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

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We'd like to thank the households who participated in the research reported here, especially those who invited us into their homes to complete follow-up interviews to their survey responses.

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

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 York and Comparative Analyses.
    a. As part of this comparative analysis, Appendix C is added to the document.
3. Population level estimates of numbers of households with positive PEV valuations are added to the results.
4. Discussion and conclusions are added to reflect these changes.
5. Cleaned up the use of acronyms referring to technology (PHEV, BEV, PEV, and FCEV) and regulatory (ZEV) definitions of vehicle drivetrain types throughout the document.
    a. Acronyms referring to specific drivetrain types, i.e., PHEV, BEV, and FCEV, will be used where a specific technology is being described or respondents' vehicle designs are being described.
        i. The acronym PEV is used to refer to PHEVs and BEVs collectively when the distinction between the two is not essential, but the grouping of vehicles that charge from the grid is germane.
    b. The acronym ZEV is reserved for discussion of policy, whether those discussions are of ZEV policies or the other environmental and energy goals that are the aim of ZEV policies. ZEV will also be used refer to experts—policy, engineering, research, or otherwise—to distinguish their roles from the respondents'.
6. Addressed comments and questions provided by NYSERDA in response to the original draft.
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.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

INTRODUCTION

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

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

This study has three objectives:

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

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

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

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

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

BACKGROUND

This background information describes the status of ZEV policy, PEV and FCEV marketing, and charging/fueling infrastructure as it pertains to New York as of the date of the on-line survey that provides the primary data for this study: December 2014.

A Multistate ZEV Policy Framework

In an attempt to improve local air quality and reduce the emissions that contribute to climate change, New York has adopted California's ZEV mandate requiring manufacturers of passenger cars and light trucks to sell a certain percentage of new vehicles sales (or leases) as ZEVs. In addition to New York, the states of Connecticut, Maine, Maryland, Massachusetts, New Jersey, Oregon, Rhode Island and Vermont have adopted these standards. ZEVs are any vehicle that releases zero emissions during on-road operation. They include BEVs and FCEVs. Other vehicle types, such as 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, i.e., low-speed 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 ten ZEV mandate states signed a memorandum of understanding (MOU) that included a ZEV Program Implementation Task Force (Task Force). This Task Force published a ZEV Action Plan (Plan) in May 2014. The Plan listed 11 priority actions, including deploying at least 3.3 million ZEVs—roughly 15% of new vehicle sales in the collective region of the signatory states—as well as adequate fueling infrastructure, both by the year 2025.

New York State ZEV Policy and Incentives

New York state ZEV drivers qualify for the federal tax incentive appropriate for their vehicle. Additional state programs, whether pilot or permanent at the time of this study, include:

1) Clean Pass Program allows HOV lane exemption for HEVs, PHEVs, and BEVs on the Long Island Expressway[3], although created in March 2006 with an expected one-year pilot program, it continues without an anticipated end date;
2) 10% discount on established E-ZPass accounts (E-ZPass offers reduced tolls and shorter wait times at tolling facilities);
3) Alternative Fuel Vehicle Recharging Tax Credit provides a tax credit of up to $5,000 for 50% of the cost to purchase and install alternative fuel vehicle refueling (including hydrogen) and electric vehicle recharging property. This is currently available to

[3] List of eligible vehicles is at: https://www.dot.ny.gov/portal/page/portal/programs/clean-pass?nd=nysdot

transportation and transmission corporations, cooperative agricultural corporations, and general business corporations. At present the tax credit is available through 12/31/2017;

4) Alternative fuel vehicle toll incentive of $6.25 toll rate during off-peak hours at Port Authority crossings, compared to the normal off-peak rate of $9.75;
5) Emissions inspection exemption for vehicles that run exclusively on electricity;
6) State and Use Tax Exemption for Alternative Fuels which exempts E85, compressed natural gas, and hydrogen from state sales and use tax when used exclusively to power a motor vehicle; and
7) Plug-in Electric Vehicle rate reduction for residential ConEdison customers (applies to electricity used during the designated off-peak period).

Per the US Department of Energy's Alternative Fuels Data Center, there were 476 electric stations and 1,064 charging outlets in the state.[4] New York State exempts hydrogen from state sales and use taxes, but there are no locations selling hydrogen for fuel cell vehicles. Further, it appears that in New York state incentives for the installation of hydrogen refueling and the purchase of fuel cell vehicles expired 31 December 2014.[5] New York has the fifth most PEV charging stations in the country and the most in the northeast.[6] Charge NY, an initiative of the NY Power Authority and the NY State Energy Research and Development Authority, aims to create a statewide network of up to 3,000 public and workplace charging stations over the next five years. During this time they also strive to place up to 40,000 ZEVs on the road.[7]

As one local initiative, New York City Council passed a law in December 2013 requiring 20% of any parking spaces in new construction of open lots and garages be ready for PEV charging and older lots be upgraded to allow PEV charging. Retail parking is exempt.[8]

According to an analysis of New York state vehicle registration data from May 2015, the top 10 brands of PEVs registered in the state were: Tesla (1,399), Nissan (535), Smart (198), Honda (123), Ford (89), Toyota (88), BMW (88), Mercedes (41), Mitsubishi (30), and Volkswagen (24).[9] As of June, 2015, 25% of the PEVs sold or leased in New York were BEVs and 75% were PHEVs, compared with the national average of 47% BEVs and 53% PHEVs sold or leased.[10]

[4] http://www.afdc.energy.gov/fuels/electricity_locations.html
[5] http://www.empirecleancities.org/incentives/
[6] http://www.lohud.com/story/news/local/westchester/2015/02/07/department-energy-numbers-new-york-fourth-electric-car-charging-stations-nationwide/22886019)
[7] http://www.ny-best.org/page/ny-best-policy-update-cuomo-announces-installation-hundereds-electric-vehicle-charging-stations
[8] http://legistar.council.nyc.gov/LegislationDetail.aspx?ID=1501659&GUID=65344E17-4C65-4751-81E7-7A0D4DD9F7CD&Options=ID|Text|&Search=
[9] http://dccargeek.com/data-shows-tesla-dominates-new-york-ev-market/
[10] http://energy.gov/eere/vehicles/fact-877-june-15-2015-which-states-have-more-battery-electric-vehicles-plug-hybrids

STUDY DESIGN

The overall study design included an on-line survey (administered in all participating states) and follow-up interviews with a sub-set of survey respondents in California, Oregon, and Washington. A single survey was designed and implemented in all states. This foreclosed customizing the survey to the specific circumstances in each state, e.g., whether and which ZEVs were for sale, state and local policies to support or (intentionally or not) oppose ZEVs. The survey was conducted from December 2014 to early January 2015. This report will be limited to results for the State of New York from the on-line survey.

Online Survey Instrument Design

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

Respondents were asked to design their likely next new vehicle across a variety of conditions. Parameters that respondents manipulated in the game included: 1) drivetrain type (ICEV, HEV, PHEV, BEV, or FCEV), 2) driving range per refueling and/or recharging, 3) home vs. non-home recharging and refueling, 4) and time to recharge or refuel. Further, multiple rounds of designs were created while other variables are 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 evaluation of PEVs and FCEVs compared to ICEVs and HEVs. The games, in effect, provided a way for respondents to register whether they are presently willing for their next vehicle to be a PEV or FCEV within the boundaries of the game.

Sample

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

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

Eligibility to complete the survey was confirmed by the sample management firm according to criteria supplied by the Center. The screening criteria were as follows

- How many vehicles does the household currently own that it drives at least once per week?
    - Eligible participants must have at least one such household vehicle.
- Of these vehicles, how many did their household buy new or lease new in the last seven years, e.g. model year 2008 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 sample sizes were determined largely by the sample provider's ability to assure sample sizes from the population of new-car buying households in each state. The maximum achievable sample size was used; in the case of New York, the target sample size was n = 1,000. Though the initial sample was slightly over this target, elimination of a few cases in which reported data did not match the qualifying conditions for participation in the survey (typically respondents reported their own age as too young or it has been too long since the household purchased a new vehicle) resulted in a final sample size of 997 respondents.

Table 1: Survey sample size, by state

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

RESULTS: WHO ARE THE NEW CAR BUYERS IN THE NEW YORK 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 those PEV and FCEV valuations is presented in the subsequent section. The basic measure of the valuation is the vehicle design in the last (of up to three) design games. The rationale for this is explained at the start of the section on Respondents' Valuation of PEVs and FCEVs.

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

Socio-economics and demographics

- Overall, deviations of the NY sample from the total sample are small.

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 readily available data may explain PEV and FCEV valuation, as opposed to custom studies (such as this one). Further, early PEV buyers are predominately male, middle-aged, have higher household incomes, and are likely to possess graduate degrees. Understanding how new car buyers who don't fit this characterization think about ZEVs will be essential to growing markets. Comparisons are made to the total sample across all states, in lieu of a comparison to other samples of new car buying households in New York as no such samples are available to this study.

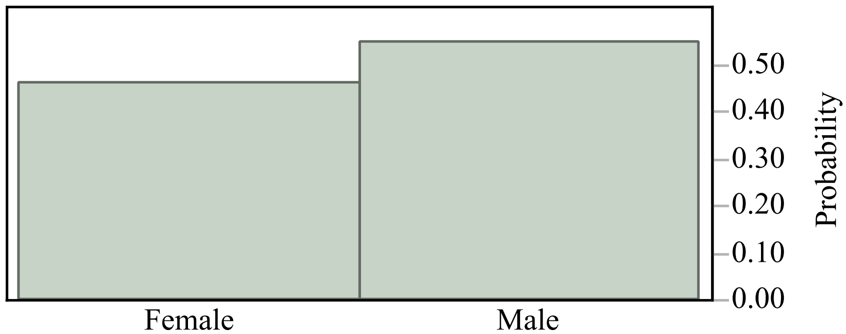
The NY respondents include more men than we would expect compared to the total sample of all participating states): 46% of the NY respondents were female; 52% of the total sample is female. Evidence from California's Clean Vehicle Rebate program and reports from vehicle manufacturers indicate that early PEV buyers have been disproportionately more likely to be male than female.

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

The age distribution of the NY and total samples are similar: in general both show 13 to 15% of respondents were age 19 to 29; then a (slight) modal value of 21 to 22% of respondents in the category 30 to 39 years old; followed by a broad plateau at 17 to 20% extending across the categories of 40 to 49, 50 to 59, and 60 to 69; the percentages drop of rapidly at higher ages. (The respondent age distribution shown is truncated to eliminate a few responses less than 19 years of age.)

> H_o: Respondents in different age groups will not differ in the probability they design their household's next new vehicle to be a PEV or FCEV.

Figure 1: NY Respondents' gender, percent

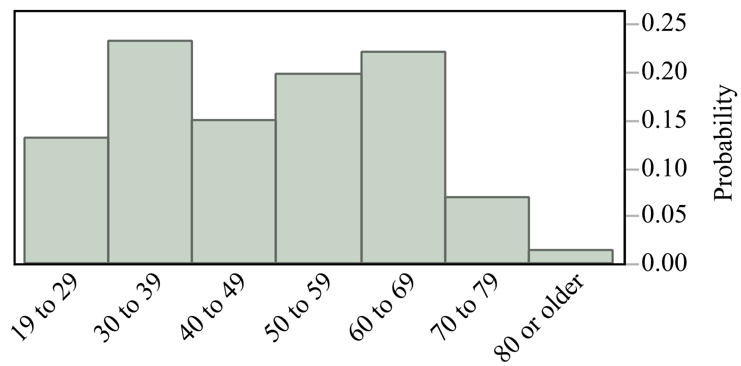


Frequencies

Level	Count	Prob
Female	454	0.45720
Male	539	0.54280
Total	993	1.00000

N Missing 4
2 Levels

Figure 2: NY Respondents Age



Frequencies

Level	Count	Prob
19 to 29	126	0.12831
30 to 39	226	0.23014
40 to 49	145	0.14766
50 to 59	193	0.19654
60 to 69	215	0.21894
70 to 79	65	0.06619
80 or older	12	0.01222
Total	982	1.00000

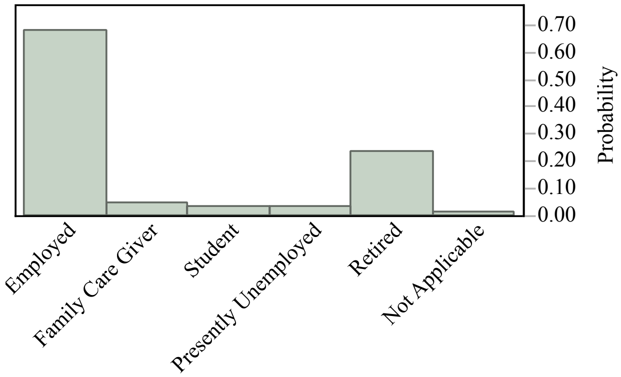
N Missing 15
7 Levels

The distribution of respondent's employment status appears similar between NY and the total sample; across both samples, 60 to 67% are employed in the paid labor force and about 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 23% of individual respondents in NY are retired, 30% of households contain at least one retired person. At the other end of the age scale, 69 percent of households report no children (persons younger than 19); the other 31 percent are split 12%/19%) as to whether the youngest reported member is younger than seven years old or is age seven to 18. All told, households range in size from one to eight or more members: most (80%) have one to four members.

Despite being a sample of households who had recently purchased a new vehicle, reported annual household incomes span from the lowest category (<$10k) to the highest (>$250k), though in NY there are more households reporting annual incomes >$200k (6.1%) than <$25k (4.2%). Compared to the total sample, the income distribution for NY is skewed slightly higher.

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

Figure 3: NY Respondents' Employment Status, percent

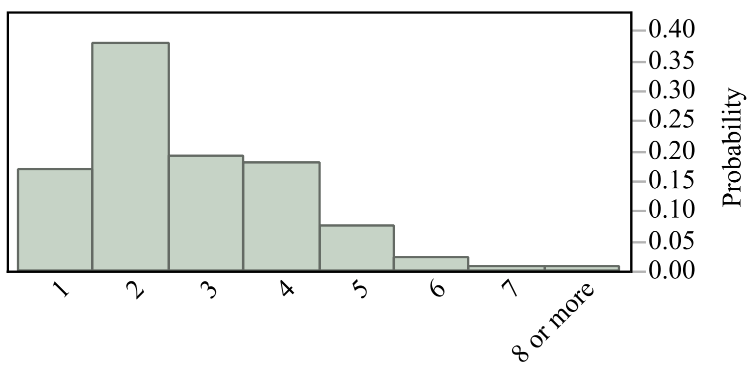


Frequencies

Level	Count	Prob
Employed	648	0.67220
Family Care Giver	37	0.03838
Student	25	0.02593
Presently Unemployed	29	0.03008
Retired	218	0.22614
Not Applicable	7	0.00726
Total	964	1.00000

N Missing 33
6 Levels

Figure 4: NY Respondents' Household Size, percent



Frequencies

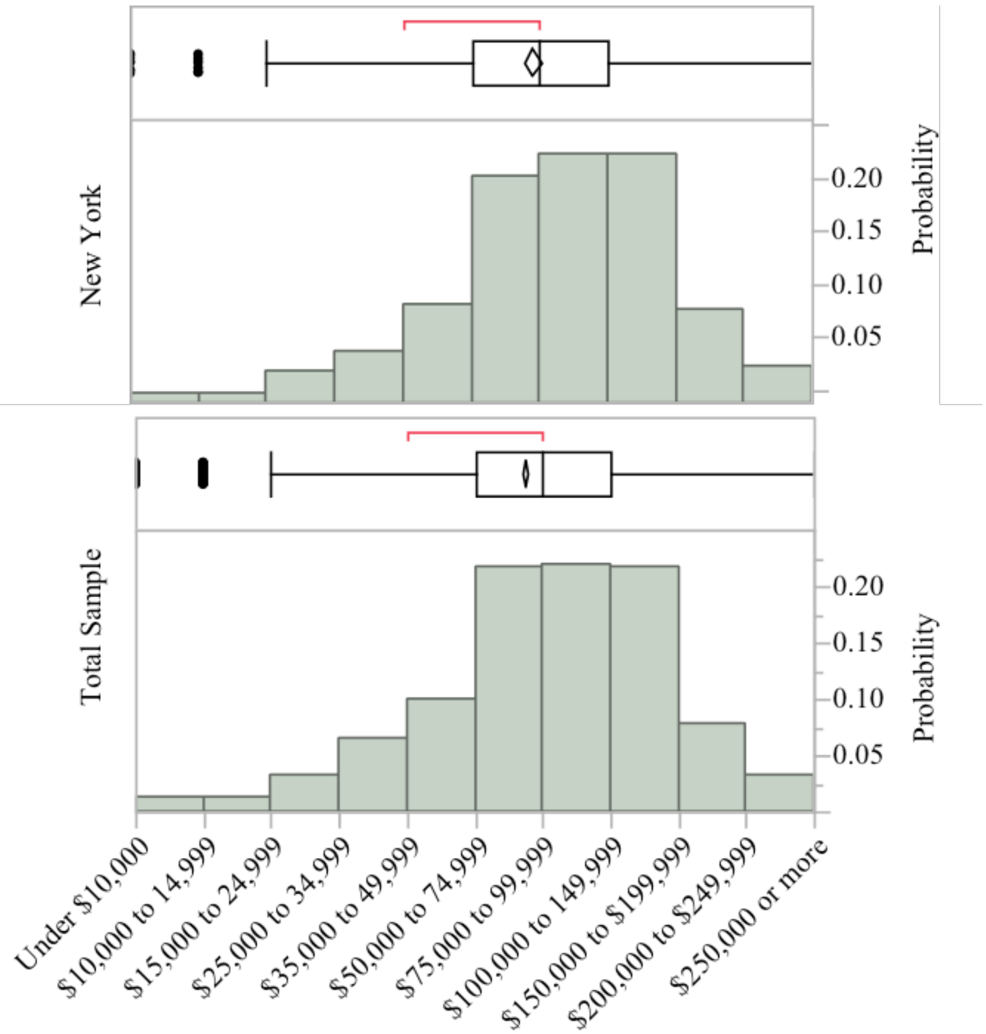
Level	Count	Prob
1	166	0.16650
2	374	0.37513
3	186	0.18656
4	175	0.17553
5	70	0.07021
6	19	0.01906
7	4	0.00401
8 or more	3	0.00301
Total	997	1.00000

N Missing 0
8 Levels

The distributions of respondents' highest education level are nearly identical except for the absence from the NY sample of anyone having less than a high school education—a level that has a very low probability (< 1%) in the total sample. The median for both samples is a college degree. 35 percent of the NY sample has some graduate level education or a graduate degree; the value for the total sample is 31%.

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

Figure 5: Annual Household Income, NY and Total Samples



To the extent that the policy drivers and social benefits of PEVs may be politicized—either because "environmentalism" is typified as a "liberal" cause or because many of the policies are the products of Democratic administrations (never mind that both the 1990s and present waves of ZEV policy making can be fairly said to have started under the administrations of three Republican governors in California)—we asked respondents their party affiliation. Political party affiliation is similar between the NY and total samples, though the NY sample has a slightly higher percentage of respondents who, "whether [they] are a member or not," most strongly identify with the Democratic Party than does the total sample (48% to 45%) and commensurately smaller percentage of who identify with the Republican Party (NY: 25%; total: 27%). The NY percentages are in keeping with the state report on political party registration in November 2014, immediately prior to this on-line survey.[11]

[11] http://www.elections.ny.gov/NYSBOE/enrollment/congress/congress_nov14.pdf

Prior Awareness, Knowledge, and Valuation of ZEVs

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

- 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; 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."

Likely replacements for gasoline and diesel fuel

- Electricity wins

The question was asked, "If for any reason we could no longer use gasoline and diesel to fuel our vehicles, what do you think would likely replace them?" Respondents could choose up to three fuels from this list: electricity, hydrogen, natural gas, ethanol, bio-diesel, propane, none, "I have no idea," and other. The response order was randomized across respondents. Most people are willing to stipulate at least one replacement: only 21% of the NY sample and 17% of the total sample answer "None" or "No idea. No single option was selected by a majority of New Yorkers, though electricity was by 50% of respondents (compared to 57% of the total sample).

Given respondents chose at least one replacement, they next pick the most likely one and provide a reason it is most likely. While the percent of people who select any single fuel must decline (since now the total percentage across fuels is now constrained to be 100%), the relative difference between electricity and all other options increases; comparatively more people think electricity is the most likely replacement fuel. Hydrogen (the fuel for FCEVs) fares poorly, selected by only 15% of respondents when they have up to three choices and only six percent when asked to pick the single most likely replacement for gasoline and diesel.

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

Reasons that distinguish electricity from other possibilities are that respondents are more likely to say electricity "has already [have] been proven to be effective" and "[be] best for the environment." (The "deviations" highlighted in bold in Table 2 have positive, large values compared to other deviations in the table.) Conversely, respondents are less likely to say, "[electricity] is safest for drivers." Hydrogen is in a three-way race with ethanol and "no idea" for the fourth most likely replacement (behind electricity, natural gas, and bio-diesel). The reason given disproportionately most often for hydrogen is that it "is safest for drivers." The "bio-fuels," bio-diesel and ethanol, are disproportionately motivated by "it will require the least amount of change for drivers and fuel providers."

