Title

2021 Multi-State Zero Emission Vehicle Market Study: Volume 1: A Subset of Zero Emission Vehicle States

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Volume 1: A Subset of Zero Emission Vehicle States

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The Electric Vehicle Research Center at the University of California, Davis Institute of Transportation Studies serves as a focal point for faculty, research and administrative staff, and students dedicated to advancing the state of the art in behavioral, planning, and policy research for the people of California. The Center launched in early 2007, under the name Plug-in Hybrid & Electric Vehicle Center, with initial support from the California Energy Commission's Public Interest Energy Research (PIER) program. The Center collaborates closely with electric utilities, automakers, regulators, and other research institutions.

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Disclaimer

Table of Contents

Table of Figures

Table of Tables

Glossary of Terms

Acronym	Term	Definition
ICE	Internal combustion engine	An engine that burns a fuel in a confined space to produce power. Relevant fuels for this report include gasoline and diesel.
ICEV	Internal combustion engine vehicle	A vehicle powered by an ICE.
HEV	Hybrid electric vehicle	A vehicle powered by both an ICE and an electric motor. Energy for the electric motor is stored in a battery that is charged solely by the ICE or the recovery of kinetic energy during coasting and braking. In normal vehicle operation, the battery cannot be charged by plugging it into the electrical grid.
PHEV	Plug-in hybrid electric vehicle	A vehicle powered by both an ICE and an electric motor. Compared to HEVs, PHEVs typically have a more powerful electric motor and a larger battery that during normal vehicle operation can be plugged into the electrical grid to charge.
BEV	Battery electric vehicle	A vehicle powered solely by an electric motor and electricity stored in a battery that must be charged
PEV	Plug-in vehicles	An overall category for all vehicles with batteries that are charged by plugging into the electrical grid, i.e., BEVs and PHEVs.
FCEV	Fuel cell electric vehicle	A vehicle powered solely by an electric motor and electricity produced onboard the vehicle by a fuel cell. To produce electricity, the fuel cell requires oxygen and hydrogen. Oxygen is taken from the atmosphere. Hydrogen must be refueled much as an ICEV is refueled.
ZEV	Zero emission vehicle	A regulatory definition denoting vehicles that produce no on-road emissions.

Executive Summary

Building on decades of policy making, California has set a goal to transform new light-duty automobile sales to 100 percent zero emissions vehicles (ZEVs) by 2035. The State has been joined by several other US states in this mission to electrify cars and trucks. These states, collectively referred to as "ZEV states," each determines its own supporting policies, but all have adopted regulations requiring automakers to sell an increasing percentage of electric passenger cars and light duty trucks. This study assesses the readiness of household consumers in a subset of ZEV states to support these goals, i.e., as electrification goals become more ambitious and requirements on manufacturers increase, are more car-owning households poised to become ZEV buyers? Based on the analysis presented here, the answer appears to be no.

This question is addressed via comparison of two large sample household surveys, one in late-2014 and the other in early-2021. The two surveys differ in study populations in two ways that shape analysis, results, and conclusions. First, in 2014 only new car buying households were surveyed while in 2021 all-car owning households were surveyed. The shift reflects that by 2021 there are more ZEVs in the used car market. The availability of used ZEVs may be expected to change which households may be engaging with ZEVs. Second, ZEV states included in the samples differ. Colorado became a ZEV state between 2014 and 2021: consumer engagement with ZEVs in Colorado is described here for 2021 but cannot be compared to 2014. Further, while Connecticut was a ZEV state at the time of both surveys, no state-level analysis was produced for Connecticut in 2014. Again, consumer engagement with ZEVs by car-owning households in Connecticut is described in 2021, but no comparison is made to 2014.

Consumer *engagement* is taken to encompass awareness, knowledge, assessment, and consideration. *Awareness* and *knowledge* are similar (awareness is knowledge that something exists), but the distinction affects many things from the details of how survey questions are phrased for respondents ("Have you seen…." vs. "Do you know…") to the ramifications for policy, marketing, education, or outreach. How we increase the chances a person notices something for the first time may differ from how they become motivated to learn more about it. *Assessment* is comparative evaluation. For example, compared to whatever baseline a person may invoke, do they think there are enough places to charge plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs)? Do they think there are enough places to refuel fuel cell electric vehicles (FCEVs)? Compared to their experience with gasoline vehicles, do they think ZEVs are as safe and reliable? *Consideration* is defined as the extent to which a person has already invested cognitive, emotional, financial, time, or other resources in the question of whether to acquire a ZEV. Thus "ZEV Consideration" is a summary of what a person has already done vis-à-vis ZEVs rather than a forward-looking measure of what a person might do.

These measures and the differences between the samples for 2014 and 2021 set the structure of the results. First, for 2021 all-car owning households' awareness, knowledge, assessments, and consideration of ZEVs are described for eight ZEV states:

California, Colorado, Connecticut, Maryland, Massachusetts, New Jersey, New York, and Oregon. In addition to comparisons between states, these results compare households who buy new cars and trucks to those who do not. Partly this gives a sense of whether to believe growth in a used ZEV market can be expected (based in part on the ZEV consideration of those who do not typically buy new vehicles) and partly it assesses whether any differences between new and non-new car buyers must be accounted for in comparisons of 2014 to 2021. Second, results of 2014-to-2021 comparisons among six ZEV states are presented. Accounting for differences in year, states, and new vs. non-new car buyers provides the results to answer this report's central question: are more consumers engaged with a transition to electric vehicles in 2021 than were so in 2014?

Regardless of year, state, or the distinction between households that buy new vehicles and those that do not, the percentage of people who have considered ZEVs to the extent they presently own one, have previously owned one, or have engaged in active shopping for one was less than ten percent in all six of the ZEV states analyzed here in 2014 and four of them in 2021. The highest levels of consideration are in California and New York: the percentages of people in the highest three levels of consideration in 2021 sum to approximately 12 percent. While every state in the six-state comparison showed an increase in the percentage of households at these high levels of consideration from 2014 to 2021, every state also showed an increase in the percentage of people who proclaim outright resistance to ZEVs, i.e., that they have not and will not consider ZEVs. In the end though, any differences in ZEV Consideration has more to do with differences between states and between new and non-new car buyers than they do with differences between 2014 and 2021. new car buyers have given more consideration to ZEVs than have non-new car buyers; this difference explains any apparent reduction in ZEV Consideration from 2014 to 2021.

What explains the equally apparent lack of any large increase in ZEV Consideration? Awareness, knowledge, and assessment are building blocks of consideration; measures of few of them indicate more consumers are more aware, more knowledgeable, or have better assessments of ZEVs in 2021 than in 2014.

Measures of "familiarity"—are you familiar enough with a vehicle type to decide whether one is right for your household—with HEVs, PHEVs, BEVs, and FCEVs are all lower in 2021 than in 2014. Knowledge of the 2021 sample as to how HEVs, PHEVs, and BEVs are fueled is mixed. While BEVs are widely known to be charged by plugging in, there is much more confusion about HEVs and PHEVs as to whether they fuel only with gasoline or both fuel with gasoline and plug-in to charge.

Awareness of federal incentives for consumers to buy vehicles powered by alternatives to gasoline and diesel did not become more pervasive from 2014 to 2021, in fact, the percentage of people who had heard of federal incentives is lower in 2021 than in 2014. Distinguishing between new and non-new car buyers in 2021 reduces—but does not eliminate—the difference: new car buyers in 2021 are less likely to have heard of federal incentives than were new car buyers in 2014. Participants in CA are less likely to say they have heard of federal incentives than those in MA, NJ, NY, and OR.

Participants' assessments of BEVs and FCEVs are worse in 2021 than in 2014 and any distinction between the assessments offered by new car buyers vs. non-new car buyers is mixed. A higher percentage of new car buyers in 2021 say they can charge a BEV at home than in 2014, though the data also show non-new car buyers (in 2021) are much less likely to agree they can do so. Otherwise, BEVs continue to be judged to take too long to charge, to have too short driving range, to cost more to buy than gasoline vehicles, and to be less reliable and safe than gasoline vehicles. new car buyers in 2021 have, on average, a worse assessment of BEVs than did new car buyers in 2014. Further, new car buyers in 2021 generally register worse assessments of BEVs than non-new car buyers in 2021.

The one BEV assessment to become more favorable over time (though not favorable in an absolute sense) is related to charging infrastructure. Across all participants there is slight disagreement there are enough places to charge BEVs. Participants in both years disagree there is enough, but that disagreement is weaker in 2021 than in 2014. Non-new car buyers in 2021 disagree more strongly than do new car buyers in 2021 but disagree at much the same level as did new car buyers in 2014.

The assessments of FCEVs show a similar pattern—the most consistent difference over time is a worse overall assessment in 2021 compared to 2014 and the one assessment to improve relates to availability of fueling. The main difference between BEV and FCEV assessments is that the difference is greater between states for FCEVs: FCEV assessment differences between states are about as important as differences between years while for BEVs differences between years account for most of the variability in participants' assessments. In general, FCEVs are assessed to take too long to fuel, have too short driving range, cost more to buy the gasoline vehicles, and to be less reliable and safe than gasoline vehicles.

Participants' improved outlook on PHEV and BEV charging infrastructure is confirmed by whether they "have seen spots to charge electric vehicles" in the parking facilities they use. In five of six ZEV states compared between 2014 and 2021, more participants not only say they have seen charging but more say they have seen it in more places. (The exception is Oregon where this measure is unchanged, though it had the highest rate of sightings of charging in 2014.) In 2021, the probabilities that new car buyers have seen EV charging and have seen EV charging in more locations are higher than for non-new car buyers. Despite this, even non-new car buyers in 2021 are more likely to have seen charging in the parking facilities they use than are the 2014 participants (all of whom were new car buyers).

The inclusion in the 2021 sample of households who do not regularly buy new vehicles allows insights into the prospects for growing used ZEV markets. Where there are differences between new car and non-new car buyers, the results often are that non-new car buyers are less aware, less knowledgeable, and have worse assessments of ZEVs. Non-new car buyers are less likely to report than they can charge a vehicle at home, are less likely to be aware of incentives, are less likely to have seen charging in the parking facilities they use. Regarding the last, there may be two reasons: 1) differences in actual numbers of charging locations correlated with where richer and poorer people live, and 2) differences in the relevance of charging and thus in the likeliness of recognizing a charger as such. Non-new car buyers have also given less consideration to the acquisition of ZEVs for their households.

These all are additional barriers to shifting sales of new vehicles to 100 percent ZEVs to the extent healthy used car markets are necessary for healthy new car markets. If the goal is for all new cars sold in California in 2035 (and beyond) to be ZEVs and if ZEV states in general are to meet their goals, the lingering unfamiliarity of consumers with HEVs cannot be repeated for ZEVs. More than 20 years after HEVs were first offered for sale in the US, only 25 percent of participants in the eight ZEV states in the 2021 analysis are quite sure they are familiar enough with HEVs to “decide if one is right for my household.” Lingering low familiarity with HEVs points to how long it may take households to become familiar with PHEVs, BEVs, and FCEVs in the absence of a concerted and pervasive effort to prompt engagement with ZEVs by all car-owning households.

1. Introduction

1.1 Background/Purpose

In 2012, the California Air Resources Board (CARB or the Board) adopted a package of regulations for light duty vehicles to control greenhouse gases (GHG), criteria pollutants, and mandate an increasing number of battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs) be produced each year through 2025. The Board reaffirmed its commitment in 2017 and directed agency staff to develop new regulations for beyond 2025 that would encourage continued zero emission vehicle (ZEV) market growth required to meet California's emission reduction goals. In the latest in a series of executive orders from California's Governors, Governor Newsom stated the goal that 100 percent of new light-duty sales be ZEVs starting in the year 2035 (Governor's Executive Order N-79-20).

new ZEV product offerings from automotive manufacturers as well as energy industry and electricity utility responses to this regulatory framework mean consumers are confronted with new vehicle technologies, performance, and fueling behaviors. Even as ZEVs enter the vehicle market and nascent PEV recharging and FCEV hydrogen fueling infrastructures are deployed, questions remain as to whether a growing number of new consumers will purchase—and continue to purchase—ZEVs in volumes large enough to meet the future regulatory requirements and Executive Order goals.

This report answers this question via large sample surveys of households in some of the "ZEV states," i.e., states that have adopted ZEV requirements based on California's. These surveys were completed in the last quarter of 2014 and the first quarter of 2021. Both questionnaires measure consumer awareness, knowledge, assessments, and consideration of ZEVs. However, the two surveys cover different sets of ZEV states and surveyed different populations. The differences and ramifications for analysis and comparison are described below in the Method section.

To assist California and the other ZEV states to monitor and manage policies promoting ZEVs and ZEV fueling infrastructure deployment, this research assesses households' responses to these new technology vehicles and new fueling behaviors. The following objectives are defined:

1. Measure consumer awareness, knowledge, assessment, and consideration of PHEVs, BEVs, and FCEVs; and,
2. Compare these measures within the context of repeated cross-section samples.

2. Method

2.1 Survey Research and Statistical Modeling

2.1.1 Data

Data in this report are from one or two surveys that differ as to year, geographic coverage, and population of study. These data sets are summarized in Table 1. The difference in geography between the multi-state studies in 2014 and 2021 is related to the ZEV mandate: in 2021 the sample is strictly limited to ZEV states. In 2014, the list of ZEV states included: California, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. In addition to these ZEV sates, the 2014 sample included Washington and Delaware, which though both are supportive of ZEVs, are not ZEV states. As non-ZEV states Delaware and Washington are not included in the 2021 study. In 2019, Colorado joined the ranks of ZEV states; it is included in the 2021 data, but not the 2014 data.

Table 1: Study Years, Study Populations, States, and Sample Sizes

Study	Population	States	Sample Size
2014 Multi-State ZEV	New car buyers	California	1,671
		Maryland	396
		Massachusetts	498
		New Jersey	495
		New York	997
		Oregon	494
2021 Multi-State ZEV	All car Owning Households	California	2,994
		Colorado	472
		Connecticut	298
		Maryland	499
		Massachusetts	570
		New Jersey	739
		New York	1,618
		Oregon	344

Note: Additional states from each study are not included in the table.

The analyses presented here are based on these geographical descriptions:

1. Eight ZEV State Comparative Analysis, Circa-2021
   a. California, Colorado, Connecticut, Massachusetts, Maryland, New Jersey, New York, and Oregon
2. Six ZEV State Comparative Analysis of 2014 and 2021
   a. California, Massachusetts, Maryland, New Jersey, New York, and Oregon

Another difference in study populations is the 2014 multi-state study included only households who buy new cars and trucks while the 2021 multi-state survey included all car-owning households in anticipation of the greater possibility of participating in a market for used ZEVs. Comparisons between 2014 and 2021 will account for this difference in study populations.

2.1.2 Measures

The measures of awareness, knowledge, assessment and consideration of ZEVs, ZEV fueling, and incentives are defined in this section along with other variables necessary for the analyses in this report, starting with the distinction between new car buyers and non-new car buyers essential to the difference in study populations between the 2014 and 2021 surveys.

2.1.2.1 New and Non-new Car Buyers

As PHEVs and BEVs have only recently been available for long enough for a used vehicle market to develop and as retail markets for FCEVs are still incipient, the population of people acquiring ZEVs has been largely made up of people who acquired their ZEV(s) as new vehicles. In addition to differences in household income that may distinguish those who buy new vehicles from those who do not, simply having shopped for any new car over the past several years may have created greater opportunities to have developed awareness of ZEVs, knowledge, and experience of them, and to have shopped for one. Some people will interpret a question about a "new" car as "new to me car." To guard against this, a question is first asked, "How many cars, trucks, vans, and sport utility vehicles does your household currently own or lease, that are driven at least once per week?" They are then asked how many of these they acquired "as a used vehicle" and only then asked how many they acquired "as a new vehicle." "new car buyers" (NCB) are defined as households who have acquired at least one vehicle as new during the seven years prior to their survey. "Buyers" includes household who purchase or lease vehicles. new car buyers may also have acquired used vehicles during the same seven-year interval. In contrast, households categorized as non-new car buyers acquired only used vehicles or no vehicles over this same period seven-year period.

2.1.2.2 Familiarity with Vehicle Types

Vehicle types are defined by their "fuel" (gasoline (or diesel), electricity, and hydrogen) and the means of converting that fuel into motion (an internal combustion engine, an electric motor, or the combination of the two). For participants, these types are named: Gasoline, Hybrid, Plug-in Hybrid Electric, Battery Electric, and Hydrogen Fuel Cell Electric. For each of these five types, participants are asked whether they "are familiar enough with this type of vehicles to make a decision about whether one would be right for your household?" Answers for each type are given on a scale from -3 (No) to +3 (Yes).

2.1.2.3 Seeing PEV Charging

Public PEV charging infrastructure is Electric Vehicle Supply Equipment (EVSE, or colloquially, chargers) installed in locations generally accessible to the public. Participants are not asked this directly as they may not know whether a charger is available to the public. Rather, participants are asked, "Have you seen any electric vehicle charging spots in the parking garages and lots you use?" The closing clause, "you use," is intended to both prompt recall of specific places participants visit and heighten the personal relevance of the question. The possible responses are paraphrased as, "No," "I don't know," "Yes, at one location," "Yes, at a few locations," and "Yes, at many locations."

2.1.2.4 Knowledge of Vehicle Fueling

Participants are asked to identify how HEVs, PHEVs, and BEVs are fueled. Responses include: "only fueled with gasoline," "only plugged in to charge with electricity," "both fueled with gasoline and plugged in to charge with electricity," or "don't know." These responses are recoded as Incorrect or Correct as appropriate to each vehicle type; "don't know" is coded as Incorrect for all vehicle types.

2.1.2.5 Assessments of ZEVs

Participants are asked to provide their assessments of several aspects of PHEVs, BEVs, and FCEVs. These assessments take the form of levels of agreement with statements made after a very brief preamble distinguishing each vehicle type. For example, this is how the assessments for BEVs are measured:

> *"Battery electric cars and trucks are powered only by batteries that must be plugged in to recharge. How much do you agree or disagree with each of the following statements about battery electric vehicles?*
>
> - ☐ *My household would be able to plug in a battery electric vehicle to charge at home.*
> - ☐ *There are enough places to charge battery electric vehicles.*
> - ☐ *It takes too long to charge battery electric vehicles.*
> - ☐ *Battery electric vehicles do not travel far enough before needing to be charged.*
> - ☐ *Battery electric vehicles cost more to buy than gasoline vehicles.*
> - ☐ *Gasoline powered cars are safer than battery electric vehicles.*
> - ☐ *Gasoline powered cars are more reliable than battery electric vehicles.*
> - ☐ *Battery electric vehicles are less damaging to the environment than gasoline powered vehicles.*
> - ☐ *Battery electric vehicle technology is ready for mass automotive markets."*

Responses are recorded on a continuous scale from -3 = Strongly Disagree to +3 = Strongly Agree. Intentionally, the items are mixed as to whether positive agreement favors BEVs or gasoline vehicles. For analysis purposes, scales for all items for which positive agreement represents a negative assessment of BEVs have had their scales inverted so that all positive agreements scores favor BEVs. In short, the assumption is made that disagreeing with a negative statement is the same as agreeing with a positive statement.

For PHEVs, the preamble is,

> *"Plug-in hybrid electric cars and trucks run on electricity and gasoline; you can both plug them in to charge their batteries and refuel them at a gasoline station."*

And for FCEVs,

> *"Hydrogen fuel cell cars and trucks are powered by an electric motor but are refueled with hydrogen at a station—something like going to a gasoline station."*

The agree-disagree statements for PHEVs are the same as those for BEVs except "PHEV" is substituted for "BEV" in all of them. For FCEVs, there are only eight statements as participants are not asked to assess whether they could refuel an FCEV at home. The same proviso about statement wording and interpretation applies for PHEVs and FCEVs: for some statements "Agreement" favors PHEVs and FCEVs while for others it favors gasoline vehicles but for analysis the scales of such statements have been inverted so positive scores favor ZEVs.

2.1.2.6 Incentives for ZEVs

Measuring awareness of incentives is complicated by differences in what incentives have been offered in which states and when as well as in differences in practical access to incentives that on their face are offered generally to broad populations. Awareness of any incentive from the federal government to households to buy PHEVs and BEVs is the most consistent measure across states and time as—all else being equal—households in every state have equal access to federal incentives. All else is not equal and as practical matter most Americans could not avail themselves of the federal tax credit for purchase of PHEVs and BEVs as most American households did not have the same practical opportunity to buy such vehicles—even within the subset of ZEV states. Offerings of PHEVs and BEVs for sale have been predominately made in California. Availability even in the other ZEV states lagged abetted in part by the "traveling provision" of the ZEV mandate that allows, within limits, for sales of ZEVs in one ZEV state to count toward the mandated number of sales in other ZEV states; that one ZEV state was often California. Further, because 1) the federal tax credit is available to only a limited number of PEVs from an individual vehicle manufacturer, 2) that limit was reached by Tesla between the 2014 and 2021 surveys, and 3) because Tesla makes up such a large part of the BEV market, it is possible that awareness of the federal incentive could decline as Tesla stops featuring information about the tax credit in its discussions with customers. While a distinction may be made between having heard of the federal incentive and having practical access to it, it seems plausible that in states with higher ZEV sales more people would be aware of the federal incentive.

Awareness of incentives is ascertained via this question, "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?" "Each of the following" includes the federal government, state and local governments, electric utilities, automobile manufacturers and dealers, oil companies, and "other businesses." The possible responses are, "No," "I'm not sure," and "Yes."

2.1.3 PHEV, BEV, FCEV, PEV, and ZEV Consideration

As assessed in this study, *Consideration* combines affect (negative, neutral, positive) and action (nothing, information search (short of shopping), active shopping, and acquisition). A question is asked separately for consideration of BEVs, PHEVs, and FCEVs. The question for BEVs is:

> *"Battery electric vehicles (BEVs) run only on electricity; they plug-in to charge their batteries. Have you considered buying a BEV for your household? Select one.*
>
> - ☐ *I (we) have not—and would not—consider buying a BEV.*
> - ☐ *I (we) have not considered buying a BEV, but maybe someday we will.*
> - ☐ *The idea has occurred, but no real steps have been taken to shop for a BEV.*
> - ☐ *Started to gather information about BEVs but haven't really gotten serious yet.*
> - ☐ *Shopped for BEVs, including a visit to at least one dealership to test drive.*
> - ☐ *I (we) already have, or have had, a BEV."*

Changes for PHEVs and FCEVs are made to the introductory sentence and the vehicle type named in the responses. The three separate questions are variously combined to assess the maximum favorable intention or action toward the appropriate vehicle types: *PEV Consideration* is the higher of the scores for BEV and PHEV Consideration and *ZEV Consideration* is the highest of the scores for BEVs, PHEVs, and FCEVs.

2.1.4 Assessing Differences between 2014 and 2021

Analysis of differences over time in familiarity, seeing PEV charging, ZEV assessments, awareness of and support for incentives, and consideration of ZEVs are all carried out via multi-variate regression models. Linear regression, ordinal logistic regression, or nominal logistic regression are used as appropriate for continuous, ordinal, and nominal measures. The purpose of the modeling is to provide a framework to simultaneously test hypotheses about whether the variables for state (State), ew car buyer status (NCB, coded "yes" for new car buyers or "no" for non-new car buyers), and survey year (Year) are related to differences in ZEV awareness, knowledge, assessments, and consideration. The explanatory variables in these regression models are listed here and explained next:

- Year,
- State,
- NCB nested in Year (NCB[Year]),
- State crossed with Year (State*Year), and
- NCB crossed with State, nested in Year (NCB*State)[Year].

