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New Car Buyers' Valuation of Zero-Emission Vehicles: Northeast States for Coordinated Air Use Management (NESCAUM)

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DISCLAIMER

The statements and conclusions in this report are those of the authors and not necessarily those of the Northeast States for Coordinated Air Use Management, any other funding agency, or the University of California. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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We'd like to thank the households who participated in the research reported here. We'd also like to thank Jennifer TyreeHageman for her assistance with survey design, 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. Graphics for the analysis of motivations for and against designing PEVs and FCEVs have been changed; the underlying analysis remains the same.
3. 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 NESCAUM and Comparative Analyses.
    a. As part of the comparative analysis, Appendix C is added to the document.
4. Population level estimates of numbers of households with positive PEV or FCEV valuations are added to the results.
5. Discussion and Conclusions are revised to reflect the changes just described.
    a. As part of these changes, a mistake in the percent difference between the people who design a PEV or FCEV in the first game and the third game is corrected. (The correct value was reported in the Conclusions of the original version of this report.)
6. 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. This includes measures of respondents' responses to such policies. ZEV will also be used when speaking about experts—policy, engineering, research, or otherwise—to distinguish their roles from the respondents'.
7. Due to difficulty confirming the presence or absence of specific makes and models of PEVs in every state as of the time of the data collection (December 2014-January 2015), the second column of Table 1 has been deleted.

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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). 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. The acronym PEV will be used to refer to PHEVs and BEVs collectively when the distinction between the two is not essential, but the group of vehicles that charge from the grid is germane. The acronym ZEV is reserved for discussion of policy, whether those discussions are of ZEV policies or the other environmental and energy policies 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'.

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 charging 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

[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

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.

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 the NESCAUM member states as of the period of data collection for this study circa December 2014 to January 2016.

A Multistate ZEV Policy Framework

To improve local air quality and reduce the emissions that contribute to climate change, several states have adopted California's zero emission vehicle (ZEV) mandate requiring a certain percentage of new light-duty vehicles sold to be ZEVs. Among these states are most of the NESCAUM member states: Connecticut, Massachusetts, Maine, New Jersey, New York, Rhode Island and Vermont. ZEVs are any vehicle that releases zero emissions during on-road operation. They include battery electric vehicles (BEVs) and hydrogen fuel cell vehicles (FCEVs). 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 and how many credits each vehicle sold earns. Notably, one credit does not equal one vehicle. For example, as of the date of this report a BEV earns between one and nine ZEV credits depending on driving range. ZEV 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 ZEVs and neighborhood electric vehicles. Automakers may apply ZEV credits earned in one state to ZEV requirements in other states as long as they sell a minimum number of ZEVs in each state.

The ten 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.

Northeast States for Coordinated Air Use Management

The Northeast States for Coordinated Air Use Management (NESCAUM) is a nonprofit association of air quality agencies from eight states: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. It was founded in 1967 to address air pollution from power plants in New England. Subsequently, New York joined in 1970 and New Jersey in 1979. It now provides analytical, technical, scientific, and policy support to the states across four areas: climate and energy, mobile sources, policy, and science and technology.

States remain the primary policy making entities and thus there is variation across the region as to laws, regulations, and policies across NESCAUM's topical interest areas. With respect to ZEVs, all NESCAUM member states except New Hampshire are both "Section 177" and "ZEV" states, meaning all NESCAUM member states except New Hampshire have adopted both California's air quality standards and ZEV program requirements. By virtue of the federal Environmental Protection Agency's Cross-Border Sales Policy, no manufacturer of ZEVs is precluded from selling ZEVs (or other "California" certified vehicles) in New Hampshire, as it is contiguous with Section 177 states (Maine, Massachusetts, and Vermont.)

NESCAUM Member State ZEV Activities

Data regarding ZEVs, incentives, and public charging for PEVs in the NESCAUM member states are summarized in Table 1. A few of these are elaborated here for states other than Massachusetts, New Jersey, and New York. Activities in those three states are described further in their individual state reports.

In 2009, the state of Connecticut created the Electric Vehicle Infrastructure Council to strategize how to support and promote PEVs. The Council made its final report to the Governor's office in Sept. 2010.[3] The Connecticut Electric Vehicle Coalition includes the Acadia Center, Connecticut Automotive Retailers Association, Connecticut Fund for the Environment, Environment Connecticut, and the Sierra Club. The Coalition supports incentives and other policies to increase the number of ZEVs in Connecticut.[4]

In Maine, the Greater Portland Council of Governments/Maine Clean Communities EV Lending Program allowed municipalities and stakeholders to borrow a Nissan Leaf for up to several days. The program is credited with subsequent PEV leases by five municipalities and one stakeholder and the installation of 14 PEV charging stations.[5]

Starting as a pilot project in 2014, Drive Electric Vermont offered consumers a $500 point-of-purchase incentive for PEVs. Funding for the incentives came from the Vermont Low-Income Trust for Electricity. The program funded 75 incentives through participating automotive dealerships. Now that the pilot is complete, Drive Electric Vermont is pursuing funding to continue the incentives. At this point, there are no additional incentives (beyond the federal tax credit) for consumer PEV purchases in Vermont.[6] Through the State Infrastructure Bank, the Vermont Economic Development Authority, along with the Vermont Agency of Transportation and the Federal Highway Administration, provides a 1% fixed interest rate on a loan up to $100,000 for sole proprietorships, partnerships, corporations, and municipalities to purchase or install PEV charging stations intended for use by the general public.[7]

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[3] http://www.ct.gov/PURA/cwp/view.asp?a=3856&q=452086
[4] http://www.ctenvironment.org/#!ct-electric-vehicle-coalition/c13ul
[5] http://www.gpcog.org/energy/maine-clean-communities/electric-vehicles/
[6] http://www.driveelectricvt.com/buying-guide/incentives
[7] http://www.veda.org/financing-options/vermont-commercial-financing/electric-vehicle-charging-station-loan-program/

Table 1: Data on PEVs and FCEVs, state and local incentives, and number of non-residential EVSEs for NESCAUM member states

State	BEV/PHEV split, %[1]	Incentives[2]	Public Chargers[3]
Connecticut	33/67	**Hydrogen and Electric Vehicle Rebate:** The Hydrogen and Electric Automobile Purchase Rebate Program (CHEAPR) provides up to $3,000 for the purchase or lease of a PEV or FCEV. **Alternative Fuel Vehicle Funding:** The Connecticut Clean Fuel Program provides funding to municipalities and public agencies to purchase, operate, and maintain alt. fuel and advanced technology vehicles, including hydrogen and electricity. The Connecticut Department of Energy and Environmental Protection provides funding to city and state agencies to purchase and install EVSEs. **Electric Vehicle Emissions Inspection Exemption:** BEVs exempt from state motor vehicle emissions inspection. **Reduced Registration Fee:** Electric vehicles are eligible for a reduced vehicle registration fee of $38. **Alternative Fuel and Hybrid Electric Vehicle Parking:** Free parking on all city streets for qualified AFVs and HEVs registered in New Haven.	185 stations; 400 outlets
Maine	18/82	**Central Maine Power: Electric Vehicle Matching Grant Program.** A limited number of matching grants for non-profit organizations to encourage adoption of PEVs. Maximum grant was $5,000 toward the purchase or lease of a PEV or $2,500 toward the purchase and deployment of a level 2 or 3 charging station. Deadline: 6/30/15	41 stations; 67 outlets
Massachusetts	39/61	**Plug-In Electric Vehicle Rebates:** The Massachusetts Department of Energy Resources program called Massachusetts Offers Rebates for Electric Vehicles (MOR-EV), offers rebates up to $2,500 to customers purchasing PEVs. **Alternative Fuel Vehicle and Infrastructure Grants:** The Massachusetts Department of Energy Resources' Clean Vehicle Project provides grants for public and private fleets to purchase alternative fuel vehicles and infrastructure, as well as idle reduction technology. **Electric Vehicle Emissions Inspection**	336 stations; 850 outlets

State	BEV/PHEV split, %[1]	Incentives[2]	Public Chargers[3]
		Exemption: Vehicles powered exclusively by electricity are exempt from state motor vehicle emissions inspections.	
New Hampshire	30/70	None	50 stations; 90 outlets
New Jersey	38/62	**Vehicle Toll Incentive:** The New Jersey Turnpike Authority offers a 10% discount from off-peak toll rates on the New Jersey Turnpike and Garden State Parkway through NJ EZ-Pass for drivers of vehicles that have a fuel economy of 45 miles per gallon or higher and meet the California Super Ultra Low Emission Vehicle standard. The discount will expire Nov. 30, 2018. **Zero Emission Vehicle Tax Exemption:** ZEVs sold, rented or leased in New Jersey are exempt from state sales and use tax.	146 stations; 349 outlets
New York	25/75	**HOV Lane Exemption:** Clean Pass Program, qualified vehicles may use the Long Island Expressway HOV lanes regardless of number of occupants. **Alternative Fuel Vehicle Recharging Tax Credit:** S.B. 2609 and A.B. 3009, tax credit for 50% of the cost, up to $5,000, to purchase and install alt. fuel vehicle refueling and PEV recharging property. Credit available through Dec. 31, 2017. **Alternative Fuel Vehicle Toll Incentive:** Through the Clean Pass Program, qualified vehicles have a $6.25 toll rate during off-peak hours at Port Authority crossings. **Electric Vehicle Emissions Inspection Exemption:** Vehicles powered exclusively by electricity are exempt from state motor vehicle emissions inspections. **Plug-In Electric Vehicle Rate Reduction:** Residential Con Edison customers will pay a reduced price for electricity used during the designated off-peak period.	496 stations; 1,091 outlets
Rhode Island	20/80	**Alternative Fuel Vehicle Tax Exemption:** The town of Warren may allow excise tax exemptions up to $100 for qualified AFVs registered in town. **Electric Vehicle Emissions Inspection Exemption:** Vehicles powered exclusively by electricity are exempt from state emissions control inspections.	61 stations; 165 outlets

State	BEV/PHEV split, %[1]	Incentives[2]	Public Chargers[3]
Vermont	23/77	**Alternative Fuel and Vehicle Research and Development Tax Credit:** Vermont high-tech business involved exclusively in the design, development, and manufacture of alt. fuel vehicles, hybrid electric vehicles, all-electric vehicles, or energy technology involving fuel sources other than fossil fuels are eligible for up to three of the following tax credits: 1) payroll income tax; 2) qualified research and development income tax; 3) export tax credit; 4) small business investment tax and 5) high-tech growth tax.	80 stations; 177 outlets

1. http://energy.gov/eere/vehicles/fact-877-june-15-2015-which-states-have-more-battery-electric-vehicles-plug-hybrids
2. Information on incentives is largely drawn from http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#ma
3. http://www.afdc.energy.gov/fuels/electricity_locations.html

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. The interviews will not be discussed further in this report. 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 PEVs or FCEVs 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.

Online Survey Instrument Design

PEV and FCEV 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 vehicles, PHEV, and BEVs.

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 changed: allowed vehicle body styles/sizes for vehicles with battery-powered, all-electric operation and incentives for PEVs and FCEVs.

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 PEVs and FCEVs compared to ICEVs and HEVs. The games, in effect, provided a way for respondents to register whether they presently desire their next vehicle be a PEV or FCEV within the boundaries of the games.

Sample

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 was confirmed by the market research firm according to criteria supplied by the Center. These were the screening criteria:

- 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 2 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 NESCAUM, the target sample size for the member states was 2,407. Following data cleaning, the final sample size for NESCAUM is n = 2,393.

Table 2: 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	-
NESCAUM sub-total	2,407	2393	-
All States Total	5,807	5,654	68

RESULTS: WHO ARE THE NEW CAR BUYERS IN THE NESCAUM REGION?

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 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 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

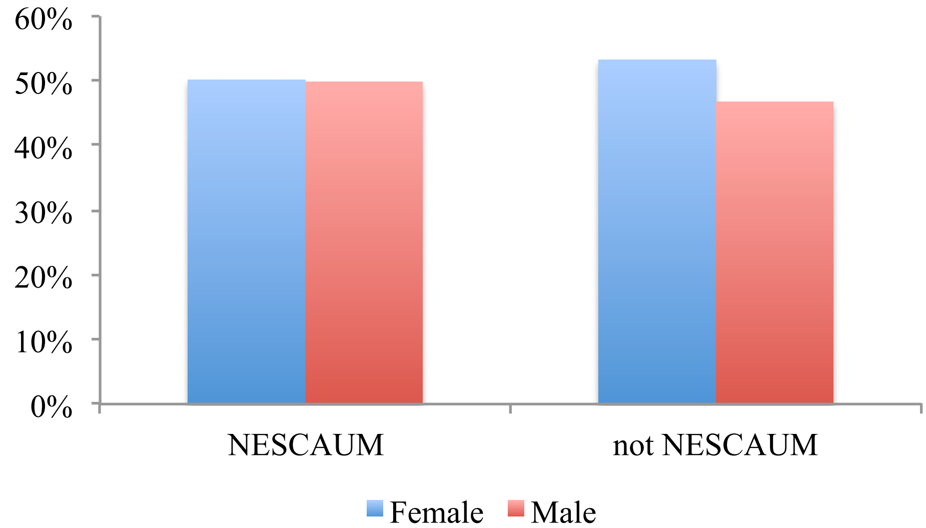
- Overall, statistically significant differences will be identified between the NESCAUM region and the total of all other states in part because the sample sizes of the two regions are much larger than for any individual state.
- Whether these differences are substantively important to explaining PEV and FCEV valuations in the NESCAUM region will depend on whether and how these socio-economic and demographic variables enter into the final multivariate model discussed in the Results: Valuation of PEVs and FCEVs section.

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 these valuations, as opposed to custom studies (such as this one). Further, early PEV buyers have been 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 distributions of the non-NESCAUM member states in lieu of a comparison to other samples of new car buying households in the NESCAUM region because no such samples are available to this study.

The NESCAUM sample is balanced 50/50 on respondent gender. This differs from the non-NESCAUM states in which the female/male balance is 53/47 (Figure 1). 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.

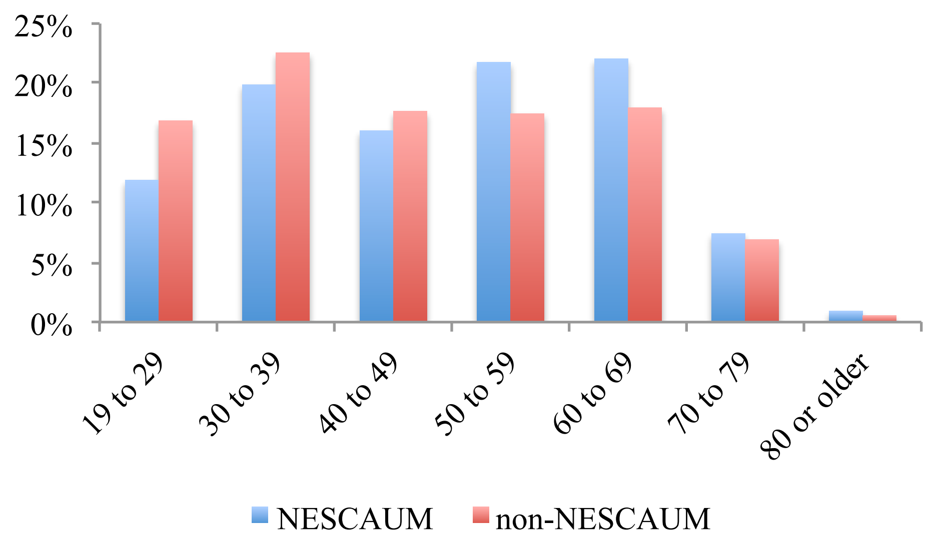
H_o: Female and male respondents will not differ in the probability they design their household's next new vehicle to be an ICEV, HEV, PHEV, BEV, or FCEV).

Figure 1: Respondent Gender



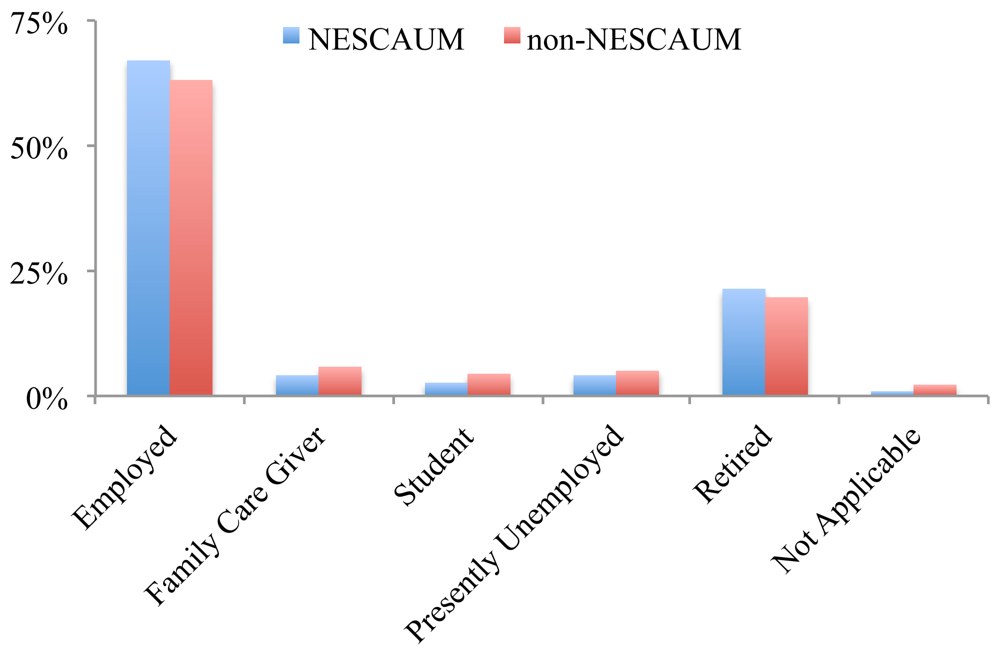
The age distributions of the respondents in the two regions differ at 95% confidence level. The NESCAUM sample is distinctly older, having a higher percentage of respondents in all age categories above 50 years, though in particular from 50 to 69 years. (The respondent age distribution shown has been 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 2: Respondent Age



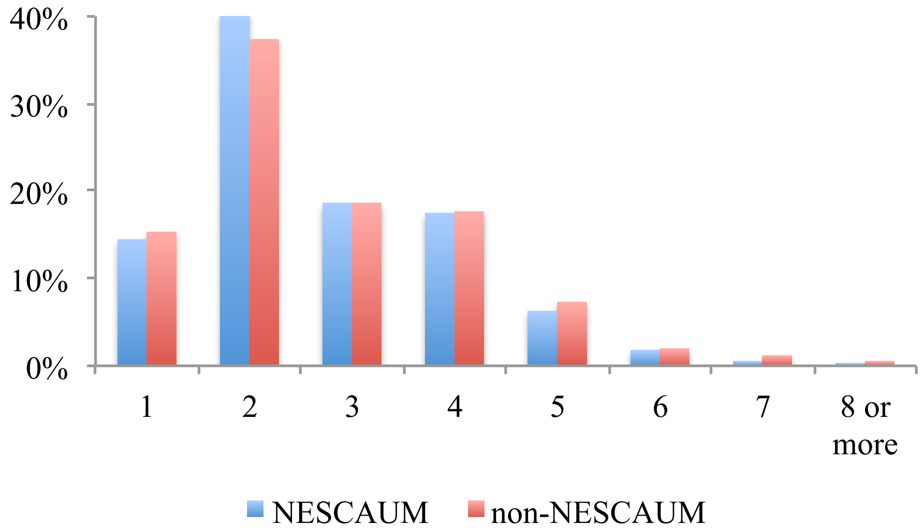
Given the differences between the age distributions for the NESCAUM and non-NESCAUM regions, that the distributions of respondents' employment status differ is not surprising (Figure 3); the NESCAUM sample contains a higher percentage of people employed in the paid labor force (67%) than does the non-NESCAUM sample (63%). About 20% of both samples are retired, but the percentage is slightly higher in the NESCAUM region. There are about one percentage point more respondents in all the other categories in the non-NESCAUM region compared to the NESCAUM region. Despite the statistically significant difference between the two distributions, substantively they are similar: the overwhelming majority of both are either employed in paid labor force or retired, and small percentages of respondents are distributed across the other categories.

Figure 3: Respondent Employment Status



While 21% of respondents in NESCAUM are retired, 30% of the households they represent contain at least one retired person. Though the percent of the sample that is retired is smaller for the non-NESCAUM sample, the ratio of retired respondents to households with at least one retired person is similar (20% retired respondents; 27% households with a retired person). At the other end of the age scale, 69% of NESCAUM respondents report no children (persons younger than 19) in the household; those who do report children in the household are split 2:3 as to whether the youngest reported member is younger than seven years old (12%) or is age seven to 18 (18%). All told, households range in size from one to seven members in the NESCAUM sample and one to eight in the other sample: most (NESCAUM, 91%; non-NESCAUM, 89%) have one to four members. The statistically significant difference between the two samples is due to the higher percentage of two-person households in the NESCAUM sample (41%) compared to the non-NESCAUM sample (375) and the countervailing probability that non-NESCAUM respondents' households are slightly more likely to have five or more people in them (Figure 4).

Figure 4: Household Size



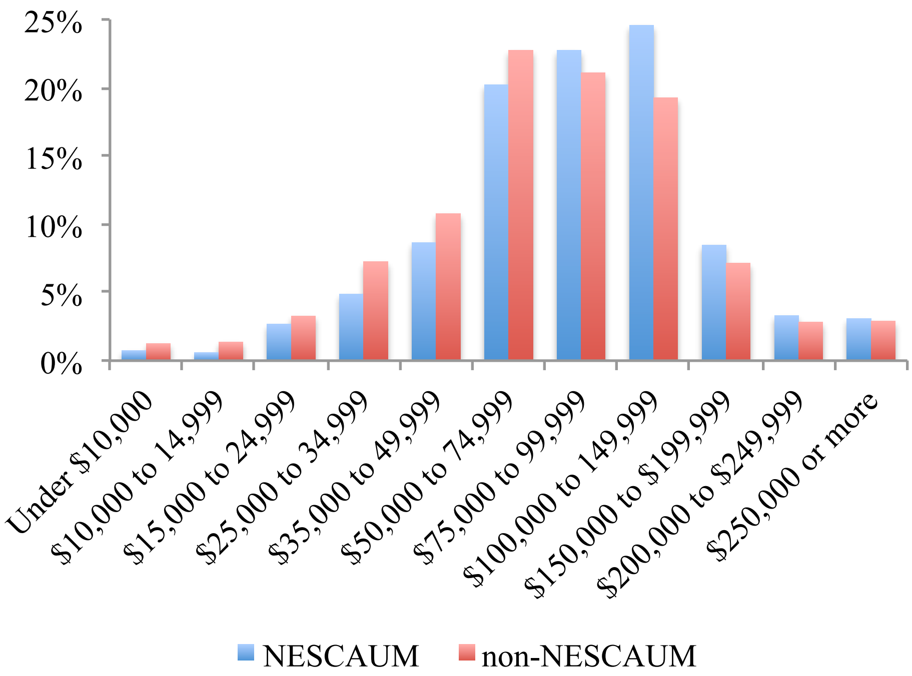
The mean household income for the NESCAUM sample is higher overall than the non-NESCAUM sample, though the inter-quartile range (the difference between the 25th and 75th percentiles) of the two distributions is the same: the 25th percentile category is $50,000 to $74,999 and the 75th percentile category is $100,000 to $149,999. That the median (and mean) incomes for NESCAUM are higher is caused by a shift toward higher incomes within these middle income categories (Figure 5). Despite being a sample of households who had recently purchased a new vehicle, reported annual household incomes includes households in the lowest income categories (as well as the highest). The mean household income in the NESCAUM region (measured as the category number, 6.93) is higher than the non-NESCAUM sample (6.60); the difference is statistically significant ($\alpha = 0.05$).

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

Comparing the distributions of respondents' highest education level shows the NESCAUM sample is slightly more likely than the non-NESCAUM sample to be at either end of the educational spectrum: to have either a high school degree or to have a graduate degree. Correspondingly, the non-NESCAUM sample is more likely than the non-NESCAUM sample to have attended some college, to have an undergraduate degree, or to have completed some graduate school. The median educational achievement for both samples is an undergraduate degree.

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

Figure 5: Annual Household Income



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. The NESCAUM respondents are more likely to declare they have no affiliation with either of the two major political parties (23%) or are affiliated with a third party (7%) than are the non-NESCAUM respondents (21% and 5%). Affiliation to the two major parties is as expected given the separate analyses of most states. In the NESCAUM sample, 44% declare an affiliation with the Democratic Party and 26% with the Republican Party. These are comparable to the non-NESCAUM states: 46% Democratic and 28% Republican.

Prior Awareness, Knowledge, and Valuation of ZEVs

Several concepts are possibly related to whether respondents design a PEV or FCEV as a plausible next new vehicle for their household. Among those 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

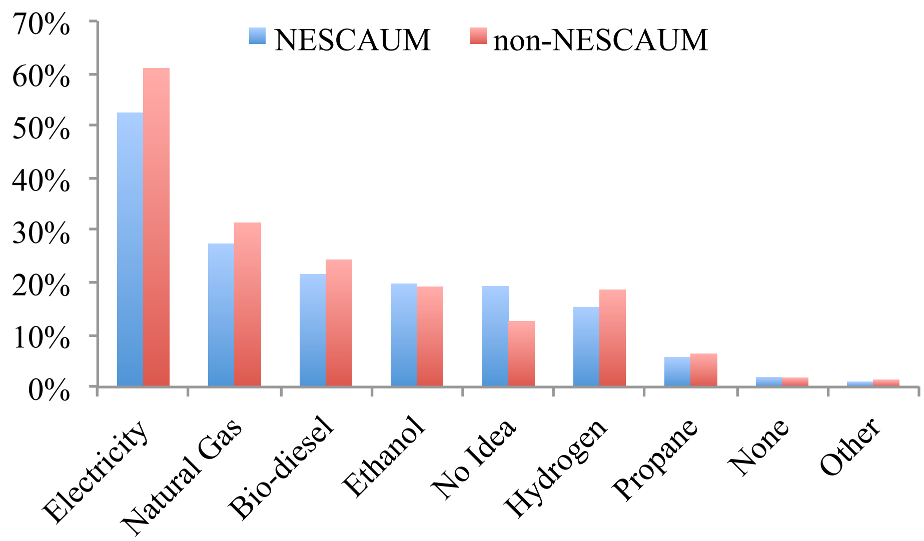
- Electricity wins.
- A smaller percentage of respondents in the NESCAUM region believe that electricity or hydrogen is either a likely or the most likely, replacement for gasoline and diesel.

Respondents were 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 electricity, hydrogen, natural gas, ethanol, bio-diesel, propane, none, “I have no idea,” and other. Response order was randomized. Most people are willing to stipulate at least one replacement. Electricity was selected by a majority of both samples, but by a smaller majority in the NESCAUM region (52%) than in the non-NESCAUM states (61%) (Figure 6). The NESCAUM sample is also less likely to select hydrogen (15% vs. 19%).

