCEV than are households with fewer vehicles. (More experimentation with vehicle types, more body styles in household fleet to accommodate a variety of driving missions, spending more money on vehicles.)	H_o accepted: No significant relationship.
Number acquired as new since 2008	H_a: Households who have acquired more new vehicles since 2008 are more likely to design a PHEV, BEV, or FCEV. (More experimentation with vehicle types, more body styles in household fleet to accommodate a variety of driving missions, spending more money on vehicles.)	H_o accepted: No significant relationship.
Price paid for most recently acquired as new	H_a: Households who spent more are more likely to design a PHEV, BEV, or FCEV. (Spending more money on vehicles.)	H_o rejected: The highest income households are more likely to design BEVs rather than FCEVs.
Respondent's vehicle's monthly miles	H_{a1}: Households who drive farther per month are more likely to design a PHEV, BEV, or FCEV. (Lower "fuel" prices of electricity may be attractive.) H_{a2}: Households who drive less per month are more likely to design a BEV or FCEV. (Existing travel may be more amenable to shorter range BEVs or FCEVs with a limited refueling network.)	H_o rejected: However, the substantive interpretation of the effect is influenced by a few high mileage outliers—longest distance drivers more likely to design HEVs and BEVs.
Respondent's car fuel spending per month	H_a: Households that spend more on fuel per month are more likely to design a PHEV or BEV. (Lower "fuel" prices of electricity may be attractive.)	H_o rejected: Households spending more on fuel are more likely to design BEVs or FCEVs.
Own fuel spending accuracy	H_a: Respondents that know their fuel spending more accurately will be more likely to design a PHEV, BEV or FCEV. (Lower "fuel" prices of electricity may be attractive.)	H_o rejected: Higher levels of self-reported accuracy of knowledge about fuel spending are generally associated with a higher likeliness of designing an HEV, BEV, or FCEV.
Household total fuel cost	H_a: Households who spend more on fuel for their whole fleet of vehicles will be more likely to design a PHEV, BEV, or FCEV.	H_o rejected: Higher total fuel cost associated with a higher likeliness to design an FCEV.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	(Lower "fuel" prices of electricity may be attractive.)	
Accuracy of total fuel cost	H_a: Households that know their fuel spending more accurately will be more likely to design a PHEV, BEV or FCEV. (Lower "fuel" prices of electricity may be attractive.)	H_o rejected: those who claim the highest accuracy of total fuel spending are more likely to design a BEV or FCEV.
Replacement for gasoline and diesel: electricity	H_a: Households who are already inclined to believe that electricity is a likely replacement for gasoline and diesel will be more likely to design a PHEV or BEV. (Predisposition toward electricity; may have already spurred search for information.)	H_o rejected: If already inclined to believe electricity will replace gasoline and diesel, then more likely to design anything but ICEV or FCEV.
Replacement for gasoline and diesel: hydrogen	H_a: Households who are already inclined to believe that hydrogen is a likely replacement for gasoline and diesel will be more likely to design a PHEV or BEV. (Predisposition toward hydrogen; may have already spurred search for information.)	H_o rejected: If already inclined to believe electricity will replace gasoline and diesel, then more likely to design anything but ICEV or FCEV.
Replacement for gasoline and diesel: natural gas	H_a: Households who are already inclined to believe that hydrogen is a likely replacement for gasoline and diesel will be more likely to design a PHEV or BEV. (Predisposition toward hydrogen; may have already spurred search for information.)	H_o accepted.
Daily flexibility (as to who drives which vehicle)	H_a: Households with more flexibility as to who drives and who drives which vehicle will be more likely to design a BEV. (Flexibility is a tool to adapt to short range.)	H_o accepted: No significant relationship.
HOV lanes	H_a: Respondents who already drive on routes with HOV lanes may be particularly attracted by the incentive of single-driver HOV lane access, thus to design a PHEV, BEV, or PHEV. (Perceived time savings may be a powerful incentive to design a qualifying vehicle.)	H_o rejected: those who do not drive in HOV lanes are more likely to design gasoline or hybrid vehicles.
Toll lanes	H_a: Respondents who already drive on routes with tools may be particularly attracted by the incentive of reduced tolls and thus to design a PHEV, BEV, or PHEV. (Perceived cost savings may be an incentive to design a qualifying vehicle.)	H_o accepted: No significant relationship. Too few toll road users to construct strong test.
Daily distance variation	H_a: Respondents with less variation in their daily travel will be more likely to design a BEV. (Greater variability may make it more difficult to imagine adapting to a limited range vehicle.)	H_o accepted: No significant relationship.
Commute to a workplace	H_a: Respondents who commute to work will	H_o rejected: those who commute