The Year and State variables test for whether there is a consistent difference in measures due to either the year of the study or the state in which the participant resides, i.e., is some part of any observed difference in measures due to a difference between the two years that is constant across all states and a difference between states that is constant between the two study years. Nesting the variable NCB inside Year is required because of the different study populations in 2014 (only new car buyers) and 2021 (all car owning households, i.e., new car buyers and non-new car buyers). The nested effect of NCB[Year]) tests whether part of the difference between participants in 2021 is due to some of them being new car buyers and others non-new car buyers. The crossed effect State*Year tests for whether any differences between years are different in different states. Finally, the crossed effect between the nested effect of NCB within Year and the crossed effect of State by Year tests for whether any difference between the effect of Year on the states is itself different between the new and non-new car buyers in 2021. The models allow for all these tests to be conducted simultaneously. If the parameters for these effects are statistically significant, we conclude the corresponding effect on the measure is different from zero controlling for all the other effects in the models.

Statistical significance itself does not tell us how influential any variable is; it only tests whether we can be confident the influence is non-zero. The influence each variable has on a measure of interest is assessed by different methods as appropriate to each analysis. These include measures of association such as Lambda Asymmetric C|R for ordinal variables and the Uncertainty Coefficient C|R for nominal variables used in cross-classifications of two variables, e.g., PEV Consideration by Year. The "C|R" notation indicates the measure assesses how much improvement there is in predicting the column values (the measure of interest) given knowledge of the rows (Year, State, or NCB). These association measures range from 0 to 1 with higher numbers indicating greater ability to correctly predict the column value knowing the row value.

The parameter estimates for the regression models are one measure to compare the influence of explanatory variables if the variables are all measured on similar scales. When there are nested and crossed effects, other measures are required to see the total effect of some variables. For models comparing 2014 and 2021, the variable State appears in three of the five explanatory variables: the direct effect of State and its two crossed effects (with Year and with NCB[Year]). Thus, its influence in any regression is more than just its direct parameter estimate. The method used in the statistical software used for this report estimates the variability in predicted responses across the range of variation for each effect in the model. If variation in an effect is associated with high variability in the response, then that effect is important relative to all the effects in the model. This allows for the measurement of main and interaction effects. Finally, the differences in estimated outcomes, e.g., odds-ratios, may also be used.

3. Results

Results are divided into two main sections. The first presents results from early-2021 for eight ZEV states. The second compares results of six of these ZEV states between late-2014 and early-2021. The rationales for which states are analyzed in each section are provided in the opening of each section. In both sections, the order of matches the order of descriptions of measures provided above in Methods:

1. Familiarity with vehicle types: ICEVs, HEVs, PHEVs, BEVs, and FCEVs
2. Seeing PEV Charging
3. Knowledge of how vehicle types are fueled
4. Assessments of ZEVs: BEVs, PHEVs, and FCEVs
5. Awareness of federal incentives and support for incentives
6. Consideration of ZEVs.

While the order is the same in both sections, details vary as some questions asked in 2021 were not asked or were asked differently in 2014. For example, the questions about knowledge of how vehicle types are fueled were not asked in 2014, so there can be no comparison to 2021 in the second section. Further, the questions about Consideration in 2014 did not ask separately about BEVs and PHEVs. The 2014 version asked about, "vehicles that are powered by electricity." This is taken here as a reasonable proxy for BEVs and thus Consideration of BEVs and FCEVs may be compared between 2014 and 2021.

3.1 2021: Eight ZEV States

This section has three purposes. The first is to describe ZEV awareness, knowledge, assessment, and consideration in eight ZEV states. The second is to assess whether participants who are classified as new car buyers differ in their measures of ZEV awareness, assessment, and consideration from those classified as non-new car buyers; results determine non-new car buyers will be treated differently when comparing 2014 and 2021. The third is to orient the reader to the measures described in the previous section and some of the analytical tools used throughout before the added complexity of comparing results from two years.

Analyses labelled, "ZEV States," are conducted only for eight states with large enough sample sizes to support statistical analysis: California, Colorado, Connecticut, Maryland, Massachusetts, New Jersey, New York, and Oregon. The states of Maine, Rhode Island, and Vermont are excluded. This section addresses the question of whether in 2021 the variation in state level policy making and ZEV market development (as might be indicated by differences ZEV sales per capita and variation in ZEV make and model availability) are associated with differences in household awareness, knowledge, and consideration of ZEVs. As is standard practice for much statistical testing, the null hypothesis is that households across these states do not differ.

3.1.1 Familiarity with Vehicle Types

Recalling the response scale ranges from -3 to +3, mean familiarity scores for each vehicle type by state are show in Figure 1. Differences between states (within vehicle types) in state means are evaluated using Tukey's Honestly Significantly Different test. On average ICEVs have very high mean scores, all other types have mean scores much lower though only FCEVs have mean scores that are negative. For ICEVs, not only are the mean scores high (all are greater than or equal to 2.50 except NY = 2.49) but the 25^{th} percentiles are all greater than or equal to 2.70, i.e., 75 percent of respondents provide a score of 2.70 or higher. In contrast, for all other vehicle types in every state the *75^{th}* percentile is higher than 2.70 (except CT = 2.53), i.e., only 25 percent (or less) of people score themselves as being as familiar with HEVs, PHEVs, BEVs, *or* FCEVs as they are with ICEVs.

Few differences in mean scores across states are statistically significant. If there is a pattern to these differences it is only this: on average, respondents in CA claim statistically significantly but substantively only slightly higher familiarity with HEVs, PHEVs, and BEVs. However, this is hardly a sweeping generalization. The mean familiarity score of CA respondents for HEVs is higher than for CT, CO, and NY; for PHEVs, the mean score from CA is higher than for CT, CO, and NJ; and for BEVs, the mean familiarity score from CA is higher only than CT. For BEVs, MD and NY also have higher mean familiarity scores than CT. There are no statistically significant differences in mean scores between states for FCEVs.

Figure 1: Familiarity with Vehicle Types, 2021; mean scores across eight ZEV States

Assuming it is generally true that people will invest some resources in search, information, and shopping when they buy vehicles and that doing so for new vehicles is more likely to bring people into contact with information, knowledge, and possibly experience with new vehicle types such as ZEVs, it is plausible new car buyers rate themselves as more familiar with ZEVs than non-new car buyers. The observed means for new car buyers and non-new car buyers within each state are shown in Figure 2. Though the mean familiarity scores for ICEVs are high for both groups, non-new car buyers rate their familiarity with ICEV higher than do new car buyers. In contrast, for all other vehicle types the opposite is true. To put this into context across states, regression equations are estimated on each of the five familiarity scores using new car buyers (NCB), State, and a crossed effect between NCB and State as explanatory variables (Table 2).

- For Familiar with ICEVs, the model confirms that even allowing for differences between states, non-new car buyers rate themselves as *more* familiar than do new car buyers.
- For Familiar with HEVs, PHEVs, BEVs, and FCEVs, the models confirm that even allowing for differences between states, non-new car buyers rate themselves as less familiar than new car buyers.

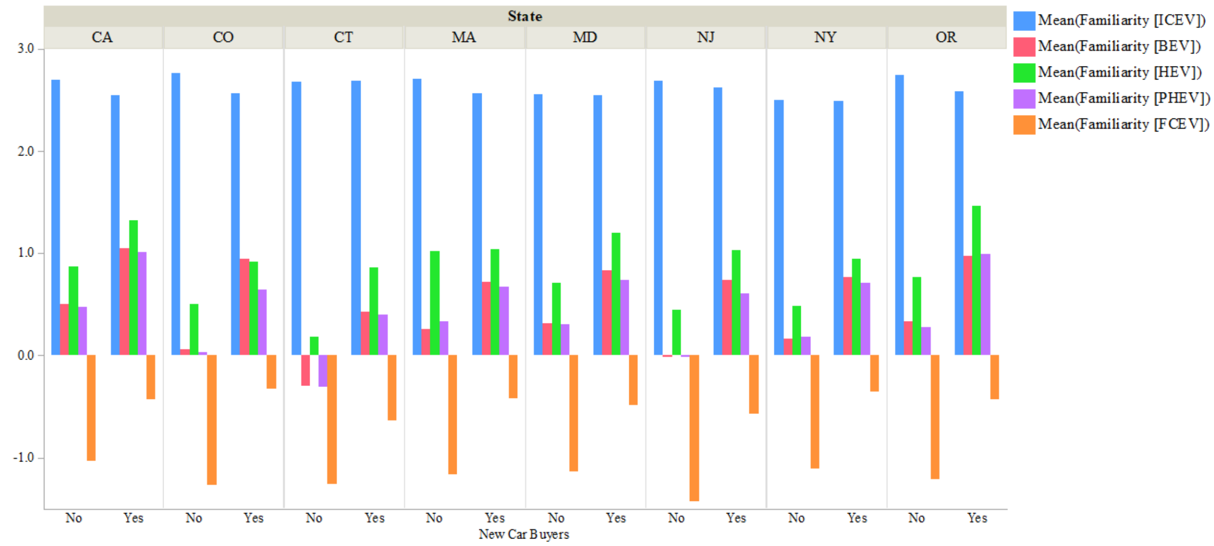


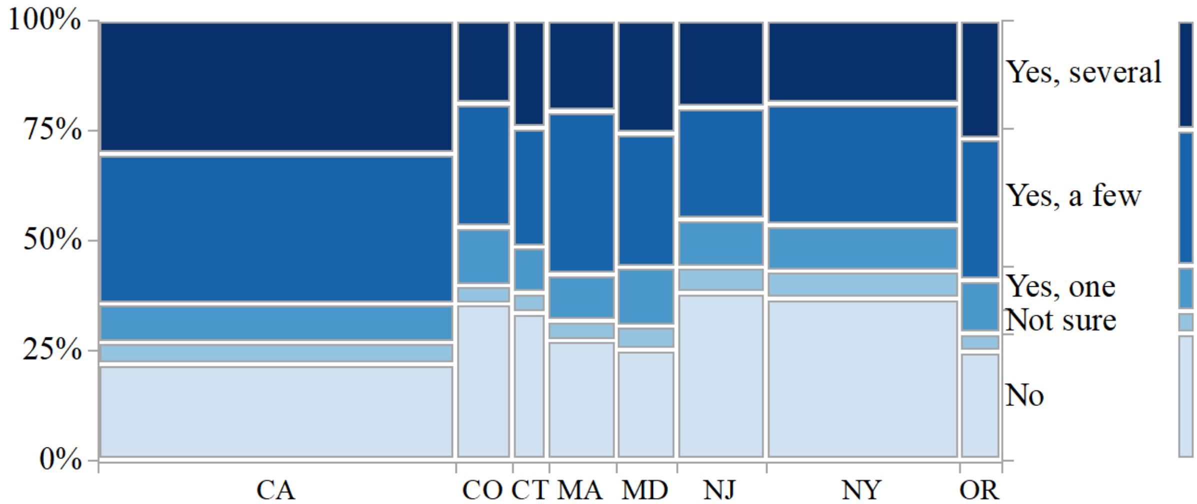
Figure 2: Familiarity with Vehicle Types, 2021; mean scores by new car buyer status within eight ZEV States

Table 2: Regressions of Familiarity with Five Vehicle Types for Eight ZEV States, 2021

Vehicle Type:	ICEV		HEV		PHEV		BEV		FCEV	
Analysis of Variance										
Degrees of Freedom	15		15		15		15		15	
F Ratio	3.435		9.162		10.510		11.769		13.262	
Probability > F	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001	
Parameter Estimates	**Estimate**	**Prob. > *t***	**Estimate**	**Prob. > *t***	**Estimate**	**Prob. > *t***	**Estimate**	**Prob. > *t***	**Estimate**	**Prob. > *t***
Intercept	2.621	<0.0001	0.858	<0.0001	0.439	<0.0001	0.483	<0.0001	-0.831	<0.0001
NCB[No]	0.043	0.0054	-0.236	<0.0001	-0.283	<0.0001	-0.320	<0.0001	-0.372	<0.0001
State[CA]	0.003	0.9055	0.239	<0.0001	0.302	<0.0001	0.292	<0.0001	0.097	0.0453
State[CO]	0.042	0.3333	-0.150	0.1039	-0.103	0.2810	0.019	0.8434	0.031	0.7417
State[CT]	0.062	0.2460	-0.340	0.0032	-0.394	0.0009	-0.421	0.0004	-0.118	0.3162
State[MA]	0.013	0.7388	0.170	0.0495	0.063	0.4842	0.002	0.9803	0.037	0.6760
State[MD]	-0.069	0.1109	0.096	0.2992	0.082	0.3926	0.088	0.3545	0.021	0.8267
State[NJ]	0.032	0.3812	-0.122	0.1218	-0.146	0.0744	-0.123	0.1317	-0.173	0.0323
State[NY]	-0.125	<0.0001	-0.147	0.0122	0.005	0.9317	-0.023	0.7047	0.098	0.1023
NCB [No]*State[CA]	0.031	0.1623	0.009	0.8570	0.010	0.8363	0.049	0.3156	0.069	0.1578
NCB [No]*State[CO]	0.053	0.2137	0.031	0.7368	-0.025	0.7899	-0.125	0.1892	-0.098	0.2988
NCB [No]*State[CT]	-0.050	0.3507	-0.101	0.3794	-0.075	0.5298	-0.044	0.7119	0.064	0.5854
NCB [No]*State[MA]	0.025	0.5351	0.229	0.0081	0.110	0.2222	0.092	0.3035	-0.002	0.9833
NCB [No]*State[MD]	-0.041	0.3378	-0.009	0.9184	0.064	0.5022	0.062	0.5192	0.047	0.6168
NCB [No]*State[NJ]	-0.013	0.7308	-0.053	0.5021	-0.028	0.7337	-0.053	0.5165	-0.055	0.4953
NCB [No]*State[NY]	-0.040	0.1486	0.005	0.9330	0.021	0.7348	0.020	0.7406	-0.006	0.9262

3.1.2 Seeing PEV Charging

The distributions of responses in 2021 are shown in a mosaic plot in Figure 3. In general, clear majorities of car owning households in these eight ZEV states claim to have seen at least one EV charging spot in the parking lots and garages they use. Further, majorities of participants in CA (64 percent), MA (58 percent), MD (56 percent) and OR (59 percent) report seeing EV charging in “a few” or “several” such locations. However, pluralities of participants in CO (36 percent), NJ (38 percent), and NY (37 percent) report they have not seen EV charging in the parking lots and garages they use. A χ^2 test indicates these differences between states are statistically significant. However, though the measure of association, Lambda Asymmetric C|R is significantly different from zero, it is modest in size (0.058) indicating that knowing which state a participant is from does little to improve a prediction of whether and how much PEV charging they have seen.



n = 7,549; degrees of freedom = 28, χ^2 = 128.482; probability > χ^2 < 0.0001

Figure 3: Seen Electric Vehicle Charging across Eight ZEV States, 2021; percent

Recoding categories into numeric values (and assuming they represent a scale) yields:

0 = No, I have not seen any or I’m not sure
1 = Yes, I have seen one location
2 = Yes, I have seen a few; and
3 = Yes, I have seen several.

Average values for this recoded measure are in Table 3. Mean scores range from a low of 1.21 (NJ) to a high of 1.68 (CA), generally corresponding to having seen EV charging at one vs. a few locations. State means are on the table diagonal; green shading indicates pairs of means for which the mean of the state on the diagonal is statistically significantly higher than the state(s) listed below it; Tukey's Honestly Significant Different test, α = 0.05. Thus, participants in CA are, on average, more likely to have seen PEV charging at more locations than participants from (in increasing order of difference) MA, CT, CO, NY, and NJ. Participants from MD are more likely to report seeing charging in more locations than those from CO, NY, and NJ.

Table 3: Seen Electric Vehicle Charging across Eight ZEV States, 2021; Means and Pairwise Significant Differences

CA	1.68							
OR		1.57						
MD			1.51					
MA				1.46				
CT					1.38			
CO						1.27		
NY							1.22	
NJ								1.21

Note: State means are on the diagonal; green shading indicates pairs of means for which the mean of the state on the diagonal is statistically significantly higher than the state(s) below; Tukey's Honestly Significant Different test, α = 0.05. Thus, the mean for CA is statistically significantly different from MA, CT, CO, NY, and NJ.

While there might be less reason to believe that a distinction between households who do and don't buy new vehicles would be relevant to whether they have seen PEV charging locations, households classified as new car buyers are more likely to report having seen PEV charging in more locations than are those classified as non-new car buyers. Means by NCB within each state are shown in Figure 4. The figure clearly indicates there are differences in self-reports of seeing PEV charging between new and non-new car buyers.

A logistic regression model on the original variable Seeing EVSE is estimated using NCB, State, and crossed effect between them; NCB and State are statistically significant (Table 4). The parameter estimates indicate new car buyers (in all states) are more likely than non-new car buyers to indicate they have seen PEV charging at more locations in every state. It is also the case though that the variable State accounts for a larger part of differences in seeing PEV charging.

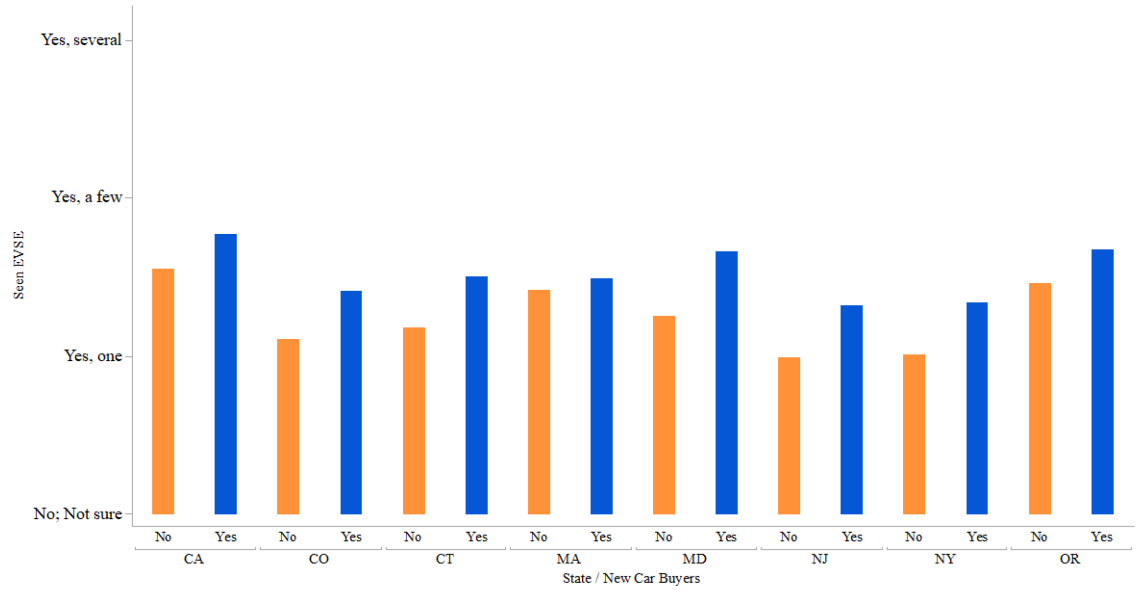


Figure 4: Seen Electric Vehicle Charging across Eight ZEV States by new car buyer status, 2021; mean values converting response categories to numeric scale

3.1.3 Knowledge of Vehicle Fueling

Across all eight states, the vehicle type with the highest percent of correct responses to the question of, "how is this type of vehicle fueled," is BEVs (77 percent), followed by PHEVs (53 percent), and HEVs (18 percent). A heatmap is produced of the nested answers by state (Figure 5). The nesting structure of Correct/Incorrect responses reads from outside-in. For example, the top row of the heatmap shows the percent of people within each state (shown by the percentage values) who, in order, incorrectly respond to HEVs, PHEVs, and BEVs. The shading shows the proportion of the total sample of all states from few (pale) to many (dark). Thus, the column for California is the darkest of all the columns as it has the largest portion of the total sample of any state. The row for HEV: Incorrect, PHEV: Correct, and BEV: Correct tends to be the darkest of all the rows because of all the possible combinations of Correct and Incorrect responses, it is most common in every state. The percentages in each cell are the percent of people within each state for each combination of Correct/Incorrect responses.

Table 4: Logistic Regression of Seeing EVSE in Eight ZEV States, 2021

Whole Model Test

Model	-LogLikelihood	Degrees of Freedom	χ^2	Probability > χ^2
Difference	158.868	15	317.736	<0.0001
Full	10,816.435			
Reduced	10,975.303			
R^2 (U)	0.0145			
Sum of Weights	7549.32			

Effect Likelihood Ratio Tests

Source		Degrees of Freedom	χ^2	Probability > χ^2
NCB		1	58.521	<0.0001
State		7	240.174	<0.0001
NCB *State		7	9.402	0.2250

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept[No]	-0.805	0.031	668.98	<0.0001
Intercept[Not sure]	-0.556	0.030	337.05	<0.0001
Intercept[Yes, one]	-0.109	0.030	13.50	0.0002
Intercept[Yes, a few]	1.281	0.033	1482.80	<0.0001
new car buyers[No]	0.212	0.028	58.32	<0.0001
State[CA]	-0.437	0.040	118.72	<0.0001
State[CO]	0.206	0.077	7.10	0.0077
State[CT]	0.065	0.097	0.46	0.4983
State[MA]	-0.097	0.072	1.79	0.1811
State[MD]	-0.129	0.077	2.79	0.0951
State[NJ]	0.355	0.067	28.08	<0.0001
State[NY]	0.318	0.050	41.15	<0.0001
NCB [No]*State[CA]	-0.051	0.040	1.65	0.1985
NCB [No]*State[CO]	0.033	0.077	0.19	0.6650
NCB [No]*State[CT]	0.032	0.097	0.11	0.7393
NCB [No]*State[MA]	-0.164	0.072	5.11	0.0238
NCB [No]*State[MD]	0.085	0.077	1.21	0.2707
NCB [No]*State[NJ]	0.051	0.067	0.57	0.4497
NCB [No]*State[NY]	0.043	0.049	0.76	0.3848

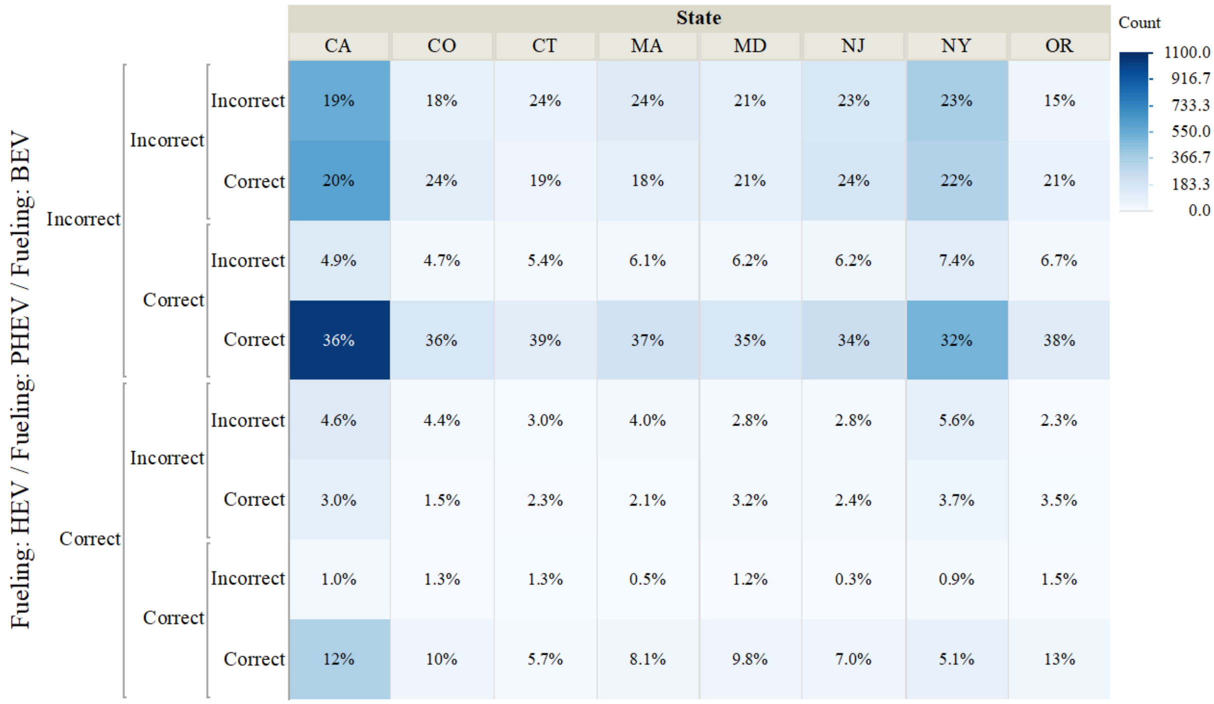


Figure 5: Heatmap of Knowledge about Fueling of HEVs, PHEVs, and BEVs within Eight ZEV States, 2021; percent, and total count across states

Figure 5 illustrates several things. First, few participants, varying from 5 percent (NY) to 13 percent (OR), correctly identify how HEVs, PHEVs, and BEVs are fueled. Second, as the top half of the heatmap corresponding to all possible combinations that start with incorrect knowledge of fueling HEVs is uniformly darker than the bottom half, we see most people in every state don't know HEVs are fueled only with gasoline. Third, from this it may be further observed that knowledge of fueling of HEVs is not positively related to understanding fueling of PHEVs and BEVs.