> 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 type.

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 natural gas is two-to-one when people choose up to three replacements for gasoline and diesel (52% electricity/27% natural gas); the advantage is three-to-one when a single fuel is chosen (52% electricity/18% natural gas).

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



The reasons NESCAUM respondents gave for why different options are the most likely to replace gasoline and diesel are explored in Table 3. 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 3 for these two reasons have large, positive, values compared to the deviations for other reasons to choose electricity.) Natural gas is favored because "it is most abundant in the United States" and "cheapest for drivers." Though details of the distributions of reasons for most likely replacements differ between the NESCAUM and non-NESCAUM samples adding variables for the distinction between the two samples and interactions with reasons for replacements adds no additional explanatory power: the substantive results are the same for the two regions.

Table 3: NESCAUM, 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	23 -6.95	139 -2.05	35 6.50	19 3.21	49 -0.7	265
It has already proven to be effective	38 0.01	229 **50.16**	25 -11.14	8 -12.02	36 -27.01	336
It is cheapest for drivers	23- 7.64	115 -29.24	35 5.85	14 -2.14	84 **33.18**	271
It is safest for drivers	24 5.12	65 -23.89	21 3.04	15 5.052	42 10.69	167
It is the best for the environment	53 -7.95	350 **63.11**	37 -20.97	47 14.89	52 -49.08	539
It is the most abundant in the U.S.	6 -5.19	28 -24.69	6 -4.65	4 -1.90	55 **36.43**	99
It will require the least change	38 22.62	39 -33.39	36 21.37	1 -7.10	22 -3.50	136
Total	205	965	195	108	340	1813

1. Table 3 excludes the two least frequently mentioned replacements (propane, and other) and 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. Expected values are calculated by multiplying the corresponding row and column totals for each cell and dividing that product by the total sample size. Thus, the expected value for "it doesn't have to be imported from foreign countries: bio-diesel" is (265x205)/1813 = 29.95. The deviation is 23 - 29.96 = -6.95. Negative deviations indicate fewer people give that reason than expected.

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

- While the NESCAUM sample registers some urgency to shift from petroleum, it is not as strong as in the non-NESCAUM sample.
- The NESCAUM sample is less concerned about air pollution in their region and less likely to personally worry about it than is the total sample. Regardless, they believe as strongly as the non-NESCAUM sample that individual lifestyles make a difference.
- NESCAUM respondents are similar 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 goals for government policies requiring and encouraging ZEVs, 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.

Without stipulating why it might be necessary, respondents were asked whether they disagree or agree, "There is an urgent national need to replace gasoline and diesel for our cars and trucks with other sources of energy." The scale ranges from -3 (strongly disagree) to 3 (strongly agree). While on average both samples agree, the NESCAUM sample may agree a bit less strongly than the total sample (mean scores: NESCAUM, 0.80; non-NESCAUM, 0.87; this difference is not statistically significant at $\alpha = 0.05$) The median values are above zero (1.0 for NESCAUM, 1.15, non-NESCAUM), indicating more than half of both samples of respondents agree there is a national urgency to replace gasoline and diesel.

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

On average, the NESCAUM sample agrees less strongly with the statement, "Air pollution is a health threat in my region" than does the total sample. The mean score on the scale of -3 (strongly disagree) to 3 (strongly agree) is 0.40 in NESCAUM and 0.63 for the non-NESCAUM sample; the difference is statistically significant at $\alpha = 0.05$. The median value for NESCAUM (0.24) is lower than for the total sample, too (0.66). The NESCAUM sample is also on average to agree less strongly with the statement, "I personally worry about air pollution." The mean and median scores for NESCAUM are 1.23 and 1.35, for the non-NESCAUM sample, 1.30 and 1.51. The difference in means is statistically significant at $\alpha = 0.05$. Regardless of regional threat or personal risk, the Northeast sample is similarly likely to agree, "Air pollution can be reduced if individuals make changes in their lifestyle." Both samples are, on average, likely to fairly strongly agree individual lifestyle affects air quality (NESCAUM mean = 1.65, non-NESCAUM mean = 1.68). Median values are the same for the two samples (2.06).

With regard to the topics of global warming and climate change, the distributions of responses for the two samples and total samples are similar. Both samples, on average, agree "there is solid evidence the average temperature on Earth has been getting warmer over the past several decades": NESCAUM, mean = 1.17 and total sample =1.19 (the difference is not statistically significant at $\alpha = 0.05$). The distribution for the non-NESCAUM sample is a bit more slightly skewed toward agreement as shown by its higher median value (1.76) compared to the NESCAUM sample (1.68) Among those who believe there is evidence for global warming, on average both samples believe it is caused by human action (3) rather than natural causes (-3): the mean scores are 1.50 for the NESCAUM sample and 1.51 for the non-NESCAUM sample (the difference is not statistically significant at $\alpha = 0.05$).

The same small percentage (8%) of each sample believes "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 4). Excluding those few who think no action regarding climate change is required, both samples were, on average, as likely to fairly strongly agree that climate change can be affected by changes to individual lifestyle (both means = 1.48; both medians = 1.78).

> H_o: Neither prior belief that air quality is a regional problem nor personal worry about air quality will be correlated with drivetrain type. Neither are beliefs that climate change is real, amenable to human action, and an urgent priority.

Table 4: Urgency to address climate change (choose one), percent[1]

	NESCAUM	Non-NESCAUM
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.	36	35
Concerns about human caused climate change are unjustified, thus no actions are required to address it.	8	8

1. Totals may not sum to 100% because of rounding.

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

- Overall, awareness of, and experience with HEVs, 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 lower in the NESCAUM region. However, BEV name recognition is largely limited to the same two vehicles everywhere.
    - Name recognition is also low in the non-NESCAUM states.
- Lack of understanding of the distinctions between HEVs, PHEVs, and BEVs is a likely explanation for why respondents name PHEVs when asked for makes and models of BEVs.

Prior awareness and familiarity with HEVs, PHEVs, BEVs, and FCEVs was measured in several ways: name recognition of HEVs, BEVs, PHEVs, and FCEVs presently sold in the US, rating whether respondents 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 PEV charging 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, BEV name recognition is low in the NESCAUM states and limited to two vehicles. Asked, "Can you name an electric vehicle that is being sold in the US," 51% say "no"; 24% correctly name a BEV, leaving 25% who name a vehicle, but it is not a BEV presently for sale in the US.[8] Among those who correctly name a BEV, just two vehicles account for 92% of correct responses: Nissan Leaf (~31%) and Tesla (~61%). The non-NESCAUM states show slightly greater incidence of name recognition but no greater variety. Compared to the 51% in the NESCAUM region who stated they could not name a BEV, only 40% of those in the non-NESCAUM states stated they could not. Still among those 34% of respondents in the non-NESCAUM states who successfully named a BEV, it is still the case that 92% of them name the same two BEVs (though the split is more even, 44% Nissan Leaf to 48% Tesla).

H_o: Prior BEV name recognition is not correlated with drivetrain type or the likeliness of designing a BEV in particular.

The most commonly misidentified vehicle by respondents in the NESCAUM region—as it is in all states—is the Chevrolet Volt: of all the people in the NESCAUM sample who offer the make and model of a vehicle that might have a plug (whether it is a BEV or not) 31% name this PHEV. In addition to misclassifying the Chevrolet Volt, the Toyota Prius is also frequently named as a BEV (12% 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 Prius Plug-in (a PHEV), never mind 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.

H_o: Those who rate them self as more familiar with PEVs and FCEVs will be neither more nor less likely to design a PEV or FCEV.

Responses to the question, "Are you familiar enough with these types of vehicles to make a decision about whether one would be right for your

[8] Any 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 this sample of NESCAUM new car buyers able to name an "EV" for sale in the US rises from 24% to 37%.

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 ICEV, HEV, PHEV, BEV, and FCEV vehicles is the percentage of respondents who are either unsure or decline to answer. As shown in Table 5, only a 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, to BEVs, to PHEVs, to a maximum of two-fifths of respondents who 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 willing to rate their familiarity (Table 5). The differences in the mean values are all significant at $\alpha < 0.001$ (Table 6). Given a respondent is willing to rate their familiarity with ICEVs, those vehicles have 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 6: on average the NESCAUM respondents rate themselves as quite familiar with conventional ICEVs, but this declines through HEVs, BEVs, PHEVs, until the average rating reaches slightly unfamiliar for FCEVs.

Table 5: NESCAUM Respondents Familiarity with drivetrain types, %

	Unsure	Decline to state	Total Unsure plus Decline to state	Mean	Median	Inter-quartile range
ICEVs	4.2	1.1	5.3	2.40	2.84	2.54 to 2.90
HEV	17.4	2.4	19.6	1.35	2.27	0.00 to 2.87
BEVs	20.0	2.0	22.0	1.04	1.81	0.00 to 2.85
PHEVs	24.3	3.7	28.0	0.68	1.33	-0.97 to 2.82
FCEVs	35.3	4.4	39.7	-0.58	-0.75	-2.90 to 1.52

Table 6: NESCAUM Differences in Respondents Ratings of Familiarity between ICEVs and HEVs, PEVs, and FCEVs, -3 = unfamiliar to 3 = familiar

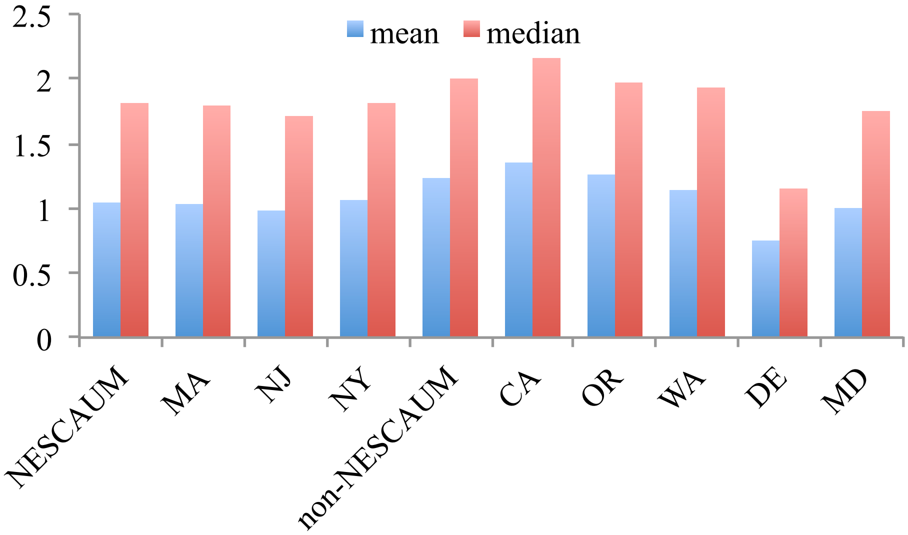
Vehicle Type	Mean[1]	Mean Difference[2]	
ICEV	2.40		—
HEV	1.01	ICEVs - HEV	1.39
BEV	0.80	ICEVs - BEVs	1.60
PHEV	0.50	ICEVs - PHEVs	1.89
FCEV	-0.50	ICEVs - FCEVs	2.90

1. Means differ from Table 5 because they are estimated on a smaller (n = 1220) set of respondents who provide a valid familiarity score for all five types of vehicles.

2. All differences statistically significant at $\alpha<0.01$.

For comparison, the mean and median scores for self-rated familiarity with BEVs are illustrated in Figure 7. That the mean scores are always lower than the median scores indicates that a group of people who rate themselves as very unfamiliar with BEVs is pulling down the mean values in all states and both regions.

Figure 7: Self-rating of familiarity with BEVs, mean and median scores: -3 = No; 3 = Yes

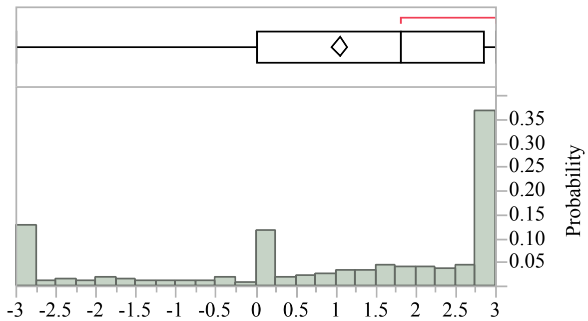


Note: The question is, "Are you familiar enough with electric vehicles to make a decision about whether one would be right for your household?"

This is illustrated in Figure 8 with data from the NESCAUM region. While a bit more than 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).

If respondents are "familiar enough…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 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 NESCAUM respondents are all negative (HEVs. -1.74; BEVs, -2.23; PHEVs, -2.34; and FCEVs, -2.44) and the median scores for all four are lower than -2.76. In short, within the realistic accuracy of the survey, more than half the sample has *no* driving experience with anything other than ICEVs. The data for NESCAUM new car buyers' experience with BEVs in Figure 8b is contrasted with their familiarity scores in Figure 8a. These results hold for the non-NESCAUM sample, too.

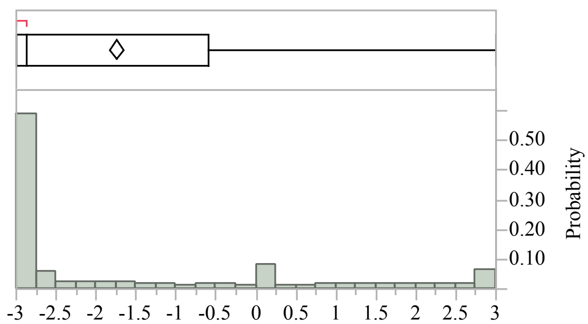
Figure 8a: NESCAUM, Self-rating of familiarity with BEVs: -3 = no; 3 = yes



Quantiles		
100.0%	maximum	2.99
99.5%		2.98
97.5%		2.96
90.0%		2.912
75.0%	quartile	2.85
50.0%	median	1.81
25.0%	quartile	0
10.0%		-2.9
2.5%		-3
0.5%		-3
0.0%	minimum	-3

Summary Statistics	
Mean	1.0417247
Std Dev	2.0618252
Std Err Mean	0.0477177
Upper 95% Mean	1.1353104
Lower 95% Mean	0.948139
N	1867
Sum Wgt	1867
Sum	1944.9

Figure 8b: NESCAUM Self-rating of driving experience BEVs: -3 = none; 3 = extensive



Quantiles		
100.0%	maximum	2.99
99.5%		2.95
97.5%		2.89
90.0%		1.716
75.0%	quartile	-0.5925
50.0%	median	-2.87
25.0%	quartile	-3
10.0%		-3
2.5%		-3
0.5%		-3
0.0%	minimum	-3

Summary Statistics	
Mean	-1.742819
Std Dev	1.877555
Std Err Mean	0.0395297
Upper 95% Mean	-1.665301
Lower 95% Mean	-1.820337
N	2256
Sum Wgt	2256
Sum	-3931.8

Prior awareness of vehicle purchase incentives

- Less than half (44%) of the NESCAUM sample of new-car buyers is aware of incentives from the federal government for alternatives to gasoline and diesel.

Analysis of awareness of incentives depends on whether different entities offer incentives. For example, buyers of PEVs are eligible for a federal tax credit no matter where they live in the country. Thus asking whether respondents have heard of such federal incentives has the same interpretation regardless of the state, city, electric utility service area, or any other jurisdiction in which they reside. The same is not true for any other entity that may offer incentives. In a state that does offer incentives, the interpretation of responses to a question about whether respondents have heard whether their state is offering incentives is different from a state that does not offer incentives. Because this analysis concerns itself with regions made up of multiple states—some of which offer incentives and some not—only an analysis of awareness of federal incentives offers a clear interpretation.

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).

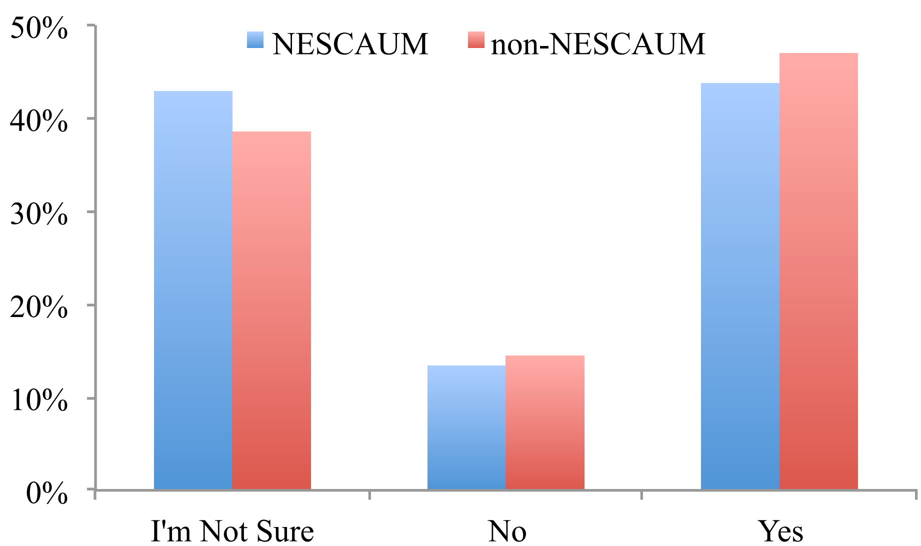
The federal tax credit is $7,500 for all BEVs presently for sale in the US; the credit for PHEVs ranges from $2,500 to $7,500 depending on the size of the traction battery.

The 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?" 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.

The percent of NESCAUM respondents who are aware of federal incentives (44%) is slightly lower than that for the non-NESCAUM states (47%) (Figure 9). The other key difference is a higher percentage of respondents in the NESCAUM region are unsure. The larger point is that across these two broad regions, fewer than half of new car buyers claim to have heard of federal incentives for consumers to buy vehicles powered by alternatives to gasoline and diesel.

H_o: Those are already aware of incentives will be neither more nor less likely to design a PEV or FCEV.

Figure 9: Awareness of incentives from the federal government to buy and drive vehicles powered by alternatives to gasoline and diesel?



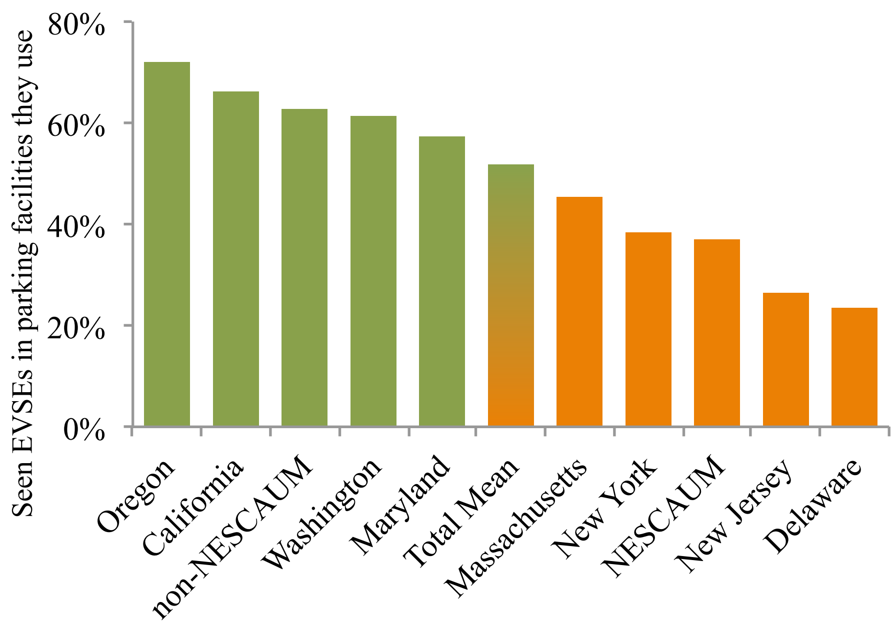
Prior awareness of PEV charging infrastructure

- More than one-third (37%) the NESCAUM sample claims to have seen PEV charging at the (non-residential) parking facilities they use; this is starkly lower than the non-NESCAUM sample (63%).

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. 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: 37% of the NESCAUM sample say they have seen a PEV charger in the places they park—well below the non-NESCAUM sample percentage (52%).

H_o: Those who have already seen PEV charging will be neither more nor less likely to design a PEV (or FCEV).

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



Household Vehicles

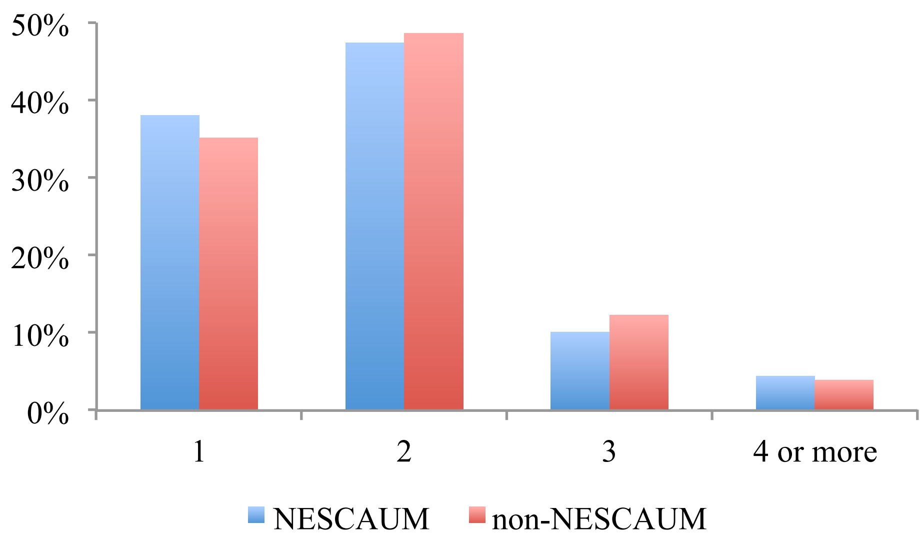
- On average, the NESCAUM sample owns slightly fewer but slightly newer vehicles than the non-NESCAUM sample.
- The NESCAUM sample is more likely to have leased a vehicle than the non-NESCAUM sample.

- On average, prices paid for the most recently acquired new vehicle are the same.

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, 38% of the NESCAUM sample owns one and 62% owns two or more. The distribution of number of vehicles owned (Figure 11) appears similar to the non-NESCAUM sample. The estimated mean number of vehicles is slightly lower in the NESCAUM sample (1.81) than in the non-NESCAUM sample (1.85).[9] The NESCAUM sample is also slightly more likely to have acquired two or more new vehicles since 2008 than is the non-NESCAUM sample (29% vs. 24%). The age distribution of these recently acquired vehicles—measured by the model year or year acquired—indicate the respondents in the NESCAUM region are more likely to have acquired their most recently acquired new vehicle even more recently than those in the non-NESCAUM region.

> H_o: Households with two or more vehicles will be neither more nor less likely to design a PEV or FCEV.

Figure 11: Number of Vehicles per household



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

[9] The estimates are produced by assuming a single numeric value for the highest category "four or more." This value is 4.0 in both samples.

and, based on additional survey and interview work with that population of PEV drivers, compared to their own past vehicle acquisitions. A higher percentage of the most recently acquired new vehicles in the sample from across the NESCAUM were leased than in the non-NESCAUM sample. In the NESCAUM sample, 19% of the most recently acquired new cars, 12% of the other household vehicle driven most often, and 22% of either these vehicles were leased. The corresponding figures for the non-NESCAUM sample are only 11%, 7%, and 13%.

H_o: Respondents with prior experience leasing vehicles will be neither more nor less likely to design a PEV or FCEV.

On average, the prices paid for their most recently acquired new vehicles were similar across the two samples: NESCAUM, $28,500 and non-NESCAUM, $28,200. The difference is not statistically significant. The median of the reported "total price including options, fees, and taxes" for the most recently acquired vehicle was $25,000 in the NESCUM sample and $25,500 in the non-NESCAUM sample. That the mean is higher but the median lower in the NESCAUM sample means the mean is skewed upwards by a small number of high prices. 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 these factors: 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.

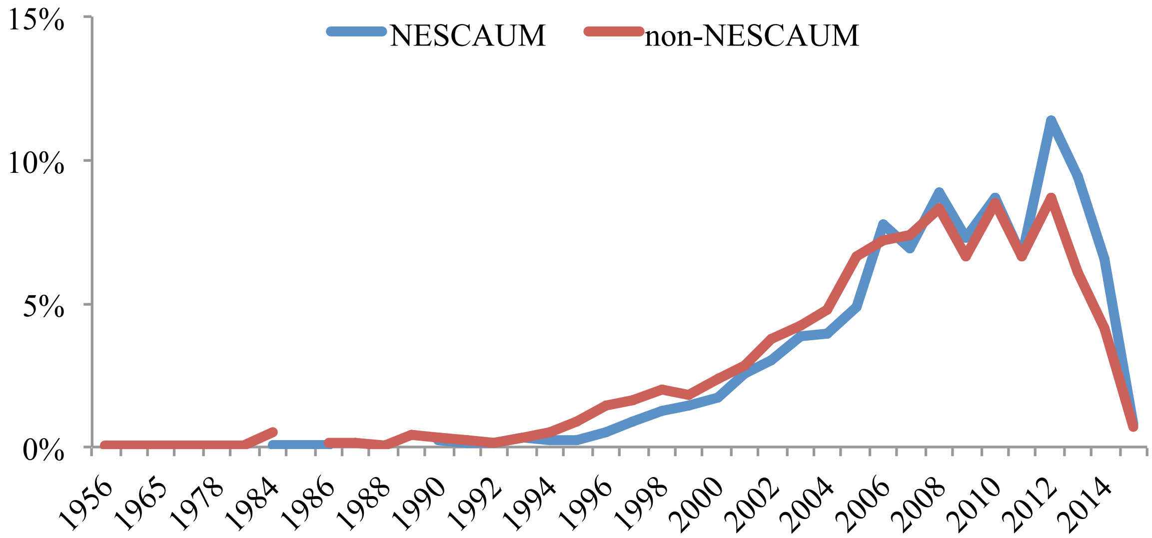
H_o: Past prices of new vehicle purchases will not be correlated with likeliness to design a PEV or FCEV.

H_o: Household income will not be correlated with likeliness to design a PEV or FCEV.

The vast majority of these most recently acquired vehicles (97% in the NESCAUM sample and 95% in the non-NESCAUM sample) are fueled by gasoline. Diesel is the most common alternative in both regions, approximately three percent of the newest vehicles in the NESCAUM sample and four percent in the non-NESCAUM sample.

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 model year data are shown in Figure 12. Despite the long tail toward older years (note the x-axis is not linear for years older than 1984), 93% of these "second" vehicles are model year 2001 or newer for the NESCAUM sample and 87% for the non-NESCAUM sample. 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 NESCAUM 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 ZEVs?

