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2021 Zero Emission Vehicle Market Study: Volume 2: Intra-California Regions Defined by Air Districts

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Volume 2: Intra-California Regions Defined by Air Districts

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About the Electric Vehicle Research Center

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

Version note

This version dated February 15, 2024 supersedes all prior versions. The document has been reformatted. Several figures have been replaced with alternate versions. The text has been edited primarily for typographical, spelling, and other minor errors. Though there are a few instances of more substantive editing, no major conclusion has been modified based on these updates.

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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, California set a goal to transition new light-duty automobile sales to 100% zero emissions vehicles (ZEVs) by the year 2035. This second volume of the 2021 Zero Emission Vehicle Market Study assesses the readiness of household consumers in California to support these goals, i.e., as stated goals become more ambitious and requirements on manufacturers increase, are more car-owning households poised to become ZEV buyers?

The analysis here differs from the analysis for California in Volume 1 in that here differences within California are explored. Six regions are defined by the boundaries of air quality districts. Five are the most populous air districts, accounting for approximately five-sixths of the state's population: in declining population order these are the South Coast Air Quality Management District, Bay Area Air Quality Management District, San Diego Air Pollution Control District, San Joaquin Valley Air Pollution Control District, and the Sacramento Metropolitan Air Quality Management District. The sixth region is the agglomeration of the remaining 30 air districts referred to here as the Balance of State (BOS).

The question of consumer engagement is addressed via two large sample household surveys, one conducted in early-2019 and the other in early-2021. The study populations in both years were all car-owning households in California. The total sample sizes for the two years are 3,636 (2019) and 2,994 (2021). The sampling goal for both years was a stratified sample of the six regions, with equal sample sizes for all six. The intent was that results for six regions—the comparatively less populous air districts of San Joaquin Valley and Sacramento, in particular—could be reported with similar sampling errors. This goal was not achieved in either year—Sacramento and the San Joaquin Valley are underrepresented compared to the other four districts and results for those two regions are subject to higher errors.

Consumer *engagement* encompasses awareness, knowledge, assessment, and consideration. *Awareness* and *knowledge* are similar (awareness is knowledge that something exists), but the distinction affects many things varying from the details of how survey questions are phrased for participants ("Have you seen…." vs. "Do you know…") to the ramifications for policy, marketing, education, or outreach. Here, knowledge extends beyond awareness to assess the ability to correctly repeat information. Information—whether right or wrong—is part of the basis for *assessment*. How we increase the chances a person notices something for the first time is different 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 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 that person might do.

Results are presented in two main sections. First, using the 2021 data, households' awareness, knowledge, assessments, and consideration of ZEVs are described for the six regions. In addition to comparisons between regions, these results compare households who buy new cars and trucks with those who do not. 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 buy only used cars). Second, results of the 2019-to-2021 comparison are presented.

Summary of Results

Accounting for differences in time, across region, and between new and used car buyers provides the results to answer this report's central question: are more California consumers engaged with a transition to electric vehicles in 2021 than in 2019? Among all car-owning households statewide only small percentages of survey participants considered any ZEV to the extent they presently own one, have previously owned one, or engaged in active shopping: seven percent in 2019 and nine percent in 2021. At the other end of the consideration scale, nearly twice as many profess to completely reject all types of ZEVs, i.e., they haven't and won't consider a PHEV, BEV, or FCEV: 18 percent in 2019 and 17 percent in 2021.

Regional differences largely reflect the history and status of ZEVs within each region; consideration tends to be higher and rejection lower in regions with a history of higher ZEV sales. The highest levels of ZEV Consideration are found in the Bay Area AQMD, South Coast AQMD, and San Diego APCD; the lowest (i.e., the highest rates of rejection) are in the Central Valley (San Joaquin Valley APCD and Sacramento Metropolitan AQMD) and the largely rural Balance of State. Rejection of all ZEVs ranges from a low of 11 percent in the San Diego APCD to a high of 24 percent in the San Joaquin Valley APCD. The South Coast AQMD shows the greatest polarization as compared to other regions it has high percentages of people at both ends of the ZEV Consideration scale. It is also the case that households who buy only used cars are more likely to be ZEV Resisters, though only in the San Joaquin Valley APCD and South Coast AQMD is the difference from households who buy new cars so large as to be statistically significant.

What explains the failure to achieve higher levels of ZEV Consideration? Awareness, knowledge, and assessment are building blocks of consideration; measures of most of them indicate few consumers are more aware, more knowledgeable, or have better assessments of ZEVs in 2021 than in 2019. Measures of "familiarity"—for example, are you familiar enough with a vehicle type to decide whether one is right for your household—with PHEVs, BEVs, and FCEVs are all slightly higher in 2021 than in 2019. Despite these small improvements, averaged across all car-owning households throughout the state familiarity with PHEVs and BEVs still scores as only slightly familiar and for FCEVs as distinctly unfamiliar. It is also the case that differences between 2019 and 2021 are less than the differences between households who buy new cars and those who do not. Households who purchased no new cars during the seven-year period prior to their survey year are, on average, much less familiar with all types of ZEVs than are households who purchased one or more new cars. It is not the case that non-new car buyers are less familiar with automobiles in general, in fact, non-new car buyers average self-rating of their familiarity with conventional vehicles is statistically significantly higher than that of new car buyers. Distinctions between regions count for the smallest part of any differences between participants.

Awareness of incentives for consumers to buy vehicles powered by alternatives to gasoline and diesel increased from 2019 to 2021. The percentage of participants claiming they are aware of federal incentives increased from 37 to 42 percent; for California, from 32 to 35 percent. Awareness of federal vs. California incentives appear to be subject to different influences. Differences in awareness of federal incentives are due more to the distinction between new and non-new car buyers (and to a lesser extent region and year) while differences in awareness of California incentives are due more to differences between regions (and to a lesser extent year and new car buyer status). New car buyers are much more likely to claim they have heard of incentives (for buying new cars) from both the federal and California governments. Participants in the Bay Area AQMD and San Diego APCD are more likely to claim they have heard of incentives from the federal government than are participants anywhere else in the state. For incentives from California, awareness of incentives is higher among participants in the Bay Area AQMD and San Diego APCD than everywhere but the Sacramento Metropolitan AQMD.

Knowledge of how different vehicle types are fueled is not better in 2021 than 2019. Participants are most likely to correctly report how BEVs are fueled: statewide nearly three-quarters of all participants (over both years and all regions) understand BEVs only plug-in to charge. However, just over half understand PHEVs may both plug into charge and fuel with gasoline. Barely half understand how *both* BEVs and PHEVs are fueled. Knowledge of PHEV and BEV fueling is, at best, not getting better over time. Year has the most influence on differences in participants' knowledge of PHEV and BEV fueling, and the effect is such that fewer participants can correctly identify how PHEVs and BEVs are fueled in 2021 than in 2019. The difference is approximately a five-percentage point reduction in correct answers. Knowledge of fueling tracks the history of vehicle sales and infrastructure development. Participants from regions with the lowest historical development are less likely to understand how PHEVs and BEVs are fueled—the difference between the lowest and highest regions is about ten percentage points. Unlike measures of self-reported familiarity, there is little difference in knowledge of PHEV and BEV fueling between new and non-new car buyers.

Knowledge of the names of ZEV makes and models appears to be worse in 2021 than in 2019. Differences across regions are slight and follow ZEV market development: participants in the Bay Area AQMD and San Diego APCD are slightly more likely to name either a BEV or a PHEV than those in the San Joaquin Valley APCD.

Participants' assessments of BEVs, PHEVs, and FCEVs are not uniformly better or worse in 2021 than in 2019. These assessments are, on average, better in 2021 than in 2019:

- BEVs: whether there is enough charging/fueling, driving range, and whether BEVs are ready for mass markets,
- PHEVs: enough charging and ready for mass markets, and
- FCEVs: enough fueling, better for the environment, and ready for mass markets.

These assessments do not differ between 2021 and 2019:

- BEVs: charging duration, purchase price, reliability, and better for the environment,
- PHEVs: driving range, purchase price, and better for the environment, and
- FCEVs: driving range.

These assessments are worse in 2021 than in 2019:

- BEVs: safety,
- PHEVs: charging duration, safety, and reliability, and
- FCEVs: fueling duration, driving range, safety, and reliability.

The one assessment that did not differ between 2019 and 2021 was of vehicle purchase price. The assessment is strongly negative in both years, i.e., ZEVs are uniformly and consistently perceived to be more expensive to purchase. This negative assessment did not differ by region or new car buyer status.

Regional differences in other assessments are less pronounced than differences by year. There are regional differences in assessments of driving range, safety, and reliability in comparison to conventional vehicles, and whether ZEVs are better for the environment. It is the case that in no region are BEVs, PHEVs, or FCEVs assessed to have long enough driving range. The highest assessment for BEV driving range is in the Bay Area AQMD where the average assessment is at the mid-point of the scale, i.e., neither agreement nor disagreement. Conversely, participants in the Bay Area AQMD had the largest negative change in their assessment of PHEVs (electric) driving range going from the best (though still negative) assessment of PHEV range in 2019 to the worst in 2021. Driving range of FCEVs is assessed negatively everywhere; participants in the Sacramento Metro AQMD showed the largest negative shift in their assessment. Differences in assessments of safety and reliability are less pervasive—in terms of both the number of regions and types of vehicles. Participants in the San Diego APCD and Bay Area AQMD offered higher assessments than did participants in other regions for PHEVs and/or BEVs.

On average all ZEVs are assessed to better for the environment than conventional vehicles, though the average assessment is modest ranging from 1.05 (FCEVs) to 1.30 (BEVs) on the -3 to +3 scale. Regional differences tend to follow ZEV market development. Participants in the San Diego APCD and Bay Area AQMD are more likely to offer higher assessments than are those throughout much of the state for PHEVs, BEVs, and FCEVs.

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. Statewide, there was an increase from 2019 to 2021 in the percentage of participants reporting they had seen EV charging. The percentage of people who reported they had not seen or were unsure if they had seen EV charging locations declined from 31% to 25%; there is a similar percentage point increase in people reporting they had seen EV parking in several locations, up from 26 to 32%.

The variable for region is of most importance to estimating differences in whether participants see EV charging, followed by year and new car buyer status. Participants in the San Joaquin Valley APCD and the Balance of the State are least likely to say they have seen EV charging. However, the interaction of Year and Region shows the greatest difference between 2019 and 2021 in whether participants report seeing EV charging occurred in the San Joaquin Valley APCD and the Balance of the State. That is while these regions still have the lowest rates at which participants report seeing EV charging, they showed the most improvement from 2019 to 2021. New car buyers are estimated to be more likely to have seen EV charging and to have seen more EV charging than non-new car buyers.

The inclusion 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 be capable of charging 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 what types of residences richer and poorer people occupy, 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% 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, 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% 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 create interest on the part of 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 to encourage continued zero emission vehicle (ZEV) market growth required to meet California's pressing and long-term emission reduction goals. In one of a series of executive orders from California's Governors supporting this policymaking, Governor Newsom stated the goal to sell only ZEVs starting in the year 2035 (Governor's Executive Order N-79-20).

New ZEV product offerings from automotive manufacturers as well as responses of the energy industry and electricity utilities 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, Executive Order goals, and automobile company targets.

Volume 1 addresses this question for several of the "ZEV States," California plus a subset of the other US states that have adopted California's ZEV sales requirements. Volume 2 of this report answers this question within California via two large sample surveys of car-owning households. These surveys were completed in first calendar quarters of 2019 and 2021. Both questionnaires measure consumer awareness, knowledge, assessments, and consideration of ZEVs. Both study populations were all car-owning households in California. The samples were stratified by regions defined by Air Districts—regional agencies that monitor air quality and implement air quality policies, rules, and regulations. The six regions are the five largest (by population) Air Districts in California and a sixth region defined as the balance of the state not contained in those five districts. In declining order of population, the regions are:

- South Coast Air Quality Management District (SCAQMD),
- Bay Area Air Quality Management District (BAAQMD,
- Balance of the State (BoS),
- San Diego Air Pollution Control District (SDAPCD),
- San Joaquin Valley Air Pollution Control District (SJVAPCD), and
- Sacramento Metropolitan Air Quality Management District (SMAQMD).

Differences in ZEV market development, i.e., vehicle sales and leases to households, PEV charging infrastructure deployment, and local incentives are all reasons to expect there may be differences between Air Districts and across time within Air Districts. The populous coastal Air Districts (SCAQMD, BAAQMD, SDAPCD) have higher PEV sales and leases than other regions in the state. The BAAQMD has the highest per capita number of BEVs and PHEVs according to estimates of Clean Vehicle Rebates (see https://cleanvehiclerebate.org/en/rebate-statistics). These three districts have higher density of PEV charging locations than the other three. The SJVAPCD has fewer PEVs, lower per capita PEV ownership, and lower density PEV charging deployment despite also having a local PEV purchase incentive (Drive Clean! Rebate Program) that offers an additional incentive of up to $3,000 to households to buy qualifying ZEVs in addition to the California Clean Vehicle Rebate available statewide which currently provides incentives of up to $2,000 for a BEV to qualifying buyers. Given these differences, the analyses in Volume 2 compare familiarity with drivetrain types, reported sighting of PEV charging infrastructure, assessments of ZEVs, awareness of incentives, and prior consideration of ZEVs across regions.

To assist California and the other ZEV states to monitor and manage the success of policies promoting ZEVs and ZEV fueling infrastructure deployment, this research assesses car-owning 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 in early 2019 and early 2021.

2. Method

2.1 Survey Research and Statistical Modeling

2.1.1 Data

The two survey data sets are summarized in Table 1. Both are based on samples stratified by regions, as previously described. The original sampling goal for both years was equal numbers of participants from each region. In both years, sample vendors were unable to meet the goals for the SMAQMD (in both years) and the SJVAPCD (in 2021). Sample weights are used throughout to produce descriptions that are representative of each region on participant age, sex, and income as assessed by data on household heads from the US Census estimates for each year and the counties that make up the regions. Note that air district and county boundaries do not always match. For example, the boundaries of the SDAPCD and San Diego County do match, but the BAAQMD contains all of seven counties and parts of two others.

Table 1: Study Years, Study Populations, Geographical Units, and Sample Sizes

Study Year	Population	Regions	Sample Size
2019	All Car Owning Households	California:	3,636
		SCAQMD	819
		BAAQMD	605
		Balance of State	633
		SDAPCD	655
		SJVAPCD	600
		SMAQMD	324
2021	All Car Owning Households	California:	2,994
		SCAQMD	534
		BAAQMD	522
		Balance of State	522
		SDAPCD	520
		SJVAPCD	497
		SMAQMD	399

2.1.2 Measures

The measures of awareness, knowledge, assessment and consideration of ZEVs, ZEV fueling, and incentives are as described in Volume 1.

2.1.2.1 New and Non-new Car Buyers

As PHEVs and BEVs have only recently been available long enough for a used vehicle market to develop and retail markets for FCEVs are still largely incipient, the large majority of households acquiring ZEVs has to date been made up mostly 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 since 2010 may have created opportunities to develop awareness of ZEVs, knowledge, and experience of them, up to the extent of having shopped for one. Some people will interpret a question about a "new" car as "new to me." To guard against this, the 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." The variable New Car Buyer status (NCB) is assigned two values. New Car Buyers are households who have acquired at least one vehicle in the seven years prior to their survey (January 2012 for the 2019 sample and January 2014 for the 2021 sample). New Car Buyers may also have acquired used vehicles so long as they acquired at least one new. Non-New Car Buyers are households who have acquired no new vehicles in the corresponding interval; they may have acquired only used vehicles or acquired no vehicles. "Buyers" includes household who purchased or leased vehicles.

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 in a hybrid drivetrain). For participants, these types are named: Gasoline, Hybrid, Plug-in Hybrid Electric, Battery Electric, and Hydrogen Fuel Cell Electric. Thus, participants are asked, "Are you familiar enough with [each type] vehicles to make a decision about whether one would be right for your household?" Answers are on a scale from -3 (No) to +3 (Yes).

2.1.2.3 Naming Vehicles by Type

A more specific question related to familiarity is whether people can recall vehicles by name and correctly distinguish these names by vehicle type. For PHEVs, BEVs, and FCEV, participants are first asked if they can name such a vehicle "presently being sold in the US." If they say no, they move on to the next vehicle type, for which this question is repeated. If they say yes, they are asked to provide a make (brand) name and a model name. Following this, they are then asked if they can name a second vehicle of the same type. The same logic applies; if no, they move to the next vehicle type, if yes, they are asked to provide a second make and model.