Tests of the sample proportions of Correct responses across states for each vehicle type are shown in Figure 6; note the vertical axes are different for each panel in the figure. Each state's proportion of Correct responses is shown as a deviation from the sample proportion which is shown as a horizontal line through the middle of each panel: 17.2 percent for HEVs, 50.4 percent for PHEVs and 66.6 percent for BEVs.

Only in CA does the proportion correct exceed the sample proportion correct by a statistically significant amount for all three vehicle types. The deviation for OR is even greater but the error around its estimate is large enough that it can't be concluded to be different from the overall mean. Conversely, only for NY is the proportion correct so much less than the sample proportion as to be statistically significant for all three vehicle types.

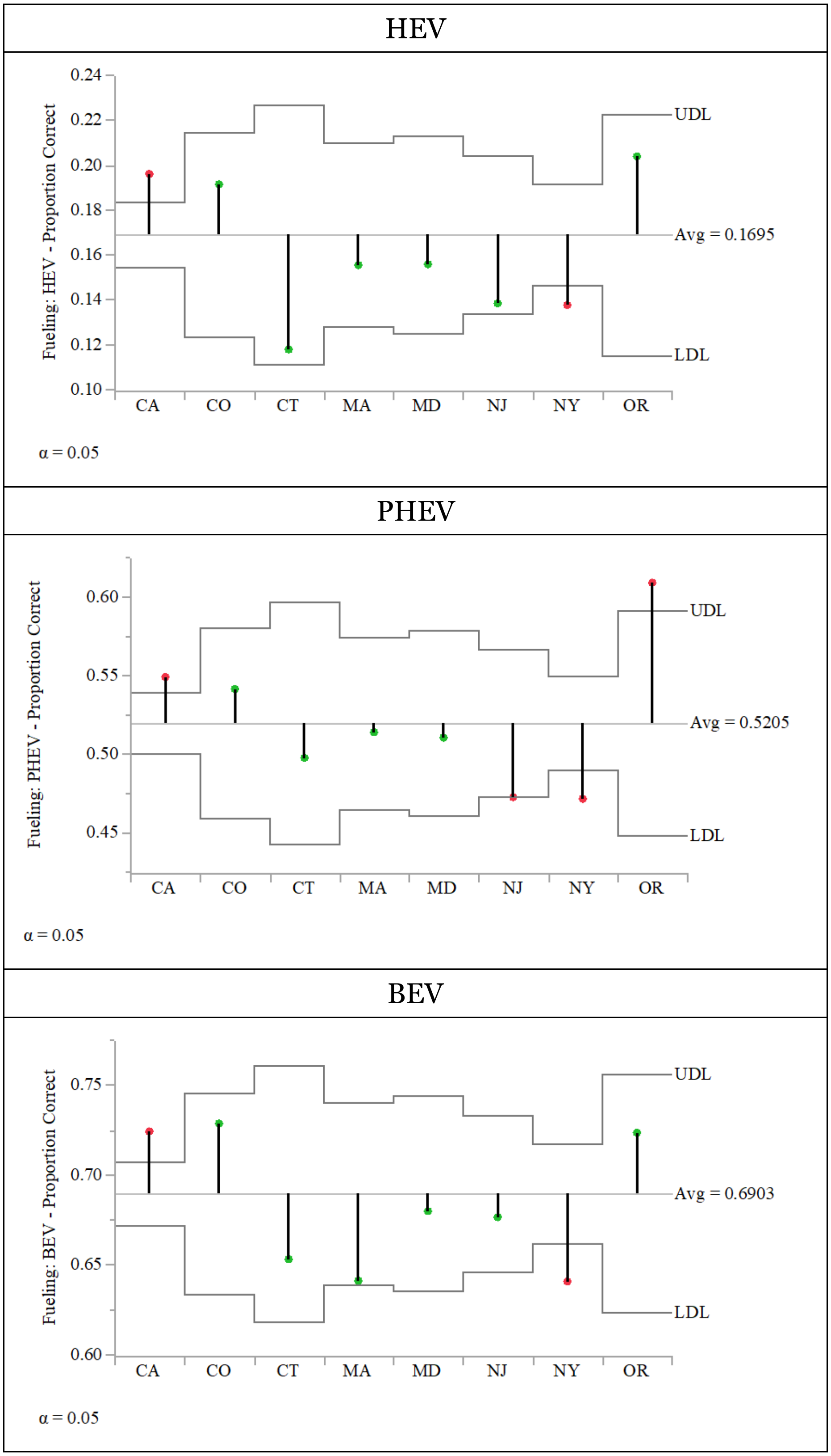


Figure 6: Analysis of Means for Proportions Vehicle Fueling by State, 2021

Testing for the effects of new car buyer status controlling for State are done via logistic regression, including a crossed effect between NCB and State. All three effects are statistically significant and produce the following results:

- The proportion of predicted Correct/Incorrect response for fueling PHEVs differs by state, but not across states between new and non-new car buyers.
    - However, the interaction between State and NCB generally indicates that new car buyers are less likely to correctly identify that PHEVs both fuel with gasoline and plug in to charge than are non-new car buyers—only in CO were new car buyers more likely to correctly identify how PHEVs are fueled.
- For both HEVs and BEVs the proportion of predicted Correct /Incorrect responses differ across states and between new and non-new car buyers.
    - In CA, NY and OR, new car buyers are estimated to be more likely to correctly identify that HEVs only fuel with gasoline than are non-new car buyers but in CT new car buyers are less likely to correctly identify how HEVs are fueled.
    - For BEVs, only in CO and CT are new car buyers estimated to be slightly more likely to correctly identify that BEVs "fuel" only by plugging in to charge. In all other states, new car buyers are predicted to be no different from or to be less likely to correctly identify who BEVs are fueled.

Odds-ratios are the ratio of the odds of an event occurring in one group to the odds it occurs in another group. Odds-ratios for State from the model for Fueling HEVs are summarized in Table 5 and those for BEVs in Table 6.

Table 5: Statistically Different Odd-Ratios for Correctly Identifying How HEVs are Fueled between Pairs of States controlling for new car buyer Status, $\alpha \leq 0.05$

	CA	CO	CT	MA	MD	NJ	NY	OR
CA			1.668		1.329	1.478	1.641	
CO			1.716			1.502	1.688	
CT	0.592	0.583						0.546
MA								
MD	0.753							
NJ	0.677	0.666						0.624
NY	0.609	0.599						0.562
OR			1.832			1.603	1.781	

Note: Shading indicates significance; $\alpha \leq 0.01$, $0.01 < \alpha \leq 0.05$.

The estimated odds-ratio for HEV fueling for CA vs. CT is 1.668; participants in CA are considerably more likely to know how HEVs are fueled. The odds-ratio for whether participants in CA know how a BEV is fueled (compared to them not knowing) compared to ratio in CT is 1.454; a participant in CA is more likely to know how a BEV is fueled than is a participant from CT. (The odds-ratio for CT-CA is simply the inverse of the CA-CT.) The same generalization holds for BEVs as for HEVs; if there is difference in the odds that participants in any two states know how BEVs are fueled, those odds ratios indicate participants from CA, CO, and OR are more likely to know BEVs are only plugged in to charge than are participants from CT, MA, MD, NJ, and NY.

Table 6: Statistically Different Odd-Ratios for Correctly Identifying How BEVs are Fueled between Pairs of States controlling for new car buyer Status, $\alpha \leq 0.05$

	CA	CO	CT	MA	MD	NJ	NY	OR
CA			1.454	1.373	1.257	1.275	1.500	
CO			1.456	1.374			1.502	
CT	0.688	0.687						0.693
MA	0.728	0.728						0.733
MD	0.795							
NJ	0.784							
NY	0.666	0.666						0.671
OR			1.444	1.363			1.490	

Note: Shading indicates significance; $\alpha \leq 0.01$, $0.01 < \alpha \leq 0.05$.

3.1.4 Assessments of ZEVs

3.1.4.1 Assessments of BEVs

A detailed description of participants' capability to charge a BEV at their residence is presented first, then a summary of all nine BEV assessments. Figure 7 shows the distributions of responses to the statement about participants' assessments of their capability "to plug in a battery electric vehicle to charge at home." The details vary across states, but they all share a "tri-modal" indicating higher percentages at the extremes of disagreement and agreement as well as at the midpoint. In most of these states, a high concentration of participants is at the strongest disagreement, i.e., from -3.0 to -1.5. Still, the peak at the positive agreement end of the scale indicates many people agree they could charge a BEV at home.

The mean agreement scores for ability to charge a BEV at home in Figure 8 are segmented by NCB. There is on average slight to modest agreement across these eight states among those who are new car buyers that they would be able to charge a BEV at home; in every state, non-new car buyers score their ability to charge a BEV at home lower. The average difference is -0.82 points (on the -3 to +3 scale); the difference is enough that in most of these states, on average the non-new car buyers (very slightly) disagree they could charge a BEV at home.

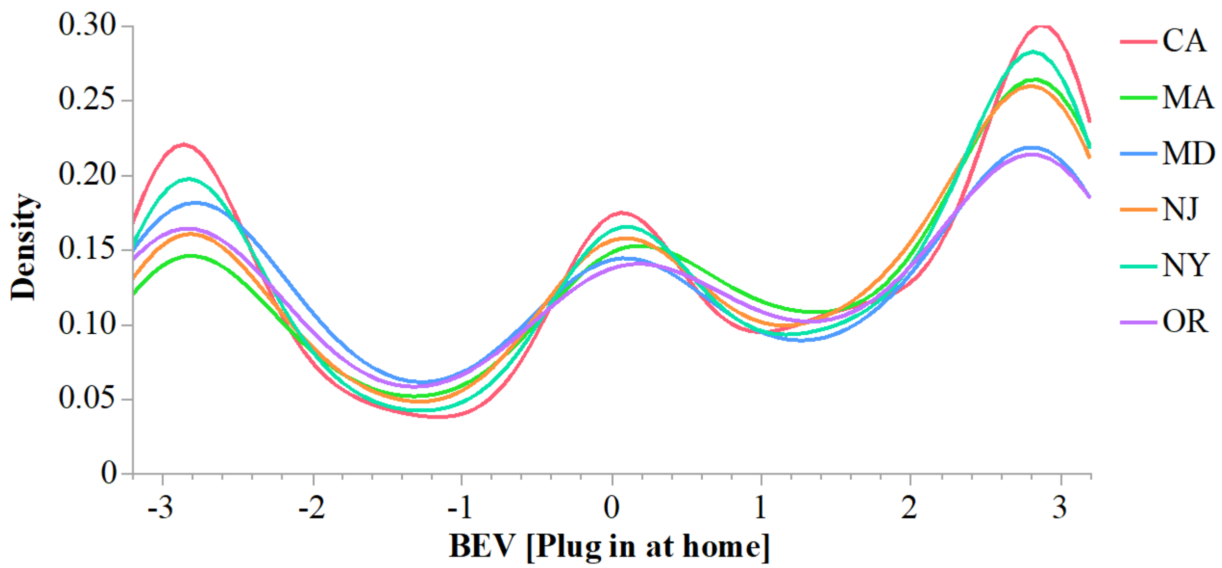


Figure 7: Distributions of Capability to Charge a BEV at Home across Eight ZEV States, 2021

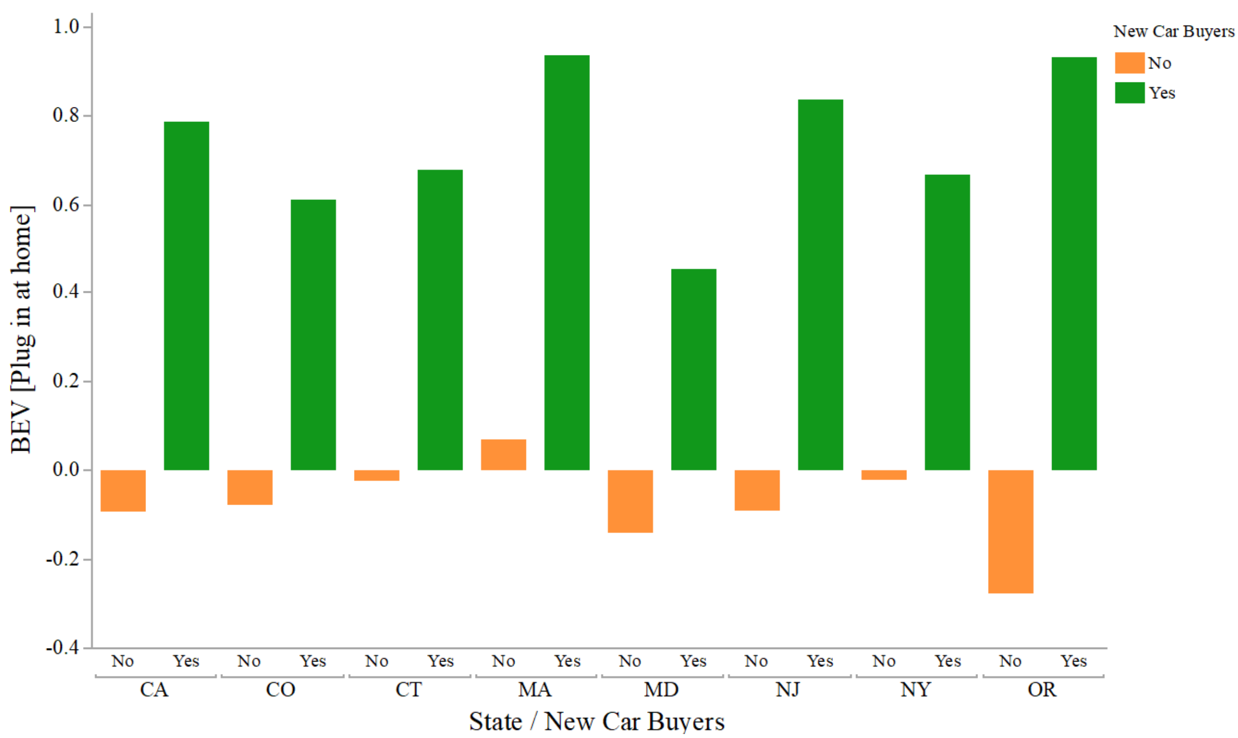


Figure 8: Mean Agreement Scores for Ability to Charge a BEV at Home across Eight ZEV States by new car buyer, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

A linear regression on the continuous agreement scale is estimated using State, NCB, and their crossed effect as independent variables; only NCB is statistically significant. The difference is large enough that those who buy new vehicles register modest average agreement while those who buy only used vehicles register slight average disagreement accounting for State and interaction between State and NCB.

Mean values for all nine BEVs assessments are shown by state in Table 7. If the mean value of each assessment over the eight ZEV states is a useful benchmark, then an Analysis of Means tests for whether the mean for each state is different from the mean of all eight states. The state-assessment mean values in Table 7 are shaded according to whether they are statistically significantly (α = 0.05) less than (orange), not different from (no shading), or greater than (green) the eight-state mean.

Table 7: Observed Mean Scores for Nine Assessments of BEVs across Eight ZEV States, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Vehicle Type [Assessment] (8-state mean)	CA	CO	CT	MA	MD	NJ	NY	OR
BEV [Charge at home] (0.410)	0.401	0.282	0.403	0.600	0.231	0.522	0.422	0.316
BEV [Enough charging] (-0.343)	-0.234	-0.641	-0.498	-0.379	-0.429	-0.396	-0.349	-0.433
iBEV [Too long to charge] (0.876)	-0.901	-0.877	-0.848	-0.777	-0.831	-1.010	-0.835	-0.810
iBEV [Range too short] (1.010)	-1.068	-1.062	-0.926	-0.736	-1.006	-1.097	-0.992	-0.855
iBEV [Higher price] (1.401)	-1.455	-1.391	-1.427	-1.366	-1.381	-1.412	-1.349	-1.235
iBEV [Gasoline safer] (0.335)	-0.275	-0.208	-0.485	-0.234	-0.366	-0.425	-0.503	-0.046
iBEV [Gasoline more reliable] (0.931)	0.837	1.004	1.059	0.709	1.070	1.00	1.137	0.579
BEV [Less damage to environment] (1.373)	1.342	1.149	1.381	1.518	1.462	1.410	1.466	1.061
BEV [Ready for mass market] (0.695)	0.765	0.504	0.613	0.700	0.616	0.543	0.764	0.528

Note: The "i" prefix for assessment names indicates those for which the scales have been inverted so that positive agreement is favorable to BEVs. Green shading indicates state means statistically significantly higher than the group mean, no shading indicates the state mean is not different from the group mean, and orange indicates the state mean is less than the group mean; α = 0.05.

The Analysis of Means for the nine BEV assessments in Table 7 produces these results:

- On average, there is slight agreement a BEV could be charged at home, but also agreement there aren't enough charging locations.
    - No individual state mean deviates from the eight-state mean assessment of ability to charge a BEV at home.
    - The mean score for CA for the assessment of the number of charging locations is higher than the eight-state mean (though still registering as slight disagreement) while CO is lower.

- On average, participants in all eight states assess BEVs take too long to charge and do not drive far enough on a charge.
    - The only deviation from the eight-state mean is in MA where participants are less strong in their agreement BEV driving range is too short.
- In these eight states, participants on average register moderate agreement BEVs cost more to buy than conventional gasoline-powered vehicles; there is no difference across states in this average assessment.
- On average, gasoline vehicles are assessed to be safer and more reliable than BEVs.
    - Participants in OR offer a mean agreement lower than the eight-state mean that gasoline vehicles are safer than BEVs (essentially neither disagreeing nor agreeing) while those in NY are more likely to agree.
    - However, agreement that gasoline vehicles are more reliable is lower in CA, MA, and OR while the average agreement in NY is higher.
- In all eight states BEVs are, on average, assessed to be less damaging to the environment than conventional gasoline-powered vehicles.
    - Participants in CO and OR offer lower mean agreement than the eight-state mean.
- On average, there is slight agreement BEVs are ready for the mass market.
    - The agreement score is higher than the eight-state mean for CA.

Within each state the means tend to have similar rank order. That BEVs are less damaging to the environment and cost more to buy garner the first or second highest average agreement in all eight states. The lowest ranked assessment in all eight states and the only one to have a negative average is “there are enough places to charge battery electric vehicles”: everywhere there is slight disagreement.

Regression models assess the effects of State, NCB, and NCB*State on BEV assessments. The statistical significance of the three explanatory variables in each of these nine regression equations are shown in Table 8. The nine linear regression models differ as to which variables are statistically significant. Only the assessment for iBEV [Higher price] is estimated to be affected by none of the three variables: the moderately-high mean agreement that BEVs cost more to buy than gasoline vehicles does not differ by state or whether participants acquired a vehicle new since 2014. All eight other BEV assessments are estimated to differ between new car and non-new car buyers. In six of the BEV assessment regressions, the State variable is statistically significant: participants in at least one state score their agreement differently than participants in at least one other state. The differences between states indicated by the regression models in Table 8 conform to those highlighted in Table 7.

Table 8: Significance of Explanatory Variables in Regression Equations of Nine Assessments of BEVs in Eight ZEV States, 2021

Dependent Variable: Vehicle Type [Assessment]	Statistically significant variables				
	Term	Degrees of Freedom	Sum of Squares	F Ratio	Prob. > F
BEV [Charge at home]	NCB	1	713.865	142.868	< 0.0001
	State	7	33.787	0.9666	0.4542
	NCB*State	7	33.389	0.953	0.4639
BEV [Enough charging]	NCB	1	376.179	88.916	< 0.0001
	State	7	96.495	3.258	0.0019
	NCB*State	7	36.184	1.222	0.2865
iBEV [Too long to charge]	NCB	1	94.413	33.459	< 0.0001
	State	7	30.958	1.567	0.1401
	NCB*State	7	27.179	1.376	0.2106
iBEV [Range too short]	NCB	1	47.001	16.212	< 0.0001
	State	7	78.223	3.830	0.0004
	NCB*State	7	16.534	0.810	0.5789
iBEV [Higher price]	NCB	1	1.851	0.712	0.3988
	State	7	24.302	1.336	0.2286
	NCB*State	7	19.430	1.068	0.3811
iBEV [Gasoline safer]	NCB	1	102.146	34.179	< 0.0001
	State	7	80.893	3.867	0.0003
	NCB*State	7	64.473	3.082	0.0030
iBEV [Gasoline more reliable]	NCB	1	30.952	11.503	0.0007
	State	7	167.009	8.867	<0.0001
	NCB*State	7	15.355	0.815	0.5744
BEV [Less damage to environment]	NCB	1	16.892	6.021	0.0142
	State	7	82.033	4.177	0.0001
	NCB*State	7	23.455	1.194	0.3021
BEV [Ready for mass market]	NCB	1	154.104	50.419	< 0.0001
	State	7	76.597	3.580	0.0008
	NCB*State	7	22.856	1.068	0.3810

Note: The "i" prefix in variable names indicates scales whose scores are inverted. Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

The nine BEV assessment statements are of "mixed sense"—positive agreement signals a better assessment of BEVs for some statements while for others positive agreement signals a better assessment of gasoline vehicles. Accounting for this by inverting the scales of statements with a negative sense for BEVs, the results indicate the following for new vs. non-new car buyers:

Positive BEV Assessments

- New car buyers are more likely to agree they can charge a BEV at home; non-new car buyers disagree they can charge a BEV at home.
- New car buyers scores for whether there are enough places to charge BEVs are not different from zero, or “I don’t know”; non-new car buyers disagree there are enough.
- On average, all participants agree BEVs are less damaging to the environment than gasoline vehicles and are “ready for the mass market,” but new car buyers’ agreement is stronger than non-new car buyers’ agreement.

Negative BEV Assessments

- New car buyers agree more strongly than non-new car buyers that BEVS take too long to charge and do not drive far enough on a charge.
- New car buyers agree more strongly than non-new car buyers gasoline vehicles are safer and more reliable than BEVs.

