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

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DISCLAIMER

The statements and conclusions in this report are those of the authors and not necessarily those of the New Jersey Department of Environmental Protection, 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. 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 New Jersey and Comparative Analyses.
3. As part of this comparative analysis, Appendix C is added to the document.
4. Population level estimates of numbers of households with positive PEV valuations are added to the results.
5. Discussion and conclusions are added to reflect these changes.
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. ZEV will also be used refer to 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), discussion of which vehicles were for sale then 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). New automotive product offerings and energy industry and utility responses to air quality, climate, energy, and ZEV regulatory frameworks mean consumers are confronted with new vehicle technologies and asked to consider new driving and fueling behaviors. Even as PHEVs, BEVs, and FCEVs enter the vehicle market, nascent PEV recharging infrastructure is being deployed and hydrogen fueling infrastructure is being planned and constructed, questions remain as to whether consumers will purchase PEVs and FCEVs.

This research addresses the questions of whether and how households who tend to acquire their vehicles as new value PEVs and FCEVs in comparison to ICEVs and 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 plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and fuel cell electric vehicles (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 conventional vehicles powered by internal combustion engines (ICEVs), hybrid vehicles (HEVs), PEVs, and FCEVs. Interviews with a subset of survey respondents in California, Oregon, and Washington elaborated on consumer awareness and knowledge of, as well as motivation and intention toward, PEVs and FCEVs. Results include an enumeration of the present responses of new car buyers to the new technologies as well as an understanding of what can be done to transform the positive intentions towards PEVs and FCEVs into purchases and the negative intentions toward PEVs and FCEVs into positive ones.

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

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

A Multistate ZEV Policy Framework

To improve local air quality and reduce the emissions that contribute to climate change, New Jersey has adopted California's ZEV mandate requiring manufacturers of passenger cars and light trucks to sell a certain percentage of ZEVs. In addition to New Jersey, the states of Connecticut, Maine, Maryland, Massachusetts, Oregon, New York, Rhode Island and Vermont have adopted these standards. ZEVs are any vehicle that releases zero emissions during on-road operation. They include battery electric vehicles (BEVs) and hydrogen fuel cell vehicles (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. Notably, one credit does not equal one vehicle. For example, a BEV earns between one and nine ZEV credits depending on driving range. In an effort to make compliance easier for automakers, credits may be traded between manufacturers and manufacturers can meet their sales requirements with a mix of vehicle technologies, for example, selling a certain number of ZEVs as well as partial zero emission vehicles and neighborhood electric vehicles. Automakers are also allowed to apply ZEV credits earned in one state to their ZEV requirements in other states as long as they sell a minimum number of ZEVs in each participating state.

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

New Jersey State ZEV Policy and Incentives

PEV buyers qualify for a federal tax incentive. Additional incentives and activities in the New Jersey include:

1) Vehicle Toll Incentive offered by The New Jersey Turnpike Authority gives a 10 percent discount from off-peak toll rates on the New Jersey Turnpike and Garden State Parkway through NJ EZ-Pass, expires November 30, 2018[3];
2) Drivers of single-occupant vehicles with "hybrid engines" or that exceed 45mpg may use the New Jersey Turnpike's HOV lane from Woodbridge to Newark[4];
3) Sales and Use Tax Exemption for Zero Emission Vehicles sold, leased, or rented in New Jersey,[5] the exemption from the 7% tax is only for vehicles defined to be ZEVs, excluding "partial ZEVs" such as HEVs[6];

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[3] http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#nj
[4] New Jersey Administrative Code 19:9-1.24. Accessed via http://www.lexisnexis.com/hottopics/njcode/; http://www.afdc.energy.gov/laws/all?state=NJ.
[5] http://www.nj.gov/dep/cleanvehicles/
[6] http://www.state.nj.us/treasury/taxation/zevnotice.shtml

4) After first enforcing state law prohibiting direct vehicle sales to consumers, New Jersey modified state law to allow motor vehicle franchisors who manufacture only ZEVs to directly sell to consumers[7];
5) Public Service Electric & Gas (PSE&G) Company provided "smart" charging equipment for 150 cars to companies in its service territory that have at least 5 employees who will use an PEV for their commute. PSG&E covered the cost of the charging equipment and the participating workplaces paid for installation and the cost of the electricity used.[8]

Per the Alternative Fuels Data Center, there are 136 electric stations and 320 charging outlets in the state.[9] In August 2015, the New Jersey Senate approved a bill requiring the New Jersey Transportation Authority to install four charging stations at rest areas on the Garden State Parkway, four along the New Jersey Turnpike, and two along the Atlantic City Expressway within the next three years. Similar legislation in the Assembly has not been voted on by the full house.[10]

The state of New Jersey joined 10 other states and the District of Columbia to form the Transportation and Climate Initiative (TCI). TCI "seeks to develop the clean energy economy and reduce oil dependence and greenhouse gas emissions from the transportation sector."[11] Among the transportation-related programs is the Northeast Electric Vehicle Network to facilitate deployment of PEV charging.

According to a solar electric industry source, New Jersey ranks 3rd among US states for installed solar capacity and has over $591 million dollars invested in solar installations as of 2014 with over 519 solar companies through out the state.[12] Despite New Jersey's commitment to both zero emission vehicles and solar energy, it does not appear the two are linked in any co-promotion by the state.

As of June 2015, 38% of the PEVs sold or leased in New Jersey were BEVs and 62% were PHEVs, compared with the national average of 47% BEVs and 53% PHEVs sold or leased.[13]

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[7] http://www.afdc.energy.gov/laws/all?state=NJ. The initial ban occurred prior to the date of the on-line survey for this study; the reversal occurred after the survey.
[8] https://www.pseg.com/info/media/newsreleases/2014/2014-07-22.jsp#.VgwXv3iAbww
[9] http://www.afdc.energy.gov/fuels/electricity_locations.html
[10] http://www.capitalnewyork.com/article/new-jersey/2015/08/8574303/electric-car-charging-stations-could-soon-dot-turnpike
[11] http://www.transportationandclimate.org/content/about-us
[12] http://www.seia.org/state-solar-policy/New-Jerseynew
[13] http://energy.gov/eere/vehicles/fact-877-june-15-2015-which-states-have-more-battery-electric-vehicles-plug-hybrids

STUDY DESIGN

The 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 at length in this report. A single survey was designed and implemented in all states. This limited any possible customization to the specific circumstances in each state, e.g., whether and which PHEVs, BEVs, AND FCEVs are for sale, state and local policies to support ZEVs. The on-line survey was conducted from December 2014 to January 2015.

Online Survey Instrument Design

PEV and FCEV valuation was 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 previously used such games to assess new car buyer interest in natural gas, plug-in hybrid and electric vehicles, plug-in hybrid electric vehicles (PHEV) and plug-in hybrid and electric vehicles.

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

The vehicle design games were customized to each participant. Participants were asked, to the extent that they have considered their next new vehicle, what that vehicle is likely to be. From that point, the design game was a constructive exercise—people put together the vehicle they want. The results of the design games were respondents' prospective designs for the new vehicle they imagined they would buy next. These prospective designs are not forecasts, but indicators of respondents' present positive or negative valuation of PEVs and FCEVs compared to ICEVs and HEVs.

Sample

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

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

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

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

Table 1 shows the target sample sizes for each state, as well as the number of interviews in those states requesting them. State sample sizes were determined largely by the sample provider's ability to assure sample sizes from the population of new-car buying households in each state. [14] The maximum achievable sample size was used; in the case of New Jersey, the target sample size was n = 500. Following data cleaning, the final sample size for New Jersey is n = 495.

Table 1: Survey sample size, by state

State/Region	State Survey Sample Size	Number of Interviews
Oregon	500	16
California	1700	36
Washington	500	16
Delaware	300	0
Maryland	400	0
NESCAUM (individually participating states)		
Massachusetts	500	0
New Jersey	**500**	**0**
New York	1000	0
NESCAUM (non-participating states):		
Connecticut	184	0
Maine	69	0
New Hampshire	68	0
Rhode Island	54	0
Vermont	32	0
All NESCAUM sub-total	2408	0
All States Total	5807	68

[14] 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 by population to the New York sample size.

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

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

> As we move through these descriptions, null hypotheses (H_o) are stated as to how the descriptive variables may relate to respondents' valuations of PEV and FCEVs, 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 PEV and FCEVs is to test whether these statements of no effect are probabilistically false.

Socio-economics and demographics

- Overall, there are few differences between the New Jersey sample and the total sample.
  - There is a difference in the gender balance between NJ and the total sample: the NJ sample has a higher percentage of female respondents (54% vs. 52%).
  - The New Jersey sample is on average slightly older than the total sample, in particular because there are more people between the ages of 50 and 69.
  - Though the quartiles of the income distributions are similar, within the middle-income categories, the NJ sample is skewed upwards.

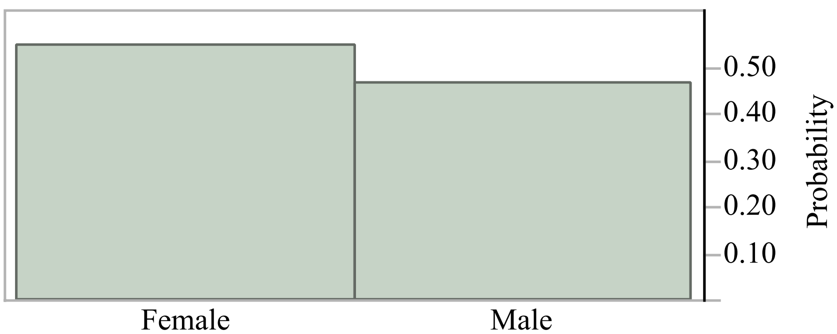
The respondents and their households are described here in terms of socio-economic and demographic variables as background to the subsequent discussion of PEV and FCEV valuation. In part, the reason for this is to understand whether and how readily available data may explain PEV and FCEV valuation, as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

The NJ respondents include a few more women than we would expect compared to the total sample (of all the participating states): 54% of the NJ respondents were female compared to 52% of the total sample (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 or HEV on the one hand or a PHEV, EV, or FCEV on the other.

The age distribution of the respondents in the NJ (Figure 2) and total samples differ slightly. The sample of new car buyers in New Jersey has fewer younger people and more people between the ages of 50 and 69 than does the total sample. (The respondent age distribution shown has been truncated to eliminate a few responses less than 19 years of age. Whether such responses were truthful, mistakes, or spoofs, the sample is intended to exclude respondents younger than 19.)

Figure 1: NJ Respondent Gender



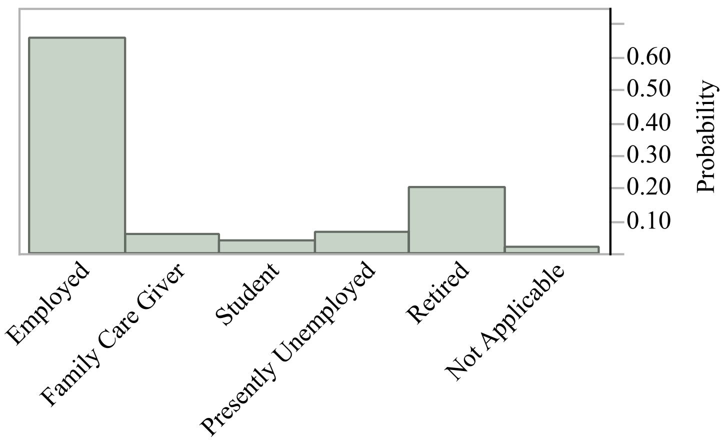
Frequencies

Level	Count	Prob
Female	266	0.54065
Male	226	0.45935
Total	492	1.00000
N Missing	3	
2 Levels		

Figure 2: NJ and Total Respondent Age

Despite the differences in the age distribution, the distribution of respondent employment status is nearly identical to that for the total sample (Figure 3); across both samples, ~65% are employed in the paid labor force and ~20% are retired. The rest are small percentages each of people who are family caregivers, students, presently unemployed, or otherwise classified as "not applicable." While 20% of individual respondents in NJ are retired, 29% of the households they represent contain at least one retired person. At the other end of the age scale, 69% of respondents report no children (persons younger than 19) in the household; those who do report children in the household are split as to whether the youngest reported member is younger than seven years old (14%) or is age seven to 18 (18%). All told, households range in size from one to eight or more members: most (91%) have one to four members (Figure 4).

Figure 3: NJ Respondent Employment Status

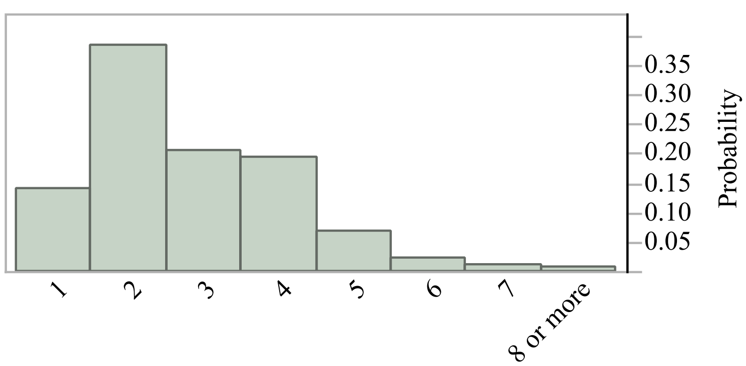


Frequencies

Level	Count	Prob
Employed	313	0.65073
Family Care Giver	26	0.05405
Student	15	0.03119
Presently Unemployed	27	0.05613
Retired	94	0.19543
Not Applicable	6	0.01247
Total	481	1.00000

N Missing 14
6 Levels

Figure 4: NJ Household Size



Frequencies

Level	Count	Prob
1	67	0.13535
2	188	0.37980
3	100	0.20202
4	94	0.18990
5	32	0.06465
6	10	0.02020
7	3	0.00606
8 or more	1	0.00202
Total	495	1.00000

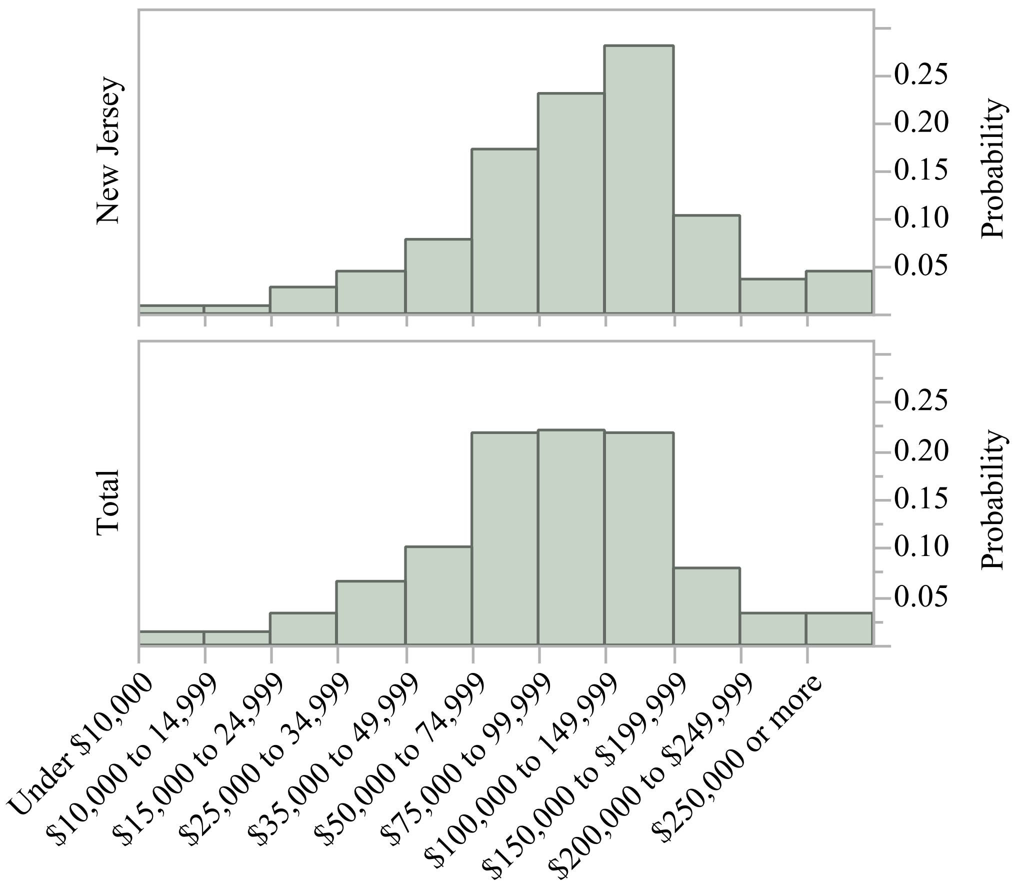
N Missing 0
8 Levels

The income distribution for the NJ sample is higher overall than the total sample and more peaked in the upper-middle incomes than the total sample (Figure 5). Despite being a sample of households who had recently purchased a new vehicle, reported annual household incomes includes

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

households in the lowest income categories (as well as the highest). The mean household income in NJ (measured as the category number, 7.14) is higher than in the total sample (6.74); the difference is statistically significant ($\alpha = 0.05$). The inter-quartile range (the 50 percent of the sample that lies between the 25th and 75th percentile) for NJ is the same as for the total sample, that is, in both samples half the households have incomes between $50,000 and $149,999. The mean in NJ is higher than for the total sample largely because more people in NJ are at or near the 75th percentile and fewer at or near the 25th.

Figure 5: NJ and Total Samples Annual Household Income



The distributions of respondents' highest education level show very little difference: the NJ sample is slightly less likely to have some graduate education but slightly more likely to have completed a graduate degree. The median educational achievement for both samples is an undergraduate degree: 36% of the NJ sample has an undergraduate degree and

H_o: Respondent education will not be correlated with likeliness to design a PEV or FCEV.

32% has some graduate level education or a graduate degree. The corresponding values for the total sample are 36% and 31%.

To the extent that the policy drivers and social benefits—and therefore respondents' valuations—of PEVs may be politicized, we asked respondents their party affiliation. Political party affiliation in NJ sample (Democratic 40%; Republican 28%, Other 5%, and None 26%) is similar to that of the total sample. However, compared to the Oct. 31 2014 and March 31 2015 New Jersey Department of State's voter registration reports, the NJ sample overstates membership in any political party. According to the official state reports, 48% of New Jersey voters are "unaffiliated," 33% are Democrats, 20% are Republicans, and less than one percent belong to all minor parties combined.[15]

Prior Awareness, Knowledge, and Valuation of PEVs and FCEVs

Several concepts are possibly related to whether respondents design a PEV or FCEV as a plausible next new vehicle for their household. Among those concepts measured in the on-line survey are:

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

Likely replacements for gasoline and diesel fuel

- Electricity wins.

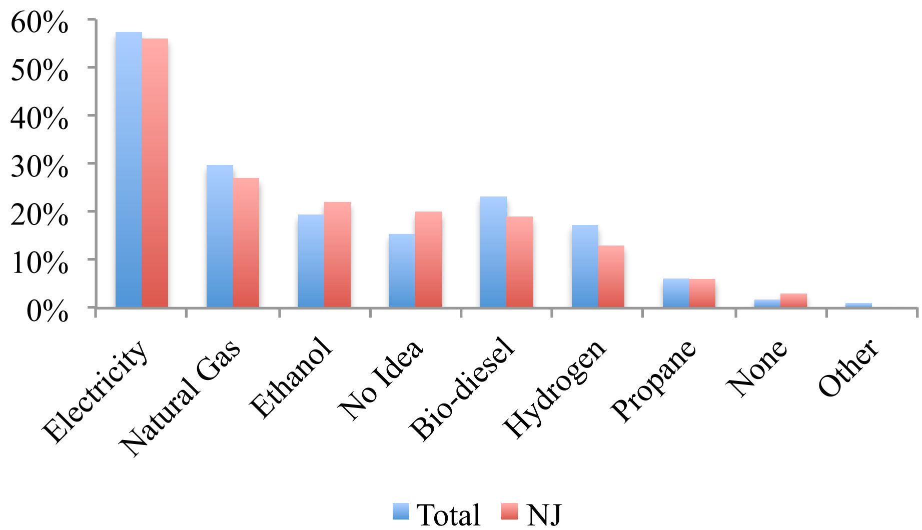
Respondents were asked, "If for any reason we could no longer use gasoline and diesel to fuel our vehicles, what do you think would likely replace them?" Respondents could choose up to three fuels from electricity, hydrogen, natural gas, ethanol, bio-diesel, propane, none, "I have no idea," and other. Response order was randomized. Most people are willing to stipulate at least one replacement, but the NJ sample is less likely than the total sample: 23% of the NJ sample answers "None" or "No idea" compared to 17% of the total sample. Electricity was selected by a similarly large majority of both samples (NJ, 56%; total, 57%) (Figure 6). The NJ sample is less likely to select hydrogen than is the total sample (13% vs. 17%).

> 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 likeliness to design a ZEV.

[15] http://www.njelections.org/2014-results/2014-1031-voter-registration-by-county.pdf
http://www.njelections.org/2015-results/2015-0331-voter-registration-by-county.pdf

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 about two-to-one when people choose up to three possible replacements for gasoline and diesel (56% electricity/27% natural gas); the advantage is more than three-to-one when a single fuel is chosen (55% electricity/17% natural gas). Hydrogen (the fuel for FCEVs) fairs poorly compared to other fuels in the NJ sample, selected by only 17% of respondents when they have up to three choices and only five percent when asked to pick the single most likely replacement.

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



The reasons NJ respondents give for why different options are the most likely to replace gasoline and diesel are explored in Table 2. Reasons that distinguish electricity from the other possible replacements are that electricity is more likely to be said to "already [have] been proven to be effective" and "[be] best for the environment." (The deviations highlighted in **bold** in Table 2 for these two reasons have large, positive, values compared to the deviations for other reasons to choose electricity.) Natural gas is favored because "it is most abundant in the United States" and "cheapest for drivers." Hydrogen is the other fuel disproportionately favored because it would be "best for the environment"

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

- The NJ sample shares a similar level of urgency with the total sample for a need to find alternatives to gasoline and diesel.
- The NJ sample is more concerned with air quality in their region than is the total sample, but are as likely to personally worry about air quality and to believe individual lifestyles make a difference.

- NJ respondents are nearly identical to the total sample in their agreement-disagreement with statements about global warming and climate change.
    - While there are those who disagree, by and large this sample believes global warming is real, is caused by humans, can be affected by changes in lifestyle, and that immediate action is required.

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

Count / Deviation[2]	Bio-Diesel	Electricity	Ethanol	Hydrogen	Natural Gas	Total
It doesn't need to be imported from foreign countries	5 0.89	32 -0.43	5 -0.28	1 -1.79	11 1.61	54
It has already proven to be effective	6 0.83	53 **12.16**	4 -2.65	1 -2.51	4 -7.83	68
It is cheapest for drivers	1 -2.65	23 -5.83	7 2.30	2 -0.48	15 **6.65**	48
It is safest for drivers	2 0.02	10 -5.61	3 0.46	3 1.66	8 3.48	26
It is the best for the environment	8 -1.51	90 **14.93**	10 -2.23	12 **5.55**	5 -16.74	125
It is the most abundant in the United States	1 -0.90	8 -7.01	1 -1.45	0 -1.29	15 **10.65**	25
It will require the least amount of change for drivers and fuel providers	5 3.33	5 -8.2	6 3.85	0 -1.14	6 2.17	22
Total	28	221	36	19	64	368

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

2. Deviations are calculated as the difference between the observed count (shown on top 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 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 (54x28)/368 = 4.11. The deviation is 5 – 4.11= 0.89. Negative deviations indicate fewer people give that reason than expected.

As environmental and energy goals are the goals for 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.