While the "no" response to "Can you name a [vehicle type]?" is straightforward, there are many possible interpretations of "yes." If participants say "yes" to the initial screening question, they must type in a make and model—no dropdown menus are provided as doing so would reveal correct answers (if only ZEV names were included) or be unworkably long (if all vehicle names were included). Thus, the names participants proffer contain spelling variants, mismatched makes and models, names mismatched to vehicle types, and names of vehicles that match none of the vehicle types. Four sets of rules have been developed and consistently applied across vehicle types and survey years. The rules are applied, first, to simplify spelling variants and second, to apply three progressively more stringent restrictions (lax, moderate, and strict) on what counts as a correct answer. First note though, the questions for all vehicle types stipulate "is being sold," but it does not stipulate "is being sold as new" nor is it the intent of these questions to probe whether people are paying so much attention to ZEVs that they know some make-models have come and gone already. For example, "Tesla Roadster" and "Honda Accord Plug-in Hybrid" generally count as right answers (subject to further restrictions described next) even though they are no longer sold as newnaming . Also, vehicles not yet for sale but announced for release or otherwise broadly reported in automotive, environmental, and business media, e.g., Rivian, count as correct subject to the different sets of rules described next. The questions also stipulate "in the US." Starting in 2021, makes and models of ZEVs being sold somewhere in the world count as correct under all but the strictest rules.

Before progressively stricter sets of rules can be applied, spelling and capitalization variants as well as common nicknames for makes and models must be reconciled. For example, "chevrolet," "Chevy," and "CHEV" would all be recoded as "Chevrolet." Misspellings are resolved by relative position of incorrect letters to correct letters on a QWERTY keyboard and information provided in the other part of the proffered name. For example, "Fird Escort" is recoded as "Ford Escort." The letter "i" is next to the letter "o" on the keyboard and "Ford" makes a model named "Escort," thus lending credence to interpreting the original as a misspelling rather than a lack of knowledge of the name.

Table 2 shows the response codes for BEVs and PHEVs under the lax rules. Under the lax rules for PHEVs and BEVs, any answer that refers to a vehicle that plausibly has a plug is a right answer. Thus, "Chevrolet Bolt" and "Ford Volt" both count as correct responses to both the question about naming BEVs *and* the question about naming PHEVs despite the fact the Bolt is a BEV, the Volt is a PHEV, and Ford does not either. Further, no matter what model name they may include, the mention of the make "Tesla" counts as a right answer to both the question about naming PHEVs and BEVs. "Prius" counts as a correct PHEV and BEV name under the lax rules. Finally, under the lax rules "right" answers are further parsed into categories based on the top mentions and distinctions between mismatched make-model names and vehicle types. Thus, under the lax rules, in response to the question about naming a PHEV, "Prius" is coded as Yes:Right:Prius but in response the question about naming a BEV, "Prius" is coded as Yes:Right:Other.

Table 2: Response codes for naming BEVs and PHEVs, lax rules

BEVs	
No	Simple declaration they are unable to name a BEV.
Yes: Wrong	Despite an initial "yes," their proffered name includes no reference to a vehicle that plausibly has an electrical plug.
Yes: Right (Tesla)	Any make-model name variant that is or contains "Tesla."
Yes: Right (Leaf)	Any make-model name variant that is or contains "Leaf."
Yes: Right (Bolt)	Any make-model name variant that is or contains "Bolt."
Yes: Right (Other)	Any other make-model name variant that contains at least a model name that refers to any vehicle that comes as a BEV or PHEV other than "Tesla," "Leaf," or "Bolt."
PHEVs	
No	Simple declaration they are unable to name a PHEV.
Yes: Wrong	Despite an initial "yes," their proffered name includes no reference to a vehicle that plausibly has an electrical plug.
Yes: Right (Prius)	Any make-model name variant that is or contains "Prius."
Yes: Right (Volt)	Any make-model name variant that is or contains "Volt."
Yes: Right (Other PHEV)	Any other make-model name variant that contains at least a model name of a PHEV other than "Prius" or "Volt."
Yes: Right (Tesla BEV)	Any make-model name variant that contains "Tesla."
Yes: Right (Other BEV)	Any make-model name variant that contains at least a model name of a BEV other than "Tesla."

The lax PHEV rules include a breakout of incorrect BEV names whereas the lax BEV rules aggregate all PHEV names offered in response to a query about BEV names into "Other." The reason is so many of the incorrect names for PHEVs were "Tesla" it seemed important to retain this information in the variable coding.

Under the moderate rules (Table 3), the proffered name must match the vehicle type: this rule accounts for the largest part of the difference between lax to moderate rules as all references to BEVs become incorrect for the question about PHEVs and all references to PHEVs become incorrect for the question about BEVs. Further, the make and model names must match. Thus while "Ford Volt" counted as a correct response to naming a PHEV under the lax rules, it is incorrect under the moderate rules. Finally, if only one word identifies a vehicle it must be the model's name, e.g., "i3," not the make name, e.g., "BMW." The exception to this rule is Tesla in the case of naming BEVs as it manufactures only BEVs.

Table 3: Response codes for naming BEVs and PHEVs, moderate rules

BEVs	
No	Simple declaration they are unable to name a BEV.
Yes: Wrong	Despite an initial "yes," their proffered name includes no reference to a vehicle that is plausibly a BEV.
Yes: Right (Tesla)	Response includes "Tesla" or "Tesla" plus any model designation or no model designation. Allows "any" and "all" in place of a specific model.
Yes: Right (Leaf)	"Nissan Leaf" or "Leaf."
Yes: Right (Bolt)	"Chevrolet Bolt," "Bolt," and "GM Bolt."
Yes: Right (Other BEV)	Any make-model name variant that contains at least a model name if not make-model that refers to any other vehicle that comes as a BEV that is not Tesla, Leaf, or Bolt.
PHEVs	
No	Simple declaration they are unable to name a PHEV.
Yes: Wrong	Despite an initial "yes," their proffered name includes no reference to a vehicle that is plausibly a PHEV.
Yes: Right (Prius)	All versions of "Toyota Prius" count as correct. "Toyota" may be omitted but no other make is allowed as correct.
Yes: Right (Volt)	"Chevrolet Volt," "Volt," and "GM Volt"
Yes: Right (Other)	Any make-model name variant that contains at least a model name if not make-model that refers to any other vehicle that comes as a PHEV that is not Prius or Volt.

The strict rules have the effect of introducing more uncertainty into responses and therefor more categories to describe that uncertainty (Table 4). The biggest change from the moderate rules is a stricter definition of correct model designations: only if the participant specifies a correct model variant (PHEV or BEV) is their answer counted as "Yes: Right: (model)." This affects vehicles that come in multiple drivetrain variants, e.g., hybrid and plug-in hybrid such as the Prius There is a further elaboration of this rule for names including "Tesla." Under the strict rules the category "Yes: Right: Tesla" is split into "Yes: Right: Tesla (actual)" and "Yes: Right: Tesla (other)." "Actual" answers must be some variation on a model designation Tesla uses, though "all" and "any" are allowed, too. "Yes: Right: Tesla (other)" responses include all model designations proffered by participants that cannot be construed as one used by Tesla plus those responses that provide no model designation. For all other manufacturers the correct model variant must be specified, otherwise the response is coded as either "Yes, Wrong" or "Yes, Maybe" depending on whether the correct drivetrain type exists at all, is properly specified, or not specified at all. If no drivetrain variant is specified, the answer is coded as "Yes: Maybe." If the incorrect drivetrain variant is specified, the response is coded as, "Yes: Wrong." For example, in response the question, "Can you name a plug-in hybrid electric vehicle presently for sale in the US":

- "Honda Clarity" is coded as "Yes: Maybe"
- "Honda Clarity Electric (or EV)" is coded as "Yes: Wrong"
- "Honda Clarity Plug-in Hybrid" is coded as "Yes: Right (Other)"
- "Toyota Prius" is coded as "Yes: Maybe" and
- "Toyota Prius Plug-in" and "Toyota Prius Prime" are coded as "Yes: Right: Prius"

Table 4: Response codes for naming BEVs and PHEVs, strict rules

BEVs	
No	Simple declaration they are unable to name a BEV.
Yes: Wrong	Despite an initial "yes," their proffered name includes no reference to a vehicle that is plausibly a BEV.
Yes: Maybe	Any otherwise correct make-model name of a vehicle that comes in a BEV variant as well as other drivetrain variants, but the proper BEV variant designation isn't proffered as part of the name.
Yes: Right (Tesla actual)	Response includes "Tesla" or "Tesla" plus a model designation that is plausibly correct, e.g., S, X, 3, or Y. Allows model variants such as "P100" in lieu of S, X, 3, and Y. Allows "any" and "all" in place of a specific model.
Yes: Right (Tesla other)	Response includes "Tesla" or "Tesla" plus a model designation that is not plausibly offered by Tesla.
Yes: Right (Leaf)	"Nissan Leaf" or "Leaf."
Yes: Right (Bolt)	"Chevrolet Bolt" or "Bolt," but also "GM Bolt."
Yes: Right (Other BEV)	Any make-model name variant that contains at least a model name if not make-model that refers to any other vehicle that comes as a BEV that is not Tesla, Leaf, or Bolt.
PHEVs	
No	Simple declaration they are unable to name a PHEV.
Yes: Wrong	Despite an initial "yes," their proffered name includes no reference to a vehicle that is plausibly a PHEV.
Yes: Maybe	Any otherwise correct make-model name of a vehicle that comes in a PHEV variant as well as other drivetrain variants, but the proper PHEV variant designation isn't proffered as part of the name.
Yes: Right (Prius)	Only for "Toyota Prius Plug-in" and "Toyota Prius Prime," though "Toyota" may be omitted in both cases.
Yes: Right (Volt)	"Chevrolet Volt," "Volt," and "GM Volt"
Yes: Right (Other)	Any make-model name variant that contains at least a model name if not make-model that refers to any other vehicle that comes as a PHEV that is not Prius or Volt.

2.1.2.4 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.”

2.1.2.5 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 as the practical effect of not knowing is similar to being incorrect.

2.1.2.6 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.

2.1.2.7 Incentives for ZEVs

Measuring awareness of incentives is complicated by differences in what incentives have been offered in which regions, which have been offered when and to whom as the limits on qualifying for California Clean Vehicle Rebates change over time, as well as in differences in practical access to incentives that on their face are offered broadly but are not of practical value to all. Awareness of any incentive from the federal government to households to buy PHEVs and BEVs is the most consistent measure as—all else being equal—households in every region have equal access to federal incentives. However, because 1) as originally implemented the federal tax credit was available to only a limited number of PEVs from an individual vehicle manufacturer, 2) that limit was reached by Tesla before the 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 regions 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 2019 and 2021

Analysis of differences over time 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 region (Region), New Car Buyer status (NCB, coded "yes" (New Car Buyers) or "no" (non-New Car Buyers), and survey year (Year) are related to differences in ZEV awareness, knowledge, assessments, and consideration. These are the explanatory variables in these regression models:

- Year,
- Region,
- NCB, and
- Year crossed with Region (Region*Year).

Unlike the ZEV state comparisons over years in Volume 1, here there is no need to nest the effect of NCB in Year as both years' samples are of all-car owning households and thus have both New and non-New Car Buyers.

The Year and Region variables test for whether there is a constant difference in measures due to either the year of the study or region where participants reside, i.e., is some part of any observed difference in measures due to a difference between 2019 and 2021 that is constant across all regions and a difference between regions that is constant across the years. The crossed effect Region*Year tests for whether any differences between years are different in different regions. If the parameters for these effects are statistically significant, we conclude the corresponding effect on the measure is different from zero.

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 for ordinal variables and the Uncertainty Coefficient for nominal variables used in cross-classifications of two variables, e.g., PEV Consideration by Year. The "C|R" notation indicates how much improvement there is in predicting the column values (PEV Consideration in this example) given knowledge of the rows (Year). These association measures range from 0 to 1 with higher numbers indicating greater ability to correctly pick the column value knowing the row value in a table.

The magnitude of parameter estimates for the regression models are another measure to compare the influence of explanatory variables if the variables are all measured on similar scales. When there are crossed effects, other measures are required to see the total effect of some variables. For models comparing 2019 and 2021, the variable Region appears in two of the three explanatory variables: the simple, direct effect of Region and its crossed effect (with Year). Thus, its influence in any regression is more than just its own parameter estimate. The method used in the JMP© 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

These results are divided into two main sections. First, 2021 results for the six regions within California defined by Air Districts are presented. Second, comparisons are made between 2019 and 2021. The rationales for which states are analyzed in each sub-section section are provided in the opening of each. The order of topics matches the order of description 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.

3.1 2021: Six Regions in California

This section has four purposes. The first is to describe ZEV awareness, knowledge, assessment, and consideration—as measures of those terms were described in the previous section—in six regions in California in 2021. The second is to present summaries of results for a new set of questions on ZEV information sources that have not previously been asked. The third 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. The fourth is to orient the reader to the measures and some of the analytical tools used before proceeding to the more complex comparisons across years.

3.1.1 Familiarity with Vehicle Types

The patterns of familiarity with drivetrain types are similar across all six regions (Figure 1). On average, participants everywhere strongly agree they are familiar enough with internal combustion engine vehicles (ICEVs) to consider whether one is right for their household. Though the mean scores for the six regions range from a low of 2.55 (Sacramento (SMAQMD)) to a high of 2.69 (San Joaquin Valley (SJVAPCD)), none is statistically significantly different from the CA statewide mean score of 2.61. The extent to which most people believe they are familiar with conventional vehicles is not entirely conveyed by these means as all are lower than their respective median values; the means are skewed downward by small percentages of people who admit they are not familiar. In all six regions, the 25th percentile is greater than or equal to 2.60; only 25% of participants in any region rate their agreement with the statement they are familiar with conventional vehicles at anything less than a strong affirmative.

Against this background, participants everywhere in California are much less familiar with all other drivetrain types—even hybrid vehicles (HEVs) which had been for sale in the US for over 20 years by the time the 2021 survey was conducted. This may be explained by HEVs continued low market share; the California New Car Dealers Association reported in the 3rd quarter of 2019 the year-to-date hybrid vehicle share of new vehicle sales was five percent statewide.[1] Only in the SDAPCD is the mean agreement regarding familiarity with hybrid vehicles even half as high (measured from zero) as for conventional vehicles (ICEVs = 2.60; HEVs = 1.30). SDAPCD also has the highest mean score across the six regions. The lowest mean familiarity score for HEVs is 0.84 in the SJVAPCD. The means for the SDAPCD, BAAQMD, and Balance of the State are statistically significantly higher than for the SJVAPCD; no other pairs of means are different (Tukey's HSD, $p = 0.05$).

[1] California New Car Dealers Association (2019) California Green Car Vehicle Report. https://www.cncda.org/wp-content/uploads/Cal-Alt-Powertrain-Report-3Q-19-Release.pdf

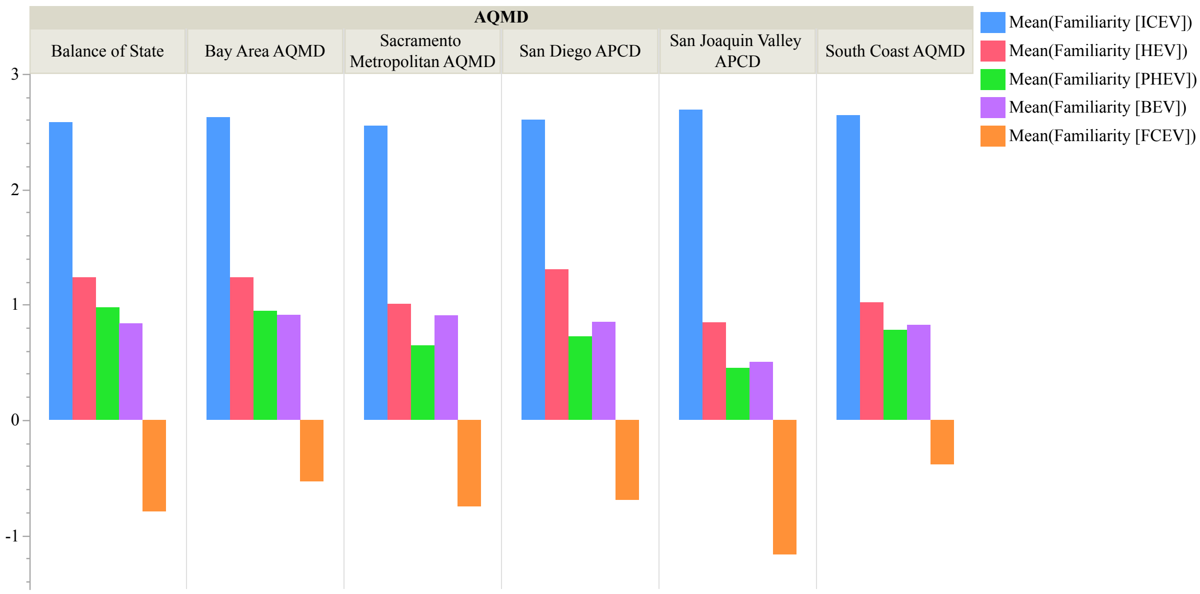


Figure 1: Familiarity with Vehicle Types, California, 2021; mean scores across six regions; scale -3 to +3

Scores for familiarity with all ZEV drivetrain types are lower still than for HEVs. For BEVs, scores range from 0.50 (SJVAPCD) to 0.91 (BAAQMD and SMAQMD); for PHEVs, from 0.45 (SJVAPCD) to 0.97 (Balance of State). Mean ratings of familiarity with PHEVs and BEVs tend to be similar within each region: only in SMAQMD is the mean score for BEVs statistically significantly less than that for PHEVs ($n = 399$, $p > |z| = 0.03$). Car-owning households everywhere in California are, on average, not familiar enough with FCEVs to decide whether one is right for them: scores range from -1.16 (SJVAPCD) to -0.34 (SCAQMD).