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	be more likely to design a ZEV. (Greater regularity of travel and possibility of workplace charging may make it easier to adapt a PEV and ZEV. May also be income and/or age correlated.)	are less likely to design conventional ICEVs.
Park at least one vehicle in a garage or carport (at home)	H_a: Respondents who park at least one vehicle in a garage or carport (attached to their residence) are more likely to design a PHEV, BEV, or FCEV. (Certainty of parking location.)	H_o accepted: No significant relationship.
Home PEV Charging Access	H_a: Respondents who more highly rate their access to charging (and to higher levels of electrical service) are more likely to design a PHEV or BEV. (Certainty of parking location and access to electricity.)	H_o rejected. Most of the effect is limited to those who design BEVs; access to the fastest charging is associated with higher likeliness to design a BEV.
Electricity installation authority	H_a: Respondents with the authority to make installations at their residence are more likely to design a PHEV or BEV. (Don't require permission from a property manager, landlord, or lender.)	H_o accepted: No significant relationship.
Home natural gas	H_a: Respondents with access to natural gas are more likely to design an FCEV. (Access to natural gas for hydrogen reforming for home hydrogen fueling.)	H_o accepted: No significant relationship.
Familiarity with gasoline vehicles	H_{a1}: Increasing familiarity with gasoline vehicles is associated with a *lower* likeliness to design an HEV, PHEV, BEV, or FCEV. (Familiarity with the present vehicle type produces conservatism toward alternatives.) H_{a2}: Increasing familiarity with gasoline vehicles is associated with a *higher* likeliness to design an HEV, PHEV, BEV, or FCEV. (Familiarity with the present vehicle type produces an attraction toward alternatives.)	H_o accepted: No significant relationship.
Familiarity with HEVs, BEVs, PHEVs, and	H_{a1}: Increasing familiarity with each of these types of vehicles is associated with a *lower* likeliness to design one. (Familiarity with the alternative vehicle types produces conservatism toward them.) H_{a2}: Increasing familiarity with these types of vehicles is associated with a *higher* likeliness to design an HEV, PHEV, BEV, or FCEV. (Familiarity with the alternative vehicle type produces an attraction toward alternatives.)	H_0 rejected: H_{a2} supported, sort of. Higher familiarity associated with lower likeliness to design an ICEV, but the probabilities of designing all alternatives increases by non-statistically significant amounts. That is, slight increases in all alternatives.
Environmental and health	H_a: Respondents who believe electricity is a	H_o rejected. Lower comparative