- Eight-of-ten respondents in the NESCAUM sample report they own their residence type
    - This is slightly higher than the non-NESCAUM sample.
- However, the NESCAUM sample is less likely to be able to park a vehicle in garage or carport attached to their residence and less likely to have electrical service at the location they park.
    - Despite these, the NESCAUM sample is more likely than the non-NESCAUM sample to report they could install a new electrical outlet at a home parking location than the non-NESCAUM sample.

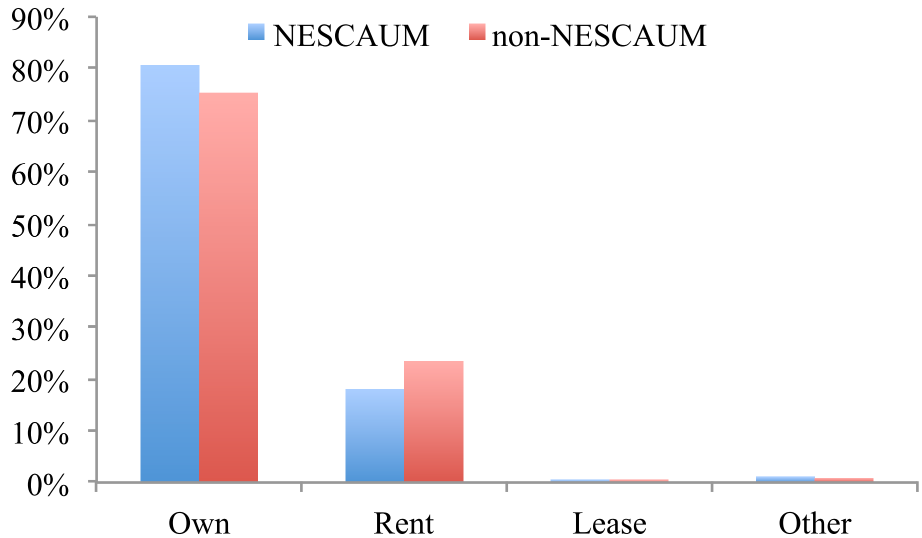
Turning from the household members and their vehicles to features of their residences that may make the respondent households more or less able to charge a PEV or fuel an FCEV at home, more of the NESCAUM sample (81%) report they own their home than of the non-NESCAUM sample (75%), with converse differences in the probability they rent or lease their residence (Figure 13). Seventy-two percent of respondents in both samples report their residence is a single-family home. There are slight differences in the relative probability they reside in an apartment, multiplex, or mobile home, but overall the distributions are similar (Figure 14).

Despite the similarity of residence type, far fewer NESCAUM respondents report they park a household vehicle in a garage or carport attached to their residence (48%) than the non-NESCAUM sample (62%). Further, slightly more report they do not have access to any electricity at the location they park their vehicles at their residence

H_o: Ownership of one's residence and type of residence will be uncorrelated with drivetrain type.
H_o: Whether the residence has natural gas or solar panels will be uncorrelated with drivetrain type.

(26% vs. 23%). Despite these two points, a higher percentage of NESCAUM respondents (70%) than non-NESCAUM respondents (65%) report their household could install a new electrical outlet near one of their home parking spots on their own authority.

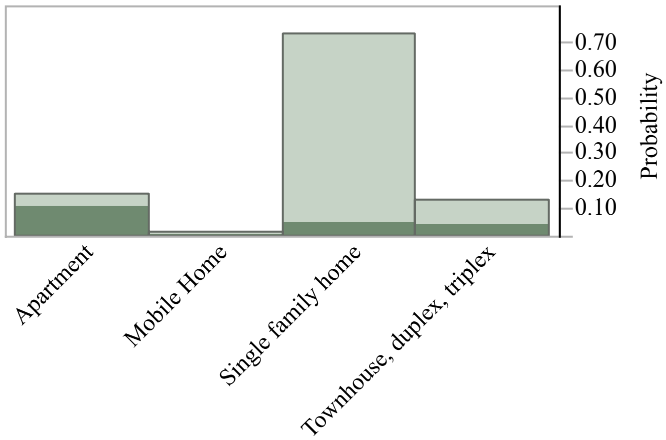
Figure 13: Own or rent residence, percent



In Figure 14, respondents who rent their residence are highlighted in a darker shade: most apartments are rented but less than half of townhouses and multiplexes and few single-family homes are rented. Multi-unit dwellings—apartments, townhomes and multiplexes—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. Only 17% of apartment renters in the NESCAUM sample say they could install a new electrical outlet near one of their home parking spots on their own authority compared to 87% of homeowners. These figures are similar for the non-NESCAUM sample (15% and 85%).

One option for home refueling hydrogen for FCEVs is reforming natural gas. Most households in the NESCAUM sample (60%) report they have natural gas at their residence; this is lower than for the non-NESCAUM sample (64%). Finally, a smaller percentage of the NESCAUM sample (11%) already has a home solar energy installation than of the non-NESCAUM sample (14%), though clearly such installations are not prevalent across either sample.

Figure 14: NESCAUM Type of Residence, percent



Frequencies

Level	Count	Prob
Apartment	351	0.14668
Mobile Home	23	0.00961
Single family home	1729	0.72252
Townhouse, duplex, triplex	290	0.12119
Total	2393	1.00000

N Missing 0

4 Levels

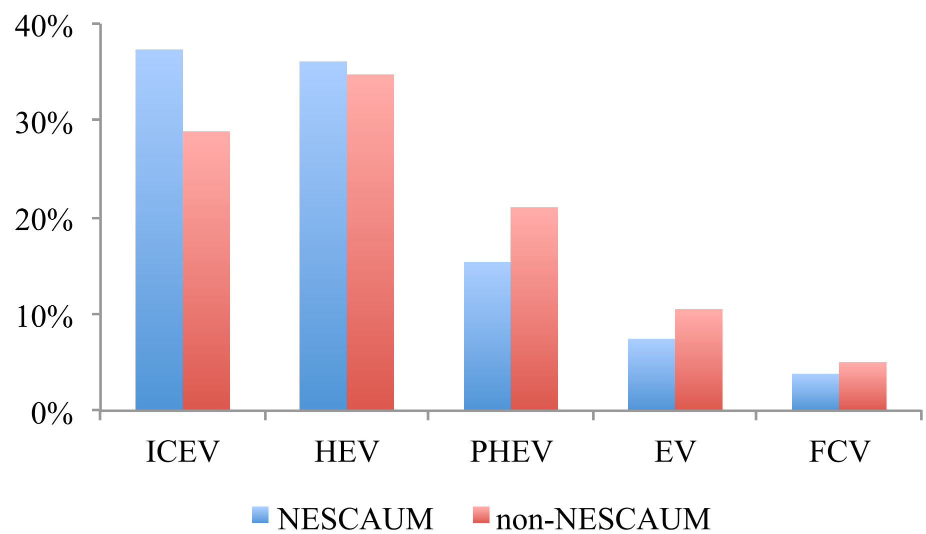
RESULTS: RESPONDENTS' VEHICLE DESIGNS

How many Respondents design their next new vehicle to be a ZEV?

PEV and FCEV valuations are determined in the final design game that most corresponds to the present reality—no ZEVs were offered with battery-powered all-electric drive and full-size body styles however there were federal, state, and local incentives offered for PEVs and FCEVs.[10] 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.

Ignoring for now differences between vehicles within each drivetrain type, e.g., differences in driving range across BEV designs, slightly more than one-of-four respondents in the NESCAUM states design their next new vehicle to be a PHEV (15%), BEV (7%), or FCEV (4%) (Figure 15). As they are important for many transportation energy goals, note HEVs (36%) are as common as ICEVs (37%)—far out-distancing the prevalence of HEVs in the on-road vehicle fleet and new vehicle sales. As seen in Figure 15, the distribution of drivetrain types created by the NESCAUM sample differs from that of the non-NESCAUM sample: the NESCAUM sample is less likely to design their next new vehicle to be a PHEV, BEV or FCEV. The differences between the two distributions are statistically significant at $\alpha \leq 0.05$.

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



[10] The exclusion of battery-powered all-electric drive for full size vehicles includes both BEVs powered solely by batteries and PHEVs that are powered only by batteries until their batteries are discharged and their ICEs are started. The exclusion is due to the mass, volume, and cost penalties of providing batteries to supply the energy and power required for full-size vehicles.

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

- PHEV designs were by far the most popular of the PEV and FCEV possibilities. In Figure 15: 367 respondents designed a PHEV compared to 177 BEVs and 91 FCEVs.
- PHEV designs emphasized longer range driving on electricity, but a mode in which gasoline is used too, i.e., "Assist" rather than all-electric charge-depleting operation.
- Fast charging at home (such as provided by the installation of an EVSE) or at a (initially limited) network of quick chargers was viewed as necessary by a small percentage of those who designed a PHEV.

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.[11] 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.[12] 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.

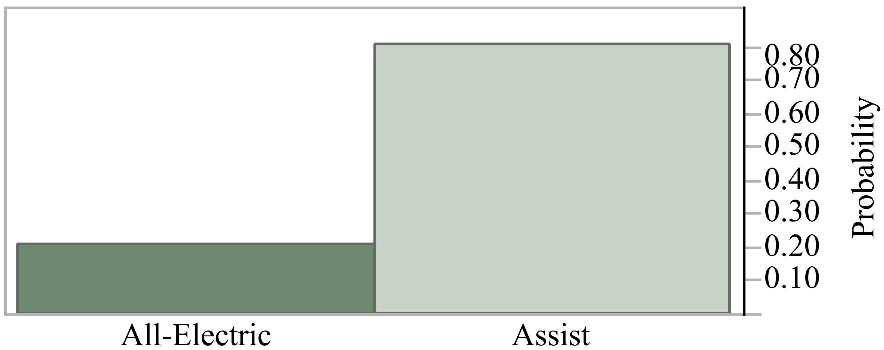
In addition to a choice between all-electric or assist capability during charge depleting operation, respondents choose the driving range over which charge depleting operation lasts, the time required to fully charge their PHEV design at home (expressed to them in hours), and whether they want access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

The dark-shaded region in Figures 16 to 18 highlights those respondents whose PHEV design include all-electric charge-depleting mode. Most of the NESCAUM sample (80%) designed a

[11] BMW's i3 with Range Extender is an example of this type.
[12] Toyota's Plug-in Prius is an example of this type.

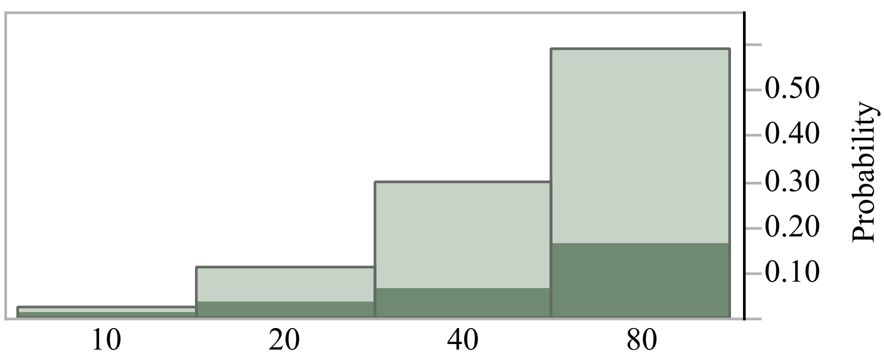
PHEV that operates in Assist mode, i.e., uses both gasoline and electricity during charge-depleting operation (Figure 16).[13]

Figure 16: PHEV Charge-depleting operation



A majority of the NESCAUM sample (58%) 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 i3 with Range Extender. At the low end, a range of 10 miles (incorporated into five NESCAUM respondents' PHEV design) approximates that of the 2014 Prius Plug-in.

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

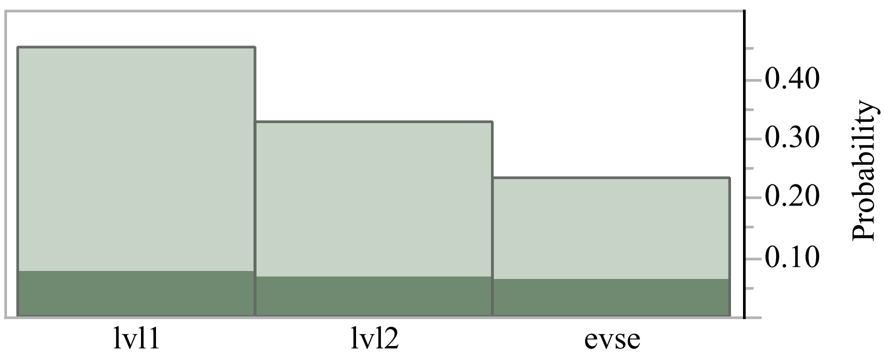


In Figure 18, home charging speeds are denoted by lvl1, lvl2, and EVSE. These are shorthand for the charging speed offered by a typical home 110-volt outlet (lvl1 ≈ 1.1kW), a higher power 220-

[13] Feedback during the follow-up interviews in California, Oregon, and Washington suggests that 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 are confused about the characteristics of, and distinctions between, these three drivetrains.

volt outlet (lvl2 ≈ 6.6kW), or a higher power, specialty appliance for charging PEVs (EVSE ≈ 9.9kW): faster charging costs more in the design games. A plurality (45%) 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. Conversely, fewer than one-in-four (23%) believe they would want the fastest home charging.[14]

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, 142 of the 367 (39%) respondents who designed a PHEV incorporated the quick charge option into their vehicle design. There is not a statistically significant difference in the speed of home charging by assist vs. all-electric operation, but there is a statistically significant greater likeliness that those who design PHEVs with longer charge-depleting range are more likely to also choose faster home charging.[15]

---

[14] All home charger 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.
[15] This result depends on grouping together PHEV designs with 10 or 20 miles of charge-depleting range. The grouping is required because so few PHEV designs incorporate only 10 miles charge-depleting range that it affects the validity of the statistical test. The grouping is justified to the extent the patterns of charging choices are similar for both these range categories.

BEV Designs

- BEV designs incorporate driving ranges from across the spectrum of offered options, i.e., 50 to 300 miles.
    - Less than one third of those who design a BEV design one with the maximum offered driving range.
    - In contrast, more than half design BEVs with driving ranges of 125 miles or less.
- Almost two-thirds of those who design BEVs (63%) believe they would be satisfied with a charging speed that could be supplied by existing household 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 49% of respondents who also opted for quick charging capability. Just over half (52%) of 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). While the fastest possible home charging (EVSE) is the most frequent choice, still it is chosen by only 37% of BEV designers. In fact the distribution of home charging speeds in Figure 20 may be considered surprisingly uniform and the fact that nearly two-thirds of those who design a BEV believe they would be satisfied with the charging speeds afforded by existing home 110 and 220V circuits equally novel.

Figure 19: Distribution of BEV Range, by whether quick charging capability was included

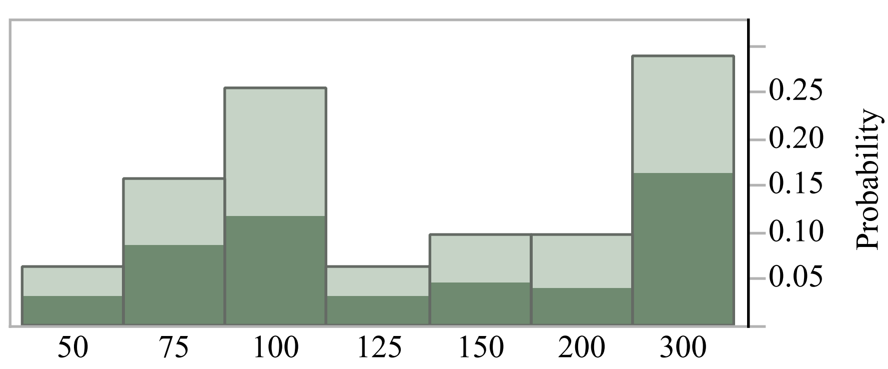
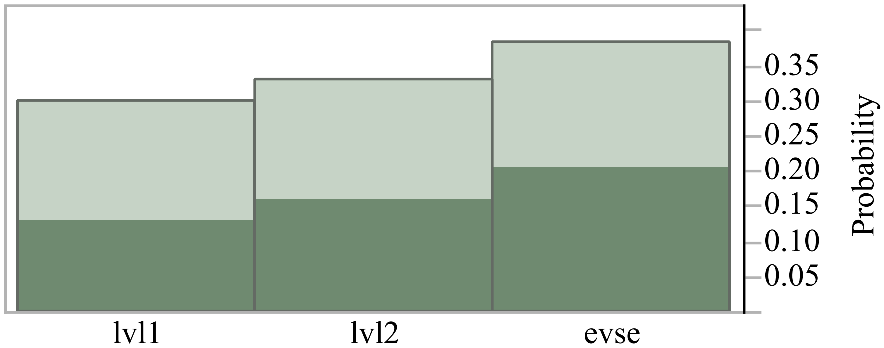


Figure 20: BEV Home Charging Duration by quick charging capability was included



Visual inspection of Figures 19 and 20 indicates that quick charging capability is no more or less likely to be incorporated into the BEV design based on driving range or home charging speeds. (The ratio of light to dark areas is very similar within each column.) It is the case that faster home charging is associated with longer range: 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. Most every other possibility appeals to someone.

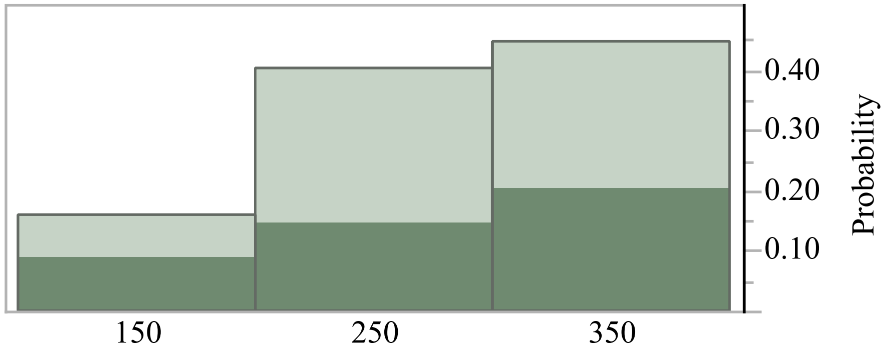
FCEV Designs

- Range includes all three possible options (150, 250, and 350 miles); a slight plurality (44%) opts for the longest range.
- Home H_2 refueling was included with 44% of FCEV designs.

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. This is how away-from-home refueling for FCEVs was described:

> "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



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_o). 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 whether they design their next new vehicle to be a PEV or FCEV. For BEVs with driving range limits, prior research indicates that households with more vehicles have more options for those instances when a driving range limit 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

Most 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. This is due in part to the comparatively large sample size—correlations that were not significant in any given state sample may be significant in the far larger NESCAUM sample. 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 PEV and FCEV valuation than the original questions.

In contrast to the models estimated for individual states, this model retains several variables that do not meet the statistical tests of significance. This can be done because of the larger sample size. The reason to do so is it allows for stronger conclusions to be made about those variables that do pass the test of statistical significance. For example, the model estimated here contains the variable for household income despite the fact it is not a statistically significant explanatory variable of respondents' vehicle designs. Keeping the income variable in the model allows us to explicitly conclude that controlling for income (because it is in the model), gender (for example) is correlated with vehicle designs.

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 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 explanatory variables present in the model for the NESCAUM region are listed below. Those that are statistically significant at $\alpha \leq 0.05$ are shown **bold**, effects significant at $0.10 \geq \alpha < 0.05$ are *italicized*, and those variables that fail to meet the threshold of $\alpha < 0.10$ are shown in plain text:

- Respondent (and their household) Socio-economic and Demographics
  - *Respondent education*
  - **Respondent gender**
  - Household income
- Household vehicles, travel and residences
  - *Respondent commutes to workplace in a household vehicle or not*
  - **Home parking in a garage or carport**
- Vehicle knowledge and experience
  - *Familiarity with ICEVs*
  - **Driving experience in HEVs**
- Attitudes related to policy goals: energy security, air quality, and global warming
  - **Perceives an urgent national need for alternatives to gasoline and diesel**
  - **Comparative assessment health and environmental risks of electricity and gasoline in their region**
- Prior ZEV evaluation and ZEV-specific attitudes
  - Prior belief electricity is a likely replacement for gasoline and diesel
  - **Prior belief hydrogen is a likely replacement for gasoline and diesel**
  - **Respondent's personal interest in ZEV technology**

- **Seen public charging in the parking locations they use**
- *Prior assessment of PEVs*
  - **Charging: extent of opportunities away from home and capability to charge a PEV at home**
  - **Range per charge and time it takes to charge**
  - **Relative safety and reliability of PEVs and ICEVs**
  - *Relative purchase price of PEVs and ICEVs*
- Prior assessment of FCEVs
  - Fueling time, driving range, and number of fueling locations
  - Relative safety and reliability of FCEVs and ICEVs
  - Relative purchase prices of FCEVs and ICEVs
- **Whether have already considered buying a PEV**
- **Whether have already considered buying an FCEV**
- Whether governments should offer incentives for electricity and hydrogen

Respondent (and their household) Socio-economic and Demographics

Data from early buyers of PEVs indicates those people are disproportionately more likely to have many more years of formal education, to be male, and to have far higher incomes than even other new car buyers. Pertinent to the project of growing markets for PEVs and FCEVs, are such markets limited to such highly educated, male, and wealthy customers? The purpose of testing socio-economic and demographic variables is to address if the question of interest in PEVs and FCEVs is limited to, or shaped by, these variables, or whether interest is broader across the population. In general, the state-level models do not include socio-economic or demographic variables. The presence of two such variables in the regional NESCAUM model may be due simply to the far larger sample size of the aggregate NESCAUM data set. The absence of socio-economic and demographic variables indicated that other variables have stronger correlations to interest in PEVs and FCEVs and thus that interest—among those who have not already acquired one—can be found across the population of car buyers.

The two descriptors of respondents that are in the NESCAUM model are respondent education and gender. Based on the model parameters, the generalization holds (within the model) that respondents with more years of formal education are estimated to be more likely to have designed an HEV, PHEV, BEV or FCEV than are respondents with fewer years of education. Income is correlated with education (in both the NESCAUM data and most any other data on households). However, if the variable for household income and an interaction effect between education and income are entered into the model, neither is statistically significant nor is the overall model performance improved. In short, something other than its effect on income shapes the role of education on PEV and FCEV valuation.

The effect of gender in the model is contrary to the characterization of early PEV buyers just stated, rather the model for the NESCAUM region estimates that women were more likely than men to design PHEVs, BEVs, and FCEVs. Thus, even accounting for all other variables that are in the model—including for example personal interest in ZEV technology—there remains some otherwise unexplained difference between women and men. That in a sample of people who have not yet purchased a PEV or FCEV more women than men appear to be interested in PEVs and FCEVs should provide additional impetus to understand why women appear to be under-represented in that market so far.

Household income is not a statistically significant explanatory variable. It is retained in the model only to retain statistical control over whether it is or not.

Household vehicles, travel and residences

Only one measure of the respondents' vehicles or travel at the time of the survey was in the final model: whether the respondent commuted to a workplace in a household vehicle. The vehicle does not have to be used for the entire commute trip for the respondent to be counted as "commuting by car." Respondents who commuted, at least part way, to work in a household vehicle is more likely to design a HEV, PHEV, or BEV than are those who did not. Employed persons commute to a workplace (by any mode(s)); in this sense, commuting is correlated with age. However, neither respondent age nor an interaction between commuting and age enters into the final model. Thus the effect of commuting via a household vehicle on forming a positive PEV valuation appears to be different from—and more strongly correlated to PEV valuation—than age. That is, people who do not commute to work in a household vehicle but are of the same age as people who do commute to a workplace were less likely to have a positive PEV valuation than same-aged, car-commuting respondents.

One measure related to the respondents' residences enters the model: whether the respondent's household parks at least one vehicle in a garage or carport attached to their residence. Respondents who do park a car in a garage or carport were estimated to be more likely to design a PEV. Dedicated garages and carports are more frequently found in single-family homes than multi-family dwellings. However, the presence of the "garage/carport" variable in the model and the absence of the variable for residence type or home ownership vs. rental would indicate that it is the parking spot—not the building type or ownership—that matters to the higher probability of designing a PEV in the design games.

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

Nine measures related to energy security, air quality, global warming, the comparative environmental and human health risks of electricity and gasoline, and whether government policy or market action would best produce any necessary incentives for alternatives to gasoline and diesel were reduced to five factors; two remain in the final model. One factor is most strongly tied to the respondents' strength of disagreement or agreement with the statement "There is an urgent national need to replace gasoline and diesel for our cars and trucks with other sources of energy." The other factor ties together respondents' comparative assessment of the environmental and health risks of electricity and gasoline—where they live.

Those who more strongly agree in a national urgency to transition from gasoline and diesel and those who think that electricity poses reduced environmental and human health risks were estimated to be more likely to have formed positive PEV or FCEV valuations.

Prior ZEV evaluation and ZEV-specific attitudes

Nine variables related to respondents' consideration of PEVs, FCEVs, and ZEV-related policy instruments prior to completing the design games in the survey are correlated to drivetrain types in the final game:

1. Prior belief whether hydrogen is a likely replacement for gasoline and diesel;
2. Respondent's personal interest in ZEV technology;
3. Prior assessment of PEVs;
4. Charging: extent of opportunities away from home and capability to charge a PEV at home;
5. Range per charge and time it takes to charge;
6. Relative safety and reliability of PEVs and ICEVs;
7. Whether have already considered buying a PEV;
8. Have already considered buying an FCEV; and,
9. Whether governments should offer incentives for electricity and hydrogen.

Prior belief hydrogen is a likely replacement for gasoline and diesel

Those respondents who choose hydrogen as a likely replacement for gasoline and diesel fuel were estimated to be more likely to design their next new vehicle as a BEV or FCEV. Given the other explanatory variables in the model, whether respondents initially believed electricity is a likely replacement for gasoline and diesel was not correlated to their vehicle drivetrain types.

Respondent's personal interest in ZEV technology

Respondents who claim higher levels of personal interest in ZEV technology were estimated to be more likely to design PHEVs, BEVs, or FCEVs than are those who claim no or low interest.

Prior PEV Factors

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

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 were on a scale from strongly disagree (-3) to strongly agree (3). A factor analysis of these seven reduces these seven variables to four factors:

Prior PEV Factor 1: driving range and charging time
Prior PEV Factor 2: comparative safety and reliability of PEVs and ICEVs
Prior PEV Factor 3: charging, home and away from home
Prior PEV Factor 4: purchase price

The first three factors are statistically significant at $\alpha < 0.05$ in the final model; the factor for purchase price only meets the threshold of $\alpha \leq 0.10$. The lower the factor score for Prior PEV Factor 1, i.e., the more strongly they disagree that PEVs don't travel far enough and take too long to charge, the more likely they were to design a PEV. Similarly for Prior PEV Factor 2, lower scores imply more favorable evaluations of the safety and reliability of PEVs and lower scores were associated with higher probabilities respondents design PEVs. The sense of the first two (of the original seven) statements was opposite that of the final five. Thus the signs of the data values were flipped positive-for-negative prior to factor analysis so that interpretation of all factor scores would be identical. Therefore, smaller scores for Prior PEV Factor 3 indicate the respondent has a more favorable evaluation of their ability to charge a PEV at home and of the adequacy of an away from home charging opportunities. Lower factor scores were associated higher probabilities of designing PEVs and ICEVs—it is HEVs whose probabilities are reduced.