Without stipulating why it might be necessary, respondents were asked whether, "There is an urgent national need to replace gasoline and diesel for our cars and trucks with other sources of energy." On average, the New Jersey sample may feel slightly less urgency than the total sample (mean scores: NJ, 0.77; total sample, 0.84), however, the difference is not statistically significant at $\alpha = 0.05$. The median values are above zero (0.9 for NJ, 1.1 for total), indicating more than half of both samples of respondents agree—to some degree—in the national urgency to replace gasoline and diesel. Both distributions show three distinct peaks (or, modes) in the distributions: two higher peaks (both ~20% of respondents) at the mid-point and maximum agreement points on the scale and the third (less than 10%) at the point of strongest disagreement.

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

On average, the NJ sample is more likely to agree with the statement, "Air pollution is a health threat in my region" than is the total sample. The mean score on the scale of -3 (strongly disagree) to 3 (strongly agree) is 0.70 in NJ and 0.53 for the total sample; the difference is statistically significant at $\alpha = 0.05$. The median value for New Jersey (0.71) is higher than for the total sample, too (0.49), meaning half the New Jersey sample agrees more strongly with the statement than does half the total sample. However, the NJ sample is similar on average to the total sample in their agreement or disagreement with the statements, "I personally worry about air pollution," and "Air pollution can be reduced if individuals make changes in their lifestyle." Both samples are, on average, likely to modestly agree they personally worry about air pollution (means ~1.0) and to fairly strongly agree individual lifestyle affects air quality (means ~1.7). Median values and inter-quartile ranges are also similar between the two samples.

With regard to the topics of global warming and climate change, the distributions of responses for the New Jersey and total samples are nearly identical. Both the NJ and total samples are on average more likely to agree "there is solid evidence the average temperature on Earth has been getting warmer over the past several decades": NJ, mean = 1.22 and total sample =1.18 (the difference is not statistically significant at $\alpha = 0.05$). Among those who believe there is evidence for global warming, on average they believe it is caused by human action (3) rather than natural causes (-3): the mean score for NJ is1.58; total sample mean = 1.51 (the difference is not statistically significant at $\alpha = 0.05$).

The NJ and total samples have early identical distributions on three statements about the reality and urgency of climate change (Table 3). Excluding those few who think no action re: climate change is required, the majority of the NJ sample is, on average, as likely as the total sample to fairly strongly agree that climate change can be affected by changes to individual lifestyle (mean score for NJ = 1.49; total sample = 1.48).

> Ho: Neither prior belief that air quality is a regional problem nor personal worry about air quality are correlated with likeliness to design their next new vehicle as a ZEV. Neither are beliefs that climate change is real, amenable to human action, and an urgent priority.

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

	NJ	Total
Human-caused climate change has been established to be a serious problem and immediate action is necessary.	58	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.	34	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 HEVs, PHEVs, BEVs, and FCEVs is so low the reasonable assumption is most new car buyers' valuations prior to the survey were based largely on ignorance.
- BEV name recognition is not pervasive across the sample and is limited to two vehicles.
- Lack of familiarity with the distinctions between BEVs, PHEVs, and HEVs is a likely explanation for why respondents name PHEVs when asked for makes and models of BEVs.

Prior awareness and familiarity with PEVs and FCEVs (and HEVs) was measured in several ways: name recognition of HEVs, BEVs, PHEVs, and FCEVs presently sold in the US, rating whether they are "familiar enough with these types of vehicles to make a decision about whether one would be right for your household," whether they have seen electric vehicle charging locations in the parking lots and garages they use, and how much driving experience they have with HEVs, BEVs, PHEVs, and FCEVs, as well as questions about their prior (to the design games) 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 and limited to two vehicles. Asked, "Can you name an electric vehicle that is being sold in the US," 52% say "no"; 25% correctly name an EV, leaving 23% who name a vehicle, but it is not a BEV presently for sale in the US.[16] Among those who

> Ho: Prior BEV name recognition is not correlated with likeliness to design a PEV or FCEV.

[16] 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 has a PEV variant—PHEV or BEV—as a "correct" answer to the question, "Can you name an EV 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 New Jersey new car buyers able to name an "EV" for sale in the US rises from 25% to 36%.

correctly name a BEV, just two vehicles account for 93% of correct responses: Nissan Leaf (~30%) and Tesla (~62%).

The most commonly misidentified vehicle is the Chevrolet Volt: of all the people who offer the make and model of a vehicle that might have plug (whether it is a BEV or not) 27% name this PHEV. In addition to misclassifying the Chevrolet Volt, the Toyota Prius is also frequently named as a BEV (7% of makes and models of vehicles that might have plugs). However, it is not clear respondents recognize the difference between the Prius (an HEV) and the Plug-in Prius (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.

Responses to, "Are you familiar enough with these types of vehicles to make a decision about whether one would be right for your household?" were made on a scale from -3 (unfamiliar) to 3 (familiar), allowing the 0-point of the scale (I'm neither unfamiliar nor familiar) to be different from "I'm unsure." The first distinction between vehicles is the percentage of people who are either unsure or decline to answer. As shown in Table 4, only a few respondents are unsure or unwilling to rate their familiarity with ICEVs. However, the combined percentage of those who are unsure or unwilling to respond rises from HEVs, to BEVs, to PHEVs, to a maximum of two-fifths of respondents who are unsure 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 4). The differences in the mean values are all significant at $\alpha < 0.001$ (Table 5). 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 5.

H_o: There is no association between familiarity and willingness to design a PEV or FCEV.

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

	Unsure	Decline to state	Total Unsure plus Decline to state	Mean	Median	Inter-quartile range
ICEVs	3.2	1.0	4.2	2.45	2.83	2.58 to 2.90
HEV	17.2	2.4	19.6	1.27	2.16	0.00 to 2.87
BEVs	21.0	2.0	23.0	0.98	1.71	000 to 2.85
PHEVs	23.7	4.0	27.7	0.63	1.10	-0.98 to 2.81
FCEVs	34.5	5.9	40.3	-0.88	-1.62	-2.95 to 0.80

Table 5: NJ Differences in Respondents Ratings of Familiarity between ICEVs and HEVs, PHEVs, BEVs, and FCEVs, -3 = unfamiliar to 3 = familiar

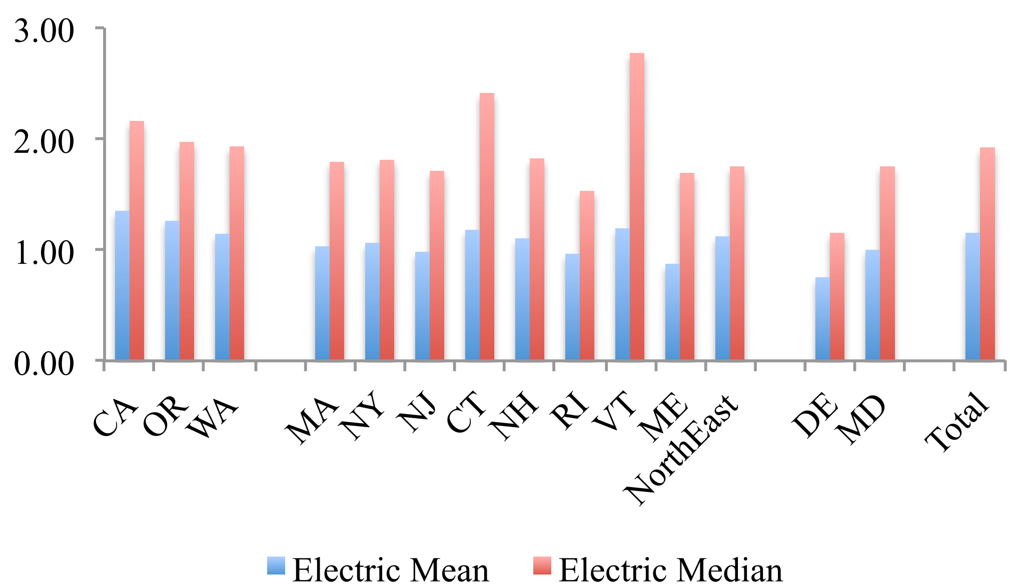
Vehicle Type	Mean[1]	Mean Difference[2]	
ICEV	2.45		—
HEV	0.95	ICEVs - HEV	1.50
BEV	0.72	ICEVs - BEVs	1.73
PHEV	0.45	ICEVs - PHEVs	2.00
FCEV	-0.74	ICEVs - FCEVs	3.19

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

2. All differences statistically significant at α<0.01.

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

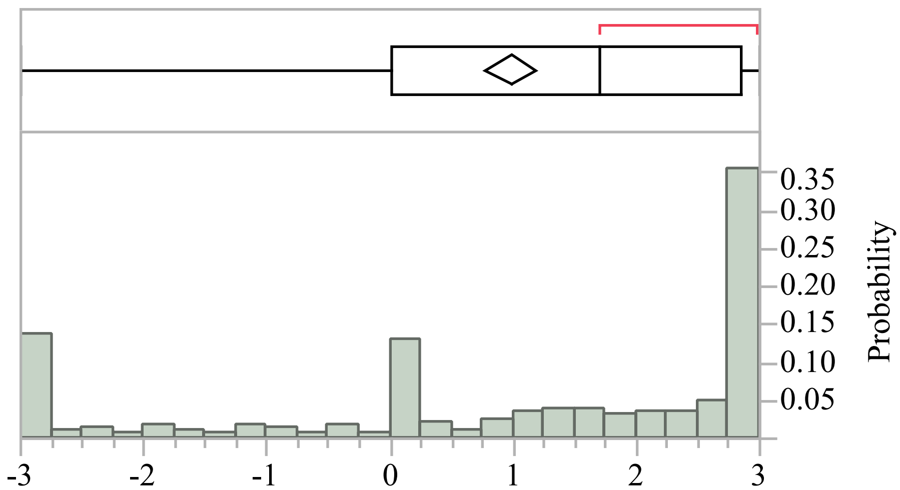
Figure 7: Self-rating of familiarity with BEVs, mean and median scores for each state and the total sample, score on scale: -3 = No; 3 = Yes



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

If respondents are "familiar enough with [these types of vehicles] to make a decision about whether one would be right for [their] household," that familiarity was not gained through actual driving experience with any PEV, 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 New Jersey respondents are all negative (HEVs. -1.90; BEVs, -2.41; PHEVs, -2.45; and FCEVs, -2.56) and the median scores for all four are lower than -2.79. In short, within the realistic accuracy of the on-screen slider used to create the scores in the survey, more than half the sample has *no* driving experience with anything other than ICEVs. This result holds for the total sample, too.

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



Prior awareness of vehicle purchase incentives

- Less than half (41%) of this sample of New Jersey new-car buyers was aware of incentives from the federal government.
- Very few respondents claim to have heard New Jersey is offering incentives—despite the sales and use tax incentive, as well as (admittedly limited) HOV and toll road incentives.

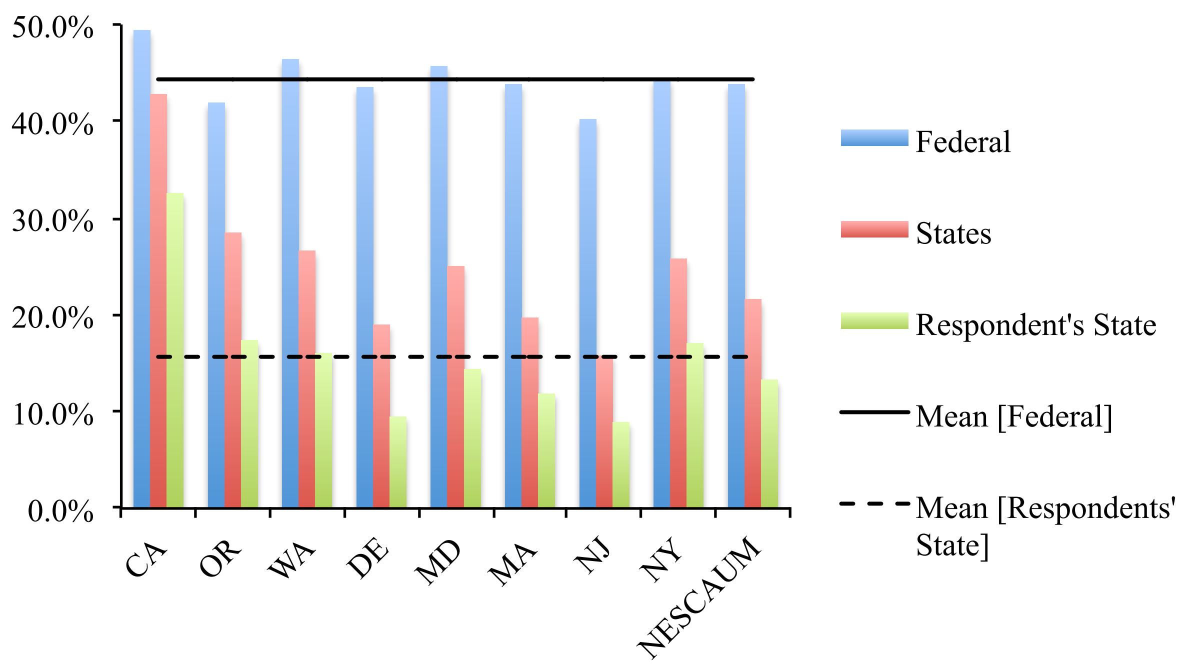
A buyer of any qualifying PEV anywhere in the country is eligible for a federal tax credit.

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

The federal tax credit is $7,500 for all BEVs presently for sale in the US; the credit for PHEVs ranges from $2,500 to $7,500 depending on the size of the traction battery. The availability of other incentives varies by state as well as by overlapping city, county, and power utility jurisdictions. The variety of these incentives include exemption from state sales tax or vehicle licensing and registration fees, rebates, single occupant vehicle access to high-occupancy vehicle lanes, and reductions or exemptions from road or bridge tolls. New Jersey offers relief from sales and use tax on the vehicle purchase, reduced tolls on the New Jersey Turnpike and Garden State Parkway, and single occupant vehicle access to the HOV lane on the Turnpike.

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?" If a respondent replies, "Yes," for states, cities, or electric utilities, a follow-up question asked about "my state," "my city," or "my electric utility. The question is a weak test: a "yes" response may be prompted by an impression of incentives for any alternative fuel. 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 PHEVs, BEVs, and FCEVs. Further, the variation in incentives across states and localities means that stating one is aware of incentives from a particular entity is not the same as being right or wrong for all respondent-entity combinations—except for the universally available federal incentive. Data from all participating states regarding awareness of federal and state incentives are shown in the Figure 9.

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



Fewer NJ respondents (40%) were aware of federal incentives the average across all states (44%). Belief that respondents' home states are offering such incentives is much lower. In NJ, barely 9% believe they have heard their state is offering incentives. This low level of claimed awareness is despite the sales and use tax exemption for PHEVs and BEVs, the longstanding (but geographically limited) single-occupant vehicle HOV access privilege and (more widespread) road toll reductions. Belief that other entities, e.g., cities, utilities, and vehicle manufacturers, are offering incentives are comparable to, or lower than, the percentages for respondents' own state.

H_o: Those who are already aware of incentives will not be more likely to design a PEV or FCEV.

Prior awareness of PEV charging infrastructure

- PEV charging infrastructure may be the most oft recognized sign of PEVs in those states that have active programs to deploy workplace and/or public charging. In this regard, the NJ sample has among the lowest percentage of respondents claiming to have seen EVSEs: 27%.

The deployment of PEV charging infrastructure at workplaces (where such charging may or may not be open and available to non-employees), retail locations, and public parking garages, lots, and spots is intended to provide charging services to PEV drivers and to provide a visible symbol to all drivers of PEVs. The question is are drivers of non-PEVs noticing? Respondents were asked, "Have you seen any electric vehicle charging spots in the parking garages and lots you use?" Data for all participating states (plus the average value of the Total sample) are shown in the Figure 10: 27% percent of the New Jersey sample say they have seen a PEV charger in the places they park—well below the total sample percentage (52%).

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

Household Vehicles

- Though the number and age of vehicles owned by the NJ sample are similar the total sample, the NJ sample is slightly more likely to own more and newer vehicles.
- This sample from New Jersey is much more likely to have leased vehicles than is the total sample.
- On average, these NJ new car buyers paid the same amount for their most recently acquired new vehicle as the total sample.

The sample is intended to represent households who have purchased a new vehicle within the previous seven years, i.e., since January 2008. The survey instrument collects data on the most recently acquired new vehicle plus the other vehicle in the household (when there is more than one vehicle) that is driven most often. ("Vehicles" are defined in the questionnaire to be "…cars, trucks, vans, minivans, or sport utility vehicles, but…not…motorcycles, recreational vehicles, or motor homes.) Given they must own at least one vehicle to be in the study, 34% of the NJ sample owns one and 66% owns two or more.

Ho: Households with two or more vehicles are not more likely to design their next new vehicle to be a PEV or FCEV.

The distribution of number of vehicles owned (Figure 11) appears similar to the total sample, however the NJ sample was slightly more likely to own three (13%) or four or more vehicles (7%) than was the total sample (11% and 4%). The NJ sample was also more likely to have acquired more than two new vehicles since 2008 than was the total sample. The age distribution of these recently acquired vehicles—measured by the model year or year acquired—also indicates the most recently acquired new vehicle is on average newer in the New Jersey sample than in the total sample; nearly 69% of the most recently acquired new cars in New Jersey were model year 2013 or newer compared to 61% in the total sample.

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

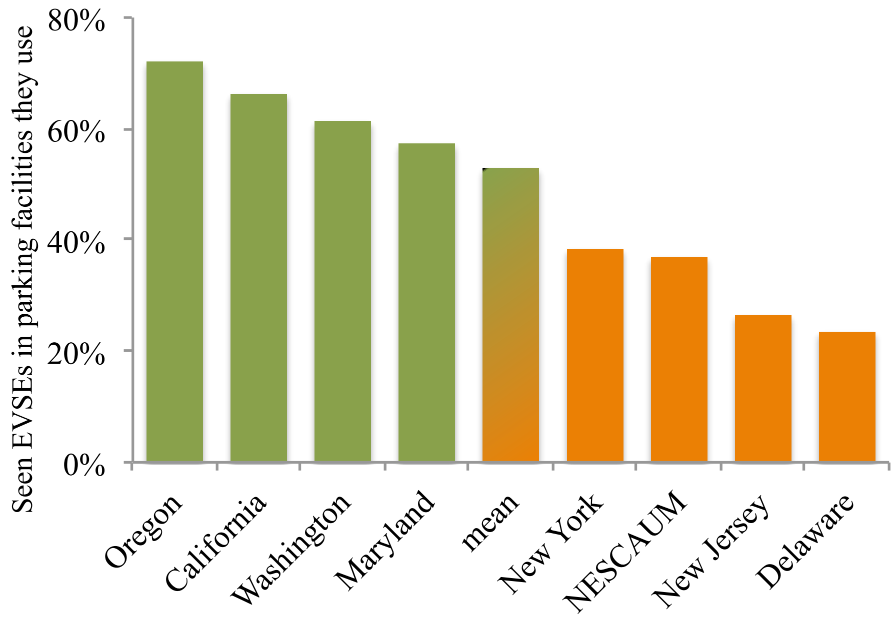
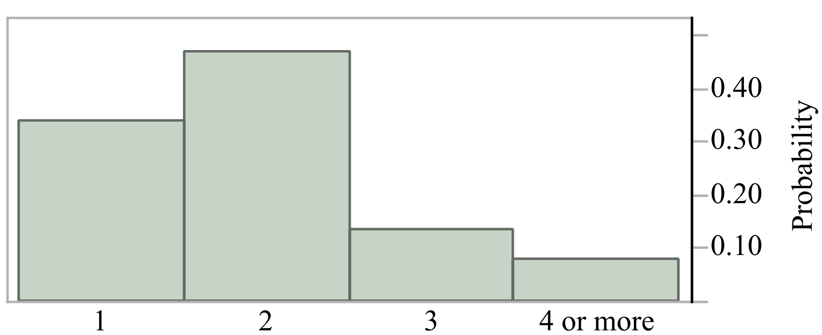


Figure 11: NJ Number of Vehicles per household



Frequencies

Level	Count	Prob
1	166	0.33535
2	229	0.46263
3	64	0.12929
4 or more	36	0.07273
Total	495	1.00000
N Missing	0	

4 Levels

According to data from California's Clean Vehicle Rebate Program, a higher percentage of early PEV acquisitions have been by lease rather than purchase compared to all vehicle acquisitions 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 New Jersey were leased than in the total sample. In the NJ sample, 22% of the most recently acquired new car, 14% of the other household vehicle driven most often, and 26% of either these vehicles were leased. The corresponding figures for the total sample are only 14%, 9%, and 17%.

> H_o: Respondents with prior experience leasing vehicles will not be more likely to design a PEV or FCEV.

On average, the NJ sample paid a similar amount for their most recently acquired new vehicles as the total sample. The median reported "total price including options, fees, and taxes" for the most recently acquired vehicle was ~$26,000 in both the NJ and total samples. The mean price in NJ ($28,630) is not significantly different than the mean price for total sample ($28,550). While we might expect people who spend more on new cars to be more likely (or at least more able) to buy PEVs during this initial market phase, this expectation is mediated by other factors. Spending on new cars is plausibly correlated with household income, but 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. The vast majority of these most recently acquired vehicles (98% in NJ and 96% in the total sample) are fueled by gasoline.

> H_o: Past prices of new vehicle purchases will not be positively 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.

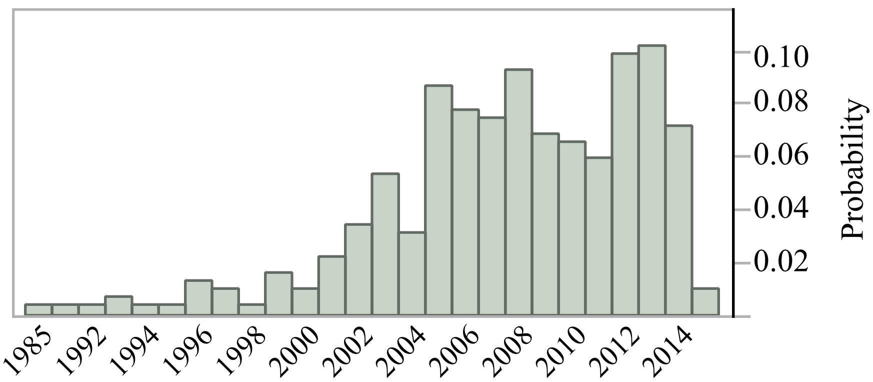
For respondents with more than one vehicle, the second vehicle for which information was collected had only to be the next most frequently driven vehicle—no stipulation was made as to age or whether it was acquired as a new or used vehicle. Thus, these vehicles show a greater age range: the data for the NJ sample are shown in Figure 12. Despite the long tail toward older years (note the x-axis is not linear for years older than 1992), 93% of these "second" vehicles are model year 2001 or newer for the NJ sample and 90% for the total 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 NJ as in the total sample.

Features of their residences that might affect PEV and FCEV valuation

- Countervailing differences between the New Jersey and total samples make it difficult to generalize whether the New Jersey sample is more or less likely to be able to charge a PEV or fuel an FCEV at home.
    - The New Jersey sample may be more likely to be able to fuel a PEV or FCEV at home because they are more likely to own their residence and more likely to reside in a single family home—and thus slightly more likely to live in a single family home they own.