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
risk of electricity compared to gasoline	lower environmental and health risk than gasoline will be more likely to design a PHEV or BEV. (Desire to reduce environmental and health risks associated with their travel.)	risk of electricity appears to be associated with lower likeliness to design an ICEV.
Seen public EVSEs	H_a: Respondents who have seen public chargers for PEVs will be more likely to design a PHEV or BEV. (Since EVSEs must have been seen "in lots and garages [they] use," seeing them may increase both the general perception that PEVs are real and provide a solution to a real or perceived barrier to using a PEV.)	H_o rejected: those who have seen public EVSEs are more likely to design a PEV.
Driving experience: BEV	H_a: Respondents who have higher levels of BEV driving experience will be more likely to design one. (Alternate measure of familiarity; higher familiarity leading to higher likeliness.)	H_0 rejected. Higher BEV driving experience associated with higher likeliness to design BEV.
Driving experience: HEV, PHEV, FCEV	H_a: Same as for BEVs.	In general, driving experience with HEVs, PHEVs, and FCEVs associated with higher likeliness to design a BEV.
Driving experience: PHEV + BEV + FCEV	H_a: Similar to above, but an effort to see if combined experience across multiple vehicle types matters as much or more than experience with any one type.	H_o rejected: Higher combined experience driving PHEVs, BEVs, and FCEVs is associated with a lower likeliness of designing an ICEV and higher likeliness to design a BEV.
BEV home charging: "My household would be able to plug in a vehicle to charge at home."	H_a: Stronger agreement associated with higher likeliness to design a PEV.	H_o rejected: Stronger agreement associated with lower likeliness to design an ICEV or HEV and increased likeliness of designing a ZEV.
BEV public charging: "There are enough places to charge electric vehicles."	H_a: Stronger agreement associated with higher likeliness to design a PEV.	H_o rejected: Stronger agreement associated with lower likeliness to design an ICEV and higher likeliness to design a BEV.
BEV charge time: "It takes too long to charge electric vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	H_0 rejected: Higher agreement associated with higher probability of designing an ICEV.
BEV range: "Electric vehicles do not travel far enough before needing to be charged|."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	H_o rejected: Stronger agreement associated with higher likeliness to design an ICEV.
BEV purchase price: "Electric vehicles cost more to buy than gasoline vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	H_o rejected: Stronger agreement associated with higher likeliness to design an ICEV.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
BEV safety: "Gasoline powered cars are safer than electric vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	H_o rejected: Stronger agreement associated with higher likeliness to design an ICEV.
BEV reliability: "Gasoline powered cars are more reliable than electric vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	H_o rejected: Stronger agreement associated with higher likeliness to design an ICEV.
Overall BEV Impression: Sum (with proper attention to the valence of the original statement) of the seven variables just describing respondent's impression of BEVs.	H_a: Attempt to measure the effect of an overall evaluation of PEVs; higher score will be associated with higher likeliness to design a PEV. Positive scores = positive impression. Simple summing treats all dimensions as equally valuable.	H_o rejected: Higher scores, i.e., more pro-BEV evaluation of BEVs, are associated with lower likeliness to design an ICEV and a higher likeliness of designing a BEV.
Four factor solution to a factor analysis of the seven dimensions of prior BEV evaluation	H_a: Attempt to measure the effect of an overall evaluation of PEVs, the factor analysis searches for a smaller number of factors that summarizes the seven dimensions of PEV evaluation.	Two of four factors correlated to drivetrain design: access to home charging (Factor 4) and (Factor 1) safety-reliability.
FCEV public refueling: "There are enough places for drivers to refuel their cars and trucks with hydrogen."	H_a: Stronger agreement associated with higher likeliness to design an FCEV.	H_0 rejected: Stronger agreement there are enough places to refuel FCEVs associated with higher likeliness to design an FCEV.
FCEV fueling time: "Hydrogen fuel cell vehicles take too long to refuel."	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o accepted: No significant effect.
FCEV range: "Hydrogen fuel cell vehicles do not travel far enough without needing to be refueled."	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o accepted: No significant effect.
FCEV purchase price: "Hydrogen fuel cell vehicles cost more than gasoline cars. |:	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o accepted: No significant effect.
FCEV safety: "Gasoline vehicles are safer than hydrogen fuel cell vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o rejected: Decreasing confidence in the relative safety of hydrogen compared to gasoline is associated with a higher likeliness to design an ICEV.
FCEV reliability: Gasoline vehicles are more reliable than hydrogen fuel cell vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o rejected: Decreasing confidence in the relative safety of hydrogen compared to gasoline is associated with a higher likeliness to design an ICEV.
Overall FCEV Impression: Sum of the six variables	H_a: Attempt to measure the effect of an overall evaluation of FCEVs; higher score will be	H_o accepted: No significant effect.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
describing respondent's impression of BEVs.	associated with higher likeliness to design an FCEV. Positive scores = positive impression. Simple summing treats all dimensions as equally valuable.	
Three factor solution to the factor analysis of the six dimensions of FCEV evaluation	H_a: Attempt to measure the effect of an overall evaluation of FCEVs, the factor analysis searches for a smaller number of factors that summarizes the seven dimensions of PEV evaluation.	H_o rejected: Factor 1 (safety-reliability) associated with a higher likeliness to design an ICEV. (High scores on the factor indicate gasoline is safer or more reliable.) Factor 3 (public fueling) associated with a higher likeliness to design a BEV (but not an FCEV).
Incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel:	For each entity, H_a: Those already aware of incentives will be more likely to design a qualifying vehicle.	
Federal government.		H_o rejected: Prior belief that federal government offers incentives associated with higher likeliness of designing a ZEV.
State government		H_o rejected: Those who are unsure whether states are offering incentives are more likely to design ICEVs. The effect is mixed for those who are sure, whether yes or no.
My state government (Oregon)		H_o accepted: No significant effect.
Should governments offer incentives	H_a: Those who believe governments should offer incentives will be more likely to design a PHEV, BEV, or FCEV. (To the extent ZEVs have been politicized, responses may be shaped by people's ideas about the "proper" role of government.)	H_0 rejected. Those who think government should offer incentives are more likely to design an HEV or ZEV. Reduced to a simple yes/no/not sure.
Prior consideration of PEVs	H_{a1}: Higher levels of consideration of PEVs prior to completing the survey will be associated with *higher* likeliness of designing a BEV. (BEVs are making a *favorable* impression on more consumers than not.) H_{a2}: Higher levels of consideration of BEVs prior to completing the survey will be associated with *lower* likeliness of designing a BEV. (BEVs are making a *unfavorable* impression on more consumers than not.)	H_{a1} supported, but statistical tests are suspect because of small sample size. Those who have given greater prior consideration to buying a BEV are more likely to design a PHEV, BEV, or FCEV.
Prior consideration of FCEVs	H_{a1}: Higher levels of consideration of FCEV prior to completing the survey will be associated with *higher* likeliness of designing an FCEV. (FCEV are making a *favorable*	H_{a1} supported: Those who say they have not and will not consider FCEV are more likely to design ICEVs.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	impression on more consumers than not.) H_{a2}: Higher levels of consideration of an FCEV prior to completing the survey will be associated with *lower* likeliness of designing an FCEV. (FCEV are making a *unfavorable* impression on more consumers than not.)	
Urgent national need to displace gasoline and diesel	H_a: Stronger agreement there is an urgent national need for alternatives will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	H_0 rejected. Stronger agreement associated with lower likeliness to design an ICEV.
Market will produce all required incentives	H_a: Those who believe free markets would produce all necessary incentives will be less likely to design a PHEV, BEV, or FCEV. (To the extent ZEVs have been politicized, responses may be shaped by people's ideas about the "proper" role of government.)	H_o rejected: Stronger belief the market would produce all necessary incentives associated with higher likeliness to design an ICEV.
Air pollution and individual lifestyle	H_a: Stronger agreement that individual lifestyle change affects air pollution will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	H_o rejected: Stronger agreement that air quality is affected by individual lifestyle is associated with lower likeliness to design and ICEV.
Personal worry about air quality	H_a: Stronger agreement that the respondent personally worries about air quality will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	H_o rejected: Stronger agreement that air quality is a personal worry is associated with lower likeliness to design and ICEV.
Air pollution a regional health threat	H_a: Stronger agreement that air pollution is a threat in the respondent's region will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	H_o rejected: Stronger agreement that air quality is a regional threat is associated with lower likeliness to design and ICEV.
Certainty there is, or is not, evidence for rising global average temperatures.	H_a: Stronger agreement there is solid evidence of global warming will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	H_o rejected: Greater certainty there **is** solid evidence of global warming is associated with lower likeliness to design an ICEV and greater likeliness to design a PHEV.
Warming human-caused or natural NOTE: This question is only asked of the people who believe there is evidence for global warming.	H_a: Stronger agreement global warming is human-caused will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	H_o rejected: Stronger agreement that global warming is human-caused is associated with lower likeliness to design an ICEV and greater likeliness to design a BEV.
Climate change and individual lifestyle	H_a: Stronger agreement that individual lifestyle change affects climate will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	H_o rejected: Stronger agreement that global warming is human-caused is associated with lower likeliness to design an ICEV.
Own or rent residence	H_a: Respondents who own their residence will	H_o accepted: No significant