3.1.4.2 Assessments of PHEVs

The assessments of PHEVs show broadly similar patterns to those for BEVs. Given the different fueling characteristics of BEVs and PHEVs, one might expect more differences in statements related to charging infrastructure, driving range, and charging duration. The combining of electricity and gasoline into a single vehicle might also be expected to produce differences in assessments of safety and reliability vis-à-vis gasoline-only vehicles and effect on the environment. As a prelude to the analysis of the effects of the NCB variable, the mean agreement scores for “My household would be able to charge a plug-in hybrid electric vehicle at home” are shown in Figure 9 by State and NCB. Mean values for all nine assessments are in Table 9.

Comparing Figure 8 and Figure 9 illustrates what is meant by saying agreement scores for patterns of assessments between PHEVs and BEVs are “broadly similar.” It is the case in both figures that in every state, new car buyers have higher mean scores than non-new car buyers. While there are, on average, fewer states in which non-new car buyers register, on average, actual disagreement that there are enough charging locations for PHEVs than for BEVs, those states with the strongest disagreement there is enough charging for BEVs (MD and OR) are the only states that register average disagreement there is enough charging for PHEVs.

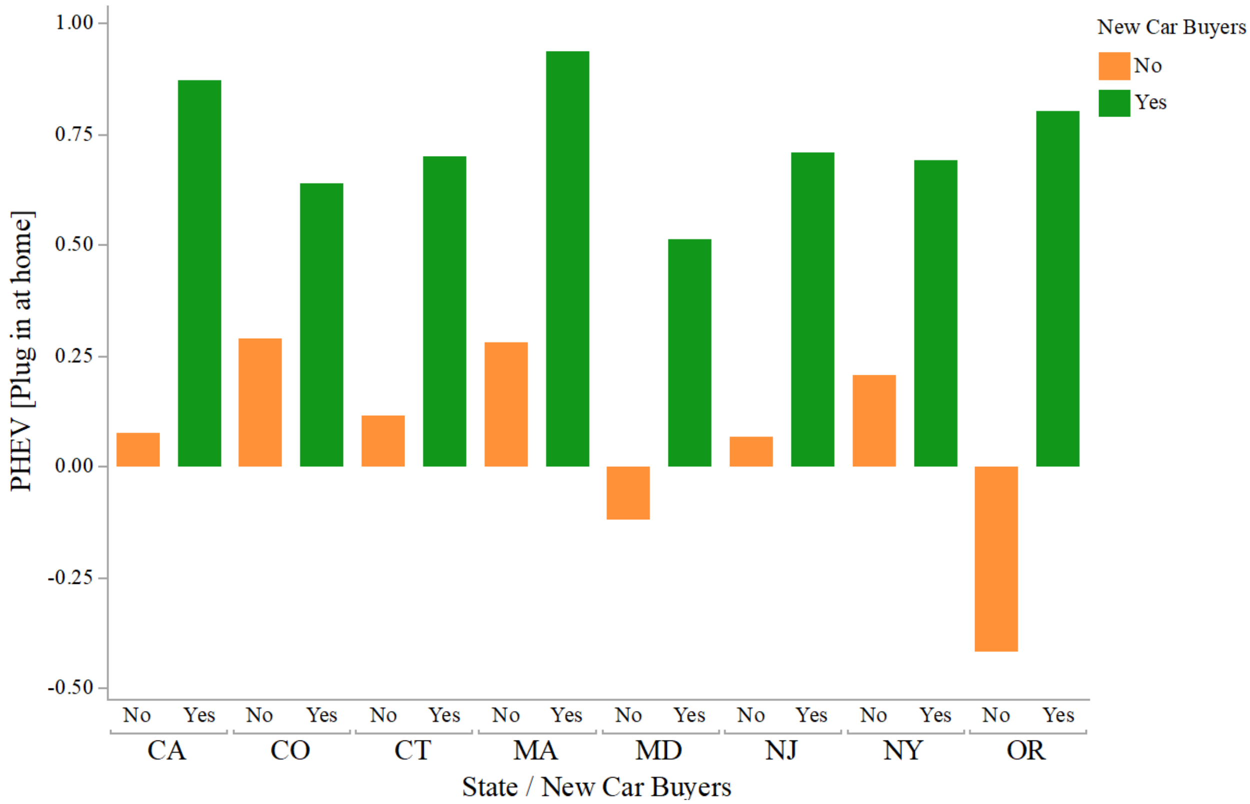


Figure 9: Observed Mean Scores for Ability to Charge a PHEV at Home across Eight ZEV States, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

State mean values for nine assessments of PHEVs and the results of an Analysis of Means are in Table 9. Values in the table are shaded according to whether they are statistically significantly (α = 0.05) less than (orange), not different from (no shading), or greater than (green) the eight-state mean. The mean assessment results for PHEVs are much like those for BEVs:

- On average, participants are slightly likely to agree they can charge a PHEV at home, but they may not think there are enough charging locations for PHEVs.
    - Participants in OR have a lower average agreement they could charge a PHEV at home than any other state.
    - As with BEVs, participants in CA have higher mean agreement score than elsewhere and those in CO have the strongest average disagreement.
- PHEVs are similarly assessed across all eight states as taking too long to charge, not driving far enough on a charge, and costing more to buy than gasoline vehicles.
- On average, gasoline vehicles are assessed to be safer and more reliable than PHEVs.
    - Participants in NY register higher agreement than the eight-state average while CA and OR register lower.
- PHEVs are assessed as less damaging to the environment and ready for the mass market.

- Participants in CO show lower average agreement that PHEVs are less damaging to the environment than the eight-state average.
- Participants in CA show higher average agreement that PHEVs are “ready for mass market” than the eight-state average; NJ shows lower agreement.

The nine linear regression models differ as to which, if any, of the three variables is statistically significant (Table 10). The variable NCB is statistically significant in all nine models: all nine PHEV assessments differ between new car buyers and non-new car buyers. This further argues for distinguishing between these two groups when comparisons are made to the 2014 new car Buyer-only data in the next section. In six of the PHEV assessment regressions, the State variable is statistically significant indicating participants in at least one state score their agreement differently than participants in at least one other state. The differences between states indicated by these regression models conform to those presented Table 9.

For all nine PHEV assessments, the effect of the NCB variable is statistically significant. As with the BEV assessments, the nine statements are of “mixed sense”—for some positive agreement signals a better assessment of PHEVs while for other positive agreement signals a better assessment of gasoline vehicles. Accounting for this by inverting the scales of statements with a negative sense of PHEV, the results indicate the following about the assessments of PHEVs by new car buyers compared to non-new car buyers:

Positive PHEV Assessments

- New car buyers, on average, slightly agree they can charge a PHEV at home; non-new car buyers average agreement score is not different from zero on the -3 to +3 scale.
- New car buyers, on average, slightly agree there are enough places to charge PHEVs; non-new car buyers, on average, slightly disagree there are enough.
- On average, all participants agree PHEVs are less damaging to the environment than gasoline vehicles and are “ready for the mass market,” but new car buyers’ agreement is stronger than non-new car buyers’ agreement.

Negative PHEV Assessments

- Though all participants register slight average agreement PHEVs take too long to charge and do not drive far enough on a charge, new car buyers more strongly agree than do non-new car buyers.
- Though all participants register slight average agreement gasoline vehicles are safer and more reliable than PHEVs, new car buyers more strongly agree than non-new car buyers.

Table 9: Mean Scores for Nine Assessments of PHEVs across and for Eight ZEV States, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Vehicle Type [Assessment] (mean)	CA	CO	CT	MA	MD	NJ	NY	OR
PHEV [Charge at home] (0.494)	0.523	0.471	0.470	0.681	0.275	0.492	0.520	0.181
PHEV [Enough charging] (-0.134)	-0.021	-0.433	-0.245	-0.077	-0.189	-0.254	-0.142	-0.308
iPHEV [Too long to charge] (0.788)	-0.777	-0.851	-0.947	-0.683	-0.707	-0.865	-0.797	-0.746
iPHEV [Range too short] (0.657)	-0.619	-0.584	-0.890	-0.652	-0.615	-0.693	-0.736	-0.502
iPHEV [Higher price] (1.360)	-1.377	-1.334	-1.555	-1.302	-1.400	-1.347	-1.316	-1.353
iPHEV [Gasoline safer] (0.413)	-0.337	-0.313	-0.577	-0.329	-0.421	-0.530	-0.579	-0.155
iPHEV [Gasoline more reliable] (0.765)	-0.700	-0.748	-0.907	-0.675	-0.757	-0.887	-0.906	-0.459
PHEV [Less damage to environment] (1.220)	1.224	0.878	1.215	1.313	1.237	1.304	1.265	1.082
PHEV [Ready for mass market] (0.811)	1.01	0.648	0.794	0.956	0.861	0.687	0.887	1.024

Note: The "i" prefix for assessment names indicates those for which the scales have been inverted so that positive scores favor BEVs. Green shading indicates state means statistically significantly higher than the group mean, no shading indicates not difference, and orange indicates the state mean is less than the group mean; $\alpha = 0.05$.

Table 10: Significance of Explanatory Variables in Regression Equations of Nine Assessments of PHEVs in Eight ZEV States, 2021

Dependent Variable: Vehicle Type [Assessment]	Statistically significant variables				
	Term	Degrees of Freedom	Sum of Squares	F Ratio	Prob. > F
PHEV [Charge at home]	NCB	1	477.713	103.250	< 0.0001
	State	7	69.780	2.156	0.0351
	NCB*State	7	62.800	1.939	0.0595
PHEV [Enough charging]	NCB	1	376.179	265.659	< 0.0001
	State	7	109.962	4.019	0.0002
	NCB*State	7	18.710	0.6838	0.6860
PHEV [Too long to charge]	NCB	1	73.068	29,965	< 0.0001
	State	7	24.726	1.449	0.1801
	NCB*State	7	15.173	0.889	0.5141
PHEV [Range too short]	NCB	1	71.205	25.367	< 0.0001
	State	7	30.122	1.533	0.1510
	NCB*State	7	26.753	1.362	0.2169
PHEV [Higher price]	NCB	1	10.706	4.788	0.0287
	State	7	20.231	1.293	0.2495
	NCB*State	7	18.935	1.210	0.2933
PHEV [Gasoline safer]	NCB	1	85.781	32.099	< 0.0001
	State	7	88.2239	4.717	0.0003
	NCB*State	7	34.206	1.829	0.0773
PHEV [Gasoline more reliable]	NCB	1	47.792	18.845	0.0007
	State	7	85.061	4.792	< 0.0001
	NCB*State	7	30.030	1.692	0.1061
PHEV [Less damage to environment]	NCB	1	29.812	12.505	0.0004
	State	7	63.124	3.783	0.0004
	NCB*State	7	19.945	1.195	0.3016
PHEV [Ready for mass market]	NCB	1	149.117	51.973	< 0.0001
	State	7	158.928	7.913	< 0.0001
	NCB*State	7	12.599	0.627	0.7337

Note: The "i" prefix in variable names indicates scales whose scores are inverted. Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

3.1.4.3 Assessments of FCEVs

There are eight statements related to assessments of FCEVs; the possibility of home fueling of hydrogen for FCEVs is ignored here. With this exception, the presentation of results follows that for BEVs and PHEVs above. State mean values for the eight FCEV assessment statements are shown in Table 11 and the statistical significance of the variables NCB, State, and NCB*State in the regressions for each FCEV assessment are shown in Table 12.

Table 11 Mean Scores for Eight Assessments of FCEVs across Eight ZEV States, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Vehicle Type [Assessment] (group mean)	CA	CO	CT	MA	MD	NJ	NY	OR
FCEV [Enough fueling] (-0.798)	-0.854	-1.066	-1.004	-0.751	-0.840	-0.690	-0.554	-1.168
iFCEV [Too long to fuel] (0.346)	-0.315	-0.250	-0.429	-0.385	-0.362	-0.387	-0.445	-0.037
iFCEV [Range too short] (0.510)	-0.48	-0.458	-0.438	-0.364	-0.489	-0.629	-0.631	-0.346
iFCEV [Higher price] (1.243)	-1.270	-1.216	-1.379	-1.156	-1.279	-1.126	-1.278	-1.109
iFCEV [Gasoline safer] (0.673)	-0.659	-0.593	-0.742	-0.584	-0.615	-0.741	-0.799	-0.343
iFCEV [Gasoline more reliable] (0.873)	-0.843	-0.785	-0.937	-0.823	-0.980	-0.964	-0.975	-0.443
FCEV [Less damage to environment] (1.048)	1.103	0.901	1.020	1.102	1.058	1.008	1.033	0.855
FCEV [Ready for mass market] (-0.065)	-0.094	-0.258	-0.084	-0.048	-0.155	-0.196	-0.163	-0.375

Note: Green shading indicates state means statistically significantly higher than the group mean, no shading indicates the state mean is not different from the group mean, and orange indicates the state mean is less than the group mean; $\alpha = 0.05$.

In general respondents create this "on average" assessment of FCEVs:

- There are not enough places to fuel FCEVs, they take too long to refuel, and their driving range is too short.
- FCEVs are more expensive to buy than conventional gasoline vehicles.
- Conventional gasoline vehicles are safer and more reliable than FCEVs.
- FCEVs are less damaging to the environment than gasoline vehicles.
- FCEVs are not ready for the mass market.

In no state do the participants diverge from this overall assessment. The only differences from the eight-state mean responses of the individual statements is participants in NY routinely score their agreement with statements higher than the eight-state means and those in OR, lower.

Table 12: Significance of Explanatory Variables in Regression Equations of Eight Assessments of FCEVs in Eight ZEV States, 2021

Dependent Variable: Vehicle Type [Assessment]	Statistically significant variables				
	Term	**Degrees of Freedom**	**Sum of Squares**	**F Ratio**	**Prob. > F**
FCEV [Enough fueling]	NCB	1	433.355	104.378	< 0.0001
	State	7	144.260	4.963	< 0.0001
	NCB*State	7	26.326	0.906	0.501
FCEV [Too long to fuel]	NCB	1	44.555	18.771	< 0.0001
	State	7	44.614	2.685	0.0089
	NCB*State	7	15.173	0.889	0.5141
FCEV [Range too short]	NCB	1	52.441	23.276	< 0.0001
	State	7	42.301	2.682	0.0090
	NCB*State	7	8.397	0.532	0.8106
FCEV [Higher price]	NCB	1	11.911	5.215	0.0224
	State	7	28.578	1.788	0.0851
	NCB*State	7	9.696	0.607	0.7511
FCEV [Gasoline safer]	NCB	1	56.578	23.329	< 0.0001
	State	7	62.650	3.690	< 0.0001
	NCB*State	7	6.644	0.3914	0.9080
FCEV [Gasoline more reliable]	NCB	1	27.972	12.280	0.0005
	State	7	89.170	5.592	< 0.0001
	NCB*State	7	20.325	1.275	0.2584
FCEV [Less damage to environment]	NCB	1	47.435	20.888	< 0.0001
	State	7	37.960	2.388	0.0194
	NCB*State	7	31.834	2.003	0.0510
FCEV [Ready for mass market]	NCB	1	238.370	73.869	< 0.0001
	State	7	137.270	6.077	< 0.0001
	NCB*State	7	22.660	1.003	0.4267

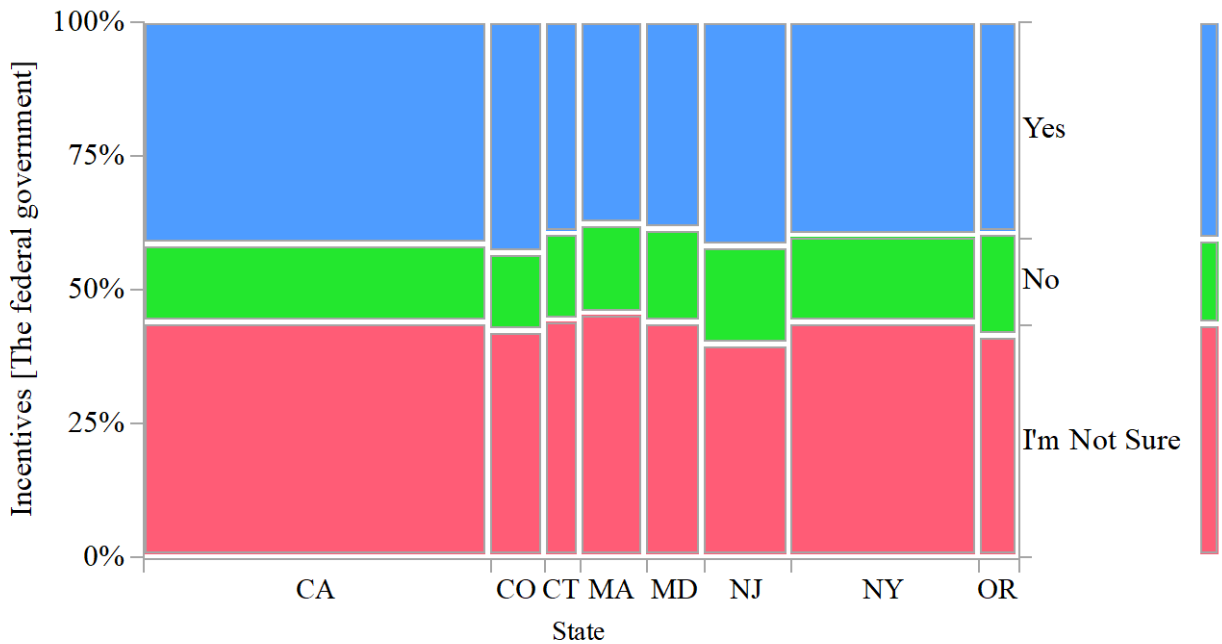
Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

The regressions in Table 12 are run as tests of whether participants' scores for the eight FCEV assessment statements differ systematically by State, whether participants are classified as new car buyers or non-new car buyers, and the potential interaction of those two variables. As the parameter effect tests show, for every assessment statement new car buyers score their agreement differently than non-new car buyers, at least some states differ from each other, but the distinction between new car buyers and non-new car buyers does not differ by state. The state parameter estimates generally confirm the results for state averages in Table 9. The NCB estimates indicate that for every statement—whether phrased to favor FCEVs or gasoline vehicles—new car buyers rate their agreement higher than non-new car buyers. Only for the assessment of whether FCEVs are ready for mass marketing is the difference enough to switch the (slight) disagreement of non-new car buyers into (slight) agreement among new car buyers. The assessment about whether FCEVs cost more to buy than conventional vehicles does not depend on state, only the difference between new car buyers and non-new car buyers.

3.1.5 Incentives for ZEVs

The state distributions of awareness of federal government incentives to consumers to purchase vehicles powered by alternatives to gasoline and diesel are shown in Figure 10. There is no statistically significant difference between these eight ZEV states in the percentage of participants who have, have not, or are unsure whether they have heard of such incentives: in these eight states about 41 percent of participants say they have heard of federal incentives. The χ^2 test is non-significant (even given the large sample size). Further, the Uncertainty Coefficient $C|R = 0.011$; knowledge of participants' state does little to improve a prediction of whether they have heard of federal incentives.

The measure for awareness of federal incentives is recoded so that "I'm not sure" and "No" are equivalent (thus becoming simply, "No" or "Yes") and a nominal logistic regression is performed on this variable using State, NCB, and NCB*State as explanatory variables. The significance tests of the model parameters are shown in Table 13. The results confirm that State and the crossed effect NCB*State are not statistically significant while NCB is: new car buyers are estimated to be about twelve percentage points more likely to have heard of federal incentives (45 percent averaged across new car buyers in all eight states) than non-new car buyers (33 percent). The result further reinforces the argument for treating new and non-new car buyers differently when comparing the 2021 data to the 2014 data.



n = 7,549; degrees of freedom = 14; χ^2 =8.744; probability > χ^2 = 0.2282

Figure 10: Awareness of Federal Incentives across Eight ZEV States, 2021; percent

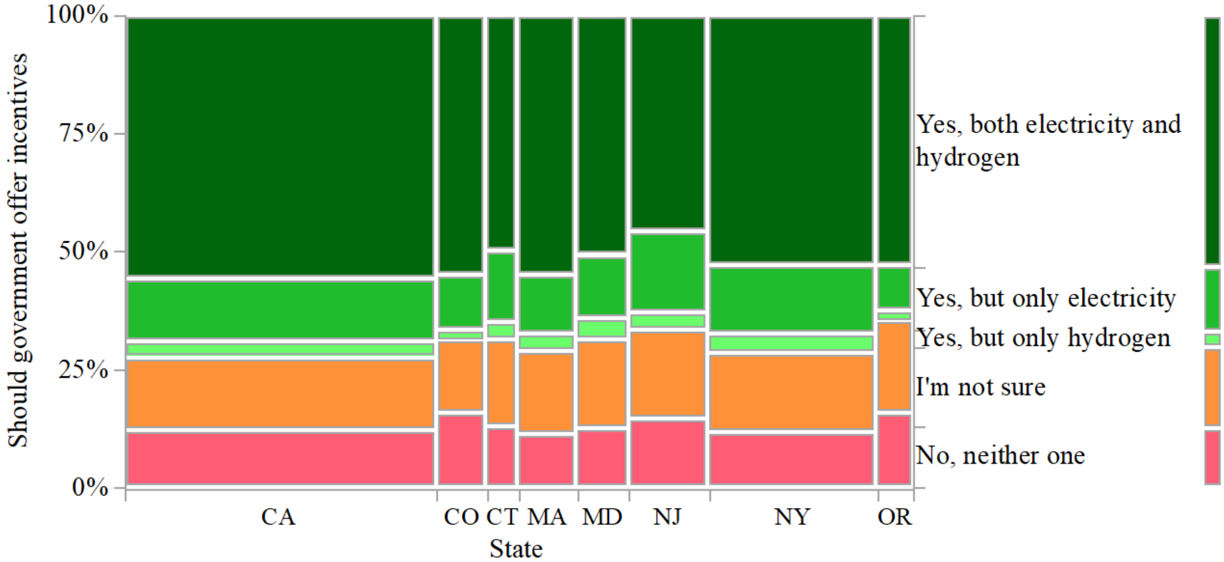
Table 13: Significance of Explanatory Variables in Regression of Awareness of Federal Incentives in Eight ZEV States, 2021

Dependent Variable	Statistically significant variables			
	Term	**Degrees of Freedom**	**Likelihood Ratio Chi-Square**	**Prob. > F**
Incentives [Federal]	NCB	1	58.564	< 0.0001
	State	7	12.273	0.0919
	NCB*State	7	10.280	0.1732

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

3.1.5.1 Support for Government Incentives

Participants are asked whether governments should "offer incentives to consumers to buy and drive vehicles that run on electricity or hydrogen?" The distributions of responses across eight ZEV states are shown in Figure 11. Participants in every state are generally supportive of incentives. Across these states, two-thirds to three-fourths of participants support government providing incentives to consumers to purchase vehicles powered by (in increasing numbers) hydrogen only, electricity only, or both. Across all these states, half or more support incentives for both hydrogen and electricity. Though there appear to be statistically significant differences between these states, the differences are substantively slight. The Uncertainty Coefficient C|R = 0.0029, which though it is significantly larger than zero, is so small as to reinforce the conclusion there is little practical improvement in predicting whether a participant supports incentives given knowledge of their state of residence.



n = 7,549; degrees of freedom = 28; χ^2 =56.829; probability > χ^2 = 0.00105

Figure 11: Support for Government Incentives across Seven non-CA ZEV States, percent

A logistic regression equation on support for government incentives for electricity and hydrogen is estimated using NCB, State, and NCB*State as explanatory variables. The parameter significance tests are shown in Table 14. The model results show that while participants classified as new car buyers are generally more likely to support incentives (whether for hydrogen, electricity, or both) than those classified as non-new car buyers, the opposite is true in one state (CT), though even among new car buyers in CT, two-thirds of participants support incentives. NJ is the state with the lowest level of support for incentives (18 percent opposed, 24 percent unsure), but again most participants their support incentives. The model risks over-complicating the big picture: while there are substantively small, statistically significant differences between new and non-new car buyers, between States, and between new and non-new car buyers between States, everywhere about two-thirds of participants support the idea of government incentives for cars and trucks that run on hydrogen or electricity instead of gasoline.