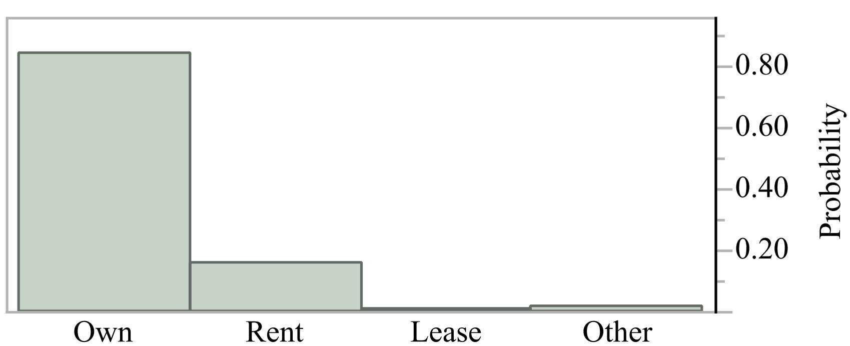
- However, the New Jersey sample is less likely to be able to park a vehicle in garage or carport attached to their residence and less likely to have any electrical service at the location they park at their residence.

Figure 12: NJ Model Year of Other Frequently Driven Household Vehicle



Turning from the household members and their vehicles to features of their residences that may make the respondent households more or less able to charge a PEV or fuel an FCEV at home, most of the NJ sample (83%) report they own their home while 15% rent (Figure 13). These percentages are skewed toward homeownership to the total sample (77% ownership/21% rental). Seventy-five percent of NJ respondents report their residence is a single-family home, 13% live in an apartment building, and 11% in a townhouse or multiplex; these figure are close to the total sample (72%, 16%, and 12%). In short, compared to the total sample the New Jersey sample is more likely to own their residence, but distribution of the types of buildings in which they reside is similar.

Figure 13: NJ Own or rent residence, percent



Frequencies

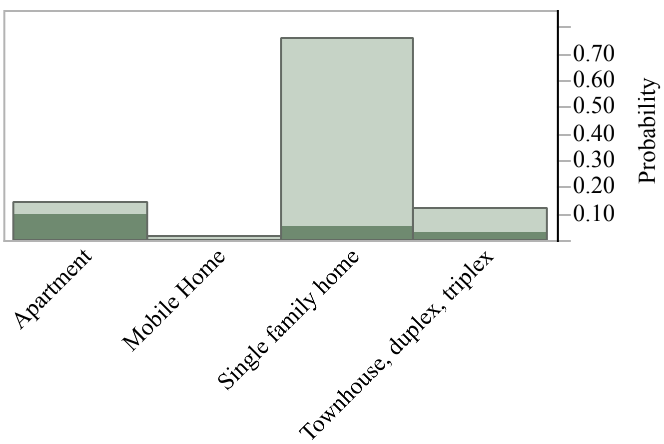
Level	Count	Prob
Own	412	0.83232
Rent	76	0.15354
Lease	1	0.00202
Other	6	0.01212
Total	495	1.00000

N Missing 0
4 Levels

Despite a higher percentage of home ownership, the New Jersey sample may be less able to charge a vehicle at home because they are less likely to have electricity at the home parking location and less likely to park in a garage or carport attached to their residence. Slightly more NJ respondents report they have no access to electricity at the location they park their vehicles at home (27%) than the total sample (24%). It is also the case that a similar percentage of the NJ sample (34%) would require permission from someone else to install electricity at his or her home parking location as for the total sample (32%). The big difference between the NJ sample and the total sample is whether the household can park a vehicle in a garage or carport attached to its residence: only 44% of the NJ sample says they can compared to 56% of the total sample.

In the Figure 14, respondents who rent their residence are highlighted in a darker shade: most apartments are rented but only a small share of townhouses, duplexes, and triplexes are rented. Multi-unit dwellings have been problematic for PEVs, as residents of such buildings may not have access to a regular, reserved parking spot and may be reluctant—or may lack authority—to install electrical infrastructure to charge a PEV.

Figure 14: NJ Type of Residence, percent



Frequencies

Level	Count	Prob
Apartment	65	0.13131
Mobile Home	4	0.00808
Single family home	371	0.74949
Townhouse, duplex, triplex	55	0.11111
Total	495	1.00000

N Missing 0
4 Levels

Among those who rent their residence in NJ, 75% indicate they could *not* make such an installation on their own authority; only 26% of those who own their residence could not do so. The group of people who own a single-family home is somewhat higher than in the total sample: 69% of NJ respondents reside in a single-family residence they own compared to 65% of the total sample. The percentage of NJ respondents and the total sample that report they have solar panels installed at their residence are similar: 11% NJ; 13% total. Finally in NJ, 78% report having natural gas in their residence, much higher than the total sample (63%).[17]

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

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

RESULTS: RESPONDENTS' VEHICLE DESIGNS

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

PEV and FCEV valuation is determined in the final design game that most corresponds to the present reality—there are no vehicles offered with battery-powered, all-electric drive and full-size body styles however there are federal, state, and local incentives offered for PHEVs, BEVs, and FCEVs. The vehicle designs that are disallowed by the body size restriction are PHEVs that run solely on electricity until their batteries are depleted (at which point they switch to run as do present day HEVs) and BEVs; PHEVs that run on both gasoline and electricity until the battery is depleted and FCEVs are allowed as full-size vehicles in the design games.

Ignoring for now differences between vehicles within each drivetrain type, e.g., ignoring differences in driving range within drivetrain types, not quite one-of-four respondents design their next new vehicle to be a PHEV (14.2%), BEV (6.1%), or FCEV (3.4%) (Figure 15). As they are important for many transportation energy goals related to ZEVs, note HEVs (37.7%) are nearly as common as ICEVs (38.7%)—far out-distancing the prevalence of HEVs in the actual on-road fleet of vehicles and in new vehicle sales. As illustrated in Figure 15, the distribution of drivetrain types created by the NJ sample differs from that of the total sample: broadly speaking, the NJ sample is less likely to design their next new vehicle to be a PEV or FCEV. The differences between the distributions are statistically significant at $\alpha = 0.001$.

The overall smaller sample size for NJ warrants caution; the small numbers of people who design specific types of PEVs and FCEVs might better be regarded as case studies highlighting values and meanings rather than population studies that generalize to a population.

Characteristics of Respondents' PEV and FCEV Designs

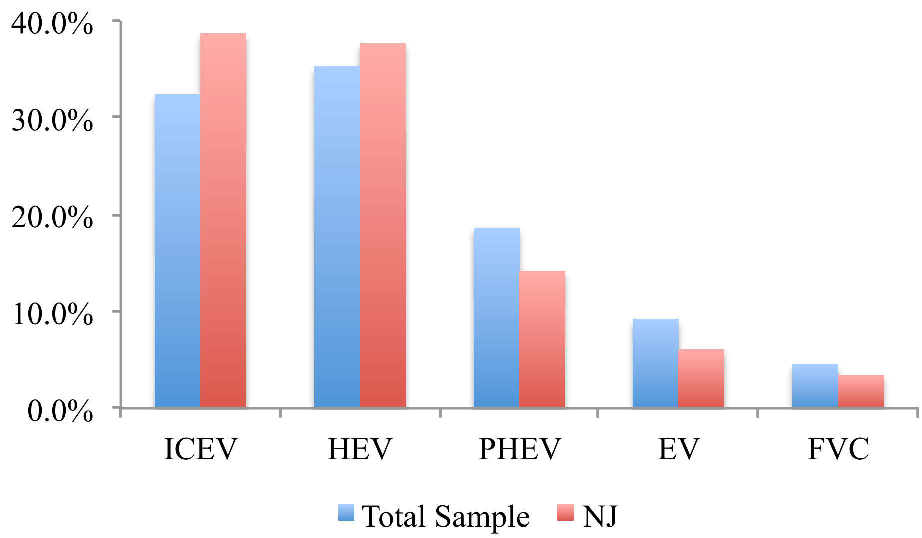
As described earlier, respondents could change various aspects of PEV and FCEV drivetrains: driving range, charging speed both at home and away-from-home, and whether or not an FCEV could be refueled at home. The distributions of these designs are described here. As in the previous section, this discussion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

In the design games as in the real world, 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 operate (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.[18] 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

[18] BMW's i3 with Range Extender is an example of this type.

charge-depleting operation.[19] For both types of PHEVs, when the high-voltage battery (where electricity from the grid is stored) reaches some minimum state-of-charge (SOC) specified by the vehicle designers, the vehicle reverts to charge-sustaining operation. The gasoline engine provides the energy (in all-electric PHEVs) or the energy and most of the power (in assist PHEVs) for the vehicle. A PHEV returns from charge-sustaining to charge-depleting operation, only after the vehicle is plugged in to recharge the high-voltage battery.

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



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

PHEV Designs

- PHEV designs were by far the most popular. As shown in Figure 15, 70 respondents designed a PHEV compared to 30 BEVs and 17 FCEVs.
- PHEV designs emphasized longer range driving on electricity, but in a mode in which gasoline is used too, i.e., more "assist PHEV" designs rather than all-electric PHEV designs.
- Faster charging at home or at an (initially limited) network of quick chargers is not viewed as necessary by most who design a PHEV
    - Only 22% of those who design a PHEV indicate they want the fastest charging offered at home; only 34% incorporate quick-charging capability (away-from-home).

[19] Toyota's Plug-in Prius is an example of this type.

The following figures illustrate the distributions of PHEV designs by charge-depleting modes, charge-depleting driving range, and home charging speed. The dark-shaded region in Figures 16 to 18 highlights those respondents whose PHEV design include all-electric charge-depleting mode. Most (81%) of the NJ sample designed a PHEV that operates in Assist mode, i.e., uses both gasoline and electricity during charge-depleting operation (Figure 16).[20]

A slight majority (53%) of the NJ sample designed a PHEV with the maximum offered charge-depleting range, 80 miles (Figure 17). Eighty miles is approximately twice the charge-depleting range of the 2014 Chevrolet Volt, though it approximates that offered by BMW's i3 with Range Extender. At the low end, a range of 10 miles (incorporated into one NJ respondent's PHEV design) approximates that of the 2014 Plug-in Prius.

Figure 16: NJ PHEV Charge-depleting operation, n =70

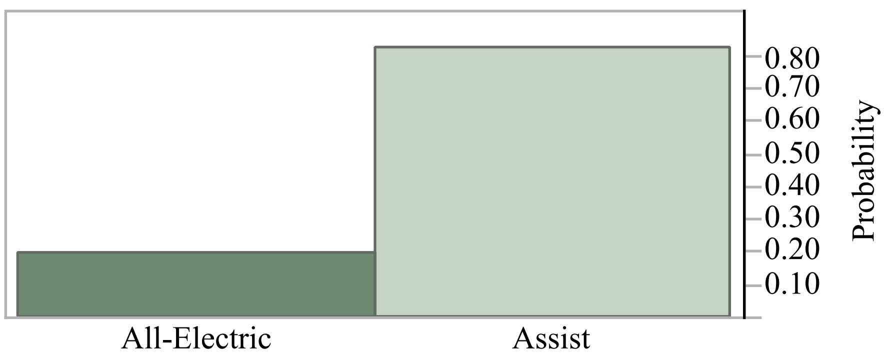
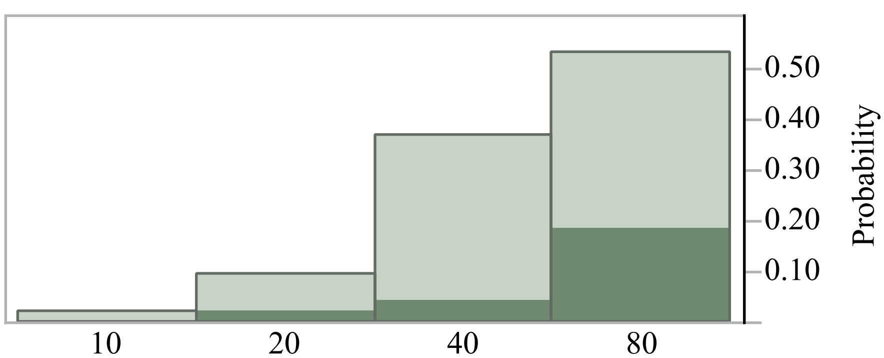


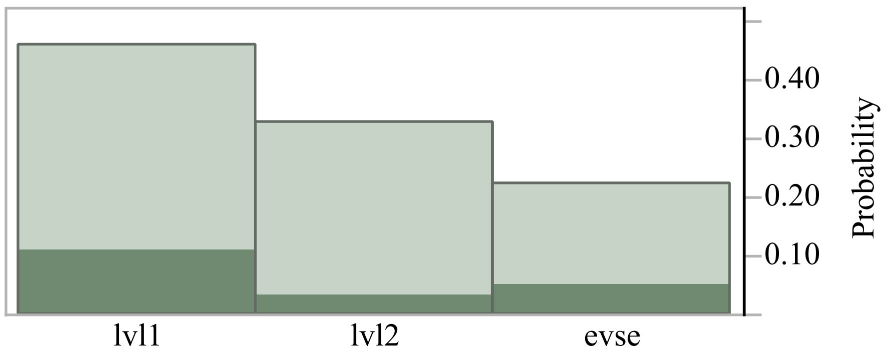
Figure 17: PHEV Charge-depleting driving range (miles) by all-electric vs. assist mode



[20] 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 distinctions between these three drivetrains.

In Figure 18, home charging speeds are denoted by lvl1, lvl2, and EVSE. These are shorthand for the charging speed offered by a typical home 110-volt outlet (lvl1 ≈ 1.1kW), a higher power 220-volt outlet (lvl2 ≈ 6.6kW), or a higher power, specialty appliance for charging PEVs (EVSE ≈ 9.9kW): faster charging costs more in the design games. A plurality (46%) 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, only one-in-five (22%) believe they would want the fastest home charging.[21]

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 to charge the vehicle from 20% to 80% charged. 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, 24 of the 70 (34%) respondents who designed a PHEV added the quick charge option to their vehicle design. There is not a statistically significant difference in the speed of home charging by assist vs. all-electric operation, but there may be a greater likeliness that those who design PHEVs with all-electric operation will include quick charging capability (recalling quick charging only occurs away from home). So few people design PHEVs with electric ranges of 10

[21] All charging 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.

or 20 miles that the statistical tests are suspect, but a visual examination of the pattern of designs shows that clear positive correlation between range and home charging speed: longer ranges tend to be matched to faster charging.

BEV Designs

- So few respondents design BEVs (n = 30) that the following descriptions cannot be regarded as generalizable, but as case studies.
- BEV designs incorporate driving ranges from across the spectrum of offered options, i.e., 50 to 300 miles.
    - A bit more than a third (37%) design BEVs with ranges of 125 miles or less;
    - The balance of designs mostly incorporates the maximum proffered range of 300 miles.
- While the single most frequently selected charging speed would require the installation of a high-power EVSE (45%), most households (55%) believe they would be satisfied with a charging speed that could be supplied by existing household 110V or 220V electrical service.

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

Figure 19: NJ Distribution of BEV Range by whether quick charging capability was included, n = 30

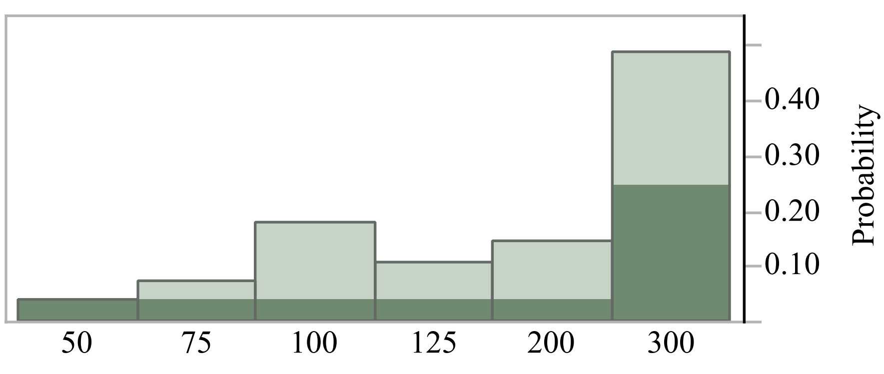
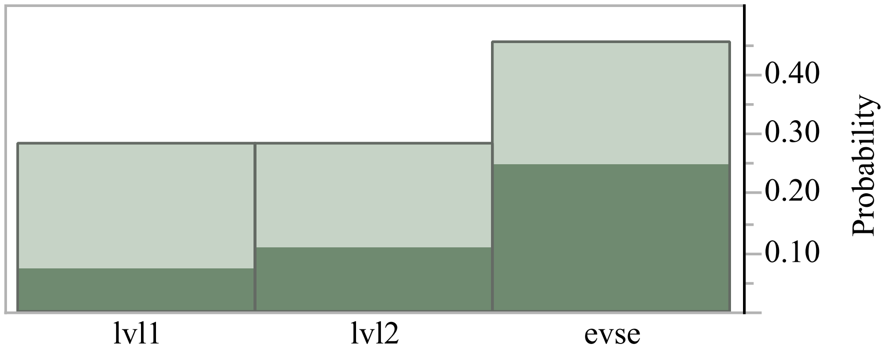


Figure 20: NJ BEV Home Charging Duration by quick charging capability was included



A bit more than one-third the BEV designs incorporate ranges that are available in many BEVs presently for sale, that is, less than or equal to 125 miles. Those who design BEVs with longer ranges are more likely to include both the fastest possible home charging and quick charging capability than are those who design shorter range vehicles. Those who select the fastest home charging are more likely to include quick charging capability.

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

FCEV Designs

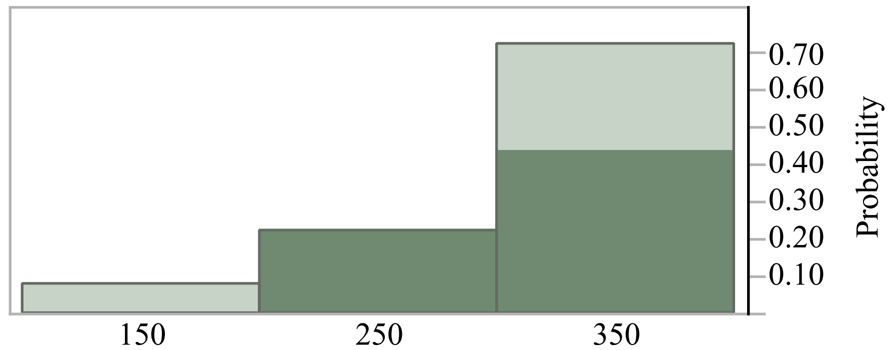
- So few respondents design FCEVs (n = 17) that the following descriptions are case studies.
- Range includes all three possible options (150, 250, and 350 miles), but by far the highest percentage opts for the longest range.
- Home H_2 refueling was included in most (82%) of FCEV designs.

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: NJ Distribution of FCEV driving range by home H_2 fueling, n = 17



RESULTS: RESPONDENT VALUATION OF PHEVS, BEVS, 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 section Results: Who are the new car buyers in the New Jersey sample? The set of possible explanatory variables and their correlations with drivetrain type is summarized in Appendix A. For each potential explanatory variable in Appendix A, an alternate hypothesis is stated. These hypotheses are alternates to the standard null hypothesis (H_o) such as those stated previously. 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 Appendix A. The threshold for statistical tests of significance to reject the null hypothesis of no effect is set to $\alpha = 0.05$. The acceptance or rejection of any null or alternative hypothesis in Appendix A is only in regards to the bivariate relationship between each explanatory variable—taken one at a time—and the dependent variable, that is, drivetrain design in the third design game. The results in Appendix A guide the construction of the more complex model reported next.

Choosing explanatory variables

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

Further, several questions about a single topic may plausibly be reduced to a smaller number of dimensions. For example, we ask seven questions about respondents’ prior evaluation of PEVs: ability to charge one at home, the extent of the away-from-home charging network, time to charge a PEV, 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.

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 rather to construct a model that allows for tests of important concepts rather than rote adherence to traditions in statistics.

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 PEV or FCEV?

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

- Respondent (and their household) Socio-economic and Demographics
    - None
- Household travel, characteristics of residence, vehicles, and travel
    - Whether respondent commutes to work in a household vehicle
    - Familiarity with ICEVs
- Attitudes related to ZEV policies and policy goals: energy security, air quality, and global warming
    - Whether heard of federal incentives
    - Whether governments should offer consumers incentives for electricity and hydrogen
- Prior PEV and FCEV evaluation and ZEV-specific attitudes
    - Prior belief whether hydrogen is a likely replacement for gasoline and diesel
    - Personal interest in ZEV technology
    - Driving experience in PHEVs
    - Seen public charging for PEVs
    - Assessment of the relative safety and reliability of PEVs and ICEVs
    - Whether has already considered buying a PEV

Overall, this sample of new car buyers in New Jersey appear most influenced by more direct knowledge, experience, and consideration of vehicles in general and PHEVs, BEVs, and FCEVs in particular than they are by contextual factors (such as whether they can charge a PEV at their residence), attitudes toward the policy goals of ZEVs, or socio-economic and demographic descriptors. These effects of these variables on respondents' drivetrain types in the final design game are elaborated below.

Household travel, characteristics of residence, vehicles, and travel

Whether respondent commutes to work in a household vehicle

Respondents who commute to work in a household vehicle are slightly more likely to design a PEV or FCEV than those who do not.

Familiarity with ICEVs

Respondents are asked to rate whether or not they are familiar with each of the major drivetrain types they will see in the design game: gasoline (ICEVs), BEVs, HEVs, PHEVs, and FCEVs. The specific statement for each vehicle type is, "Are you familiar enough with these types of vehicles to make a decision about whether one would be right for your household?" Their answers are on a scale from strongly no (-3) to strongly yes (3). A factor analysis revealed these five items could be reduced to three: one for HEVs and PEVs, one for FCEVs and a third for ICEVs. Only the factor for ICEVs enters the final model of respondents' drivetrain designs as a statistically significant explanatory variable. Respondents who rate themselves higher on a scale defined as "familiar enough to make a decision for my family," with respect to conventional vehicles are more likely to design an HEV than an ICEV; there is relatively little effect on the probabilities of designing PEVs or FCEVs.

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

Have they heard the federal government is offering incentives

Whether respondents claim to have heard the federal government is offering incentives for alternatives to gasoline and diesel has little effect on the probability of designing such alternatives. Rather, most of the difference between those who have heard and those who have not is in the likeliness of designing an HEV: those who have heard have an increased likeliness of designing an HEV compared to those who have not.

Should governments offer incentives

The effect of agreement or disagreement with governments offering incentives is complicated by the possibility respondents may support incentives for only electricity, only hydrogen, or for both. Those who believe it is appropriate for government to offer incentives for only electricity or both electricity and hydrogen are more likely to design PEVs. Those how support incentives only for hydrogen are the least likely to design PEVs—less likely even than those who oppose all incentives.

Prior PEV and FCEV evaluation and ZEV-specific attitudes

Six variables related to prior, that is, prior to completing the design games in the survey, consideration of PHEVs, BEVs, and FCEVs are correlated to drivetrain types in the final game.

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 are estimated to be more likely to design their next new vehicle as a PHEV or FCEV.

Prior PEV Factor 2: a combined assessment as to the relative reliability and safety of PEVs compared to gasoline vehicles

Respondents were asked to rate their agreement/disagreement with seven statements 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 are on a scale from strongly disagree (-3) to strongly agree (3). A factor analysis determined these seven could be reduced to three factors largely identified with these concepts:

1. Prior PEV Factor 1: charging time and driving range
2. Prior PEV Factor 2: safety and reliability
3. Prior PEV Factor 3: charging PEVs, home and away

Note that the original question related to PEV purchase price does not load onto any of these three factors.

Ultimately, only the second factor associated with respondents' prior conception of PEVs safety and reliability compared to conventional ICEVs enters the final model of respondents' drivetrain designs as a statistically significant explanatory variable. The more strongly respondents believe PEVs are safer and more reliable than ICEVs, the more likely they are to design PHEVs and BEVs.