Relatively few of the pairwise differences in familiarity scores between regions are statistically significant for any vehicle type. However, those that are indicate residents of the SJVAPCD, on average, believe they are less familiar with all three ZEV types than are Californians in some other regions. For PHEVs, the mean score for the SJVAPCD is less than that for the BAAQMD and Balance of the State. For BEVs, the mean score for the SJVAPCD is less than that for only the BAAQMD. For FCEVs, the mean sore for the SJAVPCD is less than that for the BAAQMD, SCAQMD, and SDAPCD. The only statistically significant pairwise difference not involving the SJVAPCD is the higher score for familiarity with FCEVs in the SCAQMD compared to the Balance of the State. (All pairwise differences in means compared via Tukey's HSD, $p \leq 0.05$.)

Observed means for ratings of agreement with familiarity differ between New Car Buyers and non-New Car Buyers, between regions in CA (Figure 2). Again, mean familiarity scores for ICEVs are high for both groups, but non-New Car Buyers rate their familiarity with ICEVs higher than do New Car Buyers in all regions. For all other vehicle types the reverse is true.

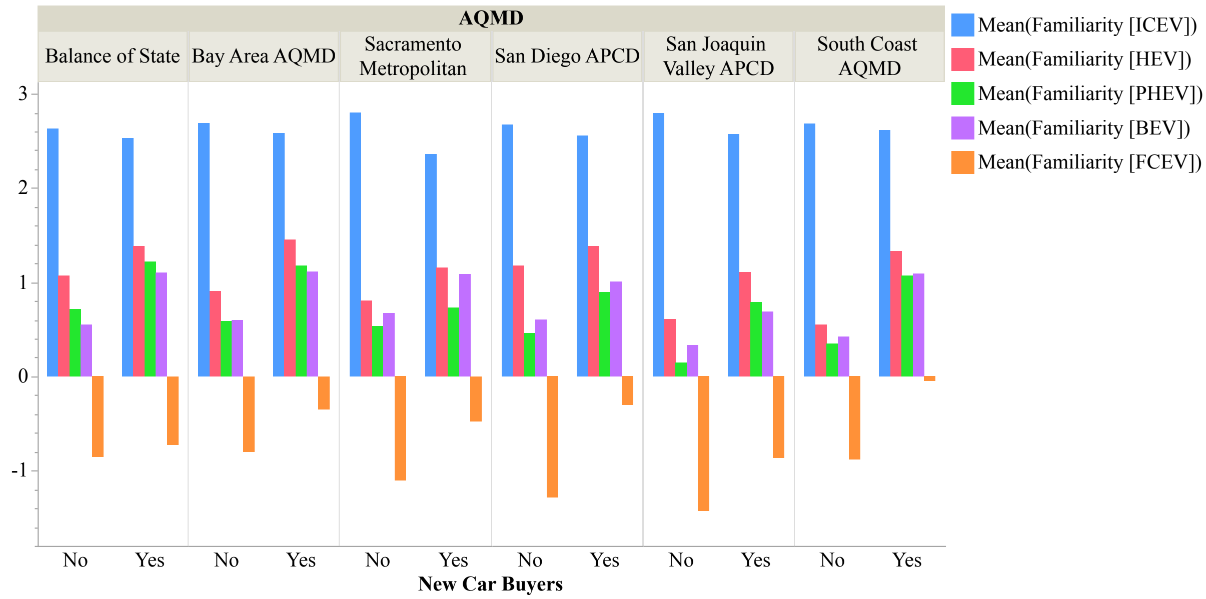


Figure 2: Familiarity with Vehicle Types, California, 2021; mean scores by new car buyer status within six regions; scale -3 to +3

Regression equations are estimated on each of the five familiarity scores controlling for NCB (coded as "yes" (New Car Buyers) or "no" (non-New Car Buyers)), Region, and a crossed effect between NCB and Region (Table 5). All models fit the data better than a model with only intercepts (n = 2,992; degrees of freedom = 11; (p > F) ≤ 0.0001). In all these models, the SCAQMD is the omitted category for purposes of model estimation, thus all regional comparisons are to the SCAQMD.

For Familiarity with ICEVs, the model indicates:

- Participants who have *not* acquired a new vehicle since January 2014 are likely to rate themselves as *more* familiar with ICEVs than those who did but there is no difference across the regions.
- The crossed effect is not significant, i.e., the difference between those who did and those who did not acquire a new vehicle is the same across all regions.

For Familiar with HEVs, PHEVs, BEVs, and FCEVs the models indicate:

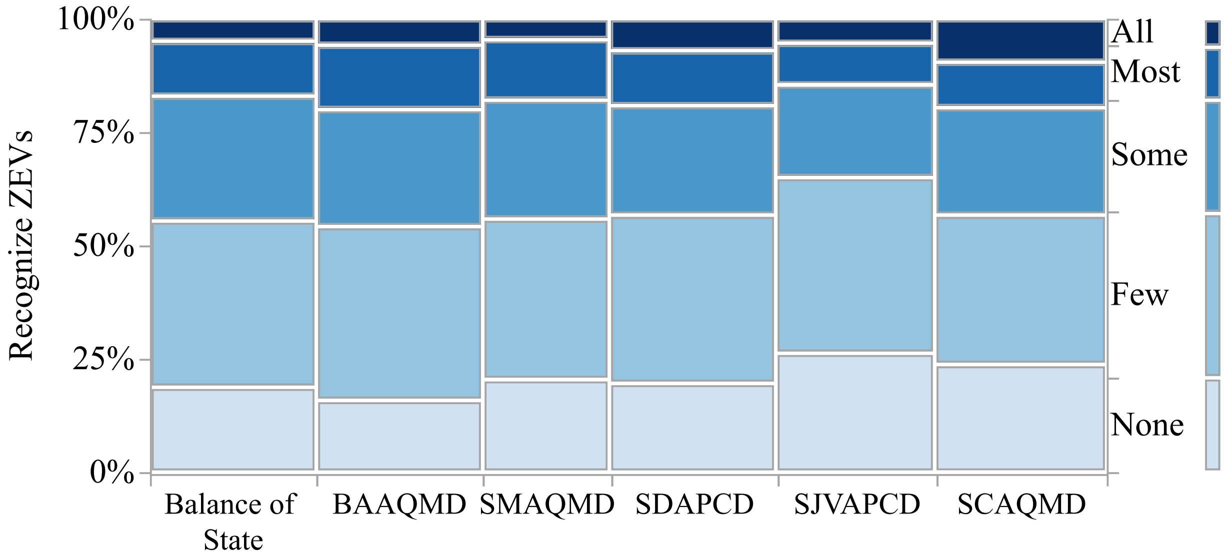
- Those who have *not* acquired new cars or trucks are likely to rate themselves as less familiar than those who did acquire at least one new car or truck.
- For Familiarity with HEVs, PHEVs, and FCEVs—but not BEVs—the variable for Region is statistically significant. Participants in the SJVAPCD are likely to rate their familiarity with HEVs, PHEVs, and FCEVs lower than participants from at least one other region.
- The model for familiarity with FCEVs is the only one in which the crossed effect of NCB*Region is statistically significant. In the Balance of the State, there is less difference between New and non-New Car Buyers while in the SDAPCD there is more difference.

Table 5: Regressions of Familiarity with Five Vehicle Types for Six Regions in California, 2021

Vehicle Type:	ICEV		HEV		PHEV		BEV		FCEV	
Analysis of Variance										
Degrees of Freedom	11		11		11		11		11	
F Ratio	3.321		5.125		5.923		4.502		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	1.077	<0.0001	0.722	<0.0001	0.771	<0.0001	-0.761	<0.0001
NCB[No]	0.088	<0.0001	-0.225	<0.0001	-0.257	<0.0001	-0.242	<0.0001	-0.299	<0.0001
AQMD [BoS]	-0.044	0.2717	0.151	0.0788	0.242	0.0064	0.054	0.5426	-0.031	0.7256
AQMD [BAAQMD]	0.012	0.7649	0.100	0.2506	0.160	0.0764	0.084	0.3497	0.186	0.0380
AQMD [SMAQMD]	-0.045	0.3211	-0.097	0.3162	-0.091	0.3632	0.107	0.2828	-0.030	0.7593
AQMD [SDPCD]	-0.008	0.8375	0.203	0.0203	-0.043	0.6313	0.0323	0.7164	-0.033	0.7115
AQMD [SJVAPCD]	0.059	0.1476	-0.220	0.0122	-0.254	0.0050	-0.262	0.0038	-0.386	<0.0001
NCB [No] * AQMD[BoS]	-0.036	0.3680	0.068	0.4310	0.004	0.9596	-0.032	0.7217	0.233	0.0081
NCB [No] *AQMD [BAAQMD]	-0.036	0.3828	-0.048	0.5825	-0.038	0.6759	-0.015	0.8684	0.074	0.4114
NCB [No]* AQMD [SMAQMD]	0.132	0.0033	0.049	0.6616	0.161	0.1068	0.037	0.7120	-0.016	0.8709
NCB [No]* AQMD [SDPCD]	-0.030	0.4643	0.121	0.1671	0.039	0.6668	0.041	0.6476	-0.192	0.0325
NCB [No]* AQMD [SJVAPCD]	0.023	0.5806	-0.023	0.7892	-0.062	0.4933	0.062	-0.4939	0.018	0.8449

3.1.2 Recognizing ZEVs

The new measure of how many ZEVs people believe they would recognize of "all the cars [they] see on the road or in parking lots and garages" is plotted by Region in a mosaic plot in Figure 3. The test of homogeneity of proportions rejects the null hypothesis of no difference but it is difficult to discern systematic differences. The SCAQMD has the highest percentage of people who say they would recognize all ZEVs but also nearly the highest percentage of those who say they would recognize none. Conversely, the BAAQMD has the lowest percentage of people who say they would recognize no ZEVs, but nowhere near the highest percentage who say they would recognize all ZEVs. Certainly, no differences between regions appear to outweigh the generalization that everywhere in California more than half of car-owning households indicate they would recognize none or few of the ZEVs on California's roads and almost everywhere in the state, more say they would recognize none than say they would recognize most or all.



n = 2,994; degrees of freedom = 20; χ^2 = 47.742; probability > χ^2 = 0.0005

Figure 3: Rating of Number of ZEVs Participants would Recognize, Six Regions, CA, 2021

While there may be a statistically significant—if substantively obtuse—relationship between ability to recognize ZEVs and region, the statistically significant relationship between ability to recognize ZEVs and New Car Buyer status is straightforward but slight: New Car Buyers are more likely to report they believe they would recognize more ZEVs than are non-New Car Buyers (n = 2,994; degrees of freedom = 4; χ^2 = 21.338; probability > χ^2 = 0.0003). However, the Uncertainty C|R = 0.0024 though significantly different from zero is so small as to indicate knowing whether a participant is a New or non-New Car Buyer does very little to improve our knowledge of how many ZEVs they would recognize.

3.1.3 Naming ZEVs

Another way to assess whether people are becoming familiar with ZEVs is name recollection. Different from whether they recognize a ZEV they see as such, recalling a name indicates exposure to information about or marketing of ZEVs that made a sufficient impression to commit the name[s] to memory. Figure 4 illustrates the overall ability of participants to name BEVs and the difference it makes about whether the lax or strict rules are applied to assess correct answers. First, less than half of participants across California in 2021 (43%) say they can name a BEV. But if confidently stating you can name a BEV, then offering an answer that can in no way be construed as correct is the same as saying "no" in the first place, then the percentage of people who can correctly name a BEV drops to 39% under the lax rules and 33% under the strict rules. One BEV manufacturer dominates the correct responses under all rules about correct names: Tesla accounts for 67% of correct responses under the lax rules (which require only participants say, "Tesla," and no model name they offer after that matters). Under the strict rules (which distinguish between actual model offerings from Tesla and other things people offer as possible model names), the unambiguously correct Tesla responses falls to 57% of correct responses. However, all manufacturers of BEVs other than Tesla, Nissan (Leaf) and Chevrolet (Bolt) are proportionally more affected by the shift from lax to strict rules: the percentage of all Yes: Right (Other) falls from 23% (of all affirmative, correct responses) to nine percent.

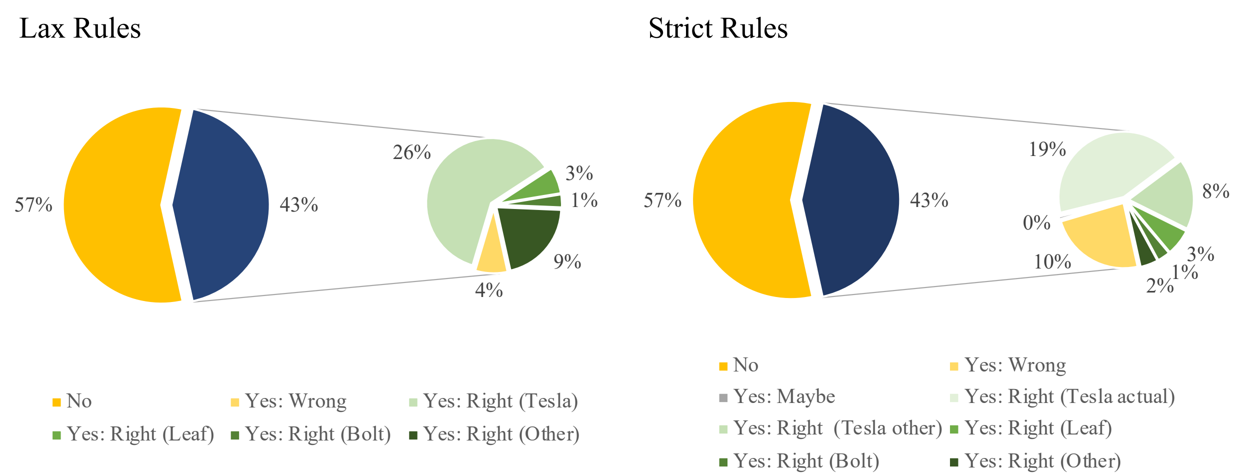


Figure 4: Name a BEV, first instance, California, 2021, percent. Lax and strict name rules

Figure 5 illustrates how many people can name two BEVs according to the lax rules. Note the "blank" 57% in the right-side of the figure are the people who could not name one BEV to start. When those 43% who claim to be able to name one BEV are asked if they can name another, fewer than half say, "yes." All manufacturers other than Tesla, Nissan (Leaf), and Chevrolet (Bolt) appear to fare relatively well in this more advanced test of name recollection—for example, the relative percentage of "Other" compared to "Tesla" is approximately 1:1 for second BEV names (right-hand side) compared to 1:3 for the first BEV name (left-hand side). Still, whether recalling one BEV name or two, Tesla is by far the single most recollected BEV name.