Prior PEV Factor 4 was associated with respondents' prior conception of PEVs comparative purchase price compared to ICEVs; it attains only a "provisional" level of significance in the final model of respondents' drivetrain design. This does not mean respondents thought prices were comparable to ICEVs or favorable for PEVs. It means that whatever they thought about PEV prices prior to their design games, we are less confident those prior thoughts determined their vehicle designs.

A reduced number of factors for the attributes of FCEVs evaluated by respondents were also estimated. The FCEV attributes were similar to the second through sixth attributes for PEVs, and were also evaluated on a scale from strongly disagree (-3) to strongly agree (3):

1. There are enough places for drivers to refuel vehicles with hydrogen.
2. Hydrogen fuel cell vehicles take too long to refuel.
3. Hydrogen fuel cell vehicles do not travel far enough before needing to be refueled.
4. Hydrogen fuel cell vehicles cost more to buy than gasoline vehicles.
5. Gasoline powered cars are safer than hydrogen fuel cell vehicles.
6. Gasoline powered cars are more reliable than hydrogen fuel cell vehicles.

The factor analysis produces these three factors:

Prior FCEV Factor 1: fueling time, driving range and extent of fueling opportunities
Prior FCEV Factor 2: comparative safety and reliability of FCEV and ICEVs
Prior FCEV Factor 3: purchase price

None of these factors meet the threshold for statistical significance. They are kept in the model because the parallel constructs for PEVs do enter the model and the inclusion of the FCEV factors explicitly controls for prior ideas about FCEVs.

Whether they have already considered buying a PEV or FCEV

The original variables offered six answers along a scale from a lack of prior consideration (reinforced by actual opposition to future consideration of plug-in vehicles) to people who already own a PEV or FCEV. For PEVs, the top two categories of engagement (have shopped for a PEV including a visit to a dealership for a test drive, and already own a PEV) were collapsed into a single category because of the relatively few number of people in those categories. For

FCEVs, the top three categories (adding the category “have searched for information on PEVs or FCEVs”) were collapsed into a single category.

In general, higher levels of prior consideration of either or both a PEV and FCEV were associated with higher probabilities of designing one in the survey. Conversely, for both vehicle types there appears to be a small—but determined—minority of people who believe they will never consider a PEV or FCEV, and indeed the model estimates high probabilities that such people designed an ICEC or HEV for their households next new vehicle.

Whether they support government incentives for electricity and hydrogen

Prior to the design games respondents were asked whether they supported the idea of governments providing incentives, specifically, if governments should offer incentives to consumers to buy vehicles that run on electricity or hydrogen. The answers allowed them to support either but not the other, both, neither, or to indicate they are unsure.

This is one variable (along with respondent education and whether the respondent commutes to work in a household vehicle) that was less statistically significant when the non-significant variables of household income, prior FCEV assessment, were included in the model. In this case though, the reduction was enough to disqualify belief in whether governments should offer incentives as a statistically significant explanatory variable. Though confidence in these effects was lower than the 10% threshold, in general, agreement that incentives should be offered for either or both was associated with a decreased likeliness to design a conventional ICEV. However, the effects on the designs of PHEVs, BEVs, and FCEVs appear to be fuel specific. That is, the higher probabilities the respondent designed a PHEV or BEV were estimated for people who think only electricity should be incentivized, not both. Similarly, for FCEVs belief that incentives should be offered for hydrogen but not electricity was associated with higher probabilities they design an FCEV than if they believe both hydrogen and electricity should be incentivized.

Overall model performance

A summary view of how well the model performs is provided in Table 7 where the actual drivetrain design is cross-classified by the drivetrain “predicted” by the model. The model “predicts” each respondent’s likely drivetrain type by estimating a probability for each drivetrain type, then assigning the type with the highest probability.

The model underestimates the number of PHEVs, BEVs, or FCEVs. For example, of 364 respondents who actually designed a PHEV, the model correctly assigns a PHEV design to 64 respondents while misestimating another 104 people design a PHEV (for total of 168 predicted PHEVs). The question of why the model doesn’t do a better job of predicting ZEV designs and how the model (of the game results) informs decisions for the real world will be taken up in the Discussion section. That the model does not precisely replicate the actual designs does not disqualify its insights.

Table 8a summarizes the values of the explanatory variables used for a baseline estimation of the likeliness of respondents’ drivetrain designs. The estimation algorithm selects values of each explanatory variable to produce a baseline estimate. For example, for explanatory variables that have only a few specific values, the value used for baseline estimates are the minimum values (if data are numeric) or the first value in the order of values specified by the researcher. Since the baseline is selected by the algorithm, using no information about the substantively interesting or important combinations of values, the baseline estimate is merely a point from which to start a conversation about what are the effects of the explanatory variables on the estimated probability each respondent designs a particular type of drive train.

Table 7: Actual and predicted drivetrain designs

Actual Game Design No trucks, plus incentives: drivetrain design	Predicted Design ICEV	HEV	PHEV	BEV	FCEV	Actual Game Total
ICEV	598	256	19	9	2	884
HEV	234	552	42	19	9	856
PHEV	67	215	64	14	4	364
BEV	31	83	31	25	6	176
FCEV	23	41	12	5	9	90
Predicted Total	953	1147	168	72	30	2370

The baseline probability estimates are shown at the top of Table 8b, followed by estimates based on the changes to the values of 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 the respondents who have the combination of values described by that row. Note that the drivetrain type assigned by the model does not have to have a large probability or even large compared to other probabilities. It simply has to be the highest probability of any of the five drivetrains. The baseline values produce a probability estimate that people described by that combination of values designed a conventional ICEV in the third game. Again, a profile of that "baseline" respondent can be read in the values in Table 8a.

As an example of how changing values of explanatory variables shifts the probability estimates drivetrain types, the next rows in Table 8b show the estimated probability distribution if we change (three variables: respondent education from "high school or less" to "some college"), interest in ZEV technology (from "none" to "a little"), and commutes to work in a household vehicle (from "no" to "yes"). The result is—by a slim margin—an assignment of an HEV as the predicted drivetrain. The next example in Table 8b is a profile of values that produces an estimate of a BEV—despite essentially identical probabilities for a PHEV or a BEV. This profile starts to conform to that of early PEV buyers—highest level of formal education, highest level of interest in ZEV technology, male, has already started a search for information on PEVs; the idea of an FCEV has occurred to him but he has taken no steps. In fact he is not particularly a fan of hydrogen and fuel cell vehicles—he neither selects hydrogen as a likely replacement for gasoline and diesel nor think governments should offer consumer incentives for vehicles powered by hydrogen. His household already parks at least one vehicle in a garage or carport attached to his residence. He agrees there is an urgent national need for a transition away from gasoline and diesel fuel. Note, this is not *the* profile of BEV-supporters; it is merely one profile that produces a higher probability a BEV is designed than any other drivetrain.

Table 8a Baseline values of explanatory variables for estimation of the probability distribution of drivetrain designs

Explanatory variables for baseline estimation[1]	Value
Respondent Education	*High school or less*
Respondent Gender	**Female**
Household income	$75,000 to $99,999
Respondent commutes to work in household vehicle	*No*
Household parks at least one vehicle in garage or attached carport	**No**
Familiarity Factor 2: ICEVs	*0.00*
Driving Experience Factor 2: HEV	**0.00**
Pro-social Factor 5: Urgent national need for transition	**0.00**
Pro-social Factor 2: environmental and health risk of electricity	**0.00**
Replacement for gasoline and diesel: electricity	No
Replacement for gasoline and diesel: hydrogen	**No**
Personal interest in ZEV technology	**None**
Seen EVSEs in parking facilities they use	**No**
PEV Factor 1: driving range and charging time	**0.00**
PEV Factor 2: safety and reliability	**0.00**
PEV Factor 3: charging; home and public	**0.00**
PEV Factor 4: purchase price	*0.00*
FCEV Factor 1: range, fueling time, fueling network	0.00
FCEV Factor 2: safety and reliability	0.00
FCEV Factor 3: purchase price	0.00
Prior Consideration of a PEV:	**Shopped or own**
Prior Consideration of an FCEV:	**Sought information, shopped or own**
Support consumer incentives for vehicles running on electric or hydrogen	Not sure

1. Variables and their values that are statistically significant at $\alpha \leq 0.05$ are shown **bold**, those significant at $0.05 \leq \alpha \leq 0.10$ are *italicized*, and those variables that fail to meet the threshold of $\alpha \leq 0.10$ are shown in plain text

Table 8b Probability of drivetrain types for profiles of explanatory variables

Drivetrain type:		ICEV	HEV	PHEV	BEV	FCEV
Base probability estimates, %		**58.7**	33.8	3.3	3.7	0.5
	Value	**Resulting Probabilities, %**				
Example changes to three variables from baseline values:		42.7	**44.6**	5.8	5.7	0.2
Respondent education:	Some college					
Interest in ZEV technology	A little					
Commute to work in household vehicle:	Yes					
Example changes to baseline profile that produce a predicted BEV design		7.5	26.9	18.0	**29.8**	17.9
Respondent education	Graduate degree					
Gender	Male					
Park at home in garage or carport	Yes					
Commute in a household vehicle	Yes					
Familiarity Factor 2: ICEVs (25^{th} percentile)	-0.39					
Pro-social Factor 2: urgent national need (75^{th} percentile)	0.52					
Pro-social Factor 5: electricity (75^{th} percentile)	0.49					
Personal interest in ZEV technology	Very interested					
Seen EVSEs in parking facilities	Yes, one place					
Prior Consideration of a PEV:	Info search, but not serious yet					
Prior Consideration of an FCEV:	Idea occurred, no steps taken					
Support consumer incentives	Electricity only					

Note the predicted designs in Table 7 are the drivetrains with the highest probability for each respondent's combination of values of the explanatory variables. For the base probability estimate at the top of Table 8b, it is clear that the conventional ICEV would be the predicted design. Note that for the example profile of a BEV the predicted design is a BEV even though the probability is not quite 30%. Nevertheless, it has the highest probability of any drivetrain type for the example combination of values of explanatory variables, and is thus the predicted design.

Table 8c shows the probabilities of each drivetrain type estimated based on the modal (most common) of the categorical explanatory variables and the starting values of the continuous variables (the factor scores and income). For the factors this starting value is approximately zero. This probability distribution should not be mistaken for being a profile of a "common" respondent. Selecting only respondents who offer the most common response to all nine of the categorical variables produces only 14 respondents. In general, the likeliness of any particular outcome for any profile of values should not be mistaken for an overall likeliness; those are shown in the predicted values in Table 7.

Table 8c Probability of drivetrain types for the most common (modal) values of the categorical explanatory variables and median values of continuous variables, percent

	Drivetrain type:	ICEV	HEV	PHEV	BEV	FCEV
	Probability Estimates:	37.3	**47.0**	13.6	1.6	0.5
Respondent education	College graduate					
Respondent gender	Female					
Commutes to work in household vehicle	Yes					
Parks at home in garage or carport	No					
Replace gasoline and diesel: hydrogen	No					
Replace gasoline and diesel: electricity	Yes					
Personal interest in ZEV technology	A little					
Seen EVSEs in parking facilities	No					
Prior Consideration of a PEV:	Have not, may someday					
Prior Consideration of an FCEV:	Have not, may someday					
Support consumer incentives	Yes, both					

Finally, Tables 8d, 8e, and 8f contain the three profiles of values of the explanatory variables that produce the maximum estimated probability of the drivetrain design in the third design game being a BEV, PHEV, and FCEV. These "extreme" profiles are not the only people interested in each drivetrain type. However, they do provide insights into the differences between respondents that provide a strong differentiation between those who design vehicles of different drivetrain types. Collectively, they provide indications of which things—because they differentiate people at this point in time—may be the best candidates for what could change people's minds over time to produce more favorable PEV and FCEV valuations. Note that in Tables 8d, e, and f household income is held constant at the baseline value (the maximization method will change the value; these changes were manually overridden). This was done because household income is not a significant explanatory variable to start but unlike the other non-significant explanatory variables—FCEV factors and belief electricity is a likely replacement for gasoline and diesel, which were allowed to change—there is no plausible policy goal to change the income distribution of the population of new car buyers.

Table 8d Profile of explanatory variables that maximizes the probability of a PHEV[1]

Drivetrain type:		ICEV	HEV	PHEV	BEV	FCEV
Maximum likeliness of designing an PHEV		~0.0	1.9	**96.9**	0.8	0.3
Respondent education	*Some college*					
Respondent gender	**Female**					
Household income[2]	$75,000 to $99,999					
Respondent commutes in household vehicle	*Yes*					
Parks at home in garage or carport	**Yes**					
Familiarity Factor 2: ICEVs	*1.47*					
Driving Experience Factor 2: HEVs	**2.67**					
Pro-social Factor 5: Urgent national need	**1.80**					
Pro-Social Factor 2: electricity	**2.51**					
Replace gasoline and diesel: hydrogen	**No**					
Replace gasoline and diesel: gasoline	Yes					
Personal interest in ZEV technology	**Interested**					
Seen EVSEs at parking facilities	**Yes, several**					
PEV Factor 1: range and charge time	**-2.83**					
PEV Factor 2: safety reliability	**-2.11**					
PEV Factor 3: charging, home and public	**1.74**					
PEV Factor 4: purchase price	*1.71*					
FCEV Factor 1: fueling time, range, fueling locations	-2.33					
FCEV Factor 2: safety and reliability	-2.71					
FCEV Factor 3: purchase price	-3.07					
Prior consideration of PEV	**Gathered info, not serious yet**					
Prior consideration FCEV	**Haven't, may someday**					
Support consumer incentives	Yes, only electricity					

1. Variables and their values that are statistically significant at $\alpha \leq 0.05$ are shown **bold**, those significant at $0.05 \leq \alpha \leq 0.10$ are *italicized*, and those variables that fail to meet the threshold of $\alpha \leq 0.10$ are shown in plain text
2. The value for income is set to the baseline value.

This "PHEV-designer" in Table 8d is familiar with ICEVs and has extensive experience driving HEVs. She strongly agrees in the national urgency of a transition from gasoline and diesel and that electricity represents lower environmental and health risks than gasoline. She does not already think of hydrogen as a replacement for gasoline but is interested in ZEV technology. She has seen charging for PEVs at several parking facilities she uses. She disagrees that PEV driving ranges are too short, charging times too long, and gasoline vehicles safer and more reliable than PEVs. She imagines she can charge a PEV at home and there are sufficient opportunities to charge away from home. She has gathered some information about PEVs, but hasn't seriously considered buying one; she hasn't considered an FCEV at all but is open to the possibility she might someday. For now though, she only supports consumer incentives for electricity.

Table 8e Profile of explanatory variables that maximizes the probability of a BEV[1]

Maximum likeliness of designing a BEV		0.2	0.3	0.2	**98.9**	0.4
Respondent education	*Graduate degree*					
Respondent gender	**Male**					
Household income[2]	$75,000 to $99,999					
Respondent commutes in household vehicle	*No*					
Parks at home in garage or carport	**Yes**					
Familiarity Factor 2: ICEVs	*-3.16*					
Driving Experience Factor 2: HEVs	**2.67**					
Pro-social Factor 5: Urgent national need	**1.79**					
Pro-Social Factor 2: electricity	**2.51**					
Replace gasoline and diesel: hydrogen	**No**					
Replace gasoline and diesel: electricity	Yes					
Personal interest in ZEV technology	**Very interested**					
Seen EVSEs at parking facilities	**Unsure**					
PEV Factor 1: range and charge time	**-2.83**					
PEV Factor 2: safety reliability	**-2.11**					
PEV Factor 3: charging, home and public	**-2.39**					
PEV Factor 4: purchase price	*-3.68*					
FCEV Factor 1: fueling time, range, fueling locations	1.99					
FCEV Factor 2: safety and reliability	1.92					
FCEV Factor 3: purchase price	1.70					
Prior consideration of PEV	**Shopped / own**					
Prior consideration FCEV	**Haven't, maybe someday**					
Support consumer incentives	Not sure					

1. Variables and their values that are statistically significant at $\alpha \leq 0.05$ are shown **bold**, those significant at $0.05 \leq \alpha \leq 0.10$ are *italicized*, and those variables that fail to meet the threshold of $\alpha \leq 0.10$ are shown in plain text
2. The value for income is set to the baseline value.

Table 8f Profile of explanatory variables that maximizes the probability of an FCEV[1]

Maximum likeliness of designing an FCEV		~0.0	~0.0	~0.0	~0.0	**99.8**
Respondent education	*College Grad.*					
Respondent gender	**Female**					
Household income[2]	\$75,000 to \$99,999					
Respondent commutes in household vehicle	*Yes*					
Parks at home in garage or carport	**Yes**					
Familiarity Factor 2: ICEVs	*-3.16*					
Driving Experience Factor 2: HEVs	**2.67**					
Pro-social Factor 5: Urgent national need	**1.80**					
Pro-Social Factor 2: electricity	**-1.17**					
Replace gasoline and diesel: hydrogen	**Yes**					
Replace gasoline and diesel: gasoline	No					
Personal interest in ZEV technology	**Very interested**					
Seen EVSEs at parking facilities	**Yes, one place**					
PEV Factor 1: range and charge time	**-1.74**					
PEV Factor 2: safety reliability	**2.14**					
PEV Factor 3: charging, home and public	**-2.39**					
PEV Factor 4: purchase price	*-3.68*					
FCEV Factor 1: fueling time, range, fueling locations	-2.33					
FCEV Factor 2: safety and reliability	-2.71					
FCEV Factor 3: purchase price	-3.07					
Prior consideration of PEV	**Haven't/won't**					
Prior consideration FCEV	**Idea occurred, no steps taken**					
Support consumer incentives	Yes, hydrogen only					

1. Variables and their values that are statistically significant at $\alpha \leq 0.05$ are shown **bold**, those significant at $0.05 \leq \alpha \leq 0.10$ are *italicized*, and those variables that fail to meet the threshold of $\alpha \leq 0.10$ are shown in plain text
2. The value for income is set to the baseline value.

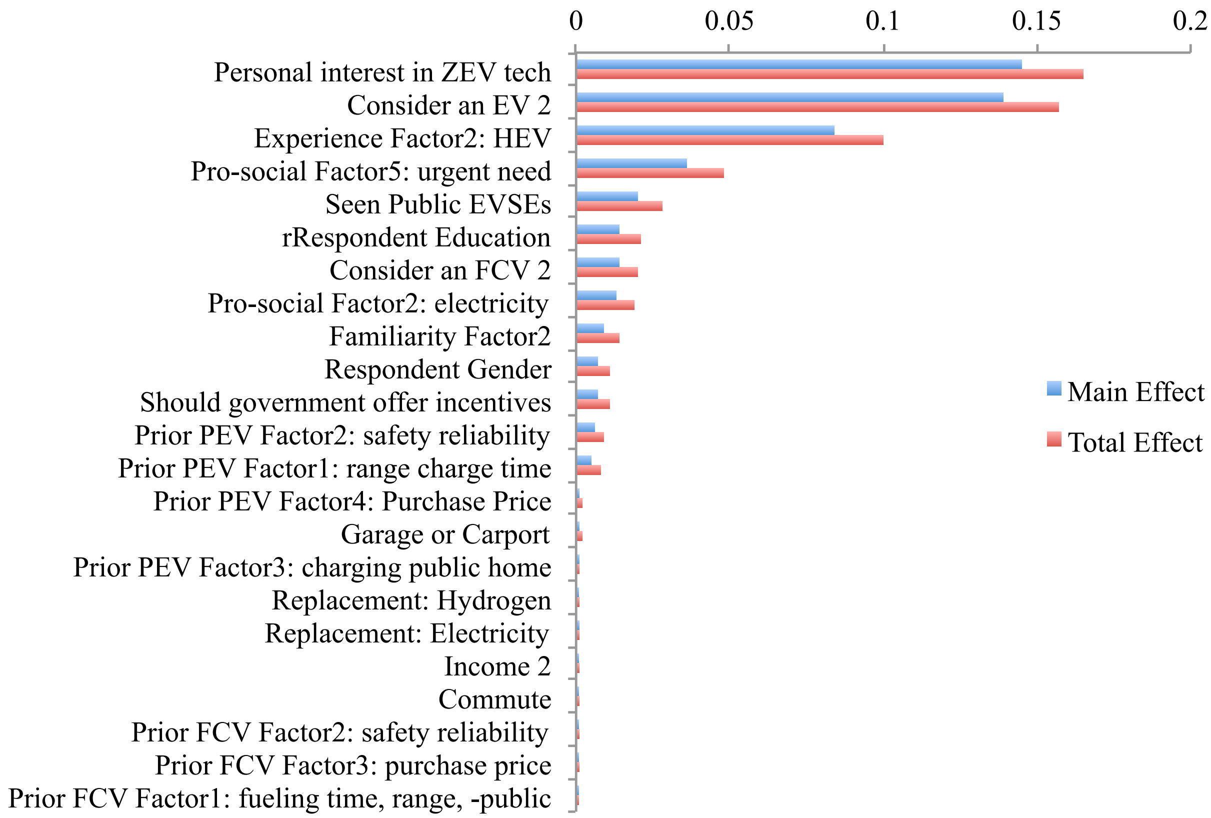
The profile that maximizes the probability of a BEV (Table 8e) vs. an FCEV (Table 8f) hint at a possible divide between supporters of PEVs and FCEVs. While both believe there is an urgent national need to transition from gasoline and diesel, the BEV-designer thinks electricity is a likely replacement but not hydrogen; the FCEV designer believes hydrogen is, but not electricity. They split as to which thinks electricity poses lower environmental and health risks than gasoline. Their experience and knowledge of existing ICEVs and HEVs is similar, but their ideas about

PEVs and FCEVs differ. The BEV designer has a favorable impression of PEVs (the negative scores for all PEV factors indicate they are strongly disagreeing with negative statements about PEVs) and an unfavorable impression of FCEVS (the positive scores for all FCEV factors indicate they are agreeing with negative statements about FCEVs). Conversely, the FCEV designer in Table 8f thinks conventional ICEVs are safer and more reliable than PEVs and has a uniformly positive evaluation of FCEVs compared to ICEVs. The example BEV-designer has already shopped for a PEV and may even own one; they haven't even considered an FCEV but may be open to it in the future. The idea of an FCEV has occurred to the example FCEV-designer, but they have taken no real steps to shop for one; they proclaim they have not and will not consider a PEV. They support consumer incentives only for hydrogen; the BEV-designer is agnostic, declaring they are unsure whether incentives should be offered at all.

This last point highlights something about the mathematical maximization of drivetrain probabilities. When nearly two-dozen explanatory variables are all pushed toward producing a single maximum probability, the resulting drivetrain probability distributions are relatively immune to changes in any one of those variables. Thus it makes little difference that the example BEV-designer is unsure whether incentives should be offered. Changing the value of that variable shifts the overall drivetrain probability distribution by only a few percentage points and certainly not far enough to change the overwhelming probability the model will predict they design a BEV.

To assess which of the explanatory variables exerts more or less influence over the drivetrain probability estimates, measures of each variables main and total effect are plotted in Figure 22. The total effect accounts for interactions between the variables, thus it is the main effect plus these interaction effects. The variables exerting the greatest influence on drivetrain design, i.e., the measure of PEV and FCEV valuation, are interest in ZEV technology and the extent to which the respondent has already considered a PEV for their household (and to a lesser degree, an FCEV). Taken individually, the relative influence of other variables starts to decline rapidly beyond these two, though respondents' experience driving HEVs is important not only because it is the third most influential variable but because HEVs are the only non-ICEV drivetrain with which most of these respondents could plausibly have had much experience. While other variables are less influential individually, collectively some of them represent suites of related variables that add up to more influential ideas. Thus the idea of support for the public policy goals of ZEVs might be better read as the combined influence of Pro-social Factors 2 and 5 plus support for governments providing consumer incentives. Also, though none of the individual factors for respondents' prior evaluations of PEVs is particularly influential to the final model outcomes, taken together they represent this study's effort to create an overall prior assessment of PEVs. That idea of an overall prior assessment is comparatively more influential than any of the individual factors (and thus, any of the individual attributes on which the factors are based). Finally, of the variables that are amenable to policy and market actions to promote PEVs, whether respondents have seen EVSEs in the parking facilities they use is comparatively influential.

Figure 22: Summary of the relative influence of each explanatory variable on the estimated probability distributions of drivetrain designs



What Incentives do People Choose?

- Upfront financial incentives are selected by an overwhelming percentage of respondents (88.5%) that design a PHEV, BEV, or FCEV.
- There is no statistically significant difference in the types of incentives chosen by respondents who design a PHEV, BEV or FCEV.
- Despite the dollar value of the vehicle and charger incentives being identical, among those who choose a direct financial incentive, they split about two-to-one as to whether they want an incentive for the purchase of the vehicle or home charging/fueling.

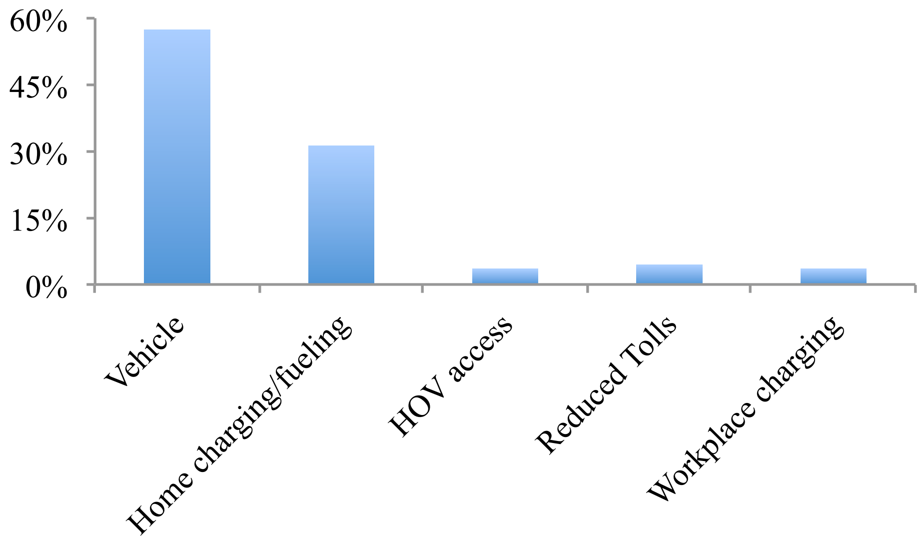
In the final game, PHEVs, BEVs, and FCEVs are eligible for federal tax credit (keeping in mind that full-size vehicles are not offered as BEVs or PHEVs that operate in all-electric mode). The amounts offered are customized for each design based on the present federal schedule. In addition, designers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

- A vehicle purchase incentive from their state (equal to CA's current schedule)

- 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)
- If workplace charging isn't available to them, imagine it is (not offered for FCEVs)

The distribution of incentive choices is shown in Figure 23. Except for workplace charging (it's counterpart—workplace H2 fueling—was not offered to those who designed FCEVs), there is no difference in the choice of incentives between people who design PHEVs, BEVs, or FCEVs.