Personal interest in ZEV technology

Higher levels of personal interest in ZEV technology—as measured on a four-point scale from not interested to very interested—are correlated with higher likeliness of designing a PHEV, BEV or FCEV.

Driving experience: PHEVs

Respondents are asked to rate their driving experience with HEVs, PHEVs, BEVs, and FCEVs on a scale from -3 (none at all) to 3 (extensive). A factor analysis reduces this to two factors. Only driving experience with PHEVs loads on one factor and only driving experience with BEVs on the other. Of these two, only the factor identified with PHEV driving experience enters into the model. Greater levels of PHEV driving experience are associated with a higher likeliness of designing a PHEV.

Seeing PEV charging infrastructure

Respondents were asked, "Have you seen any electric vehicle charging spots in the parking garages and lots you use?" While originally asked on a scale including how many places they had seen such charging spots, the answers were reduced to simply yes or no before the variable was used for modeling. Those how have seen PEV charging in the parking facilities they use are more likely to design an HEV than an ICEV; the effect on PEVs and FCEVs is small.

Whether they have already considered buying a PEV

The original variable offered six answers along a scale from people who have not and would not consider a PEV to people who already own a vehicle that is powered by electricity. The top three categories of engagement with PEVs (have searched for information on PEVs, have shopped for a PEV including a visit to a dealership for a test drive, and already own a PEV) are collapsed into a single category because of the relatively few number of people in those categories.

Those who have already considered PEVs (information search, test drive, or ownership) are estimated to be more likely than those who have not to design their next new vehicle to be a PHEV or BEV.

Overall model performance

A summary view of how well the model performs is provided in Table 6 where the actual drivetrain design (created by each of the 494 respondents used to estimate the model) is cross-classified by the drivetrain "predicted" by the model. The model predictions are created by estimating a probability that each respondent creates a vehicle with each of the five possible drivetrains, then assigns the drivetrain with the highest probability as the predicted drivetrain.

Table 6: Actual and predicted drivetrain designs

Actual Game Design	**Predicted Design**					
No trucks, plus incentives: drivetrain design	**Gas**	**HEV**	**PHEV**	**BEV**	**FCEV**	**Actual Game Total**
Gas	139	44	4	1	3	191
HEV	59	111	12	2	2	186
PHEV	15	33	22	0	0	70
BEV	3	21	4	1	1	30
FCEV	2	10	1	0	4	17
Predicted Total	218	219	43	4	10	494

The model does a poor job predicting who will design PHEVs, BEVs, or FCEVs (underestimating all three types). Of 70 respondents who actually designed a PHEV (the sum of the PHEV row), the model correctly assigns a PHEV design to a bit less than a third (22) while misestimating another 21 people design a PHEV (for total of 43 predicted PHEVs). The model does a poor job distinguishing who designs a BEV (1 of 30) or an FCEV (4 of 19). The question of why the model doesn't do a better job of predicting PEV and FCEV designs and how the model (of the game results) informs decisions for the real world will be taken up in the Discussion section.

Table 7a summarizes the values of the explanatory variables used for a baseline 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 discrete values, the value used for baseline estimates are the minimum values. Since the baseline is selected by the algorithm using no information about the substantively interesting or important values or 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 7a Values of explanatory variables for baseline estimation of the probability distribution of drivetrain designs

Values of explanatory variables for baseline estimation
Respondent commutes to work in household vehicle: *No*
Familiarity with ICEVs: *~0.00*
Heard of federal incentives: *No*
Should governments offer incentives: *Not sure*
Prior belief hydrogen is a replacement: *No*
Prior PEV Factor 2: safety-reliability: *~0.00*
Prior interest in ZEV technology: *Not at all*
Driving experience PHEVs: *~0.00*
Seen PEV charging infrastructure: *No*
Prior Consideration of a PEV: *No*

The baseline probability estimates are shown at the top of Table 7b, 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 with the combination of values described by that row.[22] Next, the probabilities of each drivetrain type are estimated based on the most common and median values of the explanatory variables. This should not be mistaken for being a profile of an overall "common" respondent. Selecting only people who offer the most common response to all seven of the

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

categorical variables (Commutes, Heard of federal incentives, Should Governments offer incentives, Prior belief hydrogen is a replacement, Prior interest in ZEV technology, Seen PEV charging infrastructure, and Prior Consideration of a PEV) produces only eight respondents out of 494. In general, the likeliness of any particular outcome (probability of drivetrain design) for any profile of values should not be mistaken for an overall likeliness; those are shown in Table 6. Finally, there are 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. Note the predicted designs in Table 6 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 7b, it is clear that the conventional ICEV would be the predicted design. Note that for the example profile of a BEV and for the profile of modal and median values, the predicted designs are a BEV and ICEV even though neither has more than a 50% probability. Nevertheless, they have the highest probability for their combination of values of explanatory variables, and are thus the predicted design.

The base probability estimate produces a very high probability a conventional ICEV is designed. The profile describes a person who would not consider a PEV for their household, isn't interested in ZEV technology, has neither heard about nor supports incentives, doesn't think hydrogen is a likely replacement for gasoline and diesel, is generally familiar with vehicles—conventional or otherwise—and thinks PEVs might be about as safe and reliable as ICEVs.

The models indicates that if there is another new car buyer in New Jersey who is very different from the person just described in three key ways, this person is most likely to have designed a BEV. This person must have a strong personal interest in ZEV technology, have already expressed such an interest at least in the form of a search for information about PEVs and FCEVs, and must have heard the federal government is offering incentives to consumers to buy vehicles powered by alternatives to gasoline and diesel. Such a person is estimated to be most likely—not overwhelmingly likely, but most likely—to have designed a BEV.

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

Drivetrain type:		ICEV	HEV	PHEV	BEV	FCEV
Base probability estimates, %		**80.9**	17.3	1.2	0.3	0.3
	New Value	**Resulting Probabilities, %**				
Example profile that produces a predicted BEV design,		5.3	31.3	8.4	**49.6**	5.4
Change these three from their base values, leave all others at their base values:						
Prior consider PEV:	*Info search/test drive/own*					
Personal interest in ZEV technology:	*Very interested*					
Heard of federal incentives:	*Yes*					

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

Drivetrain type:		ICEV	HEV	PHEV	BEV	FCEV
Base probability estimates, %		**80.9**	17.3	1.2	0.3	0.3
Modal and Median responses to explanatory variables						
Full profile of explanatory variable values		**49.5**	33.7	15.5	0.1	0.1
Respondent commutes to work in household vehicle:	*Yes*					
Familiarity with ICEVs:	*~0.00*					
Heard of federal incentives:	*Not sure*					
Should governments offer incentives:	*Yes, both electricity and hydrogen*					
Prior belief hydrogen is a replacement:	*No*					
Prior PEV Factor 2: safety-reliability:*)*	*~0.00*					
Prior interest in ZEV technology:	*A little interested*					
Driving experience factor PHEVs:	*~0.00*					
Seen PEV charging infrastructure:	*No*					
Prior Consideration of a PEV:	*Not considered, may some day*					
Maximum likeliness of designing a BEV		2.1	3.6	0.0	**85.6**	8.6
Respondent commutes to work in household vehicle:	*No*					
Familiarity with ICEVs:	*-2.8 (least familiar)*					
Heard of federal incentives:	*Yes*					
Should governments offer incentives:	*Yes, but only hydrogen*					
Prior belief hydrogen is a replacement:	*No*					
Prior PEV Factor 2: safety-reliability:*)*	*-2.3 (PEVs safer, more reliable*					
Prior interest in ZEV technology:	*Very interested*					
Driving experience factor PHEVs:	*~5.1 (extensive experience)*					
Seen PEV charging infrastructure:	*Yes*					
Prior Consideration of a PEV:	*Info search/test*					

Table 7b Probability distribution of drivetrain designs for profiles of values of the explanatory variables						
Drivetrain type:		ICEV	HEV	PHEV	BEV	FCEV
Base probability estimates, %		**80.9**	17.3	1.2	0.3	0.3
	drive/own					
Maximum likeliness of designing an PHEV		0.4	0.5	**97.5**	0.1	1.4
Respondent commutes to work in household vehicle:	*Yes*					
Familiarity with ICEVs:	*-2.3 (very low familiarity)*					
Heard of federal incentives:	*Not sure*					
Should governments offer incentives:	*Yes, but only electricity*					
Prior belief hydrogen is a replacement:	*No*					
Prior PEV Factor 2: safety-reliability:*)*	*-2.3 (PEVs safer, more reliable*					
Prior interest in ZEV technology:	*Very interested*					
Driving experience factor PHEVs:	*~5.1 (extensive experience)*					
Seen PEV charging infrastructure:	*No*					
Prior Consideration of a PEV:	*Have not, but may some day.*					
Maximum likeliness of designing an FVC		0.0	0.0	0.0	0.0	**99.8**
Respondent commutes to work in household vehicle:	*Yes*					
Familiarity with ICEVs:	*0.77 (high familiarity)*					
Heard of federal incentives:	*No*					
Should governments offer incentives:	*Yes, but only hydrogen*					
Prior belief hydrogen is a replacement:	*Yes*					
Prior PEV Factor 2: safety-reliability:	*1.9 (ICEVs safer, more reliable*					
Prior interest in ZEV technology:	*Very interested*					
Driving experience factor PHEVs:	*~5.4 (extensive experience)*					

Table 7b Probability distribution of drivetrain designs for profiles of values of the explanatory variables						
Drivetrain type:		ICEV	HEV	PHEV	BEV	FCEV
Base probability estimates, %		**80.9**	17.3	1.2	0.3	0.3
Seen PEV charging infrastructure:	*No*					

Comparing the example of a profile of variable values that predicts a BEV to the profile that maximizes the probability of a predicted BEV, this person "most likely to design a BEV" is not a commuter, has very low familiarity with conventional vehicles, has heard of federal incentives for alternatives—but prior to playing the design games thought those incentives should only be offered for hydrogen. They are very interested in ZEV technology, have seen public chargers for PEVs, and think PEVs are safer and more reliable than conventional ICEVs. They claim driving experience in PHEVs, which may be corroborated by the fact they have already considered a PEV for their household to the extent they have at least searched for information.

The person "most likely to design a PHEV" differs from the person "most likely to design a BEV" in that they are a commuter. They are not sure whether they have heard the federal government is offering incentives, but think they should be offered only for electricity. They have not seen public chargers for PEVs in the parking facilities they use. They have not yet considered a PEV for their household, but are open to doing so some day.

The person "most likely to design an FCEV" differs from the person "most likely to design a BEV" in that they are a commuter. They are highly familiar with conventional vehicles, have not heard the federal government is offering incentives, but think such incentives should be offered for hydrogen only. They do already believe hydrogen is a likely replacement for gasoline and diesel. They believe ICEVs are safer and more reliable than PEVs and have not seen PEV chargers in the parking facilities they use.

What Incentives do People Choose?

- Financial incentives are selected by an overwhelming percentage of respondents (86.6%).
- 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.
- While few people chose incentives tied to vehicle use rather than purchase, among those who do reduced tolls are slight favorite.

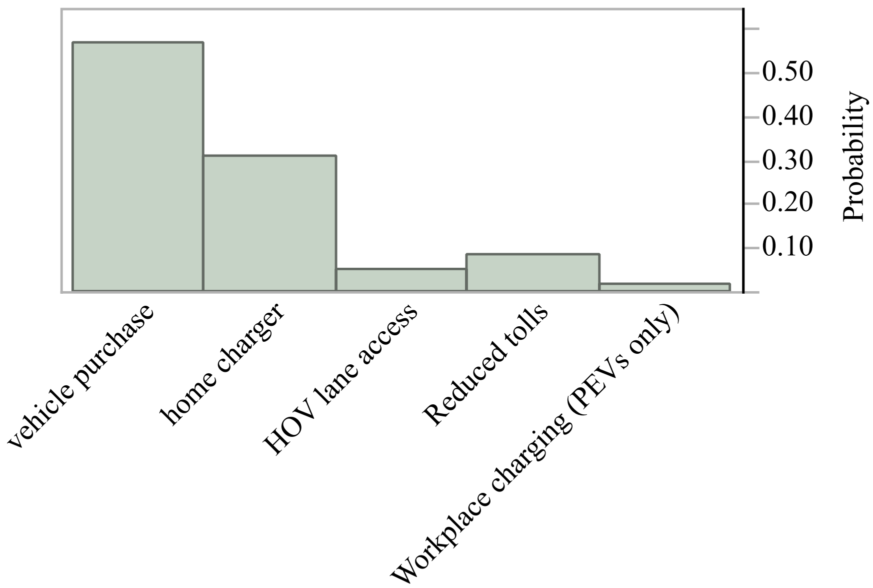
In the final game, PHEVs, BEVs, and FCEVs are eligible for federal tax credit (keeping in mind that full-size vehicles are not offered as BEVs or PHEVs that operate in all-electric mode). The amounts offered are customized for each design based on the present federal schedule. In addition, designers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

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

- 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 22. 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 22: NJ, Incentives selected in addition to a federal tax credit, n = 117, percent



Why do people design PHEVs, BEVs, and FCEVs?

- Highly rated motivations to design a PEV or FCEV are a mix of private and societal
    - o Private: Savings on (fuel) costs, interest in new technology, fun to drive, safer than a gasoline car, and convenient to charge at home.
    - o Societal: 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

Information on what motivated some respondents to design PHEVs, BEVs, and FCEVs indicates possible messages to appeal to other households in New Jersey. Motivations for designing PHEVs, BEVs, 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 New Jersey sample is 1.42. Any item scoring higher than this is interpreted as having a “high” score. The possible motivations are listed in Table 8, sorted from high to low by their mean score; the percent of respondents assigning maximum importance, i.e., five points, is shown, too.

Table 8: Motivations for Designing a PEV or FCEV, high to low mean score

Motivation	Mean	% > 5
To save money on gasoline or diesel fuel	2.99	40.2
I'm interested in the new technology	2.51	30.8
It will reduce the effect on climate change of my driving	1.97	20.5
It will reduce the effect on air quality of my driving	1.93	20.5
I’ll pay less money to oil companies or foreign oil producing nations	1.81	20.5
It will be fun to drive	1.66	16.2
It will be safer than gasoline or diesel vehicles	1.60	15.4
Charging the vehicle at home will be a convenience	1.56	14.5
It will reduce the amount of oil is imported to the United States	1.44	10.3
Mean points per item per person	1.42	
I like how it looks	1.23	9.4
I'll save on the cost of maintenance and upkeep	1.00	6.8
The incentives made it too attractive to pass up	0.96	6.0
It will be more comfortable	0.87	7.7
I think it makes the right impression on family, friends, and others	0.86	6.7
I'll save on the cost of vehicle purchase	0.86	4.3
It fits my lifestyle/activities	0.81	5.1
Another motivation	0.06	1.0

The top seven motivations have individual mean scores higher than the global mean. The top motivations are a mix of private and societal benefits. 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—and possibly even differently from—other costs. 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.

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 PEV or FCEV. This motivation directly enters the model of drivetrain design through the respondents’ self-reported interest in ZEV technology and may be further signaled by whether the respondent had considered a PEV for their household prior to completing the survey.

The four motivations related to policy goals of climate change, energy security, and air quality all score above average, but no direct measure or factor related to these policy goals enters into the model. It seems that these societal motivations are more likely to appear as “after the fact” explanations for PEV and FCEV designs.

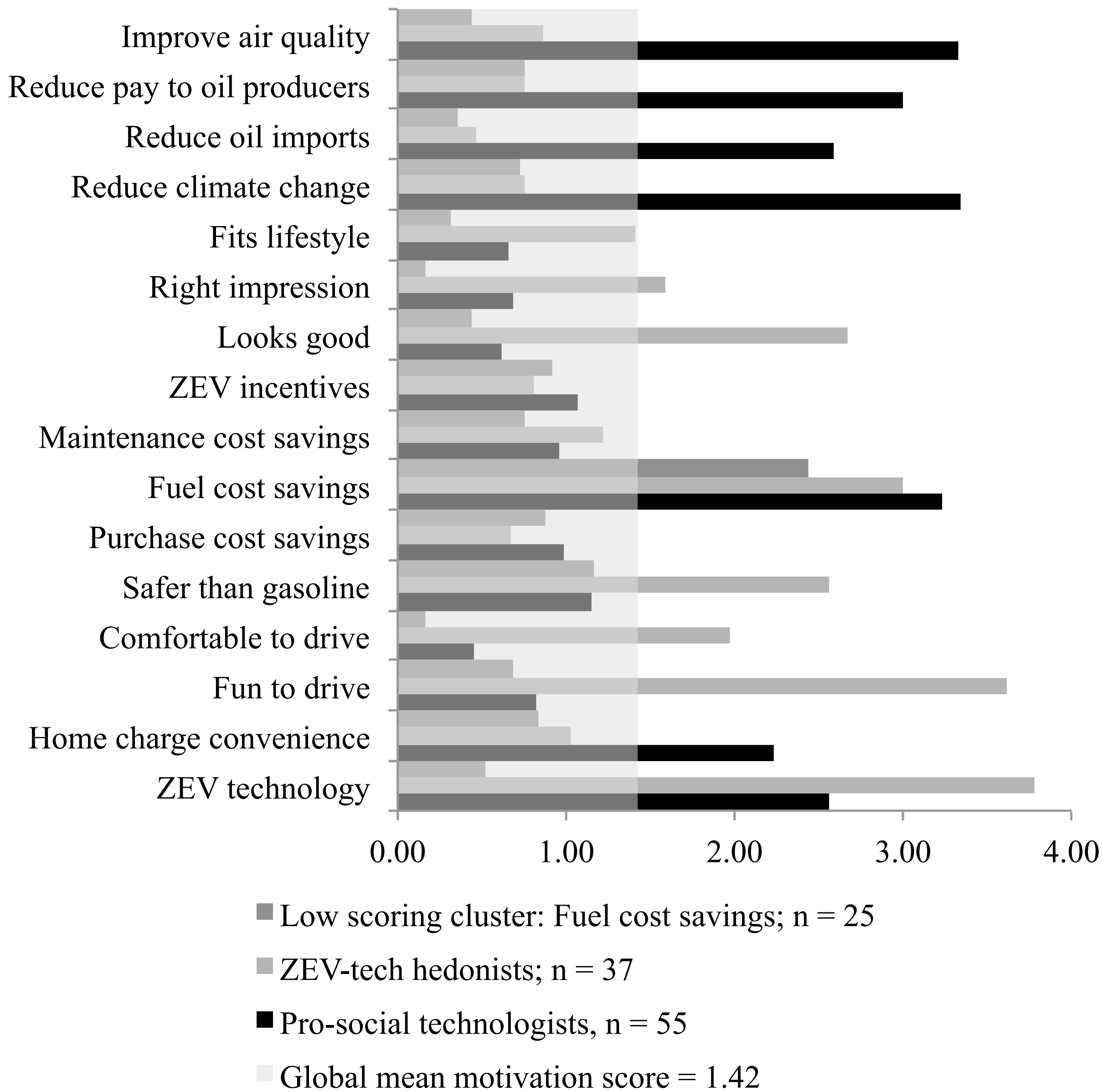
“It will be fun to drive” and “Charging the vehicle at home will be a convenience” are also rated above average, yet neither is directly reflected in the model of drivetrain designs.

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 6.0 percent scored it as high as possible. In the 1st game (no incentives offered, but full-size vehicles with all-electric operation allowed), 101 people designed PHEVs, BEVs, 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 117 respondents. This increase in the number of PHEVs, BEVs and FCVs despite full-size PHEVs and BEVs with battery-powered all-electric drive no longer being offered would be consistent with a greater importance of incentives on respondents’ vehicle designs. As with the case for attitudes toward climate change, energy security, and clean air, there is some distinction to be made between the effects expressed while playing the design games and those expressed in post-hoc explanation by the respondent of why they did what they did in the design game.

Distinct motivational groups among those who design PHEVs, BEVs, or FCEVs

In this section the motivations are analyzed to discover whether distinct groups of people share similar motivations. This extends and refines the explanations of who is interested in PHEVs, BEVs, or FCEVs 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 sub-sets of people who share similar motivations. In Figure 23 the mean motivation scores for a three-cluster solution are plotted along with a demarcation of the global mean scores for all motivations by all of these respondents. The final stage of cluster analysis rests on the analyst and the reader to decide whether any observed patterns offer interpretable and actionable information; the group labels shown in Figure 23 are the authors' interpretation based on which motivations exceed the global mean. Before reading the authors' rationale below, readers are encouraged to test whether they would have named these clusters of respondents differently based on the highly scored motivations they share.

Figure 23: Mean motivation scores for three clusters of respondents who design PHEVs, BEVs, or FCEVs.



All three clusters share one motivation: saving money on fuel. Indeed, for one cluster this is the only motivation that exceeds the global mean. This low-scoring cluster spent an average of fewer than 12 of the maximum of 30 points allotted to respondents for the motivation scoring exercise. (The other two clusters both spent over 27 points.)

The other two clusters are distinguished by whether their strongest motivations are about the private performance attributes of the car or about the pro-social goals of ZEV technology. The "ZEV-tech hedonists" care about the technology and whether it simply produces a better car. The final cluster—"pro-social technologists"—may be the one most people are expecting to find for PHEVs, BEVs, and FCEVs. They are highly motivated by the public policy goals of ZEV technology, i.e., clean air, reduced threat of climate change, and improved energy security. They are motivated by the idea that these goals are embodied in new technology and by a new behavior—home charging—they believe will be a convenience.

Why don't people design PHEVs, BEVs, and FCEVs?

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

Because more new-car buyers in NJ appear to not be interested in PHEVs, BEVs, and 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 PHEVs, BEVs, and FCEVs. Respondents assigned points on a scale from 0 = not at all important to 5 = very important. The 19 possible motivations were derived from prior research. The global mean score for all motivations against PHEVs, BEVs, and FCEVs was 0.94. Any item scoring higher than this is interpreted as having a "high" score. The possible motivations against designing a PEV or FCEV as their next new car are listed in Table 9, sorted from high to low by their mean score.

The mean score assigned to eight motivations are higher than the global mean score. Almost all the highest ranked motivations are related to the inherent newness of the vehicles: limited away-from-home fueling, respondent's unfamiliarity with new technology, and the high initial purchase price (as first generation technology). Arguably distance per charge or fueling also belongs to this category of "teething problems of new technology." This is not to dismiss the importance of these concerns in the here and now, but to note that all may improve with 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 3rd game is somewhat different than for those respondents who did design a PEV or FCEV. For those who did not design a PEV or FCEV, few are willing to state that higher incentives would have changed their minds: the mean score for "higher incentives would have convinced me" is 0.38 and only three percent assign "higher incentives" the maximum number of points. In effect, despite the importance of high vehicle purchase price as a motive against designing a PEV or FCEV, simply offering more money (in the form of vehicle, charger, or home fueling rebates or reduced tolls) or (limited) charging infrastructure (in the form of workplace charging if it doesn't already exist) doesn't solve enough other problems.