Figure 6: NY Replacements for Gasoline and Diesel, percent selecting each response (up to three selections per respondent)

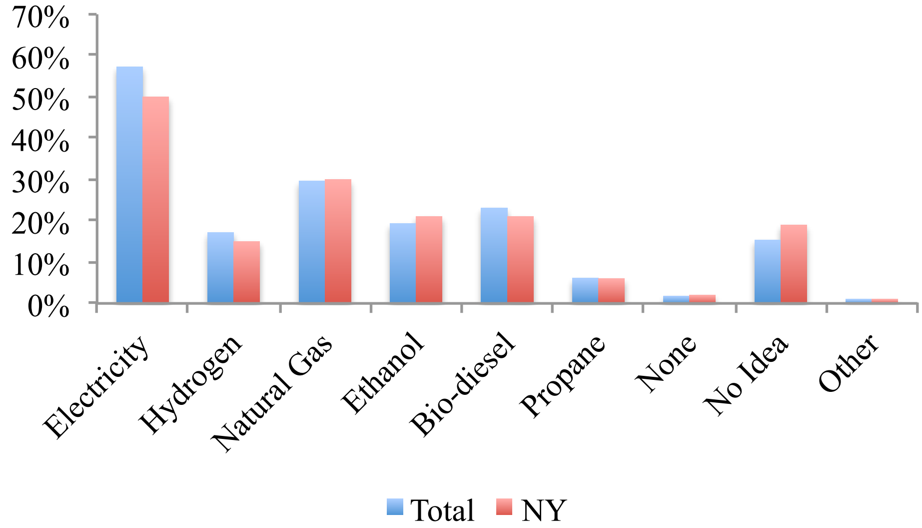


Table 2: NY Reason for Most Likely Replacement By Likely Replacement

Count Deviation	Bio-Diesel	Electricity	Ethanol	Hydrogen	Natural Gas	Total
It doesn't need to be imported from foreign countries	8 -3.2549	45 -4.2885	20 7.19276	8 1.79043	19 -1.4398	100
It has already proven to be effective	17 2.81889	80 **17.8965**	10 -6.1371	5 -2.8241	14 -11.754	126
It is cheapest for drivers	9 -6.3066	57 -10.032	20 2.58215	6 -2.445	44 16.2018	136
It is safest for drivers	14 4.09573	31 -12.374	11 -0.2704	10 4.53558	22 4.01294	88
It is the best for the environment	20 -5.6611	143 **30.6223**	20 -9.2005	15 0.84217	30 -16.603	228
It is the most abundant in the United States	2 -2.3894	9 -10.223	3 -1.9948	4 1.57827	21 13.0285	39
It will require the least amount of change for drivers and fuel providers	17 10.6973	16 -11.602	15 7.82794	0 -3.4774	8 -3.4463	56
Total	87	381	99	48	158	773

1. Deviations are calculated as the difference between the observed count (shown as the upper number in each cell) and the value that would be expected if there were no differences between the distributions of reasons across likely replacements. Expected values are derived by multiplying the corresponding row and column totals for each cell, and dividing that product by the total sample size. Thus, the expected value for "it doesn't have to be imported from foreign countries: bio-diesel" is (100x87)/773 = 11.2549. The deviation for that cell is 8 – 11.2549 = -3.2549. Negative deviations indicate fewer people give that reason for that fuel than would be expected if the same proportion of people gave that reason for all fuels.

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

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

Without stipulating why it might be necessary, respondents were asked whether, "There is an urgent national need to replace gasoline and diesel for our cars and trucks with other sources of energy." New Yorkers may feel slightly more urgency than the total sample (mean scores: NY, 0.91; total sample, 0.84. However, the modal value, i.e., the most frequent value, for both samples was the strongest level of agreement (about 24%) and both distributions had an only slightly smaller percentage of people indicating they neither agree nor disagree.

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

The sample of new-car buyers in NY are slightly more likely to believe, "Air pollution is a health threat in my region," on average, than is the total sample: the mean score on the scale of -3 (strongly disagree) to 3 (strongly agree) is 0.65 in NY and 0.59 for the total sample. However, it is also true that the two modal values, i.e., the values that occur most often, for both NY and the total sample are 0 and 3. The distributions (as indicated by their median, modal, and mean values) of the NY and total samples are similar in their levels of agreement with the statement, "I personally worry about air pollution," i.e., they are likely to agree, but not too strongly, with the statement. The samples are also similar in their response to the statement; "Air pollution can be reduced if individuals make changes in their lifestyle." This air quality statement garners the highest level of agreement, scoring an average 1.70 among New Yorkers and 1.67 among the total sample.

> 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 PEV or FCEV. Neither are beliefs that climate change is real, amenable to human action, and an urgent priority.

Both samples are on average more likely to agree "there is solid evidence that the average temperature on Earth has been getting warmer over the past several decades": NY, mean = 1.29 and total sample =1.18. Among those who believe there is evidence for global warming, the NY sample is certain this warming is due to human, rather than natural, causes (NY, mean = 1.54; total 1.51). The two samples have nearly identical distributions on three statements about the urgency of actions to address climate change (Table 3).

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

	NY	Total
Human-caused climate change has been established to be a serious problem and immediate action is necessary.	59	57
We don't know enough about climate change or whether humans are causing it; more research is necessary before we decide whether we need to take action and which actions to take.	35	35
Concerns about human caused climate change are unjustified, thus no actions are required to address it.	6	8

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

- Overall, awareness of PHEVs, BEVs, and FCEVs is so low that the reasonable assumption is most new car buyers' prior evaluations of these vehicles are based largely on ignorance.

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

- BEV name recognition is not pervasive across the sample and is limited to a few vehicles.
- Lack of familiarity with the distinctions between BEVs and PHEVs is a likely explanation for why respondents name PHEVs when asked for makes and models of BEVs.

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. Asked, "Can you name an electric vehicle that is being sold in the US," more than half (51%) say "no"; 23% correctly name a BEV, leaving 26% who name a vehicle, but it is not a BEV.[12]

Ho: Prior BEV name recognition is not correlated with likeliness to design their next new vehicle as a PEV or FCEV.

Among those who correctly name a BEV, two vehicles account for 89% correct responses: Nissan Leaf (32%) and Tesla (57%). (Tesla model

[12] The rules for determining "right" and "wrong" BEV names are subject to disagreement. Two 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 PEV—PHEV or BEV—as a "correct" answer to the question, "Can you name a BEV sold in the US?"; the other disallows PHEVs. Both 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. For example, if they reply, "BMW i3" they are counted as correct under both sets of rules. However, if they go on to stipulate "BMW i3 REx," they are wrong under the more stringent version of the previous rule. It is, as discussed in the text, the Chevrolet Volt that makes the most difference between the less and more stringent rules about identifying the make and model of BEVs. If it is allowed as a correct answer, the percentage of New Yorkers able to name a "BEV" for sale in the US rises from 23% to 37%.

designations of the Roadster (as it had up until recently been for sale), Model S, and "all" were accepted as correct.) The most commonly misidentified vehicle is the Chevrolet Volt: of all the people who offer any vehicle name (whether it is in fact a BEV or not) 33% name this PHEV.

In addition to misclassifying the Chevrolet Volt, the Toyota Prius is also frequently named as a BEV (accounting for 15% of all proffered "BEV" names). However, it is not clear people recognize the difference between the Prius (an HEV) and the Plug-in Prius (a PHEV) (never mind that both are incorrect). This distinction between HEVs, PHEVs, and BEVs is one analysts proficient with ZEVs make easily, however the result reported here and those upcoming indicate the public is in general confused about the concepts of HEVs and PHEVs, perhaps even more so than they are about BEVs.

Responses to the question, "Are you familiar enough with these types of vehicles to make a decision about whether one would be right for your household?" were made on a scale from -3 (unfamiliar) to 3 (familiar), with allowance for a distinction between the 0-point of the scale (I'm neither unfamiliar nor familiar) from "I'm unsure."

The first distinction between ICEV, HEV, PHEV, BEV, and FCEV vehicles is the percentage of people who are either unsure or simply decline to answer. As shown in Table 4, few respondents are unsure or unwilling to rate their familiarity with gasoline and diesel fueled ICEVs. However, the combined percentage of those unable or unwilling to do so rises in order from HEVs, BEVs, PHEVs, to a maximum of nearly four of ten respondents for FCEVs.

H_o: Those who rate themselves as more familiar with PHEVs, BEVs, or FCEVS will not be more likely to design one.

Table 4: NY Respondents Unwillingness to Rate Drivetrain Types, %

	Unsure	Decline to state	Total Unsure plus Decline to state
ICEVs	4.3	1.3	5.6
HEV	18.6	2.5	21.1
BEVs	19.7	2.4	23.1
PHEVs	24.6	3.5	28.1
FCEVs	34.5	4.1	38.6

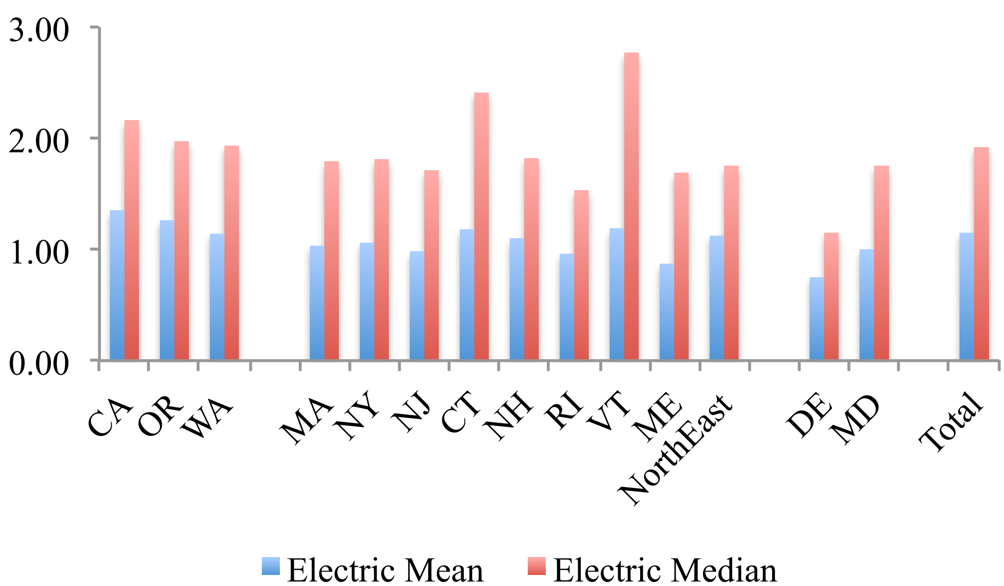
Given these results, the mean differences between drivetrain types are reported only for those respondents willing to rate their familiarity (Table 5). The mean differences are all significant at $\alpha < 0.001$. Given that one is willing to rate one's familiarity with conventional ICEVs, those vehicles have a high relative score and the highest familiarity score of the five types of vehicle drivetrains. On average, self-rated familiarity matches the same order as being willing to rate one's familiarity, i.e., familiarity declines in order from HEVs, BEVs, PHEVs, to FCEVs.

Table 5: NY, Differences in Respondents Ratings of Familiarity between ICEVs and HEVs and ZEVs, -3 = unfamiliar to 3 = familiar

	Number of cases	Mean
ICEV	510	2.30
		Mean Difference
ICEVs - HEV	510	-1.51
ICEVs - BEVs	510	-1.37
ICEVs - PHEVs	510	-1.89
ICEVs - FCEVs	510	-2.77

For comparison, the mean and median scores for self-rated familiarity with electric vehicles from all states are illustrated in the next figure. (Note that for the smaller northeast states—CT, NH, RI, VT, and ME—the 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 means a smaller number of people rate themselves very lowly—as very unfamiliar with BEVs. This is illustrated in Figure 8 with data from NY. While approximately 4-of-10 respondents rate themselves as definitely familiar enough with BEVs to assess whether one is right for their household (3), smaller concentrations are found at the dividing line between familiar and unfamiliar (0) and at definitely not familiar enough (-3).

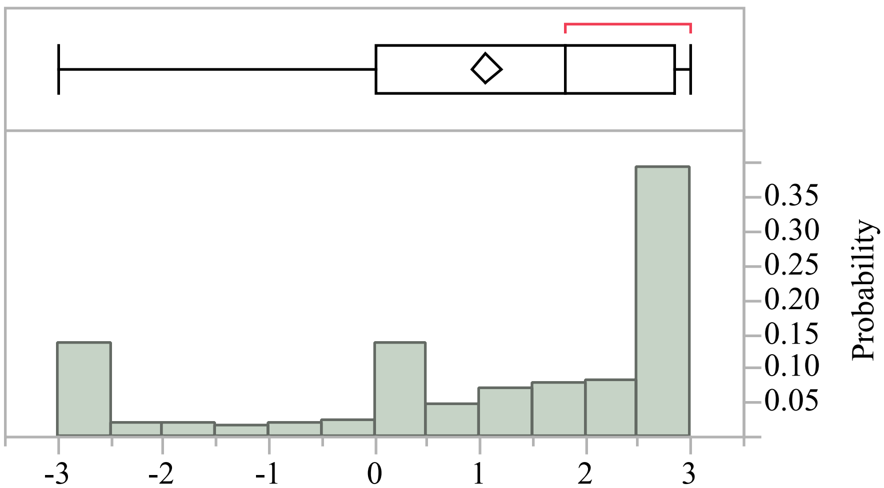
Figure 7: Self-rating of familiarity with BEVs, mean and median scores for each state and the total sample, score on scale: -3 = No; 3 = Yes



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 experience with any PEV, 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 NY are all negative (HEVs, -1.59; PHEVs, -2.15; BEVs, -1.96; and FCEVs, -2.22) and the median scores for all four are nearly -3. That is, more than half of those willing to rate their experience driving HEVs, PEVs, or FCEVs had no experience. These mean and median values are all similar to those for the total sample.

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



Prior awareness of vehicle purchase incentives

- Less than half of new-car buyers are aware of incentives from the federal government; the proportion is far lower for incentives from all other entities including states, cities, and electric utilities.

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.

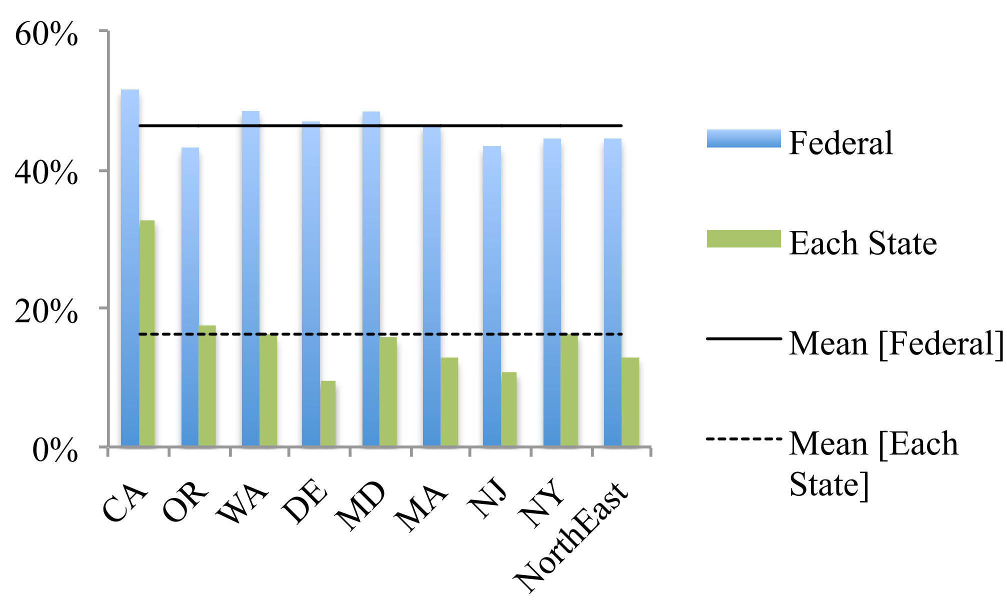
The availability of other incentives varies by state as well as by overlapping city, county, and power utility jurisdictions. The variety of these incentives include exemption from state sales tax or vehicle licensing and registration fees, rebates, single occupant vehicle access to high-occupancy vehicle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

The question about awareness of incentives is not specific to any presently available incentive, but more generally asks, "As far as you are aware, is each of the following offering incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel?" A dozen types of entities are listed; a yes/no/I'm not sure response is elicited for each. If a respondent replies, "Yes," for states, cities, or electric utilities, a follow-up question is asked regarding whether they have heard of such incentives from "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, such as bio-fuels or natural gas. Further, the variation in incentives across states and localities means that stating one is aware of incentives from a particular entity is not the same as being right or wrong for all respondent-entity combinations—except for the universally available federal incentive. Data from all participating states regarding awareness of federal incentives is shown in the following figure.

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

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

Note: "Northeast" includes NESCAUM member states.



The percent of respondents from New York who are aware of federal and state incentives is about average (across states participating in this study). It should be noted "Yes" and "No" are not the same as right and wrong for all respondents. A respondent may live in a state that does not offer any purchase incentives for vehicles powered by alternatives to gasoline and diesel. In such states, "No" is the right answer. However, for all New Yorkers, the right answer to whether the federal government and "my state" offer such incentives is, "Yes."

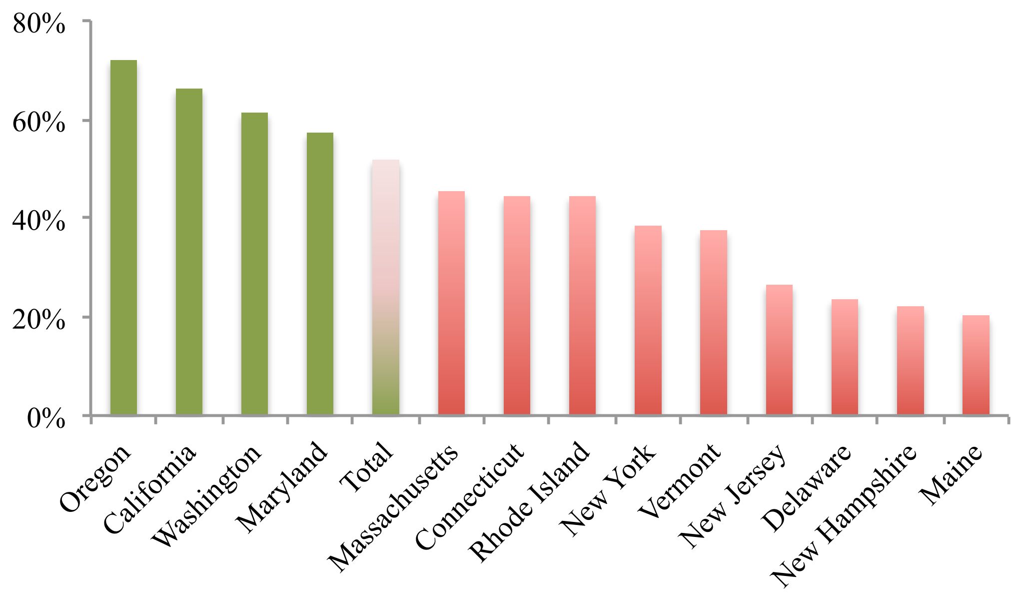
Prior awareness of PEV charging infrastructure

- PEV charging infrastructure may be the most oft recognized sign of PEVs in those states that have had active programs to deploy workplace and/or public charging

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 following figure. While just over 40% of the New York respondents say they have seen a PEV charger in the places they park, this is well below the average of the total sample (~55%).

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

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

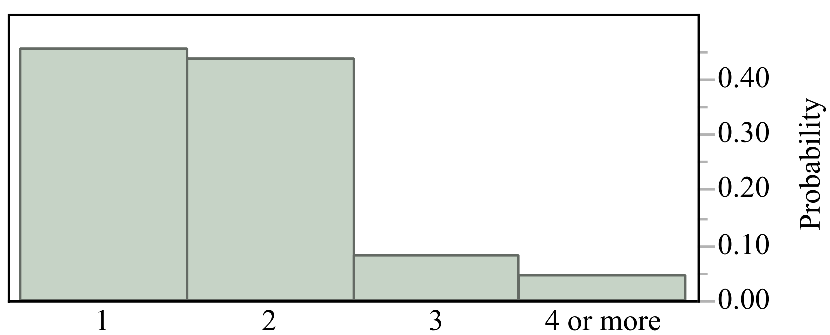


Household Vehicles

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, 45% of the NY sample owns one and 55% owns two or more. The largest, though still minor, difference between the NY sample and the total sample is the total sample is less likely to own only one vehicle and more likely (than the NY sample) to own three. The NY sample is slightly less likely than the total sample to have purchased only one new vehicle during the period of interest than is the total sample (NY, 71% vs. total, 73%). The "age" distributions of these recently acquired vehicles—whether measured by the model year or year acquired—are similar for NY and the total sample.