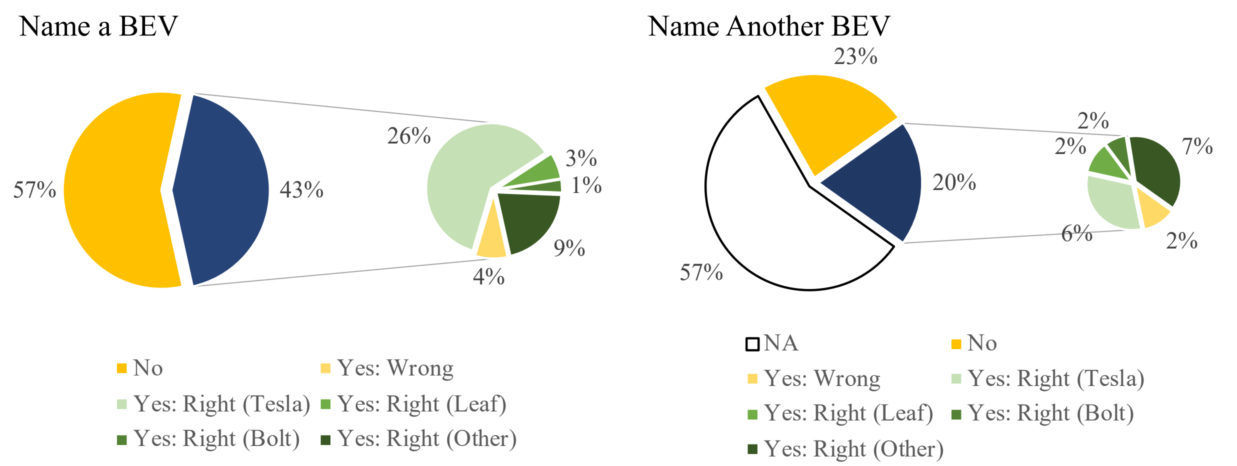


Figure 5: Name another BEV, California, 2021, percent. Lax rules.

Participants' name recollection of PHEVs is worse than for BEVs. The percent of participants who say they can name no PHEV (66%) is nearly ten percentage points higher than for BEVs (57%). Further, nearly 80% of participants either say no or give a PHEV name that is incorrect. Concentrating on the first proffered names of PHEVs, under the moderate rules which count names of BEVs as wrong answers for PHEV names, of those who say they can name a PHEV the most common response category is "Yes: Wrong" (39%) followed by "Yes: Right (Prius) (36%). In contrast, the most frequently proffered response for the first instance of naming a BEV is a correct response under the moderate rules: "Yes: Right (Tesla)" (61%) followed by far fewer "Yes: Wrong" responses (24%). Further, fewer participants claim they can name a second PHEV (14%) than claim they can name a second BEV (20%). As was the case for the first proffered names, the second named PHEV is more likely to be incorrect (42%) than the second named BEV (37%).

Far fewer people can name an FCEV. There are so few possible correct answers that once the decision was made that even under the lax rules PHEV and BEV names would be incorrect, no other rules, e.g., whether make and model names matched, made any substantive difference. Just over 10% of participants said they could name an FCEV, but their most common response was an incorrect answer. Thus, approximately six percent of all participants correctly named an FCEV. Of these, nearly three-fourths named the Toyota Mirai. The first set of rules for all these naming questions is to resolve spelling variants. Of the answers counted as "Toyota Mirai," about three-fourths are unambiguously correct. This means if the ambiguously correct "Mirai" responses were broken out as their own category, they would be the next most common response, ahead of Honda Clarity and Hyundai Nexo. The total percentage of participants who say they can name two FCEVs is about three percent. Mirai, Nexo, and Clarity each account for similar percentages of second FCEV names.

Participants who claim they could name a PHEV or a BEV were subsequently asked if they could name a second such vehicle (irrespective of whether their first answer was correct). The same sets of rules are applied regarding correct responses. For the entire state, about one-in-eight (13%) participants recollect a correct name of both a BEV and a PHEV ("Both Right" in Figure 6) while far fewer claim to be able to name both but are wrong about both (3%). Still, 45% say they can name neither a BEV nor a PHEV; another 10% can name a PHEV but not a BEV or vice versa.

3.1.3.1 Naming PEVs across Regions

To assess whether participants in the different regions of the state differ in their ability to name electric vehicles, simplified measures of the ability to name them are first created. PHEVs and BEVs will be analyzed together as they represent the largest part of the present "electric vehicle" market and both can or must, respectively, plug in to charge. The moderate naming rules will be used for PHEVs and BEVs (Table 3). These are the possible values for the new naming variables:

None = Unable to correctly name a PHEV (BEV),

One = Able to correctly name one PHEV (BEV), or

Two = Able to correctly name two PHEVs (BEVs).

The number of correctly named PHEVs (None, One, or Two) are cross tabulated by the number of correctly named BEVs for each region in the heatmaps in Figure 6; darker shading indicates more participants. The only clear conclusion is that in nearly every region, most participants can name neither a PHEV nor a BEV. Figure 7 reorganizes Figure 6; the percentages in each cell are of participants in each region. For example, 65% of participants in the Balance of State (BoS) can name neither a PHEV nor BEV (either because they decline to try or because the answer(s) they give are incorrect) while 1.2% are able to name two PHEVs and two BEVs. Only in the BAAQMD can most participants (54%) name at least one PHEV or one BEV. However, categorical analysis confirms the statistically significant difference between regions occurs only at the high end of ability to name PHEVs and BEVs: participants in the SMAQMD are more likely to be able to name two PHEVs and two BEVs than are participants from all other regions except the SDAPCD.

In no region can as many as one-third the participants name one PHEV, one BEV, or one of each. In no region can as many a four percent of participants name two PHEVs and two BEVs. In every region, if a participant can name either one PHEV or one BEV, they are approximately one-fourth as likely or less to be able to name *one* PHEV as *one* BEV. This is true even in the region in which the most participants can name either or both PHEVs and BEVs: 23% of participants in the BAAQMD can name one BEV but no PHEVs while 4.3 % can name one PHEV but no BEV. Given the discussion of naming of the individual vehicle types in earlier sections, i.e., given the extent to which the name "Tesla" dominates the first named BEV (yet still achieves parity with the other most-mentioned BEVs for second-named BEV), the difference between being able to name a BEV vs. a PHEV largely comes down to whether people can say, "Tesla," in response to naming a BEV.

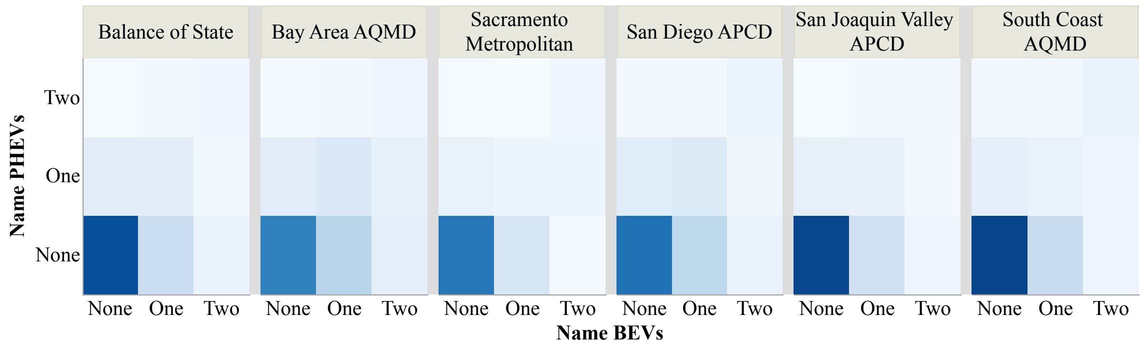


Figure 6: Naming PHEVs and BEVs; number of correct names up to two. California, 2021, percent. Moderate rules.

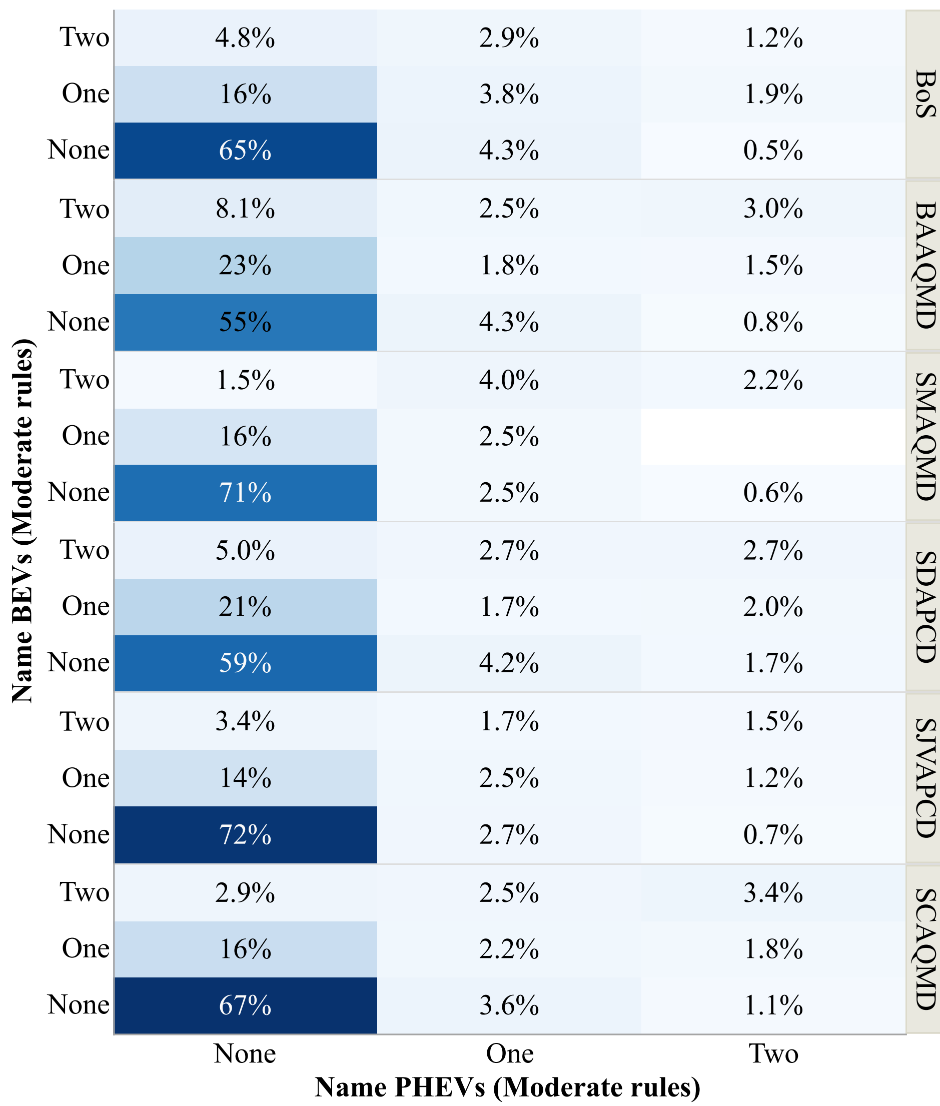


Figure 7: Name None, One, or Two PHEVs and BEVs across Six Regions in CA; 2021; percent

To test the significance of any effects of Region, NCB, or their crossed effect on participants ability to name PHEVs and BEVs, categorical data analysis is performed on the cross-tabulation in Figure 7. The actual data analyzed are constructed by replacing the within-region percentages in Figure 7 with the counts of participants in each cell. The null hypothesis of categorical analysis is homogenous proportions, i.e., in this case that the distributions of whether participants can name zero, one, or two BEVs are the same for those who can name zero, one, or two PHEVs whether they buy new cars or not and regardless of where they live. The results of the tests of homogeneity of proportions are in Table 6. The results indicate there is no statistically significant variation in the response proportions between New and non-New Car Buyers across the six regions in participants ability to name PHEVs and BEVs: across all regions New Car Buyers are more likely to be able to name BEVs regardless of how many PHEVs they can name.

Table 6: Likelihood Ratio Chi-square p-values on pairs of Regions in Figure 7

Region, Name BEVs = None, Name PHEVs						
	BoS	BAAQMD	SMAQMD	SDAPCD	SJVAPCD	SCAQMD
Bos	1	0.3626	0.5412	0.0763	0.6654	0.1741
BAAQMD	0.3626	1	0.1869	0.6613	0.1604	0.1903
SMAQMD	0.5412	0.1869	1	0.0733	0.9446	0.6099
SDAPCD	0.0763	0.6613	0.0733	1	0.0411	0.1755
SJVAPCD	0.6654	0.1604	0.9446	0.0411	1	0.3885
SCAQMD	0.1741	0.1903	0.6099	0.1755	0.3885	1
Region, Name BEVs = One, Name PHEVs						
Bos	1	0.7394	0.0703	0.8997	0.7416	0.2617
BAAQMD	0.7394	1	0.1636	0.9316	0.3971	0.0905
SMAQMD	0.0703	0.1636	1	0.0976	0.0679	0.0370
SDAPCD	0.8997	0.9316	0.0976	1	0.5037	0.1219
SJVAPCD	0.7416	0.3971	0.0679	0.5037	1	0.7146
SCAQMD	0.2617	0.0905	0.0370	0.1219	0.7146	1
Region, Name BEVs = Two, Name PHEVs						
Bos	1	0.4030	0.0040	0.5897	0.9796	0.1478
BAAQMD	0.4030	1	0.0082	0.1246	0.4769	0.0387
SMAQMD	0.0040	0.0082	1	0.0142	0.0133	0.1045
SDAPCD	0.5897	0.1246	0.0142	1	0.7577	0.5645
SJVAPCD	0.9796	0.4769	0.0133	0.7577	1	0.2850
SCAQMD	0.1478	0.0387	0.1045	0.5645	0.2850	1

Adding NCB as a factor in Table 7, False Discovery Rate (FDR) p-values are reported because of the multiple comparisons required to complete all the tests of response homogeneity, i.e., FDR are more conservative than simple p-values and are likely to return fewer false-positive statistically significant results. There are statistically significant differences in the response proportions within some regions but only among those who can name no PHEVs. Examination of the cell-χ^2 values (not shown) indicates the statistically significant differences exist solely within the BAAQMD. Rather than no difference in ability to name PHEVs based on ability to name BEVs, in the BAAQMD ability to name a PHEV appears positively correlated with ability to name a BEV. The interaction between NCB and Region indicates this effect is stronger among non-New Car Buyers in the BAAQMD than among New Car Buyers.

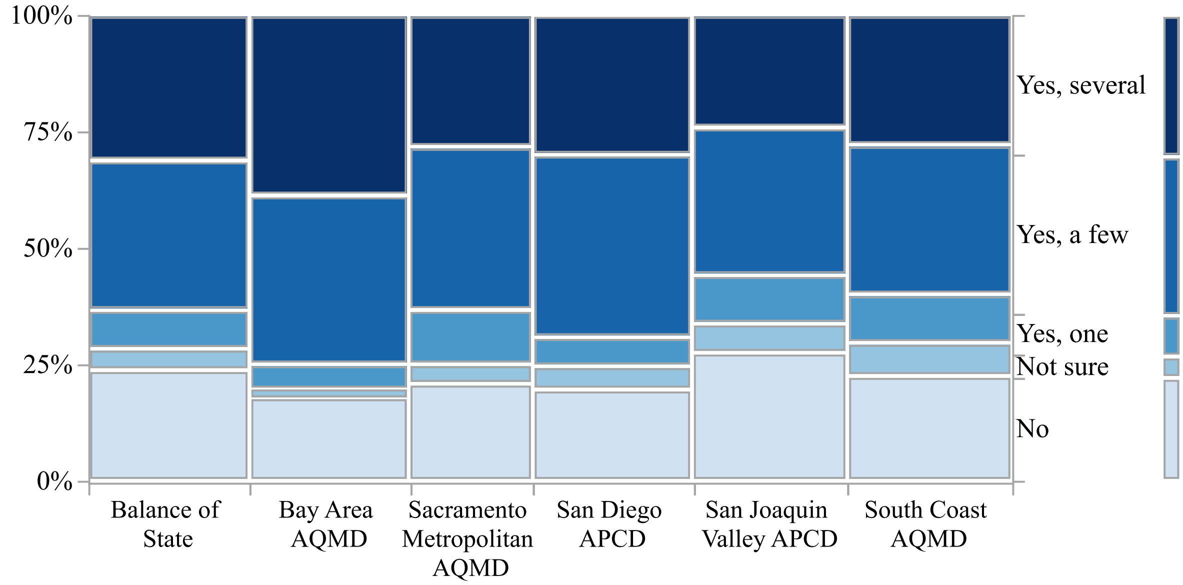
Table 7: Tests of Response Homogeneity for Naming PHEVs and BEVs, by New Car Buyer Status and Region, CA, 2021

Effect	PHEV Name Category; BEV Name	Likelihood-Ratio χ^2	False Discovery Rate p Value
NCB	Name PHEVs Moderate = None, Name BEVs Moderate	3.347	0.313
NCB	Name PHEVs Moderate = One, Name BEVs Moderate	5.469	0.156
NCB	Name PHEVs Moderate = Two, Name BEVs Moderate	0.144	0.931
Region	Name PHEVs Moderate = None, Name BEVs Moderate	42.146	< 0.0001
Region	Name PHEVs Moderate = One, Name BEVs Moderate	4.860	0.931
Region	Name PHEVs Moderate = Two, Name BEVs Moderate	13.027	0.313
NCB = No, Region	Name PHEVs Moderate = None, Name BEVs Moderate	35.450	0.001
NCB = Yes, Region	Name PHEVs Moderate = None, Name BEVs Moderate	18.876	0.132
NCB = No, Region	Name PHEVs Moderate = One, Name BEVs Moderate	16.761	0.160
NCB = Yes, Region	Name PHEVs Moderate = One, Name BEVs Moderate	12.809	0.313
NCB = No, Region	Name PHEVs Moderate = Two, Name BEVs Moderate	18.717	0.132
NCB = Yes, Region	Name PHEVs Moderate = Two, Name BEVs Moderate	11.564	0.378

Red text highlights statistically significant tests.