Figure 23: Incentives selected in addition to a federal tax credit, percent



Why do people design PEVs or FCEVs?

- Highly rated motivations to design a PEV or FCEV are a mix of private and pro-social benefits:
    - Private: Savings on (fuel) costs, interest in new technology, and safer than gasoline
    - Pro-social: Reducing personal effects on climate change, air quality, oil imports, and 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 NESCAUM sample is 1.38. Any item scoring higher than this is interpreted as having a "high" score. The possible motivations are listed in Table 9, sorted from high to low by their mean score; the percent of respondents assigning maximum importance, i.e., five points, is shown, too.

Eight motivations have mean scores higher than the mean for all items and a ninth is nearly equal to the mean (Table 9). The top motivations are both private and pro-social. The motivation with the highest mean score and by far the highest percentage of 5-point scores is "to save money on gasoline or diesel fuel." The combination with, and contrast to, the low scores for saving money on maintenance, upkeep, and purchase costs, may reveal a "partial rationality" that apportions costs to different categories and treats them separately. The idea that saving money on fuel costs would be an important motivation is not directly signaled by any variable in the model of who designs which drivetrains in the design games.

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

Motivation	**Mean**	**% > 5**
To save money on gasoline or diesel fuel	2.88	40.0
I'm interested in the new technology	2.41	30.4
It will reduce the effect on climate change of my driving	1.79	20.3
It will reduce the effect on air quality of my driving	1.79	20.3
Pay less to oil companies or foreign oil producing nations	1.52	17.2
Reduce the amount of oil that is imported to the United States	1.51	14.8
It will be safer than gasoline or diesel vehicles	1.50	14.5
It will be fun to drive	1.46	14.5
Mean points per item	1.38	
Charging the vehicle at home will be a convenience	1.35	13.7
I like how it looks	1.11	8.8
I'll save on the cost of maintenance and upkeep	1.10	10.1
It fits my lifestyle/activities	1.07	8.0
I'll save on the cost of vehicle purchase	1.00	8.8
It will be more comfortable	0.98	9.6
The incentives made it too attractive to pass up	0.93	6.5
It makes the right impression on family, friends, and others	0.82	6.6
Another motivation	0.11	0.1

The importance of an attraction to ZEV technology is underscored by the fact this motivation is the second most highly scored. A personal interest in new technology is given the highest possible score by almost one-third of those who design a ZEV. This post-game motivation directly echoes the most influential explanatory variable for new car buyers across the NESCAUM region, i.e., the respondents' self-reported interest in ZEV technology. The four motivations related to policy goals of climate change, energy security, and air quality all score above average. However, none of the pro-social factors most directly related to air quality or climate change is included in the final model, though Pro-social Factor 2 that is associated with whether respondents believe electricity in their region represents a smaller or larger risk to the environment and human health than gasoline is included. It seems these pro-social motivations are more likely to appear as "after the fact" explanations for PEV and FCEV designs. Of the motivations scored highly after the design games, "It will be safer than gasoline and diesel vehicles" has a direct corollary in the explanatory variables of the drivetrain types in the final design game, i.e., Prior PEV Factor 2.

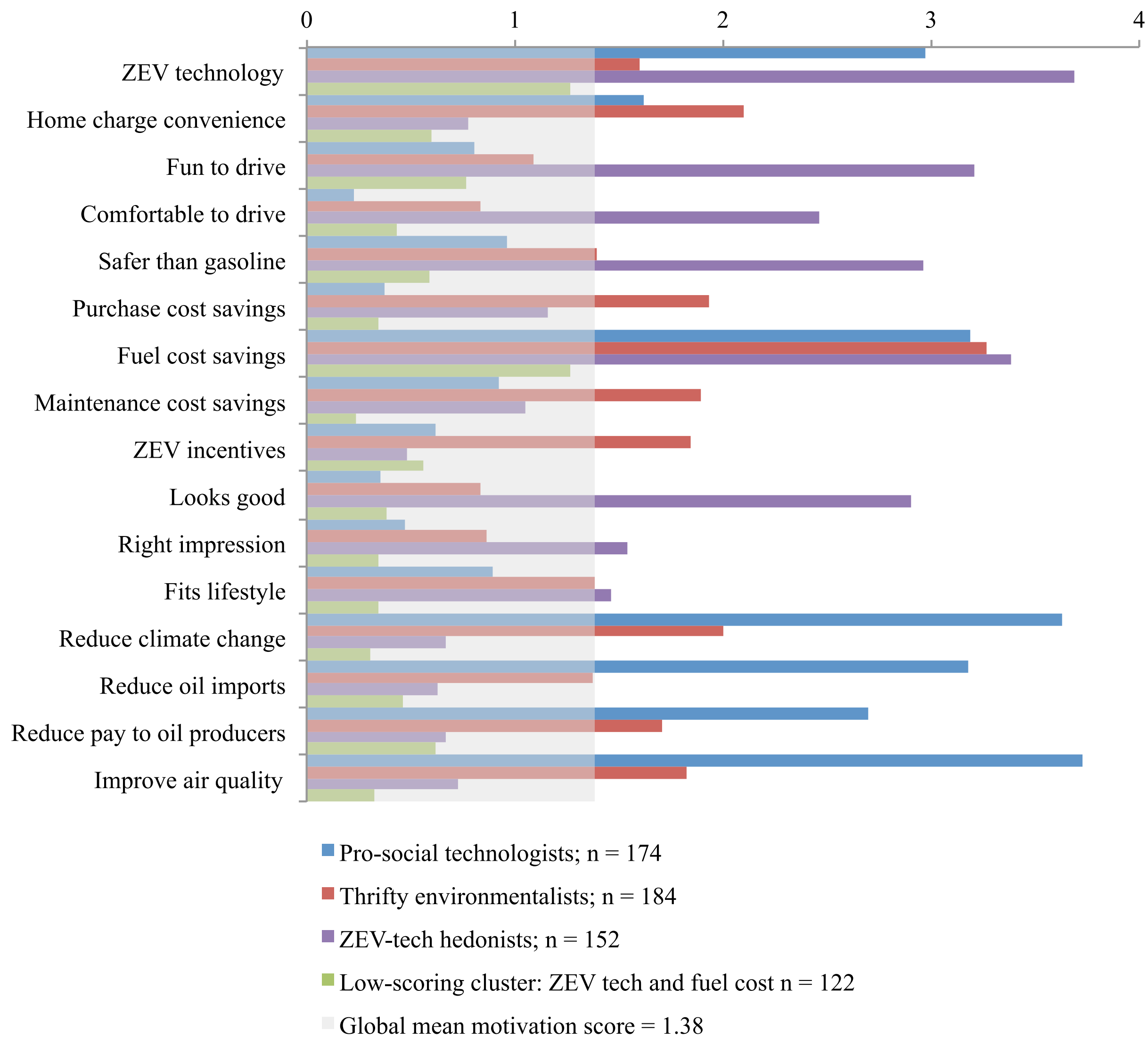
As to the importance of incentives, few people acknowledge that the incentives were important to the design of their vehicle in the final game. The mean points assigned to incentives rank well below the mean and only 6.5 percent scored it as high as possible. In the first game (no incentives offered, but full-size vehicles with all-electric operation allowed), 565 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 635 respondents. This 12% increase (despite the added limits on vehicle types) would be consistent with the importance of incentives on respondents' vehicle designs. As with the case for attitudes toward climate change, energy security, and clean air, there may be a 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 and FCEVs

The motivation scores and rankings in Table 9 indicate possible messages to appeal to other households in the NESCAUM region similar to the survey respondents who designed PEVs and FCEVs. In this section the motivations are analyzed to discover distinct groups of people who share motivations. This extends and refines the explanations of who is interested in ZEVs and why they are interested. The search for groups of people who share patterns of motivations is done by cluster analysis. One output of the cluster analysis is the mean motivation scores within clusters of people who share similar motivations. In Figure 24 the means motivation scores for a four-cluster solution are plotted along with a demarcation indicating the global mean score. 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 24 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.

Before discussing the differences between the four clusters, note two highly scored motivations that three clusters have in common, that is, in all three clusters the average score for two motivations exceeds the global mean: interest in ZEV technology and fuel cost savings. Further, in the one cluster in Figure 24 for which no motivations has an average score above the global mean ("Low-scoring cluster"), these two motivations are the ones with the highest mean scores.[16] This is not to say everyone who designed a PHEV, BEV, or FCEV was motivated by an interest in ZEV technology and fuel cost savings: of those who do design one, 28% assign zero points to the motivation "ZEV technology" and 24% assign zero points to "fuel cost savings." However, that these two motivations have high mean scores in all four clusters emphasizes that many people share these motivations and thus messages based on them may appeal to many groups of people.

Figure 24: Mean motivation scores for four clusters that design PEVs or FCEVs.



[16] As discussed in the opening of this section, respondents were given up to 30 points to spend across all the possible motivations. The respondents in the "low-scoring" cluster used an average of fewer than nine points; respondents in the other three used an average of 26 to 27 points

Starting with "Pro-social technologists," this cluster is the only one strongly motivated by all four motivations associated with policy related goals of ZEVs—air quality, climate change, and energy security. They appear to be interested in the application of ZEV technology to these pro-social ends, as well as to the private goal of fuel cost savings. "Thrifty environmentalists" appear to switch this priority—emphasizing private cost benefits over pro-social ones. They are the only cluster highly motivated by all four private cost motivations; it is the only cluster that was highly motivated by incentives. To the extent most of those who design a ZEV chose a financial incentive, the ZEV incentive motivation is also largely a financial one. They also have mean motivation scores above the global mean for three of the four motivations associated with ZEV policy goals, but their mean scores are much lower than for the "Pro-social technologists." The people in the "ZEV-tech hedonists" cluster score none of the pro-social motivations highly. Rather, they appear to be most motivated by the idea that ZEV technology will produce the best car: a fun, comfortable, safe, good-looking car that makes the right impression, fits their lifestyle and saves fuel costs.

Why don't people design PEVs and FCEVs?

- The highest scoring motivations against designing a PEV or FCEV have to do with their inherent newness: limited charging and fueling networks, high initial purchase price, and unfamiliarity with the technology. Other highly scored concerns included:
  - Driving range and time to charge or fuel
  - Immediate, practical limits on the ability to charge a PEV at home
  - Overall reliability of electricity supply
- Few acknowledged that greater incentives (of the kinds offered in the game) would have changed their minds.

Because more new-car buyers across the NESCAUM region 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. Motivations against designing a PEV or FCEV were assessed by a similar process as motivations for ZEVs. Respondents assigned points on a scale from 0 = not at all important to 5 = very important. There were 19 possible motivations against ZEVs derived from prior research. The global mean score for all motivations was 0.96. Any item scoring higher than this (rather than higher than 2.5, i.e., the mid-point of the rating scale) is interpreted as having a "high" score.) The possible motivations against designing a PEV or FCEV as the next new car are listed in Table 10, sorted from high to low by their mean score.

The mean score assigned to eight motivations are higher than the global mean score (and three more are almost equal to it). Almost all the highest ranked motivations are related to the inherent newness of the vehicles: limited away-from-home fueling, the high initial purchase price, and respondent's unfamiliarity with new technology. Arguably distance per charge or fueling also belongs to this category of "teething problems" of new technology. The negative response to new technology—as opposed to the positive response of the majority of people who did design a PEV or FCEV—is reinforced by the additional presence of "waiting for the technology to become more reliable" in the list of motivations (which scores just below the global mean). Characterizing these concerns as initial problems of new technology is not to dismiss the importance of these concerns in the here and now, but to note that all may improve with each new generation 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 in the third game on people who did not design a PEV or FCEV is different from that for those who did. For those who did not design a PEV or FCEV, few were willing to state that higher incentives would change their minds: the mean score for "higher incentives would have convinced me" is 0.45 and only 4.1% assign it the maximum number of points. In effect, despite the importance of high vehicle purchase price as a motive against designing a ZEV, simply offering more money (in the form of vehicle, charger, or home fueling rebates or reduced tolls) doesn't solve enough other perceived problems.

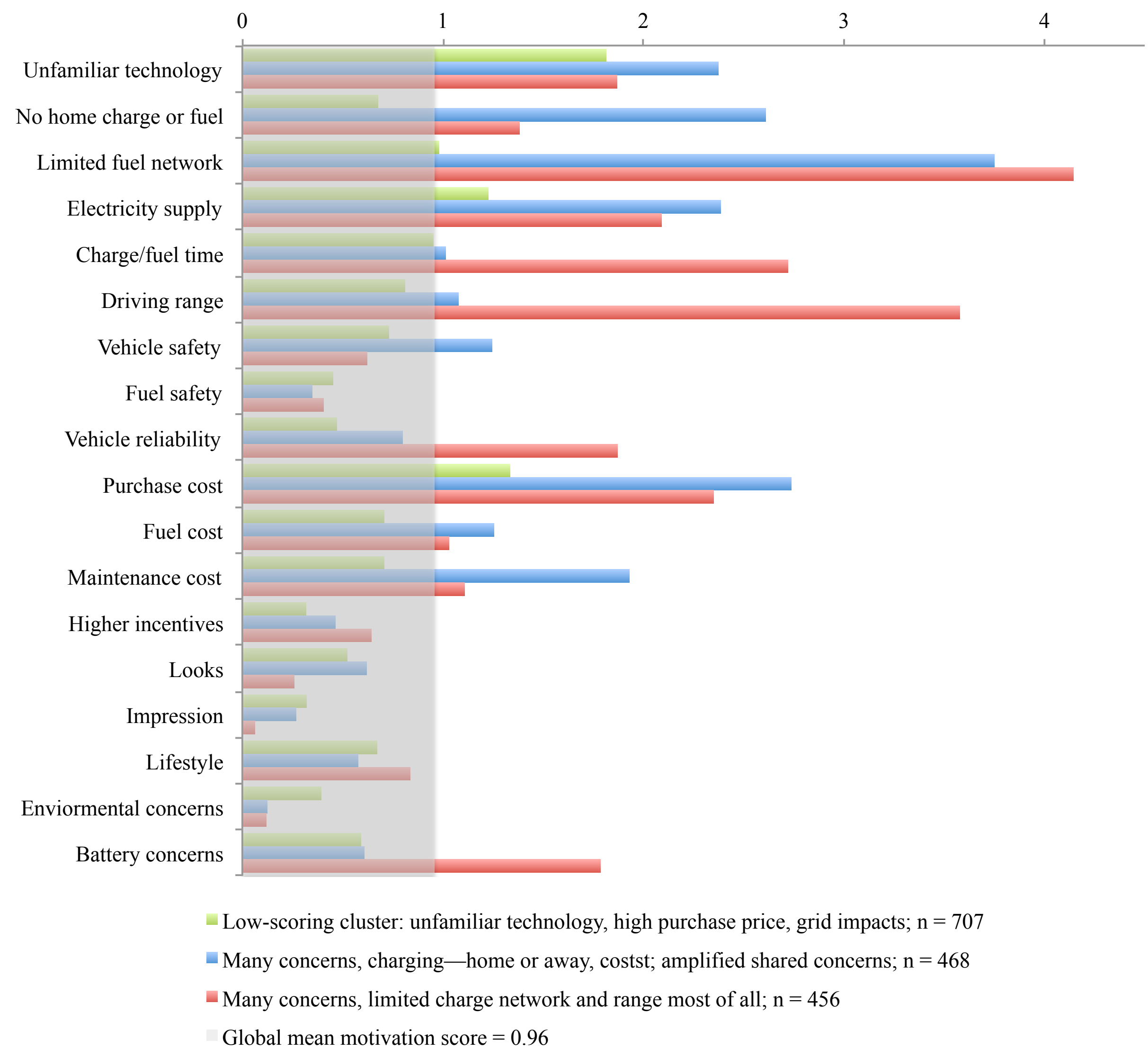
Table 10: Motivations against Designing a ZEV, high to low mean score

	Mean	% = 5
Limited number of places to charge or fuel away from home	2.64	39.1
Cost of vehicle purchase	2.02	29.3
I'm unfamiliar with the vehicle technologies	1.98	27.9
Concern about unreliable electricity, e.g. blackouts and overall supply	1.79	22.8
Distance on a battery charge or tank of natural gas is too limited	1.65	23.1
Concern about time needed to charge or fuel vehicle	1.47	18.3
I can't charge vehicle with electricity or fuel one with natural gas at home	1.42	19.5
Cost of maintenance and upkeep	1.17	12.8
Mean points per item	0.96	
Cost to charge or fuel	0.95	10.7
I'm waiting for technology to become more reliable	0.95	11.1
Concerns about batteries	0.93	10.6
Concern about vehicle safety	0.84	9.4
Doesn't fit my lifestyle/ activities	0.69	8.2
I don't like how they look	0.48	5.2
I was tempted; higher incentives would have convinced me.	0.45	4.1
Concern about safety of electricity or natural gas	0.41	3.5
I don't think they make the right impression	0.24	1.4
Environmental concerns	0.24	1.9
Another motivation	0.16	2.6

Distinct motivational groups among those who do not design ZEVs

Here the motivations (or perhaps, concerns) of those who did not design a ZEV are examined. Results of a three-cluster solution are illustrated in Figure 25.

Figure 25: Mean motivation scores for three clusters who do not design PEVs or FCEVs



In comparison to the cluster analysis for those who did design PEVs and FCEVs, the cluster analysis of the motivations of those who did not design ZEVs appears more singular in its conclusion: most of these people have many concerns about ZEVs. This may not be entirely true for the "Low-scoring cluster" but they do share three highly scored dis-motivations with both the other clusters. First, almost by definition the vehicles will initially be unfamiliar to them. Second, they are concerned about high vehicle purchase prices. Third they are concerned for the reliability of electricity supply, ostensibly because of their perceptions of the added load to charge PEVs.

Despite these concerns this cluster shares with the other two, by comparison this low-scoring cluster seems almost blithely unconcerned.[17] The primary distinction between this first cluster and the other two is the other two are first characterized as having many “concerns” because their mean scores for more than half the possible motivations to not design a ZEV are higher than the global mean.[18]

Most respondents who do not design ZEV have a long list of concerns—differences between the latter two clusters have mostly to do with the details. The second cluster has high mean scores for ten motivations for not designing a ZEV. They have the highest mean scores for all three of the shared concerns. The high mean score for “no home charge or refuel” likely indicates several respondents in this cluster can’t charge a PEV or fuel an FCEV at home. Their concern about limited away from home charging/fueling locations would define the top of the chart—if not for the fact the third clusters’ mean score on this motivation exceeds it. While both the second and third clusters score the three cost categories above the mean, the second cluster scores all three highest. The final cluster scores eleven motivations above the global mean. The distinguishing concerns are the very high scores for the extent of networks for charging/fueling, the time it takes to charge, and driving range. The concerns of this cluster for ZEV technology are broader, including not only unfamiliarity with the technology, but also a desire to wait for the technology to become more reliable.

No cluster credits the idea that higher incentives would have caused them to design ZEV. The average scores on the item “higher incentives would have convinced me” are higher than the global mean for none of the three clusters.

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[17] This low-scoring cluster used an average of fewer than 14 points compared to 24 and 27 points for the other two clusters.

[18] There are nineteen items in the list, but the incentive item is not a motivation against designing a ZEV, rather an effort to see if higher incentives would overcome those motivations and the “other motivation” option is selected by almost no one and is not included in the cluster analysis.

RESULTS: COMPARISON OF STATE RESULTS

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 ZEV 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.
    - While low overall, levels of prior consideration of PEVs and FCEVs are variable across the NESCAUM member states.
- 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 their strictly proscribed geographic availability (limited largely to Los Angeles, CA).

Respondents' consideration of PEVs and FCEVs prior to completing the on-line survey is plotted in Figures 26 (PEVs) and 27 (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 thus the NESCAUM region. Some degree of resistance—"I have not and will not consider…"—to PEVs and FCEVs is more common in the eastern states.

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

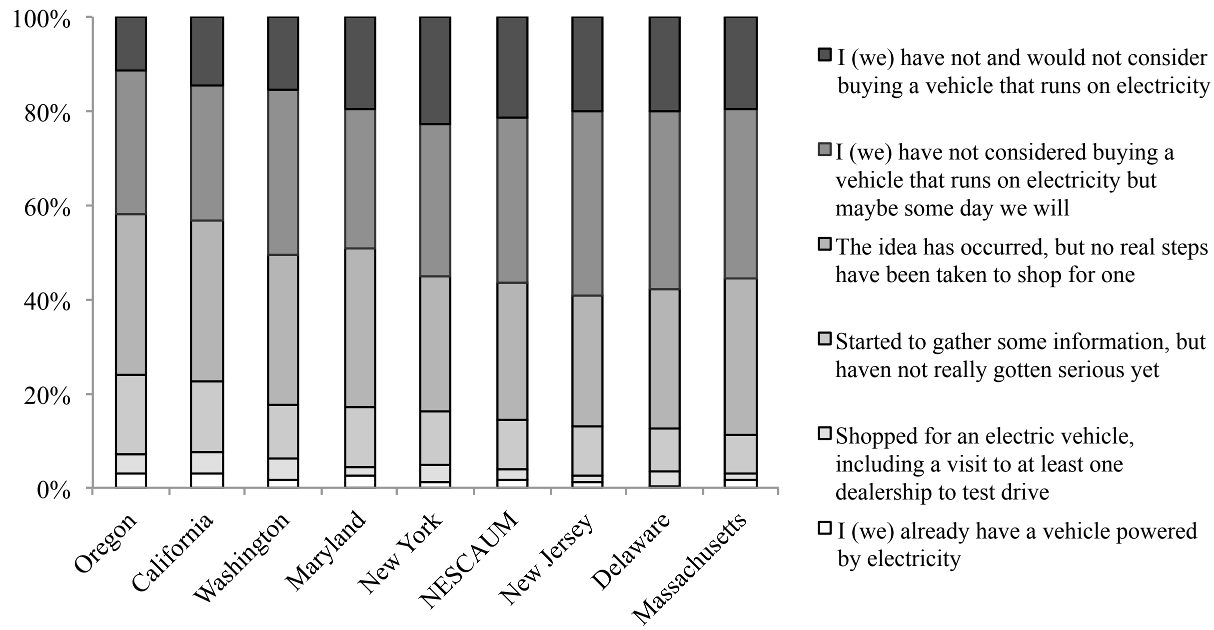
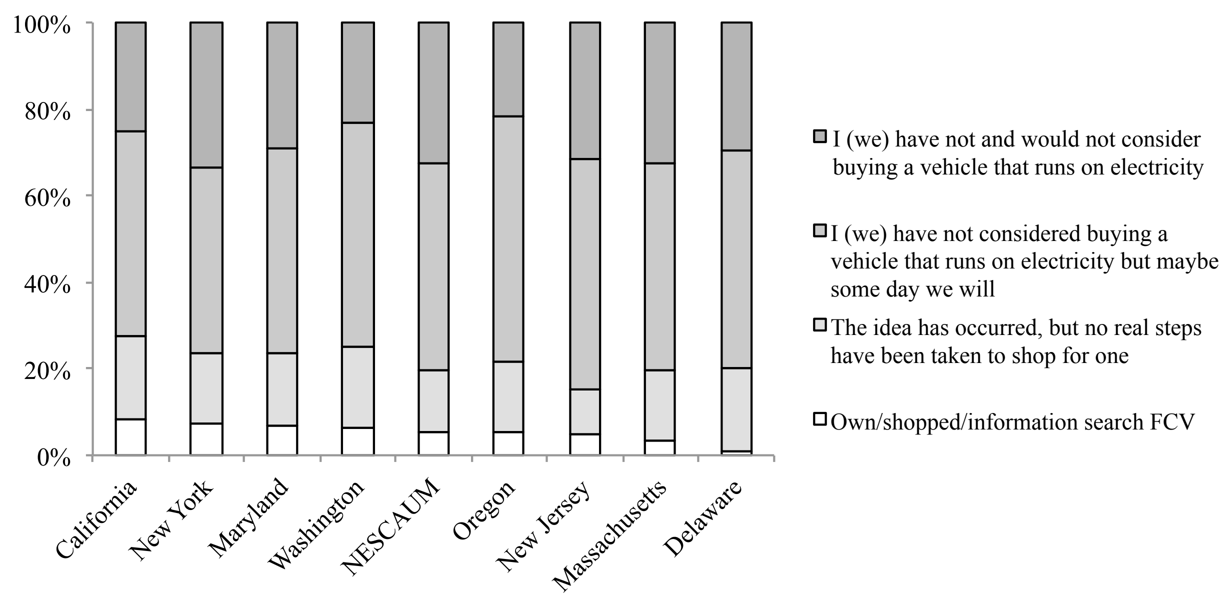


Figure 27: Comparison of Consideration of FCEVs by state and region



For FCEVs (Figure 27), 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).[19] 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.

Table 11: State/Region by Consider PEV, count and row percent

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

[19] 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.

Table 12: 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:

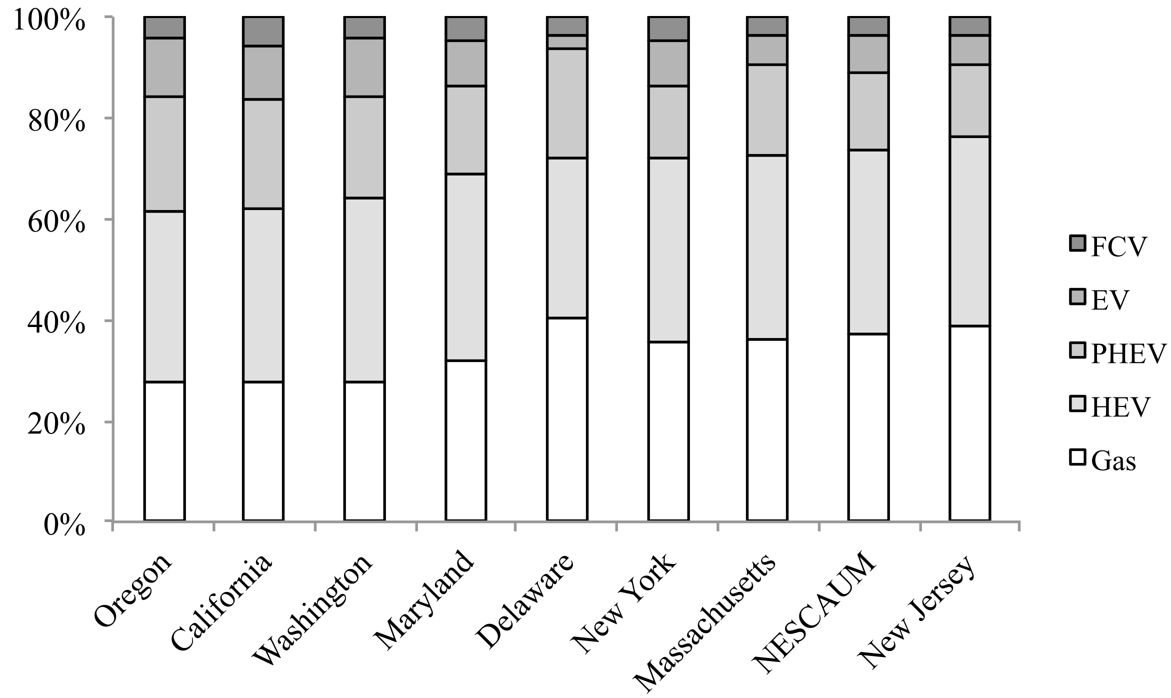
Test	**ChiSquare**	**Prob>ChiSq**
Pearson	78.524	<0.0001

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 one to be an ICEV or HEV.
- 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% in Oregon to a low of 27 across the NESCAUM region that designs a PHEV, BEV or FCEV.
    - In New York and Massachusetts the total is 28%, in New Jersey 24%.