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

Figure 11: NY Number of Vehicles per household



Frequencies

Level	Count	Prob
1	448	0.44935
2	430	0.43129
3	78	0.07823
4 or more	41	0.04112
Total	997	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 vehicles historically. A higher percentage of New York respondents leased their most recently acquired new car (22%), the other household car driven most often (15%), or both (24%) than amongst the total sample, e.g., (17% both leased in the total sample).

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

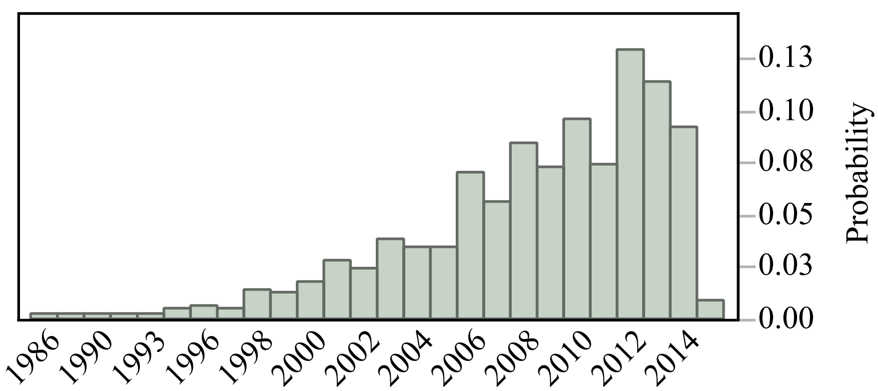
Other characteristics of the most recently acquired vehicle are similar between the NY and total samples, though it appears the New York sample paid more for their vehicles than did the total sample. The median of the reported "total price including options, fees, and taxes" for the most recently acquired vehicle is $500 more in NY than for the total sample and the mean price in New York is $2,132 higher—a difference that is significant at $\alpha < 0.05$. While we might expect people who spend more on new cars to be more likely (or at least more able) to buy PEVs, this expectation is mediated by 1) spending on new cars is plausibly correlated with household income, but 2) the effect of income is mediated by differing propensities across households to spend differing amounts of their income (or more generally, their wealth) on new (and used) vehicles.

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

The vast majority of these recently acquired vehicles (96% in both the NY and total samples) are fueled by gasoline.

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 total sample is shown in Figure 12 for reference. Despite the long tail toward older years (note the x-axis is not linear for years older than 1996), 95% of these "second" vehicles are model year 2000 or newer; for the total sample, only 91% are model year 2000 or newer. The oldest reported vehicle in the NY sample is 1986 compared to 1956 in 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 vehicle fleet may be turning over faster on average in NY than on average in the total sample.

Figure 12: NY Model Year of Other Frequently Driven Household Vehicle, %

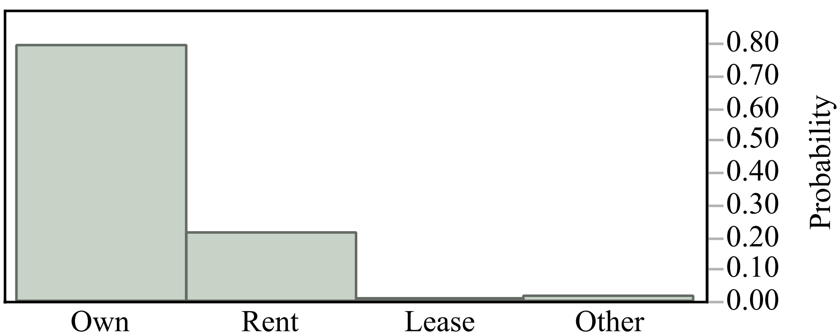


What are the features of their residences, especially those that might affect their valuation of ZEVs?

Turning from the household members to their residences, most of the NY sample (78%) report they own their home while 20% rent (Figure 13); these match the total sample percentages. Two-thirds of respondents report their residence is a single-family home (slightly lower than the total sample). In the Figure 14, respondents who rent their residence are highlighted in a darker shade: clearly most apartments are rented as are about half of townhouses, duplexes, and triplexes. Such multi-unit dwellings have been problematic markets for PEVs as residents of such buildings may not have access to a regular, reserved parking spot and be reluctant—or may lack authority—to install electrical infrastructure to charge a plug-in vehicle. Conversely, 63% of all NY respondents reside in a single-family residence they own (compared to 65% of the total sample). Finally, we note that two-thirds of the NY respondents report having natural gas in their residences and 13 percent report they have solar panels installed (both matching the total sample.)[13]

H_o: Ownership of one's residence is not correlated to vehicle design; neither is type of residence
H_o: Whether the residence has natural gas or solar panels is not correlated to vehicle design.

Figure 13: NY Own or rent residence, %

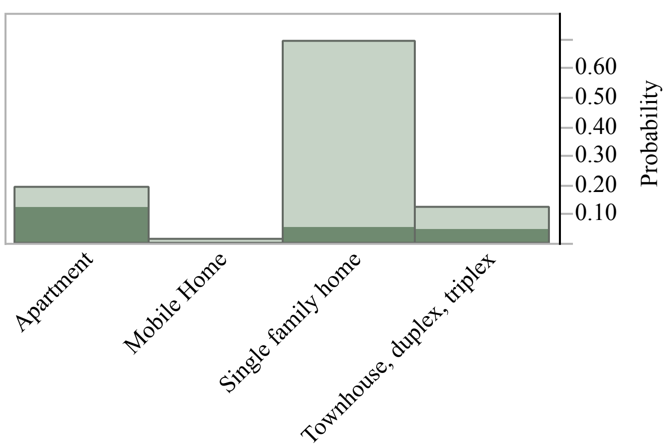


Frequencies

Level	Count	Prob
Own	782	0.78435
Rent	204	0.20461
Lease	1	0.00100
Other	10	0.01003
Total	997	1.00000

N Missing 0
4 Levels

Figure 14: NY Type of Residence, %



Frequencies

Level	Count	Prob
Apartment	187	0.18756
Mobile Home	9	0.00903
Single family home	683	0.68506
Townhouse, duplex, triplex	118	0.11836
Total	997	1.00000

N Missing 0
4 Levels

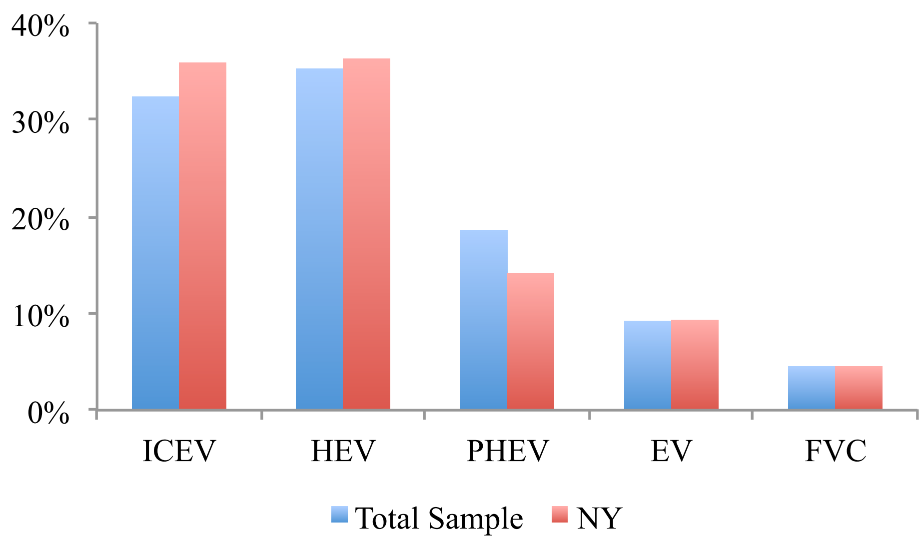
[13] The home hydrogen fueling offered to respondents in the vehicle design games will be based on reforming natural gas.

RESULTS: HOW MANY RESPONDENTS' DESIGN ZEVS?

PEV and FCEV valuations are determined in the final design game that most corresponds to present reality—there are no full-size PHEVs or BEVs offered with battery-powered, all-electric drive, but there are federal, state, and local incentives offered for PHEVs, BEVs, and FCEVs. As described earlier, respondents could customize drivetrains for—as appropriate—driving range, charging speed both at home and away-from-home, and whether or not an FCEV could be refueled at home. The distributions of these designs are described here. As in the previous section, this discussion details the results of the final game in which no full-size vehicle may be designed with all-electric operation but incentives are offered for ZEVs.

Ignoring for now differences within each drivetrain type, e.g., ignoring differences in driving range across the BEV designs created by respondents, a bit more than one-third of respondents design their next new vehicle to be a PHEV (14.1%), BEV (9.3%), or FCEV (4.5%). (As it is important for many related transportation energy goals, the single most common drivetrain design is, just barely, HEVs—far out-distancing the prevalence of HEVs in the actual on-road fleet of vehicles and in new vehicle sales.) As seen in Figure 15, the New York respondents are more likely to stay with conventional gasoline powered vehicles ("ICEV" in the figure) and less likely to design a plausible next new vehicle to be a PHEV than is the total sample.

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



PHEV Designs

- PHEV designs were by far the most popular (of the non-ICEV and non-HEV possibilities): 140 respondents designed a PHEV compared to 92 BEVs and 45 FCEVs.
- PHEV designs emphasize longer range driving on electricity, but a mode in which more gasoline is used, i.e., “Assist” designs.
- Faster charging at home or at a (initially limited) network of quick chargers is less popular than charging at the lower speeds afforded by existing home electrical outlets. Nearly half those who design a PHEV indicate they would make do with 110v electrical service to charge at home.

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

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

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 all three figures illustrates those respondents whose PHEV design include all-electric charge-depleting mode. One-in-four people who design a PHEV design one that uses only electricity during charge-depleting operation.[14]

Over half (55%) of those who design a PHEV design one with the maximum offered charge-depleting range, 80 miles. (This is approximately twice that of the Chevrolet Volt, though it

[14] Feedback during the follow-up interviews in California, Oregon, and Washington suggests that the concepts of charge-depleting and charge-sustaining operation caused considerable confusion. Clarifying these concepts for consumers might lead to more people designing PHEVs and more of those designing PHEVs that use only electricity during charge-depleting operation. (Much of the confusion crosses from HEVs to PHEVs to BEVs; many respondents are confused about the distinctions between these three drivetrains.)

approximates that offered by BMW's i3 with Range Extender.) At the low end, a range of 10 miles approximates that of the Plug-in Prius.

Figure 16: PHEV Charge-depleting operation, n = 140, %

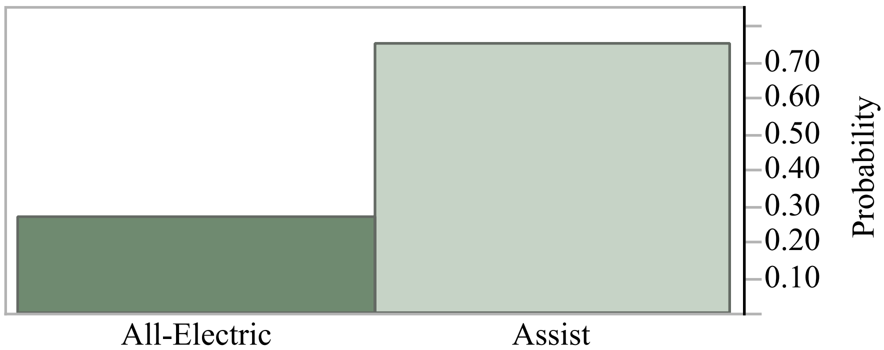
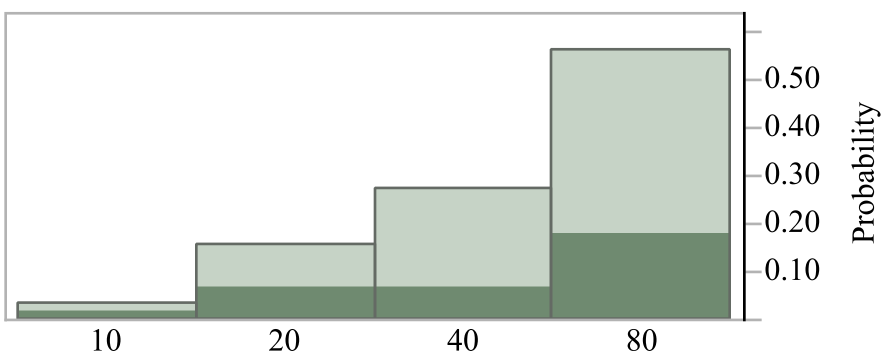
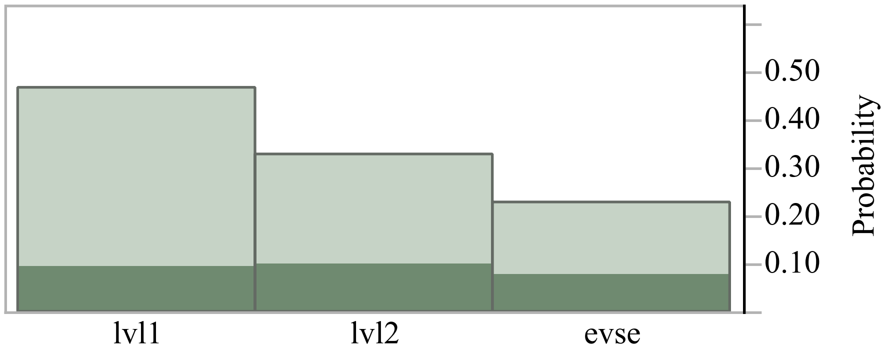


Figure 17: Charge-depleting driving range (miles) by all-electric (dark shaded area) vs. assist mode, %



The home charging speeds are denoted by "level 1" (lvl1), "level 2" (lvl2), and electric vehicle supply equipment (EVSE). These are shorthand for the charging speed that could be achieved 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. Almost half (46%) of those who design PHEVs believe they would be satisfied to charge the vehicle at the speeds afforded by a conventional home 110v outlet; barely one-in-five (21%) believes they would value the faster charging afforded by a EVSE enough to pay the posited higher cost. (All charging prices are customized based on the 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.)

Figure 18: Home Charging Speed by all-electric (dark shaded area) vs. assist mode, %



The cost for the capability to quick charge at a network of stations was presented as a $500 vehicle option; charging time was stipulated to be 30 minutes. Respondents were given this description of what to expect by way 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 all this, 59 of the 140 people (42%) who designed a PHEV added the quick charge plug to their vehicle design.

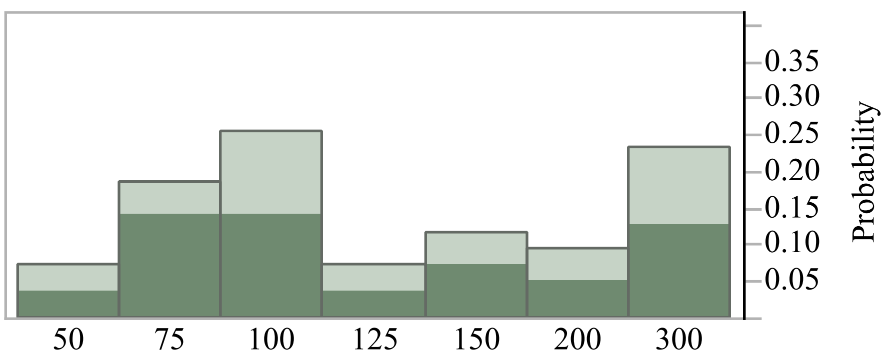
BEV Designs

- BEV designs split as to whether they emphasize short or long range: half of designs incorporate range 100 miles or less.
- There is a strong positive correlation between the longest ranges (200 and 300 miles) and interest in the fastest possible home charging.
- Conversely, among those who design the shortest range BEVs (50 and 75 miles) none selects the fastest possible home charging and up to and including 150 miles range, there is less interest in away-from-home quick charging

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 option was offered 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 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 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.

The BEV designs are spread across the offered options with higher concentrations at or near the short and long options. The relatively high incidence of designs with the longest possible range is in contrast to past studies by the lead author over many years. The difference is likely due to the offer of a 300-mile range option—past studies had offered maximum BEV range of 200 miles. The advent of the longest-range Tesla options necessitated updating the design space to include this possibility in the near term.[15]

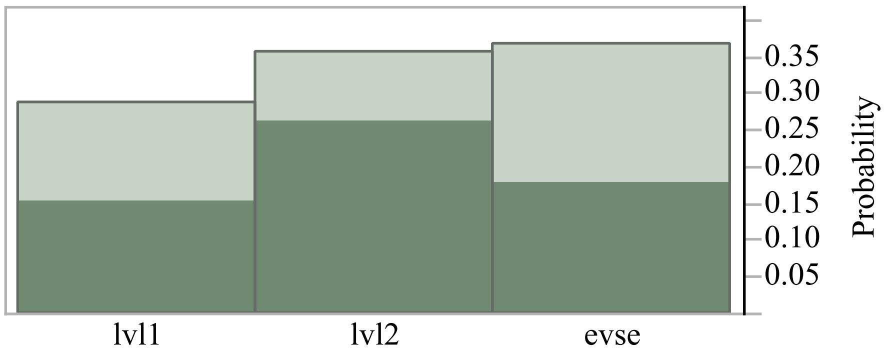
Figure 19: Distribution of BEV Range by whether quick charging capability was included (dark shaded area), n = 92, %



In contrast to the PHEV designs, the highest possible home charging rate, i.e., the shortest possible time to fully recharge, are far more prevalent among the BEV designs. As the units of charging presented to respondents are hours (rather than kilowatts), and as most BEVs have larger batteries than do any of the PHEVs, the greater emphasis on faster charging for BEVs than for PHEVs is plausible. (The costs to upgrade to lvl2 and EVSE are similar for PHEVs and BEVs.) Compared to the PHEV designs, a higher percentage of BEV designs (59%) also include the capability to charge at an away-from-home quick charge network.

[15] Though the addition of the 300-mile range option has skewed the desired distances upwards compared to those older studies, the distribution in Figure 19 repeats one feature of past results: the desired range distribution is multi-modal. It peaks at about 100 miles then descends into a trough until reaching the maximum range option.

Figure 20: BEV Home Charging Duration by whether quick charging capability was included (dark shaded area), %.



FCEV Designs

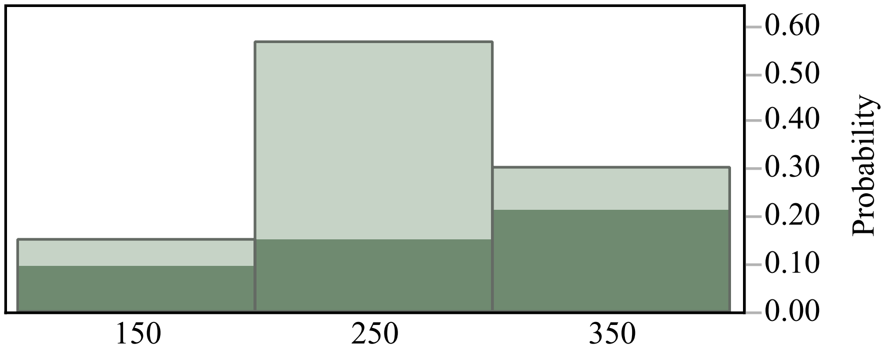
- A plurality of FCEV designs incorporate the middle offered range (250 miles)
- Home H_2 refueling was included in most designs, though proportionally less for this preponderance of "middle-range" vehicles.

Respondents could manipulate the 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. Away-from-home refueling for FCEVs was described thusly:

> "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."

The dark shaded area in Figure 21 indicates respondents who included home H_2 refueling. Four-of-ten people who designed an FCEV included home refueling in their design. Home refueling is proportionally far less common among the most frequently chosen range.

Figure 21: Distribution of FCEV driving range by home refueling included (dark shaded area), n = 45, %



RESULTS: RESPONDENT VALUATION OF ZEVS

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 Results section above describing the New York sample. The set of explanatory variables explored in this study is summarized in Appendix A. For each potential explanatory variable, i.e., dependent variable, an alternate hypothesis is stated. These hypotheses are alternates to the standard null hypothesis (H_o). In statistical jargon, null hypotheses are stated as no effect, e.g., for the number of vehicles owned by each household, the null hypothesis is that how many vehicles a household already owns has no effect on whether they design their next new vehicle to be a PEV or FCEV. For BEVs with driving range limits, prior research indicates that households with more vehicles have more options for those instances when a driving range limit would prevent a BEV from making a trip. Thus the alternate hypothesis can be stated that the more vehicles a household owns, the more likely it is to design its next new vehicle to be a BEV. We do state the null hypothesis of no effect for each dependent variable in Appendix A. The threshold for statistical tests of significance to reject the null hypothesis is set to $\alpha = 0.05$. The rejection of any null hypothesis (or failure to reject) in Appendix A is only in regards to the simple relationship between each explanatory variable—taken one at a time—and the dependent variable, that is, the drivetrain design in the third design game. The results in Appendix A guide the construction of the more complex model reported next.