3.1.4 Seeing PEV Charging Infrastructure

Distributions of how many people say they've seen PEV charging infrastructure "in the parking lots and garages [they] use" are shown in a mosaic plot in Figure 8. In general, large majorities of car owning households in all regions claim to have seen at least one spot for EV charging. The chi-square test indicates differences between regions are statistically significant. However, Lambda Asymmetric C|R is not significantly different from zero indicating that knowing which region a participant is from does nothing to improve a prediction of whether and how much PEV charging they have seen.



n = 2,992; degrees of freedom = 20, χ^2 = 73.408; probability ≤ 0.0001

Figure 8: Seen Electric Vehicle Charging, Six Regions, CA, 2021; percent

Assuming the measure may be treated as a scale, the following categories are defined:

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 each region are in Table 8. The regional means range from 1.46 (SJVAPCD) to 1.94 (BAAQMD)—generally corresponding to seeing EV charging at one to a few locations. Regional means are on the diagonal; green shading in the columns below each mean indicates pairs of means for which the mean of the region on the diagonal is statistically significantly higher than the region(s) listed below it; Tukey's Honestly Significant Different test, α = 0.05. Thus, participants in BAAQMD are, on average, more likely to have seen PEV charging at more locations than participants everywhere in the state except the SDAPCD. The only other statistically significant difference in means is between the SDAPCD and the SJVAPCD.

Table 8: Seen Electric Vehicle Charging across Six Regions, California, 2021; Means and Pairwise Significant Differences

BAAQMD	1.94					
SDAPCD		1.74				
SMAQMD			1.66			
Balance of State				1.66		
SCAQMD					1.58	
SJVAPCD						1.46

Note: Region means are on the diagonal; green shading indicates pairs of means for which the mean of the region on the diagonal is statistically significantly higher than the region(s) below; Tukey's Honestly Significant Difference test, $\alpha = 0.05$. Thus, the mean for BAAQMD is statistically significantly higher than for SMAQMD, Balance of State, SCAQMD, and SJVAPCD.

The assumption that whether someone has seen PEV charging in the parking facilities they use does *not* depend on whether they buy new vehicles is shown by region in Figure 9. The evidence contradicts the assumption: people who purchased at least one new car or truck since 2014 are more likely have seen PEV charging. In all six regions the mean value for New Car Buyers is higher than for non-New Car Buyers.

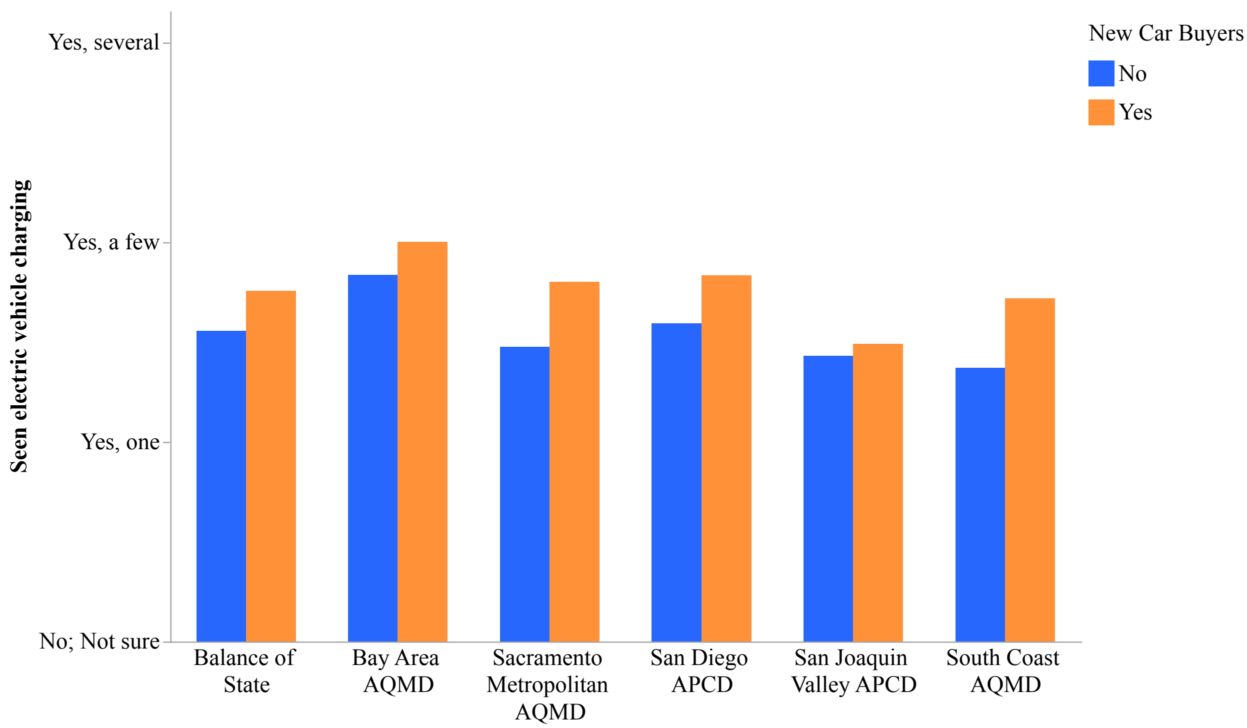


Figure 9: Seen Electric Vehicle Charging across Six Regions by New Car Buyer status, CA, 2021; mean values of responses converted to a numeric scale, 0 (No; not sure) to 3 (Yes, several)

To simultaneously assess the effects of Region, NCB, and any interaction between them, an ordinal logistic regression equation is estimated on the ordinal version of Seen EVSE (Table 9). The estimated model indicates that both Region and NCB have independent effects with little probability the effect of either is different across the different categories of the other. The parameter with the largest effect is whether a participant lives in the BAAQMD (compared to the SCAQMD); participants there are more likely than anywhere else in the state to report they have seen electric vehicle charging and have seen it many places. New Car Buyers living in the BAAQMD are estimated to have a 41 percent chance of having seen PEV charging in several of the parking facilities they use while even the non-New Car Buyers there are estimated to have a 36 percent chance. In the BAAQMD, only 18 percent of New Car Buyers and 21 percent of non-New Car Buyers are estimated to have *not* seen any PEV charging or to be unsure whether they have. In contrast, in the SJVAPCD both New Car Buyers and non-New Car Buyers are estimated are both estimated to have about a 34 percent probability they have seen no BEV charging in the parking facilities they use.

Table 9: Model of Seeing EVSE by NCB, Region, and Region*NCB, CA, 2021

Whole Model	**-Log Likelihood**	**DF**	**χ^2**	**Prob> χ^2**
Difference	38.66	11	77.32	<0.0001
Full	3833.95			
Reduced	3872.61			

Effect Tests

Source	**DF**	**L-R χ^2**	**Prob> χ^2**
NCB	1	23.88	<0.0001
Region	5	45.96	<0.0001
Region*NCB	5	5.50	0.3582

Parameter Estimates

Term	**Estimate**	**Std Error**	**χ^2**	**Prob> χ^2**
Intercept[No; not sure]	-0.984	0.042	554.80	<0.0001
Intercept[Yes, one]	-0.571	0.039	216.47	<0.0001
Intercept[Yes, a few]	0.896	0.041	477.71	<0.0001
NCB[No]	0.166	0.034	23.84	<0.0001
Region[BoS]	-0.013	0.073	0.03	0.8630
Region[BAAQMD]	-0.428	0.075	32.29	<0.0001
Region[SMAQMD]	0.039	0.082	0.22	0.6385
Region[SDAPCD]	-0.073	0.075	0.96	0.3267
Region[SJVAPCD]	0.303	0.075	16.38	<0.0001
Region[BoS]*NCB[No]	-0.009	0.073	0.02	0.9019
Region[BAAQMD]*NCB[No]	-0.072	0.075	0.92	0.3387
Region[SMAQMD]*NCB[No]	0.084	0.082	1.03	0.3097
Region[SDAPCD]*NCB[No]	0.021	0.075	0.08	0.7815
Region[SJVAPCD]*NCB[No]	-0.124	0.075	2.74	0.0980

Note: n = 2,994; $R^2(U)$ = 0.010

3.1.5 Knowledge of Vehicle Fueling

For the state of California, the vehicle type with the highest percent of correct responses to the question of, "how is this type of vehicle fueled," is BEVs (72%), followed by PHEVs (55%), and HEVs (20%). (The question is not asked for FCEVs.) The differences between the six regions are statistically significant for HEVs (χ^2 = 17.68; degrees of freedom = 5; p = 0.003) and BEVs (χ^2 = 13.22; degrees of freedom = 5; p = 0.021), but not PHEVs (χ^2 = 7.04; degrees of freedom = 5; p = 0.218). The values of percent correct for HEVs range from a low of 16% (SCAQMD) to a high of 24% (BAAQMD); for PHEVs, from 51% (SCAQMD) to 58% (Balance of State); and for BEVs, from 68% (SCAQMD) to 77% (BAAQMD).

A heatmap of the nested answers for HEVs, PHEVs, and BEVs for each region is shown in Figure 10. The nesting of Correct/Incorrect responses on the left-axis reads from outside-in. For example, the top row of the heatmap shows the percent of people within each region who incorrectly respond to HEVs, PHEVs, and BEVs. The shading shows the number of the total sample of all regions from few (pale) to many (dark). Thus, the column for Sacramento Metropolitan AQMD and San Joaquin Valley APCD are overall slightly paler than the other columns because their sample sizes are smaller—thus the colors are most readily interpreted within each column. The percentages shown are the percentages of participants in each region.

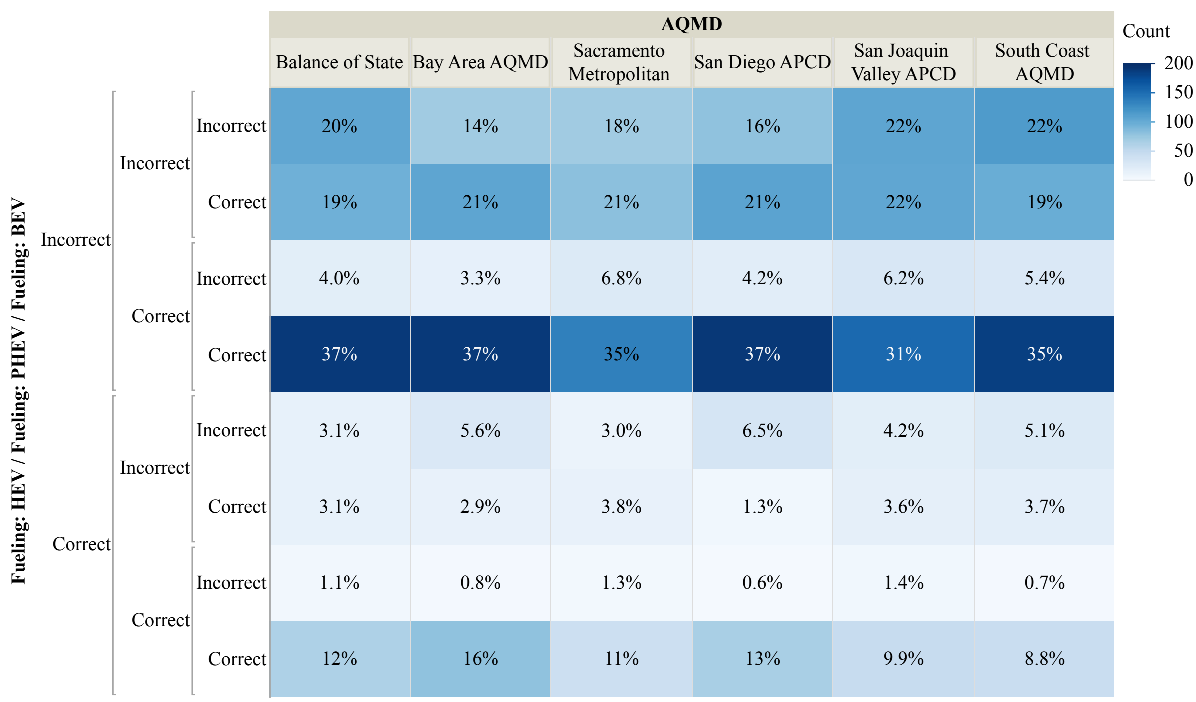


Figure 10: Heatmap of Knowledge about Fueling of HEVs, PHEVs, and BEVs within Six Regions in California defined by Air Districts, 2021; percent, and total count across states

Several things are evident in Figure 10. First, few participants, varying from 9% (SCAQMD) to 16% (BAAQMD), correctly identify how all three types—HEVs, PHEVs, and BEVs—are fueled (bottom row of the figure). The BAAQMD is the only region in which a (slightly) higher percentage of participants know how all three vehicle types are fueled (bottom row) than know none of them (top row). Second, as the top half of the heatmap corresponding to all possible combinations that include incorrect knowledge of fueling HEVs is darker than the bottom half, we see most people in every region don't know HEVs are fueled only with gasoline. The belief HEVs must be both fueled with gasoline *and* plugged in to charge with electricity is more common than the correct assessment that HEVs fuel only with gasoline in all six regions, ranging from 53 to 59% of participants. Third, from this it may be further observed that knowledge of fueling of HEVs is not related to understanding fueling of PHEVs and BEVs.

Testing for the effects of New Car Buyer status controlling for Region is done via logistic regression, including a crossed effect between the variables NCB and Region. In none of the three models (one each for HEVs, PHEVs, or BEVs) is the crossed effect statistically significant. For HEVs and BEVs both Region and NCB are significant; for PHEVs, only NCB is significant. Odds-ratios are the ratio of the odds of an event occurring in one group to the odds of it occurring in another group. Odds-ratios for Region in the model for Fueling HEVs and BEVs are summarized in Table 10 and Table 11; odds-ratios not statistically significantly different from 1.00 are omitted. The odds-ratio for Balance of State to SCAQMD is 1.55, i.e., a participant in the Balance of the State is more likely to know how an HEV is fueled than is a one from the SCAQMD. (The odds-ratio for SCAQMD-Balance of State is simply the inverse.)

Table 10: Odds Ratios Statistically Different from 1.00 for Correctly Identifying How HEVs are Fueled between Pairs of Regions controlling for New Car Buyer Status, $\alpha \leq 0.05$

	Balance of State	BAAQMD	SCAQMD	SDAPCD	SJVAPCD	SMAQMD
Balance of State			0.64			
BAAQMD			0.55			
SCAQMD	1.55	1.81		1.81	1.43	
SDAPCD			0.55			
SJVAPCD			0.70			
SMAQMD						

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

The model parameters (not shown) and odds-ratios in Table 10 and Table 11 support these conclusions:

- In all six regions, non-New Car Buyers are more likely to correctly identify how HEVs, PHEVs, and BEVs are fueled than are New Car Buyers.
- For both HEVs and BEVs the odds-ratios differ between regions.

- For HEVs, all the statistically significant regional differences involve the SCAQMD: fewer participants there—whether they are New Car Buyers or non-New Car Buyers—correctly identify how HEVs are fueled than do participants in the Balance of the State, BAAQMD, SDAPCD, and SJVAPCD.
- For BEVs, participants in BAAQMD and SDAPCD are more likely to correctly identify how BEVs are fueled than those in SCAQMD. Participants in the BAAQMD are also more likely to correctly identify how BEVs are fueled than are participants in the SJVAPCD.