Table 14: Significance of Explanatory Variables in Regression of Support for Government Incentives in Eight ZEV States, 2021

Dependent Variable	Statistically significant variables			
	Term	Degrees of Freedom	Likelihood Ratio Chi-Square	Prob. > F
Support for Government Incentives	NCB	1	95.876	< 0.0001
	State	7	70.071	< 0.0001
	NCB*State	7	52.931	0.0030

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

3.1.6 Consideration

The question of whether and to what extent participants have already considered ZEVs was asked separately for PHEVs, BEVs, and FCEVs. Subsequently, responses for PHEVs and BEVs are combined into a measure of PEV Consideration, assigning the highest value of PHEV or BEV consideration. Likewise, ZEV Consideration is constructed by assigning the highest value of PEV or FCEV Consideration. The distributions of these five measures for the total sample of the eight ZEV states analyzed here are shown in Figure 12.

Creating the PEV and ZEV Consideration measures as the highest level of consideration for the individual vehicle types has the greatest effect at the lowest Consideration level (by definition). Outright resistance—"I haven't and would not consider"—is expressed by 27 percent of participants for PHEVs and 29 percent for BEVs. Yet for the combined measure of PEV Consideration, "Haven't; won't" is 21 percent (because some people who offer outright resistance to PHEVs offer a higher level of consideration for BEVs and vice versa). The same observation holds for FCEVs: outright resistance to FCEVs is expressed by 37 percent of participants, yet only 19 percent express outright resistance to all ZEVs. At least at present, the multiplicity of possible electric drivetrain and fueling options reduces—if in no way eliminates—the percentage of car-owning households who say they will not consider a ZEV.

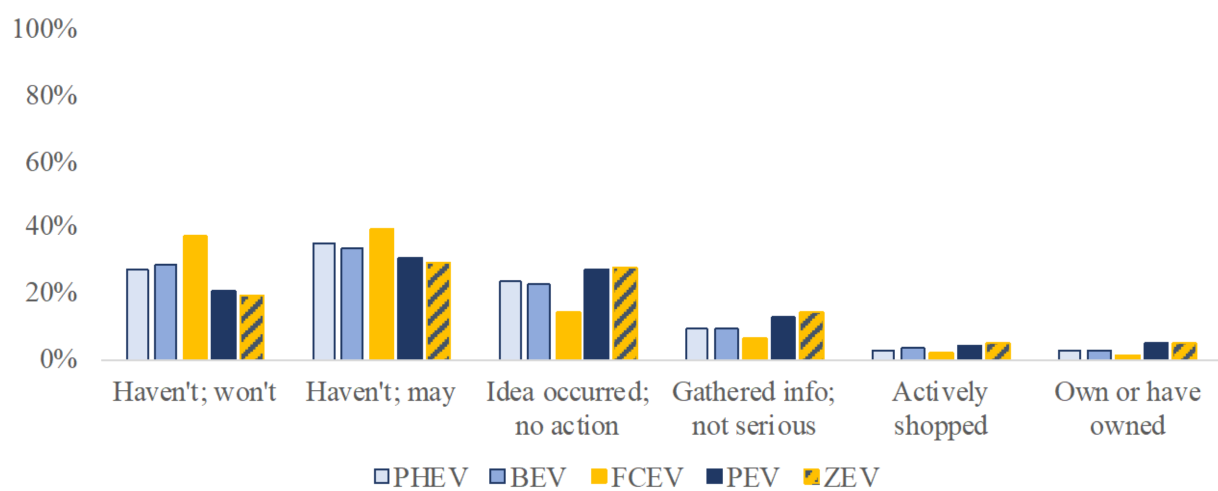
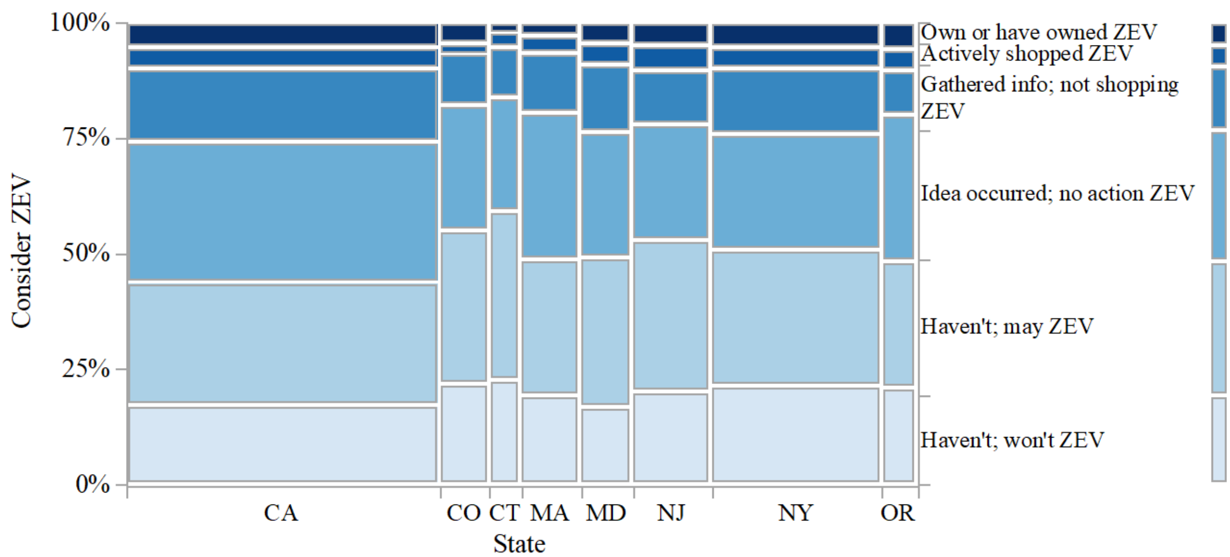


Figure 12: Consideration of PHEVs, BEVs, FCEVs, PEVs, and ZEVs, aggregate of Eight ZEV States, 2021; percent

3.1.6.1 Consideration By ZEV State and New Car Buyer Status

The distributions of ZEV Consideration for the eight ZEV states considered here are shown in Figure 13: there is little substantive difference. While this appears to be contradicted by a χ^2 test indicating statistically significant differences, the χ^2 test returns significant results even for very small effects when the sample size is this large. In this case, knowing the state offers no meaningful improvement in predicting the level of ZEV Consideration as indicated by the very small Lambda Asymmetric C|R = 0.009. Visual inspection of Figure 13 provides little additional insight as to what difference there is between these states.

Further analysis is conducted using logistic regression to analyze whether there are differences in PEV and ZEV Consideration by State, NCB, and their crossed effect. Recall the difference between PEV and ZEV Consideration is FCEV Consideration. To date FCEVs have been almost solely limited to CA. As a practical matter in the ZEV states other than CA, any opportunity to consider "ZEVs" has been limited to PEVs. Tests of significance of the variables in the logistic regressions on PEV and ZEV Consideration are summarized in Table 15. Both PEV and ZEV Consideration models indicate both State and NCB are associated with how much consideration participants have already given to PEVs and ZEVs. The estimated probabilities of ZEV Consideration by State are shown in Figure 14. In all states except CT, new car buyers are estimated to be more likely to have given more consideration to PEVs or ZEVs than non-new car buyers. Participants in California are less likely to have given less consideration to PEVs or ZEVs than participants from CT. While it is apparent that participants in California are less likely than participants in the other seven states to be in either of the two lowest levels of ZEV Consideration, for higher levels of consideration it isn't possible to conclude Californians are consistently at higher levels of Consideration.



n = 7,534; degrees of freedom = 35; χ^2 = 102.851; probability of a greater $\chi^2 \leq 0.0001$

Figure 13: Mosaic Plot of Consider ZEV by Eight ZEV States, 2021; percent

Table 15: Effect Significance for Models of PEV Consideration and ZEV Consideration for Eight ZEV States, 2021

Model:	PEV Consideration			ZEV Consideration		
Source	DF	L-R χ^2	Prob. > χ^2	DF	L-R χ^2	Prob. > χ^2
NCB	1	84.021	< 0.0001	1	97.682	< 0.0001
State	7	48.352	< 0.0001	7	154.217	< 0.0001
NCB*State	7	10.032	0.1868	7	9.332	0.2297

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

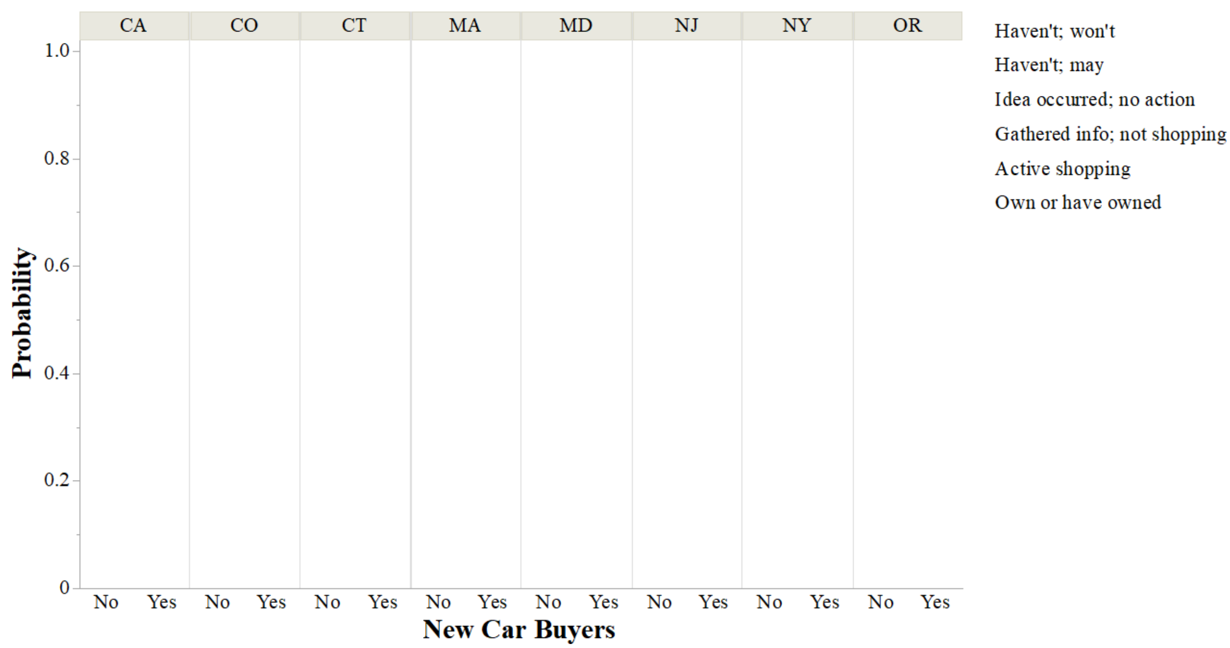


Figure 14: Estimated Probabilities of ZEV Consideration by Eight ZEV States and new car buyer Status, 2021; percent

3.2 Differences between 2014 and 2021: Six ZEV States

This section addresses differences between measures of ZEV awareness, knowledge, assessments, and consideration between 2014 and 2021. Fewer ZEV states are analyzed here than in the previous section. Colorado is not included here since it was not a ZEV state in 2014. Further, there was no state-level analysis for Connecticut in 2014. [1] Thus, the six ZEV states analyzed here are California, Maryland, Massachusetts, New Jersey,

[1] Analysis of the 2014 data were published in a series of state-level reports. For California see, K.S., Kurani, N. Caperello, and J. TyreeHageman (2016) new car buyers' Valuation of Zero-Emission Vehicles: California. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-16-05. https://escholarship.org/uc/item/28v320rq

New York, and Oregon. Based on the results for the year 2021 in the previous section, new car buyers, i.e., households in 2021 who acquired at least one new vehicle during the seven-year period between the two surveys, have different levels of awareness, knowledge, assessments, and prior consideration of ZEVs than households who acquired only used vehicles. As the 2014 data contain only new car buyers, differences between new car buyers and non-new car buyers can only be observed in 2021. The implication for the analysis here is the NCB variable must be nested within the Year variable. Also, questions regarding participants' knowledge of fueling of different vehicle types were not asked in 2014, thus comparisons over time are not possible here.

3.2.1 Familiarity

Familiarity with ICEVs, HEVs, PHEVs, BEVs, and FCEVs is defined as, "familiar enough to make a decision about whether one would be right for your household" and measured on a scale from -3 to +3. The means are shown by State and Year in Figure 15. While the mean familiarity for ICEVs is higher in 2021 than in 2014, the mean scores for HEVs, PHEVs, BEVs, and FCEVs are lower. Recalling the 2021 data contain both new car buyers and non-new car buyers while the 2014 data contains only new car buyers, the question is to what extent are the different scores in 2014 and 2021 associated with differences over time (Year), two different study populations (NCB nested within Year), and State.

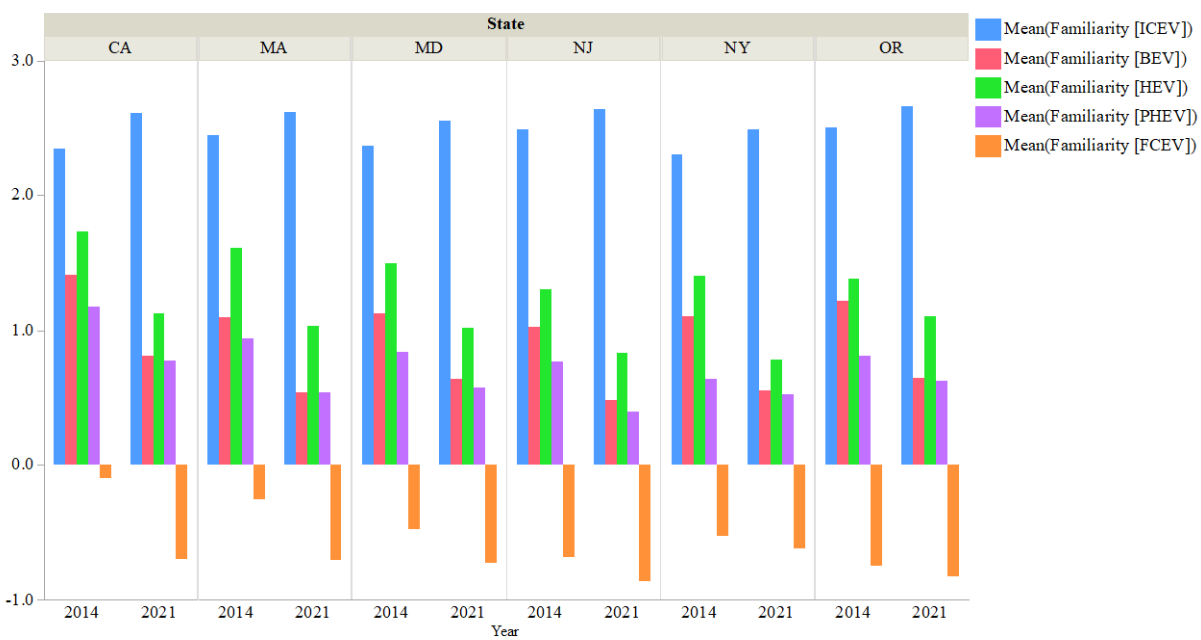


Figure 15: Familiarity with Vehicle Types in 2014 (new car buyers) and 2021 (All-car Owning Households) across Six ZEV States, original scale -3 to +3; mean scores

Regression models are estimated on the five familiarity measures using Year, State, NCB nested within Year (NCB[Year]), Year crossed with State, and NCB[Year] crossed with State. All five models are statistically significant; tests of parameter estimates are summarized in Table 16. For all five familiarity measures, the State, Year, and

NCB[Year] effects are statistically significant. For ICEVs, HEVs, PHEVs, and BEVs the differences between (at least some) states, 2014 and 2021, and new car buyers and non-new car buyers in 2021 are large enough to conclude they are not zero. However, there are no reasons to believe that the differences between years are different by state (or that differences between states are different by year) or that the differences between new car buyers and non-new car buyers vary by state (in 2021). For FCEVs, the State*Year variable is also significant; for FCEVs differences in familiarity scores in (some states) were different in 2021 than they were in 2014 years.

Parameter estimates for the five models of familiarity are in Table 17. The magnitude and signs of the parameters as well as the results of assessments of variable importance indicate the following:

For ICEVs,

- Year has the greatest effect on differences in familiarity with ICEVs—larger than the State and NCB effects found in the previous section focusing on 2021.
    - The 2021 participants score their familiarity with ICEVs higher than those in 2014.
- Non-new car buyers in 2021 are estimated to have the highest familiarity with ICEVs. new car buyers in 2021 score their familiarity with ICEVs higher than did the new car buyers in 2014.
    - However, the effect of NCB[Year] is such that new car buyers in 2021 score their familiarity with ICEVs lower than non-new car buyers in 2021.

For HEVs,

- Year has the largest effect on differences in familiarity.
    - The 2021 sample reports lower familiarity with HEVs than the 2014 sample.
- The effect of NCB[Year] is to increase the estimated familiarity score of new car buyers in 2021 compared to non-new car buyers in 2021.
    - However, despite this effect new car buyers in 2021 still have lower estimated familiarity scores than new car buyers in 2014.
- Compared to OR (the value of the variable State omitted for model estimation), the State effect indicates participants in CA score their familiarity with HEVs higher and those in NJ and NY, lower.

For PHEVs,

- State has the greatest effect on familiarity though it is not much more important than Year.
    - Regardless of Year or NCB[Year], participants in CA are estimated to score themselves as more familiar with PHEVs.
- Participants in 2021 are estimated to have lower familiarity with PHEVs than participants in 2014.
- NCB[Year] is the next most important effect.
    - Estimated familiarity with PHEVs is higher for new car buyers than non-new car buyers (in 2021).

For BEVs,

- Year is the most important variable determining estimates of familiarity.
  - Participants in 2021 are estimated to have lower familiarity with BEVs than participants in 2014.
- The effect of NCB[Year] is to increase the estimated familiarity with BEVs among new car buyers compared to non-new car buyers in 2021.
  - However, new car buyers in 2021 are still estimated to have lower familiarity with BEVs than the new car buyers that make up the 2014 sample.
- Participants in CA are estimated to have higher familiarity with BEVs in OR while those in NJ are estimated to have lower.

For FCEVs

- The mean familiarity score is the only one that is negative: participants disagree they are familiar enough with FCEVs to consider one for their household.
- NCB[Year] is the most important variable to estimating values of familiarity.
  - new car buyers in 2021 are estimated to have higher FCEV familiarity scores than non-new car buyers in 2021.
- The effect of Year though is to cause estimates of FCEV familiarity to be highest (least negative) for participants in 2014, i.e., FCEV familiarity is worse in 2021.
- Participants in CA are estimated to have higher FCEV familiarity than those in OR; those in NJ, lower than OR.

Table 16: Significance of Effect Tests for Models of Familiarity with ICEV, HEVs, PHEVs, BEVs, and FCEVs between 2014 and 2021 across Six ZEV States

Familiarity	Degrees of Freedom	Sum of Squares	F Ratio	Probability > F
ICEVs				
State	5	39.900	6.9330	< 0.0001
Year	1	76.766	6.9330	< 0.0001
NCB[Year]	1	6.861	5.961	0.0146
State*Year	5	7.628	1.326	0.2500
NCB*State[Year]	5	6.653	1.156	0.3282
HEVs				
State	5	285.412	12.887	< 0.0001
Year	1	577.706	130.428	< 0.0001
NCB[Year]	1	192.587	43.480	< 0.0001
State*Year	5	29.970	1/353	0.239
NCB*State[Year]	5	33.887	1.530	0.1767
PHEVs				
State	5	351.434	13.675	< 0.0001
Year	1	211.257	41.102	< 0.0001
NCB[Year]	1	270.600	52.648	< 0.0001
State*Year	5	31.910	1.242	0.2866
NCB*State[Year]	5	10.171	0.3958	0.8520
BEVs				
State	5	268.116	10.795	<0.0001
Year	1	706.881	142.308	<0.0001
NCB[Year]	1	326.946	65.820	<0.0001
State*Year	5	2.511	0.1011	0.9919
NCB*State[Year]	5	8.705	0.3510	0.8822
FCEVs				
State	5	214.772	8.094	< 0.0001
Year	1	204.293	38.494	< 0.0001
NCB[Year]	1	513.820	96.816	< 0.0001
State*Year	5	94.684	3.568	0.0032
NCB*State[Year]	5	12.589	0.4744	0.7956

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

Table 17: Parameter Estimates for Models of Familiarity with ICEV, HEVs, PHEVs, BEVs, and FCEVs between 2014 and 2021 across Six ZEV States

	ICEV		HEV		PHEV		BEV		FCEV	
Term	Estimate	Prob>|t|	Estimate	Prob>|t|	Estimate	Prob>|t|	Estimate	Prob>|t|	Estimate	Prob>|t|
Intercept	2.507	< 0.0001	1.214	< 0.0001	0.692	< 0.0001	0.857	< 0.0001	-0.641	< 0.0001
Year[2021]:NCB[No]	0.042	0.0146	0.202	< 0.0001	0.267	< 0.0001	0.235	< 0.0001	0.223	< 0.0001
State[CA]	-0.023	0.1743	0.1070	0.0628	0.029	0.6534	-0.065	0.2935	0.117	0.0863
State[MA]	0.036	0.2086	0.010	0.862	-0.013	0.8503	-0.008	0.8965	-0.003	0.9662
State[MD]	-0.047	0.1047	-0.194	0.0004	-0.163	0.0073	-0.165	0.0050	-0.203	0.0021
State[NJ]	0.065	0.0169	-0.157	0.0003	-0.149	0.0020	-0.075	0.1041	0.012	0.8221
State[NY]	-0.106	< 0.0001	0.274	<0 .0001	0.17	< 0.0001	0.306	< 0.0001	0.176	< 0.0001
Year[2014]	-0.096	< 0.0001	-0.224	<.0001	-0.266	< 0.0001	-0.292	< 0.0001	-0.366	< 0.0001
Year[2014]*State[CA]	-0.043	0.0113	0.045	0.1936	0.047	0.2133	0.010	0.7801	0.14	0.0006
Year[2014]*State[MA]	0.005	0.8662	0.018	0.7488	0.049	0.4440	0.000	0.9965	0.095	0.1659
Year[2014]*State[MD]	0.004	0.8885	-0.004	0.9486	-0.011	0.8636	-0.03	0.6441	-0.009	0.8969
Year[2014]*State[NJ]	0.015	0.5795	0.010	0.8572	0.066	0.2814	0.025	0.673	-0.016	0.8135
Year[2014]*State[NY]	0.002	0.9238	0.072	0.0973	-0.071	0.1396	0.015	0.7418	-0.072	0.1652
Year[2021]: NCB [No] *State[CA]	0.032	0.1822	-0.003	0.9462	-0.007	0.8963	0.021	0.6656	0.063	0.2151
Year[2021]: NCB [No] *State[MA]	0.026	0.5365	0.218	0.0074	0.093	0.2894	0.064	0.4569	-0.007	0.9335
Year[2021]: NCB [No] *State[MD]	-0.041	0.3551	-0.021	0.8066	0.047	0.6106	0.033	0.7153	0.042	0.6606
Year[2021]: NCB [No] *State[NJ]	-0.012	0.7488	-0.065	0.3843	-0.045	0.5786	-0.081	0.3031	-0.061	0.4574
Year[2021]: NCB [No] *State[NY]	-0.039	0.1732	-0.007	0.9039	0.004	0.9492	-0.008	0.8921	-0.011	0.8565

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

3.2.2 Seeing PEV Charging

Generally, more households report seeing "EV charging spots in the parking lots and garages I use" in 2021 than did so in 2014 across CA, MA, MD, NJ, and NY though the increase in CA is slight and in OR there is no difference (Figure 16). In five of these six ZEV states, the distributions for 2021 show distinctly fewer people say they have seen not EV charging or are unsure whether they have and more people who say they have seen EV charging in a few or several of the places they park. In 2014, nearly half to three-fourths of participants in MA, MD, NJ, and NY said they had seen no EV charging or didn't know whether they had. By 2021, clear majorities of participants in MA and MD state they've seen a few or several such locations; in NJ and NY, about half report they've seen EV charging in the parking facilities they use. The exception to this pattern of increases is OR which shows no difference between years but had (in 2014) and has (in 2021) the highest level of "seeing EV charging" of these six states.