Table 9: Motivations against Designing a PEV or FCEV, high to low mean score

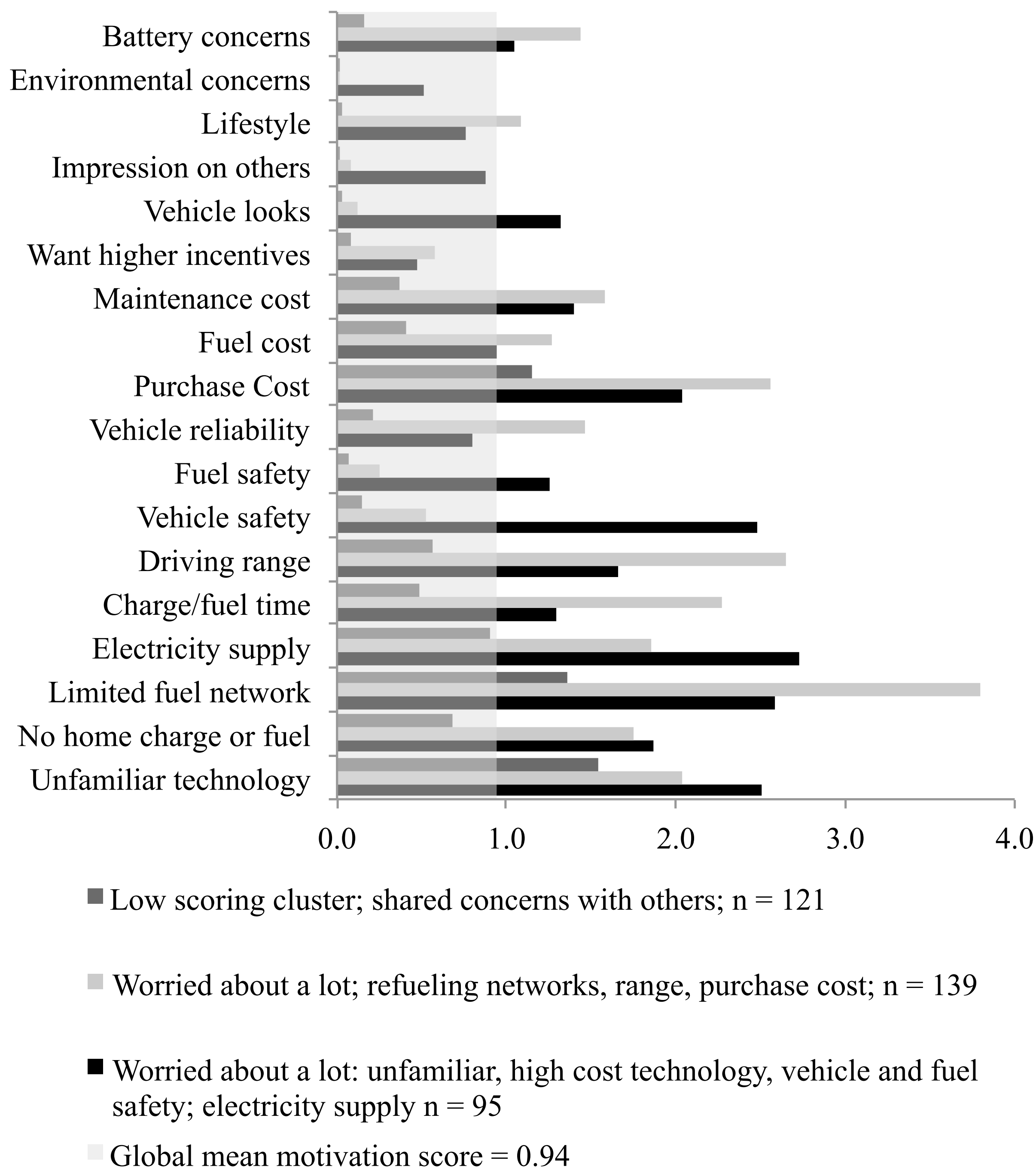
	Mean	% = 5
Limited number of places to charge or fuel away from home	2.62	39.1
I'm unfamiliar with the vehicle technologies	1.99	28.4
Cost of vehicle purchase	1.94	28.5
Concern about unreliable electricity, e.g. blackouts and overall supply	1.74	21.2
Distance on a battery charge or tank of natural gas is too limited	1.66	23.1
I can't charge vehicle with electricity or fuel one with natural gas at home	1.41	19.3
Concern about time needed to charge or fuel vehicle	1.41	16.4
Cost of maintenance and upkeep	1.11	12.3
Mean points per item per person	0.94	
Concern about vehicle safety	0.91	11.7
Cost to charge or fuel	0.89	9.5
Concerns about batteries	0.89	10.0
I'm waiting for technology to become more reliable	0.85	8.9
Doesn't fit my lifestyle/ activities	0.64	8.1
Concern about safety of electricity or natural gas	0.48	4.2
I don't like how they look	0.41	3.6
I was tempted; higher incentives would have convinced me.	0.38	3.1
I don't think they make the right impression	0.27	1.7
Environmental concerns	0.17	1.1
Another motivation	0.16	2.8

1. Only 17 respondents listed an "another" motivation; ten assigned 5 points to their other motivation.

Distinct motivational groups among those who do not design PHEVs, BEVs, or FCEVs

Here the motivations (or perhaps, concerns) of those who did not design a PEV or FCEV are examined. Results of a three-cluster solution are illustrated in Figure 24.

Figure 24: Mean motivation scores three clusters that do not design PHEVs, BEVs, or FCEVs.



In comparison to the cluster analysis for those who did design PHEVs, BEVs, or FCEVs, the cluster analysis of the motivations of those who did not appears more singular in its conclusion: most of these people have many highly scored concerns about PHEVs, BEVs, and FCEVs. This may not be entirely true for the first, low-scoring cluster. (This cluster spent barely six points on average of the 30 points available. The other two clusters both spent about 22 points.) However, the highly scored motivations are shared with the other two clusters (for whom it is certainly true they have many highly scored motivations): these vehicles are made with unfamiliar technology, with an unknown charging/fueling network, and will be expensive to buy.

The primary distinction between this cluster and the other two is the other two are first characterized as "worried about a lot" because their mean scores for three-fourths of all motivations against designing a PEV or FCEV are higher than the global mean.[23] Most respondents who do not design PEV or FCEV have a long list of concerns—differences between the groups have mostly to do with the details. The second group may be most concerned overall—on nine of 12 motivations that any cluster scores above the global mean they have either the highest score above the global mean or the only score above it. If there is a distinguishing set of concerns for them it may be charging/fueling for PHEVs, BEVs, and FCEVs. Their average scores for limited fuel networks, range per charge/fill, and charging/filling time are far higher than the other two groups. The final group also scores highly on a dozen motivations against designing a PEV or FCEV. Without dismissing their concerns for unfamiliar technology, recharging/fueling networks and high vehicle purchase costs, what distinguishes them from the other clusters are concerns for safety and reliability: vehicle safety, the safety of electricity or hydrogen, and the effects of PEVs on electricity supply.

No group credits the idea that higher incentives would have caused them to design a PEV or FCEV. The average scores on the item "higher incentives would have convinced me" are higher than the global mean for none of the three clusters.

[23] There are eighteen items in the list (excluding the "other" category because it was seldom selected and even more rarely scored highly), but the incentive item is not a motivation against designing a PEV or FCEV, rather an effort to see if higher incentives would overcome such motivations

RESULTS: COMPARISON OF STATE RESULTS

In this section, results from the states where the on-line survey was conducted are compared. There are multiple geographies represented 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 they have exercised their prerogative under Section 177 of the federal Clean Air Act to adopt 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 PHEVs, BEVs, and FCEVs and if so what incentives.

This section compares and contrasts the states and NESCAUM analyses. The intent is to explore at both the general conceptual level and at the level of specific measures within classes of concepts the extent to which the multiple analyses have produced a mutually reinforcing and unifying set of understandings across the multiple policy and market geographies vs. the extent to which there are idiosyncratic findings for individual states or NESCAUM. This discussion starts with the measures of prior PEV or FCEV consideration. Then, the distributions of drivetrain designs will be compared across the state and regional analyses. This will compare both their actual designs and the multivariate models to explore the explanatory variables in the models of those vehicle design distributions. Finally, motivations of both those who did design a PEV or FCEV and those who designed an ICEV or HEV will be compared.

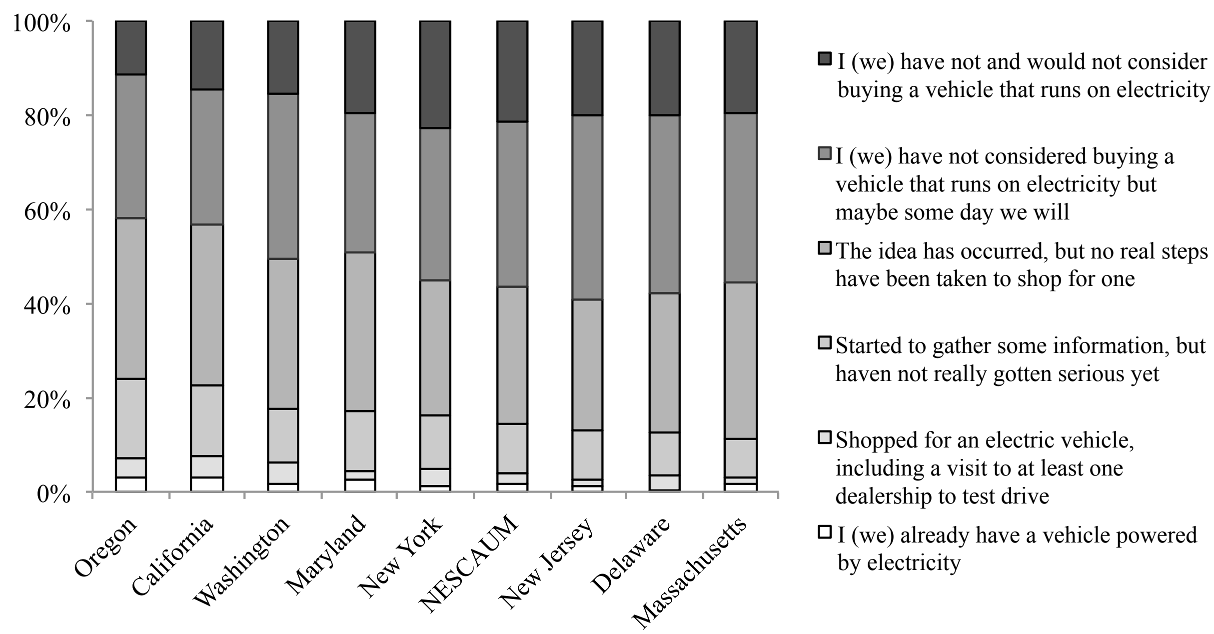
Because their data has only been used in the aggregate NESCAUM regional study, the reader is reminded data was collected from samples of new car buying households in all NESCAUM states, including Connecticut, Rhode Island, Vermont, New Hampshire and Maine. These smaller states do not have individual state analyses because their samples sizes are too small.

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 in New Jersey score among the lowest levels of prior consideration of a PEV or an FCEV.
- Respondents are more likely to have given higher levels of prior consideration to PEVs and FCEVs in California, Oregon, and Washington than in the NESCAUM region, Maryland and Delaware.
- Prior consideration is higher for PEVs than FCEVs across all states, as one might expect given the tiny number of FCEVs that have been leased and the strictly proscribed regions in which those leases are available at the time of this study (limited largely to small regions within the greater Los Angeles, CA area).

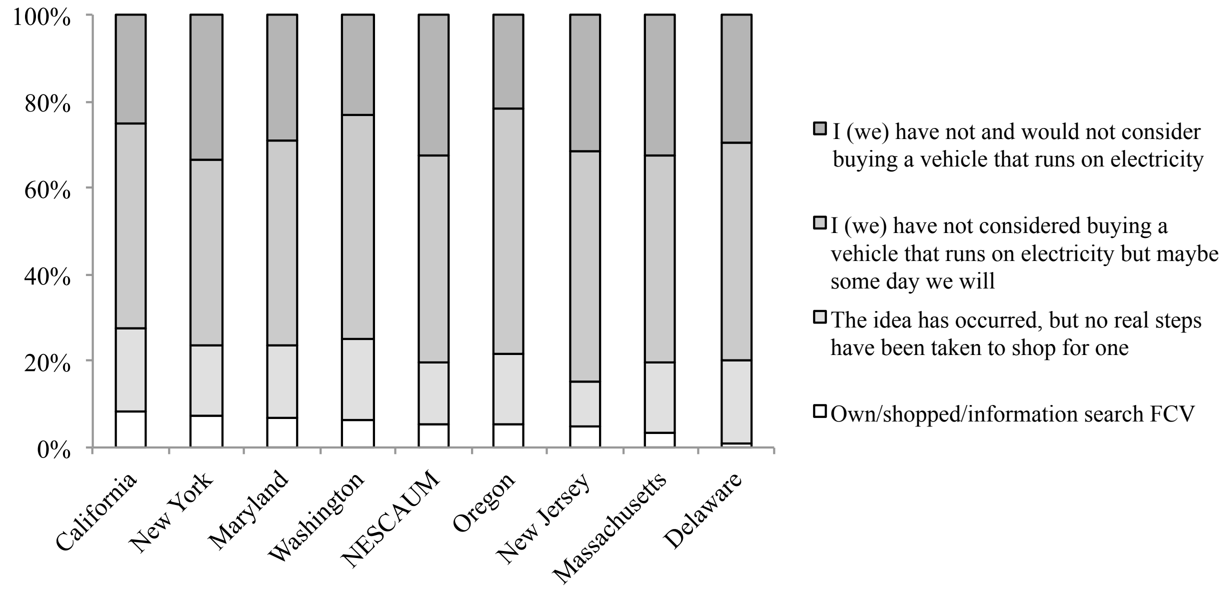
Respondents' consideration of PEVs and FCEVs prior to completing the on-line survey is plotted by state and the NESCAUM region in Figures 25 (PEVs) and 26 (FCEVs). The order of the results from left to right in each figure is by the sum of the three highest or most active levels of consideration: own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

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



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

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



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 10 (PEVs) and 11 (FCEVs).[24] 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 specific order differs.

PEV and FCEV Valuation: Drivetrain designs

- In every state and region, fewer respondents design a next new vehicle for their household to be a PEV or FCEV than design them to be ICEVs or HEVs.
- Still, between one-fourth and two-fifths of new car buyers appear ready to consider a PEV or FCEV for their household, i.e., they design such vehicle in the design games.
- The differences between states in drivetrain designs—and in particular between western and eastern states—is greater than the differences in prior consideration.
- Respondents from New Jersey show the least likeliness to design a PEV or FCEV among the states and region analyzed.

[24] Massachusetts, New Jersey, and New York are not shown separately in Tables 10 and 11 because to do so would double count their data in the statistical tests.

Table 10: State/Region by Consider PEV

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

Note:

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

Table 11: State/Region By Consider FCEV

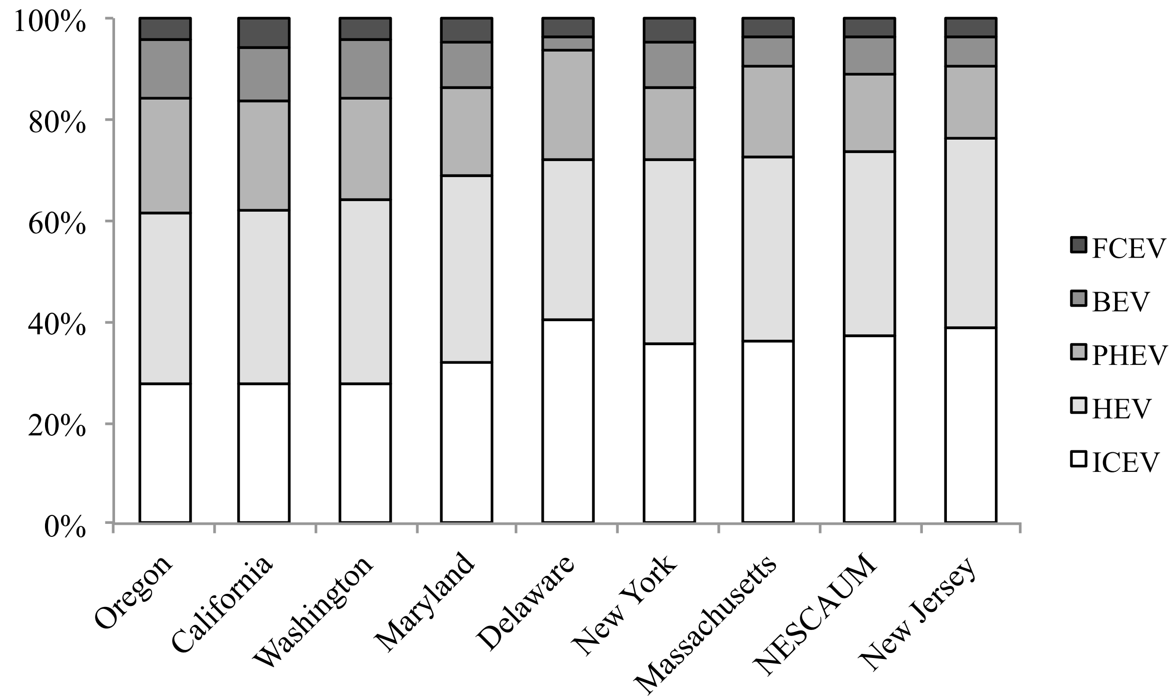
Count Row %	Own/shop/ information search	The idea has occurred, but no real steps have been taken to shop for one	Have not considered buying a vehicle that runs on hydrogen but maybe someday we will	Have not and would not consider buying a vehicle that runs on hydrogen	Total
California	**141** **8.44**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

Note:

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

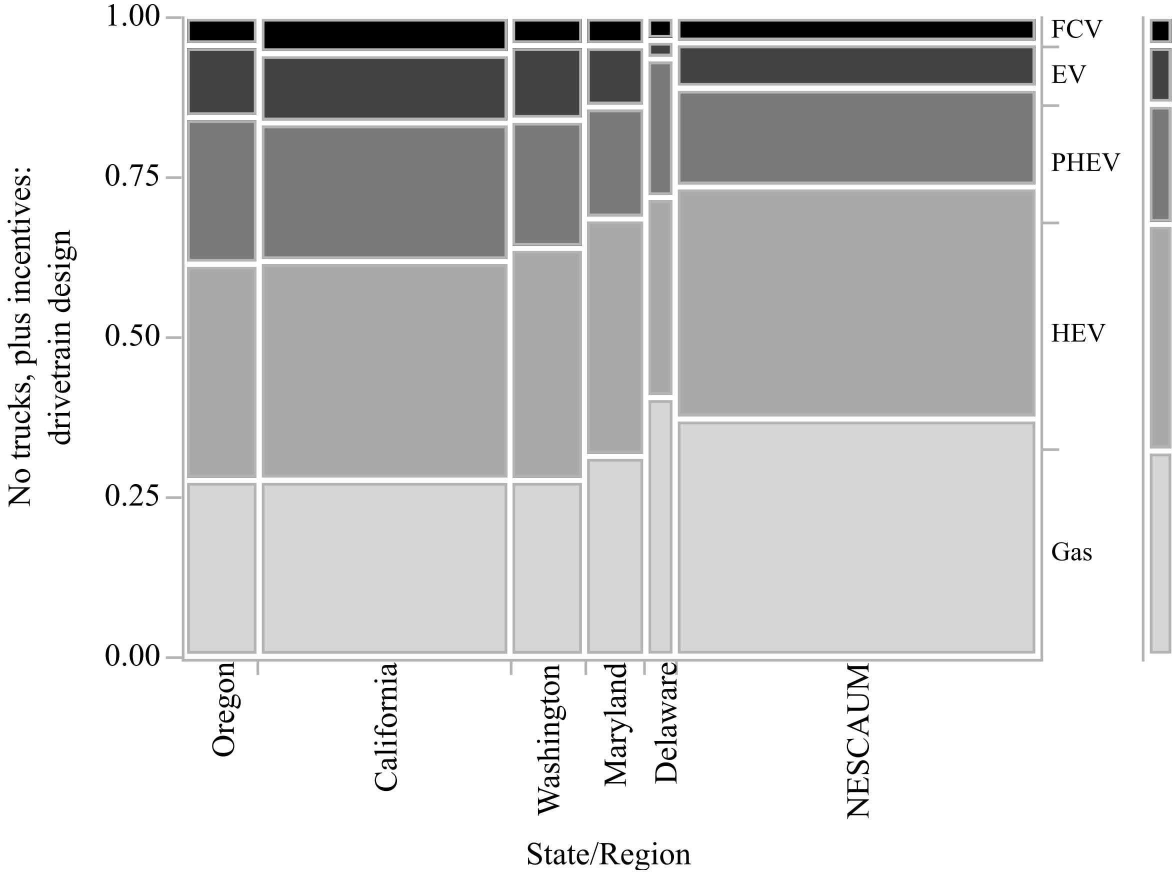
The design games address whether respondents value PEVs or FCEVs highly enough to design one as a plausible next new vehicle for their household based on the conditions stipulated in the design games and their own awareness, knowledge, and experience. The distributions of drivetrain designs (described in the individual state and regional reports) are compared in Figure 27. The results are much the same as for prior consideration: higher percentages of respondents in the western states create vehicle designs with PHEV, BEV or FCEV drivetrains than do in any eastern state. The NESCAUM member states have the lowest percentage of PEV and FCEV drivetrains. New Jersey has the lowest percentage of PEV or FCEV designs: 24 percent. Still, approximately one-in-four respondents throughout the NESCAUM region do design a PEV or FCEV: nearly four-in-ten do in Oregon, California, and Washington.

Figure 27: Drivetrain Types from Game 3, ordered left to right from high to low of the total percent of PEV 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. The cross-tabulation is illustrated in Figure 28 and provided in Table 12. The vehicle design distributions in Figure 28 have been ordered by the total of the percent of respondents who design a PEV or FCEV. The mosaic plot in Figure 28 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).

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



The order from top to bottom in Table 12 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).

Table 12: State/Region Drivetrain Designs, Game 3

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

Note:

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

PEV and FCEV Valuation: Who designs their next new vehicle to be a PEV 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 largest statistically significant coefficients. Rather, the question addressed here is which explanatory variables are particular to one or a few states and which are pervasive across states and the different "geographies" of policies and markets they represent.

- Almost no measures of socio-economics, demographics and political affiliations appear in any model of respondents' drivetrain designs, i.e., given the other variables that do appear in the models, these measures offer no real explanation for who presently has a high enough valuation of PEVs or FCEVs to seriously consider one for their household.

- The contextual measures appearing across the largest number of state and regional models pertain to whether respondents are likely to be able to charge a PEV at home.
- The measure of vehicle travel that appears in a few models is whether or not the respondent commutes (at least part way) to work in a household vehicle.
    - The model for Oregon is quite different from any other in that several measures pertaining to the households existing vehicles and vehicle travel are included as statistically significant explanatory variables of respondents' PEV and FCEV valuations.
- Of the measures pertaining to policy goals and instruments, those measuring attitudes about air quality are the most common across states and regions.
    - In a few states, whether respondents are aware of federal incentives for alternatives to gasoline and diesel or support the idea of government incentives enter the models of respondents' vehicle designs as statistically significant.
- The conceptual category that provides the most measures of respondents' drivetrain designs is the category containing measures specific to PEVs, FCEVs, electricity, and hydrogen.
    - Whether electricity and/or hydrogen is already believed to be a likely replacement for gasoline and diesel;
    - Personal interest in ZEV technology;
    - Familiarity with all vehicle drivetrain types included in the design games: ICEVs, HEVs, PHEVs, BEVs, and FCEVs;
    - Prior assessments of PEVs and FCEVs on six dimensions: charging/fueling, purchase price, safety, and reliability;
    - Experience driving vehicles of the different drivetrain types;
    - Whether respondents have already seen PEV charging in the parking facilities they use; and,
    - Extent to which respondents have already considered acquiring a PEV or FCEV.