Choosing explanatory variables

Several of the simple correlations between possible explanatory variables and the drivetrain of the vehicle designed in the final survey game (ICEV, HEV, PHEV, BEV, or FCEV) surpass the level of significance set for rejecting the null hypothesis. 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).

Further, several questions about a single topic may plausibly be reduced to a smaller number of dimensions. For example, we ask eight 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 eight questions can be represented by a smaller number of linear combinations (factors), say, one for all cost measures, one for all measures related to the availability of 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.

Ultimately, explanatory variables are selected for substantive interest and statistical strength. The resulting multivariate model is thus only one of many that could be produced. This is not to say that statistical models can be made to say anything, but to say that this model was constructed to test important concepts. The description of the "best" model is qualified by the fact that it is the best model built on the absence of interactions between explanatory variables. In short, it is the best model to describe whether each explanatory variable is correlated to the drivetrain design of the survey respondents, controlling for the effects of all the other variables in the model on drivetrain design. The numerical details of the model are presented in Appendix B. The substantive meaning of the model is discussed next.

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

The variables present in the model for New York to explain who does and does not design their next new vehicle to be a PHEV, BEV, or FCEV are the following.

- Demographic
    - Respondent gender
- Household travel
    - Respondent's estimated monthly miles driven
- Attitudes
    - Respondent's interest in ZEV technology
    - Personal worry about air pollution
- Prior PEV and FCEV evaluation or experience
    - Have they already seen public EVSEs
    - Have they already considered buying a PEV
    - Have they already considered buying an FCEV

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

- Women are more likely than men to design their household's next new vehicle to be anything other than a conventional ICEV.
- Increasing monthly distance driven by the respondent has a complex effect
    - Increasing probability of designing a conventional ICEV or a BEV
    - No effect on probability of designing a PHEV or FCEV
    - Decreasing probability of designing an HEV
- Respondents who are interested in ZEV technology specifically are more likely to design a PHEV or BEV.
- Being personally worried about air pollution increases the probability of designing a PHEV or BEV.
- Observing signs PEVs are "happening"—in this case, seeing PEV charging being deployed—increases the probability of designing a PHEV or BEV
- Having already considered a PEV increases the probability of designing an HEV or BEV.
- Having already considered an FCEV increases the probability of designing an ICEV, BEV, or (likely) an FCEV.

The following concepts do not appear in the final model: prior awareness of incentives for ZEVs, prior assessments of specific attributes of PEVs and FCEVs, attitudes regarding climate change and energy security. Further, despite a distinct socio-economic and demographic profile of early

PEV buyers—middle age, wealthy men—age and income don't enter the model and the gender result indicates that in the abstract world of the model, women value the idea of their household's next new vehicle being a PEV or FCEV more highly than do men.

A summary view of how well the model performs is provided in Table 6 where the actual drivetrain design (created by each of the 844 respondents used to estimate the model) is cross-classified by the drivetrain "predicted" by the model. The model predictions are created by assigning a probability that each respondent creates one of the five possible drivetrain types, then picks the drivetrain design with the highest estimated probability.

Table 6: Actual and predicted drivetrain designs

Actual	Predicted				
No trucks, plus incentives: drivetrain design	ICEV	HEV	PHEV	BEV	FCEV
ICEV	169	120	4	3	0
HEV	79	222	6	6	1
PHEV	17	81	8	12	1
BEV	9	35	10	12	2
FCEV	5	13	2	6	3

The model results are quite conservative—in the sense that it does a relatively poor job of predicting that people will design PHEVs, BEVs, or FCEVs. For example, of 126 respondents who actually designed a PHEV, the model predicts that over half of them (84) designed an HEV. The question of why the model doesn't do a better job of predicting PEV and FCEV designs will be taken up in the Discussion section.

A selection of the probabilities produced by the model is shown in Table 7. The respondent profile is in the left column and top rows. The profile defines respondents according to specific values of the explanatory variables. The table covers some of the possibilities that are more or less subject to policy. For example, the table illustrates differences for men and women by whether they have seen EVSEs in the parking lots and garages they use. (One policy option is to support the deployment of public charging infrastructure.) For people who match the profile described in the top half of Table 7, the difference for men and women between not having and having seen EVSEs in the parking facilities they use is a doubling of the probability the model estimates they design PHEVs or BEVs—but a doubling from a very small base (for men, PHEV from 4% to 9% and BEV from 3% to 7%; the changes in probabilities are similar for women).

Greater differences are seen for both men and women for differences between those who are not interested in ZEV technology and those who are interested as well as differences between those who had not considered a PEV prior to taking the survey and those who had. For men who have seen an EVSE, the probability they design a BEV increases from 7% to 23%; among women who have seen an EVSE, the probability increases from 7% to 18%.

Table 7: Estimated Probabilities of Drivetrain Design for Select Respondent Profiles

Respondent profile	Response Profiles, probability				
Gender		Male		Female	
Seen Public EVSEs		No	Yes	No	Yes
ZEV Technology: **little to no personal interest**	ICEV	0.79	0.67	0.71	0.59
Monthly miles: mean	HEV	0.14	0.16	0.21	0.23
Prior Consider a PEV: **No**	PHEV	0.04	0.09	0.05	0.11
Prior Consider an FCEV: No	BEV	0.03	0.07	0.03	0.07
Air pollution personal worry: mean	FCEV	0.00	0.01	0.00	0.00
ZEV Technology: **interested**	ICEV	0.26	0.16	0.19	0.12
Monthly miles: mean	HEV	0.46	0.37	0.56	0.46
Prior Consider a PEV: **Yes**	PHEV	0.14	0.21	0.14	0.22
Prior Consider an FCEV: No	BEV	0.12	0.23	0.09	0.18
Air pollution personal worry: mean	FCEV	0.02	0.03	0.01	0.01

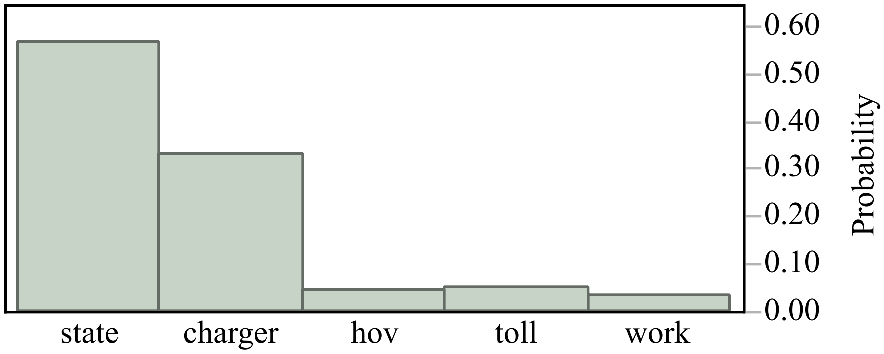
What Incentives do People Choose?

- Financial incentives are the most frequently chosen additional incentive rather than use incentives such as HOV lane access, reduced tolls, and workplace charging.
    - Still, almost one-in-eight of the respondents who designed a qualifying vehicle chose use incentives over upfront financial incentives in a setting in which they must choose one or the other.
- Despite the dollar value being identical, among those who choose an upfront financial incentive, they split about two-to-one as to whether they want it for the vehicle or home charging/fueling.

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

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

Figure 22: Incentives selected in addition to a federal tax credit, %



Why do people design PEVs and 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, safe, fun to drive
  - Societal: Reducing personal contribution to air pollution and climate change
- Little acknowledgement that incentives were important to their vehicle design

Motivations for designing PEVs and FCEVs were assessed on a scale from 0 = not at all important to 5 = very important. Respondents were presented with a list of 17 possible motivations derived from prior research. However, respondents were restricted to spend a maximum of 30 points summed across all 17 items. Because not all respondents spent the maximum number of points, an "average" score for any individual item is the total number of points spent by all respondents, divided by the number of respondents, and divided again by the number of items. The resulting "mean" score is 1.42. Any item scoring higher than this (rather than higher than 2.5, i.e., the mid-point of the rating scale) is interpreted as having a "high" score. The possible motivations are listed in the following table, sorted from high to low by their mean score; the percent of respondents assigning maximum importance, i.e., five points, is shown, too.

The top six rated motivations have mean scores higher than the global mean. The top motivations are a mix of personal and societal benefits. Saving money (in this case, restricted to fuel cost savings) is not often at the top of the list of ZEV market discussions in academic papers, policy discussions, and market analyses that tend to emphasize the higher upfront purchase prices. However 35 percent of respondents give the maximum number of possible points to saving money on fuel costs (and 78% assign two or more)—possibly revealing a "partial rationality" that apportions costs to different categories and treats them separately—and possibly even differently than vehicle purchase costs.

The importance of an attraction to new technology is underscored by the fact this motivation is the second most highly ranked. Nearly a third (31%) give their personal interest in new technology the highest possible score and total of 60% give it 2 or more points. The pro-environmental motivations related to air quality and climate change have similar mean scores.

Similar percentages assign the maximum number of points (17%, climate change; 16% air quality).

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

Motivation	Mean	% = 5
To save money on gasoline or diesel fuel	2.60	35
I'm interested in the new technology	2.51	31
It will be safer than gasoline or diesel vehicles	1.60	14
It will be fun to drive	1.55	16
It will reduce the effect on climate change of my driving	1.52	17
It will reduce the effect on air quality of my driving	1.49	16
Average points per person per item	**1.42**	
It will reduce the amount of oil that is imported to the United States	1.38	14
It fits my lifestyle/activities	1.28	11
Charging the vehicle at home will be a convenience	1.27	12
It will be more comfortable	1.24	13
I like how it looks	1.20	9
I'll pay less money to oil companies or foreign oil producing nations	1.17	13
I'll save on the cost of maintenance and upkeep	1.10	11
I'll save on the cost of vehicle purchase	1.08	9
I think it makes the right impression for family, friends, and others	0.92	7
The incentives made it too attractive to pass up	0.87	5
Other[1]	0.10	0

1. Only 13 respondents listed "another" motivation, and only six of these assigned more than 1 point to their specified motivation.

The pro-environmental motivations related to air quality and climate change have similar mean scores. Similar percentages assign the maximum number of points (17%, climate change; 16% air quality).

As to the importance of incentives, few people acknowledge that the incentives were important to the design of their vehicle in the final game. Incentives rank last by both the mean points assigned to it and the percent of respondents who assign the maximum points. Further, 63% assign zero points and another 13 percent assign only one point. This scoring for incentives may be lower than one would expect from the differences between the 1st game (no incentives, but full-size all-electric operation allowed) and the 3rd game: 253 people designed ZEVs in the first game; 264 did so in the third game despite there being no full-size vehicles allowed with all-electric operation. Thus despite the fact full-size vehicles with all electric operation were taken away in the 3rd game, approximately 4% more people designed a PEV or FCEV. The only two substantive differences remaining between the 1st and 3rd game are the offer of incentives and the additional time respondents have had to work with the concepts of ZEVs.

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 four-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 cluster names 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.

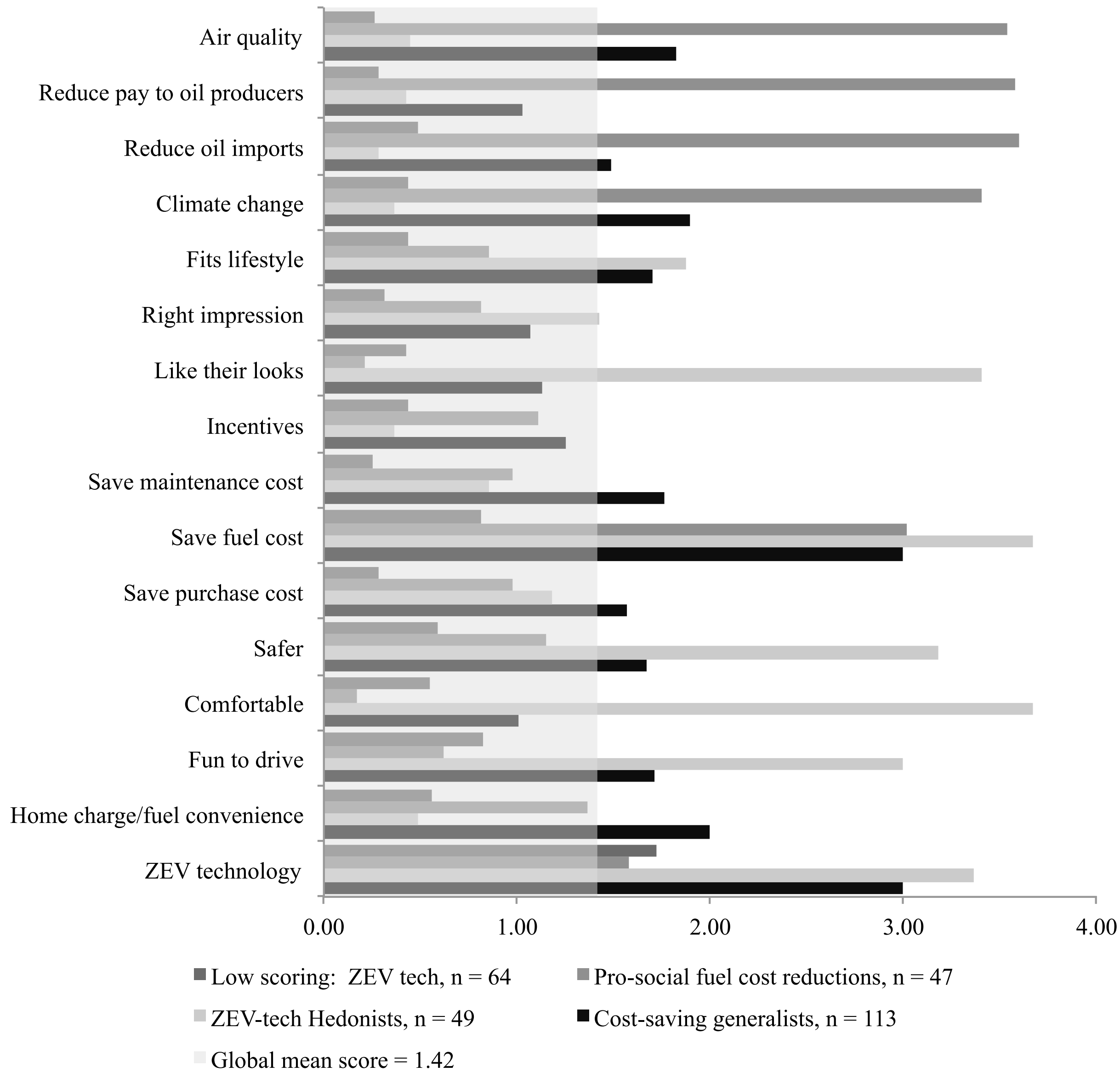
All four clusters share a single motivation with a high cluster average score: interest in ZEV technology. For one cluster, this is the only motivation mean score that is above the global mean average. The occurrence of this singular motivation occurs because in comparison to the three other clusters, this "low scoring: ZEV tech" cluster used an average of less than nine of the up to 30 points available to them in the motivation exercise. The other three clusters used an average of 27 to 28 of the 30 points. In effect, what makes the respondents in the low-scoring cluster alike is they tended to assign points to only one or two motivations. Respondents in the other clusters have six to eleven highly scored motivations.

"Pro-social fuel cost reductions" share high average scores for all pro-social motivations: climate, air quality, and energy supply and security. As with all the other clusters (except the low-scoring cluster) they also score fuel cost savings highly—a benefit that flows directly from their other highly scored motivation, that is, the ZEV technology in which they are interested.

"ZEV-tech hedonists" share this interest in ZEV technology, but any similarity with the pro-social cluster stops there. This cluster appears to simply think ZEV technology is going to produce the best possible car: a good-looking, fun, comfortable and safe to drive car that is economical on fuel, looks good, and makes the right impression on friends and family.

The final cluster are "cost-saving generalists" in the sense they draw motivation from all the categories of motivations: interest in ZEV technology that will provide the convenience of home charging or fueling, a car that is fun and safe to drive while reducing impacts on air quality, climate and oil imports—and all while providing a comprehensive savings across purchase, fuel, and maintenance costs.

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



Why DON'T people design ZEVs?

- The highest scoring motivations against designing PEVs and FCEVs have to do with their inherent newness: limited charging and fueling networks, unfamiliarity with the technology, high initial purchase price.
    - In addition to high initial purchase prices, maintenance and fueling costs were highly rated concerns.
- Immediate, practical limits on the ability to charge a PEV at home as well as concerns about the overall reliability of electricity supply
- Concerns about driving range for PEVs and FCEVs as well as the time required to recharge PEVs scored highly as reasons to not design one.

- Few indicate that greater incentives would have changed their minds.

Because more new-car buyers in NY appear to not be interested in PEVs or FCEVs (at least at this point in time), why they are not interested is as, if not more, important than why a smaller number are interested. Motivations against designing a PEV or FCEV were assessed by a similar process as motivations for ZEVs. Respondents assigned points on a scale from 0 = not at all important to 5 = very important. There were 19 possible motivations against designing PEVs and FCEVs derived from prior research. The global mean score for all these motivations was 1.03. Any item scoring higher than this is interpreted as having a "high" score. These motivations are listed in Table 9 sorted from high to low by their mean score.

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

Motivation	Mean	% = 5
Limited number of places to charge or fuel away from home	2.69	39
I'm unfamiliar with the vehicle technologies	2.08	29
Cost of vehicle purchase	2.07	30
Concern about unreliable electricity, e.g. blackouts and overall supply	1.95	26
Distance on a battery charge or tank of hydrogen is too limited	1.62	22
Concern about time needed to charge or fuel vehicle	1.55	20
I can't charge vehicle with electricity or fuel one with natural gas at home	1.53	21
Cost of maintenance and upkeep	1.14	11
Cost to charge or fuel	1.05	12
Average points per person per item	1.03	
I'm waiting for technology to become more reliable	1.01	12
Concern about vehicle safety	0.89	10
Concerns about batteries	0.85	10
Doesn't fit my lifestyle/ activities	0.65	7
I don't like how they look	0.45	5
Concern about safety of electricity or natural gas	0.41	4
I was tempted; higher incentives would have convinced me.	0.40	5
Environmental concerns	0.26	2
I don't think they make the right impression	0.21	1
Other[1]	0.12	2

1. Only 30 respondents listed an "other" motivation; 18 of these assigned more than 1 point to their specified motivation.

The mean scores of nine motivations against designing a PEV or FCEV are higher than the global mean. Almost all the highest ranked motivations against designing a PEV or FCEV have to do with the inherent newness of the vehicles and vehicle technology: limited away-from-home fueling, high initial purchase price, unfamiliarity with new 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 and with continued market growth and infrastructure deployment.

The interpretation of the (lack of) effect of incentives in the third game is somewhat different than for those respondents who did design a PEV or FCEV. For those who did not, they are unwilling to state that higher incentives would have changed their minds—now. 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: the average score assigned to higher incentives is very small, and more importantly, only four percent of people who did not design PEV or FCEV indicate that higher incentives would have changed their minds.

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

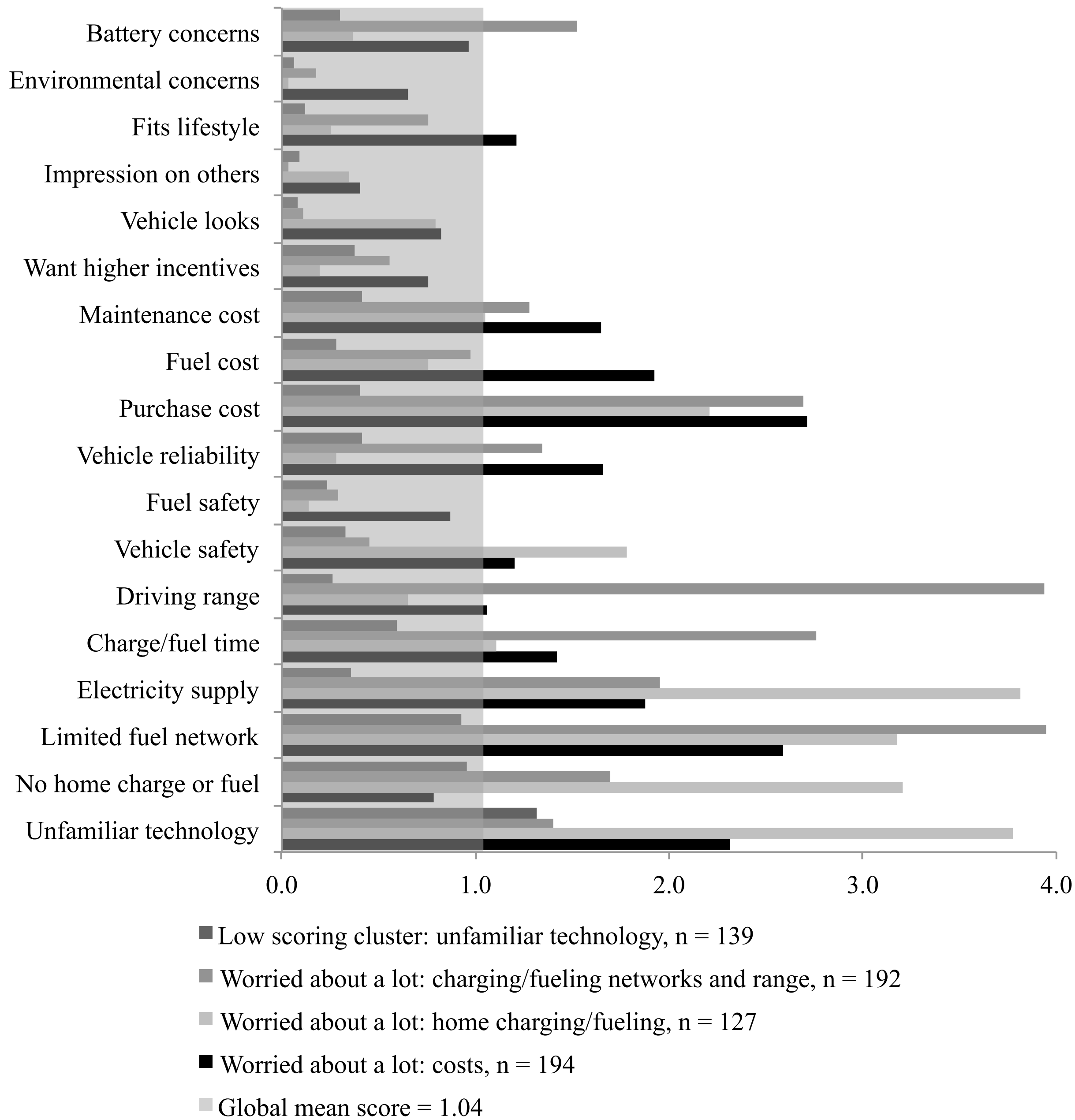
Following the procedure used for those who did design a PEV or FCEV, this section presents the cluster analysis of the motivations for not doing so. Results of a four-cluster solution are illustrated in Figure 24. Again there is a cluster of respondents who spend few of the points available to them. In this case, this cluster spends on average fewer than eight of the 30 points available to them; the other three clusters spend an average of 24 to 26 points.