An ordinal logistic regression equation is estimated on the responses to the question about seeing EV charging spots to simultaneously test whether the apparent differences between years and across states are large enough to be statistically significant. The explanatory variables are State, Year, NCB[Year], and crossed effects between State and Year (State*Year) and NCB[Year] and State (NCB[Year]*State). The effect tests and parameter estimates are summarized in Table 18.

The effect tests indicate the variables State, Year, NCB[Year], and State*Year are significant but not NCB[Year]*State. Participants differ in whether and how many electric vehicle charging spots they have seen in the parking facilities they use and their estimated probabilities for selecting each response are different across (at least some) states, between 2014 and 2021, and between new and non-new car buyers (in 2021). Further the estimated differences between (at least some) states depends on the year. Differences between new and non-new car buyers does not differ by state (in 2021).

Rather than interpreting the parameter estimates directly, their effects may be observed in the patterns of predicted probabilities they produce. The predicted probabilities are shown in Table 19. Note there is no row for non-new car buyers in 2014 for any state as there are no non-new car buyers in the 2014 sample. The following patterns emerge from Table 19:

- The largest differences are between states with lesser differences between years and between new and non-new car buyers in 2021.
    - Participants from OR and CA are estimated to be most likely to report they have seen EV charging; those from NY and NJ, least likely.
    - The estimated probabilities that participants have seen EV charging are higher for participants in 2021 than in 2014.
    - Especially in CA and OR there are smaller differences between years and between new and non-new car buyers in 2021.
- In 2021, the estimated probabilities that new car buyers have seen EV charging and have seen EV charging in more locations are higher than for non-new car buyers.
- The effect of Year is larger than the effect of NCB[Year] such that even non-new car buyers in 2021 are estimated to be more likely to have seen EV charging and

to have seen it in more locations than are the 2014 participants all of whom were new car buyers.

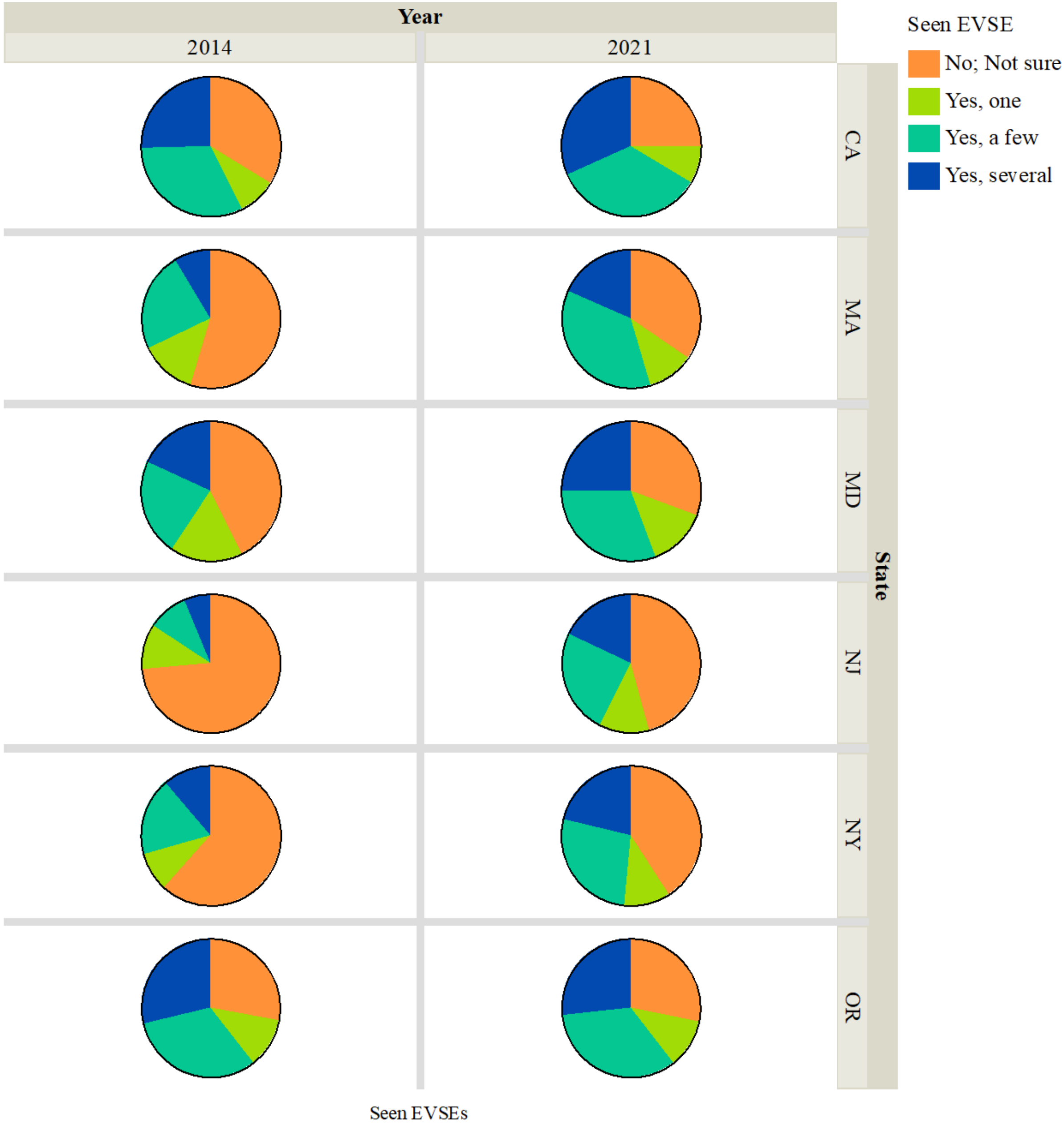


Figure 16: Distributions of "Have seen Electric Vehicle Spots," between 2014 and 2021 and Across Six ZEV States; Percent within Year and State

Table 18: Significance of Effect Tests and Parameter Estimates for Ordinal Logistic Regression on Seeing Electric Vehicle Charging, 2014 and 2021 across Six ZEV States

Effect Tests	Degrees of Freedom	Likelihood Ratio χ^2	Probability > χ^2
State	5	655.109	< 0.0001
Year	1	178.313	< 0.0001
NCB[Year]	1	47.877	< 0.0001
State*Year	5	103.251	< 0.0001
NCB*State[Year]	5	9.414	0.0937

Parameter Estimates	Estimate	Standard Error	χ^2	Probability > χ^2
Intercept[No; Not sure]	-0.0378	0.0291	1.68	0.1951
Intercept[Yes, one]	0.4051	0.0294	190.52	< 0.0001
Intercept[Yes, a few]	1.7408	0.0328	2824.30	< 0.0001
State[CA]	-0.7255	0.0416	304.55	< 0.0001
State[MA]	0.2206	0.0669	10.87	< 0.0001
State[MD]	-0.1474	0.0652	5.10	0.0239
State[NJ]	1.0300	0.0764	181.98	< 0.0001
State[NY]	0.4464	0.0555	64.73	< 0.0001
Year[2021-2014]	-0.5420	0.0410	174.85	< 0.0001
Year[2021]:NCB[No]	0.2018	0.0295	46.73	< 0.0001
Year[2021-2014]*State[CA]	0.3441	0.0577	35.58	< 0.0001
Year[2021-2014]*State[MA]	-0.2779	0.0969	8.22	< 0.0001
Year[2021-2014]*State[MD]	0.0756	0.0993	0.58	0.4463
Year[2021-2014]*State[NJ]	-0.6440	0.1006	40.98	< 0.0001
Year[2021-2014]*State[NY]	-0.0822	0.0742	1.23	0.2678
Year[2021]: NCB [No] *State[CA]	-0.0399	0.0402	0.99	0.3204
Year[2021]: NCB [No] *State[MA]	-0.1530	0.0701	4.76	0.0291
Year[2021]: NCB [No] *State[MD]	0.1062	0.0749	2.01	0.156
Year[2021]: NCB [No] *State[NJ]	0.056	0.0656	0.73	0.3936
Year[2021]: NCB [No] *State[NY]	0.0626	0.0493	1.61	0.2039

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

Table 19: Predicted Probabilities: Seeing EV Charging across Six ZEV States, 2014 and 2021, and NCB

			Estimated Probabilities of Seeing EV Charging			
State	Year	NCB[Year]	No; Not sure	Yes, one	Yes, a few	Yes, several
CA	2014	New	32	10	31	27
CA	2021	Non-New	31	10	32	27
CA	2021	New	25	9	32	34
MA	2014	New	55	11	23	12
MA	2021	Non-New	36	11	30	23
MA	2021	New	33	10	31	25
MD	2014	New	45	11	27	17
MD	2021	Non-New	41	11	28	19
MD	2021	New	28	10	32	31
NJ	2014	New	73	8	13	6
NJ	2021	Non-New	52	11	24	14
NJ	2021	New	39	11	29	21
NY	2014	New	60	10	20	10
NY	2021	Non-New	51	11	24	14
NY	2021	New	38	11	29	21
OR	2014	New	30	10	32	29
OR	2021	Non-New	34	11	31	24
OR	2021	New	27	10	32	31

3.2.3 Assessments of ZEVs

Only seven of the nine BEV assessment statements from the 2021 survey were in the 2104 survey. As discussed in the Method section, separate statements were not asked for BEVs and PHEVs in 2014. The statement wording from 2014 may be interpreted as applying to BEVs. This shorter list statements are available for comparison between years:

- *My household would be able to plug in a BEV to charge at home.*
- *There are enough places to charge BEVs.*
- *It takes too long to charge BEVs.*
- *BEVs do not travel far enough before needing to be charged.*
- *BEVs cost more to buy than gasoline vehicles.*
- *Gasoline powered cars are safer than BEVs.*
- *Gasoline powered cars are more reliable than BEVs.*

The list for FCEVs is similar, omitting the first statement about home fueling.

3.2.3.1 BEV Assessments

As an example, mean scores for whether participants agree they could charge a BEV at home by Year, State, and NCB[Year] are shown in Figure 17. It appears the mean scores for new car buyers may have increased slightly from 2014 to 2021 (signaling an increase in their modest agreement they could charge a BEV at home) in most of these six ZEV states. The 2021 data indicate non-new car buyers are distinctly different from new car buyers: in five of six states non-new car buyers, on average, report slight disagreement they could charge a BEV at home. The extent to which apparent differences are statistically significant and which effects are most influential for all seven BEV assessments are examined via regression models. The significance tests for the effects in the models are in Table 20; significant effects are highlighted red.

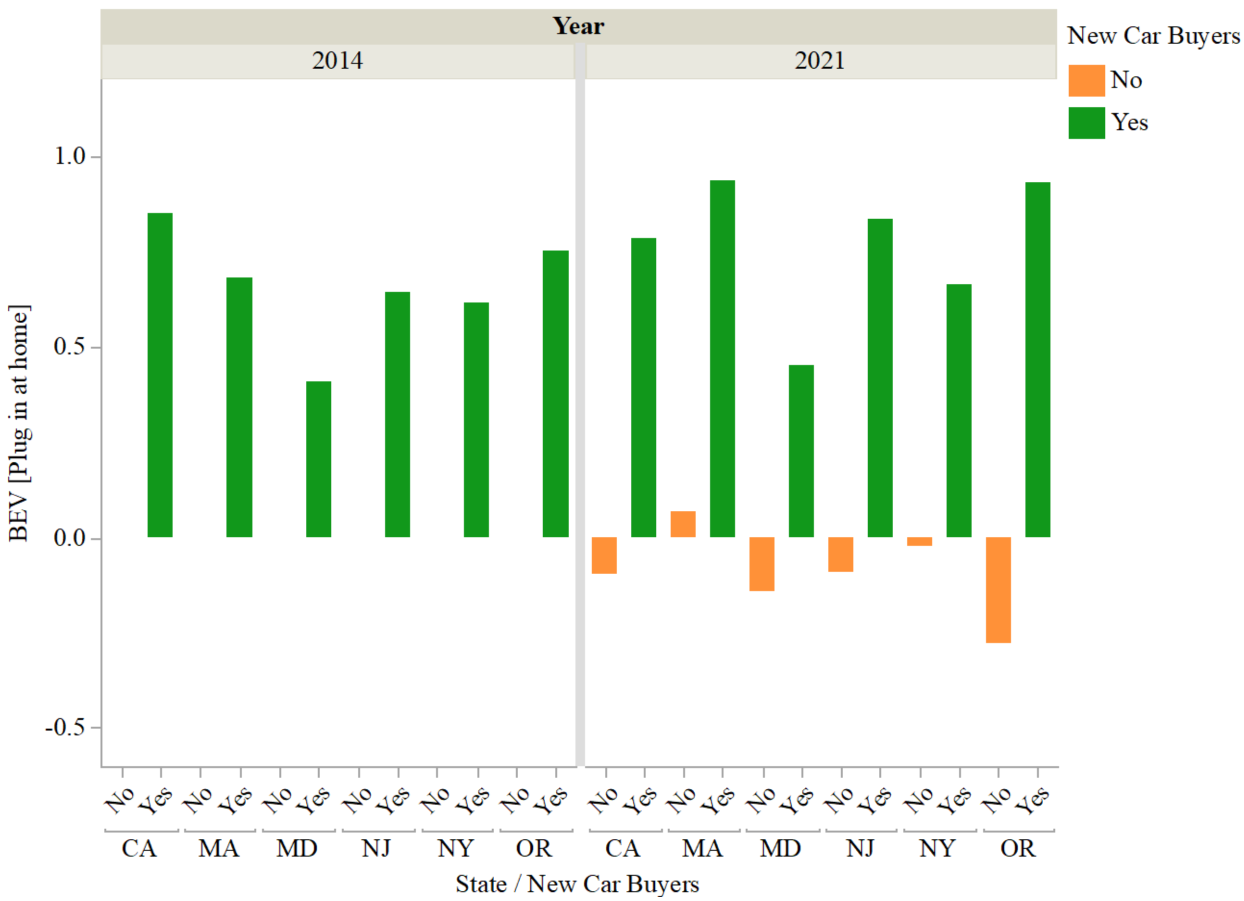


Figure 17: Mean Agreement Scores for Ability to Charge a BEV at Home across Six ZEV States by NCB, 2014 (new car buyers only) and 2021 (new and non-new car buyers); scale -3 (strongly disagree) to +3 (strongly agree)

Table 20: Significant Explanatory Variables in Regression Equations of Seven Assessments of BEVs in Six ZEV States, 2014-2021

Dependent Variable: Vehicle Type [Assessment]	Statistically significant variables				
	Term	DF	Sum of Squares	F Ratio	Prob. > F
BEV [Charge at home]	State	5	101.2333	4.5226	0.0004
	Year	1	114.7956	25.6426	< 0.0001
	NCB[Year]	1	728.2099	162.6649	< 0.0001
	Year*State	5	42.7173	1.9084	0.0894
	NCB*State[Year]	5	23.0105	1.028	0.3991
BEV [Enough charging]	State	5	147.1466	7.5203	< 0.0001
	Year	1	147.1262	37.5961	< 0.0001
	NCB[Year]	1	280.4635	71.6686	< 0.0001
	Year*State	5	58.5625	2.993	0.0105
	NCB*State[Year]	5	14.9141	0.7622	0.5769
BEV [Too long to charge]	State	5	28.86615	2.3431	0.0390
	Year	1	353.1779	143.3397	< 0.0001
	NCB[Year]	1	70.68033	28.6861	< 0.0001
	Year*State	5	20.12004	1.6332	0.1474
	NCB*State[Year]	5	15.40272	1.2503	0.2826
BEV [Range too short]	State	5	16.6538	1.2677	0.2748
	Year	1	72.5757	27.6221	< 0.0001
	NCB[Year]	1	20.0203	7.6197	0.0058
	Year*State	5	22.9443	1.7465	0.1203
	NCB*State[Year]	5	19.0769	1.4521	0.2021
BEV [Higher price]	State	5	1.9187	0.1576	0.9778
	Year	1	39.8267	16.3541	< 0.0001
	NCB[Year]	1	1.8216	0.748	0.3871
	Year*State	5	1.0402	0.0854	0.9945
	NCB*State[Year]	5	4.8644	0.3995	0.8495
BEV [Gasoline safer]	State	5	62.2794	4.6428	0.0003
	Year	1	496.3401	185.007	< 0.0001
	NCB[Year]	1	78.653	29.3173	< 0.0001
	Year*State	5	7.6644	0.5714	0.7220
	NCB*State[Year]	5	22.1067	1.648	0.1436
BEV [Gasoline more reliable]	State	5	47.1064	3.8682	0.0017
	Year	1	220.0002	90.3285	< 0.0001
	NCB[Year]	1	32.2608	13.2458	0.0003
	Year*State	5	35.1698	2.888	0.0131
	NCB*State[Year]	5	4.6838	0.3846	0.8597

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

An Analysis of Means on the least square means, i.e., not the observed means but the means estimated by the regression model, shows how any one group—participants from one year compared to the other, across states, or between new vs. non-new car buyers—differs from the estimated mean values across those groups. For Year and NCB[Year] differences are assessed via a t-test (for Year and NCB[Year]; for State, differences are assessed via Tukey's Honestly Significantly Different test to control for multiple comparisons.

The variable Year is the most important for all BEV assessments except capability to plug-in a BEV at home. The variability in participants scores is influenced more by Year than by what state they are from or whether they are a new or a non-new car Buyer in 2021. Year is entered as both a simple effect, as part of a nested effect, and as part of a crossed effect. The direct effect of Year is most important in these six assessments. As discussed next, for capability to charge at home, whether participants are new car buyers is most important.

Across all participants there is slight agreement they can charge a BEV at home (mean = 0.51). The effect of NCB[Year] is the most important in determining differences followed by Year and then State. Averaged over both years as well as over new and non-new car buyers, participants in CA score their agreement they can charge a BEV at home higher than the mean of all six states while those in MD score theirs lower. Participants in 2014 score their agreement higher while those in 2021 score theirs lower. new car buyers in both years score their capability to charge at home higher than the non-new car buyers (in 2021).

Across all participants there is slight disagreement there are enough places to charge BEVs (mean = -0.42). Year is most important to determining differences followed by State and then NCB[Year]. Participants in both years disagree there is enough BEV charging, but that disagreement is weaker in 2021 than in 2014. Participants in CA disagree less strongly than the average across all six states while those in NJ disagree more strongly. The effect of NCB[Year] is such that non-new car buyers in 2021 disagree more strongly than do new car buyers in 2021 but disagree at much the same level as did new car buyers in 2014.

Across all participants there is modest agreement that BEVs take too long to charge (mean = 0.71). Participants in 2021 agree more strongly that BEVs take too long to charge than do those in 2014. This is true for both new car buyers and non-new car buyers in 2021. new car buyers in 2021 score their agreement higher even than the non-new car buyers. Only in Oregon does the mean score differ from the six-state mean by enough to be statistically significant—participants in Oregon agree less strongly that BEVs take too long to charge.

Across all participants there is modest agreement that BEVs do not travel far enough on a charge (mean = 0.92). Agreement scores are affected by Year and NCB[Year] but not by State. Participants in 2021 more strongly agree BEV driving ranges are not enough than those in 2014. new and non-new car buyers from 2021 agree more strongly than do the new car buyers from 2014. In 2021, new car buyers agree more strongly than non-new car buyers.

The statement that, “BEVs cost more to buy than gasoline vehicles,” garners the highest average agreement of any statement (mean = 1.33). Participants in 2021 agree more strongly with this statement than do those in 2014—and new car buyers in 2021 have the highest agreement (mean = 1.40). No state mean is different from the six-state mean.

Across all participants there is slight agreement that gasoline vehicles are safer than BEVs (mean = 0.14). The effect of Year is such that the slight average disagreement of the 2014 respondents is more than counter-balanced by the slight average agreement of the 2021 respondents. The shift toward positive agreement that gasoline vehicles are safer is not attributable to the presence of non-new car buyers in the 2021 sample—the new car buyers in 2021 have the highest mean agreement that gasoline vehicles are safer.

Finally, across all participants, there is moderate agreement that gasoline vehicles are more reliable than BEVs (mean = 0.79). Participants in both years agree, but mean scores are higher in 2021 than 2014. Again, though both new and non-new car buyers from 2021 have higher agreement scores than the 2014 sample, the highest mean agreement is among new car buyers in 2021. Only in OR is the mean agreement statistically significantly different from the six-state mean: mean agreement scores for participants from OR are lower though still in agreement.

3.2.3.2 FCEV Assessments

This section is organized as the previous one. The mean agreement scores for the statement, “There are enough places to fuel [FCEVs]” by Year, State, and NCB are shown as example (Figure 18) followed by the multivariate modeling is used to determine whether differences are attributable to the participants’ survey year, state, or new car Buyer status (Table 21).

Immediately it is apparent from Figure 18 that on average all participants disagree there are enough places to fuel FCEVs. However, it seems as if the levels of disagreement diminish from 2014 to 2021 and that it diminishes more so if we control for the fact the 2021 sample contains both new and non-new car buyers while the 2014 sample contained only new car buyers. In effect, though there is still disagreement that there is enough fueling for FCEVs, that disagreement is less in 2021 than in 2014.

For FCEVs the variable State places a larger role than it did in the assessments of BEVs. State is most important for “FCEVs too long to fuel,” “FCEV range too short,” and “Gasoline vehicles are more reliable.” Year is most important for “enough places to fuel,” “FCEVs cost more,” and “Gasoline vehicles are safer.” However, for “enough places to fuel” and “Gasoline vehicles safer” the main effect of State, that is the effect of the variable by itself not counting additional contributions it makes through nested and crossed effects, is larger than the main effect of Year. Overall, for FCEVs, state-to-state variability and differences over time are of similar importance, both much more so than differences between new and non-new car buyers.

Averaged across all participants, there is modest disagreement with the statement that there are enough places to fuel FCEVs (mean = -0.93). The State least square means range from -0.862 (MD) to -1.58 (MA). These are the two values that deviate from the six-state mean by enough to be significantly different. Respondents in all states disagree there is enough fueling for FCEVs: participants in MA even more so and those in MD a little less so. Participants in 2021 are also statistically significantly weaker in their disagreement; new car buyers in 2021 register the weakest disagreement.