Table 11: Odds Ratios Statistically Different from 1.00 for Correctly Identifying How BEVs are Fueled between Pairs of Regions controlling for New Car Buyer Status, $\alpha \leq 0.05$

	Balance of State	BAAQMD	SCAQMD	SDAPCD	SJVAPCD	SMAQMD
Balance of State						
BAAQMD		0.62			0.68	
SCAQMD		1.61		1.38		
SDAPCD			0.73			
SJVAPCD		1.48				
SMAQMD						

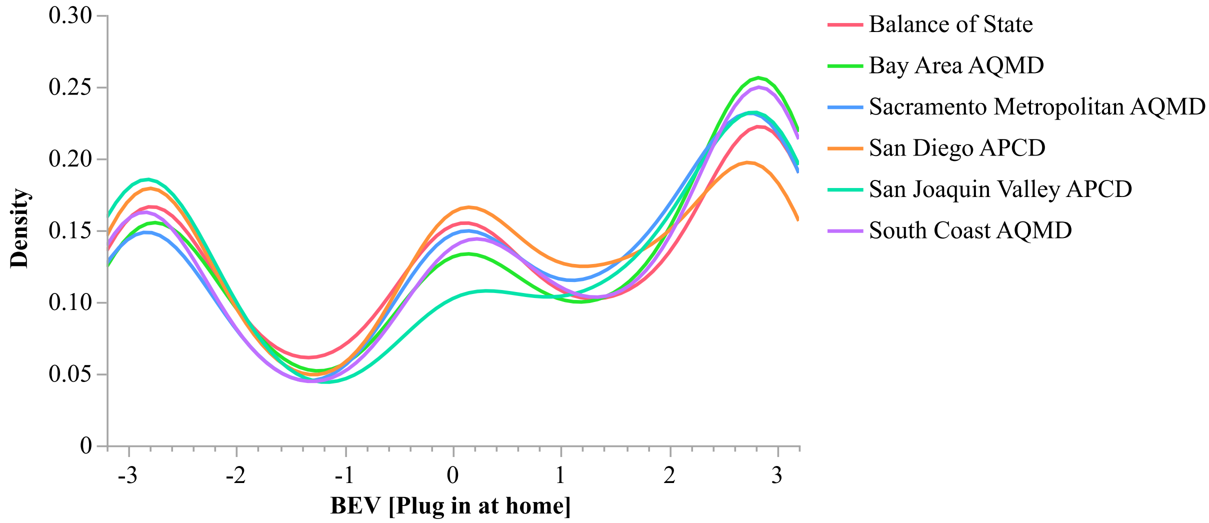
Note: Shading indicates significance; $\alpha \leq 0.01$, $0.01 < \alpha \leq 0.05$.

3.1.6 Assessments of ZEVs

3.1.6.1 Assessments of BEVs

A detailed description of one assessment—participants' assessment of their capability to charge a BEV at their residence—is presented first followed by a summary of all nine BEV assessments. Figure 11 shows the density of participants' assessments of their capability "to plug in a battery electric vehicle to charge at home" (-3 = disagree to +3 = agree). Details of each regions' distribution vary, but they share a tri-modal appearance with peaks at the extremes of disagreement and agreement as well as at the midpoint. In most of the six regions, the highest concentration is at the level of strongest agreement. The means of the distributions do not differ across regions. The median for the SDAPCD (0.03) is statistically significantly lower than the median for the BAAQMD and SCAQMD (both equal 1.3). These are the only statistically significant pairwise differences in medians (Steel-Dwass Method, $\alpha = 0.05$).

Figure 11: Density Distributions for Participants' Assessments of their Capability to Charge a BEV at Home across Six Regions, California, 2021



The regional mean agreement scores for capability to charge a BEV at home are shown in Figure 12 segmented by whether participants are New Car Buyers. Across all regions, New Car Buyers' mean scores are higher than non-New Car Buyers. A linear regression on the continuous agreement scale is estimated using Region, NCB, and their crossed effect as independent variables; only NCB is statistically significant. There is no difference across regions as to whether participants, on average, believe they can charge a BEV at home, but there is a difference between New Car and non-New Car Buyers. The difference is large enough that those who bought new vehicles since January 2014 are estimated to have modest average agreement (Least Square Mean = 0.80) they could charge a BEV at home while those who bought only used vehicles or bought no vehicles are estimated to have slight average disagreement (Least Square Mean = -0.08).

State and region mean values for all nine BEV assessments are shown in Table 12. If the mean assessment of the entire state of California is a useful benchmark, then an Analysis of Means tests whether the mean for each region is different from the mean for the whole state. The regional assessment mean values in each row of Table 12 are shaded according to whether they are statistically significantly less than (orange), not different from (no shading), or greater than (green) the statewide mean ($\alpha = 0.05$). The Analysis of Means for the nine BEV assessments support these overall conclusions:

- While there is some regional deviation from the statewide average for six of the nine assessments, there is only one assessment for which more than one regional mean is different from the state-wide mean.
  - Four regions register slight average disagreement there is enough BEV charging (the BoS registers even lower agreement than the state as a whole), in the BAAQMD and SMAQMD there is the slightest agreement there is enough.
- In the SDAPCD, BEVs are, on average, assessed more favorably than statewide as to driving range and safety compared to conventional gasoline vehicles.

- In the SCAQMD, BEVs fare worse than statewide in comparison to the reliability of conventional gasoline vehicles.
- Participants from the large and heterogenous region defined as the Balance of the State give BEVs less favorable assessments for not only the availability of charging, but also for whether BEVs are less damaging to the environment and are ready for mass market.

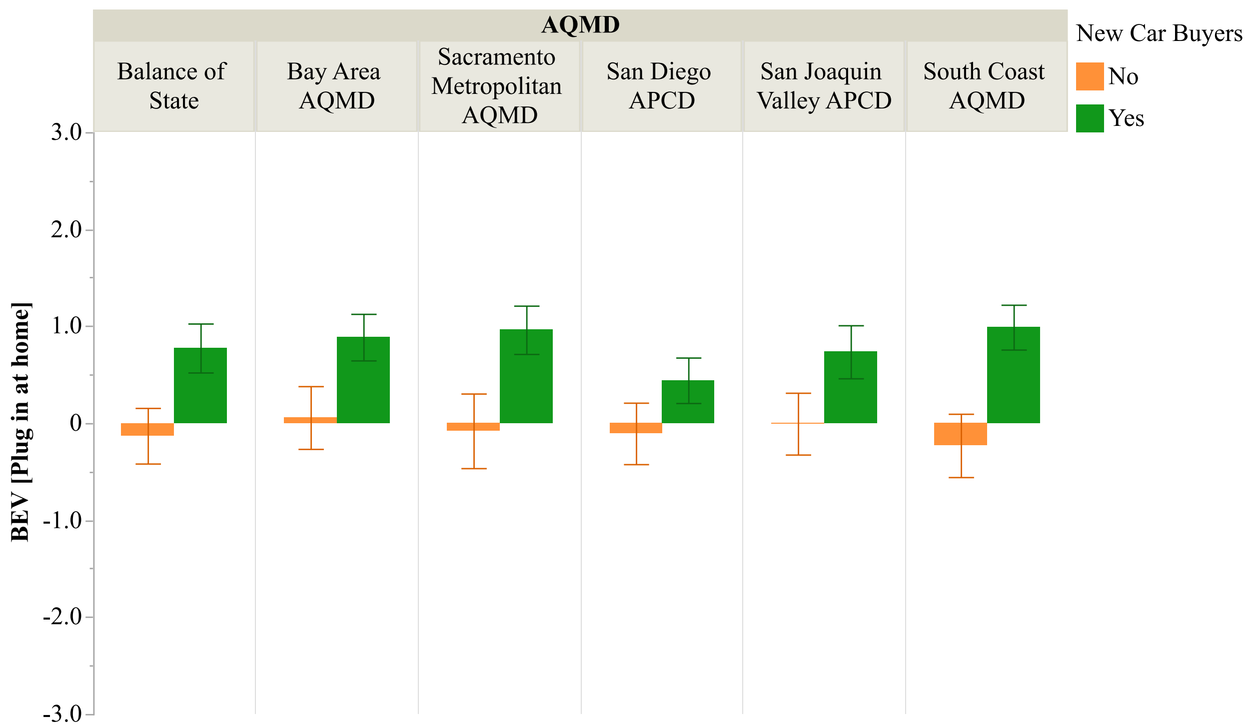


Figure 12: Mean Agreement Scores for Ability to Charge a BEV at Home across Six Regions in CA, by New Car Buyer, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Regression models are used to assess the effects of Region, NCB, and their crossed effect on the nine BEV assessments. The statistical significance of the three explanatory variables in each of these nine regression equations are shown in Table 13. Results are summarized as:

- The distinction between those who have acquired new cars since 2014 and those who have not (NCB) is statistically significant in six of the nine regressions.
  - However, only for capability to charge a vehicle at home is this distinction the only significant variable.
- The region in which participants reside (Region) is also statistically significant for the following five BEV assessments:
  - Whether there is enough charging for BEVs,
  - Whether BEVs take too long to charge,
  - Whether BEV range is too short,
  - The relative safety of BEVs vs. conventional gasoline vehicles, and

  - Whether BEVs are ready for mass market.
- Region is the sole statistically significant variable for two BEV assessments:
  - The relative reliability of BEVs vs. conventional gasoline vehicles, and
  - Whether BEVs are less damaging to the environment.
  - Despite the marginal significance of the crossed effect for NCB and Region in the model for the assessment of whether BEVs are higher priced, no least square means for any pair are statistically significantly different.

Table 12: Observed Mean Scores for Nine Assessments of BEVs across Six Regions, CA, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Vehicle Type [Assessment] (CA-state mean)	Balance of State	BAAQMD	SMAQMD	SDAPCD	SJVAPCD	SCAQMD
BEV [Charge at home] (0.53)	0.338	0.559	0.514	0.227	0.356	0.503
BEV [Enough charging] (-0.07)	-0.509	0.005	0.108	-0.319	-0.332	-0.225
BEV [Too long to charge] (-0.90)*	-0.840	-1.030	-0.9441	-0.766	-0.757	-1.068
BEV [Range too short] (-1.03)*	-1.198	-1.179	-1.120	-0.843	-0.913	-1.127
BEV [Higher price] (-1.40)*	-1.558	-1.434	-1.373	-1.496	-1.354	-1.524
BEV [Gasoline safer] (-0.34)*	-0.221	-0.357	-0.328	-0.041	-0.282	-0.416
BEV [Gasoline more reliable] (-0.87)*	-0.755	-0.807	-0.842	-0.702	-0.847	-1.048
BEV [Less damage to environment] (1.36)	1.013	1.443	1.490	1.363	1.256	1.494
BEV [Ready for mass market] (0.86)	0.462	0.870	0.830	0.800	0.633	0.912

*Scale inverted so that for all assessments positive values favor BEVs.

Note: Green shading indicates region means statistically significantly higher than the state mean, no shading indicates no difference, and orange indicates the region mean is less than the state mean; α = 0.05.

Table 13: Significance of Explanatory Variables in Regression Equations of Nine Assessments of BEVs, Six Regions, California, 2021

Dependent Variable: Vehicle Type [Assessment]	Effect Tests				
	Term	Degrees of Freedom	Sum of Squares	F Ratio	Prob. > F
BEV [Charge at home]	NCB	1	560.519	112.424	< 0.0001
	Region	5	28.138	1.129	0.343
	NCB*Region	5	33.832	1.357	0.237
BEV [Enough charging	NCB	1	220.816	52.497	< 0.0001
	Region	5	85.444	4.063	0.0011
	NCB*Region	5	32.2212	1.532	0.1765
BEV [Too long to charge]	NCB	1	36.753	13.362	0.0003
	Region	5	38.638	2.809	0.0155
	NCB*Region	5	5.990	0.536	0.8240
BEV [Range too short]	NCB	1	10.998	3.830	0.0504
	Region	5	52.631	3.666	0.0026
	NCB*Region	5	16.478	1.148	0.3328
BEV [Higher price]	NCB	1	0.094	0.358	0.8499
	Region	5	16.456	1.291	0.2646
	NCB*Region	5	28.209	2.211	0.0506
BEV [Gasoline safer]	NCB	1	10.186	3.228	0.0725
	Region	5	44.587	2.826	0.0150
	NCB*Region	5	23..935	1.517	0.1811
BEV [Gasoline more reliable]	NCB	1	4.732	1.684	0.1945
	Region	5	37.112	2.642	0.0217
	NCB*Region	5	20.958	1.492	0.1890
BEV [Less damage to environment]	NCB	1	0.468	0.158	0.6909
	Region	5	87.001	5.876	< 0.0001
	NCB*Region	5	9.259	0.625	0.6805
BEV [Ready for mass market]	NCB	1	75.456	24.886	< 0.0001
	Region	5	62.492	4.122	0.0010
	NCB*Region	5	16.395	1.0814	0.3685

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

3.1.6.2 Assessments of PHEVs

As a prelude to the analysis of the effects of the NCB variable, mean agreement scores for “My household would be able to charge a plug-in hybrid electric vehicle at home” are shown in Figure 13 by Region and New Car Buyer status. Mean values for the nine assessments are in Table 14. Density distributions for charging PHEVs at home (not shown) appears similar to those for BEVs (Figure 11)—the densities for all six regions show the same tri-modal pattern and all are mostly overlaid atop each other. There are no statistically different differences in means (Tukey Honestly Significant Difference, α = 0.05) or medians (Steel-Dwass, α = 0.05).

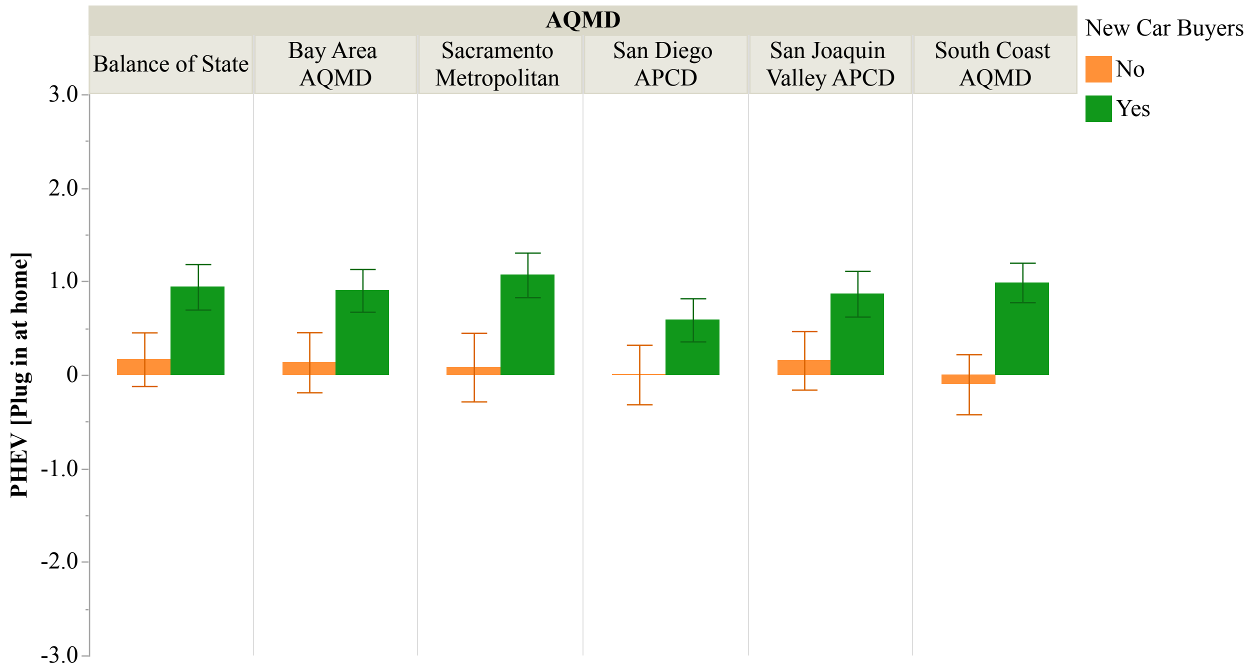


Figure 13: Observed Mean Scores for Capability to Charge a PHEV at Home, Six Regions, CA, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Mean values for all nine assessments of PHEVs are shown by region within CA in Table 14. Analysis of Means tests for whether the mean for each state is different from CA state mean. The state-assessment mean values in Table 14 are shaded according to whether they are statistically significantly ($\alpha = 0.05$) less than (orange), not different from (no shading), or greater than (green) the statewide mean.