Despite their low totals points, this low-scoring cluster does score one motivation for not designing a PEV or FCEV so highly that they do share with all other clusters a single highly scored motivation: "I am unfamiliar with the vehicle technologies." At the most basic level, all people who do design an ICEV or HEV are motivated by a basic lack of familiarity with PHEVs, BEVs, and FCEVs.

In contrast, the three other clusters have mean scores above the global mean for eight to eleven motivations: these clusters can all be characterized as worried about a lot of things about PEVs and FCEVs. What they have in common—beyond unfamiliar technology—are concerns about limited charging/fueling networks, the effects of PEVs on electricity supplies, charging/fueling times for PEVs and FCEVS, and purchase costs of PEVs and FCEVs.

Beyond these shared concerns these three clusters are distinguished from each other as follows. The cluster named "Worried about a lot: costs" calls out all three cost items for concern: purchase, fuel, and maintenance. This is the only cluster registering high concern with fuel costs. Further, they have concerns about vehicle reliability and safety and whether PEVs or FCEVs would fit their lifestyle. Those respondents in the "Worried about a lot: home charging/fueling" are likely signaling they are simply unable to charge or fuel a PEV or FCEV at home. They also report by far the highest mean scores for "unfamiliar technology" and "electricity supply." The remaining cluster is distinguished from the others by its comparatively extravagant concern with driving range and limited fuel networks.

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



RESULTS: COMPARISON OF STATE RESULTS

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

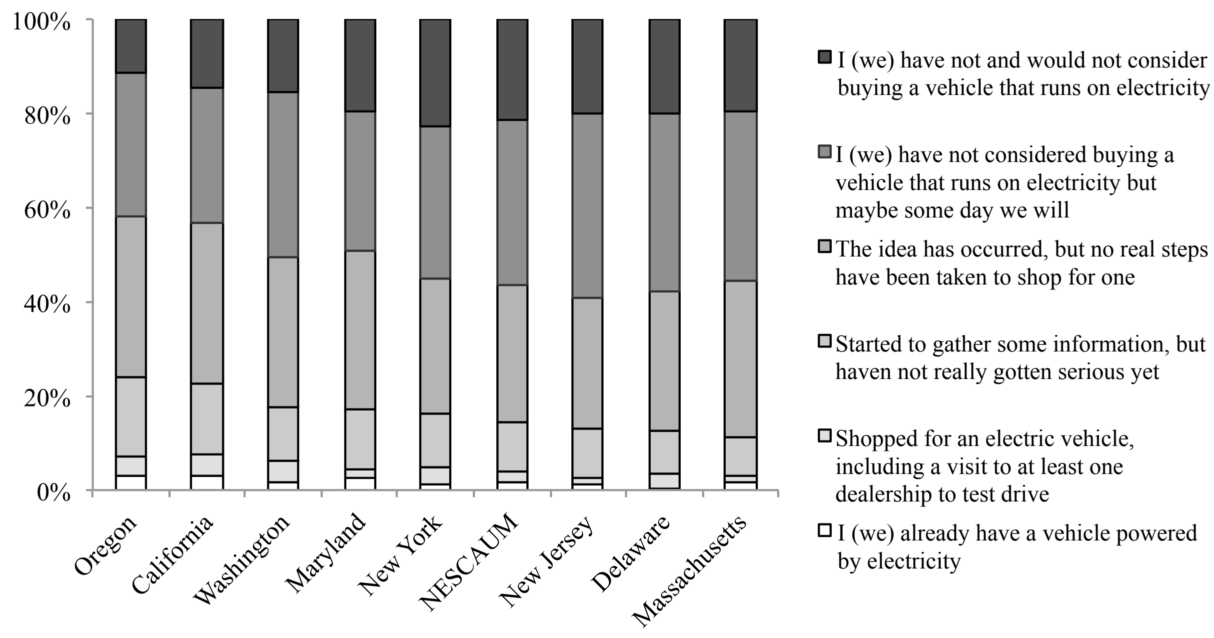
The intent is to explore both general concepts and specific measures indicating whether the multiple state and regional analyses are mutually reinforcing and unifying across the multiple policy and market geographies vs. the extent to which they present idiosyncratic findings for states or NESCAUM. This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

PEV and FCEV Consideration

- Levels of prior consideration of PEVs and FCEVs are low among new car buyers across all the study states and the NESCAUM region.
- Respondents are more likely to have higher levels of prior consideration of PEVs in western states than eastern.
    - New Yorkers have the highest level of prior consideration of PEVs of all eastern states except Maryland.
- 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).
    - New Yorkers report the highest levels of prior consideration of PEVs among the states in NESCAUM and are second only to Californians in having already considered FCEVs.

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

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



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

Cross-classifying the distributions of PEV and FCEV consideration by state/region confirms the distributions are statistically significantly different. The data are shown in Tables 11 (PEVs) and 12 (FCEVs).[16] The test is whether the state/region (row) distributions of row probabilities are the same. The very small probability of getting a larger chi-square value indicates we can be quite confident the row probabilities are different. To illustrate the differences, values for each state have been highlighted in **bold** for each level of consideration where there are more people than expected if the row probabilities were the same. The states and regions have then been ordered top to bottom in the table from those states with more people at the higher levels of consideration to those with lower levels. The general flow of **bold** cells from upper left to lower right in both tables illustrates a flow from higher to lower levels of consideration. The western states are highest in consideration for both PEVs and FCEVs—though the ordering is different.

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

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

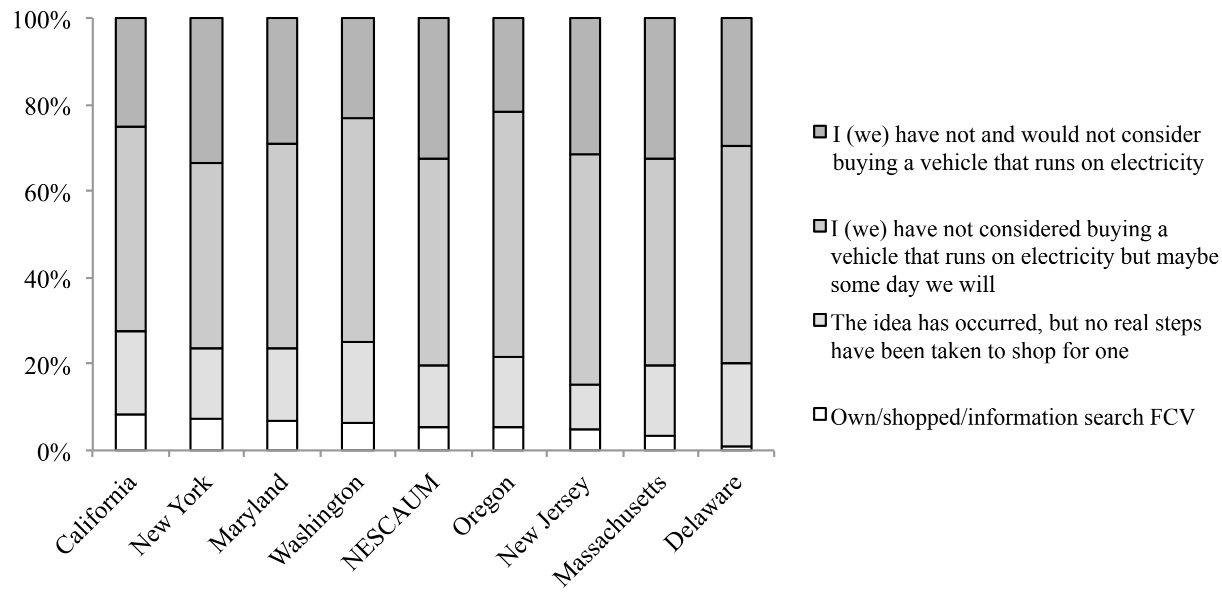


Table 10: State/Region by Consider PEV

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

Note:

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

Table 11: State/Region By Consider FCEV

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

Note:

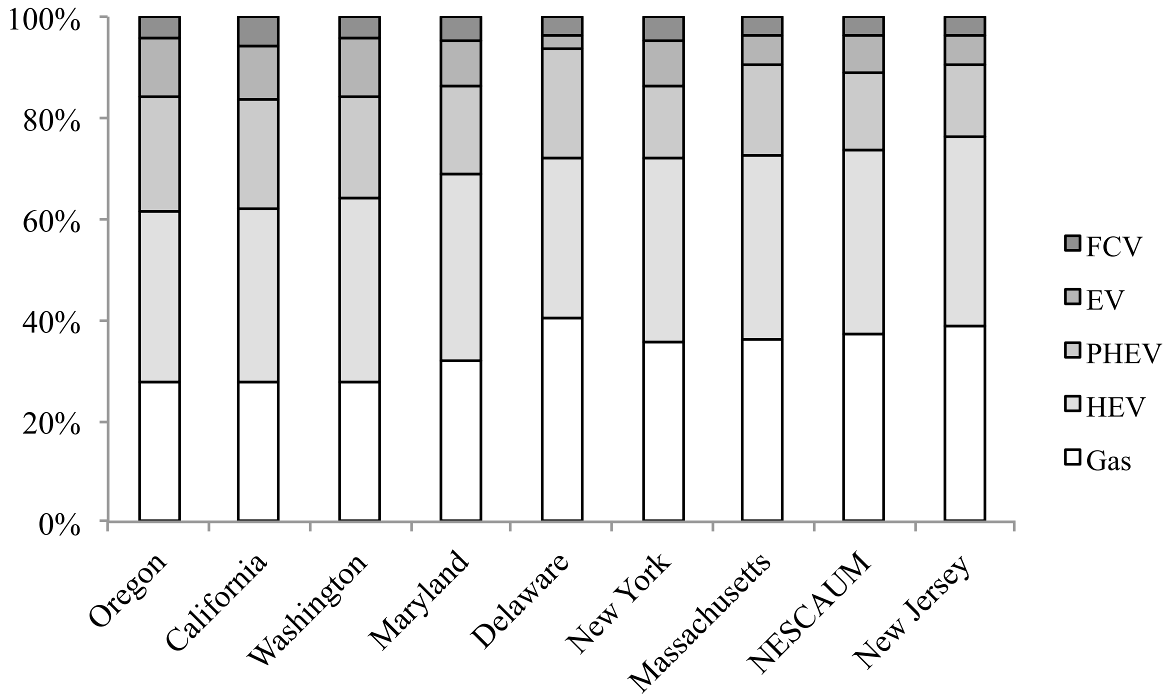
Test	**ChiSquare**	**Prob>ChiSq**
Pearson	78.524	<0.0001

PEV and FCEV Valuation: Drivetrain designs

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

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

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



Cross-tabulating the distribution of drivetrain designs by state and region samples allows testing whether the drivetrain probability distributions are statistically significantly different.[17] The cross-tabulation is illustrated in Figure 28 and provided in Table 13. The vehicle design distributions in Figure 28 have been ordered by the total of the percent of respondents who design a PHEV, BEV, or FCEV. The mosaic plot in Figure 29 highlights both the differences between western and eastern states (the vertical axis) and the different sample sizes (the width of each column is proportional to sample size).

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

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

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

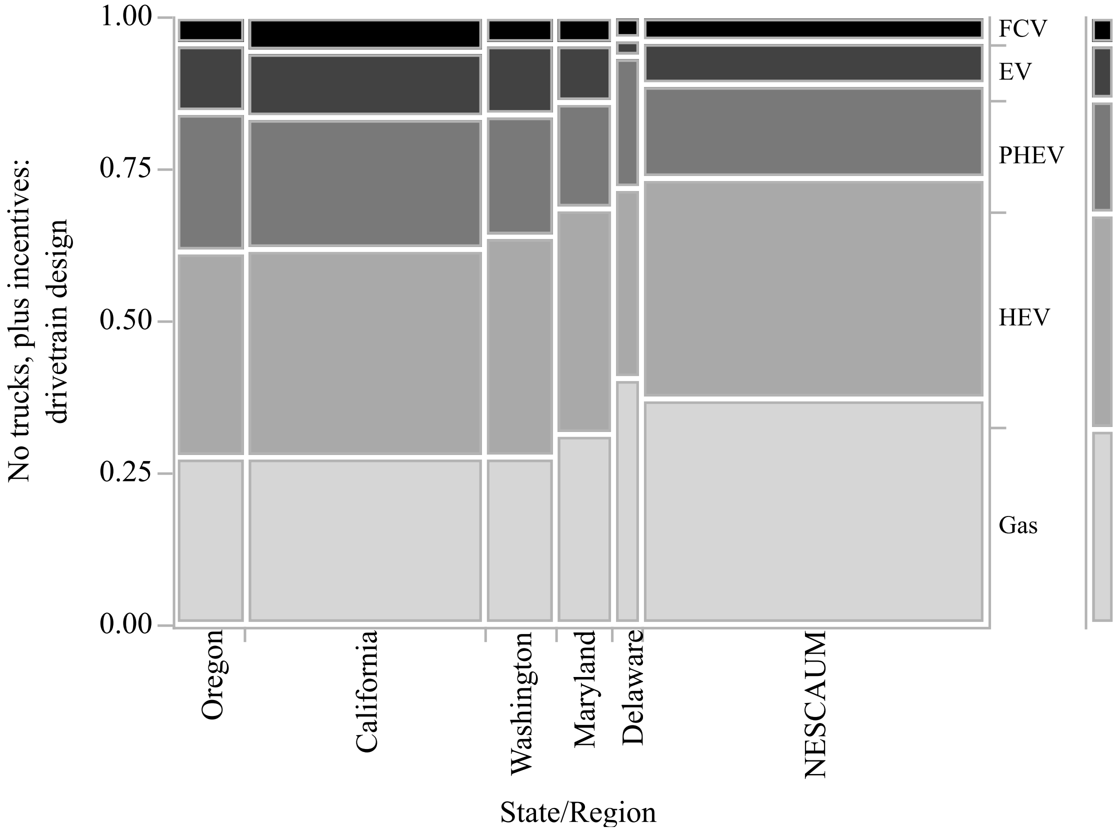


Table 12: State/Region Drivetrain Designs, Game 3

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

Note:

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

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

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

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

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

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

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

Socio-economic, demographic, and political measures

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

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

Contextual measures: existing vehicles and their use; residences

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

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

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

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

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

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

In California, Delaware and New Jersey variables measuring awareness of and support for government-provided incentives to consumers are associated with valuation of PEVs and FCEVs.[18] 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

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

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

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

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

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

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

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

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

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

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

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

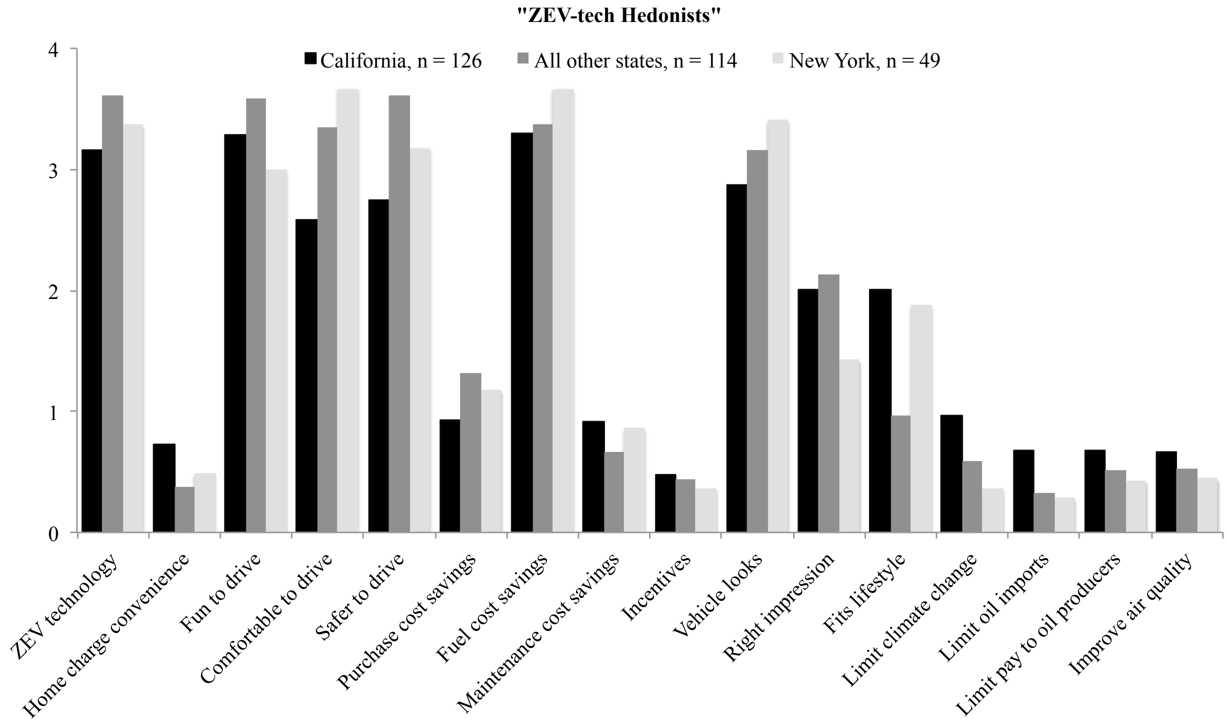
Post-Game Motivations: Why *do* respondents design PHEVs, BEVs, and FCEVs?

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

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

There is little difference in the mean motivations scores in Figure 30 between CA and all the other states for the cluster identified in California as "ZEV-tech Hedonists": people who on average have no highly scored pro-social motivation but appear to think a vehicle powered by an electric motor will simply be the best car: a fun, comfortable car that is safe to drive, good looking, makes a good impression on family and friends, and is fuel economical.

Figure 29: Mean motivation scores for “ZEV tech hedonists”



A close mapping is also possible for clusters identified as “Pro-social” (Figure 31), even if the added emphasis for New York is on fuel cost savings over interest in ZEV technology compared to California and the aggregate of all states other than California. On average, respondents in this cluster score highly all pro-social motivations: climate change, energy supply and security, and air quality. In naming this cluster, emphasis was given to interest in technology over fuel cost savings because the convenience of home charging follows directly from the new technology.

Similarly, the three analyses produce “generalist” clusters (Figure 32). These clusters share the attribute that their members draw from across all the categories of motivations: ZEV technology, driving performance, costs, and pro-social motives. The “CA Thrifty environmentalists” differ from the generalists for the aggregate of all other states and New York in that they place less emphasis on most all the vehicle performance and personal and social impression motivations, e.g., fun, comfort, looks, making a good impression and lifestyle. The “CA thrifty environmentalists place more emphasis on than the other generalists on purchase cost savings.