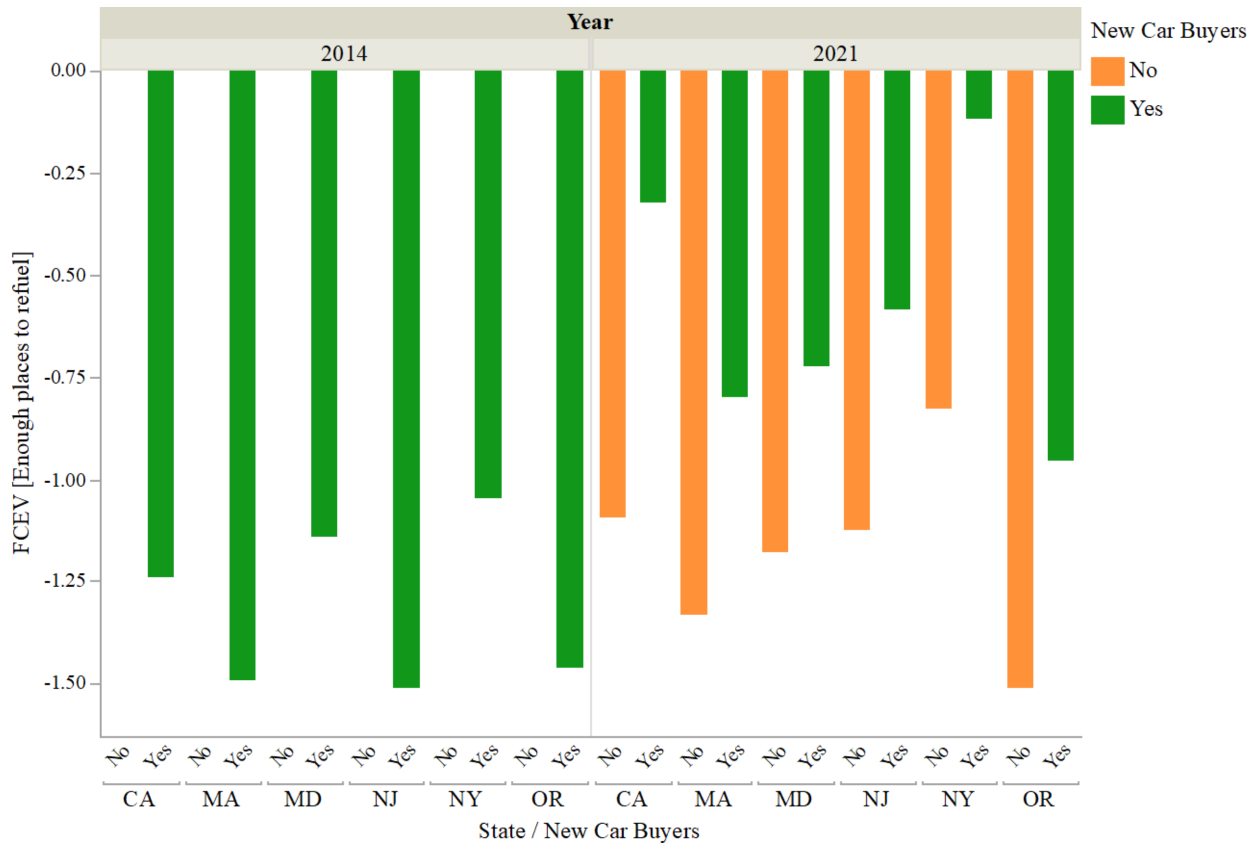


Figure 18: Mean Agreement Scores for FCEV Fueling Locations across Six ZEV States by NCB, 2014 (new car buyers only) and 2021 (new and non-new car buyers); scale -3 (strongly disagree) to +3 (strongly agree)

On average all participants register slight agreement that FCEVs take too long to fuel (mean = 0.32). This is the one FCEV assessment for which Year unambiguously is most important (and State the least important). The least square mean for 2021 participants is higher than for 2014: participants in 2021 are stronger in their agreement that FCEVs take too long to fuel than were participants in 2014. The additional effect of NCB[Year] is such that new car buyers in 2021 register the strongest agreement that FCEVs take too long to fuel. Two states differ from the six-state mean: participants in NY register higher agreement and those in OR, lower.

Across all participants, the mean agreement for "FCEV range is too short" is 0.49 signaling slight agreement. State is again the most important variable, followed by Year, and NCB[Year]. Still, compared to the six-state mean, only participants in NY participants agree more strongly by enough to be statistically significantly different and even in pairwise comparisons, NY is statistically significantly higher than only OR.

Participants in 2021 agree more strongly than those in 2014 that FCEV range is too short; new car buyers in 2021 agree more strongly than non-new car buyers.

Table 21: Significant Explanatory Variables in Regression Equations of Six Assessments of FCEVs in Six ZEV States, 2014-2021

Dependent Variable: Vehicle Type [Assessment]	**Statistically significant variables**				
	Term	**DF**	**Sum of Squares**	**F Ratio**	**Prob. > F**
FCEV [Enough Fueling]	State	5	169.4538	7.3360	< 0.0001
	Year	1	267.00412	57.7959	< 0.0001
	NCB[Year]	1	347.76546	75.2775	< 0.0001
	Year*State	5	115.06489	4.9814	0.0001
	NCB*State[Year]	5	16.23028	0.7026	0.6214
FCEV [Too long to fuel]	State	5	54.51226	3.9551	0.0014
	Year	1	25.60919	9.2903	0.0023
	NCB[Year]	1	37.9019	13.7498	0.0002
	Year*State	5	19.69034	1.4286	0.2103
	NCB*State[Year]	5	14.23374	1.0327	0.3963
FCEV [Range too short]	State	5	41.682	3.2127	0.0067
	Year	1	13.98329	5.389	0.0203
	NCB[Year]	1	35.75313	13.7787	0.0002
	Year*State	5	12.66358	0.9761	0.4307
	NCB*State[Year]	5	6.894401	0.5314	0.7527
FCEV [Higher price]	State	5	75.16037	6.2823	< 0.0001
	Year	1	179.7077	75.1043	< 0.0001
	NCB[Year]	1	6.08536	2.5432	0.1108
	Year*State	5	81.2176	6.7886	< 0.0001
	NCB*State[Year]	5	7.51794	0.6284	0.6781
FCEV [Gasoline safer]	State	5	24.0444	1.7364	0.1226
	Year	1	4.3886	1.5846	0.2081
	NCB[Year]	1	60.0072	21.6673	< 0.0001
	Year*State	5	17.4512	1.2602	0.2781
	NCB*State[Year]	5	1.9702	0.1423	0.9823
FCEV [Gasoline more reliable]	State	5	52.7948	4.2123	0.0008
	Year	1	40.871	16.3048	< 0.0001
	NCB[Year]	1	52.7363	21.0382	< 0.0001
	Year*State	5	20.7117	1.6525	0.1425
	NCB*State[Year]	5	6.3666	0.508	0.7705

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

As with the corresponding assessment for BEVs, the FCEV assessment garnering the highest level of agreement is that they cost more to buy than conventional vehicles (mean = 1.32). It is the only FCEV assessment that is more favorable to FCEVs in 2021 than in 2014. Year is most important to variability in agreement that FCEVs cost more to buy, followed by State and NCB[Year]. Participants in 2021 are estimated to have lower agreement than those in 2014, still as with all other FCEV assessment non-new car buyers are estimated to be more favorable toward FCEVs than new car buyers in 2021. In this case the estimated mean for non-new car buyers is less than that for new car buyers. Participants in MA register higher agreement and those in MD, lower.

All participants, on average, score modest agreement with the statement that gasoline vehicles are safer than FCEVs (mean = 0.63). Only the variable of NCB[Year] is statistically significant in the model. Its effect is such that while there is no overall difference in estimated agreement scores between 2014 and 2021, allowing 2021 contains both new and non-new car buyers, it is the case that new car buyers in 2021 are estimated to agree more strongly than both new car buyers in 2014 and non-new car buyers in 2021 that gasoline vehicles are safer than FCEVs. Participants in 2014 (all of which are new car buyers) and non-new car buyers in 2021 are not different, on average, in their assessment of the relative safety of gasoline vehicles and FCEVs.

Finally, participants register modest average agreement that gasoline vehicles are more reliable than FCEVs (mean = 0.91). State is of the most importance to the variability in agreement scores, followed by (in nearly equal importance) by NCB and Year. Only participants in OR deviate far enough from the six-state mean to be statistically different; participants in OR are estimated to have lower mean agreement that gasoline vehicles are more reliable. The pair wise comparisons (via Tukey's Honestly Significantly Different test) indicate that only MA and MD has estimated mean agreement scores so much higher than OR as to be significantly different. Estimated mean agreement scores are lower in 2021 than in 2014—but they are lower because non-new car buyers in 2021 have such lower scores. In this case, new car buyers in 2021 offer similar agreement as the new car buyers that make up the 2014 sample.

3.2.4 Incentives for ZEVs

Whether participants are aware of incentives offered by the federal government for consumers to buy vehicles that are powered by alternatives to gasoline and diesel is plotted by State and Year in the mosaic plot in Figure 19. It appears in each state as if awareness of such federal incentives is lower in 2021 than in 2014. The answer categories in Figure 19 are simplified to two for further analysis: No/Not Sure vs. Yes. A nominal logistic regression equation is used to test whether the distributions of this version of the variable are different over time (and states) while testing whether any such difference can be attributed to differences between the new car buyers and non-new car buyers in the 2021 sample. The model parameter significance is presented in Table 22.

The observed frequency across the total sample is 57 percent of participants had not or were not sure they heard of federal incentives while 43 percent had heard. In decreasing order, the variables Year, NCB[Year], and State influence the probabilities that participants have heard of federal incentives. The variable Year is most influential; the percentage of people who had heard of federal incentives is lower in 2021 than in 2014. The effect of NCB[Year] is to reduce—but not eliminate—the difference between the new car buyers in the 2014 sample and those in the 2021 sample. Participants in CA are less likely to say they have heard of federal incentives than those in MA, NJ, NY, and OR.

The overall view of support for government providing incentives for electricity and hydrogen is that in almost all states and both years more than half of participants support incentives for both and if those who support incentives for only one or the other are added, then two-thirds to three-fourths of participants support government providing incentives (Figure 20). Slight discernible difference between 2014 and 2021 are not consistent across states; in CA, MD, and OR there may be a slight reduction in the percent of participants who support incentives while in MA, NJ, and NY there may be a slight increase.

The significance tests for a nominal logistic regression equation on the categories from Figure 20 are shown in Table 23. The parameter estimates themselves produce mostly small effects. While there are slight differences between years in support for any incentives, in most states there is a small shift away from supporting incentives for *both* electricity and hydrogen and toward only one or the other. Only in NJ is there an effect based on the effect of NCB[Year]: non-new car buyers in NJ in 2021 are less likely to say government should offer incentives than are new car buyers.

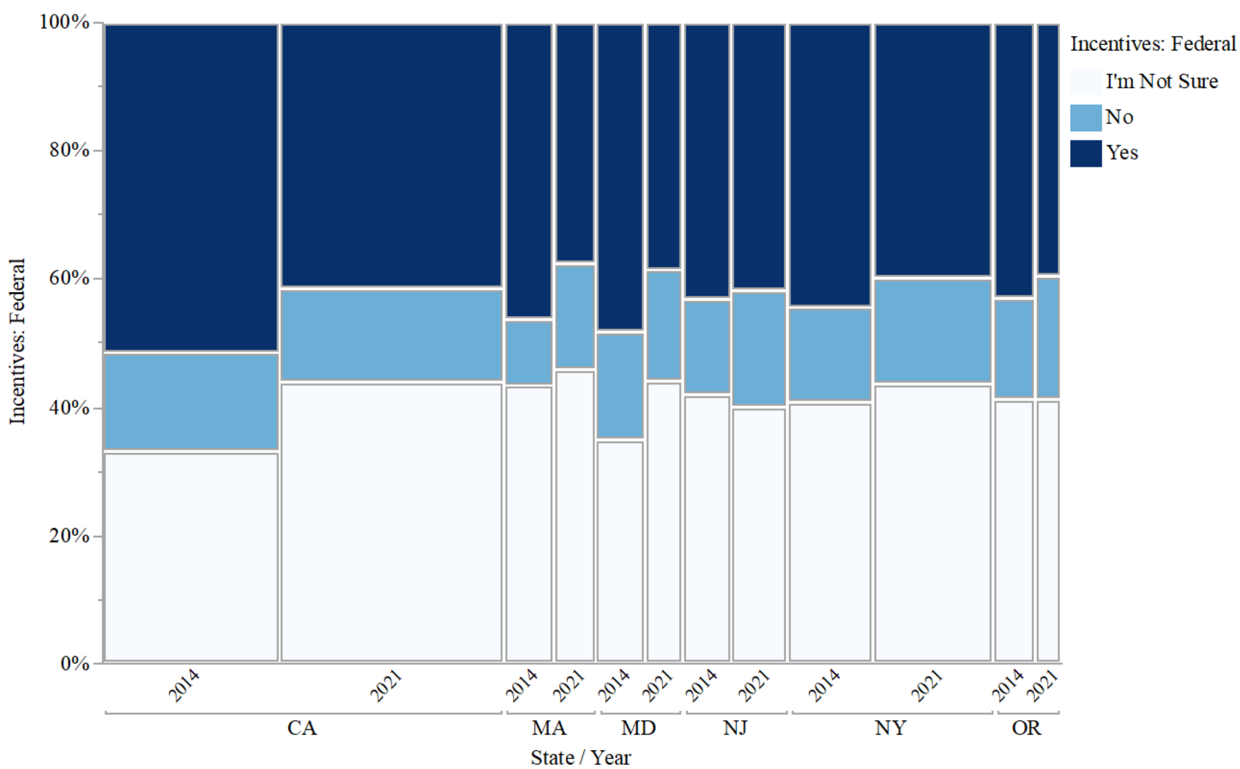


Figure 19: Awareness of Federal Incentives for Alternatives to Gasoline and Diesel in Six ZEV States, 2014 and 2021; percent

Table 22: Significance of Explanatory Variables in Regression of Awareness of Federal Incentives in Six ZEV States, 2014 and 2021

Dependent Variable	Statistically significant variables			
	Term	DF	Likelihood Ratio Chi-Square	Prob. > F
Incentive Awareness [Federal]	State	5	29.047	< 0.0001
	Year	1	50.224	< 0.0001
	NCB[Year]	1	40.721	< 0.0001
	Year*State	5	8.933	0.1118
	NCB*State[Year]	5	7.737	0.1713

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

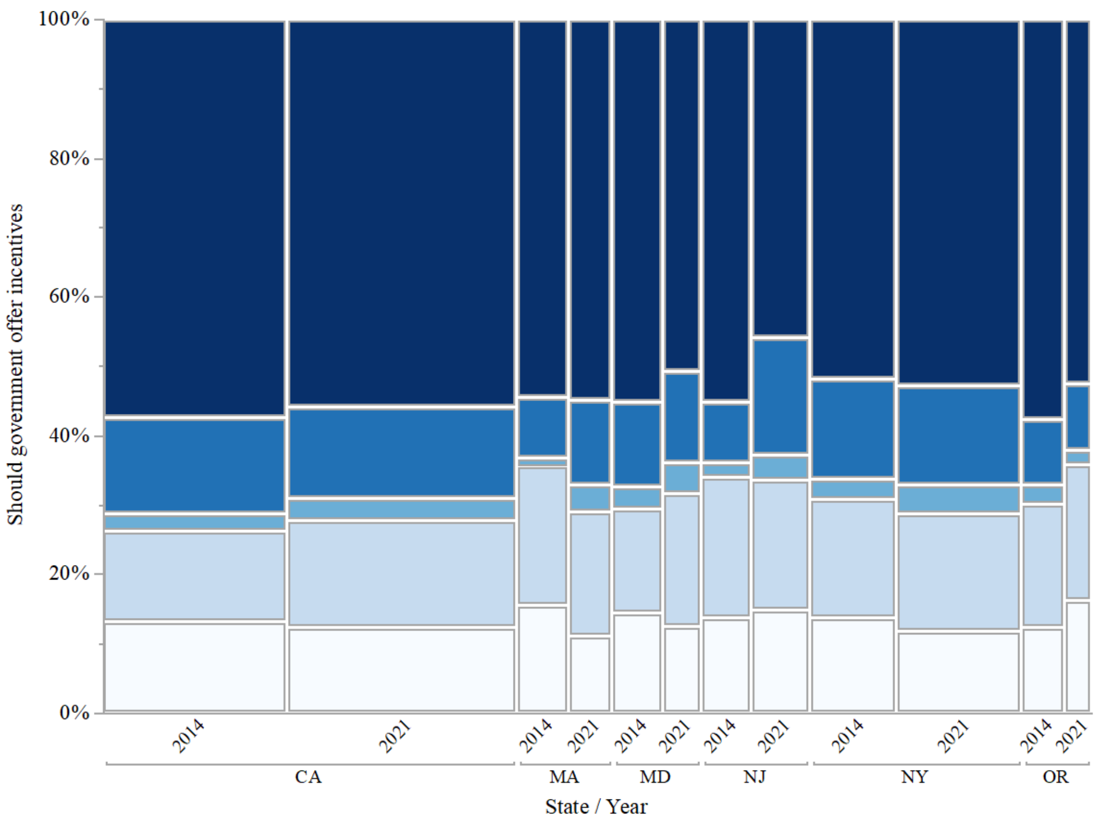


Figure 20: Support for Governments to Offer Incentives for Electricity and Hydrogen in Six ZEV States, 2014 and 2021, percent

Table 23: Significance of Explanatory Variables in Regression of Support for Government Incentives in Six ZEV States, 2014 and 2021

Dependent Variable	Statistically significant variables			
	Term	DF	Likelihood Ratio Chi-Square	Prob. > F
Incentive Awareness [Federal]	State	20	75.046	< 0.0001
	Year	4	5.904	0.2064
	NCB[Year]	4	94.976	< 0.0001
	Year*State	20	54.300	< 0.0001
	NCB*State[Year]	20	32.864	0.0349

Note: Red shading indicates significantly different from zero at $\alpha \leq 0.05$.

3.2.5 Consideration of ZEVs

Recalling the measure "Consideration of ZEVs" is the highest level of consideration given to BEVs, PHEVs, or FCEVs, the distributions by Year and State are shown in Figure 21. Before moving to the analysis of differences, the overall result is that only small minorities of participants in any state and either year have given high levels of consideration to ZEVs. There has been a greater increase in outright resistance to ZEVs (Haven't and won't consider one).

The analysis here addresses the extent to which differences are due to state-to-state differences, differences between two points in time, or the potentially confounding effect of the difference in study populations, i.e., new car buyers only in 2014 vs. new and non-new car buyers in 2021. The analysis is done via an ordinal logistic regression equation on ZEV Consideration using State, Year, NCB[Year], Year*State, and NCB[Year]*State. The effect tests and parameter estimates are in Table 24. The estimated probabilities from the model are in Table 25.

The effect tests indicate there are differences among participants' consideration of any ZEV for their household by State, Year, NCB[Year], and Year*State, i.e., any state-to-state differences are themselves different in 2014 and 2021 (or alternatively, the difference between years is different in at least some states). There are no statistically significantly differences between new and non-new car Drivers (in 2021) across states.

The estimated probabilities in Table 25 show that much of the overall difference between years is due to the fact the 2021 sample contains new and non-new car buyers while the 2014 sample contains only new car buyers. Since the underlying coding of both Year and NCB[Year] is (0, 1), the differences in their parameter sizes (Year[2021-2014] = 0.111 and Year[2021]:new car buyers[No] = 0.313) indicate this difference in the size of the effects. (That is, the differences in parameter magnitude aren't due to the fact they are measured on different scales.) For example, in Figure 21 it appears as if outright resistance to ZEVs (dark red slices of the pie charts) is higher in 2021 than in 2014. However, in Table 25, we see that resistance to ZEVs is generally lower in 2021 than 2014 among new car buyers and any apparent increase in resistance in 2021 is in fact due to the higher resistance of non-new car buyers present in the 2021 sample.

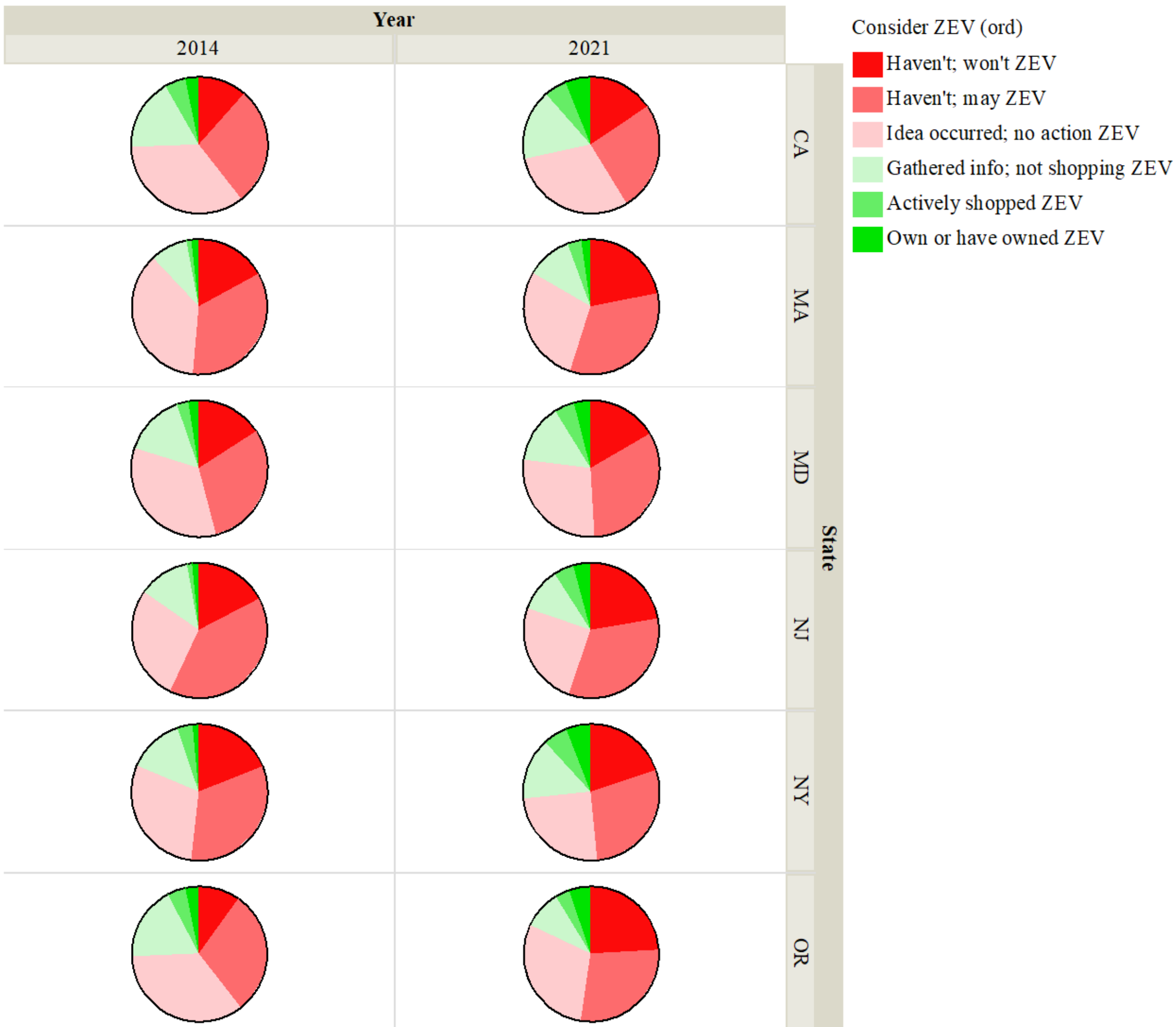


Figure 21: Consideration of ZEVs by Year and State, percent

Table 24: Significance of Effect Tests and Parameter Estimates for Ordinal Logistic Regression on ZEV Consideration, 2014 and 2021 across Six ZEV States