The distributions of drivetrain designs are compared in Figure 28. 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 28: 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.[20] The cross-tabulation is illustrated in Figure 29 and provided in Table 13. The vehicle design distributions in Figure 29 have been ordered by the total of the percent of respondents who design a PHEV, BEV, or FCEV. The figure 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).

[20] 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 29: 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

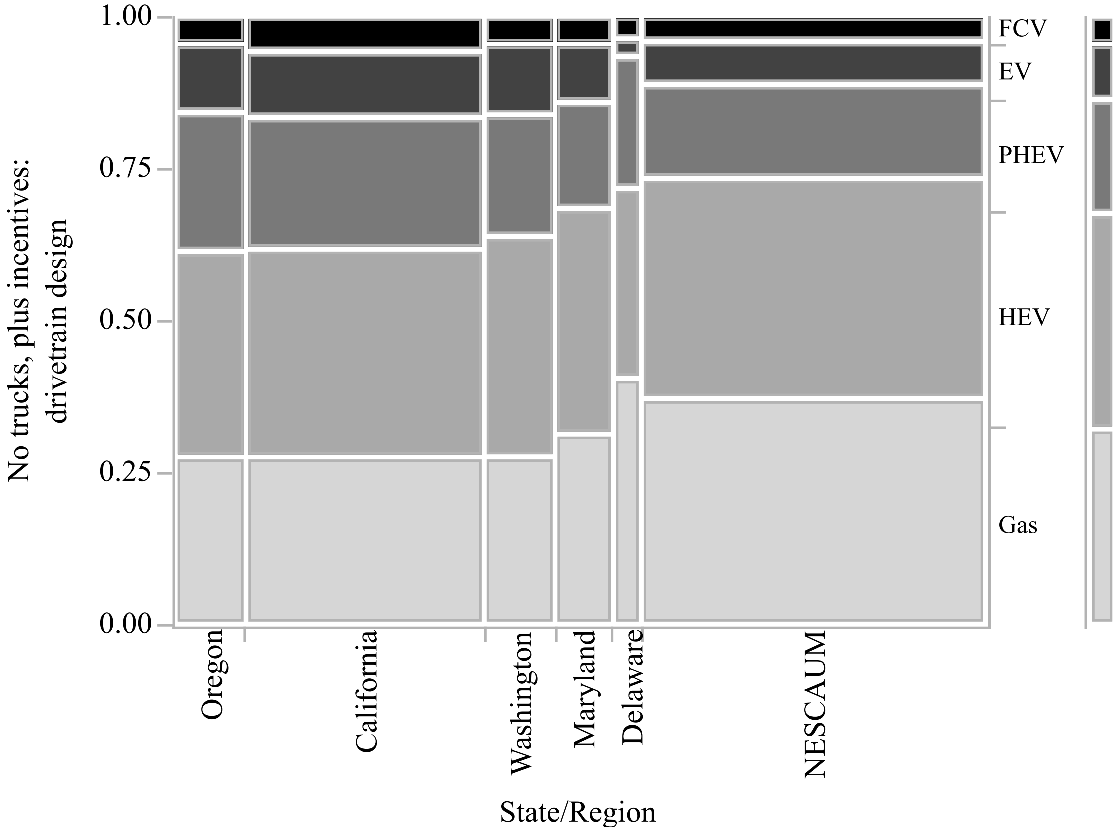


Table 13: State/Region Drivetrain Designs, Game 3

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, Massachusetts, and Washington factor that combines regional threat and personal worry is associated with differences in drivetrain designs. In New York, 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, New Jersey, and Washington variables measuring awareness of or support for government-provided incentives to consumers are associated with valuation of PEVs and FCEVs.[21] 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

[21] 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 and Washington's models.

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 six 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. Prior consideration of an FCEV does appear in the models for California, Massachusetts, New York, and NESCAUM.

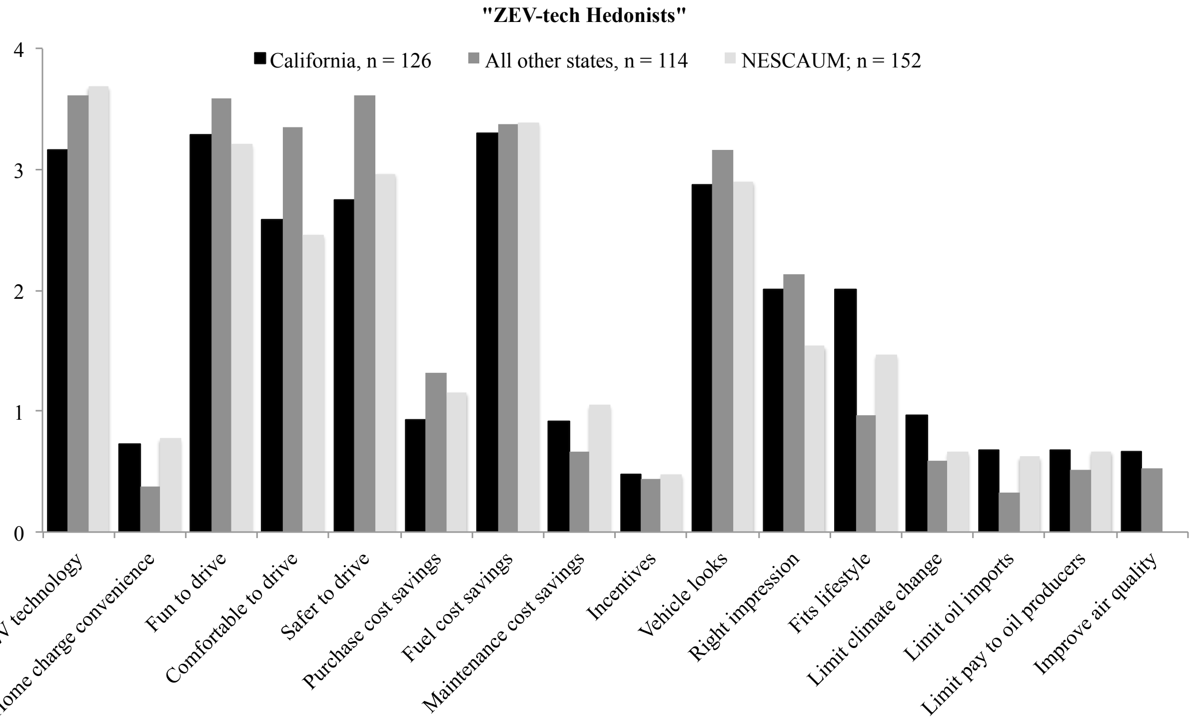
Post-Game Motivations: Why *do* respondents design PHEVs, BEVs, and FCEVs?

- 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 all participating states. The comparison here is of NESCAUM to California as well as the aggregate of all states other than California. Figure 30 through 33 illustrates the results of a four-cluster solution from the cluster analysis of NESCAUM, California, and the aggregate of the other states. The question these figures address is whether similar clusters of motivations exist for designing PEVs and FCEVs. The answer is generally, yes. Though there is no specific statistical test, the figures illustrate it is possible to match clusters from all three analyses.

There is little difference in the mean motivations scores in Figure 30 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.

Figure 30: Mean motivation scores for “ZEV tech hedonists”



A close mapping of California, all other states, and Washington is also possible for clusters identified as “Pro-social” (Figure 31). 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 because the convenience of home charging follows directly from the new technology.

The analyses produce “thrifty environmentalist” clusters (Figure 32) though these are not as similar to each other as those in Figures 30 and 31. For California and NESCAUM, these clusters score all four cost motivations—purchase, fuel, maintenance, and incentives—above their respective global mean scores. These are the only clusters in which incentives were acknowledged as being highly motivating. These clusters score three each of the four pro-social motivations highly, though not as highly as the pro-social clusters. Notably, for the NESCAUM region interest in ZEV technology is not highly scored by this cluster.

Finally, all three analyses produce a low-scoring cluster, shown in Figure 33. 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" cluster emphasized fuel cost savings. While no cluster mean for the low-scoring California and NESCAUM clusters are 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 31: Mean motivation scores for "Pro-social" clusters

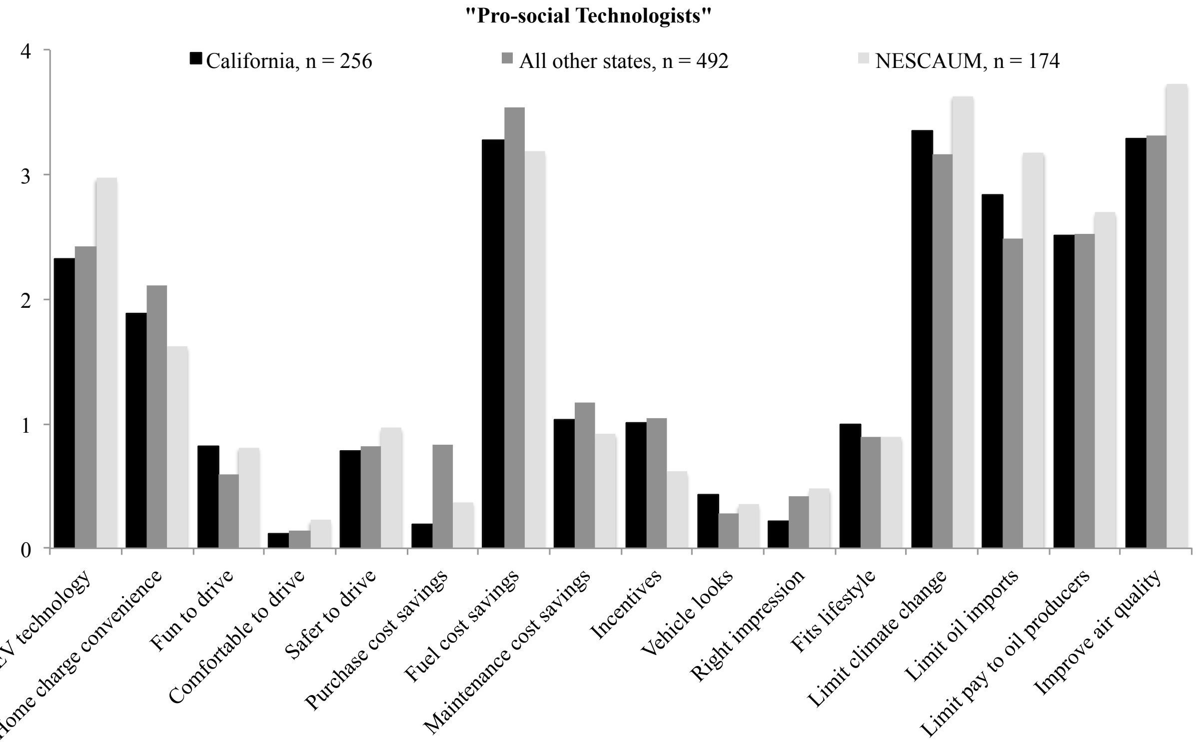


Figure 32: Mean motivation scores for "Thrifty Environmentalists"

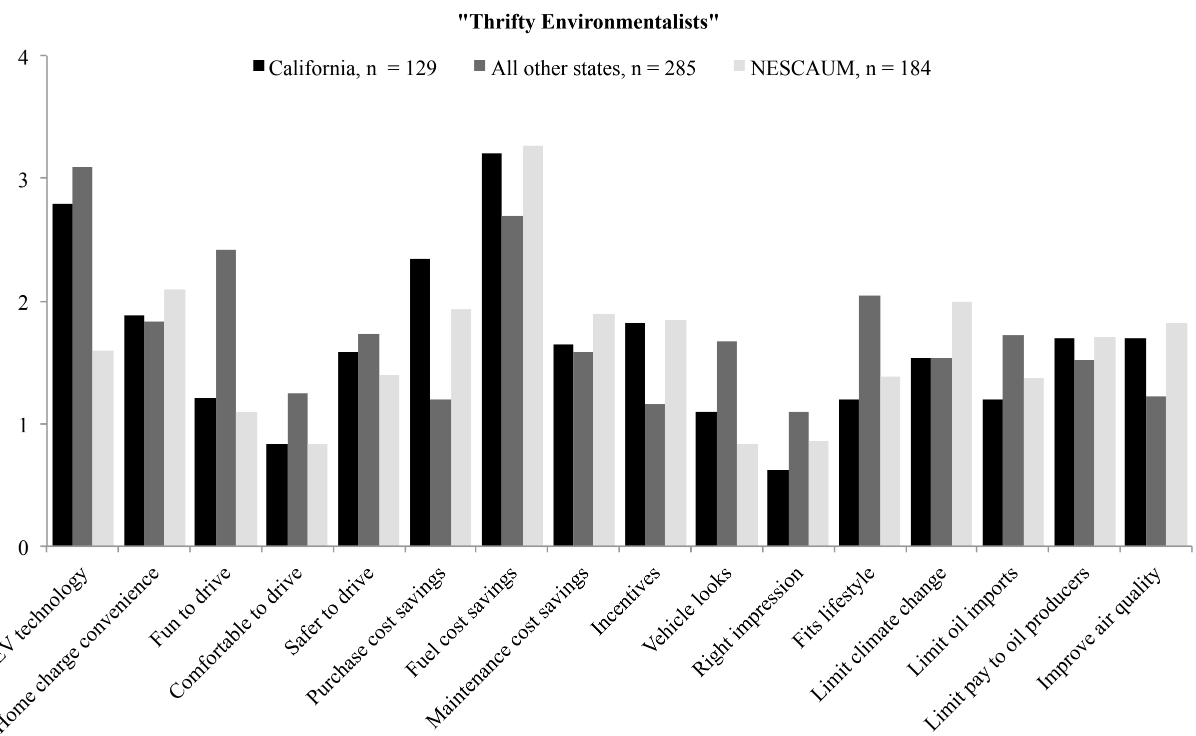
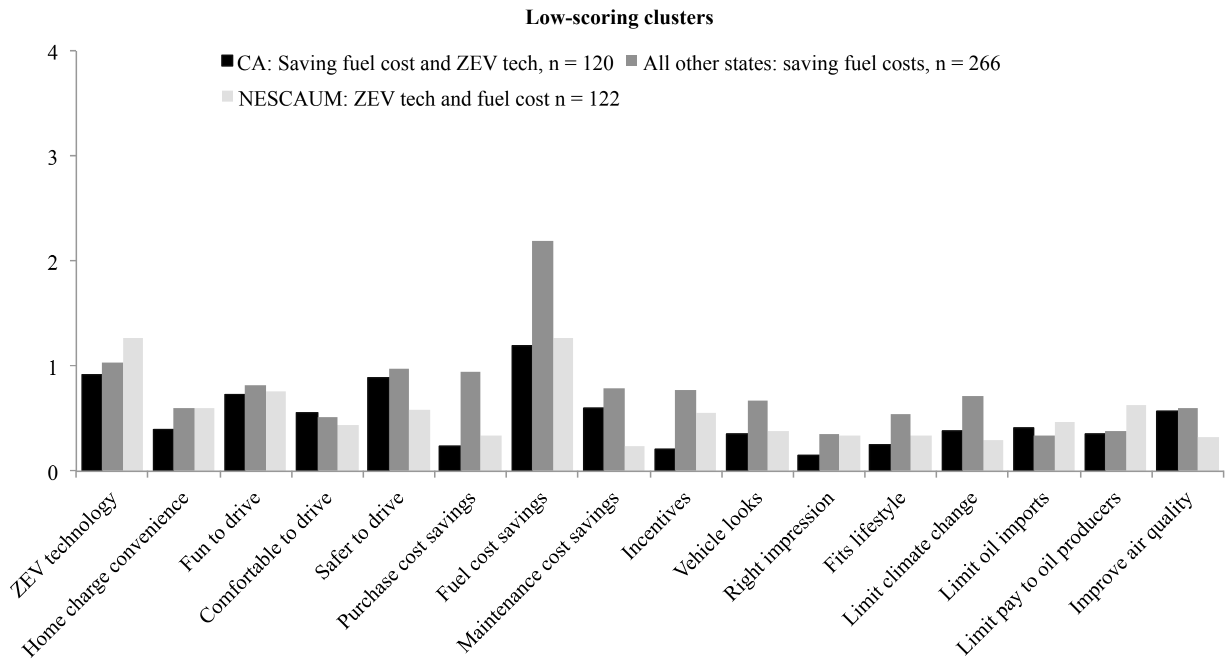


Figure 33: Mean motivation scores for low scoring clusters for those who design PEVs and FCEVs



Post-Game Motivations: Why *don't* respondents design PEVs or FCEVs?

Motivations of those who design an ICEV or HEV 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 NESCAUM. Cluster mean scores are shown in Figures 34 through 36 for a three-cluster solution for California, the aggregate of all other states and NESCAUM. The motivations to not to design a PEV or FCEV map into similar clusters for all three regional analyses, as they did for the cluster analyses of motivations for designing PEVs and FCEVs. The overarching conclusion is the large number of reasons people give for not designing a PEV or FCEV. At least as much as any single motivation on their lists of motivations to not design a PEV or FCEV, it is the length of the litany of concerns—along with the high score given to "unfamiliar technology" in many of the clusters—that signals the first problem for most people in forming a positive valuation of PEVs or FCEVs is they simply know nothing about them.

For NESCAUM, California, and the aggregate of all states other than California there is a cluster that emphasize the stereotypical complaints about BEVs: limited driving range, sparse charging networks, and high purchase prices (Figure 34). These three regions also have a cluster that shares these three concerns, but also have high mean motivation scores across several categories of motivations: technology, charging, vehicle performance and safety, and concerns about batteries (Figure 35). In contrast to Figure 34, the clusters in Figure 35 put additional emphasis on unfamiliar technology, a lack of home charge/fuel capability, impacts on electricity supply, and maintenance costs.

Figure 34: Mean motivation scores for "Range, away from home charging, purchase price."

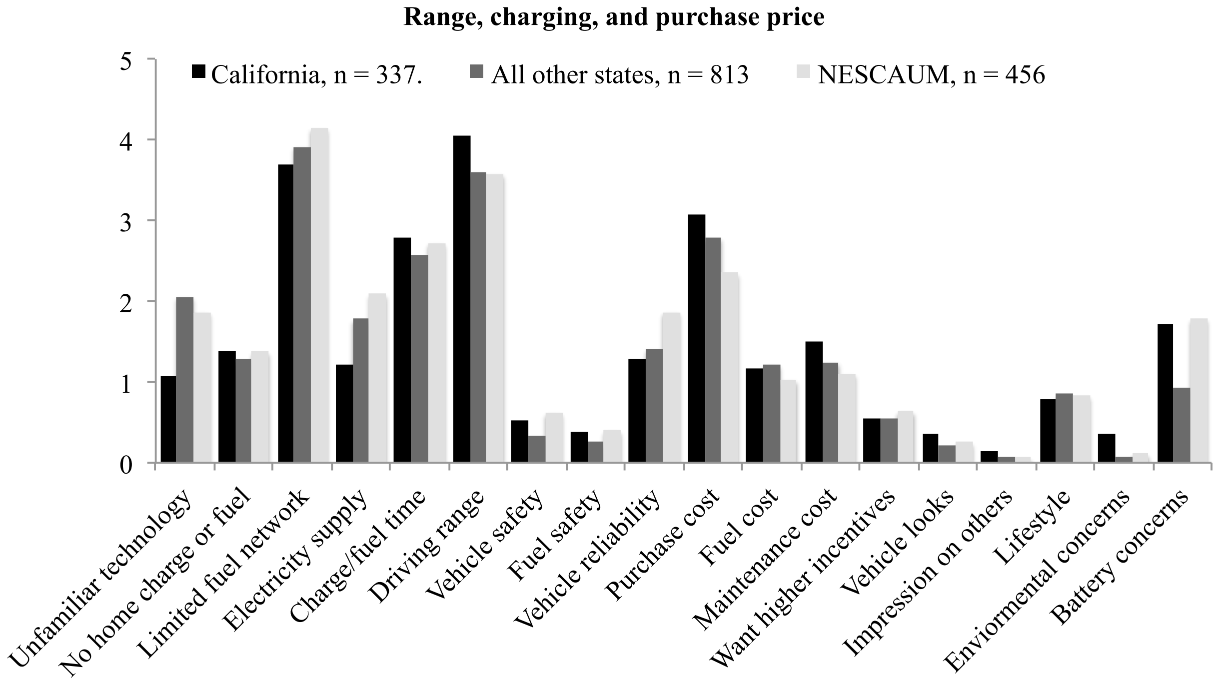
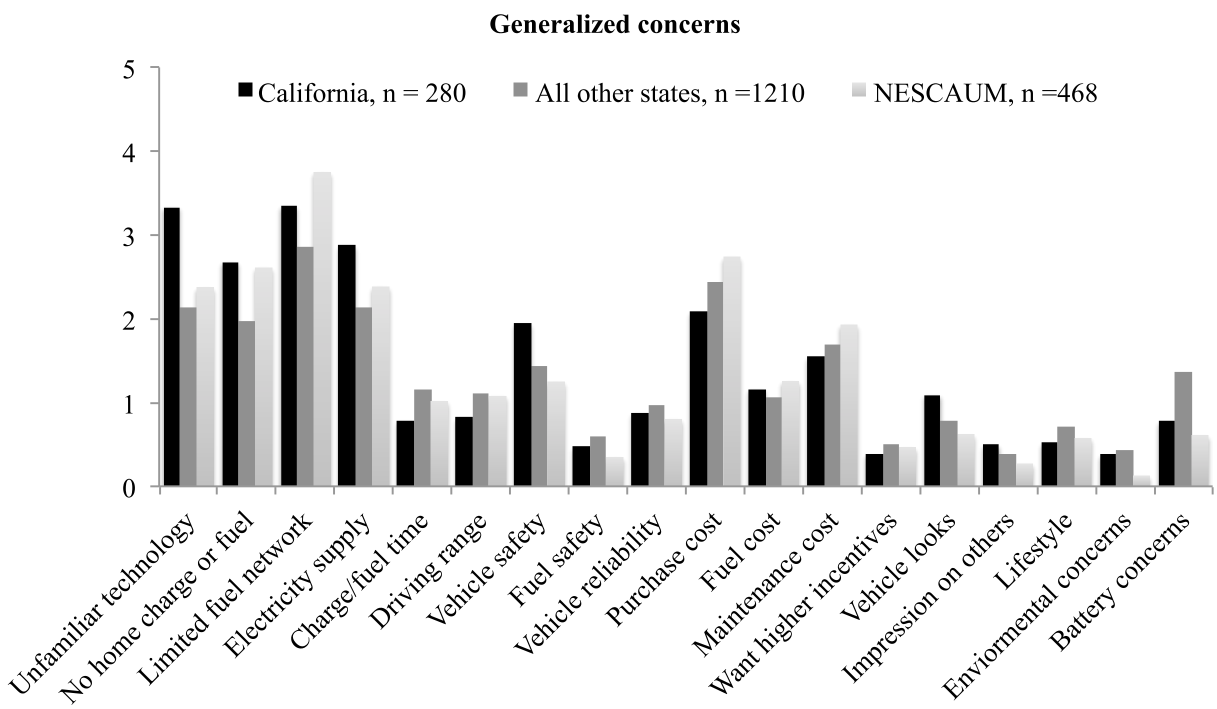
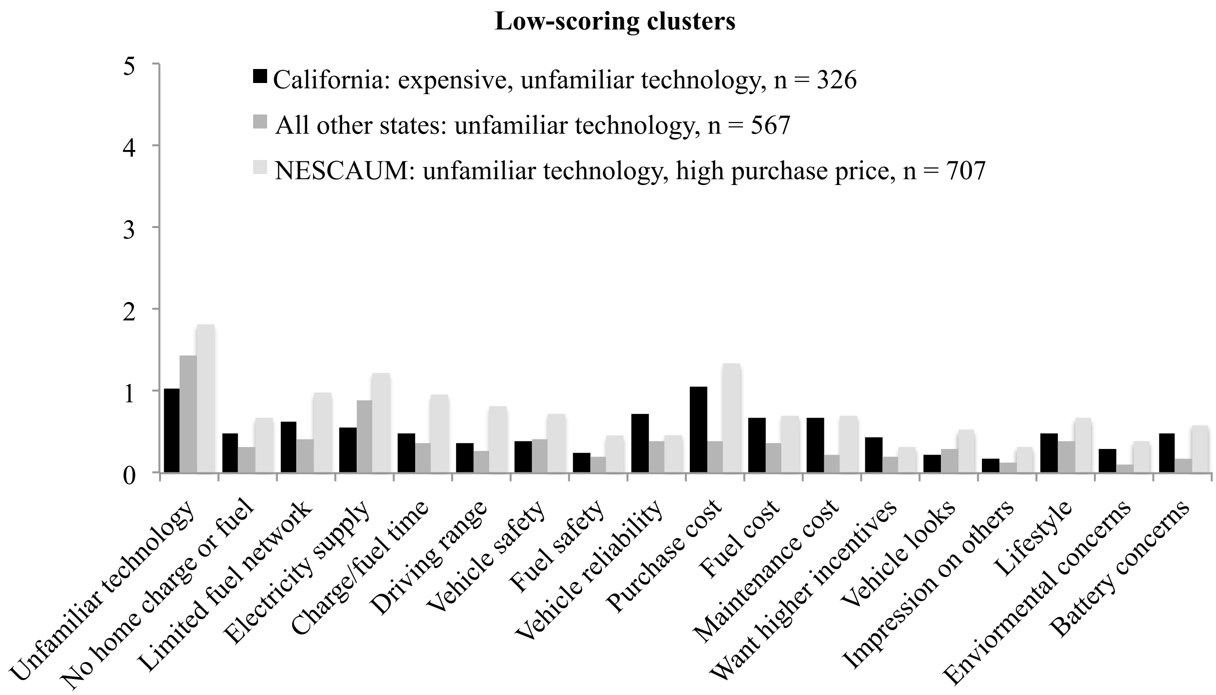


Figure 35: Mean motivation scores for clusters with concerns across all categories



The clustering algorithm separates respondents who use comparatively few of the allowed points in the motivation scoring exercise from those who spend nearly all the allowed points. The low-scoring cluster for NESCAUM, California, and the aggregate of all other states are shown in Figure 36. Examination of the distribution of individual respondent motivation scores for those in these clusters confirms that "unfamiliar technology" is as great a concern as these respondents register. The clusters for California and NESCAUM also note high vehicle prices and the NESCAUM cluster also registers concern for effects on electricity supply.