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

Figure 30: Mean motivation scores for "Pro-social" clusters

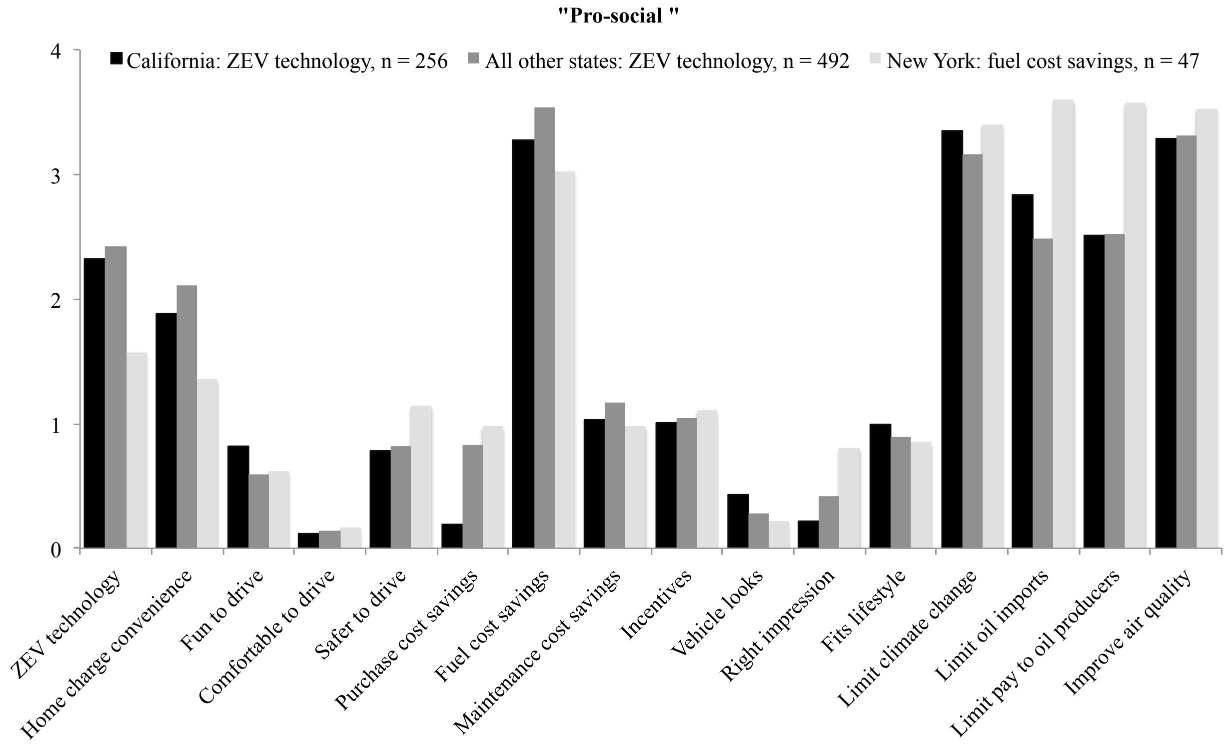


Figure 31: Mean motivation scores for "Generalists" clusters

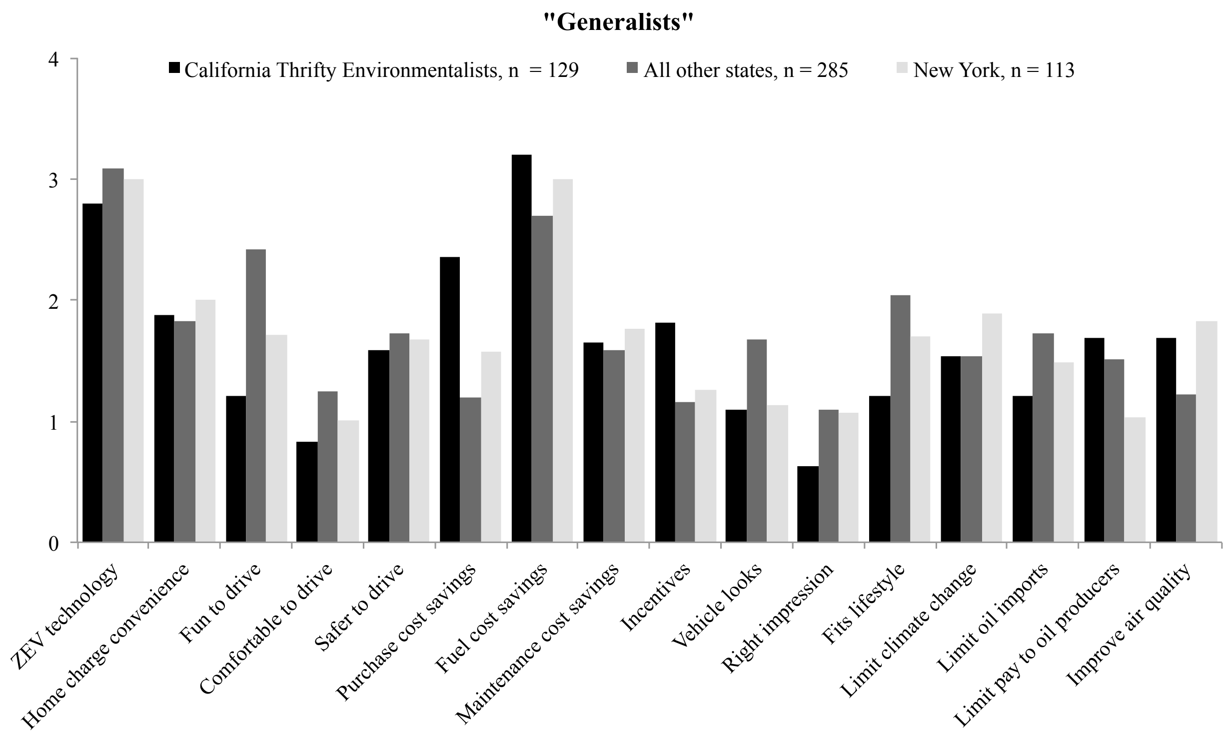
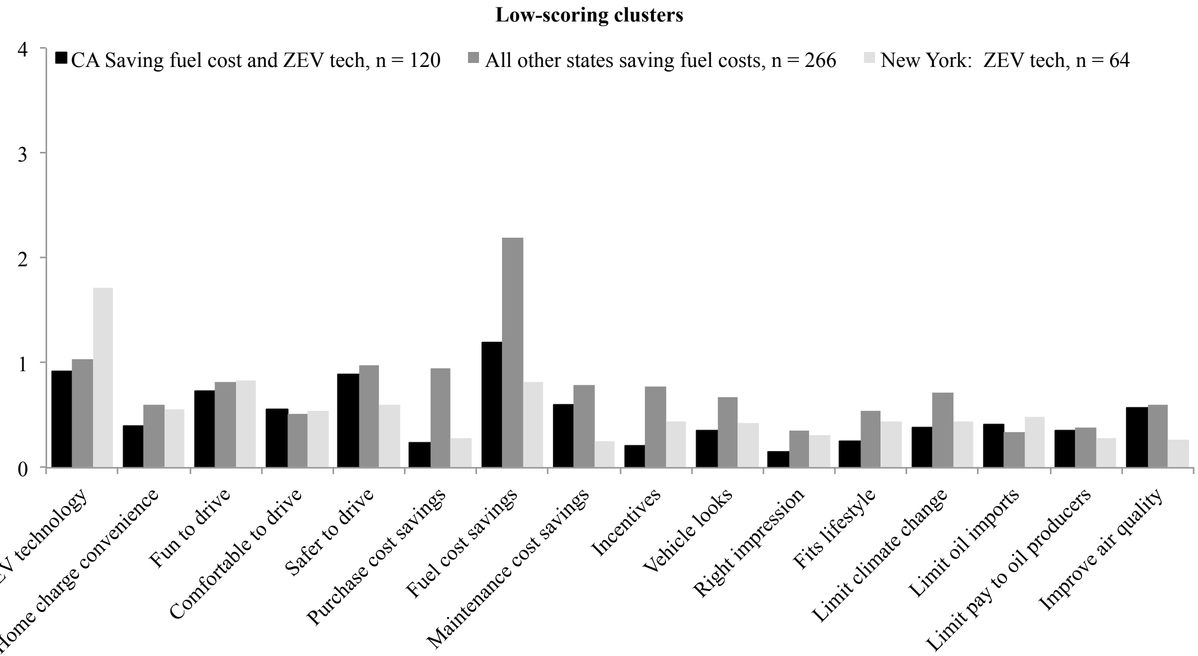


Figure 32: Mean motivation scores for low scoring clusters.



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

Motivations of those who design ICEVs and HEVs for not designing a PEV or FCEV are compared here. Clusters of respondents appear broadly similar between California, the aggregate of other participating states, and New York. Cluster mean scores are shown in Figures 33 through 36 for a three-cluster solution for California and the aggregate of all other states and the four-cluster solution for New York presented earlier.

Figure 33 illustrates a cluster from all three analyses that had several highly scored motivations for not designing a PEV or FCEV, especially concerns about driving range, away-from-home charging/fueling networks, and vehicle purchase prices. In both California and New York a cluster stands apart from all other clusters in each state for the high scores given to "no home charge or fuel" (Figure 34). In general both these clusters also give high scores to "unfamiliar technology," concern about limited charging/fueling networks, and the effects of PEVs on electricity supply. The clusters illustrated in Figure 35 are broadly similar to each other, though the cluster for the aggregate of all states but California score "no home charge or fuel" higher than does the one from New York. The New York cluster "fuel cost" higher than does the other cluster. What sets these two apart from all other clusters in Figures 33 and 34 is that despite also having several motivation scores higher than the global mean they have no high scores that match all those other clusters. In Figures 33 and 34, all clusters have at least two and as many as four motivations scoring an average higher than 3.0 points. Finally, the low scoring clusters for all three analyses are shown in Figure 36.

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

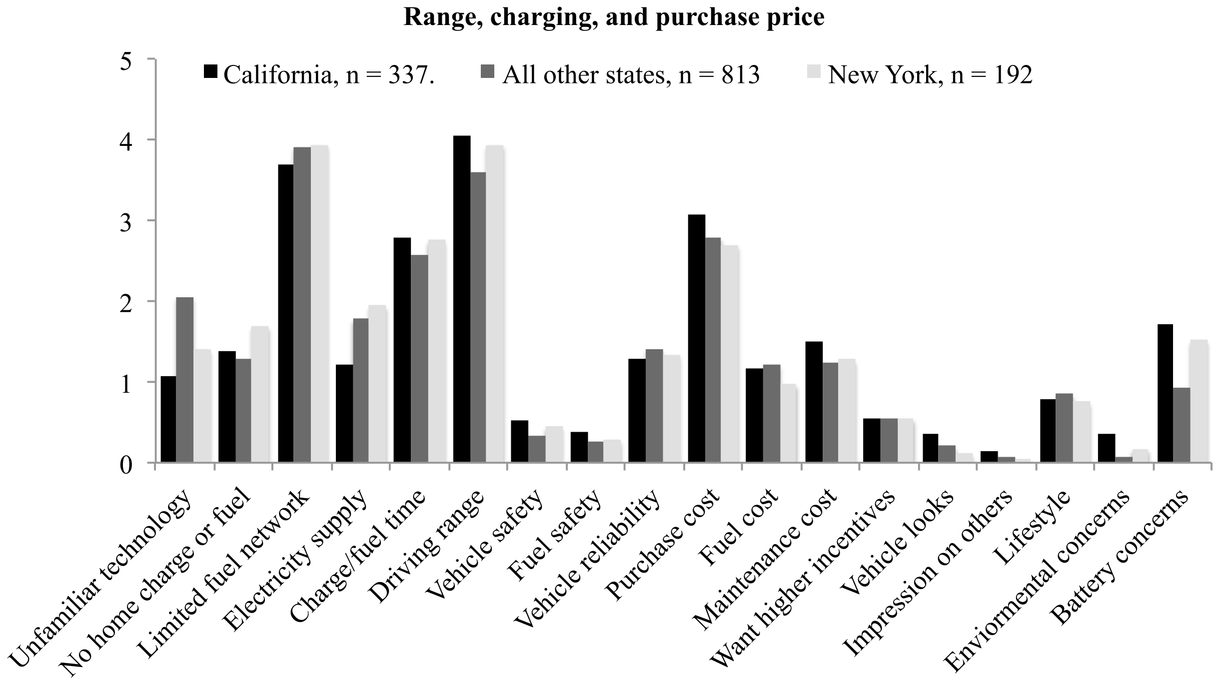


Figure 34: Mean motivation scores for clusters emphasizing an inability to charge/fuel a PEV or FCEV at home

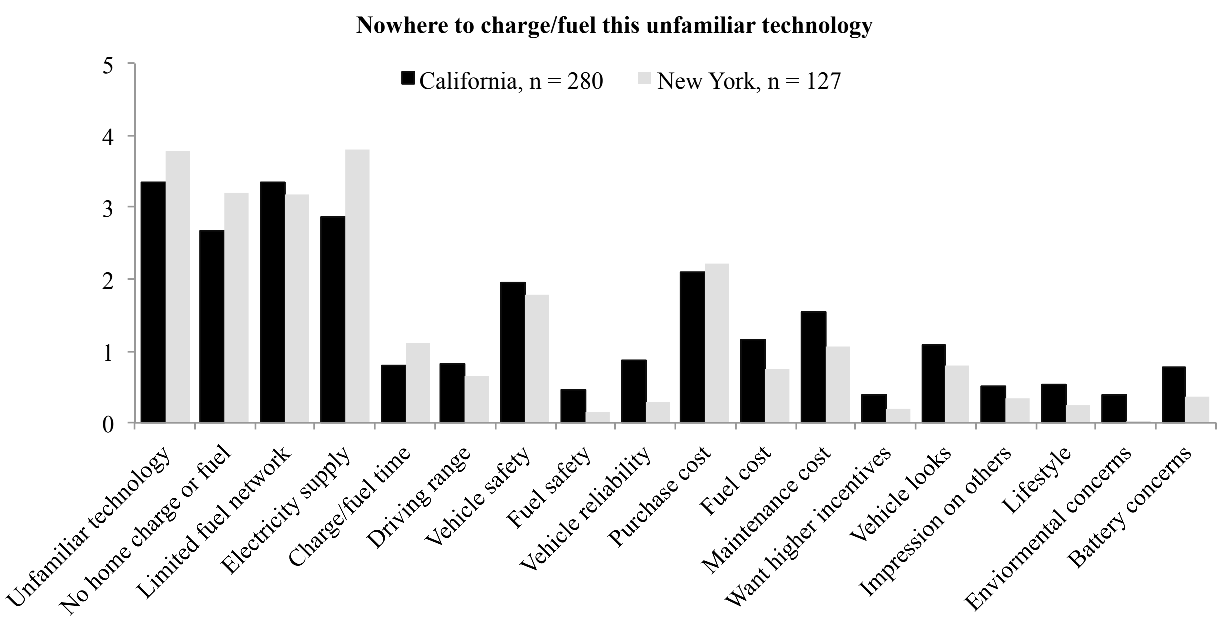


Figure 35: Mean motivation scores for "Tempered concerns"

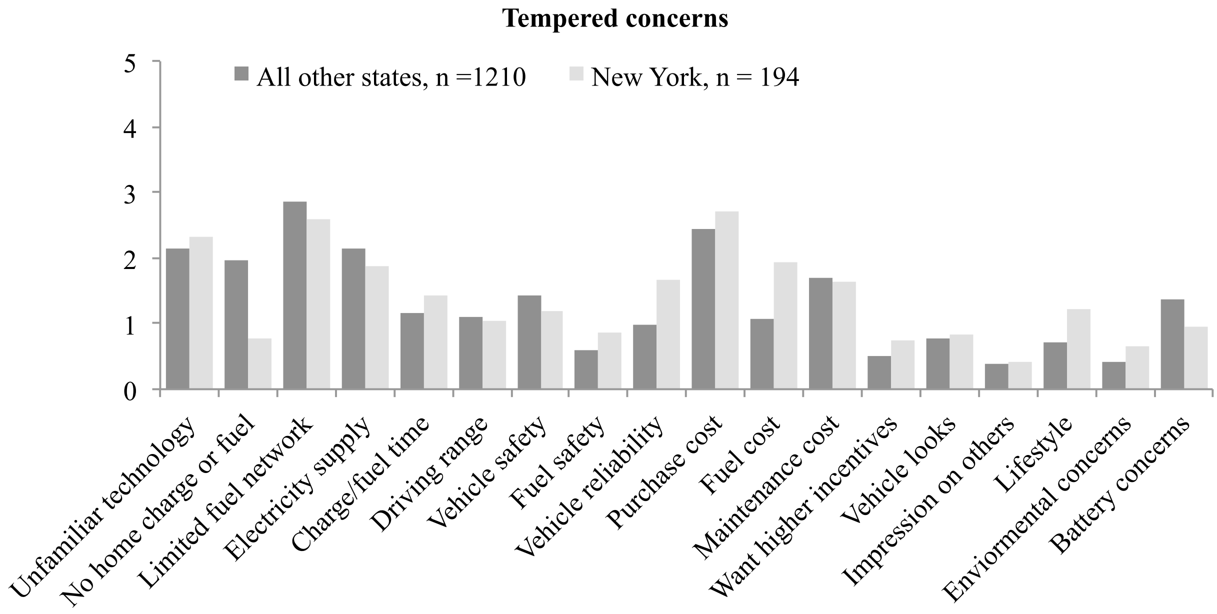
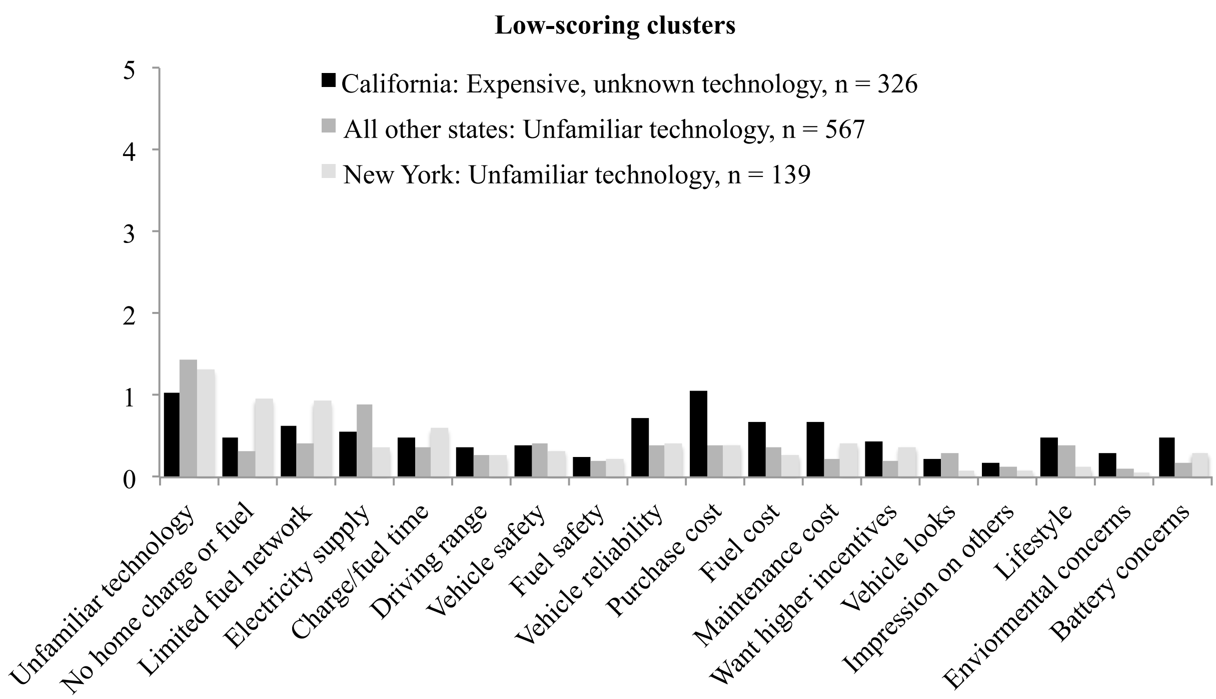


Figure 36: Mean motivation scores for low-scoring clusters



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

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

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

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

1. US Census http://www.census.gov/quickfacts/table/HSG010214/00
2. American Community Survey. Figures are as of July 1, 2014.
3. Based on a survey in November 2014 by UCD of all car-owning households in California the subset estimated to meet the definition of new car buyers used in this study.
4. Does not double count Massachusetts, New York, and New Jersey as part of NESCAUM.

DISCUSSION

Part of the overall framework for this study was to trace consumers through awareness, to knowledge, and then their valuation of PEVs and FCEVs. The measure of valuation in this study is whether or not the respondent would design a PEV or FCEV for their household's next new vehicle. A valuation does not have to be based solely on knowledge of PHEVs, BEVs, and FCEVs, ZEV technology, supporting infrastructures, social goals, and private vehicle performance attributes, e.g., prices and body styles. A valuation certainly does not have to be based on accurate knowledge, but can be based on what the respondent thinks they know, whether or not their "knowledge" matches that of other consumers, ZEV engineers and designers, policy makers, or other experts. A valuation does depend on awareness—consumers are unlikely to form valuations of things of which they are entirely unaware. Thus, the vehicle design games are not an attempt to estimate markets but to explore present valuations—no matter how imperfectly formed—and to understand whether and how those present valuations can be affected. The rest of this discussion turns to this question.