The mean assessment scores for PHEVs create a portrait much like that for BEVs:

- On average, participants in all six regions are similarly slightly likely to agree they can charge a PHEV at home.
- Despite some regional average values being positive and others negative, there is no statistically significant regional variation in mean agreement scores for whether there is enough charging for PHEVs—everywhere in the state the mean is at the mid-point of the disagreement-agreement scale.
- In every region, participants agree on average PHEVs take too long to charge—strength of this assessment is a little stronger (more negative) in the SCAQMD than the statewide average and a little weaker (closer to zero) in the SDAPCD.
- In every region, participants agree on average PHEVs do not drive far enough on a charge—the strength of this is a little higher in the BAAQMD than statewide and a little lower in the SDAPCD.
- With no regional variation, PHEVs are assessed to cost more to buy than gasoline vehicles but to be less reliable and less safe gasoline vehicles.
- In every region, PHEVs are assessed to be both less damaging to the environment and ready for the mass market.

- The only regional variation is agreement that PHEVs are less damaging to the environment is, on average, weaker among participants from the Balance of the State than the statewide average.

Table 14: Mean Scores for Nine Assessments of PHEVs across Six Regions, CA, 2021 and comparison to CA state mean; scale -3 (strongly disagree) to +3 (strongly agree)

Vehicle Type [Assessment] (CA mean)	Balance of State	BAAQMD	SMAQMD	SDAPCD	SJVAPCD	SCAQMD
PHEV [Charge at home] (0.532)	0.567	0.599	0.644	0.358	0.492	0.553
PHEV [Enough charging] (-0.026)	-0.211	0.093	0.076	-0.104	-0.057	0.065
PHEV [Too long to charge] (-0.767)*	-0.733	-0.866	-0.799	-0.542	-0.734	-0.928
PHEV [Range too short] (-0.596)*	-0.587	-0.845	-0.460	-0.412	-0.490	-0.738
PHEV [Higher price] (-1.364)*	-1.443	-1.401	-1.352	-1.331	-1.242	-1.406
PHEV [Gasoline safer] (-0.334)*	-0.258	-0.445	-0.268	-0.179	-0.358	-0.477
PHEV [Gasoline more reliable] (-0.699)*	-0.623	-0.754	-0.647	-0.626	-0.691	-0.835
PHEV [Less damage to environment] (1.224)	1.016	1.337	1.300	1.216	1.144	1.343
PHEV [Ready for mass market] (0.0.944)	0.838	1.043	0.946	0.941	0.836	1.050

*Scale inverted so that for all assessments positive values favor PHEVs.

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

The nine linear regression models of the PHEV assessments differ as to which, if any, of the three variables are statistically significant, i.e., whether their parameters can be concluded to be different from zero (Table 15). The variable NCB is statistically significant in seven of the nine models. In four of the PHEV assessment regressions, the Region variable is statistically significant indicating participants in at least one region score their agreement differently than participants in at least one other region—these are the same four assessments that show regional differences in Table 14.

Table 15: Significance of Explanatory Variables in Regression Equations of Nine Assessments of PHEVs in Six Regions of California, 2021

Dependent Variable: Vehicle Type [Assessment]	Effect Tests				
	Term	**DF**	**Sum of Squares**	**F Ratio**	**Prob > F**
PHEV [Charge at home]	NCBs	1	484.617	104.54	<0.0001
	Region	5	25.232	1.089	0.3645
	NCBs*Region	5	20.823	0.898	0.4811
PHEV [Enough charging]	NCBs	1	208.804	54.499	<0.0001
	Region	5	23.941	1.25	0.2831
	NCBs*Region	5	54.376	2.838	0.0146
PHEV [Too long to charge]	NCBs	1	38.102	16.327	<0.0001
	Region	5	42.226	3.619	0.0029
	NCBs*Region	5	11.951	1.024	0.4015
PHEV [Range too short]	NCB	1	22.155	7.932	0.0049
	Region	5	70.632	5.058	0.0001
	NCB*Region	5	25.7	1.84	0.1017
PHEV [Higher price]	NCBs	1	2.596	1.168	0.2800
	Region	5	12.61	1.134	0.3397
	NCBs*Region	5	27.023	2.431	0.033
PHEV [Gasoline safer]	NCBs	1	25.126	9.294	0.0023
	Region	5	34.184	2.529	0.0272
	NCBs*Region	5	10.563	0.781	0.563
PHEV [Gasoline more reliable]	NCBs	1	11.135	4.218	0.0401
	Region	5	15.735	1.192	0.3104
	NCBs*Region	5	11.568	0.876	0.4960
PHEV [Less damage to environment]	NCBs	1	6.988	2.875	0.0900
	Region	5	40.591	3.341	0.0052
	NCBs*Region	5	11.791	0.97	0.4343
PHEV [Ready for mass market]	NCBs	1	70.55	25.68	<0.0001
	Region	5	16.403	1.194	0.3094
	NCBs*Region	5	12.138	0.884	0.4911

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

The results in Table 15 (plus parameter estimates for the nine models (not shown)) are summarized as:

- Participants in different regions within California do not differ in their slight agreement they would be able to charge a PHEV at home, but everywhere throughout the state those who acquired at least one new car rate their agreement higher than do those who did not.
- Those who buy new cars assess whether there are enough places to charge PHEVs as slight agreement in contrast to those who do not buy new cars whose assessment is slight disagreement.
  - While the variable Region is not itself significant, the interaction between NCB and Region indicates this difference between those who buy new cars and those who do not is greater in the SMAQMD and SCAQMD than in other regions.
- Everywhere in CA there is on average, slight agreement PHEVs take too long to charge and do not travel far enough on a charge. New Car Buyers are, on average, less negative in their assessment than those who have not acquired a new car.
- The regression on the assessment for whether PHEVs have higher purchase prices than conventional gasoline vehicles produces the result that neither main effect (Region and NCB) is statistically significant, but their interaction is. On balance this is the most negative assessment, rating moderate agreement that PHEVs cost more to buy.
  - The interaction between Region and NCB allows for the effect of NCB to be different in the SMAQMD than in the SVJAPCD. In the SMAQMD, those who acquired new cars have a much less negative assessment of PHEV range while in the SVJAPCD those who acquired new cars registered more negative assessment than do those who did not acquire a new car.
- Safety and reliability of PHEVs compared to conventional gasoline vehicles both depend on whether participants are New Car Buyers, but only safety also varies by Region.
  - PHEVs are generally assessed to be less safe and reliable and New Car Buyers are *more* negative in these assessments than non-New Car Buyers. The assessment of the relative safety of PHEVs is worse in the BAAQMD and SCAQMD and better in the SDAPCD.
- In every region, PHEVs garner modest agreement they are less damaging to the environment; this varies by region of the state but does not differ between those who do or do not buy new cars.
- In every region, PHEVs garner modest agreement they are ready for mass market—an assessment that does not vary across regions. However, everywhere those who acquired new cars are, on average, stronger in their agreement than are those who did not.

The assessments of PHEVs by participants within CA show broadly similar patterns to those for BEVs. Given the different fueling characteristics of BEVs and PHEVs and the possibility of longer total (gasoline plus electric) driving range, one might expect more differences in assessments of BEVs and PHEVs related to charging infrastructure, driving range, and charging duration. The combining of electricity and gasoline into a single vehicle might also have been expected to produce differences in assessments of safety and reliability vis-à-vis gasoline-only vehicles and effect on the environment.

3.1.6.3 Assessments of FCEVs

There is one fewer assessment of FCEVs than of BEVs and PHEVs as any possibility of home fueling of hydrogen is ignored here. Mean values for the eight FCEV assessment statements for each region are shown in Table 16 and the statistical significance of the variables NCB, Region, and NCB*Region in the regressions for each FCEV assessment are in Table 17. Participants offer this general "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.
- The only regional deviations are even less favorable assessments of the amount of hydrogen fueling, the environmental effects, and readiness for market among participants in the large, heterogenous Balance of the State.

Table 16: Mean Scores for Eight Assessments of FCEVs across and for Six Regions, CA, 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Vehicle Type [Assessment] (mean)	Balance of State	BAAQMD	SDAPCD	SMAQMD	SJVAPCD	SCAQMD
FCEV [Enough fueling] (-0.859)	-1.221	-0.835	-0.629	-0.951	-0.735	-0.729
FCEV [Too long to fuel] (-0.328)*	-0.251	-0.300	-0.455	-0.264	.0.307	-0.419
FCEV [Range too short] (-0.479)*	-0.394	-0.615	-0.540	-0.351	-0.380	-0.598
FCEV [Higher price] (-1.267)*	-1.233	-1.329	-1.235	-1.208	-1.208	-1.378
FCEV [Gasoline safer] (-0.657)*	-0.513	-0.740	-0.639	-0.566	-0.733	-0.747
FCEV [Gasoline more reliable] (-0.847)*	-0.691	-0.920	-0.820	-0.830	-0.903	-0.915
FCEV [Less damage to environment] (1.102)	0.935	1.161	1.264	1.085	0.980	1.214
FCEV [Ready for mass market] (-0.098)	-0.369	-0.104	0.020	00.243	-0.055	0.184

*Scale inverted so that for all assessments positive values favor PHEVs.

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; $\alpha = 0.05$.

Table 17: Significance of Explanatory Variables in Regression Equations of Eight Assessments of FCEVs in Six Regions, CA, 2021

Dependent Variable: Vehicle Type [Assessment]	Effect Tests				
	Term	Degrees of Freedom	Sum of Squares	F Ratio	Prob. > F
FCEV [Enough fueling]	NCB	1	332.371	83.313	<0.0001
	Region	5	97.576	4.892	0.0002
	NCB*Region	5	39.941	2.002	0.0752
FCEV [Too long to fuel]	NCB	1	39.847	17.373	<0.0001
	Region	5	14.541	1.268	0.2749
	NCB*Region	5	8.622	0.752	0.5846
FCEV [Range too short]	NCB	1	19.825	9.024	0.0027
	Region	5	25.944	2.362	0.0378
	NCB*Region	5	24.043	2.189	0.0528
FCEV [Higher price]	NCB	1	0.722	0.330	0.5658
	Region	5	13.493	1.232	0.2911
	NCB*Region	5	30.119	2.751	0.0174
FCEV [Gasoline safer]	NCB	1	53.428	22.022	<0.0001
	Region	5	26.378	2.175	0.0543
	NCB*Region	5	3.504	0.289	0.9194
FCEV [Gasoline more reliable]	NCB	1	36.855	16.371	<0.0001
	Region	5	17.893	1.590	0.1595
	NCB*Region	5	2.326	0.207	0.9598
FCEV [Less damage to environment]	NCB	1	12.861	5.677	0.0173
	Region	5	39.416	3.480	0.0039
	NCB*Region	5	10.788	0.952	0.4459
FCEV [Ready for mass market]	NCB	1	73.729	23.889	<0.0001
	Region	5	90.717	5.879	<0.0001
	NCB*Region	5	11.148	0.722	0.6066

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

Turning to questions of whether the eight assessments of FCEVs differ by Region controlling for whether participants are New Car Buyers or not and allowing this to differ by Region, the results are summarized as:

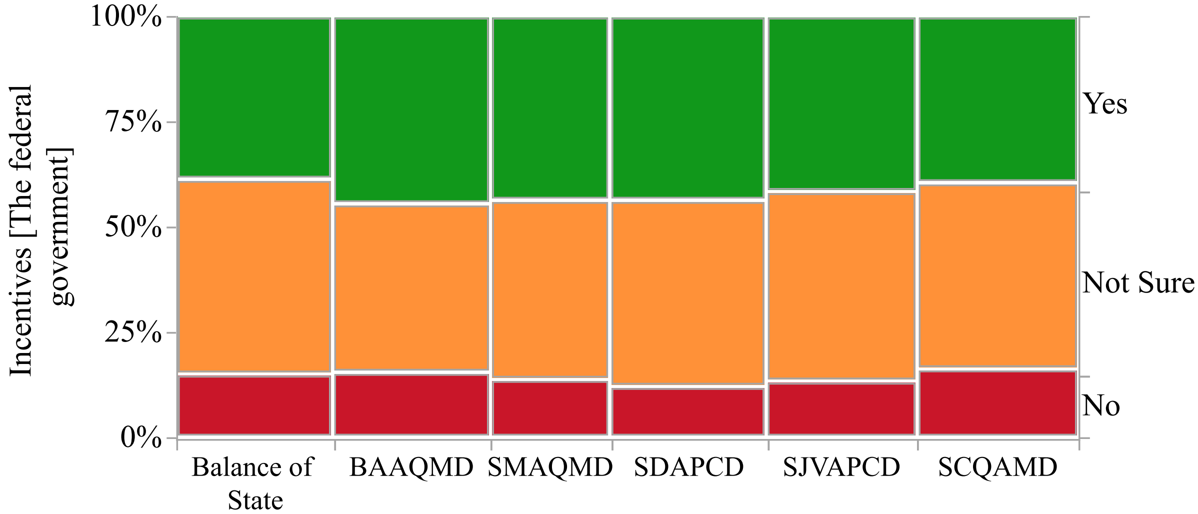
- Differences in assessments of FCEVs depend more consistently on the distinction between New Car Buyers than between regions; seven of the eight assessments differ by NCB while four of eight differ by Region.
- Assessments of whether there are enough places to fuel FCEVs are negative everywhere and though differences depend on both Region and NCB, the difference between those who have and have not acquired a new car since 2014 are greater than the differences between regions.

- There is similarly slight agreement regions that FCEVs take too long to fuel. New Car Buyers average statistically significantly stronger agreement, i.e., a worse assessment, than non-New Car Buyers.
- Driving range of FCEVs is generally regarded as too short. The strength of this assessment depends on both NCB and Region to similar degrees. The crossed effect NCB*Region (which is marginally significant) produces different effects most notably in the BAAQMD (producing much more negative assessments of FCEV driving range among New Car Buyers) and the SDAPCD (producing somewhat less negative assessments among New Car Buyers).
- Everywhere, FCEVs are assessed to be more expensive to purchase than conventional gasoline vehicles. Neither of the main effects for NCB nor Region are significant, but their interaction effect is. The result is that in the SMAQMD, New Car Buyers have much better (though still negative) assessments of FCEV purchase prices while the situation is reversed in the SDAPCD and SJVAPCD.
- With no difference between regions, FCEVs are assessed to be less safe and less reliable than conventional gasoline vehicles—more strongly by New Car Buyers.
- While FCEVs are assessed, on average, to be less damaging to the environment than conventional gasoline vehicles, these assessments differ by NCB and Region. New Car Buyers are likely to agree more strongly FCEVs are less damaging. Participants in the SMAQMD and SCAQMD more strongly agree; those in the Balance of State and SJVAPCD less strongly agree. Differences between Regions tend to be larger than differences due to NCB.
- FCEVs are generally assessed to not be ready for mass market, but the distinctions due to NCB and Region produce subsets of participants who at a minimum don't have an average negative assessment of FCEVs market readiness: New Car Buyers in SMAQMD and SCAQMD.

3.1.7 Incentives for ZEVs

The distributions of awareness that the federal government offers incentives to consumers to purchase vehicles powered by alternatives to gasoline and diesel are shown in Figure 14. There is no statistically significant difference across the six regions: in all six regions about 42% of participants say they have heard of federal incentives. Though this value ranges from 38% (Balance of State) to 44% (BAAQMD), the χ^2 test is non-significant (even given the large sample size). Further, as indicated by the small Uncertainty Coefficient C|R (0.021) knowledge of participants' region does little to improve a prediction of whether they have heard of federal incentives.