Figure 36: 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 final estimates for all other states and regions depend on the assumption this percentage is similar in other states. 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 PEVs and FCEVs. A valuation—does the respondent think there is a PEV or FCEV they would buy for their household in the near-term—does not have to be based solely on knowledge of PEVs and FCEVs, 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 PEVs and FCEVs—no matter how imperfectly formed—and to understand whether and how those present valuations can be affected.

The summary measure of respondents' valuation of PEVs and FCEVs is the vehicle design they create in the third design game, in which no full-size vehicles are allowed battery-powered all-electric drive but incentives are offered for PHEVs, BEVs, and FCEVs. As earlier illustrated in Fig. 15, a total of 26% of respondents in the combined sample of the NESCAUM member states designed a plausible next new vehicle for their household that was a PHEV (15%), BEV (7%), or FCEV (4%). The remainder of this section elaborates on the results sections, drawing connections and putting the respondents' vehicle valuations into context.

Lack of awareness, knowledge, and experience

Across the NESCAUM states—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 PEV 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 PEVs. Given FCEVs had yet to be offered in the NESCAUM region, it would still be possible to begin to prepare consumers if automobile manufacturers are contemplating releasing FCEVs for sale in the region. Ostensibly, the effects of heightened awareness, improved knowledge, and greater consideration could be measured both through increases in measures such as the distribution of ZEV designs created in surveys such as the one performed for this study and actual ZEV sales.

Name recognition of the available BEVs is low. Less than one-in-four respondents in this sample of new-car buyers could name a BEV—and nearly all of those respondents (92%) name one of only two BEVs. This level of name recognition is ten percentage points lower than that for the respondents from non-NESCAUM states in the study, of who most reside in the west coast states California, Oregon, and Washington. While it might be argued that the higher success rate naming a BEV in the samples from western states is a product of the more pervasive marketing of BEVs in the west and California in particular, i.e., the greater availability of more makes and models of PEVs. This argument is contradicted by the fact the equally high percentages of the western samples who successfully name a BEV also name the same two BEVs.

At this early stage of PEV markets, 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 (see for example, BMW's i3 with range extender) vs. assist (see for example, Toyota's Prius Plug-in)—is another source of profound confusion. While this confusion can only be inferred from the survey data, the follow-up interviews in the three western states added supporting insights. Interviewees were routinely confused by the differences in operating modes of PHEVs; some had avoided "all-electric" operating modes for PHEVs in their design games 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 respondents understood how different vehicles operate.

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 supported by respondents' answers to whether they have already considered buying a BEV or FCEV: 85% of new car-buyers indicate they have made no real effort to consider PEVs; for FCEVs, the figure is 95%.

Prior PEV-related Evaluations

Despite the lack of BEV name recognition, the mistaken concepts about how different PEVs operate, and 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 already started to search for information (11%), perhaps already visiting a dealership for a test drive (2%), or even acquiring one for their household (1%) for PEVs; for FCEVs, 5% claim to have started to gather information.

The explanatory variable related to incentives that enters the statistical model of respondents' drivetrain designs in the NESCAUM sample is whether respondents believe governments should be offering incentives. While a majority of respondents in NESCAUM believe incentives should be offered for both electricity and hydrogen, there are statistically significant ($a < 0.05$) differences from the aggregate of non-NESCAUM states. Despite a majority of NESCAUM respondents (52%) supporting incentives, that majority is smaller than the average across the non-NESCAUM states in the study (56%). This is a different variable for incentives than appears in most of the studies for individual states. In those studies, the variable for whether respondents had heard of federal incentives helped to explain differences in drivetrain types in the vehicles respondents designed. The percentage of the NESCAUM sample that claims to have heard of federal incentives for vehicles powered by alternatives to gasoline and diesel (44%) is less than non-NESCAUM states (47%). However, the difference is not really about "Yes" and "No," but

"Yes" and "I'm not sure." Fewer respondents in the NESCAUM region positively affirm they have heard of federal incentives and more are unsure than in the non-NESCAUM states.

Other concepts that appear as important to respondents' valuations of PEVs and FCEVs within the NESCAUM region include whether they believe hydrogen is a likely replacement for gasoline and diesel—a low incidence belief at 6% of the sample—and whether they have already noticed charging for PEVs in the (non-residence) parking facilities they use—45% claim to have seen such charging, but this is less than the average across all states of 52%.

Other measures of the respondents' consideration of PEVs and FCEVs prior to their completing the on-line survey enter into a multivariate model of respondents' drivetrain designs in the third vehicle design game.

1. Personal interest in ZEV technology: those indicating they have an interest in ZEV technology were more likely to design ZEVs.
2. Have already seen PEV charging in the away-from-home parking facilities they use: those who have seen them were more likely to design PEVs.
3. Prior evaluation of the extent of away-from-home PEV charging: the more strongly they agree there are enough places to charge PEVs, the more likely they were to design one.
4. Prior assessment of PEV driving range and charging times: the more strongly they disagree PEV driving ranges are too short and charging times too long, the more likely they were to design a PEV.
5. Prior assessment of the comparative safety and reliability of PEVs and ICEVs: the more strongly respondents disagree ICEVs are more reliable and safer than PEVs, the more likely they were to design HEVs, PHEVs, and BEVs.
6. Those who have already given any consideration to the question of buying a PEV or an FCEV were 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 or FCEVs enter the model attempting to explain their vehicle drivetrain designs supports the importance of initiating and shaping such consideration, but these measures 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, there were many candidate variables that were tried) 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 ZEVs, other aspects of this analysis must inform conclusions and next steps—including other variables in the multivariate model.

Two of these other variables were associated with a factor related to environmental beliefs, specifically, whether the respondent believes there is an urgent national need to replace gasoline and diesel for our cars and trucks with other sources of energy and their comparative assessment of the environmental and human health risks of electricity and gasoline in their region. Those who more strongly agree there is an urgent need for a transition were more likely to design ZEVs, as were those who judged electricity to pose lower health and environmental risks than gasoline.

Motivations for ZEVs

What we have called motivations for and against PEVs and FCEVs are different from other variables affecting the likeliness a household designs such vehicles 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.

Motivations for designing a PEV or FCEV that scored highly include:

- To save money on gasoline or diesel fuel;
- Interest in the new technology;
- Reduce the effect on climate change of my driving;
- Reduce the effect on air quality of my driving;
- Pay less to oil companies or foreign oil producing nations;
- Reduce the amount of oil that is imported to the United States;
- Safer than gasoline or diesel vehicles; and,
- Fun to drive.

The convenience of charging or fueling a vehicle at home just misses the cut-off to be included in this this list.

Of these motivations, the link to the environmental issues of air quality and climate change may reflect the modeling results in the prior section—though the questions about the relative environmental and health risks of electricity and gasoline do not mention air quality or climate change specifically. The post-game motivation of safety does directly reflect the appearance of respondent's prior evaluation of the safety (and reliability) of PEVs in the model of respondents' vehicle designs. Still, these after-the-fact explanations for designing a PEV or FCEV indicate personal and social goals ancillary to ZEV-related policy motivates 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 and knowable prior to purchase.

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 PEV or FCEV by all the major public policy issues associated with ZEVs: air quality, climate change, and energy security (the "Pro-social technologist" cluster in Figure 24). Another cluster that does claim some pro-social motivations ("Thrifty environmentalists") is, as the first phrase in the name indicates, more motivated by the prospects of cost savings—purchase, fuel, and maintenance costs. Also, they are the only cluster of respondents to credit the incentives offered in the third game with convincing them to design a PEV or FCEV. A third cluster ("ZEV-tech hedonists") may be the most surprising clustering: these respondents say they designed a PEV or FVEV because they believe such vehicles will be a comfortable, safe, cost saving, and good looking car that fits their lifestyle, makes the right impression, is fun to drive—and will be cheap to fuel. It sounds like they expect a PEV or FCEV will be the best car for many of the reasons consumers by any car. Finally, a low-scoring cluster does not score any motivation high enough to exceed the global mean of all motivations. Seeing that all three other groups share the highly scored motivations of ZEV technology and fuel cost savings, we note that within this low-scoring cluster the two motivations with the highest scores are interest in ZEV technology and fuel cost savings.

In closing this discussion of clusters sharing similar motivations it is worth noting two things. One, similar clusters of motivations for designing PEVs and FCEVs are identified across the data, whether the subset considered is the NESCAUM states, California, or the aggregate of all states other than California. Two, cluster analysis assigns respondents to clusters probabilistically. That is, there is less of a clear distinction between clusters than this discussion may imply. Hypothetically then, appeals to fuel cost savings and interest in ZEV technology (the two motivations scored highly by respondents in all four clusters) and public policy goals of air quality should appeal to most of those with a positive PEV or FCEV valuation. At the same time, two clusters comprising about a third of those who designed a PEV or FCEV in the survey would appear to be open to messages about how ZEV technology just makes for better cars.

Barriers to ZEVs: lack of knowledge

Because more respondents don't design a PEV or FCEV than do, understanding why people do not have positive valuations of PEVs 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 than understanding why some people do. These are the eight top-scoring motivations given by those who did not design a PEV or FCEV for not doing so:

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

Three additional motivations have scores that are essentially the same as the threshold to divide higher from lower scoring motivations:

- Cost to charge or fuel;
- I'm waiting for technology to become more reliable; and,
- Concerns about batteries.

Taken as a whole, these lists illustrate 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 PEV and FCEVs. The prior argument about low familiarity causing people to avoid PEVs and FCEVs is echoed by the third highest rated motivation: "I am unfamiliar with [ZEV] technology." The lower scoring motivation, "I'm waiting for technology to become more reliable," reinforces this conclusion. All this leads to the possibility that the list of other motivations is itself a rationalization—a way of explaining in a reasoned way opposition to something that is simply unknown.

The list indicates important barriers to considering PEVs and FCEVs include charging/fueling (away from home networks, inability to fuel/charge at home, time to charge/fuel), costs (purchase and maintenance). Solutions to charging at home are likely to be idiosyncratic and specific to each situation—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 actual 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 costs are discoverable 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 until they perceive charging and range are not problems (or don't perceive that they are). Images that make PEVs "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 is the length of the 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 examination of cluster solutions with more than three clusters to see whether other top-level ideas would distinguish between clusters, the three cluster solution shown in Figure 25 makes the point: the main distinction between clusters appears to be how many highly scored motivations they have. One cluster appears comparatively unconcerned scoring only three motivations above the global average: "unfamiliar ZEV technology," "purchase cost," and "concern about unreliable electricity, e.g., blackouts and overall supply." It is the case these three motivations are shared by all three clusters of respondents who do not design a PEV or FCEV. The two other clusters have long lists of highly scored concerns. Their litany of concerns can be read in Figure 25. While there are some differences between these two clusters in which motivations each scores highly, the other distinguishing feature is how much higher the mean scores are for one: six of nine high mean scores for shared motivations are the highest mean score for a motivation against designing a PEV or FCEV.

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

Financial incentives alone do not overcome the "dis-motivations" of the respondents who did not design a PEV or FCEV. Only 4% 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, to PEV or FCEV acquisition and use. Even for those who did design a PEV or FCEV, only 6.5% assigned the maximum possible number of points to the statement, “incentives made [a ZEV] too attractive to pass up.” Neither awareness of federal incentives nor support for government incentives in general was statistically significant explanatory variables 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: 12% 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 the NESCAUM region who designed one choose the optional additional financial incentive (splitting on whether that incentive was for the vehicle or home charging/fueling), the primary effect is incentives 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 ZEV in the third game would have increased less than 12% from the first game.

Access to home charging for PEVs

Lack of access to charging or fueling at home is one of the motivations against designing a PEV or FCEV that earns a higher score than average; 19.5% 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.” Measures of both the respondent’s home parking and their prior evaluation of whether they could charge a PEV at home enter the model of their vehicle drivetrain design. Respondents who presently park at least one household vehicle in a garage or carport attached to their residence are more likely to design a ZEV. Respondents who more strongly agree they could charge a PEV at home are more likely to design a PEV. Over 28% of this sample doubt they would be able charge a PEV at home.

The ability to fuel an FCEV at home would depend on many of the same conditions as home charging for PEVs: control over a parking space, the availability of electricity at that location, and—as stipulated in the survey—the availability of natural gas. The measure of the availability of natural gas at the residence is not statistically significantly related to vehicle designs.

Descriptions of household vehicles and use

The other variable associated with differences in respondents’ vehicle designs is whether the respondent regularly commutes to work in a household vehicle: those who do are more likely to design an HEV, PHEV, or BEV.

What is not in or is not statistically significant in the multivariate model?

Some variables are retained in the model of drivetrain designs despite not achieving statistical significance; notable of these is household income. Other measures that might be expected to appear include respondent age, home ownership, and residence type, e.g., single-family house vs. multi-unit dwelling. 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 income and age 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 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, and direct assessments of such vehicles and ZEV policy goals, most general descriptors of people are not important to explaining who has a pro-PEV or pro-FCEV valuation vs. who does not.

CONCLUSIONS: NESCAUM

Who is in the NESCAUM 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 NESCAUM sample looks very similar to the total sample from all states. This is despite the fact that nearly every variable for socio-economic and demographic measures shows statistically significant differences between the NESCAUM region and the balance of all other states in the study. Due to the large sample sizes for these two multi-state regions, differences that may not be substantively interesting or important can be statistically significant.

Of potential importance is the NESCAUM sample is more “middle-aged” than the non-NESCAUM sample. The NESCAUM sample is also more “upper middle income” than “middle income.” As it turns out though, neither age nor household income is a statistically significantly correlated to respondents vehicle designs, i.e., their PEV and FCEV valuations. Gender distributions are similar between the two regions. Respondents in both regions own similar numbers of vehicles of similar ages, and they paid similar amounts for their most recently purchased vehicles. More respondents in the NESCAUM region own their residence than in the non-NESCAUM states; also, fewer have natural gas or a solar energy installation at their residence. As with respondent age and income, these will not turn out to be important to explaining who designs their next new vehicle to be a PEV or FCEV and who does not.

In general, several concepts that may be related to a respondent’s valuation of a PEV or FCEV as a plausible next new vehicle for their household were assessed prior to assessing this valuation. Among such concepts, these are measured in the survey:

- Likely replacements for gasoline and diesel fuel, in the abstract;
- 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;
- 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; 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.

Across the NESCAUM region, as in all of the state-level studies, the majority selects electricity as one 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 samples: respondents across the NESCAUM on average are less likely to agree that air quality represents a health threat in their region and that they personally worry about air quality. Still, they are as likely on average to believe changes in individual lifestyle affect air quality. The percentage of NESCAUM respondents (56%) who believe, “Human-caused climate change has been established to be a serious problem and immediate action is necessary” is similar as for the non-NESCAUM sample (57%).

Overall, prior awareness and experience—measured in the survey before valuation was assessed—of HEVs, PHEVs, BEVs, and FCEVs was so low that the reasonable assumption is most new car buyers' prior evaluations of these vehicle types were based largely on ignorance. BEV name recognition was lower across the NESCAUM region (24%) than across the other states (34%). However, both regions were comparable in the extent to which correct responses were dominated by only two vehicles: 92% of all correct names were either Nissan Leaf or Tesla. Asked to rate their familiarity with HEVs, PHEVs, BEVs, and FCEVs, from 21% (HEVs) to 41% (FCEVs) of respondents said they were unsure or decline to answer. Of those who did rate their familiarity, the mean scores were low: compared to a mean score (on a scale from -3 to 3) of 2.54 for conventional ICEVs, mean familiarity scores range from 1.54 (HEVs) to -0.41 (FCEVs).

If respondents were "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 NESCAUM respondents were all negative for HEVs, BEVs, PHEVs, and FCEVs: median scores were less than or equal to -2.76. In short, more than half the sample had *no* driving experience with anything other than ICEVs. This result holds for the non-NESCAUM sample, too.

The percentage of the new car buyers in the NESCAUM region who have heard the federal government "is offering incentives for consumers to buy vehicles that are powered by alternatives to gasoline and diesel" (44%) is lower than the non-NESCAUM sample. The real difference seems to be along a dimension of certainty-uncertainty. The percentage of respondents in the NESCAUM region who provide a definitive yes or no response is less than in the non-NESCAUM sample; the NESCAUM sample is more likely to say they are unsure. These differences between samples are statistically significant. However, the substantive interpretations of whether or not respondents have heard of such federal incentives are similar for both regions. Fewer than half the respondents claimed definitively to have heard of federal incentives for consumers to buy vehicles powered by alternatives to gasoline and diesel. Of those who did not claim to have heard, most were unsure.

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, the NESCAUM region lags behind the non-NESCAUM states. Further, no NESCAUM-member state had a percentage of respondents reporting they had seen PEV charging in the parking facilities they use higher than the average of all states (NESCAUM plus non-NESCAUM). In the NESCAUM region only 37% claim to have seen EVSE in the parking facilities they use compared to 63% for the non-NESCAUM states (and 72% for the state with the highest reported sighting, Oregon).

On average, the NESCAUM sample owned slightly fewer but slightly newer vehicles than the non-NESCAUM sample. Sixty-two percent of the NESCAUM sample owned two or more vehicles compared to 69% averaged across the non-NESCAUM states. Despite this, in the NESCAUM region respondents were slightly more likely to have acquired more than one new vehicle since 2008 than were respondents in the non-NESCAUM states. Those vehicle acquisitions were more likely to have been leases in the NESCAUM states (19%) than the non-NESCAUM states (11%).

On average, prices paid for the most recently acquired new vehicle are substantively the same in the two samples. Though the mean prices for the most recently acquired new vehicle is $300 higher in the NESCAUM region than in the non-NESCAUM states, the difference is not statistically significant.

More respondents across the NESCAUM-member states reported they own their home (81%) compared to the aggregate of the non-NESCAUM states (75%). Despite differences in rates of home ownership, identical percentages (72%) in both regions reported living in a single-family home. Taking ownership and building type together, 67% of all NESCAUM respondents resided in a single-family residence they owned; this was higher than the 63% for the non-NESCAUM respondents. Most apartments were rented, most units in townhouses, duplexes, and triplexes owned. 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. In the NESCAUM region, the percentage of those who claimed the authority to make such an installation was far higher (87%) among those who owned a single-family home than those who rented an apartment (17%). A similar result holds for the respondents in the aggregate of non-NESCAUM states

PEV and FCEV Designs

Respondents' valuations of PEVs and FCEVs were determined in the final design game in which no PHEVs or BEVs were offered with both battery-powered, all-electric drive and full-size body styles however there incentives were offered for PEVs and FCEV vehicles. The vehicle designs that were disallowed by the body size restriction were 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 were 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, 26% of the NESCAUM respondents design their next new vehicle to be a PHEV (15%), BEV (7%), or FCEV (4%). These percentages are appreciably lower than for the aggregate of the non-NESCAUM states: PHEV, 21%; BEV, 10%; and, FCEV, 5%. (As it is important for other policy goals, the single percentage of respondents designing an HEV is 37% in the NESCAUM region and 35% in the non-NESCAUM states.

PHEV Designs

- PHEV designs were by far the most popular of the PEV and FCEV possibilities. In Figure 15: 367 respondents designed a PHEV compared to 177 BEVs and 91 FCEVs.
- PHEV designs emphasize longer range driving on electricity, but a mode in which gasoline is used too, i.e., "Assist" rather than all-electric charge-depleting operation.

- Fast charging at home (such as provided by the installation of an EVSE) or at a (initially limited) network of quick chargers is viewed as necessary by a small percentage of those who design a PHEV.

BEV Designs

- BEV designs incorporate driving ranges from across the spectrum of offered options, i.e., 50 to 300 miles.
  - Less than one third of those who design a BEV design one with the maximum offered driving range.
  - In contrast, more than half design BEVs with driving ranges of 125 miles or less.
- Almost two-thirds of those who design BEVs (63%) believe they would be satisfied with a charging speed that could be supplied by existing household 110V or 220V circuits.

FCEV Designs

- Range includes all three possible options (150, 250, and 350 miles); a slight plurality (44%) opts for the longest range.
- Home H_2 refueling was included with 44% of FCEV designs.

Who in the NESCAUM Region Designs Their Next New Vehicle to be a ZEV?

The explanatory variables present in the model for the NESCAUM region are listed below. Those that are statistically significant at $\alpha \leq 0.05$ are shown **bold**, effects significant at $0.10 \geq \alpha < 0.05$ are *italicized*, and those variables that fail to meet the threshold of $\alpha < 0.10$ are shown in plain text. The general effect on the probability of designing a PHEV, BEV, or FCEV is stated based on holding all other variables constant at baseline values. No statement of general effect is made for statistically non-significant variables.

- Respondent (and their household) Socio-economic and Demographics
  - *Respondent education: More years of formal education are associated with a higher probability of designing an HEV, PHEV, BEV, or FCEV than fewer years of formal education.*
  - **Respondent gender: Women are more likely to design PHEVs, BEVs, and FCEVs than men.**
  - Household income
- Household vehicles, travel and residences
  - *Respondent commutes to workplace in a household vehicle or not: Those who commute at least part way to work in a household vehicle are more likely to design an HEV, PHEV, BEV than those who do not.*
  - **Home parking in a garage or carport: Households who park at least one vehicle in a garage or carport attached to their residence are more likely to design a PEV than those who do not.**
- Vehicle knowledge and experience
  - *Familiarity with ICEVs: Those more familiar with ICEVs are more likely to design HEVs and PHEVs and less likely to design BEVs and FCEVs than those who are less familiar with ICEVs.*

- **Driving experience in HEVs: Respondents with more driving experience in HEVs are more likely to design PEVs (though the greater effect is to increase the probability they design an HEV) than those with less HEV driving experience.**

- Attitudes related to policy goals: energy security, air quality, and global warming
  - **Perceives an urgent national need for alternatives to gasoline and diesel: The more strongly the respondent agrees with the need for alternatives, the more likely they are to design one.**
  - **Comparative assessment health and environmental risks of electricity and gasoline in their region: Respondents who think electricity poses lower risks than gasoline are more likely to design vehicles that use no or little gasoline, i.e., they are also more likely to design HEVs, than people who think gasoline poses lower environmental and human health risks than electricity.**
- Prior ZEV evaluation and ZEV-specific attitudes
  - Prior belief electricity is a likely replacement for gasoline and diesel
  - **Prior belief hydrogen is a likely replacement for gasoline and diesel: Those who already believe hydrogen is a likely replacement for gasoline and diesel are more likely to design a BEV or FCEV.**
  - **Respondent's personal interest in ZEV technology: Increased interest in ZEV technology is associated with increased probability of designing a PHEV, BEV, or FCEV.**
  - **Seen public charging in the (non-home) parking facilities they use: Those respondents who have seen PEV charging in the parking facilities they use are more likely to design PEVs than those who have not or are unsure whether they have.**
  - *Prior assessment of PEVs*
    - **Charging: extent of opportunities away from home and capability to charge a PEV at home: The more strongly the respondent agrees they can charge a PEV at home and there are enough other locations to charge PEVs, the more likely they are to design PEVs.**
    - **Range per charge and time it takes to charge The more strongly the respondent disagrees PEVs don't travel far enough per charge and take too long to charge, the more likely they are to design a PEV.**
    - **Relative safety and reliability of PEVs and ICEVs: The more strongly the respondent disagrees that gasoline-fueled vehicles are safer and more reliable than vehicles powered by electricity the more likely they are to design a PEV.**
    - *Relative purchase price of PEVs and ICEVs: The more strongly the respondent disagrees that vehicles powered by electricity cost more to buy than gasoline powered vehicles, the more likely they are to design a PHEV.*
  - Prior assessment of FCEVs
    - Fueling time, driving range, and number of fueling locations
    - Relative safety and reliability of FCEVs and ICEVs
    - Relative purchase prices of FCEVs and ICEVs

- **Whether have already considered buying a PEV: The more respondents have already considered whether a PEV is right for their household, the more likely they are to design one.**
- **Whether have already considered buying an FCEV: The more respondents have already considered whether an FCEV is right for their household the more likely they are to design one.**
- Whether governments should offer incentives for electricity and hydrogen

Why do people design ZEVs?

- Highly rated motivations to design a ZEV are a mix of private and pro-social benefits
  - Private: Savings on (fuel) costs, interest in new technology, and safer than gasoline
  - Pro-social: Reducing personal effects on climate change, air quality, oil imports, and payments to oil producers
- Little acknowledgement that incentives were important to their vehicle design

Cluster analysis was used to answer whether identifiable groups of people share similar motivations: a four-cluster solution was selected. The four clusters are found also in California and in the aggregate of all states except California. All four clusters share two motivations: interest in ZEV technology and fuel cost savings. One of these clusters is identified primarily by how few of the available points in the motivation exercise they used. Thus this low-scoring cluster has no mean motivation scores higher than the global mean of all possible motivations. Still, it is the case that their two highest scores were for “interest in ZEV technology” and “Fuel cost savings.”

A cluster we have named “Pro-social technologists” is the only one strongly motivated by all the four motivations associated with pro-social motivations—air quality, climate change, and energy security. They appear to be interested in the application of ZEV technology to these pro-social ends, as well as to the private goal of fuel cost savings. The “Thrifty environmentalists” cluster shares similar motivations, but appears to switch their priority—emphasizing private benefits over pro-social ones, to the extent it is the only cluster that was highly motivated by incentives offered in the third design game. The people in the cluster named “ZEV-tech hedonists” appear to be most motivated by the idea that ZEV technology will produce the best car: a fun, comfortable, safe, good-looking car that makes the right impression, fits their lifestyle and saves fuel costs.

Given these clusters of shared motivations, pro-technology, fuel cost savings messages would appear to be broadly appealing to those who already have a favorable valuation of PEVs and FCEVs. Messages about pro-social benefits could be more carefully directed to people who would be receptive and motivated by those benefits. A non-trivial part of the population of new car buyers would appear to be receptive to messages more in line with general automotive marketing highlighting the private benefits flowing from the performance attributes of electric-drivetrains.

Why don't people design ZEVs?

- The highest scoring motivations against designing PEVs or FCEVs have to do with their inherent newness: limited charging and fueling networks, high initial purchase price, and unfamiliarity with the technology. Other highly scored concerns included:
    - Driving range and time to charge or fuel
    - Immediate, practical limits on the ability to charge a PEV at home
    - Overall reliability of electricity supply
- Few acknowledged that greater incentives (of the kinds offered in the game) would have changed their minds.