Lack of awareness, knowledge and experience

In New York—where PEVs are presently offered for sale—the results of this research indicate a lack of general consumer awareness of availability is the first problem to be overcome to expand PEV markets, followed immediately by aiding consumers to learn what it is they don't know (or to unlearn what they think they know but is incorrect) about HEVs, PHEV, BEVs, and FCEVs. Less than one-fourth of this sample of new-car buyers could name a BEV. Of the people who can correctly name a BEV, nine-of-ten can name one of only two: the Nissan Leaf or Tesla.

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 respondents' familiarity and distinguishing what they know from what they think they know. The distinction between charge-depleting modes of PHEVs—all-electric operation (see for example, BMW's i3 with range extender) vs. assist (see for example, Toyota's Prius Plug-in) is another source of profound confusion. Hypothesizing misunderstandings about HEVs, PHEVs, and BEVs provides a partial explanation for why so many more people design HEVs in the survey than buy them in the real world, but also provides encouragement that some consumers would more highly value PHEVs—especially those with all-electric charge-depleting operation—if those people understood how the different vehicles operate and are fueled and charged.

In general, the assertion that respondents are unfamiliar is supported by low self-ratings of their familiarity and limited or absent driving experience with HEVs, PHEVs, BEVs, and FCEVs. The assertion is further supported by respondents' answers to whether they have already considered buying a BEV or FCEV.

If many respondents don't understand the distinctions between HEVs and PHEVs in particular, why do as many design a PEV or FCEV for their next new vehicle, especially compared to existing sales (leaving aside for now FCEVs are not for sale in New York)? Some explanations are on the supply side; not all manufacturers have had PEVs since sales started (nor do all have at least one, now). Nor do all dealerships carry PEVs, even if the manufacturer(s) they represent make them. On the demand side, 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 survey world that aren't available in the real world.

Prior PEV Evaluations

Despite the lack of name recognition, the mistaken concepts about how vehicles operate, and the admitted low familiarity and experience, as well as the limited opportunity to buy PEVs because of their recent and limited introduction to retail markets in New York, a small percentage of respondents claim to have already started to search for information, perhaps already visiting a dealership for a test drive, or even acquiring one for their household (16% for PEVs and 7% for FCEVs). It is a hopeful sign for ZEVs that prior consideration—that is, prior to the design games in the survey—is associated with a greater (rather than lower) likeliness to design the next new household vehicle as a PHEV, BEV, or FCEV.

This generalized search behavior enters into a multivariate model of respondent valuation of PEVs and FCEVs, i.e., respondents' drivetrain designs in the third vehicle design game. That these measures of whether respondents have already considered such vehicles enter the model support the importance of shaping consumers' consideration, but are vague as to how exactly to do so. If measures of more specific dimensions entered the model (and as shown in Appendix Table A, there were many candidate variables that were tried) those measures would have spotlighted areas for education and information, incentive deployment, infrastructure development, product availability or any of a number of possible specific actions. In the absence of these measures of specific dimensions of PEVs and FCEVs, other aspects of this analysis must inform conclusions and next steps—including other variables that are in the multivariate model.

Motivations

Motivations and barriers are different from the variables affecting the likeliness a household designs a PEV or FCEV in that motivations and barriers are assessed after the respondents have created and selected their vehicle. In this sense, the questions are less about inferring what matters through the exploration of statistical correlation than they are a challenge to the respondent to explain themselves. It is a validation of the inferences from the modeling that these explanations for those who design PEVs or FCEVs are recognizable from the modeling results—with a few surprises.

Two of the most highly scored motivations for designing a PEV or FCEV directly reflect explanatory variables in the multivariate model:

- Motivation: I'm interested in the new technology; Model explanatory variable: respondent's own interest in ZEV technology
- Motivation: It will reduce the effect on air quality of my driving; Model explanatory variable: personal concern for air pollution

These speak to the usefulness of connecting PEV or FCEV promotion with existing communities of interest and media used by those communities. While ZEV technology interest groups may or may not take the message very far outside existing PEV owners, related technology groups may be use similar media sources. Air quality groups—whether formal agencies or not—would appear to be natural allies. This may be to state the obvious—but the validation of this idea from potential consumers at least indicates environmental policy makers are not making a mistake in believing some consumers will be motivated by their ability to take action on air pollution.

Though they are not further supported directly by variables in the multivariate model, some possible surprises come in motivations associated with cost and driving fun:[19]

- To save money on gasoline or diesel fuel, and
- It will be fun to drive.

These post-hoc explanations for designing a PEV or FCEV indicate personal and social goals ancillary to ZEV-related policy motivates some consumers. In effect, some consumers would switch from gasoline to electricity to take control over specific types of spending. Gasoline costs—as ongoing and uncertain—are accounted differently both because prices (and thus costs) vary over time. Finally, some respondents remind us that vehicles with electric drivetrains can be fun—and fun can be motivating.

The cluster analysis searching for respondents with shared sets of motivations is especially important regarding the motivation of saving money on gasoline or diesel fuel. If consumers have an expectation of saving money substituting electricity or hydrogen for gasoline or diesel, those expectations were likely going to be disappointed for hydrogen, and may now be for electricity too given the lower gasoline prices contemporaneous with this report. The cluster analysis indicates that while the expectation of fuel cost savings is pervasive among those who designed a PEV or FCEV, but also that almost all those respondents also had other highly scored motivations. Messages about new technology, environmental benefits, and fun remain valid even in the face of low gasoline and diesel prices.

Barriers: lack of knowledge

Aside from the lack of awareness of the present availability of PEVs discussed above, understanding why more people do not have positive valuations of ZEVs—at least not positive enough to cause them to design one as a plausible next new vehicle for their household—may be the next most important to understand. Recall these are the top-scoring individual 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
- Concern about unreliable electricity, e.g. blackouts and overall supply
- Distance on a battery charge or tank of hydrogen is too limited

[19] Their absence doesn't contradict their importance. They may be subsumed inside the variables for prior consideration of vehicles powered by electricity or hydrogen.

- Concern about time needed to charge or fuel vehicle
- I can’t charge vehicle with electricity or fuel one with natural gas at home
- Cost of maintenance and upkeep
- Cost to charge or fuel

Taken as a whole, this list illustrates that for many people it is the sheer number of questions, uncertainties, and doubts they have that add up to their negative (or at least, not sufficiently positive) valuation of ZEVs. 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 [PEV or FCEV] 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 PEVs and FCEVs include charging/fueling (away from home networks, inability to fuel/charge at home, time to charge/fuel), costs (purchase, maintenance, and fueling). Solutions to charging at home may be idiosyncratic and specific to each situation—but amenable to general actions on codes, standards, and designs for EVSE installations.

Beyond some initial threshold of away-from-home charging and fueling locations, addressing concerns about availability of away from home charging is as much about the appearance of an extensive fueling network, about developing and disseminating images and information about such networks. It is the case that respondents who say they have seen EVSEs in the parking lots and garages they use are more likely to agree there are enough places to charge PEVs.

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).

Maintenance and fuel costs are discoverable only with use, that is, over time. Other barriers that share this are concerns about reliability of electricity supply, the ability of an away-from-home network to provide adequate charging/fueling, and coupled with this, the suitability of any particular driving range charge/fueling. While experience might be the best teacher, the problem discussed here is people who aren’t interested in accumulating the relevant experience in a PEV or FCEV. Images that make PEVs “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.

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

Financial incentives alone do not overcome the barriers and “dis-motivations” of the people who do not already have a favorable valuation of PEVs or FCEVs. Only 5% of those who did not design a PEV or FCEV indicated that larger incentives would have changed their minds. Simply making the vehicles less expensive doesn’t address the barriers of awareness, their long list of questions, or the perceptual and real barriers to vehicle acquisition and use, especially charging and fueling networks. Even for those who did design PEVs or FCEVs, only 5% assigned the maximum value to the statement, "incentives made [a PEV or FCEV] too attractive to pass up."

Constraints to PEVs? Measuring access to home charging

Lack of access to charging at home is cited as one of the stronger motivations against designing a PEV. Overall, one-in five respondents strongly disagrees they would be able to charge a PEV at home and nearly 30 percent is at least doubtful. Access to electricity at the home parking location is correlated to home ownership (home owners are more likely to have access), residence type (residents of single family homes are more likely to have access than are residents of other types of dwellings) and to the respondents' self-ratings of whether they think they could charge a PEV at home (there is a positive linear relationship between self-rating of ability to charge a PEV at home and access to electricity at the home parking location).

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 serves the purpose of identifying households who are more or less likely to already have access to electricity at their home parking and to be able to make it available if desired. However, these other variables change our focus from the respondent (their self-evaluation of access) to their physical residential context (ownership, building type). The hazard is that by focusing on, for example, owners of single family homes, because they are most likely to be able to charge PEVs at home—now—we miss the renter, the apartment dweller, or even the condominium owner. Models such as those tested here may tell us what is most effective, but they may not tell us what to do next, after we have done the most effective thing.

What is not in the multi-variate model?

Socio-economic and demographic descriptors of respondents

Home ownership may be an inexpensive and readily available proxy measure for the probability the resident could charge a PEV at home, but we can't say the same thing for the residents themselves. That is, measures such as income, age, and education may be unreliable indicators of interest in ZEVs—even if the early market for PEVs showed a strong and specific socio-economic and demographic profile. In fact, respondent gender enters the model for New York with the opposite sign of the present early-PEV owner profile: in the survey data, women are more interested in ZEVs than men. The absence of age, income, and education are explained by two factors. 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 for the only the effects of other 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 the vehicles and ZEV policy goals, most general descriptors of people are not important to explaining who does or does not have a pro-PEV or FCEV valuation.

Why are women in the model more interested than women in the real world?

As noted, the demographic descriptor that enters the model is gender. In general terms, the explanations for why gender appears in the model but with the opposite sense of the profile of early PEV buyers include that there is something about the real world that is not accounted for by the model. This is likely because the model is simpler than the world. We can exclude those things that are in the model. That is, the model accounts for differences in interest in ZEV technology (in the survey data, women are less likely to be interested than men), personally worry about air quality (no difference in average level of concern between women and men), prior consideration of BEVs and FCEVs (women are less likely than men to have already considered a BEV or an FCEV), having previously seen an EVSE in the parking lots and garages they use (women are less likely than men), and monthly driving distance (women drive less on average than men).

The explanation for why women appear to be more likely to design their next new vehicle to be a PEV than men (controlling for the other variables in the model) must be incomplete at this time. The results are not a strong enough case to specifically single out women for education, information, outreach, and other sources of information and experience. It is enough to caution against ignoring them simply because the earlier PEV buyers were disproportionately likely to be male.

CONCLUSIONS

Who are the New York Sample of New Car Buyers; What are Their Prior Notions about ZEVs

On socio-economic and demographic measures including respondent age, gender, education, and employment status as well as household income, the New York sample looks very similar to the total sample from all participating states. Perhaps the largest deviation is the higher percentage of respondents who are men.

Several concepts are possibly related to a respondent's valuation of a PEV or FCEV as a plausible next new vehicle for their household. These are among such concepts measured in the on-line survey:

- Likely replacements for gasoline and diesel fuel, in the abstract
- Attitudes toward climate change and air quality
- Prior familiarity with the specific technologies that were 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."

Among likely replacements for gasoline and diesel, a substantial majority selects electricity. Reasons given include it has "already been proven to be effective" and "it is best for the environment." Concerns for air quality and climate differ only slightly between the NY and total sample: respondents from NY on average are slightly more likely to agree that air quality represents a health threat in their region but are as likely the total sample to agree that they personally worry about air quality. Overall, a slightly larger majority (59% vs. 57%) of NY respondents believe, "Human-caused climate change has been established to be a serious problem and immediate action is necessary."

Overall, prior awareness—measured in the survey before valuation is assessed—of 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. Despite the availability of several PEVs in New York, BEV name recognition is not pervasive across the sample and is largely limited to two BEVs. Asked to rate their familiarity with HEVs, PHEVs, BEVs, and FCEVs, 21% (HEVs) to 39% (FCEVs) of respondents say they are unsure or decline to answer. Of those who do respond, the mean familiarity scores are low. Less than half of new-car buyers are aware of incentives from the federal government; the proportion is far lower for incentives from all other entities including states, cities, and electric utilities. If respondents are "familiar enough with these types of vehicles to make a decision about whether one would be right for [their] household," that familiarity was not gained through actual experience with any PHEV, BEV, FCEV, or even HEV. Measured on a scale of -3 (none at all) to 3 (extensive driving experience), the *mean* scores for these new-car buyers' driving experience are negative (HEVs, -

1.59; PHEVs, -2.15; BEVs, -1.97; and FCEVs, -2.22) and the median scores for all four are nearly -3.

The most positive outcome for ZEV proponents would be with regard to public PEV charging infrastructure. PEV charging infrastructure may be the most oft recognized sign of PEVs in those states that have had active programs to deploy workplace and/or public charging. In NY, 62 percent of respondents claim to have seen a charger in a parking garage or lot they use.

More than half (55%) of NY respondents' households own two or more; this is lower than the total sample. The "age" distributions of these recently acquired vehicles—whether measured by the model year or year acquired—are similar for NY and the total sample. The distributions of self-reported vehicle purchase prices indicate the NY sample may have paid slightly more on average for their most recently acquired new car than did the total samples. The vast majority of these vehicles (96% for the NY and total samples) are fueled by gasoline.

Most of the NY sample (78%) report they own their home; 20% rent. These match the total sample percentages. Two-thirds of respondents report their residence is a single-family home. Taking ownership and residence type together, 63% of the NY sample resides in a single-family residence they own. Most apartments are rented as are about half of townhouses, duplexes, and triplexes. These multi-unit dwellings have been problematic markets for PEVs as residences of such buildings may not have access to a regular, reserved parking spot and be reluctant—or may lack authority—to install electrical infrastructure to charge a plug-in vehicle.

PEV and FCEV Designs

Respondents' valuations of ZEVs are determined in the final (of two or three, depending on the specifics of each respondent's vehicle designs) design game in which no PHEVs or BEVs are offered with the combination of 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 BEVs; PHEVs that run on both gasoline and electricity until the battery is depleted and FCEVs are allowed as full-size vehicles.

Ignoring for now differences between vehicles within each drivetrain type, e.g., ignoring differences in driving range across the BEV designs created by respondents, a bit more than one-third of respondents design their next new vehicle to be a PHEV (20%), BEV (12%), or FCEV (4%). (As important for other policy goals, the single most common drivetrain design is HEV—far out-distancing the prevalence of HEVs in the actual on-road fleet of vehicles and in new vehicle sales.)

PHEV Designs

- PHEV designs were by far the most popular of the PEV or FCEV possibilities: 140 respondents designed a PHEV compared to 92 BEVs and 45 FCEVs.

- PHEV designs emphasize longer range driving on electricity, but a mode in which more gasoline is used, i.e. assist mode (such as the Prius Plug-in) rather than all-electric (such as the BMW i3 REx).
- Faster charging at home or at a (initially limited) network of quick chargers is less popular than charging at the lower speeds afforded by existing home electrical outlets—though some of these believe they would use a higher power 220 volt outlet (such as for electric dryers, stoves, ovens, and air conditioners).

BEV Designs

- BEV designs split as to whether they emphasize short or long range: half of designs incorporate range 100 miles or less.
- There is a strong positive correlation between the longest ranges (200 and 300 miles) and interest in the fastest possible home charging.
- Conversely, among those who design the shortest range BEVs (50 and 75 miles) none selects the fastest possible home charging and up to and including 150 miles range, there is less interest in away-from-home quick charging

FCEV Designs

- A plurality of FCEV designs incorporate the middle offered range (250 miles)
- Home H_2 refueling was included in most designs, though proportionally less for this preponderance of "middle-range" vehicles.

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

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

- Having already seen electric vehicle charging being deployed; specifically, having seen public charging in the parking lots or garages the respondent uses.
- Being personally worried about air pollution.
- Having someone in the household who is interested in new technology, especially if the respondent is specifically interested in ZEV technology.
- Having already considered—including having already shopped for—a PEV is associated with a higher likeliness of designing a PEV.
- Having already considered a FCEV and being *unwilling* to consider a PEV is associated with a higher likeliness of designing a FCEV.

These variables have mixed effects on the likeliness of designing an HEV, PHEV, BEV, or FCEV:

- Monthly miles driven by the respondent
- Respondent gender

Why do people design PEV or FCEVs?

Motivations for designing a PHEV, BEV, or FCEV (assessed after the vehicle design games) are a mix of private and societal

- Private
  - To save money on gasoline or diesel fuel
  - I'm interested in the new technology
  - It will be safer than gasoline or diesel vehicles
  - It will be fun to drive
- Societal
  - It will reduce the effect on climate change of my driving
  - It will reduce the effect on air quality of my driving

There is little acknowledgement that incentives offered in the final design game—a mix of purchase and use incentives—were important to their vehicle designs.

Clusters of respondents are identified who share similar motivations:

- Pro-social fuel cost reductions: these respondents tend to highly score all pro-social motivations, i.e., air quality, climate change, and energy supply and security.
- ZEV-tech Hedonists: in stark contrast, these respondents score none of the pro-social motivations highly, but focus on how ZEV technology is simply going make a better car.
- ZEV technology: the least likely to score multiple motivations, this group does emphasize their personal interest in ZEV technology
- Cost-saving generalists: while emphasizing cost savings in every category, i.e., purchase, fuel, and maintenance, this cluster also highly scores at least one motivation in all the other categories: pro-social, ZEV technology, vehicle performance, and social image and lifestyle.

Broadly speaking, these clusters are similar to those found in the California analysis and in an analysis of the aggregate of all states except California.

Why don't people design PEVs or FCEVs?

The most important motivations against designing PEVs or FCEVs have to do with their inherent newness:

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

Few acknowledged that greater incentives—especially the primarily financial incentives offered to them—would have changed their minds. Taking the list of motivations to not design a PEV or FCEV and the apparent lack of effectiveness of incentives to sway these respondents together, it appears that financial and use incentives alone don't answer all the many questions that many respondents have about PEVs or FCEVs.

The Role of Government Incentives

Respondents who design their next new vehicle to be a PEV or FCEV within the confines of the "survey world" presented to them believe PEVs or FCEVs are "the right thing." Those who do not design a PEV or FCEV are either not convinced or outright resistant. When asked about whether they have already considered ZEVs, 23% of the sample replies that they have not and *would not* consider buying PEV; 33%, an FCEV.

If an actual opposition (at present) to PEVs and FCEVs or ZEV policy seems a small portion of new-car buyers, incentives play an unacknowledged role in positive valuations of PEVs and FCEVs may not address the first problems of those with negative valuations. We start by observing that prior to the introduction of incentives (modeled on those actually offered in the real world) in the design games, very few respondents were aware such incentives exist. Offered financial purchase incentives and use incentives, financial incentives were far more frequently selected.[20]

However, among those who did not design a PEV or FCEV, only 5% assigned the highest possible score to the statement, "higher incentives would have convinced me [to design a PEV or FCEV]." (Only 18% assigned any points to this statement.) Among those who did design a PEV or FCEV, very few people who designed a PEV or FCEV (and selected their incentives) indicated that those incentives were influential to their vehicle design.

This doesn't mean incentives can be terminated in the real world where they are already being paid without negative consequences. Incentives are an important part of the "saving money" arguments some make for PEVs. Incentives are routinely reported to be instrumental to explain differences in PEV sales by states: high in those with high incentives, lower otherwise. Whether individual survey respondents are willing to say so or not, incentives have become part of the public discussion of ZEVs.

What are the biggest problems for those who don't value ZEVs?

If a financial hurdle—which incentives can help push them over—isn't the most pressing problem, what is?

1) Lack of awareness that PEVs are for sale, the result is people don't know to formulate the question of whether a PEV or FCEV is right for their household. The results of this study indicate that four years after the advent of PEV sales, many new-car buyers—people who have been on car lots in the last few years, shopping for, and buying new cars—don't know PEVs are for sale. It is clear in the difference between answers to questions about familiarity vs. experience, from the lack of PEV name recognition, from the low percentage of people in the sample who already own a PEV, and from the interview discussions that the vast majority of

[20] 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 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.

respondents were constructing their valuation of PEVs and FCEVs for the first time in the course of answering our survey and interview questions.

2) Lack of knowledge and experience: the multiplicity of questions that most people have about PEVs and FCEVs is itself a barrier. Many people simply have too many questions. Answering those questions is an opportunity to build coalitions both on the supply side with vehicle, EVSE, and electricity providers and with communities of interest among potential consumers.

Building a market segment by segment

How do we use these results to build ZEV markets? 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.