Socio-economic, demographic, and political measures

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

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

Contextual measures: existing vehicles and their use; residences

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

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

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

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

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

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

In California, Delaware and New Jersey variables measuring awareness of and support for government-provided incentives to consumers are associated with valuation of PEVs and FCEVs.[25] In New Jersey both the variable measuring awareness of federal incentives and another assessing whether governments should offer incentives (or leave the matter to "markets") are associated with drivetrain designs. Note the presence of the variable in the model for New Jersey does not mean that new car buyers in the Garden State are more likely to have heard of the federal tax credit than respondents from other states. It simply means that of all states, only in New Jersey is whether they have heard of the federal incentive associated with their likeliness they incorporate different drivetrains in their vehicle designs. This same variable on the role of government in providing incentives is statistically significant in California. The variable measuring awareness of federal incentives is also retained in Delaware's model.

Prior PEV and FCEV Evaluation and Experience; ZEV-specific attitude

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

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

Questions about respondents' familiarity with the types of vehicles they would be asked to design later in the questionnaire were framed in terms of whether the respondents believed they are familiar enough "to make a decision whether one would be right" for their household. Questions addressed each of the five main drivetrain types in the study: ICEVs, HEVs, PHEVs,

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

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

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

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

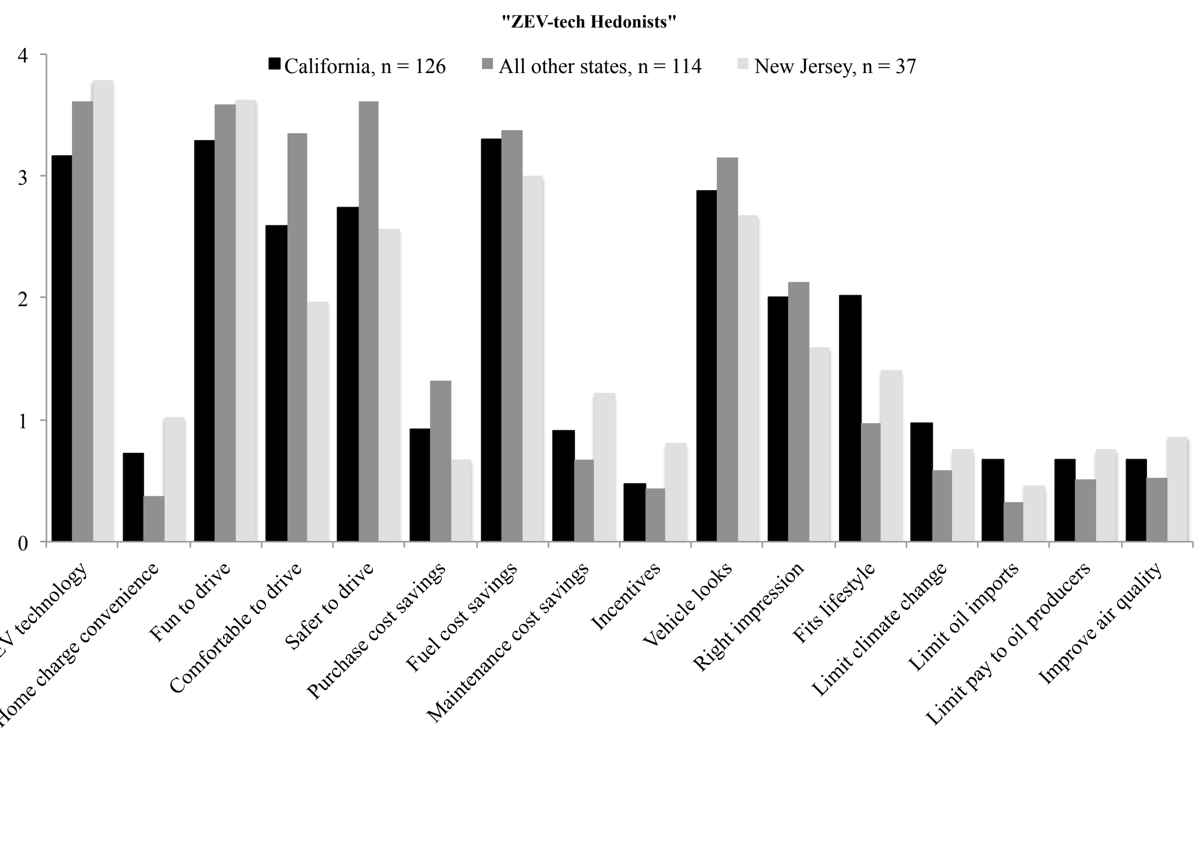
The last set of variables is the extent to which respondents have already considered a PEV or FCEV for their household. The measure of prior consideration of a PEV appears in the models for every state and the NESCAUM region, except Washington. Prior consideration of an FCEV does appear in the model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

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

The same analysis of post-game motivations was performed for the other participating states. The comparison here is between respondents from California, New Jersey, and the aggregate of all states other than California. Figure 29 through 31 illustrate the results of the four-cluster solutions from the cluster analysis of California and the aggregate of all other states as well as the three-cluster solution from New Jersey. The fourth clusters from CA and all other states are shown in Figure 32. The question these figures address is whether the same clusters of respondent motivations exist for designing PEVs and FCEVs. Keeping in mind that scores less than ~1.0 are disregarded as "low," the answer is generally, yes. Though there is no specific statistical test, the figures illustrate that at least for three of the four clusters identified for California, it is possible to match them to clusters of similar motivations for designing PEVs and FCEVs in Massachusetts and the aggregate of all states except California.

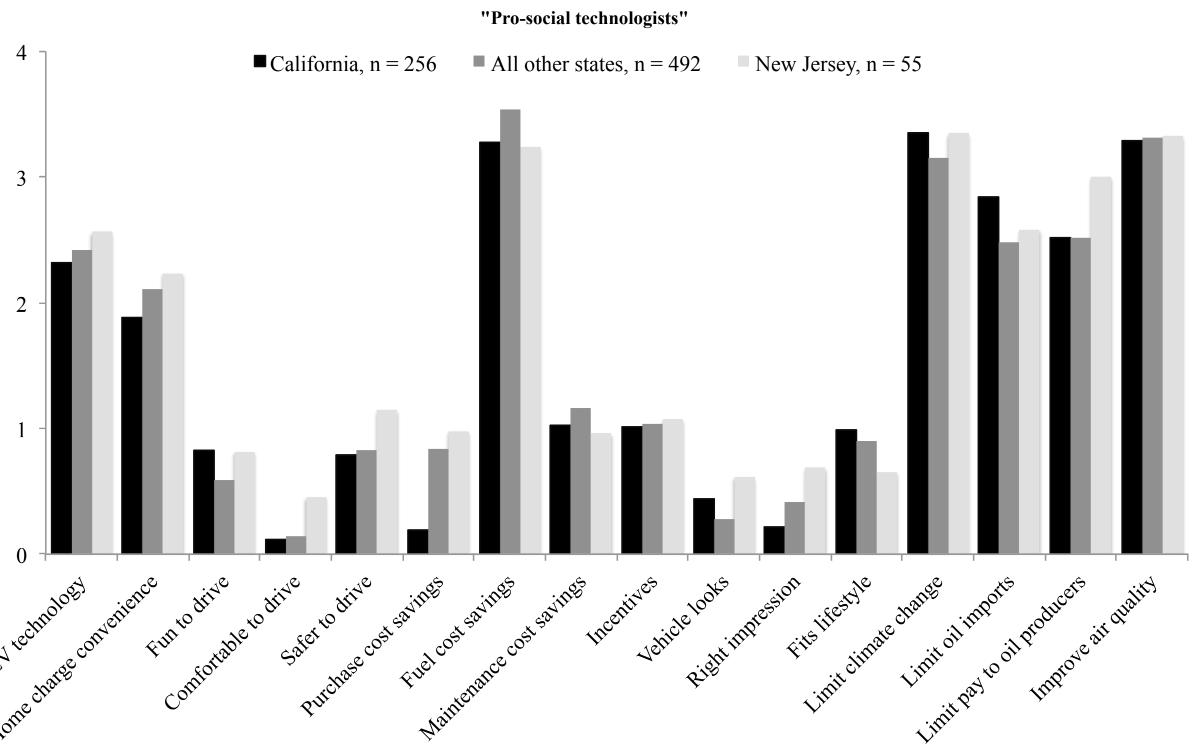
Figure 29 confirms the pervasiveness across states and regions of a cluster of respondents identified as "ZEV-tech Hedonists": people who on average have no highly scored pro-social motivation but appear to think a vehicle powered by an electric motor will simply be the best car: a fun, comfortable and safe to drive vehicle that is inexpensive to fuel, looks good, makes the right impression on family and friends and fits the respondent's lifestyle.

Figure 29: Mean motivation scores for "ZEV-tech Hedonists"



A similarly close mapping is also possible for the clusters identified as “Pro-social technologists” (Figures 30) in California, New Jersey, and the aggregate of all states other than California. These respondents score all four pro-social motivations highly. Further, they appear motivated by the fuel cost savings and home charging convenience that come from ZEV technology.

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



As noted in the prior analysis of New Jersey state results, one cluster is distinguished from the others by the difference in points spent in the motivation exercise. This is also the case in California and the aggregate of all other states. Mean motivation scores are plotted for these low scoring clusters in Figure 31. Fuel cost savings is the motivation that consistently receives a high average score, especially in New Jersey and the aggregate of all states except California.

The remaining clusters—one each from California and the aggregate of all other states—are plotted in Figure 32. In California, the fourth cluster is named “thrifty environmentalists” because it emphasizes all cost savings motivations—purchase, fuel, maintenance, and the importance of incentives. While scoring pro-social motivations highly, they do not score them as highly as did the “pro-social technologists.” The fourth cluster from the aggregate of all other states contains “generalists” drawing from pro-social, technology, costs, and performance motivations. It differs from California’s “thrifty environmentalists” in being less interested in purchase and fuel savings and more motivated by the idea of a fun-to-drive vehicle that fits their lifestyle.

Figure 31: Mean motivation scores for low scoring clusters

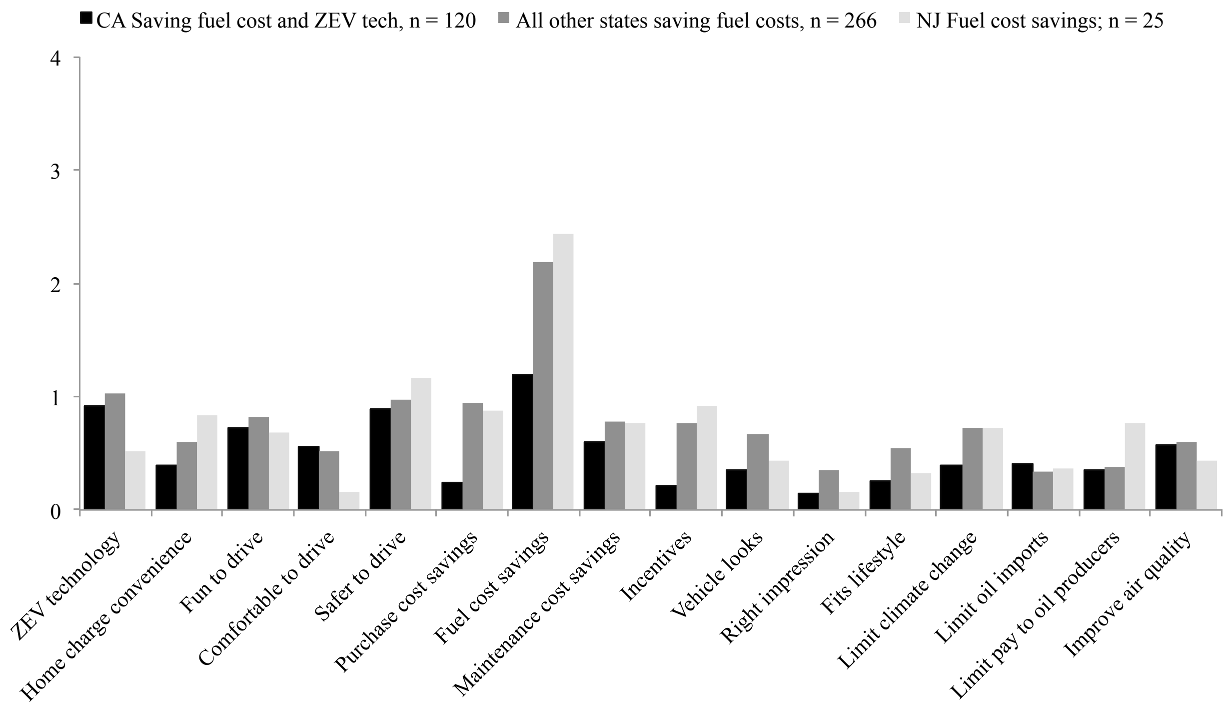
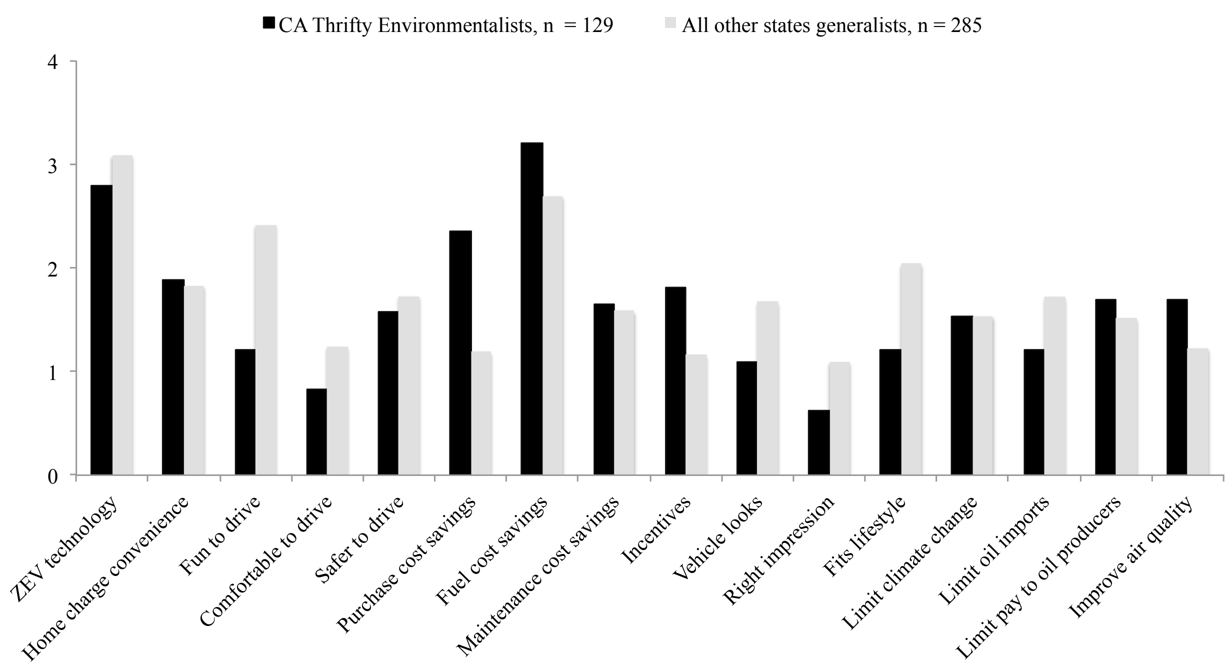


Figure 32: Mean motivation scores for All-other state and Massachusetts "Generalists"



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

The motivations of those who design ICEVs and HEVs for not designing a PEV or FCEV are compared here for California, New Jersey, and all the aggregate of all states other than California. As in the previous section the result here is that clusters of motivations appear broadly similar between the respondents from California and those from all other participating states. Cluster mean scores are shown in Figures 33 through 35 for three-cluster solutions.

With one adjustment, all three analyses produce a cluster of respondents who may be characterized as "worried about a lot including range, charging, and purchase price" (Figure 33). The adjustment is to switch the order of naming the New Jersey cluster from "charging, range, purchase price" to range, charging, purchase prices. As all three of these are highly scored and as the purpose of this cluster analysis is to identify respondents with shared motivations and concerns, this adjustment seems acceptable. The same adjustment is made for the aggregate of all other states. In effect, driving range concerns are scored, on average, higher than charging/fueling network concerns while the order appears reversed most everywhere else studied. What is shared is that both are the highest scored concerns. Each of the clusters has mean motivation scores higher than their respective state or regional global means for nine or more motivations against designing a PEV or FCEV. The clusters for New Jersey and all other states emphasize "unfamiliar technology" more so than the California cluster.

Figure 33: Mean motivation scores for "Worried about a lot: range, charging, and purchase price"

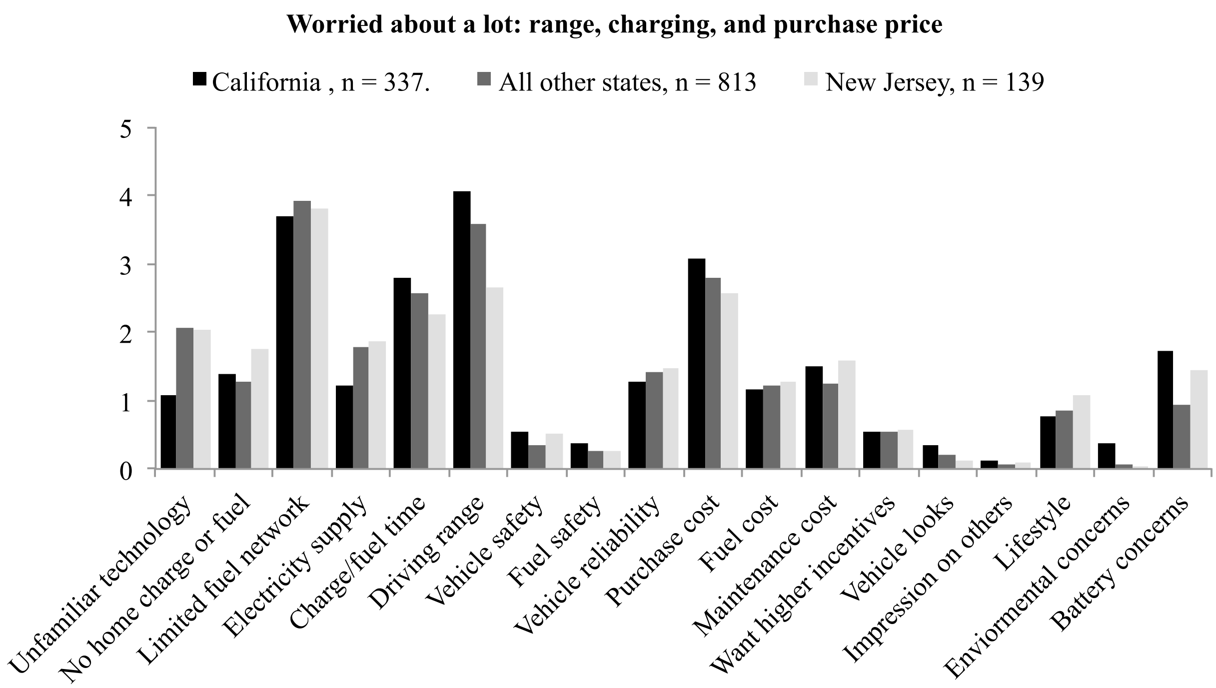


Figure 34 shows similarities across all three analyses in the highest mean scores: unfamiliar technology with a high purchase price. All three clusters score several other motivations highly, though they start to diverge in the details. In CA, this cluster high mean scores for almost every measure of home and away-from-home charging/fueling—but not driving range. The cluster for the aggregates of all states scores is also concerned about charging/fueling, but more so regarding away-from-home networks. The New Jersey cluster additionally emphasizes vehicle and fuel safety.

Figure 34: Mean motivation scores for "Unfamiliar, expensive technology, and more"

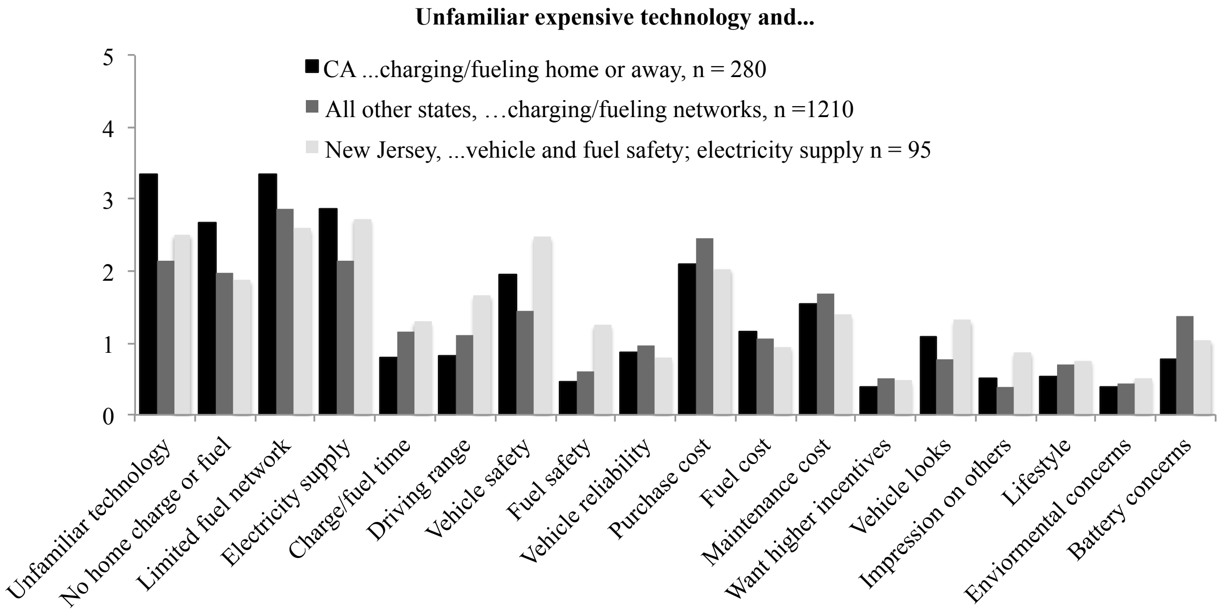
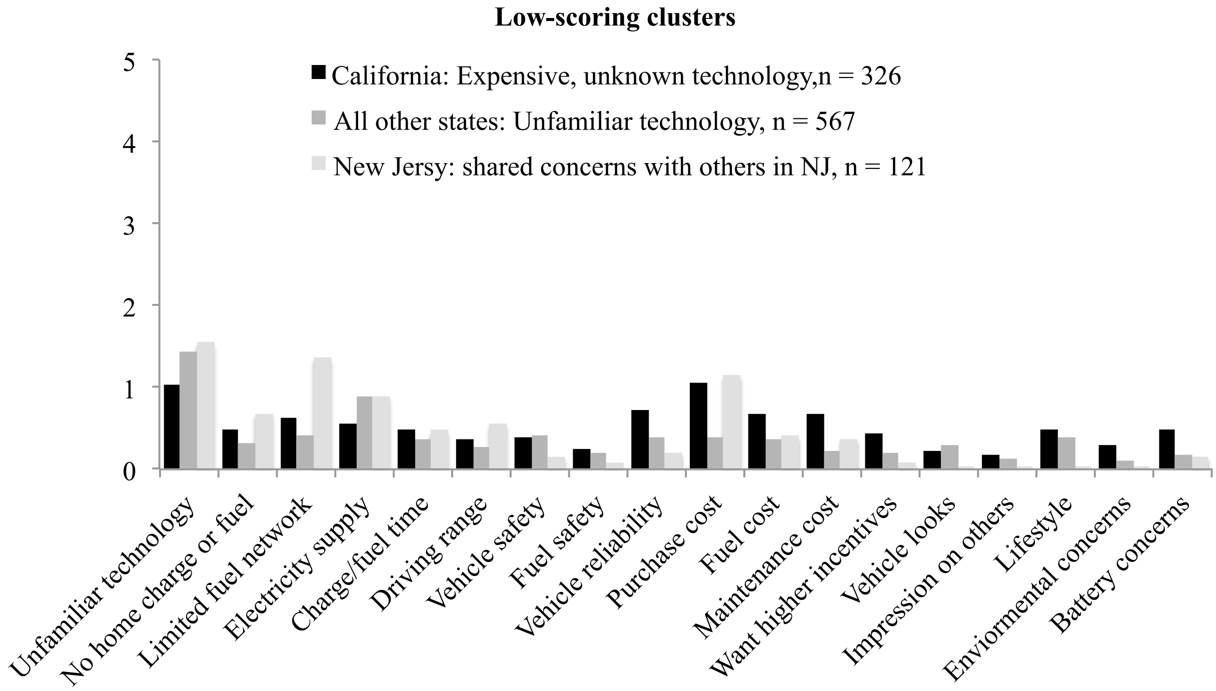


Figure 35 shows that though there may be minor differences in detail, there is a cluster in all samples that registers low levels of concern for all the motivations compared to the other clusters.[26] The emphasis that respondents in all three low-scoring clusters share is on the unfamiliar technology of PEVs and FCEVs. Additionally, CA and New Jersey respondents emphasize purchase cost. Further, the New Jersey respondents emphasize limited fuel networks.