Independent (Explanatory) Variable	**Alternate Hypothesis (Rationale)**	**Bivariate Statistical Relationship to Dependent Variable: Drivetrain design**
	be more likely to design a PHEV, BEV, or FCEV.	relationship.
Residence type	H_a: Residents of single family dwellings will be more likely to design a PHEV, BEV, or FCEV.	H_o accepted: No significant relationship.
Solar panels on residence	H_a: Respondents who already have solar panels installed on their residence will be more likely to design a PHEV, BEV, or FCEV.	H_o rejected: Effect is mixed; those with solar are more likely to design ICEVs, BEVs, and FCEVs.
Household size	H_a: No specific alternative hypotheses.	H_o accepted: No significant effect.
Respondent age	H_a: Respondents age 40 to 59 will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	H_o rejected, but H_a not supported: Households age 50 to 69 more likely to design ICEVs and PHEVs.
Respondent gender	H_a: Male respondents will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	H_o rejected, but H_a not supported: Effect is mixed: women are more likely to design ICEVs and PHEVs. Men are more likely to design HEVs and BEVs.
Respondent employment status	H_a: Employed persons more likely to design ZEVs because of age, income, and commute.	H_o rejected; H_a supported.
Retired person in home	H_a: Proxy for age; should show same relationship as respondent age.	H_o rejected, but H_a not supported: Households with a retired person are more likely to design ICEVs and less likely to design ZEVs
Children in household	No specific alternative hypothesis.	H_o accepted: No significant effect.
Technophile in the household	H_a: Households with a technophile will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	H_o rejected, but H_a not supported: Greater likeliness of a technophile in the home is associated with a lower likeliness to design an ICEV, but the effect is mixed as to which other vehicle type they are more likely to design.
Respondent's own interest in ZEV technology	H_a: Respondents who are personally interested in ZEV technology will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	H_o rejected: Greater interest in ZEV technology is associated with higher likeliness to design a PHEV, BEV, or FCEV.
Respondent's education	H_a: Respondents with higher education will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	H_o rejected: Weak statistical relationship; those with the highest education are more likely to design ZEVs.
Political party affiliation	H_a: Lefties more likely to design a PHEV, BEV, or FCEV. (Presently, federal initiatives are the product of a Democratic	H_o accepted: No significant effect.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	administration.)	
Household income	H_a: Higher income households will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	H_o rejected: Higher income associated with higher likeliness to design a BEV.
History leasing vehicles	H_a: Households with a history of leasing will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	H_o accepted: No significant effect.