The model built to explain respondents' vehicle designs includes a measure of attitudes toward air quality: the more strongly a respondent agrees they are personally worried about the health effects of air quality, the more likely they are to design a PHEV or BEV in their survey. The model does not contain a measure of belief in or concern for climate change. This does not mean no one interested in PEVs or FCEVs believes in or is concerned by climate change. It means that given the other variables in the model, adding measures related to climate doesn't make the model better in statistical sense. All three of the simple tests of correlation between attitudes and beliefs regarding climate change and vehicle design in Appendix A: Table A reject the null hypothesis of no effect, i.e., taken by themselves, measures of belief in the reality and urgency of climate change are associated with PEV and FCEV design. The likely explanation for why they don't enter the model is the correlation between attitudes and beliefs regarding air quality and climate—people concerned about one tend to be concerned about the other. That air quality "wins" this particular statistical battle does not preclude outreach to communities of interest around climate issues—it merely suggests that the first most effective step may be to reach out to communities of interest around air quality. If membership in the two communities overlaps, then social effects between private citizen/consumers may amplify the efforts of marketers and social marketers.

A similar effect may occur for those concerned with energy security, oil imports, payments to oil developers, though in this specific data set, there is less overlap of these people with those who have concerns about air quality and climate.

Fostering communities of interest around ZEV technology is supported by several variables in both models. Whether it is having a technophile in the household or a respondent with an interest in how ZEVs work, those households with a high interest on technology are more likely to design their next household vehicle to be a PEV or FCEV than are those households who don't have such an interest in technology.

The positive effects of prior experience of HEVs, prior evaluations of BEVs (driving range and comparative safety seem to rise to the top) and prior consideration of FCEVs all suggest the importance of information and experience in shaping valuations of ZEVs.

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 $\boldsymbol{\alpha} = 0.05$ is used to establish statistical significance.

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

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
Number of vehicles	H_a: Households with more vehicles are more likely to design a PHEV, BEV, or FCEV than are households with fewer vehicles. (More experimentation with vehicle types, more body styles in household fleet to accommodate a variety of driving missions, spending more money on vehicles.)	H_o accepted: No significant relationship.
Number acquired as new since 2008	H_a: Households who have acquired more new vehicles since 2008 are more likely to design a PHEV, BEV, or FCEV. (More experimentation with vehicle types, more body styles in household fleet to accommodate a variety of driving missions, spending more money on vehicles.)	H_o accepted: No significant relationship.
Price paid for most recently acquired as new	H_a: Households who spent more are more likely to design a PHEV, BEV, or FCEV. (Spending more money on vehicles.)	H_o accepted: No significant relationship.
Respondent's vehicle's monthly miles	H_{a1}: Households who drive farther per month are more likely to design a PHEV, BEV, or FCEV. (Lower "fuel" prices of electricity may be attractive.) H_{a2}: Households who drive less per month are more likely to design a BEV or FCEV. (Existing travel may be more amenable to shorter range BEVs or FCEVs with a limited refueling network.)	More miles, more likely to design PHEV, BEV, or FCEV
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.)	Higher spending, more likely to design BEV or FCEV
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.)	In general, higher accuracy of fuel spending is associated with higher likeliness to design PHEVs, BEVs, and FCEVs. (Two "least accurate" responses collapsed into one.)
Household total fuel cost	H_a: Households who spend more on fuel for	Higher spending, more likely to

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	their whole fleet of vehicles will be more likely to design a PHEV, BEV, or FCEV. (Lower "fuel" prices of electricity may be attractive.)	design BEV or FCEV
Accuracy of total fuel cost	H_a: Households that know their fuel spending more accurately will be more likely to design a PHEV, BEV or FCEV. (Lower "fuel" prices of electricity may be attractive.)	Relationship is significant (barely better than the threshold value), but not orderly.
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.)	If already inclined to believe electricity will replace gasoline and diesel, then more likely to design anything but ICEV.
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.)	If already inclined to believe hydrogen will replace gasoline and diesel, then more likely to design anything but ICEV or HEV.
Daily flexibility (as to who drives which vehicle)	H_a: Households with more flexibility as to who drives and who drives which vehicle will be more likely to design a BEV. (Flexibility is a tool to adapt to short range.)	If "every day we decide who will drive…" or if the household has only one driver, then less likely to design an ICEV.
HOV lanes	H_a: Respondents who already drive on routes with HOV lanes may be particularly attracted by the incentive of single-driver HOV lane access, thus to design a PHEV, BEV, or PHEV. (Perceived timesavings may be a powerful incentive to design a qualifying vehicle.)	If they regularly drive routes with HOV lanes, then—whether they can use those lanes or not—they are more likely to design a PHEV, BEV, or FCEV
Toll lanes	H_a: Respondents who already drive on routes with tools may be particularly attracted by the incentive of reduced tolls and thus to design a PHEV, BEV, or PHEV. (Perceived cost savings may be an incentive to design a qualifying vehicle.)	If they regularly drive routes with toll lanes, then—whether they can use those lanes or not—they are more likely to design a PHEV, BEV, or FCEV
Daily distance variation	H_a: Respondents with less variation in their daily travel will be more likely to design a BEV. (Greater variability may make it more difficult to imagine adapting to a limited range vehicle.)	Relationship statistically significant, but not orderly that is, it isn't strictly the case that increasing or decreasing variability is associated with increasing or decreasing likeliness to design one type of vehicle or another.
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	Those able to park at least one vehicle in a garage or carport are

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	residence) are more likely to design a PHEV, BEV, or FCEV. (Certainty of parking location.)	more likely to design a PHEV, BEV, 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.)	Those with access—and in particular those with more powerful electrical service access—are more likely to design ZEVs.
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.)	Those who would require authorization from someone else to install charging at home are more likely to design ICEVs and HEVs.
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.)	Those with natural gas at home are more likely to design an FCEV.
Familiarity with gasoline vehicles	H_{a1}: Increasing familiarity with gasoline vehicles is associated with a *lower* likeliness to design an HEV, PHEV, BEV, or FCEV. (Familiarity with the present vehicle type produces conservatism toward alternatives.) H_{a2}: Increasing familiarity with gasoline vehicles is associated with a *higher* likeliness to design an HEV, PHEV, BEV, or FCEV. (Familiarity with the present vehicle type produces an attraction toward alternatives.)	Higher familiarity associated with higher likeliness to design an ICEV or 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, PHEV, BEV, or FCEV. (Familiarity with the alternative vehicle type produces an attraction toward alternatives.)	H_{a2} supported, sort of. Higher familiarity associated with lower likeliness to design an ICEV, but the probabilities of designing all alternatives increases by non-statistically significant amounts. That is, slight increases in all alternatives.
Environmental and health risk of electricity compared to gasoline	H_a: Respondents who believe electricity is a lower environmental and health risk than gasoline will be more likely to design a PHEV or BEV. (Desire to reduce environmental and health risks associated with their travel.)	Higher comparative risk of electricity appears to be associated with lower likeliness to design a BEV.
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	If they have seen public EVSEs they are more likely to design a PHEV, BEV, or FCEV

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	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 that respondent using 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.	Higher BEV driving experience associated with higher likeliness to design BEV. Higher HEV, PHEV, and FCEV experience associated with higher likeliness to design BEV or FCEV.
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.	Higher experience driving PHEVs, BEVs, and FCEVs is associated with a higher likeliness to design a BEV.
One factor solution to factor analysis of the four measures of HEV, PEV, or FCEV driving experience	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.	Factor correlated to drivetrain design.
BEV home charging: "My household would be able to plug in a vehicle to charge at home."	H_a: Stronger agreement associated with higher likeliness to design a PEV.	Stronger agreement associated with lower likeliness to design an ICEV.
BEV public charging: "There are enough places to charge electric vehicles."	H_a: Stronger agreement associated with higher likeliness to design a PEV.	Stronger agreement associated with lower likeliness to design an ICEV and higher likeliness to design a BEV.
BEV charge time: "It takes too long to charge electric vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	Stronger agreement associated with higher likeliness to design an ICEV.
BEV range: "Electric vehicles do not travel far enough before needing to be charged|."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	Stronger agreement associated with higher likeliness to design an ICEV.
BEV purchase price: "Electric vehicles cost more to buy than gasoline vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	Stronger agreement associated with higher likeliness to design an ICEV.
BEV safety: "Gasoline powered cars are safer than electric vehicles."	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	Stronger agreement associated with higher likeliness to design an ICEV (but less likely to design an HEV) or FCEV.
BEV reliability: "Gasoline powered cars are more reliable than electric	H_a: Stronger agreement associated with *lower* likeliness to design a PEV.	Stronger agreement associated with higher likeliness to design an ICEV.

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

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
buy and drive vehicles powered by alternatives to gasoline and diesel: Federal government. State government My state government (New York)	incentives will be more likely to design a qualifying vehicle.	Prior belief that federal government offers incentives associated with higher likeliness of designing PHEV, BEV, or FCEV. Prior belief that state governments offers incentives associated with higher likeliness of designing PHEV, BEV, or FCEV. Prior belief that New York is offering incentives is associated with **lower** likeliness of designing BEV or FCEV.
Should governments offer incentives	H_a: Those who believe governments should offer incentives will be more likely to design a PHEV, BEV, or FCEV. (To the extent ZEVs have been politicized, responses may be shaped by people's ideas about the "proper" role of government.)	Belief that governments should offer incentives is associated with a higher likeliness of designing a PHEV, BEV, or FCEV.
Prior consideration of BEVs	H_{a1}: Higher levels of consideration of BEVs prior to completing the survey will be associated with *higher* likeliness of designing a BEV. (BEVs are making a *favorable* impression on more consumers than not.) H_{a2}: Higher levels of consideration of BEVs prior to completing the survey will be associated with *lower* likeliness of designing a BEV. (BEVs are making a *unfavorable* impression on more consumers than not.)	H_{a1} supported. Those who have given greater prior consideration to buying a BEV are more likely to design a PHEV, BEV, or FCEV. (The relationship holds even if those people who say they already own "a vehicle powered by electricity" are excluded.)
Prior consideration of FCEVs	H_{a1}: Higher levels of consideration of FCEVs prior to completing the survey will be associated with *higher* likeliness of designing an FCEV. (FCEVs are making a *favorable* impression on more consumers than not.) H_{a2}: Higher levels of consideration of FCEVs prior to completing the survey will be associated with *lower* likeliness of designing FCEVs. (FCEVs are making a *unfavorable* impression on more consumers than not.)	H_{a1} supported. Those who have given greater prior consideration to buying an FCEV are more likely to design a PHEV, BEV, or FCEV. (The relationship holds even if those people who say they already own "a vehicle powered by electricity" are excluded.)
Urgent national need to displace gasoline and diesel	H_a: Stronger agreement there is an urgent national need for alternatives will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	Stronger agreement associated with higher likeliness to design a PHEV or BEV.
Market will produce all required incentives	H_a: Those who believe free markets would produce all necessary incentives will be less	Stronger agreement associated with lower likeliness to design an

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	likely to design a PHEV, BEV, or FCEV. (To the extent ZEVs have been politicized, responses may be shaped by people's ideas about the "proper" role of government.)	HEV.
Air pollution and individual lifestyle	H_a: Stronger agreement that individual lifestyle change affects air pollution will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	Stronger agreement that changes in lifestyle affect air quality associated with lower likeliness to design an ICEV.
Personal worry about air quality	H_a: Stronger agreement that the respondent personally worries about air quality will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	Stronger agreement the respondent is personally worried about air quality is associated with a lower likeliness to design an ICEV.
Air pollution a regional health threat	H_a: Stronger agreement that air pollution is a threat in the respondent's region will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	Stronger agreement associated with lower likeliness to design an ICEV (and higher to design a BEV or FCEV).
Certainty there is, or is not, evidence for rising global average temperatures.	H_a: Stronger agreement there is solid evidence of global warming will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	Greater certainty there **is no** solid evidence associated with higher likeliness to design an ICEV; greater certainty there **is** solid evidence associated with higher likeliness to design a PHEV, BEV, or FCEV.
Warming human-caused or natural	H_a: Stronger agreement global warming is human-caused will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	Among those who think temperatures have been rising, stronger belief the change is human-caused associated with lower likeliness to design an ICEV.
Climate change and individual lifestyle	H_a: Stronger agreement that individual lifestyle change affects climate will be associated with a higher likeliness to design a PHEV, BEV, or FCEV.	Stronger agreement that changes in lifestyle affect climate associated with lower likeliness to design an ICEV or HEV.
Own or rent residence	H_a: Respondents who own their residence will be more likely to design a PHEV, BEV, or FCEV.	H_o accepted: No significant relationship.
Residence type	H_a: Residents of single-family dwellings will be more likely to design a PHEV, BEV, or FCEV.	H_o accepted: No significant relationship.
Solar panels on residence	H_a: Respondents who already have solar panels installed on their residence will be more likely to design a PHEV, BEV, or FCEV.	Those who already have solar panels on their residence are more likely (than those who don't) to design a PHEV, BEV, or FCEV.
Respondent age	H_a: Respondents age 40 to 59 will be more	Respondents older than 50 are

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	more likely to design ICEVs or HEVs; respondents younger than 40 are more likely to design PHEVs, BEVs, or FCEVs; and those in their 40s are bit of a mix—less likely to design an ICEV or PHEV, but more likely to design an HEV, BEV, or FCEV.
Respondent gender	H_a: Male respondents will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	Women are more likely to design ICEVs or HEVs; men, PHEVs, BEVs, or FCEVs.
Respondent employment status	No specific alternative hypothesis.	The relationship is complex across the categories. In general, respondents who are not employed in the paid labor force, i.e., are unpaid family care givers in their own home, students, presently unemployed, or retired, they are more likely to design an ICEV or HEV.
Retired person in home	No specific alternative hypothesis.	Households with one (or more) retired persons are more likely to design an ICEV or HEV.
Children in household	No specific alternative hypothesis.	The relationship is complex, though generally households without children are more likely to design an ICEV.
Technophile in the household	H_a: Households with a technophile will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	If friends would describe someone in the household and family would describe as very interested in new technology, the respondent is more likely to design a PHEV, BEV, or FCEV.
Respondent's own interest in ZEV technology	H_a: Respondents who are personally interested in ZEV technology will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	Greater interest associated with higher likeliness to design a PHEV, BEV, or FCEV.
Respondent's education	H_a: Respondents with higher education will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	In general, higher levels of education are associated with a higher likeliness to design a PHEV, BEV, or FCEV.
Political party affiliation	H_a: Lefties more likely to design a PHEV, BEV, or FCEV. (Presently, federal initiatives are the product of a Democratic	Democrats are less likely to design ICEVs (and more likely to design anything else);

Independent (Explanatory) Variable	Alternate Hypothesis (Rationale)	Bivariate Statistical Relationship to Dependent Variable: Drivetrain design
	administration.)	Republicans are more likely to design ICEVs. "Other" looks more like Democrats; "none" look more like Republicans.
Household income	H_a: Higher income households will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	H_o accepted: No significant relationship.
History leasing vehicles	H_a: Households with a history of leasing will be more likely to design a PHEV, BEV, or FCEV. (Matches profile of the majority of early PEV buyers/lessors.)	People who leased either the most recently acquired new vehicle or the other vehicle driven most often are more likely to design ICEVs or HEVs.

APPENDIX B: RESPONDENT VALUATION OF ZEVS

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

Nominal logistic regression is used to assemble and test models because the variable to be explained consists of a small number of distinct possibilities—ICEV, HEV, PHEV, BEV, or FCEV—rather than a continuous scale. The whole model test (Table B1) evaluates whether all the explanatory variables taken together provide a better fit to the data than simply fitting the overall probability of each drivetrain type. In this case, the tiny probability (<0.001) of obtaining a larger chi-square by chance indicates that the explanatory variables, taken as a whole, do provide a better fit.

Table B1: Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	159.9689	36	319.9378	<0.0001
Full	944.9888			
Reduced	1104.9577			

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. That the sample size N (= 826) is less than the total sample size (997) indicates 171 individual cases are not used in this final model estimation because they lack data for one or more of the explanatory variables that appears in the model.

Table B2: Goodness of fit measures

Measure	Training	Definition
Entropy RSquare	0.145	1-Loglike(model)/Loglike(0)
Generalized RSquare	0.345	(1-(L(0)/L(model))^(2/n))/(1-L(0)^(2/n))
Misclassification Rate	0.498	∑ (ρ[j]≠ρMax)/n
N	826	

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	3180	934.761	1869.523
Saturated	3216	10.227	**Prob>ChiSq**
Fitted	36	944.989	1.0000

Table B4: Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Respondent Gender	4	4	12.610	0.0133
Personal interest in ZEV tech 2	4	4	46.545	<0.0001
Respondent's vehicle's monthly miles	4	4	9.5575	0.0486
Seen Public EVSEs yes/no	4	4	22.5280	0.0002
Consider BEV	8	8	41.4160	<0.0001
Consider FCEV	8	8	20.517	0.0085
Air pollution: personal worry	4	4	22.762	0.0001

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 substantive meaning of the parameters is interpreted in the text. Parameters shown in **bold** are statistically significant at $\alpha \leq 0.10$.

Table B5: Parameter Estimates

Term	Estimate	Std Error	Chi-Square	Prob>ChiSq
Intercept	**3.251**	**0.696**	**21.820**	**<0.001**
Respondent Gender[Female]	0.373	0.293	1.620	0.204
Personal interest in ZEV tech 2[Little to no interest]	**1.592**	**0.529**	**9.060**	**0.003**
Respondent's vehicle's monthly miles truncated	**0.000**	**0.000**	**3.830**	**0.050**
Seen Public EVSEs yes/no[No]	**0.489**	**0.223**	**4.800**	**0.028**
rConsiderEV[Maybe-No]	1.000	0.736	1.850	0.174
rConsiderEV[Yes-Maybe]	-0.517	0.641	0.650	0.420

Table B5: Parameter Estimates

Term	Estimate	Std Error	Chi-Square	Prob>ChiSq
rConsider FCEV[No]	0.707	0.417	2.870	0.090
rConsider FCEV[Maybe]	0.209	0.349	0.360	0.549
Air pollution: personal worry (trunc)	-0.188	0.150	1.580	0.209
Intercept (HEV)	**2.368**	**0.705**	**11.280**	**0.001**
Respondent Gender[Female]	**0.634**	**0.290**	**4.790**	**0.029**
Personal interest in ZEV tech 2[Little to no interest]	**1.194**	**0.529**	**5.080**	**0.024**
Respondent's vehicle's monthly miles	**-0.001**	**0.000**	**8.290**	**0.004**
Seen Public EVSEs yes/no[No]	0.343	0.219	2.450	0.117
Consider BEV[Maybe-No]	**2.100**	**0.743**	**8.000**	**0.005**
Consider BEV[Yes-Maybe]	-0.128	0.630	0.040	0.839
Consider FCEV[No]	0.646	0.416	2.410	0.121
Consider FCEV[Maybe]	0.478	0.343	1.930	0.164
Air pollution: personal worry	-0.029	0.149	0.040	0.844
Intercept (PHEV)	**1.579**	**0.731**	**4.670**	**0.031**
Respondent Gender[Female]	**0.552**	**0.297**	**3.460**	**0.063**
Personal interest in ZEV tech 2[Little to no interest]	**0.949**	**0.537**	**3.120**	**0.077**
Respondent's vehicle's monthly miles	**0.000**	**0.000**	**3.610**	**0.057**
Seen Public EVSEs yes/no[No]	0.030	0.227	0.020	0.894
Consider BEV[Maybe-No]	**1.450**	**0.772**	**3.530**	**0.060**
Consider BEV[Yes-Maybe]	0.023	0.648	0.000	0.971
Consider FCEV[No]	0.415	0.432	0.920	0.337
Consider FCEV[Maybe]	0.319	0.355	0.810	0.368
Air pollution: personal worry	0.126	0.157	0.640	0.425
Intercept (BEV)	0.743	0.768	0.930	0.334
Respondent Gender[Female]	0.400	0.311	1.660	0.198
Personal interest in ZEV tech 2[Little to no interest]	0.791	0.555	2.030	0.154
Respondent's vehicle's monthly miles	0.000	0.000	1.090	0.296
Seen Public EVSEs yes/no[No]	-0.086	0.241	0.130	0.721
Consider BEV[Maybe-No]	0.685	0.843	0.660	0.416
Consider BEV[Yes-Maybe]	0.816	0.718	1.290	0.255

Table B5: Parameter Estimates

Term	Estimate	Std Error	Chi-Square	Prob>ChiSq
Consider FCEV[No]	0.685	0.448	2.330	0.127
Consider FCEV[Maybe]	-0.030	0.379	0.010	0.937
Air pollution: personal worry	0.219	0.170	1.660	0.198

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 PHEV, BEV, and FCEV Evaluation and Experience; PHEV, BEV, and FCEV-specific attitudes	
California, Oregon, Washington and, Delaware	• Prior belief electricity is a likely replacement for gasoline and diesel
California, New Jersey, Massachusetts and NESCAUM	• Prior belief hydrogen is a likely replacement for gasoline and diesel
California, Delaware, New Jersey, New York and NESCAUM	• Personal interest in ZEV technology
Washington	• Technophile at home
California and Oregon	• Familiarity with HEVs, PHEVs, BEVs, and FCEVs
Washington	• Familiarity with HEVs
California, New Jersey and NESCAUM	• Familiarity with ICEVs
California, Massachusetts, New Jersey, Washington and NESCAUM	• Relative reliability and safety of BEVs and ICEVs
California, Oregon and NESCAUM	• Driving range and charging time of PEVs

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