[26] As discussed in the section on post-game motivations for California, these low scores average scores for all motivations are the result of a cluster of people who spend few of the total of 30 points available to them in the motivation scoring exercise.

Figure 35: Mean motivation scores for Low Scoring Clusters



RESULTS: POPULATION-LEVEL ESTIMATES OF NEW-CAR BUYING HOUSEHOLDS WITH POSITIVE PEV 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 PEV 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" as defined for this study: households who have acquired a new vehicle since January 2008. The fourth column—Buy new vehicles, %—is an estimate based on data for California only, thus the estimates for all other states and regions depends on the assumption this percentage in other states is similar. Taking the product across each row produces the Population Estimate in the sixth column. The result is that something like three million households—who already spend the income, wealth, or credit it takes to buy new cars—sufficiently value the idea of a vehicle that runs on electricity (in part or in whole) or hydrogen to design one as their household's next new vehicle.

Table 13: Population-level estimates of new-car buying households with positive PEV 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 Valuation, 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 PHEVs, BEVs, 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 PHEVs, BEVs, 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 PHEVs, BEVs, and FCEVs—no matter how imperfectly formed—and to understand whether and how those present valuations can be affected.

Lack of awareness, knowledge, and experience

In New Jersey—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 and FCEV 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 PHEVs, BEVs, and FCEVs.

Name recognition of the available BEVs is low. Barely one-fourth the respondents in this sample of new-car buyers could name a BEV—and despite there being nearly a dozen different BEVs on the market, more than nine-of-ten of those respondents name one of two BEVs. At this early stage of introducing PEVs, it may seem picky to disallow valid names of PHEVs as answers to the question of naming a BEV, but the inability of consumers to distinguish BEVs from PHEVs—and PHEVs from HEVs—speaks to the core problems measuring familiarity and distinguishing what people know from what they think they know about PEVs and FCEVs. The distinction between charge-depleting modes of PHEVs—all-electric operation (see for example, BMW's i3 with range extender) vs. assist (see for example, Toyota's Plug-in Prius)—is another source of profound confusion.[27]

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

In general, the assertion that respondents are unfamiliar with PHEVs, BEVs, and FCEVs is supported by self-ratings of their familiarity with ICEVs, HEVs, BEVs, PHEVs, and FCEVs.

[27] While this confusion can be inferred from the survey data, the follow-up interviews in other states add supporting insights. Interviewees were routinely confused by the differences in operating modes of PHEVs; some had avoided "all-electric" operating modes in PHEVs because they believed they would be stranded when the battery discharged.

Not only do familiarity scores drop on average as we move from start to finish of this list, but the percentage of people even willing to offer an answer declines, too. The assertion is further supported by respondents' limited or absent driving experience with HEVs, PHEVs, BEVs, and FCEVs. Finally, the assertion is further supported by respondents' answers to whether they have already considered buying a PEV or FCEV: 87% of new car-buyers indicate they have made no real effort to consider PEVs; for FCEVs, the figure is 95%.

If many people can't name a BEV presently for sale, don't understand the distinctions between HEVs and PHEVs in particular, and have no driving experience with PHEVs, BEVs, or FCEVs, why do nearly one-fourth of the New Jersey survey respondents design one for their next new vehicle, especially compared to existing sales (leaving aside for now FCEVs are not for sale in New Jersey)? Again, the survey is not intended to estimate market share, but to assess whether (and which) consumers are forming positive or negative valuations of PHEVs, BEVs, and FCEVs. Differences between the "game world" and the real world illustrate this. On the supply side in the real world, not all manufacturers have offered PEVs since sales started (nor do all offer at least one, now). Nor do all dealerships carry PEVs, even if the manufacturer(s) they represent make them. On the demand side in the game world, we have allowed respondents to start their design with any make/model vehicle they want, so that many issues of brand, body style/size, performance, and any other idiosyncratic feature of a vehicle they want is available to them in the game world that aren't available in the real world.

Prior PEV-related Awareness, Knowledge, and Assessments related to PEV and FCEV Valuations

Despite the lack of 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 about PEVs (11%), already visit a dealership for a test drive (1%), or even acquiring one for their household (1%); for FCEVs, 4% have started to gather information. Despite these claims, fewer respondents in the NJ sample are aware of federal incentives than the average level of awareness across the study states. Awareness of NJ state incentives for consumers to purchase vehicles fueled by alternatives to gasoline and diesel is low (9%) in comparison to awareness of federal incentives and in comparison to awareness of state incentives in other states that do offer incentives.

Incentive awareness appears as an explanatory variable in the model of the NJ respondents' vehicle designs: those who have heard of federal incentives are more likely to have designed an HEV in particular. Further, whether or not respondents believe governments should be offering incentives for electricity, hydrogen or both has a complicated effect on PEV and FCEV valuation. Those who believe governments should offer incentives only for electricity and those who believe incentives should be offered for both are more likely to design a PEV. In contrast, those who think incentives should be offered only for hydrogen are less likely to design a PEV.

Following from these beliefs about incentives, respondents' prior belief that hydrogen is a likely replacement for gasoline and diesel is associated with differences in drivetrain types, but not their prior belief that electricity is such a replacement. Prior concepts about electricity that do matter are more specific to the vehicles rather than the "fuel." These include whether they personally have an interest in ZEV technologies (14% claim to be “very interested), whether they have seen PEV charging in the parking facilities they use (26% say they have, but only 6% say they have seen them “several places”), whether they have formed a favorable evaluation of the safety and reliability of PEVs compared to ICEVs (on balance the sample is split 50/50 as to whether PEVs are safer and are bit less likely to judge PEVs are more reliable), and whether they have already considered a PEV for their household (as reviewed above, 14% have at least started to search for information about PEVs).

That these measures of whether respondents have already considered PEVs enter the model of their valuation of PHEVs, BEVs, and FCEVs—and that those respondents who have a more favorable prior evaluation of PEVs claim a higher level of familiarity with PHEVs in particular—supports the importance of initiating and shaping PEV and FCEV consideration, but are vague as to how exactly to do so. If measures of more specific PEV and FCEV attributes entered the model (and as shown in Appendix Table A, 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. The specific vehicle measures that do enter the model for the NJ respondents are vehicle safety and reliability—two aspects of PHEVs, BEVs, and FCEVs that are much less discussed than purchase price, range, and charging networks.

Notable by their absence for the model for NJ are any direct measures of respondents’ opinions regarding the social goals for ZEVs: air quality, climate change, and energy security. The NJ sample is more likely to be worried about the regional threat of air pollution than is the total sample and as likely to believe individuals’ lifestyles affect air quality. They share similar (high) likeliness to believe global warming is real, caused by humans, and requires immediate action. However, while these beliefs—typically around air quality—do appear in the models for respondents in other states, they don’t in New Jersey.

Pro- PEV and FCEV Motivations

What we have called motivations for and against PHEVs, BEVs, and FCEVs are different from other variables affecting PEV and FCEV valuations in that motivations are assessed after the respondents have created and selected 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 and FCEV that scored highly across the sub-sample of people who designed one include:

- Save money on gasoline or diesel fuel
- Interested in the new technology
- Reduce the effect on climate change of my driving
- Reduce the effect on air quality of my driving
- Pay less money to oil companies or foreign oil producing nations
- Fun to drive
- Safer than gasoline or diesel vehicles
- Charging the vehicle at home will be a convenience

- Reduce the amount of oil is imported to the United States

Not all possible motivations are directly reflected in the list of potential explanatory variables. Of those that do, personal interest in ZEV technology and the comparative safety of PEVs vs. ICEVs directly reflect the model of drivetrain types that is the primary measure of PEV and FCEV valuation. Further, some of these motivations relate to each other. For example, some consumers would switch from gasoline to electricity to reduce fuel spending. Gasoline costs—being ongoing and uncertain—may be accounted for differently than vehicle purchase costs that are more fixed. Further, it gives a measure of control over where their fuel spending is going.

Additional insights are gained by examining subsets of respondents who share similar motivations. The most striking finding is a distinction between a cluster of people who say they were strongly motivated to design a PEV and FCEV by all the major public policy issues associated with ZEVs: air quality, climate change, and energy security (the "Saving the planet…" cluster in Figure 23) and other groups who claimed at most, below average motivation by any of these. The other two clusters are motivated by fuel cost savings too—fuel cost savings is the only motivation highly scored by all three clusters. One group appears highly motivated only by these savings. The other is highly motivated by their imagination that a PEV or FCEV will simply be a great car: fun to drive, comfortable, safe, good-looking, and making the right impression on others. In closing this discussion of clusters sharing similar motivations it is worth noting that 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 public policy goals should appeal to about half of those with a positive PEV or FCEV valuation. The other half may be reached by more conventional automotive marketing messages.

Con- PEV and FCEV Motivations

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

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

Taken as a whole, this list illustrates that for many people it is the sheer number of questions, uncertainties, and doubts they have that add up to their negative (or at least, not sufficiently positive) valuation of PHEVs, BEVs, and FCEVs. Those who do not design a PEV or FCEV echo the prior argument about low familiarity: the second highest rated motivation for designing an ICEV or HEV is simply "I am unfamiliar with [ZEV] technology." This leads to the possibility that the list of barriers is itself a rationalization—a way of explaining in a seemingly reasoned way opposition to something that is simply unknown.

The list indicates important barriers to considering PHEVs, BEVs, and FCEVs include charging/fueling (away from home networks, inability to fuel/charge at home, time to charge/fuel) and 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 such as New Jersey has already initiated. The state has already taken steps to streamline the permitting process for home installations of home chargers. This helps those who are able because of they have authority, parking, and proximity of that parking to electrical service. Beyond some initial threshold of away-from-home charging and fueling locations, addressing concerns about availability of away from home charging is as much about the perception of an extensive fueling network, that is, about developing and disseminating images and information about such networks.

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

Maintenance costs are discoverable only with use, that is, over time. Other barriers that share this are concerns the ability of an away-from-home network to provide adequate charging/fueling, and coupled with this, the suitability of any particular driving range. 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 because of their lack of this "experiential" knowledge. 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 PEV and FCEV market to include these households who, at present, demonstrate a negative valuation of PHEVs, BEVs, and FCEVs is their long list of questions and concerns (more than any single question or concern), is borne out by the cluster analysis done on these respondents' motivations. The main distinction is between one cluster that appears *comparatively* unconcerned (scoring above average on three items, "unfamiliar ZEV technology," "purchase cost," and "limited fuel networks") and two other clusters that both have long lists of highly scored concerns. Both of these other clusters score a dozen (of a possible eighteen) different dis-motivations well above average. The two are distinguished from each other by one cluster's elevated concern for safety (vehicle safety and the safety of electricity or hydrogen) and the other's elevated concern for many things (of their twelve highly rated motivations against designing a PEV or FCEV, this group has the highest or only above average score for nine). The litany of concerns of both groups can be read in Figure 24.

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

Financial incentives alone do not overcome the barriers and "dis-motivations" of the people who do not already have a favorable valuation of PHEVs, BEVs, and FCEVs. Only 3% of those who did not design a PEV or FCEV strongly indicated that larger incentives—of the kind offered to them in the survey—would have changed their minds. Simply making the vehicles less expensive doesn't address the litanies of concerns and barriers, perceptual and real. Even for those who did design PHEVs, BEVs, and FCEVs, only 6% assigned the maximum value to the statement, "incentives made [a PEV or FCEV] too attractive to pass up." While awareness of federal incentives appears in the model of respondents' vehicle designs, awareness of New Jersey's own incentives does not—perhaps because to few respondents say they have heard New Jersey is offering incentives.

The one sign of a positive effect of incentives comes from the difference between the first and third design games: 17% 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 New Jersey choose the optional additional financial incentive (splitting on whether that incentive was for the vehicle or home charging/fueling), the primary effect on the New Jersey respondents is for incentives to reduce the upfront costs of acquiring a PEV or FCEV. It is not possible to know from this survey design the effect of the federal incentive alone; ostensibly in the absence of any greater incentive than the equivalent of the federal tax credit, the increase in the percentage of respondents willing to design a PEV or FCEV in the third game would have increased less than 17% from the first game.

Contextual constraints to PEVs and FCEVs? Measuring access to home charging/fueling

Lack of access to home charging/fueling is one of the motivations against designing a PEV or FCEV that earns a high score in two clusters. Combined, these two-thirds of respondents who do not design a PEV FCEV doubt they would be able charge a PEV or fuel an FCEV at home; 19% of those who don't design a PEV or FCEV assign the maximum possible score to the statement, "I can't charge a vehicle with electricity or fuel one with hydrogen at home." Despite this, variables related to home parking and charging do not enter the model, i.e., other variables appear to provide more power to explain respondents' vehicle designs than does access to charging at home.

Since data on self-assessments of whether people have access to electricity at their home parking location are not common (this study is likely the only source for any state in which it was conducted), such data would be difficult and expensive to use for home PEV infrastructure and PEV market development. Other, perhaps statistically less powerful but more available data may serve the purpose of identifying households who are more or less likely to already have access to electricity at their home parking and to be able to make it available if desired. However, none of these other variables, e.g., building type, ownership status, or availability of electricity and natural gas at the residence appears in the model of drivetrain types. Further, these other variables change our focus from the respondent (their self-evaluation of PEV charging or FCEV fueling access) to the physical context of their residence. The hazard is that by focusing now on, for example, owners of single family homes because they are most likely to be able to charge

PEVs at home, we miss the renter, the apartment dweller, or even the condominium owner who is favorably disposed toward PHEVs, BEVs, and FCEVs.

Descriptions of household vehicles and use

The only variable related to the households' present vehicles and travel that was related to their drivetrain design in the third design game is whether the respondent commutes to work in a household vehicle: those who do were more likely to design a PEV or FCEV than those who do not. The other variables related to the households' present vehicle and travel that are not in the model including vehicle purchase price, fuel spending, distances travelled, variability of daily travel, and the households' propensity to maintain strict assignments of vehicles to particular drivers vs. flexibility in who drives which vehicles.

Absence of Socio-economic and demographic descriptors of respondents

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

CONCLUSIONS

Given the estimate that the survey respondents in New Jersey who design their next new vehicle to be a PHEV, BEV, or FCEV represent approximately 220,000 households who likely have a similar positive valuation, these conclusions review who those survey respondents are, why they have positive valuations of PHEVs, BEVs, or FCEVs, why many of their fellow New Jerseyans do not, and what these conclusions suggest for building ZEV markets.

Who is in the New Jersey Sample of New Car Buyers?

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 New Jersey sample looks very similar to the total sample from all states. The largest difference between the NJ sample and the total sample of survey respondents is the gender split and age distribution. There are a few more women in the NJ sample than in the overall sample (or in the NJ population). However, gender does not enter as an important explanatory concept in the valuation of PHEVs, BEVs, and FCEVs by the NJ sample. The NJ sample has slightly more people in the age categories from 50 to 69 years old. Again, age does not enter the explanatory model.

The number and age of vehicles owned by the NJ sample are similar the total sample, but the NJ sample is slightly more likely to own more and newer vehicles than the total sample. The New Jersey respondents are also much more likely (26%) to have leased household vehicles than is the total sample (17%). On average, these NJ new car buyers paid the same amount for their most recently acquired new vehicle as did the total sample: the median price was $26,000. As with the total sample, almost all the vehicles owned by the NJ sample are fueled by gasoline. None of these measures are in the final model of PEV and FCEV valuation.

Countervailing differences between the New Jersey sample of new car buyers and the total sample make it difficult to assess whether the New Jersey sample is more or less likely to be able to charge a PEV or fuel an FCEV at home. The New Jersey sample may be more likely to be able to fuel a PEV or FCEV at home because they are slightly more likely to own their residence (83%, compared to 80% in the total sample) and more likely to reside in a single family home—and thus slightly more likely to live in a single family home they own (69% in NJ sample, 63% in the total sample. However, the New Jersey sample is less likely to be able to park a vehicle in garage or carport attached to their residence and less likely to have any electrical service at the location they do park.

What are Their Prior Notions about PHEVs, BEVs, and FCEVs?

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

In New Jersey a majority—similar to the majority for the total sample—selects electricity as a likely replacement for gasoline and diesel. Reasons given include it has "already been proven to be effective" and "it is best for the environment." Natural gas was a distant second with only half as many people selecting it as electricity. Hydrogen fared even worse, selected by less than one-third as many people as selected electricity.

Concerns for air quality are higher in NJ than in the total sample; belief in climate change is similar. Respondents from NJ on average are more likely to agree that air quality represents a health threat in their region, are as likely as the total sample to agree that they personally worry about air quality, and to agree that changes in individual lifestyle have much affect. The percentage of NJ respondents (58%) who believe, "Human-caused climate change has been established to be a serious problem and immediate action is necessary" is virtually the same as for the total sample (57%).

Overall, prior awareness, familiarity, and experience—measured in the survey before valuation is assessed—of HEVs, PHEVs, BEVs, and FCEVs is so low that the reasonable assumption is most new car buyers' prior evaluations of these vehicle types are based largely on ignorance. BEV name recognition is lower in New Jersey than in most other states for which this analysis has been completed: 25% of the sample provides a correct make-model name of a vehicle that is a BEV or comes in a BEV variant. The New Jersey sample is comparable to other states in the extent to which correct responses are dominated by only two vehicles: 93% of all correct names are either Nissan Leaf or Tesla. Asked to rate their familiarity with HEVs, PHEVs, BEVs, and FCEVs, 20% (HEVs) to 40% (FCEVs) of respondents say they are unsure or decline to answer. Of those who do respond, the mean familiarity scores are low: compared to a mean score (on a scale from -3 to 3) of 2.45 for conventional vehicles, mean familiarity scores range from 1.27 (HEVs) to -0.88 (FCEVs). If respondents are "familiar enough with these types of vehicles to make a decision about whether one would be right for [their] household," that familiarity was not gained through actual experience with any PEV or 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 NJ respondents decrease from -1.90 (HEVs), to -2.41 (BEVs) and -2.45 (PHEVs), to -2.56 (FCEVs). The median scores for all four are equal to or less than -2.79. While this might be expected, the NJ respondents confirm few of them have any actual experience driving a PEV or FCEV.

The percentage of the new car buyers in New Jersey who have heard the federal government "is offering incentives for consumers to buy vehicles that are powered by alternatives to gasoline and diesel" (41%) is slightly lower than in the total sample (44%). The percentages of those who claim to be aware other entities are offering incentives are far lower for those entities including states, cities, electric utilities, and automotive manufacturers. For state incentives in particular, few in the sample (9%) claim to have heard New Jersey offers any.

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, New Jersey is behind all the states in this study: only 27% of NJ respondents claim to have seen a PEV charger in parking facilities they use, half as many as in the total sample.

PEV and FCEV Valuation: Vehicle Designs

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

Slightly less than one-fourth of the NJ respondents design their next new vehicle to be a PHEV (14.2%), BEV (6.1%), or FCEV (3.4%). HEVs (37.7%) are nearly as common as ICEVs (38.7%) in the design game results. The distribution of drivetrain types created by the NJ sample differs from that of the total sample: broadly speaking, the NJ sample is less likely to design their next new vehicle to be a PEV or FCEV. The differences between the distributions are statistically significant at $\alpha = 0.001$.

PHEV Designs

- PHEV designs emphasized longer range driving on electricity, but in a mode in which gasoline is used too, i.e., more "assist PHEV" designs rather than all-electric PHEV designs.
- Faster charging at home or at an (initially limited) network of quick chargers is not viewed as necessary by most who design a PHEV
    - Only 22% of those who design a PHEV indicate they want the fastest charging offered at home; only 34% incorporate quick-charging capability (away-from-home).

BEV Designs

- BEV designs incorporate driving ranges from across the spectrum of offered options, i.e., 50 to 300 miles.
    - A bit more than a third (37%) design BEVs with ranges of 125 miles or less;
    - The balance of designs mostly incorporates the maximum proffered range of 300 miles.
- While the single most frequently selected charging speed would require the installation of a high-power EVSE (45%), most households (55%) believe they would be satisfied with a charging speed that could be supplied by existing household 110V or 220V electrical service.

FCEV Designs

- Range includes all three possible options (150, 250, and 350 miles), but by far the highest percentage opts for the longest range.
- Home H_2 refueling was included in most (82%) of FCEV designs.

Who Designs Their Next New Vehicle to be a PEV or FCEV?

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

- Respondent (and their household) Socio-economic and Demographics
  - None
- Household travel, characteristics of residence, vehicles, and travel
  - Whether respondent commutes to work in a household vehicle
  - Familiarity with ICEVs
- Attitudes related to policy goals: energy security, air quality, and global warming
  - Whether heard of federal incentives
  - Whether governments should offer consumers incentives for electricity and hydrogen
- Prior PEV evaluation and ZEV-specific attitudes
  - Prior belief whether hydrogen is a likely replacement for gasoline and diesel
  - Personal interest in ZEV technology
  - Driving experience in PHEVs
  - Seen public charging for PEVs
  - Assessment of the relative safety and reliability of PEVs and ICEVs
  - Whether would consider buying a PEV

Why do people design PHEVs, BEVs, or FCEVs?

- Highly rated motivations to design a PEV or FCEV are a mix of private and societal:
  - Private: Savings on (fuel) costs, interest in new technology, fun to drive, safer than a gasoline car, and convenient to charge at home.
  - Societal: Reducing personal effects on climate change, air quality, oil imports, and payments to oil producers
- There is little acknowledgement that incentives were important to their vehicle design
- These findings are robust across states and regions
  - Analyses in New Jersey, California, and the aggregate of all states other than California indicate the existence of clusters of respondents named by the authors as "ZEV-tech hedonists" and "Pro-social technologists."
  - Analyses across these states and regions indicate that interest in ZEV technology and fuel cost savings are pervasive regardless of other clusters in each state and region.

Those who design PHEVs, BEVs, or FCEVs can be described by three clusters distinguished by the motivations shared by the respondents in each cluster. Two clusters are motivated largely by private wants and desires; they score below average on all societal motivations. Of these two, one appears motivated only by fuel cost savings (the one motivation all three groups share). The other ("ZEV-tech Hedonists) is highly interested in ZEV technology and believes PHEVs, BEVs, or FCEVs will be fun, good looking, comfortable, safe cars that make the right impression on family and friends. The third cluster ("Pro-social technologists") shares high scores on all the pro-social issues (energy security, climate change, and air quality), as well as being very highly motivated to save on "fuel" and (to a lesser degree) their interest in ZEV technology.

Why don't people design PHEVs, BEVs, or FCEVs?