APPENDIX B: RESPONDENT VALUATION OF ZEVS

Multivariate model for Game 3: No trucks allowed with all-electric operation; incentives offered

Nominal logistic regression is used to assemble and test models because the variable to be explained consists of a small number of distinct possibilities—ICEV, HEV, PHEV, BEV, or FCEV—rather than a continuous scale. The whole model test (Table B1) evaluates whether all the explanatory variables taken together provide a better fit to the data than simply fitting the overall probability of each drivetrain type. In this case, the tiny probability (<0.0001) of obtaining a larger chi-square by chance indicates that the explanatory variables, taken as a whole, provide a better fit.

Table B1: Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	102.12290	48	204.2458	<0.0001
Full	419.07347			
Reduced	521.19636			

The measures of how well the model performs (Table B2) are not high compared to what one sees for linear regression, but are typical for nominal logistic regression.

Table B2: Goodness of fit measures

Measure	Training	Definition
Entropy RSquare	0.196	1-Loglike(model)/Loglike(0)
Generalized RSquare	0.457	(1-(L(0)/L(model))^(2/n))/(1-L(0)^(2/n))
Misclassification Rate	0.497	∑ (ρ[j]≠ρMax)/n
N	361	

The lack of fit test (Table B3) evaluates whether more complex terms such as interactions between the explanatory variables would add to the explanatory power of the model. In this case, the statistical tests reject this idea and we accept the model as it is. The effect tests in Table B4 simply confirm that all the explanatory variables are statistically significant.

Table B3: Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	1392	419.07347	838.1469
Saturated	1440	0.00000	**Prob>ChiSq**
Fitted	48	419.07347	1.0000

Table B4: Effect Likelihood Ratio Tests

Source	Number of parameters	DF	L-R ChiSquare	Prob>ChiSq
Respondent's car fuel spending per month	4	4	12.3392993	0.0150
Replacement for gasoline and diesel: Electricity	4	4	16.8785274	0.0020
Familiarity Factor1: HEV, PHEV, BEV, FCEV	4	4	13.909108	0.0076
Prior BEV Factor1: safety and reliability	4	4	13.7079131	0.0083
Consider a BEV	4	4	31.0054252	<0.0001
Fuel economy of respondent's vehicle	4	4	8.82186062	0.0657
Vehicle 1 (Most recent new car) Total Price	4	4	12.9256478	0.0116
Pro-social plus electricity Factor4: lifestyle and air quality	4	4	8.87425526	0.0643
Commute	4	4	8.56022315	0.0731
Daily Flexibility	12	12	29.4268578	0.0034