Three clusters appear adequate to understand shared groups of motivations; all three clusters are found in the analyses for NESCAUM, California, and the aggregate of all states other than California. The first distinction is between a relatively smaller number of people who are—at least judged by this survey—comparatively unconcerned compared to all others who have long lists of highly scored motivations against designing their next new vehicle to be a PEV or FCEV. All three clusters share concern for unfamiliar technology, that may be expensive to buy, and that may have negative impacts on the reliability of electricity supply. The other two clusters are a characterized by the long litany of concerns they have beyond these three. The two can be distinguished from each other by their highest scoring concerns. One of these clusters has high average scores for all cost related-related items—except they are not inclined to believe higher incentives would have changed their minds. The other has the highest level of concern with dimensions of PEV charging and ZEV fueling: limited networks of charging/fueling opportunities, limited range, and time it takes to charge a PEV or fuel an FCEV.

The Role of Government Incentives

While most of those who do not design a ZEV appear overwhelmed with a long list of concerns, fewer seem outright resistant. When asked about whether they have already considered PEVs and FCEVs, 22% of the NESCAUM sample replies they have not and *would not* consider buying a PEV, 32% an FCEV, and 18% neither one. The corresponding figures for all non-NESCAUM states are lower: 15% (PEV), 25% (FCEV), and 12% neither. If an actual opposition (at present) to PEVs and FCEVs seems a small portion of new-car buyers (smaller than the percent who decline to design one as their next new vehicle in this survey), incentives play an unacknowledged role among those who have positive valuations of ZEVs and may not address the first problem of those with negative valuations. We start by observing that prior to the introduction of incentives (modeled on incentives offered in the real world) in the design games, few respondents were aware such incentives exist (44% of the NESCAUM sample claims to have heard of federal incentives for alternatives to gasoline and diesel). Offered financial purchase incentives and use incentives in the survey, respondents were far more likely to choose financial incentives.[22] Further, despite the dollar value being identical for both the vehicle and

[22] 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.

home charging, among those who choose a direct financial incentive, respondents split about two-to-one (vehicle-to-charger) as to which they want.

There appears to be an unwillingness (among those who do design a PEV or FCEV) to give credit to the introduction of incentives in the third game to their design despite the fact 12% more of the respondents in the NESCAUM region designed a PEV or FCEV in the third game than in the first. The difference between the first and third design games was larger among the respondents in the non-NESCAUM states; the aggregate increase was 16% more PEV and FCEV designs when incentives were added but battery-powered, all-electric, full-size options taken away. In both samples, the larger conclusion is most respondents who committed to a PEV or FCEV design at any point in the survey did so without incentives. There were few among those unwilling to design a PEV or FCEV who indicated that higher incentives would have changed their minds; in the NESCAUM region only four percent of those who did not design a PEV or FCEV gave the highest score to the statement "higher incentives would have convinced me."

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 were willing to say incentives affected their vehicle designs, incentives are part of the public discussion of PEVs (and likely will be for FCEVs when those vehicles are more widely available). Taking incentives away now erodes part of the "saving money" rationale at a time when that rationale depends on incentives.

What are the biggest problems for those who don't value PEVs and 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 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 had been on new car lots in the last few years, shopping for and buying new cars—didn't know PEVs were for sale. This is clear in the difference between answers to questions about familiarity vs. experience, from the lack of BEV name recognition, and from the low percentage of people in the sample who already own a PEV. The vast majority of respondents were constructing their valuation of ZEVs for the first time while completing the survey. It can be anticipated FCEVs will have the same problems unless lessons learned from PEVs are used to amplify messages regarding availability of vehicles and fueling as well as information and experience opportunities to overcome the other concerns.

2) Lack of knowledge of and experience with PEVs and FCEVs. The lengthy 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

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 motivations for—and against—a positive valuation of ZEVs.

The attachment of pro-social goals such as reduced threats from energy insecurity, climate change, and air pollution to PEVs and FCEVs by some 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 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 with electric drivetrains—PHEVs, BEVs, and FCEVs—to simply be the best available cars on many metrics including performance and other kinesthetic and aesthetic criteria.[23]

It seems clear from these results that the initial valuations that the majority of new car buyers 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 plus 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.

[23] 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 $\alpha = 0.05$ 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 rejected: Households that own more vehicles are less likely to design an ICEV, and more likely to design a PEV or FCEV—except among those household who have the most vehicles.
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 statistically significant association between number of new vehicles since 2008 and drivetrain designs in the survey.
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: Those who spent more for their most recently acquired new vehicle are slightly more likely to design a BEV.
Fuel economy of respondent's vehicle	H_a: higher fuel economy of respondent's current vehicle will be associated with a higher likeliness to design a PEV or FCEV.	H_o rejected, H_a supported.
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, H_{a1} supported.
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, H_a supported.
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, H_a supported.
Household total fuel cost	H_a: Households who spend more on fuel for	H_o rejected, H_a supported.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	their whole fleet of vehicles will be more likely to design a PHEV, BEV, or FCEV. (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, H_a supported.
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, H_a supported.
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, H_a supported.
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 PEV or FCEV. (Predisposition toward natural gas; may have already spurred search for information.)	H_o rejected, H_a supported.
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 rejected, H_a supported. Further, greater flexibility is also associated with higher likeliness to design a PHEV or FCEV.
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, H_a supported.
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 rejected, H_a supported.
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	H_o rejected, support for H_a mixed. The relationship between variability and likeliness to design a BEV is not well ordered.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	vehicle.)	
Commute to a workplace	H_a: Respondents who commute to work will 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.)	H_o rejected, H_a supported.
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 rejected; H_a supported.
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; H_a supported.
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 rejected; H_a supported.
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 not rejected; 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 rejected; H_{a2} partially supported—those more familiar with gasoline vehicles are more likely to design HEVs and PHEVs, but not BEVs or FCEVs.
Familiarity with HEVs, BEVs, PHEVs, and FCEVs	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	H_0 rejected: H_{a2} supported.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	produces an attraction toward alternatives.)	
Two factor solution to the four familiarity variables	H_a: Familiarity with all vehicle types associated with higher likelihood to design ZEV. One factor includes HEVs, PEVs and FCEV; the other does not load strongly on any vehicle type.	H_0 rejected: H_{a2} supported: Higher scores on the factor associated with HEVs, PEVs, and FCEVs are associated with lower likeliness to design an ICEV.
Environmental and health risk of electricity compared to gasoline	H_a: Respondents who believe electricity is a 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.)	H_o rejected. Lower comparative risk of electricity is 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 Driving experience: HEV, PHEV, FCEV	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_a: Same as for BEVs.	H_0 rejected. Higher BEV driving experience associated with higher likeliness to design ZEV. In general, driving experience with HEVs, PHEVs, and FCEVs associated with higher likeliness to design a ZEV.
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 or HEV.
Two factor solution to the four driving experience variables	H_a: Similar to above. Driving Exp Factor 1 includes PHEVs, BEVs and FCEVs Driving Exp Factor 2 includes HEVs.	H_o rejected: Higher scores on both factors associated with higher likeliness to design a ZEV
PEV 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.
PEV 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 higher likeliness to design a ZEV.
PEV 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.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
PEV 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.
PEV 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.
PEV 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.
PEV 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.
Four factor solution to a factor analysis of the seven dimensions of prior PEV evaluation	H_a: 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. Prior PEV Factor 1: range charging time Prior PEV Factor 2: safety Prior PEV Factor 3: home charge Prior PEV Factor 4: public charging	H_o rejected, four factors correlated to drivetrain design:
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_o rejected; H_a supported
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 not rejected: 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 not rejected: 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 not rejected: 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	H_a: Stronger agreement associated with *lower*	H_o rejected: Decreasing

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
vehicles are more reliable than hydrogen fuel cell vehicles."	likeliness to design an FCEV.	confidence in the relative reliability of FCEVs compared to ICEVs is associated with a higher likeliness to design an ICEV.
Three factor solution to the factor analysis of the six dimensions of FCEV evaluation	H_a: Factor analysis searches for a smaller number of factors that summarizes the six dimensions of FCEV evaluation. Prior FCEV Factor1: -public fueling, range and fueling time Prior FCEV Factor 2: safety and reliability Prior FCEV Factor 3: purchase price	H_o rejected, three factors associated with drivetrain type
Incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel: Federal government. State government	For each entity, H_a: Those already aware of incentives will be more likely to design a qualifying vehicle.	H_o rejected: Prior belief federal government offers incentives associated with higher likeliness of designing a ZEV. H_o rejected: Prior belief states are offering incentives associated with higher likeliness to design PEVs and FCEVs, PHEVs especially.
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 unsure or think government should not offer incentives are more likely to design an ICEV or HEV.
Prior consideration of BEVs	H_{a1}: Higher levels of consideration of BEVs 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_0 rejected, H_{a1} supported. The two categories of greatest levels of consideration have been collapsed into a single category because of small numbers of people in each.
Prior consideration of FCEVs	H_{a1}: Higher levels of consideration of FCEVs prior to completing the survey will be associated with *higher* likeliness of designing an FCEV. (FCEVs are making a *favorable* impression on more consumers than not.) H_{a2}: Higher levels of consideration of FCEVs prior to completing the survey will be associated with *lower* likeliness of designing FCEVs. (FCEVs are making a *unfavorable*	H_0 rejected, H_{a1} supported The three categories of greatest levels of consideration have been collapsed into a single category because of small numbers of people in each.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	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 an 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 an 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 an 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 be more likely to design a PHEV, BEV, or FCEV.	H_o not rejected: No significant relationship.
Residence type	H_a: Residents of single-family dwellings will be more likely to design a PHEV, BEV, or FCEV.	H_o not rejected: No significant relationship.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
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, H_a supported.
Household size	H_a: No specific alternative hypotheses.	H_o rejected: Households with more people are more likely to design a ZEV.
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: Respondents older than 50 less likely to design PEVs or FCEVs.
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; Ha supported.
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: Households with a retired person in them are more likely to design ICEVs.
Children in household	No specific alternative hypothesis.	H_o rejected: Households without children less likely to design ICEVs.
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, H_a supported.
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 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, H_a supported.
Political party affiliation	H_a: Lefties more likely to design a PHEV, BEV, or FCEV. (Presently, federal initiatives are the product of a Democratic administration.)	H_o rejected, H_a supported.
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 but H_a not supported: higher income households are more likely to design HEVs.
History leasing vehicles	H_a: Households with a history of leasing will	H_o rejected, but Ha is wrong, too:

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	Those who have previously leased a vehicle are less likely to design a PEV or FCEV.
State (within NESCAUM)	H_a: Respondents in states with more ZEV sales and incentives will be more likely to design a ZEV	H_o not rejected: no difference by state within the NESCAUM region.

APPENDIX B: RESPONDENT VALUATION OF ZEVS

Multivariate model for Game 3: No battery-powered, all-electric operation in full-size vehicles; 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—not a continuous scale. The whole model test (Table B1) evaluates whether the 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	578.1695	156	1156.339	<0.0001
Full	2599.3042			
Reduced	3177.4737			

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	
Entropy RSquare	0.182
Generalized RSquare	0.415
Misclassification Rate	0.473
N	2,370

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	9308	2599.3042	5198.608
Saturated	9464	0.0000	**Prob>ChiSq**
Fitted	156	2599.3042	1.0000

The Effect Likelihood Ratio Tests in Table B4 show that overall each variable has a statistically significant effect on the probabilities respondents' vehicle designs incorporate each of the five major categories of drivetrain types: ICEV, HEV, PHEV, BEV, or FCEV.

Table B4: Effect Likelihood Ratio Tests

Source	**Nparm**	**L-R ChiSquare**	**Prob>ChiSq**
Respondent Education	16	24.34	**0.0824**
Personal interest in ZEV tech	12	65.66	**0.0001**
Respondent Gender	4	14.93	**0.0048**
Household Income	4	4.87	0.3013
Garage or Carport	4	10.30	**0.0356**
Commute	4	8.58	**0.0726**
Pro-social Factor2: electricity	4	12.19	**0.0160**
Pro-social Factor5: urgent need	4	31.36	**0.0001**
Should government offer incentives	16	23.10	0.1112
Replacement: Hydrogen	4	25.86	**0.0001**
Replacement: Electricity	4	5.71	0.2222
Seen Public EVSEs	16	38.96	**0.0011**
Prior PEV Factor1: range charge time	4	13.79	**0.0080**
Prior PEV Factor2: safety reliability	4	17.01	**0.0019**
Prior PEV Factor3: charging public home	4	10.81	**0.0288**
Prior PEV Factor4: Purchase Price	4	8.24	**0.0832**
Prior FCEV Factor1: fueling time, range, -public fueling	4	3.57	0.4672
Prior FCEV Factor2: safety reliability	4	2.15	0.7083
Prior FCEV Factor3: purchase price	4	1.39	0.8464
Experience Factor2: HEV	4	30.08	**0.0001**
Familiarity Factor2: ICEV	4	25.95	**0.0001**
Consider a BEV	16	61.85	**0.0001**
Consider an FCEV	12	31.78	**0.0015**

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	1.334	0.590	5.11	**0.024**
Respondent Education[High School Grad, GED, or less]	0.224	0.373	0.36	0.549
Respondent Education[Some College]	0.055	0.274	0.04	0.842
Respondent Education[College Graduate]	0.180	0.226	0.63	0.428
Respondent Education[Some Graduate School]	0.078	0.371	0.04	0.833
Personal interest in ZEV tech[Not interested]	1.086	0.485	5.01	**0.025**
Personal interest in ZEV tech[A little interested]	0.346	0.297	1.36	0.244
Personal interest in ZEV tech[Interested]	-0.514	0.249	4.28	**0.039**
Respondent Gender[Female]	-0.084	0.139	0.37	0.545
Pro-social Factor2: electricity	0.230	0.159	2.09	0.148
Pro-social Factor5: urgent need	-0.555	0.229	5.88	**0.015**
Prior PEV Factor1: range charge time	0.306	0.178	2.95	**0.086**
Prior PEV Factor2: safety reliability	-0.170	0.217	0.62	0.431
Prior PEV Factor3: charging public home	0.189	0.159	1.42	0.233
Experience Factor2: HEV	-0.684	0.198	11.86	**0.001**
Familiarity Factor2	0.379	0.207	3.37	**0.066**
Consider a BEV 2[Own/shopped]	0.240	0.478	0.25	0.616
Consider a BEV 2[Started to gather some information, but haven not really gotten serious yet]	-0.483	0.318	2.31	0.129
Consider a BEV 2[The idea has occurred, but no real steps have been taken to shop for one]	-0.189	0.254	0.55	0.458

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
Consider a BEV 2[I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will]	0.262	0.286	0.84	0.360
Consider an FCEV 2[Own/shopped/information]	-0.436	0.332	1.72	0.190
Consider an FCEV 2[The idea has occurred, but no real steps have been taken to shop for one]	-0.560	0.234	5.75	**0.017**
Consider an FCEV 2[I (we) have not considered buying a vehicle that runs on hydrogen but maybe some day we will]	0.470	0.239	3.87	**0.049**
Should government offer incentives[I'm not sure]	0.526	0.415	1.61	0.205
Should government offer incentives[No, neither one]	0.093	0.348	0.07	0.789
Should government offer incentives[Yes, but only electricity]	-0.133	0.309	0.18	0.668
Should government offer incentives[Yes, but only hydrogen]	-0.521	0.416	1.57	0.210
Garage or Carport[No]	0.140	0.140	1.01	0.315
Commute[No]	0.178	0.144	1.54	0.214
Replacement: Hydrogen[No]	0.614	0.143	18.38	**0.000**
Replacement: Electricity[No]	-0.037	0.135	0.07	0.785
Seen Public EVSEs[No. I haven't seen any.]	0.432	0.247	3.08	**0.080**
Seen Public EVSEs[I'm not sure whether I've seen any or not.]	0.449	0.519	0.75	0.387
Seen Public EVSEs[Yes. I've seen them at one place.]	-0.805	0.303	7.06	**0.008**
Seen Public EVSEs[Yes. I've seen them at a few places.]	0.052	0.274	0.04	0.848
Income 2	0.094	0.078	1.46	0.227
Prior FCEV Factor1: fueling time, range, -public fueling	0.200	0.230	0.76	0.384
Prior FCEV Factor2: safety reliability	0.224	0.190	1.40	0.237

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
Prior FCEV Factor3: purchase price	0.151	0.216	0.49	0.484
Prior PEV Factor4: Purchase Price	-0.059	0.148	0.16	0.692
Intercept HEV	1.190	0.580	4.21	**0.040**
Respondent Education[High School Grad, GED, or less]	-0.091	0.374	0.06	0.809
Respondent Education[Some College]	0.041	0.271	0.02	0.880
Respondent Education[College Graduate]	0.075	0.223	0.11	0.736
Respondent Education[Some Graduate School]	0.277	0.360	0.59	0.441
Personal interest in ZEV tech[Not interested]	0.653	0.488	1.79	0.181
Personal interest in ZEV tech[A little interested]	0.169	0.296	0.33	0.568
Personal interest in ZEV tech[Interested]	-0.152	0.244	0.39	0.533
Respondent Gender[Female]	0.080	0.136	0.34	0.559
Pro-social Factor2: electricity	-0.028	0.157	0.03	0.859
Pro-social Factor5: urgent need	-0.275	0.227	1.47	0.226
Prior PEV Factor1: range charge time	0.184	0.173	1.13	0.287
Prior PEV Factor2: safety reliability	-0.319	0.211	2.28	0.131
Prior PEV Factor3: charging public home	0.318	0.155	4.18	**0.041**
Experience Factor2: HEV	-0.204	0.189	1.17	0.279
Familiarity Factor2	0.737	0.206	12.82	**0.000**
Consider a BEV 2[Own/shopped]	0.522	0.427	1.49	0.222
Consider a BEV 2[Started to gather some information, but haven not really gotten serious yet]	-0.124	0.289	0.18	0.669
Consider a BEV 2[The idea has occurred, but no real steps have been taken to shop for one]	0.086	0.240	0.13	0.719
Consider a BEV 2[I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will]	0.128	0.278	0.21	0.646
Consider an FCEV 2[Own/shopped/information]	-0.534	0.303	3.10	**0.078**

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
Consider an FCEV 2[The idea has occurred, but no real steps have been taken to shop for one]	-0.505	0.218	5.36	**0.021**
Consider an FCEV 2[I (we) have not considered buying a vehicle that runs on hydrogen but maybe some day we will]	0.682	0.230	8.77	**0.003**
Should government offer incentives[I'm not sure]	0.402	0.414	0.94	0.331
Should government offer incentives[No, neither one]	0.002	0.346	0.00	0.996
Should government offer incentives[Yes, but only electricity]	-0.245	0.304	0.65	0.419
Should government offer incentives[Yes, but only hydrogen]	-0.394	0.393	1.00	0.316
Garage or Carport[No]	0.126	0.137	0.84	0.359
Commute[No]	0.159	0.142	1.26	0.261
Replacement: Hydrogen[No]	0.569	0.137	17.33	**0.000**
Replacement: Electricity[No]	-0.067	0.133	0.26	0.613
Seen Public EVSEs[No. I haven't seen any.]	0.364	0.244	2.22	0.136
Seen Public EVSEs[I'm not sure whether I've seen any or not.]	0.017	0.520	0.00	0.974
Seen Public EVSEs[Yes. I've seen them at one place.]	-0.430	0.290	2.19	0.139
Seen Public EVSEs[Yes. I've seen them at a few places.]	0.255	0.264	0.93	0.335
Income 2	0.137	0.077	3.18	**0.075**
Prior FCEV Factor1: fueling time, range, -public fueling	0.267	0.225	1.41	0.235
Prior FCEV Factor2: safety reliability	0.149	0.184	0.66	0.417
Prior FCEV Factor3: purchase price	0.170	0.210	0.65	0.419
Prior PEV Factor4: Purchase Price	0.018	0.144	0.02	0.901
Intercept PHEV	0.344	0.611	0.32	0.574
Respondent Education[High School Grad, GED, or less]	0.032	0.394	0.01	0.935

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
Respondent Education[Some College]	0.083	0.284	0.09	0.770
Respondent Education[College Graduate]	0.151	0.233	0.42	0.517
Respondent Education[Some Graduate School]	-0.018	0.380	0.00	0.963
Personal interest in ZEV tech[Not interested]	0.436	0.507	0.74	0.389
Personal interest in ZEV tech[A little interested]	-0.031	0.308	0.01	0.920
Personal interest in ZEV tech[Interested]	-0.016	0.254	0.00	0.950
Respondent Gender[Female]	0.174	0.142	1.52	0.218
Pro-social Factor2: electricity	0.039	0.166	0.06	0.812
Pro-social Factor5: urgent need	0.031	0.238	0.02	0.896
Prior PEV Factor1: range charge time	0.005	0.178	0.00	0.976
Prior PEV Factor2: safety reliability	-0.605	0.221	7.53	**0.006**
Prior PEV Factor3: charging public home	0.285	0.162	3.11	**0.078**
Experience Factor2: HEV	-0.157	0.195	0.64	0.422
Familiarity Factor2	0.666	0.218	9.31	**0.002**
Consider a BEV 2[Own/shopped]	0.076	0.445	0.03	0.865
Consider a BEV 2[Started to gather some information, but haven not really gotten serious yet]	0.141	0.296	0.23	0.634
Consider a BEV 2[The idea has occurred, but no real steps have been taken to shop for one]	0.104	0.251	0.17	0.679
Consider a BEV 2[I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will]	0.063	0.291	0.05	0.827
Consider an FCEV 2[Own/shopped/information]	-0.353	0.314	1.26	0.261
Consider an FCEV 2[The idea has occurred, but no real steps have been taken to shop for one]	-0.425	0.230	3.40	**0.065**
Consider an FCEV 2[I (we) have not considered buying a vehicle that runs on hydrogen but maybe some day we will]	0.730	0.238	9.37	**0.002**

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
Should government offer incentives[I'm not sure]	0.103	0.436	0.06	0.813
Should government offer incentives[No, neither one]	-0.209	0.375	0.31	0.578
Should government offer incentives[Yes, but only electricity]	0.302	0.313	0.93	0.335
Should government offer incentives[Yes, but only hydrogen]	-0.398	0.438	0.83	0.363
Garage or Carport[No]	-0.071	0.143	0.25	0.619
Commute[No]	-0.010	0.149	0.00	0.945
Replacement: Hydrogen[No]	0.685	0.146	21.94	**0.000**
Replacement: Electricity[No]	-0.197	0.140	2.00	0.158
Seen Public EVSEs[No. I haven't seen any.]	0.074	0.256	0.08	0.772
Seen Public EVSEs[I'm not sure whether I've seen any or not.]	-0.242	0.554	0.19	0.663
Seen Public EVSEs[Yes. I've seen them at one place.]	-0.525	0.308	2.90	**0.088**
Seen Public EVSEs[Yes. I've seen them at a few places.]	0.328	0.275	1.42	0.234
Income 2	0.102	0.080	1.62	0.203
Prior FCEV Factor1: fueling time, range, -public fueling	0.052	0.237	0.05	0.825
Prior FCEV Factor2: safety reliability	0.145	0.193	0.57	0.451
Prior FCEV Factor3: purchase price	0.129	0.220	0.34	0.557
Prior PEV Factor4: Purchase Price	0.187	0.151	1.54	0.215
Intercept BEV	0.192	0.663	0.08	0.772
Respondent Education[High School Grad, GED, or less]	-0.183	0.448	0.17	0.684
Respondent Education[Some College]	-0.125	0.320	0.15	0.695
Respondent Education[College Graduate]	0.319	0.254	1.58	0.208
Respondent Education[Some Graduate School]	-0.172	0.429	0.16	0.689
Personal interest in ZEV tech[Not	0.127	0.568	0.05	0.823

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
interested]				
Personal interest in ZEV tech[A little interested]	-0.030	0.341	0.01	0.929
Personal interest in ZEV tech[Interested]	-0.102	0.282	0.13	0.717
Respondent Gender[Female]	-0.061	0.154	0.16	0.692
Pro-social Factor2: electricity	0.152	0.176	0.75	0.387
Pro-social Factor5: urgent need	0.074	0.262	0.08	0.776
Prior PEV Factor1: range charge time	-0.100	0.190	0.27	0.600
Prior PEV Factor2: safety reliability	-0.530	0.236	5.06	**0.024**
Prior PEV Factor3: charging public home	0.033	0.174	0.04	0.848
Experience Factor2: HEV	-0.180	0.211	0.73	0.394
Familiarity Factor2	0.320	0.230	1.93	0.165
Consider a BEV 2[Own/shopped]	0.959	0.430	4.97	**0.026**
Consider a BEV 2[Started to gather some information, but haven not really gotten serious yet]	0.220	0.307	0.51	0.473
Consider a BEV 2[The idea has occurred, but no real steps have been taken to shop for one]	-0.027	0.266	0.01	0.920
Consider a BEV 2[I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will]	-0.704	0.327	4.62	**0.032**
Consider an FCEV 2[Own/shopped/information]	-0.273	0.319	0.73	0.392
Consider an FCEV 2[The idea has occurred, but no real steps have been taken to shop for one]	-0.353	0.243	2.11	0.146
Consider an FCEV 2[I (we) have not considered buying a vehicle that runs on hydrogen but maybe some day we will]	0.422	0.255	2.74	**0.098**
Should government offer incentives[I'm not sure]	0.445	0.463	0.92	0.337
Should government offer incentives[No, neither one]	-0.156	0.412	0.14	0.705
Should government offer incentives[Yes,	0.142	0.331	0.18	0.669

Term	Estimate	Std Error	Chi-Square	Prob > ChiSq
but only electricity]				
Should government offer incentives[Yes, but only hydrogen]	-0.523	0.473	1.22	0.269
Garage or Carport[No]	-0.001	0.155	0.00	0.997
Commute[No]	0.201	0.159	1.61	0.204
Replacement: Hydrogen[No]	0.342	0.152	5.03	**0.025**
Replacement: Electricity[No]	-0.180	0.151	1.43	0.233
Seen Public EVSEs[No. I haven't seen any.]	0.102	0.274	0.14	0.710
Seen Public EVSEs[I'm not sure whether I've seen any or not.]	0.557	0.554	1.01	0.314
Seen Public EVSEs[Yes. I've seen them at one place.]	-0.675	0.342	3.88	**0.049**
Seen Public EVSEs[Yes. I've seen them at a few places.]	0.250	0.287	0.76	0.383
Income 2	0.062	0.087	0.50	0.478
Prior FCEV Factor1: fueling time, range, -public fueling	0.266	0.254	1.10	0.295
Prior FCEV Factor2: safety reliability	0.248	0.207	1.44	0.230
Prior FCEV Factor3: purchase price	0.270	0.239	1.28	0.259
Prior PEV Factor4: Purchase Price	-0.014	0.157	0.01	0.932

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