- The highest scoring motivations against designing PHEVs, BEVs, or FCEVs have to do with their inherent newness: limited charging and fueling networks, unfamiliarity with the technology, and high initial purchase price.
- Immediate, practical limits on the ability to charge a PEV at home as well as concerns about the overall reliability of electricity supply were highly rated motivations against PEVs.
- Concerns about driving range of BEVs and FCEVs, as well as the time required to charge PEVs, scored highly as reasons to not design a PEV or FCEV.
- Few acknowledged that greater incentives (of the kinds offered in the game) would have changed their minds.
- These generalizations are robust across states and regions in the study.

Three clusters of respondents who do not design PHEVs, BEVs, or FCEVs who share sets of motivations were identified. The highest-level distinction is between one cluster of people who share three concerns with the other two clusters: vehicle purchase cost, limited charging/fueling network, and the simple fact that PHEVs, BEVs, and FCEVs are unfamiliar technology. The other two groups are distinguished from the first by the sheer number of concerns they have. Though the precise lists of motivations against designing a PEV or FCEV differ between the two clusters, they share the distinction of scoring 12 of 17 possible items higher than the global average of all items. One group is more concerned with vehicle and "fuel" safety than the other. The other is distinguished by the extreme level of their concern: for nine of their twelve highly scored motivations against designing a PEV or FCEV they have either the only score above the global mean (cost of fuel, reliability, and "doesn't fit my lifestyle") or the highest score.

The Role of Government Incentives

Most of those who do not design a PEV or FCEV may be overwhelmed with a long list of concerns; a third to a fifth of respondents outright refuse to consider the idea. When asked about whether they have already considered vehicles powered by electricity or hydrogen, 20% of the NJ sample replies they *have not and would not* consider buying a vehicle powered by electricity, 32% *have not and would not consider* a vehicle powered by hydrogen, and 17% neither one. If an actual opposition (at present) seems a small portion of new-car buyers, incentives play an unacknowledged role in positive valuations of PHEVs, BEVs, and FCEVs or may not address the first problems 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. Offered financial purchase incentives and use incentives, respondents were far more likely to choose financial incentives.[28] Further, despite the

[28] Anyone designing a qualifying PEV or FCEV 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

dollar value being identical for both the vehicle and home charging, among those who choose a direct financial incentive, respondents split about two (vehicle) to one (home charger/fueler) 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 17% more respondents designed a PEV or FCEV in the third game. Most of those who committed to a PEV or FCEV design at any point in the survey had done so without incentives. There are few among those unwilling to design a PEV or FCEV who indicate that higher incentives would have changed their minds.

This doesn't mean incentives aren't important in the real world—there was a 17% increase in PEV and FCEV designs after incentives were introduced and full-size all-electric drive vehicles eliminated. The present financial incentives, such as the federal tax credits, are an important part of the "saving money" motivations some give for PHEVs, BEVs, and FCEVs. Incentives are routinely reported to be instrumental to explain differences in PEV sales between states: high in those with high incentives, lower otherwise. Whether or not individual survey respondents are willing to say incentives are affecting their choices, incentives have become part of the public discussion of PHEVs, BEVs, and FCEVs. Taking them away now erodes part of the "saving money" rationale for PHEVs, BEVs, and FCEVs.

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

2) Lack of knowledge and experience. The litany of questions and concerns that most respondents have about PHEVs, BEVs, 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.

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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.

Building a market

The New Jersey sample shows the same lack of general awareness and knowledge of PEVs as do the samples from other states. Given that, how do we use these results to build markets for PEVs? 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 PHEVs, BEVs, and FCEVs.

The attachment of societal goals such as reduced threats from energy insecurity, climate change, and air pollution to PHEVs, BEVs, and FCEVs by the survey respondents points to interest groups around those issues who may be enlisted in a broader campaign to market the idea of PHEVs, BEVs, and FCEVs—as much or more than any specific make and model of vehicle. (The latter being the purview of that vehicle's manufacturer.) Taking another tack, the constituency represented by the automotive enthusiast and consumer press was slow to see the consumer value of HEVs. Automotive reviews contemporaneous with the writing of this report indicate the potential for vehicles powered by electric motors to simply be the best available cars on many metrics including performance and other kinesthetic and aesthetic criteria.[29] The overlap of interest in new technology by clusters of respondents who demonstrate a positive valuation of PHEVs, BEVs, and FCEVs through their vehicle designs suggests messages about ZEV technology may bridge between the one cluster who is otherwise highly motivated by the societal goals of that technology and the other that is otherwise highly motivated by its performance capabilities.

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

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

APPENDIX A: POTENTIAL EXPLANATORY VARIABLES

The table summarizes statistical associations between the dependent variable, i.e., the design of the drivetrain in the third design game, and several possible independent variables previewed in the previous section. In general, a threshold of $\alpha = 0.05$ 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 PEV or FCEV than are households with fewer vehicles. (More experimentation with vehicle types, more body styles in household fleet to accommodate a variety of driving missions, spending more money on vehicles.)	H_o accepted: No significant relationship.
Number acquired as new since 2008	H_a: Households who have acquired more new vehicles since 2008 are more likely to design a PEV or FCEV. (More experimentation with vehicle types, more body styles in household fleet to accommodate a variety of driving missions, spending more money on vehicles.)	H_o accepted: No significant relationship.
Price paid for most recently acquired as new	H_a: Households who spent more are more likely to design a PEV or FCEV. (Spending more money on vehicles.)	H_o accepted: No significant relationship.
Respondent's vehicle's monthly miles	H_{a1}: Households who drive farther per month are more likely to design a PEV or FCEV. (Lower "fuel" prices of electricity may be attractive.) H_{a2}: Households who drive less per month are more likely to design a PEV 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: However, the result is sensitive to a few very high mileage households. Without those households, the apparent strength of the correlation is less.
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 accepted: No significant relationship.
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 accepted: No significant relationship.
Household total fuel cost	H_a: Households who spend more on fuel for their whole fleet of vehicles will be more likely to design a PEV or FCEV. (Lower "fuel" prices of electricity may be attractive.)	H_o accepted: No significant relationship.
Accuracy of total fuel cost	H_a: Households that know their fuel spending	H_o accepted: No significant

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	more accurately will be more likely to design a PHEV, BEV or FCEV. (Lower “fuel” prices of electricity may be attractive.)	relationship.
Replacement for gasoline and diesel: electricity	H_a: Households who are already inclined to believe that electricity is a likely replacement for gasoline and diesel will be more likely to design a PHEV or BEV. (Predisposition toward electricity; may have already spurred search for information.)	H_o rejected: If already inclined to believe electricity will replace gasoline and diesel, then more likely to design anything but ICEV or FCEV.
Replacement for gasoline and diesel: hydrogen	H_a: Households who are already inclined to believe that hydrogen is a likely replacement for gasoline and diesel will be more likely to design a PHEV or BEV. (Predisposition toward hydrogen; may have already spurred search for information.)	H_o rejected: If already inclined to believe hydrogen will replace gasoline and diesel, then more likely to design anything but ICEV or PHEV.
Replacement for gasoline and diesel: natural gas	H_a: Households who are already inclined to believe that hydrogen is a likely replacement for gasoline and diesel will be more likely to design a PHEV or BEV. (Predisposition toward hydrogen; may have already spurred search for information.)	H_o rejected: If already inclined to believe natural gas will replace gasoline and diesel, then more likely to design BEV or FCEV.
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 PEV. (Flexibility is a tool to adapt to short range.)	H_o rejected: Those with more flexibility are more likely to design a PEV. Statistical test is suspect because of small sample size.
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 PEV or PHEV. (Perceived time savings may be a powerful incentive to design a qualifying vehicle.)	H_o accepted: No significant relationship.
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 PEV or PHEV. (Perceived cost savings may be an incentive to design a qualifying vehicle.)	H_o rejected, if those respondents with an exemption or for whom someone else pays the toll are excluded (due to small sample size): those who travel on roads with tolls are less likely to design an ICEV.
Daily distance variation	H_a: Respondents with less variation in their daily travel will be more likely to design a PEV. (Greater variability may make it more difficult to imagine adapting to a limited range vehicle.)	H_o accepted: No significant relationship.
Commute to a workplace	H_a: Respondents who commute to work will be more likely to design a PEV or FCEV. (Greater regularity of travel and possibility of	H_o rejected: those who commute are more likely to design a PEV or FCEV.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	workplace charging may make it easier to adapt to a PEV and FCEV. May also be income and/or age correlated.)	
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 PEV or FCEV. (Certainty of parking location.)	H_o rejected, H_a supported: Households who park a vehicle in a garage or carport attached to their residence are more likely to design a PEV or FCEV
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: Access to higher levels of electrical is associated with lower likeliness to design an ICEV and higher to design a PEV or FCEV.
Electricity installation authority	H_a: Respondents with the authority to make installations at their residence are more likely to design a PHEV or BEV. (Don't require permission from a property manager, landlord, or lender.)	H_o accepted: No significant relationship.
Home natural gas	H_a: Respondents with access to natural gas are more likely to design an FCEV. (Access to natural gas for hydrogen reforming for home hydrogen fueling.)	H_o accepted: No significant relationship.
Familiarity with gasoline vehicles	H_{a1}: Increasing familiarity with gasoline vehicles is associated with a *lower* likeliness to design an HEV, PEV 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, PEV or FCEV. (Familiarity with the present vehicle type produces an attraction toward alternatives.)	H_o rejected, H_{a1} supported: Higher familiarity with ICEVs is associated with a lower likeliness to design one; the countervailing increase is in the likeliness of designing an HEV.
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, PEV or FCEV. (Familiarity with the alternative vehicle type produces an attraction toward alternatives.)	H_0 rejected: H_{a2} supported partially: Higher familiarity associated with lower likeliness to design an ICEV, but increased likeliness appears to be stronger for HEVs than PEVs.
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	H_o rejected. Lower comparative risk of electricity is associated with lower likeliness to design an

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	or BEV. (Desire to reduce environmental and health risks associated with their travel.)	ICEV—and an FCEV.
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 BEV. In general, driving experience with HEVs, PHEVs, and FCEVs associated with higher likeliness to design a PEV.
Driving experience: PHEV + BEV + FCEV	H_a: Similar to above, but an effort to see if combined experience across multiple vehicle types matters as much or more than experience with any one type.	H_o rejected: Higher combined experience driving PHEVs, BEVs, and FCEVs is associated with a lower likeliness of designing an ICEV and higher likeliness to design a PEV.
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 lower likeliness to design an ICEV.
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.
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 accepted: No correlation between relative purchase price of PEVs and ICEVs and the likeliness of designing either.
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	H_a: Stronger agreement associated with *lower*	H_o rejected: Stronger agreement

Independent (Explanatory) Variable	**Alternate Hypothesis (Rationale)**	**Bivariate Statistical Relationship to Dependent Variable: Drivetrain design**
powered cars are more reliable than electric vehicles."	likeliness to design a PEV.	associated with higher likeliness to design an ICEV.
Overall PEV Impression: Sum (with proper attention to the valence of the original statement) of the seven variables just describing respondent's impression of PEVs.	H_a: Attempt to measure the effect of an overall evaluation of PEVs; higher score will be associated with higher likeliness to design a PEV. Positive scores = positive impression. Simple summing treats all dimensions as equally valuable.	H_o rejected: Higher scores, i.e., more pro-PEV evaluation of PEVs, are associated with lower likeliness to design an ICEV and a higher likeliness of designing a PEV.
Three factor solution to a factor analysis of the seven dimensions of prior PEV evaluation	H_a: Attempt to measure the effect of an overall evaluation of PEVs, the factor analysis searches for a smaller number of factors that summarizes the seven dimensions of PEV evaluation.	All three factors correlated to drivetrain design: Factor 1: charge time and range Factor 2: safety and reliability Factor 3: charging public and home
FCEV public refueling: "There are enough places for drivers to refuel their cars and trucks with hydrogen."	H_a: Stronger agreement associated with higher likeliness to design an FCEV.	H_0 rejected: Stronger agreement there are enough places to refuel FCEVs associated with higher likeliness to design an FCEV.
FCEV fueling time: "Hydrogen fuel cell vehicles take too long to refuel."	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o accepted: No significant effect.
FCEV range: "Hydrogen fuel cell vehicles do not travel far enough without needing to be refueled."	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o rejected: Stronger agreement that FCEV range is too short associated with higher likeliness to design an ICEV.
FCEV purchase price: "Hydrogen fuel cell vehicles cost more than gasoline cars. |:	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o accepted: No significant effect.
FCEV safety: "Gasoline vehicles are safer than hydrogen fuel cell vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o rejected: Decreasing confidence in the relative safety of hydrogen compared to gasoline is associated with a higher likeliness to design an ICEV.
FCEV reliability: Gasoline vehicles are more reliable than hydrogen fuel cell vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design an FCEV.	H_o rejected: Decreasing confidence in the relative safety of hydrogen compared to gasoline is associated with a higher likeliness to design an ICEV.
Overall FCEV Impression: Sum of the six variables describing respondent's impression of PEVs.	H_a: Attempt to measure the effect of an overall evaluation of FCEVs; higher score will be associated with higher likeliness to design an FCEV. Positive scores = positive impression.	H_o rejected: More positive overall impression of FCEV associated with higher likeliness to design one.

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	Simple summing treats all dimensions as equally valuable.	
Three factor solution to the factor analysis of the six dimensions of FCEV evaluation	H_a: Attempt to measure the effect of an overall evaluation of FCEVs, the factor analysis searches for a smaller number of factors that summarizes the seven dimensions of PEV evaluation.	H_o rejected, two of three factors associated with drivetrain type: Factor 1 (safety-reliability) and Factor 3 (range and purchase price) associated with a higher likeliness to design an ICEV. (High factor scores indicate (Factor 1) gasoline is safer or more reliable and (Factor 3) FCEV range is too short and prices higher than ICEVs.
Incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel:	For each entity, H_a: Those already aware of incentives will be more likely to design a qualifying vehicle.	
Federal government.		H_o rejected: Prior belief federal government offers incentives associated with higher likeliness of designing a PEV or FCEV.
State government		H_o rejected: Prior belief states are offering incentives associated with higher likeliness to design PEVs and FCEVs, PHEVs especially.
My state government (New Jersey)		H_o accepted: No significant effect.
Should governments offer incentives	H_a: Those who believe governments should offer incentives will be more likely to design a PEV or FCEV. (To the extent PHEVs, BEVs, and FCEVs 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 PEVs	H_{a1}: Higher levels of consideration of PEVs prior to completing the survey will be associated with *higher* likeliness of designing a PEV. (PEVs are making a *favorable* impression on more consumers than not.) H_{a2}: Higher levels of consideration of PEVs prior to completing the survey will be associated with *lower* likeliness of designing a PEV. (PEVs are making a *unfavorable* impression on more consumers than not.)	H_0 rejected, H_{a1} supported: Those who have given greater prior consideration to buying a PEV are more likely to design a PEV or FCEV. The three 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_0 rejected, H_{a1} supported: Those who say they have not and will not consider FCEVs are more likely to design ICEVs. The three categories of greatest

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	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* impression on more consumers than not.)	levels of consideration have been collapsed into a single category because of small numbers of people in each.
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 PEV 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 PEV or FCEV. (To the extent PHEVs, BEVs, and FCEVs 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 PEV 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 PEV 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 PEV 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 PEV 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 PEV 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 PEV.
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 PEV or FCEV.	H_o rejected: Stronger agreement that global warming is human-caused is associated with lower likeliness to design an ICEV.
Own or rent residence	H_a: Respondents who own their residence will	H_o accepted: No significant

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

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	be more likely to design a PEV or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	

APPENDIX B: RESPONDENT VALUATION OF PHEVS, BEVS, AND FCEVS

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

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

Table B1: Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	143.09	72	286.1879	<0.0001
Full	498.19			
Reduced	641.28			

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

Table B2: Goodness of fit measures

Measure	Training	Definition
Entropy RSquare	0.223	1-Loglike(model)/Loglike(0)
Generalized RSquare	0.475	(1-(L(0)/L(model))^(2/n))/(1-L(0)^(2/n))
Misclassification Rate	0.439	∑ (ρ[j]≠ρMax)/n
N	494	

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	1900	498.19	996.38
Saturated	1972	0.00	**Prob>ChiSq**
Fitted	72	498.19	1.00

Table B4: Effect Likelihood Ratio Tests

Source	Number of parameters	DF	L-R ChiSquare	Prob > ChiSq
Personal interest in ZEV tech	12	12	24.98	0.01
Previously Consider a PEV	12	12	37.66	0.00
Should government offer incentives	16	16	28.72	0.03
Incentives: Federal	8	8	15.62	0.05
Prior PEV Factor2: safety reliability	4	4	21.43	0.00
Driving Experience Factor1: PHEVs	4	4	13.31	0.01
Seen Public EVSEs: yes/no	4	4	7.95	0.09
Familiarity Factor 3: ICEV	4	4	19.06	0.00
Commuter	4	4	10.19	0.04
Replacement: Hydrogen	4	4	11.16	0.02

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	ChiSquare	Prob>ChiSq
Intercept ICEV	2.823	1.210	5.440	**0.020**
Personal interest in ZEV tech [A little interested-Not interested]	-0.261	1.295	0.040	0.840
Personal interest in ZEV tech [Interested-A little interested]	-0.597	0.867	0.470	0.492
Personal interest in ZEV tech [Very interested-Interested]	-1.171	0.844	1.920	0.166
Previously Consider PEV [I (we) have not and would not consider buying a vehicle that runs on electricity]	1.073	0.727	2.180	0.140
Previously Consider PEV [I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will]	0.663	0.576	1.320	0.250
Previously Consider PEV [The idea has occurred, but no real steps have been taken to shop for one]	-0.674	0.505	1.780	0.182

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Should government offer incentives [I'm not sure]	-0.015	0.786	0.000	0.985
Should government offer incentives [No, neither one]	-0.284	0.699	0.160	0.685
Should government offer incentives [Yes, but only electricity]	0.645	0.984	0.430	0.512
Should government offer incentives [Yes, but only hydrogen]	-0.797	0.956	0.690	0.405
Incentives: Federal [I'm Not Sure]	0.065	0.469	0.020	0.890
Incentives: Federal [No]	-0.668	0.457	2.140	0.144
Prior PEV Factor2: safety reliability	0.383	0.443	0.750	0.387
Driving Experience Factor1: PHEV	-0.909	0.298	9.280	**0.002**
Seen Public EVSEs yes/no [No]	0.194	0.371	0.270	0.601
Familiarity Factor3 ICEV	-1.077	0.578	3.480	**0.062**
Commute [No]	0.946	0.439	4.630	**0.031**
Replacement: Hydrogen [No]	0.795	0.360	4.880	**0.027**
Intercept HEV	2.951	1.204	6.000	**0.014**
Personal interest in ZEV tech [A little interested-Not interested]	-0.421	1.300	0.110	0.746
Personal interest in ZEV tech [Interested-A little interested]	0.181	0.855	0.040	0.832
Personal interest in ZEV tech [Very interested-Interested]	-1.555	0.789	3.880	**0.049**
Previously Consider PEV [I (we) have not and would not consider buying a vehicle that runs on electricity]	-0.032	0.728	0.000	0.965
Previously Consider PEV [I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will]	0.355	0.568	0.390	0.532
Previously Consider PEV [The idea has occurred, but no real steps have been taken to shop for one]	-0.131	0.482	0.070	0.786
Should government offer incentives [I'm not sure]	-0.018	0.787	0.000	0.982
Should government offer incentives [No, neither one]	-0.625	0.696	0.800	0.370

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Should government offer incentives [Yes, but only electricity]	1.115	0.965	1.340	0.248
Should government offer incentives [Yes, but only hydrogen]	-1.404	0.971	2.090	0.148
Incentives: Federal [I'm Not Sure]	-0.032	0.462	0.000	0.945
Incentives: Federal [No]	-0.707	0.442	2.560	**0.110**
Prior PEV Factor2: safety reliability	-0.081	0.422	0.040	0.848
Driving Experience Factor1: PHEV	-0.745	0.269	7.650	**0.006**
Seen Public EVSEs yes/no [No]	-0.205	0.362	0.320	0.572
Familiarity Factor3 ICEV	-0.200	0.579	0.120	0.731
Commute [No]	0.909	0.437	4.330	**0.037**
Replacement: Hydrogen [No]	0.769	0.339	5.150	**0.023**
Intercept PHEV	-2.353	309.915	0.000	0.994
Personal interest in ZEV tech [A little interested-Not interested]	-0.311	1.380	0.050	0.822
Personal interest in ZEV tech [Interested-A little interested]	0.706	0.897	0.620	0.431
Personal interest in ZEV tech [Very interested-Interested]	-0.648	0.829	0.610	0.434
Previously Consider PEV [I (we) have not and would not consider buying a vehicle that runs on electricity]	-0.063	0.799	0.010	0.937
Previously Consider PEV [I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will]	0.479	0.603	0.630	0.427
Previously Consider PEV [The idea has occurred, but no real steps have been taken to shop for one]	-0.195	0.515	0.140	0.705
Should government offer incentives [I'm not sure]	2.010	309.913	0.000	0.995
Should government offer incentives [No, neither one]	2.277	309.913	0.000	0.994
Should government offer incentives [Yes, but only electricity]	4.710	309.914	0.000	0.988

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Should government offer incentives [Yes, but only hydrogen]	-13.047	1239.649	0.000	0.992
Incentives: Federal [I'm Not Sure]	0.235	0.491	0.230	0.633
Incentives: Federal [No]	-0.887	0.489	3.290	**0.070**
Prior PEV Factor2: safety reliability	-0.790	0.449	3.100	**0.078**
Driving Experience Factor1: PHEV	-0.399	0.277	2.080	0.149
Seen Public EVSEs yes/no [No]	0.038	0.384	0.010	0.921
Familiarity Factor3 ICEV	-0.468	0.600	0.610	0.435
Commute [No]	0.584	0.454	1.650	0.198
Replacement: Hydrogen [No]	1.223	0.382	10.250	**0.001**
Intercept BEV	-0.369	1.618	0.050	0.820
Personal interest in ZEV tech [A little interested-Not interested]	0.519	1.701	0.090	0.760
Personal interest in ZEV tech [Interested-A little interested]	0.102	0.987	0.010	0.917
Personal interest in ZEV tech [Very interested-Interested]	-0.443	0.885	0.250	0.617
Previously Consider PEV [I (we) have not and would not consider buying a vehicle that runs on electricity]	-0.089	0.910	0.010	0.923
Previously Consider PEV [I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will]	-0.617	0.741	0.690	0.405
Previously Consider PEV [The idea has occurred, but no real steps have been taken to shop for one]	0.273	0.566	0.230	0.630
Should government offer incentives [I'm not sure]	0.444	0.972	0.210	0.648
Should government offer incentives [No, neither one]	-1.007	0.925	1.180	0.277
Should government offer incentives [Yes, but only electricity]	0.232	1.138	0.040	0.838
Should government offer incentives [Yes, but only hydrogen]	-0.545	1.231	0.200	0.658

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Incentives: Federal [I'm Not Sure]	-1.125	0.628	3.210	**0.073**
Incentives: Federal [No]	-0.214	0.543	0.150	0.694
Prior PEV Factor2: safety reliability	-0.510	0.478	1.140	0.286
Driving Experience Factor1: PHEV	-0.627	0.308	4.130	**0.042**
Seen Public EVSEs yes/no [No]	-0.085	0.412	0.040	0.836
Familiarity Factor3 ICEV	-0.553	0.654	0.720	0.398
Commute [No]	0.774	0.474	2.660	**0.103**
Replacement: Hydrogen [No]	0.875	0.408	4.590	**0.032**

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	• Air pollution a personal risk

Washington	
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 PEV or FCEV Evaluation and Experience; ZEV-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: PEV 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