Effect Tests	Degrees of Freedom	Likelihood Ratio χ^2	Probability > χ^2
State	5	113.762	< 0.0001
Year	1	8.147	0.0043
NCB[Year]	1	114.035	< 0.0001
State*Year	5	13.084	0.0226
NCB*State[Year]	5	2.785	0.7331

Parameter Estimates	Estimate	Standard Error	χ^2	Probability > χ^2
Intercept[Haven't; won't ZEV]	-1.6077	0.0316	2583.0	< 0.0001
Intercept[Haven't; may ZEV]	-0.1092	0.0274	15.9	< 0.0001
Intercept[Idea occurred; no action ZEV]	1.2674	0.0298	1807.7	< 0.0001
Intercept[Gathered info; not shopping ZEV]	2.5279	0.0391	4183.1	< 0.0001
Intercept[Actively shopped ZEV]	3.2969	0.0507	4230.8	< 0.0001
State[CA]	-0.3277	0.0398	67.88	< 0.0001
State[MA]	0.2132	0.0627	11.56	0.0007
State[MD]	-0.0311	0.0628	0.25	0.6200
State[NJ]	0.2605	0.0630	17.11	< 0.0001
State[NY]	0.1371	0.0507	7.32	0.0068
Year[2021-2014]	0.1107	0.0391	8.03	0.0046
Year[2021]: NCB [No]	0.3127	0.0291	115.27	< 0.0001
Year[2021-2014]*State[CA]	0.1172	0.0561	4.37	0.0366
Year[2021-2014]*State[MA]	-0.1348	0.0936	2.08	0.1495
Year[2021-2014]*State[MD]	-0.0179	0.0968	0.03	0.8533
Year[2021-2014]*State[NJ]	-0.1317	0.0895	2.17	0.1411
Year[2021-2014]*State[NY]	-0.0642	0.0698	0.85	0.3574
Year[2021]: NCB[No] * State[CA]	-0.0117	0.0396	0.09	0.7686
Year[2021]: NCB[No] * State[MA]	-0.0080	0.0694	0.01	0.9088
Year[2021]: NCB[No] * State[MD]	-0.0871	0.0737	1.39	0.2376
Year[2021]: NCB [No] * State[NJ]	-0.0095	0.0636	0.02	0.8809

Table 25: Predicted Probabilities: ZEV Consideration across Six ZEV States, 2014 and 2021, and NCB

			Estimated Probabilities of ZEV Consideration					
State	Year	NCB[Year]	Haven't; won't	Haven't; may	Idea occurred; no action	Gathered info; not shopping	Actively shopped	Own or have owned
CA	2014	New	13	27	33	18	5	5
CA	2021	Non-New	20	33	29	13	3	3
CA	2021	New	12	26	33	19	5	5
MA	2014	New	20	33	29	12	3	3
MA	2021	Non-New	25	35	26	10	2	2
MA	2021	New	15	29	32	16	4	4
MD	2014	New	16	30	31	15	4	4
MD	2021	Non-New	21	33	28	12	3	3
MD	2021	New	15	29	32	16	4	4
NJ	2014	New	21	33	28	12	3	3
NJ	2021	Non-New	26	35	25	10	2	2
NJ	2021	New	16	30	31	15	4	4
NY	2014	New	19	32	30	13	3	3
NY	2021	Non-New	25	35	26	10	2	2
NY	2021	New	15	29	32	16	4	4
OR	2014	New	13	28	32	17	5	5
OR	2021	Non-New	25	35	25	10	2	2
OR	2021	New	12	26	33	18	5	5

However, most of the effect of Year and NCB[Year] is at the lower levels of consideration as would be expected given how the variable ZEV Consideration is constructed. There are no differences at the highest levels of consideration—actively shopped for a ZEV and owned or have owned a ZEV—between the new car buyers in 2014 and 2021. Non-new car buyers in 2021 are less likely to be at either of these levels. This may be explainable by a time lag in developing a used ZEV market, but that rationale contains its own problem for continued ZEV market growth—both the new and used markets must grow.

4. Conclusions

There is very little evidence in these results of a growing consumer base to support accelerating ZEV sales to 100 percent of new car sales by the year 2035. Across several measures of consumer awareness, knowledge, assessment, and consideration there is no sign of consistent improvement from 2014 to 2021. One of the key differences between the 2014 and 2021 survey samples from multiple ZEV states is the restriction of the 2014 sample to households who had purchased a new car in the seven years prior to the survey (new car buyers) while the 2021 sample contains both new car buyers and households who had acquired only non-new cars over a similar interval preceding the 2021 survey (non-new car buyers). Whether or not participants were new car or non-new car buyers is associated with differences in measures of awareness, knowledge, assessment, and consideration of ZEVs in 2021. However, these differences between new car and non-new car buyers do not account for all the differences in ZEV awareness, knowledge, assessment, and consideration from 2014 to 2021. Where there are differences between new car and non-new car buyers, the results often are that non-new car buyers are less aware, less knowledgeable, and have worse assessments of ZEVs. They have also given less consideration to the acquisition of ZEVs for their households. Thus, an additional barrier to 100 percent sales of ZEVs is the even greater unpreparedness of non-new car buyers, buyers who must be willing, even eager, to buy used ZEVs. From 2014 and 2021 there are few signs that more new car buyers are becoming engaged in a transition to ZEVs.

For each of the measures of awareness, knowledge, assessment, and consideration of ZEVs, these conclusions are structured as an initial statement about the results comparing eight ZEV states in 2021 (California, Colorado, Connecticut, Maryland, Massachusetts, New Jersey, New York, and Oregon) then a subsequent description of how six of those ZEV states compare to their own results from 2014. The smaller number of states for the multi-year comparison is due to a lack of prior data or analysis for Colorado and Connecticut.

4.1 Familiarity with Vehicle Types

Familiarity is measured as whether a person is familiar enough with broad types of vehicles—gasoline, hybrid electric, plug-in hybrid electric, battery electric, and fuel cell electric—to decide whether one is right for them. Self-ratings of familiarity with HEVs and ZEVs are not only low in 2021 (compared to familiarity with ICEVs) in eight ZEV states, but familiarity with HEVs and ZEVs are also lower than they were in 2014 in all six of the ZEV states for which comparisons of 2014 to 2021 can be made. For ICEVs, HEVs, BEVs, and FCEVs the variable Year along with its nested effect distinguishing new car buyers from non-new car buyers (NCB) and crossed effect with the states (State) in which the participants reside has the greatest influence on Familiarity scores—more so than differences between states and between new car buyers and non-new car buyers. That is, more of the difference in Familiarity scores across all participants in the six states across two survey years is due to the difference between years and not the difference between states or between those who do or do not buy new cars. In the case of PHEVs, differences between states have the most influence on Familiarity scores—but it is still the case that self-ratings of "Familiar with PHEVs" are lower in 2021 than in 2014.

The case of Familiarity with HEVs—that more than 20 years after HEVs first became available for sale familiarity remains far lower than for ICEVs—points to how long it may take households to become familiar with PHEVs, BEVs, and FCEVs in the absence of a concerted and pervasive effort to create interest on their part in learning more. Only 25 percent of participants in the eight ZEV states described in 2021 are quite sure they are familiar enough with HEVs to "decide if one is right for my household."

4.2 Seeing PEV Charging

Regarding whether people have seen "electric vehicle charging spots in the parking lots and garages [they] use," the optimistic conclusion is that in 2021 in all eight of the ZEV states examined here most people say they have seen PEV charging in at least one place. Further, majorities of participants in CA (64 percent), MA (58 percent), MD (56 percent) and OR (59 percent) report seeing EV charging in "a few" or "several" such locations. However, pluralities of participants in CO (36 percent), NJ (38 percent), and NY (37 percent) report they have not seen EV charging in the parking lots and garages they use. Further, it is the case that non-new car buyers in 2021 are less likely to report having seen EV charging than are new car buyers in 2021. Two non-exclusive reasons for this may be 1) differences in actual EV charging locations and 2) differences in the relevance of PEV charging and thus in the likeliness of recognizing a PEV charger as such. As to the first, analysis of PEV charging locations in California indicates they are less likely to be in lower income communities.[2] Thus, if people who do not buy new cars have lower incomes (than people who do buy new cars) and subsequently are more likely to live in lower income communities, then at least regarding their local travel there may be fewer PEV chargers to be seen. As to the second, if based on all the other evidence from this analysis that non-new car buyers are even less engaged with ZEVs than new car buyers, then even in the presence of PEV Charging, non-new car buyers may be less likely to notice it or recognize it for what it is.

Generally, more households report seeing "EV charging spots in the parking lots and garages I use" in 2021 than in 2014 across five of the six states in the multi-year comparison: CA, MA, MD, NJ, and NY; there was no apparent increase over time in OR. Differences between states are most important to explaining differences in whether participants have seen PEV charging and how many locations they have seen it. Differences between years are larger than differences between new and non-new car buyers (within 2021) such that even non-new car buyers in 2021 are estimated to be more likely to have seen PEV charging and to have seen it in more locations than were new car buyers in 2014.

4.3 Knowledge of Vehicle Fueling

Whether participants know how HEVs, PHEVs, and BEVs are fueled was not measured in 2014, so only conclusions regarding the between state comparisons for 2021 are possible. In general, while the fact that BEVs only plug-in to charge may be a bit self-evident, there is a fair amount of confusion about HEVs and PHEVs across all eight states. The vehicle type with the highest percent of correct responses is BEVs (77 percent), followed by PHEVs (53 percent), and HEVs (18 percent) averaged across the eight ZEV states. Few people, ranging from 6 percent (CT and NY) to 13 percent (OR), correctly identify how all three types are fueled. The differences between new and non-new car buyers are not a simple matter of one group knowing better than another. non-new car buyers are more likely to correctly identify that PHEVs both fuel with gasoline

[2] Chih-Wei, H. and K. Fingerman (2021) Public electric vehicle charger access disparities across race and income in California. Transport Policy 100: 59-67. https://doi.org/10.1016/j.tranpol.2020.10.003

and plug-in to charge. The differences for HEVs and BEVs are mixed: new car buyers perform better in some states for HEVs or BEVs while non-new car buyers perform better in others. Since so few people correctly identify that HEVs are only fueled with gasoline, knowledge of how HEVs are fueled is not positively related to understanding fueling of PHEVs and BEVs.

4.4 Assessments of ZEVs

The overall conclusion regarding consumer assessments of ZEVs is they are worse in 2021 than they were in 2014. If there is good news it is the slight agreement across eight ZEV states in 2021 that PHEVs and BEVs are "ready for mass market, " though a comparison to 2014 is not possible for this assessment. There are instances within the individual assessment statements and across vehicle types (PHEVs, BEVs, and FCEVs) in which participants in CA—where there are comparatively high ZEV sales and supportive policy—offer more favorable assessments than participants from other states. However, this is far from a general conclusion. Participants in 2021 from OR consistently provide better (though still slightly negative) assessments of the safety and reliability of BEVs, PHEVs, and FCEVs vis-à-vis gasoline vehicles. Participants from CA do distinguish themselves from the average of all eight ZEV states in the 2021 analysis in their slightly stronger positive agreement that PHEVs and BEVS are "ready for mass market."

In the discussion of each vehicle type that follows, conclusions are offered first for BEVs and FCEVs as these allow for comparison between years, then the findings for PHEVs in 2021 are reviewed.

4.4.1 BEV Assessments

Overall, BEVs garner broadly unfavorable assessments with respect to charging availability, driving range as well as price, safety, and reliability in comparison to gasoline vehicles. Despite this, they also elicit slight agreement to a summary assessment that BEVs "are ready for mass marketing." Across all states, participants are apt to agree, on average, that they can charge a BEV at home, though the average tends to obscure that while many participants are quite sure they can, some are equally sure they cannot. On the other hand, across all states the participants register disagreement with a statement, "There are enough places to charge a battery electric vehicle." There are only slight differences across the states, such that participants in CA are likely to disagree less strongly while those in CO are likely to disagree more strongly. Participants in these eight ZEV states assess BEVs take too long to charge, do not drive far enough on a charge, and cost more to buy than conventional gasoline-powered vehicles; there is no difference across states in this average assessment. Gasoline vehicles are assessed to be safer and more reliable than BEVs. In all these states the mean assessment is BEVs are less damaging to the environment than conventional gasoline-powered ICEVs.

All these broad assessments are mediated by the variable indicating whether participants are new or non-new car buyers (NCB). These differences do not produce a consistent picture of one group being more positive in their overall assessment of BEVs than the other. new car buyers are more likely to agree they can charge a BEV at home and their disagreement that there are enough BEV charging locations isn't as strong as that of non-new car buyers. While on average all participants agree BEVs are less damaging to the environment than gasoline vehicles and are "ready for the mass market," new car buyers agree more strongly than non-new car buyers. However, for neither new nor non-new car buyers should "agreement" be construed as strong on the overall response scale. For all those ways in which new car buyers assess BEVs more positively than do non-new car buyers, in the following ways, that pattern is reversed. Non-new car buyers are likely to have weaker agreement that BEVs take too long to charge and do not drive far enough on a charge. Non-new car buyers also register weaker agreement that gasoline vehicles are safer and more reliable than BEVs.

For all the BEV assessments except the one pertaining to capability to plug-in a BEV at home, the variable Year is most important: the variability in participants scores is influenced more by whether they are in the 2014 or 2021 survey than by what state they are from or whether they are a new or a non-new car Buyer in 2021. If we take any two participants from the combined 2014-2021 sample and ask what explains the differences in their assessments of BEVs, the thing that determines most of the difference is whether they responded in 2014 or in 2021; if they responded in 2021 their assessment of BEVs is likely to be less favorable.

The assessment of whether there is enough charging for BEVs is one of the few assessments that is improved in 2021 over 2014. Participants in both years disagree there is enough BEV charging, but that disagreement is weaker in 2021 than in 2014.

For the other assessments that allow comparison between the two years, participants from 2021 offer worse assessments of BEVs and the new car buyers among the 2021 sample offer the worst assessments. Across all participants there is agreement BEVs take too long to charge; participants in 2021—whether they are new or non-new car buyers—agree more strongly do those in 2014.

Participants in 2021 more strongly agree BEV driving ranges are not long enough and that BEVs cost more to buy than conventional gasoline vehicles. new and non-new car buyers from 2021 have higher mean agreement than do the new car buyers from 2014 and new car buyers in 2021 have the highest agreement.

Participants in 2021 agree on average that gasoline vehicles are safer than BEVs; participants in 2014 disagreed. The shift toward agreement that gasoline vehicles are safer is not attributable to the presence of non-new car buyers in the 2021 sample: new car buyers in 2021 have the highest mean agreement that gasoline vehicles are safer.

Finally, participants in both years register agreement that gasoline vehicles are more reliable than BEVs, but 2021 participants have higher mean agreement scores than 2014 participants. Again, the highest agreement is among new car buyers in 2021.

4.4.2 FCEV Assessments

Against a background of almost no actual FCEV sales or hydrogen fueling availability anywhere except California, assessments of FCEVs are generally worse across six ZEV in 2021 than they were in 2014. This is especially true knowing that separating the new car and non-new car buyers in 2021 results in non-new car buyers providing more favorable scores on three of six assessments than new car buyers. Only assessments of whether there is enough fueling for FCEVs are better (though still not favorable) in 2021 than they were in 2014.

There are eight assessments for FCEVs in the 2021 data and six available for comparison between 2014 and 2021; there is no statement related to a possibility of home fueling of hydrogen for FCEVs. The assessments offered of FCEVs in 2021 may be summarized as: there are not enough places to fuel FCEVs, they take too long to refuel, and their driving range is too short; FCEVs are more expensive to buy than conventional gasoline vehicles; conventional gasoline vehicles are safer and more reliable than FCEVs; and FCEVs are less damaging to the environment than gasoline vehicles. On balance, FCEVs are assessed to not be ready for the mass market.

For every FCEV assessment, new car buyers score their agreement differently than non-new car buyers. Whether the assessment is phrased to favor FCEVs or gasoline vehicles, new car buyers rate their agreement higher than non-new car buyers. This consistent direction in scoring produces inconsistent differences in assessments. Still, it is a measure of degree (how much each group agrees or disagrees) not a difference between agreement and disagreement except for the assessment of whether FCEVs are ready for mass market: on average, non-new car buyers slightly disagree while new car buyers slightly agree.

For the comparison between 2014 and 2021, participants disagree there are enough places to fuel FCEVs, but the disagreement diminishes from 2014 to 2021 especially as we control for the fact the 2021 sample contains both new and non-new car buyers while the 2014 sample contained only new car buyers. Though there is still disagreement that there is enough fueling for FCEVs, that disagreement is less so in 2021 than in 2014. However, across the FCEV assessments that can be compared between 2014 and 2021, the state in which a participant resides plays a larger role than does the year in which the assessment was offered. The variable State is most important for "FCEVs take too long to fuel," "FCEV range too short," and "Gasoline vehicles are more reliable." The variable for year is most important for "enough places to fuel [FCEVs]," "FCEVs cost more," and "Gasoline vehicles are safer."

Participants in all states disagree there is enough fueling for FCEVs. Participants in 2021 are weaker in their disagreement: new car buyers in 2021 register the weakest disagreement, i.e., the most favorable (if not favorable in an absolute sense) assessment of fueling for FCEVs.

For their assessments of how long FCEVs take to fuel, FCEV's driving range, and whether gasoline vehicles or FCEVs are more reliable, all participants register slight agreement that FCEVs take too long to fuel, do not drive far enough before refueling is required, and gasoline vehicles are more reliable. It is also the case for these three that new car buyers in 2021 offer the least favorable scores; worse than new car buyers in 2014 and worse than non-new car buyers in 2021.

Participants in all the states, on average, agree with the statement that gasoline vehicles are safer than FCEVs. new car buyers in 2021 are estimated to agree more strongly than both new car buyers in 2014 and non-new car buyers in 2021 that gasoline vehicles are safer than FCEVs.

As with the corresponding assessment for BEVs, the FCEV assessment garnering the highest level of agreement is that they cost more to buy than conventional vehicles. It is the only FCEV assessment that is more favorable to FCEVs in 2021 than in 2014. However, non-new car buyers are more favorable toward FCEVs than new car buyers in 2021.

4.4.3 PHEV Assessments; 2021

The assessments of PHEVs generally concur with reasonable hypotheses about how a vehicle that is both fueled with gasoline and charged with electricity might compare to BEVs that run only on electricity. The same general patterns of assessments as those offered for BEVs hold true for PHEVs but the overall strength of disagreement or agreement with the individual statements may be stronger or weaker. As with BEVs, participants are slightly likely to agree they can charge a PHEV at home—perhaps even more so than a BEV—but they also not think there are enough charging locations for PHEVs. As with BEVS, participants in CA are a bit more positive in their assessment of the amount of charging and those in CO a bit more negative. PHEVs are assessed by participants in every state to take too long to charge, not drive far enough on a charge, and cost more to buy than gasoline vehicles. On average, gasoline vehicles are assessed to be safer and more reliable than PHEVs with participants in NY registering higher agreement with these assessments and those in CA and OR, lower. PHEVs are assessed to be less damaging to the environment than gasoline vehicles and ready for the mass market.

4.5 Awareness of and Support for Incentives

The analysis of awareness of incentives is limited to whether participants have heard of incentives from the federal government as the federal tax credit for the purchase of PHEV or BEV is the only constant across states and survey years. There is a substantively slight though statistically non-significant difference between participants from the eight states in 2021: 41 percent of participants, almost regardless of which state they reside in, say they have heard the federal government is offering incentives for the purchase of vehicles fueled by "alternatives to gasoline and diesel." What makes a difference is whether participants are new car buyers or non-new car buyers: the likeliness that new car buyers have heard of federal incentives (45 percent) are about a dozen percentage points higher than new car buyers (33 percent). The biggest difference between the subset of six ZEV states compared between 2014 and 2021 is attributable to Year; the percentage of people who had heard of federal incentives is lower in 2021 than in 2014.

Participants in every state are generally supportive of government offering incentives for hydrogen, electricity, or both. Across eight states in2021, two-thirds to three-fourths of participants support government providing such incentives to consumers: half or more support incentives for both hydrogen and electricity. There are slight differences between years in support for any incentives: in most states there is a small shift away from supporting incentives for both electricity and hydrogen and toward only one or the other. However, analysis of differences in this case obscures the big picture; everywhere large majorities of participants in both survey years support the idea of government incentives for cars and trucks that run on hydrogen or electricity instead of gasoline.

4.6 Consideration of PEVs and ZEVs

Consideration is the extent to which participants have already invested attention, time, energy, financial, or any other resources in the question of whether to acquire ZEV for their household. Majorities of participants in all eight of these ZEV states say they have given no consideration to any ZEV.

Outright resistance—a person has not and would not consider a ZEV—is stated by 27 percent of participants for PHEVs and 29 percent for BEVs across the eight ZEV states in the 2021 analysis. Yet for the combined measure of PEV Consideration, that is PHEVs *or* BEVs, outright resistance averages 21 percent: at least a few people who are resistant to PHEVs may (or may have) considered BEVs and vice versa. The same holds for FCEVs: outright resistance to FCEVs averages 37 percent, yet for ZEV Consideration (PHEVs, BEVs, *or* FCEVs) resistance is 19 percent. At least at present, the multiplicity of possible electric drivetrain and fueling options reduces—if in no way eliminates—resistance to ZEVs. At the opposite end of the scale, small single digit percentages of participants are at the highest levels of consideration: actively shopped or ownership (present or prior).

Both the state in which participants reside and whether they are new car buyers or non-new car buyers are associated with how much consideration they may have already given to ZEVs. In all eight states, new car buyers are more likely to have given more consideration to ZEVs than non-new car buyers. Participants in California are more likely to have given greater consideration to ZEVs than participants in some other of these eight states, in particular, Connecticut. While it is apparent that participants in California are less likely than participants in the other seven states to be in either of the two lowest levels of ZEV Consideration, for any higher level of consideration it isn't possible to conclude that Californians are consistently and pervasively at higher levels of ZEV Consideration.

Much of the overall difference between 2014 and 2021 in six ZEV states is due to the fact the 2021 sample contains new car and non-new car buyers while the 2014 sample contains only new car buyers. Outright resistance to ZEVs is higher in 2021 than in 2014, but that resistance to ZEVs is generally lower in 2021 than 2014 among new car buyers and the apparent "growth" in resistance from 2014 to 2021 is due to the higher resistance of non-new car buyers present in the 2021 sample. This cannot be construed as unqualified good news. Resistance to ZEVs among new car buyers appears to be lower in 2021 than in 2014 in three of six states, but the same in both years in the other three despite increasing makes and models of PEVs, growing charging networks, and the generally more supportive state policies in 2021 compared to 2014.

Further, most of the difference between new car buyers and non-new car buyers is evident at the lower levels of consideration. There are no differences at the highest levels of consideration—actively shopped for a ZEV and owned or have owned a ZEV—between the new car buyers in 2014 and 2021. Non-new car buyers in 2021 are less likely than new car buyers to be at either of these high levels of PEV or ZEV Consideration . This may be explainable by a time lag in developing a used ZEV market, but that rationale contains its own problem for continued ZEV market growth—both the new and used ZEV markets must grow if sales of new light-duty vehicles are to reach goals of 100 percent ZEVs.