The parameter estimates in Table B5 provide the details of how and to what extent the explanatory variables affect the relative odds that a respondent with any particular set of responses would design one type of drivetrain rather than another. The statistical algorithm sets aside one of the possible answers and calculates the odds of all other answers compared to that one. In this case, FCEVs are the excluded category. So, strictly speaking the parameter estimates address the question of how likely it is a respondent designs any other drivetrain type in comparison to the odds they design an FCEV. The model parameters are interpreted in the text.

Table B5: Parameter Estimates

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
Intercept (ICEV)	4.021	1.805	4.96	**0.026**
Respondent's car fuel spending per month	-0.003	0.002	2.71	**0.100**
Replacement: Electricity[No]	1.354	0.631	4.60	**0.032**
Familiarity Factor1: HEV, PHEV, BEV, FCEV	-0.715	0.401	3.18	**0.074**
Prior BEV Factor1: safety-reliability	-0.192	0.474	0.16	0.685
Consider a BEV[No]	1.732	0.564	9.43	**0.002**
Fuel economy, respondent's most frequent vehicle	-0.053	0.044	1.45	0.228
Recent New Vehicle Total Price	0.000	0.000	4.18	**0.041**
Pro-social plus electricity Factor 4: AQ-lifestyle	-1.161	0.549	4.48	**0.034**
Respondent Commute[No]	-0.468	0.314	2.22	0.137
Daily Flexibility[1-0]	-2.532	0.869	8.48	**0.004**
Daily Flexibility[2-1]	3.633	1.151	9.96	**0.002**
Daily Flexibility[3-2]	-1.507	1.099	1.88	0.170

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
Intercept (HEV)	3.249	1.746	3.46	**0.063**
Respondent's car fuel spending per month	-0.005	0.002	5.10	**0.024**
Replacement: Electricity[No]	1.349	0.626	4.64	**0.031**
Familiarity Factor1: HEV, PHEV, BEV, FCEV	-0.205	0.396	0.27	0.605
Prior BEV Factor1: safety-reliability	-0.919	0.452	4.14	**0.042**
Consider a BEV[No]	1.604	0.559	8.22	**0.004**
Fuel economy, respondent's most frequent vehicle	0.011	0.041	0.07	0.786
Recent New Vehicle Total Price	0.000	0.000	4.10	**0.043**
Pro-social plus electricity Factor 4: AQ-lifestyle	-0.859	0.544	2.49	0.115
Respondent Commute[No]	-0.631	0.303	4.35	**0.037**
Daily Flexibility[1-0]	-2.472	0.818	9.14	**0.003**
Daily Flexibility[2-1]	3.393	1.110	9.34	**0.002**
Daily Flexibility[3-2]	-1.873	1.078	3.02	**0.082**
Intercept (PHEV)	2.796	1.763	2.52	0.113
Respondent's car fuel spending per month	-0.007	0.002	9.40	**0.002**
Replacement: Electricity[No]	0.778	0.635	1.50	0.221
Familiarity Factor1: HEV, PHEV, BEV, FCEV	-0.213	0.400	0.28	0.594
Prior BEV Factor1: safety-reliability	-0.823	0.452	3.31	**0.069**
Consider a BEV[No]	1.060	0.565	3.52	**0.061**
Fuel economy, respondent's most frequent vehicle	0.004	0.041	0.01	0.914
Recent New Vehicle Total Price	0.000	0.000	2.70	0.101
Pro-social plus electricity Factor 4: AQ-lifestyle	-0.834	0.544	2.35	0.125
Respondent Commute[No]	-0.789	0.305	6.71	**0.010**
Daily Flexibility[1-0]	-0.903	0.784	1.33	0.249
Daily Flexibility[2-1]	2.266	1.083	4.38	**0.036**
Daily Flexibility[3-2]	-2.038	1.087	3.51	**0.061**
Intercept (BEV)	0.177	1.876	0.01	0.925
Respondent's car fuel spending per month	-0.003	0.002	2.18	0.140
Replacement: Electricity[No]	1.059	0.658	2.59	0.108
Familiarity Factor1: HEV, PHEV, BEV, FCEV	0.131	0.452	0.08	0.772
Prior BEV Factor1: safety-reliability	-1.000	0.496	4.07	**0.044**
Consider a BEV[No]	1.018	0.592	2.95	**0.086**
Fuel economy, respondent's most frequent vehicle	0.010	0.044	0.05	0.818
Recent New Vehicle Total Price	0.000	0.000	8.09	**0.004**
Pro-social plus electricity Factor 4: AQ-lifestyle	-1.052	0.564	3.48	**0.062**
Respondent Commute[No]	-0.641	0.338	3.60	**0.058**
Daily Flexibility[1-0]	-1.806	0.916	3.88	**0.049**
Daily Flexibility[2-1]	2.724	1.204	5.12	**0.024**
Daily Flexibility[3-2]	-1.234	1.150	1.15	0.283

APPENDIX C: EXPLANATORY VARIABLES FROM LOGISTIC REGRESSIONS FOR ALL STATES AND THE NESCAUM REGION

States	Variables
1. Respondent and household Socio-economic and Demographic Measures	
California, Oregon, Washington, Maryland, Delaware, New Jersey, and Massachusetts	• None
New York, NESCAUM	• Gender
NESCAUM	• Education
2. Respondent and Household Vehicles, Travel, and Residences	
Oregon, New Jersey and NESCAUM	• Commutes to work in household vehicle
Oregon	• Price paid for most recent new vehicle • Respondent's own monthly fuel spending • Fuel economy of vehicle respondent drives most often • Daily flexibility in assigning vehicles to different drivers
New York	• Monthly miles driven by respondent
California, Washington, Delaware and Massachusetts	• Highest level of electrical service at parking location
NESCAUM	• Park at home in garage or carport
Massachusetts	• Install a PEV charger at their residence on their own authority or would require permission from another party
California	• Natural gas at residence
3. Attitudes related to policy goals: air quality, energy security, and global warming	
California, Maryland and, Massachusetts	• Air pollution a regional threat and personal risk
New York and Washington	• Air pollution a personal risk

Oregon	• Individual lifestyle affects air quality
California and New Jersey	• Should government offer incentives for electricity and/or hydrogen
Delaware and New Jersey	• Heard of federal incentives for alternatives to gasoline and diesel
NESCAUM	• Urgent national need for transition to alternative fuels
NESCAUM	• Comparative risk to environment and human health of electricity and gasoline "in your region"
4. Prior PHEV, BEV, and FCEV Evaluation and Experience; PHEV, BEV, and FCEV-specific attitudes	
California, Oregon, Washington and, Delaware	• Prior belief electricity is a likely replacement for gasoline and diesel
California, New Jersey, Massachusetts and NESCAUM	• Prior belief hydrogen is a likely replacement for gasoline and diesel
California, Delaware, New Jersey, New York and NESCAUM	• Personal interest in ZEV technology
Washington	• Technophile at home
California and Oregon	• Familiarity with HEVs, PHEVs, BEVs, and FCEVs
Washington	• Familiarity with HEVs
California, New Jersey and NESCAUM	• Familiarity with ICEVs
California, Massachusetts, New Jersey, Washington and NESCAUM	• Relative reliability and safety of BEVs and ICEVs
California, Oregon and NESCAUM	• Driving range and charging time of PEVs
Maryland	• Extent of away-from-home PEV charging

NESCAUM	• Ability to charge PEV at home and extent of away-from-home PEV charging
NESCAUM	• Relative purchase price of PEVs vs. ICEVs
California	• Driving range and fueling time of FCEVs
California and New Jersey	• Driving Experience: PHEV, BEV, or FCEV
California and NESCAUM	• Driving Experience: HEV
California, Massachusetts, New Jersey, New York, Washington and NESCAUM	• Seen charging for PEVs at (non-residential) parking facilities they use
California, Delaware, Oregon, Maryland, Massachusetts, New Jersey, New York and NESCAUM	• Whether they have already considered buying an PEV
California, Massachusetts, New York Washington and NESCAUM	• Whether they have already considered buying an FCEV