If "I'm not sure" and "No" are equivalent, the measure can be recoded as simply "No" or "Yes." A nominal logistic regression is performed on this variable using Region, NCB, and NCB*Region as explanatory variables. The model parameter significance tests are in Table 18. Results show NCB is statistically significant and the parameter estimates indicate the odds-ratio a participant who acquired at least one new car since 2014 has heard of federal incentives are 1.30 times greater than the odds of a participant who acquired only used cars or no cars. The parameters of the (statistically significant) interaction term are such that there is relatively little difference by NCB in the BAAQMD (about 45% regardless of NCB), slight differences in the Balance of the State, SMAQMD, SDAPCD, and SJVAPCD, but a large difference in the SCAQMD. In the latter, New Car Buyers have the highest rate of awareness of federal incentives (49%) while non-New Car Buyers have the lowest (30%).



n = 2,994; degrees of freedom = 10; χ^2 =11.017; probability > χ^2 = 0.3562

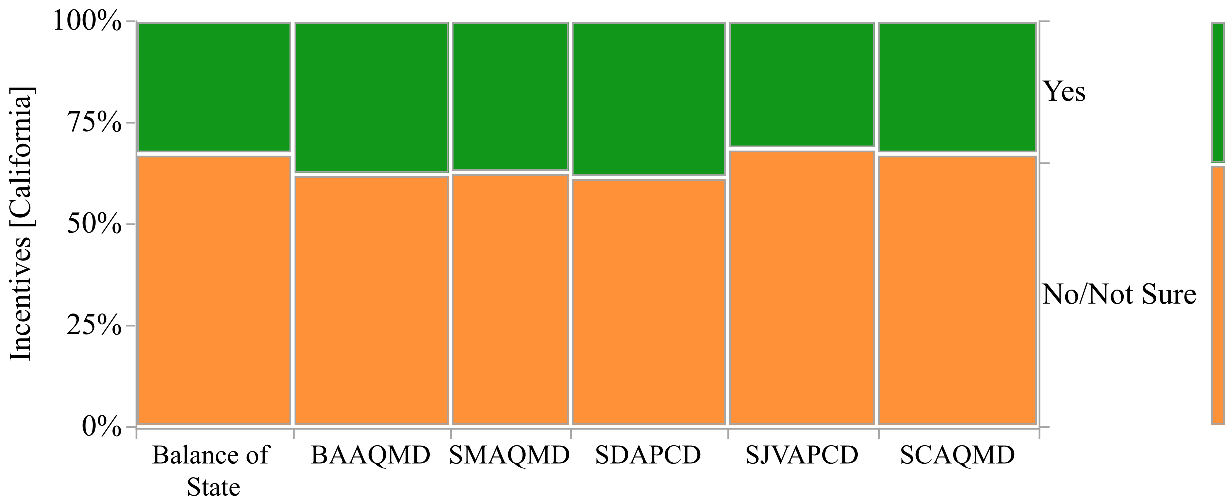
Figure 14: Awareness of Federal Incentives across Six Regions, CA, 2021; percent

Table 18: Significance of Explanatory Variables in Regression of Awareness of Federal Incentives in Six Regions, CA, 2021

Dependent Variable	Effect Tests			
	Term	**Degrees of Freedom**	**Likelihood Ratio**	**Prob. > Chi-Square**
Incentives [Federal]	NCB	1	12.136	0.0005
	Region	5	8.269	0.1420
	NCB*Region	5	13.080	0.0226

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

As this analysis is conducted entirely within in California and as the state's Clean Vehicle Rebates are available to residents anywhere in the state, that program serves as a basis to measure whether awareness of state incentives varies by region within the state. The distributions of the percent of participants who've heard of incentives from the State of California are shown by region in Figure 15 (where "no" and "not sure" have been combined). Though the percentage of all car-owning households who have heard of state incentives varies from a low of 31% (SJVAPCD) to a high of 38% (BAAQMD and SDAPCD), the null hypothesis of homogeneity of proportions is not rejected, i.e., there is no basis to conclude awareness of state incentives varies across the six regions.



n = 2,994; degrees of freedom = 5; χ^2 =10.758; probability > χ^2 = 0.0564

Figure 15: Awareness of California State Incentives across Six Regions, CA, 2021; percent

However, if the possibility of a difference in awareness of state incentives between New and non-New Car Buyers is allowed, there may be differences between a few regions. Based on results of a nominal logistic regression on awareness of state incentives in Table 19, we conclude there is no difference between New Car Buyers and non-New Car Buyers, but there are differences between at least some regions. The estimated odds-ratios in Table 20 indicate that—controlling for any effect of New Car Buyer status and any interaction between it and Region—the odd-ratio that a participant from the SJVAPCD has heard the State of California is offering incentives is only about 0.75 times the odds-ratio in the BAAQMD, SMAQMD, and SDAPCD. Additionally, participants in the SCAQMD are also less likely to have heard of California state incentives than those in the BAAQMD.

Table 19: Significance of Explanatory Variables in Regression of Awareness of California State Incentives, Six Regions, CA, 2021

Dependent Variable	Effect Test			
	Term	Degrees of Freedom	Likelihood Ratio Chi-Square	Prob. > Chi-Square
Incentives [California]	NCB	1	0.026	0.8717
	Region	5	11.700	0.0392
	NCB*Region	5	6.614	0.2509

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

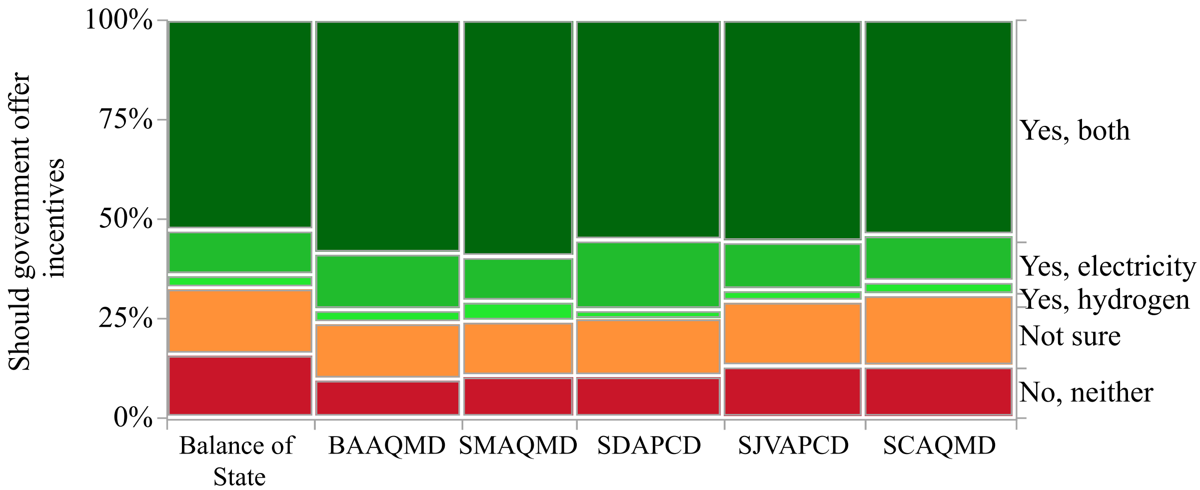
Table 20: Statistically Different Odd-Ratios for Awareness California offers Incentives between Pairs of Regions in CA controlling for New Car Buyer Status, $\alpha \leq 0.05$

	BoS	BAAQMD	SMAQMD	SDAPCD	SJVAPCD	SCAQMD
BoS						
BAAQMD					1.370	1.317
SMAQMD					1.332	
SDAPCD					1.346	
SJVAPCD		0.730	0.751	0.743		
SCAQMD		0.759				

Notes: "BoS" = Balance of State. Shading indicates significance; $\alpha \leq 0.01$, $0.01 < \alpha \leq 0.05$. Odds-ratios not significantly different from 1.00 are omitted.

3.1.7.1 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 across regions are shown in Figure 16. Participants everywhere are likely support such incentives. Two-thirds to three-fourths of participants support incentives to consumers to purchase vehicles powered by (in increasing numbers) hydrogen only, electricity only, or both. In all six regions, more than half support incentives for both hydrogen and electricity. Though there are statistically significant differences between regions, the differences are substantively slight. The Uncertainty Coefficient C|R = 0.0045 is so small as to reinforce the conclusion there is little practical improvement in predicting whether a participant supports incentives given knowledge of their region.



n = 2,994; degrees of freedom = 20; χ^2 =35.023; probability > χ^2 = 0.02

Figure 16: Support for Government Incentives, Six Regions, CA, percent

A logistic regression equation on support for government incentives for electricity and hydrogen is estimated using NCB, Region, and NCB*Region as explanatory variables. The parameter significance tests are shown in Table 21. The model results show that for whatever differences appear to exist by region, the statistically significant difference is due to NCB. However, the difference is such that New Car Buyers are less likely to support incentives for hydrogen, electric, or both types of vehicles than are those who purchased only used vehicles or none.

Table 21: Significance of Explanatory Variables in Regression of Support for Government Incentives, Six Regions, CA, 2021

Dependent Variable	Effect Tests			
	Term	Degrees of Freedom	Likelihood Ratio Chi-Square	Prob. > Chi-Square
Support for Government Incentives	NCB	4	45.954	< 0.0001
	Region	20	28.830	0.0914
	NCB*Region	20	9.544	0.9757

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

3.1.8 Consideration

The distributions of PHEV, BEV, and FCEV Consideration are presented first for all participants in California as well as the value for consideration of PHEVs *or* BEVs (PEV Consideration) and consideration of PHEVs, BEVs, or FCEVs (ZEV Consideration) in Figure 17. Following this, any differences between the six regions within California are tested for significance and differences correlated with New Car Buyer status (Figure 18).

Given how the measures of PEV and ZEV Consideration are defined, their comparisons to the measures of the individual vehicle types are as expected: the percentage of people who claim they won't consider any type of ZEV is lower than the percentages of those who say they won't consider a specific type of ZEV. Conversely, though difficult to perceive since so few people are at the highest levels of Consideration, more people have actively shopped, owned, or have owned any type of ZEV than a particular type of ZEV. For example, statewide 3.1% of participants report they own or have owned a PHEV, 3.1% report they own or have owned a BEV, while 5.3% reporting they own or have owned one or the other.

Differences between the regions conform to expectations from knowledge of where ZEV ownership is higher (Figure 18). The SCAQMD, BAAQMD, and SDAPCD (in declining order) report the highest levels of ZEV ownership and active shopping for ZEVs—levels approaching twice that for the SJVAPCD. One insight though from measuring the full spectrum of Consideration rather than only the highest level of ZEV sales and leases is it reveals that the SCAQMD exhibits the most divergence in ZEV consideration—while it reports among the highest rates of high levels of consideration it is also true that only the SJVAPCD shows higher rates of ZEV rejection than the SCAQMD.

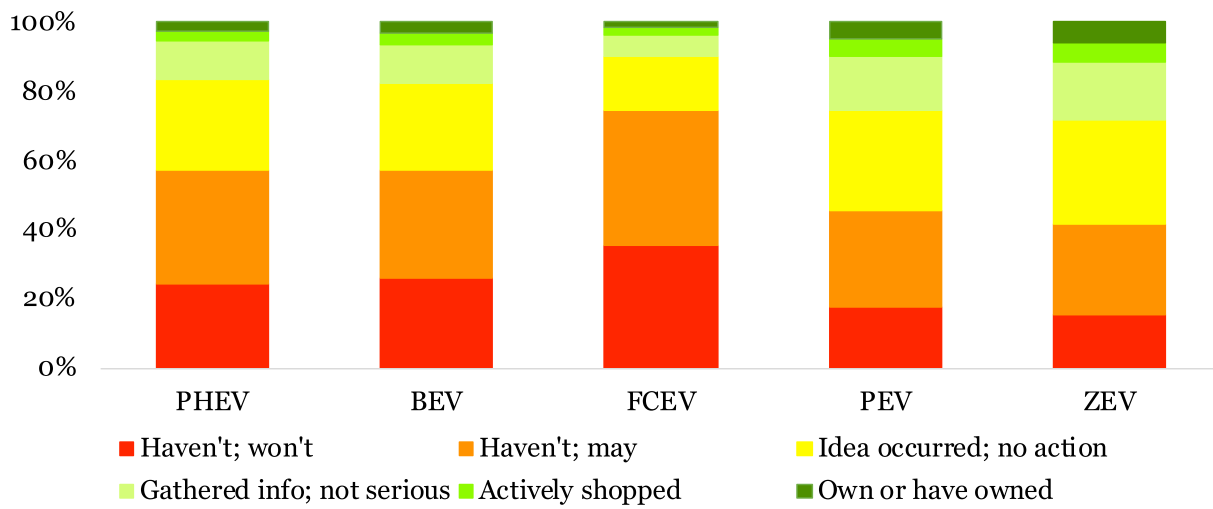
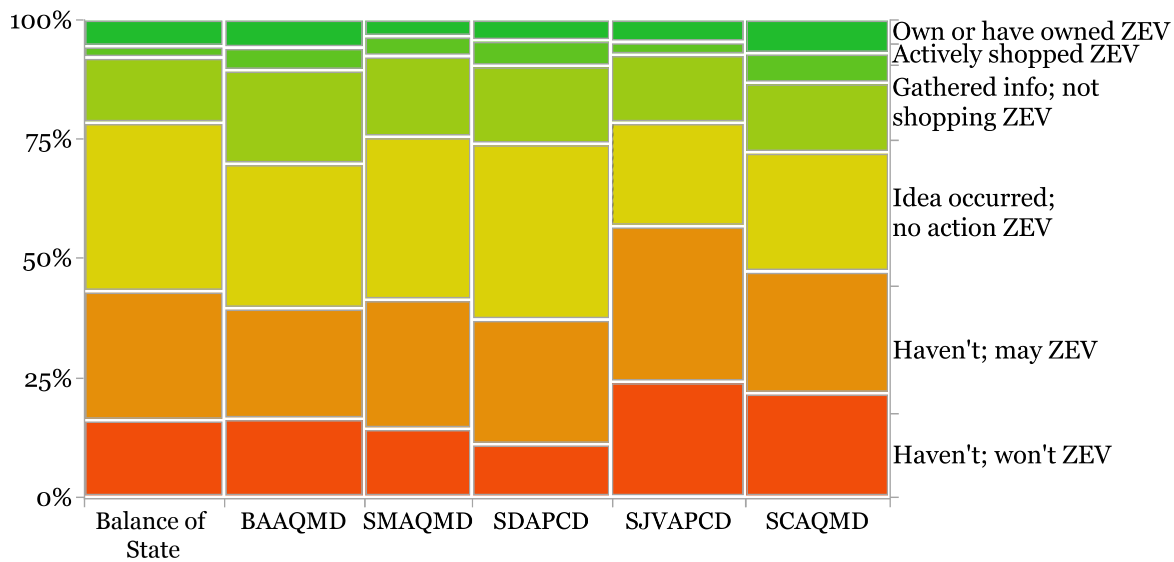


Figure 17: Consideration of PHEVs, BEVs, FCEVs, PEVs, and ZEVs, CA, 2021; percent



n = 2,994; degrees of freedom = 25; χ^2 = 105.00; probability > χ^2

Figure 18: Consideration of ZEVs by Six Regions, CA, 2021; percent

Logistic regression equations are estimated on PEV and ZEV Consideration using NCB, Region, and their crossed effect as explanatory variables. The significance of the parameter estimates for the two models are shown in Table 22. All three variables are statistically significant in both models. Results are such that in every region those who acquired at least one vehicle as new since 2014 are more likely to be at higher levels of PEV and ZEV Consideration than are those who acquired only used vehicles or no vehicles over the same interval. The interaction effect is interpreted as an adjustment to the regional effect based on new car buyer status. In the SJVAPCD the probability of being at higher levels of consideration is lower for New Car Buyers than in other regions (all of whom have similar estimated probabilities). However, among those who acquired only used cars or no cars, participants in the SCAQMD join those in the SJVAPCD as being more likely to be at the lowest level of PEV and ZEV Consideration (30 to 31%) compared to all the other regions (18 to 23%).

Table 22: Effect Significance for Models of PEV Consideration and ZEV Consideration for Six Regions, CA 2021

Model:	PEV Consideration			ZEV Consideration		
Source	DF	L-R χ^2	Prob. > χ^2	DF	L-R χ^2	Prob. > χ^2
New Car Buyer (NCB)	1	56.833	< 0.0001	1	64.498	< 0.0001
Region	5	33.644	< 0.0001	5	33.971	< 0.0001
NCB*Region	5	15.541	0.0083	5	13.415	0.0198

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

The estimated probabilities of ZEV Consideration by Region and NCB are shown in Figure 19. In all regions new car buyers are estimated to be more likely to have given more consideration to ZEVs than non-new car buyers. The least difference between new and not new car buyers is estimated to be in the BAAQMD (shallowest lines connecting the left to right sides of the column) while the greatest difference is in the SJVAPCD and the SCAQMD (steepest lines from left to right within their respective columns). These two are also the two with the highest estimated percentage of people haven't considered a ZEV whether they won't or may eventually.

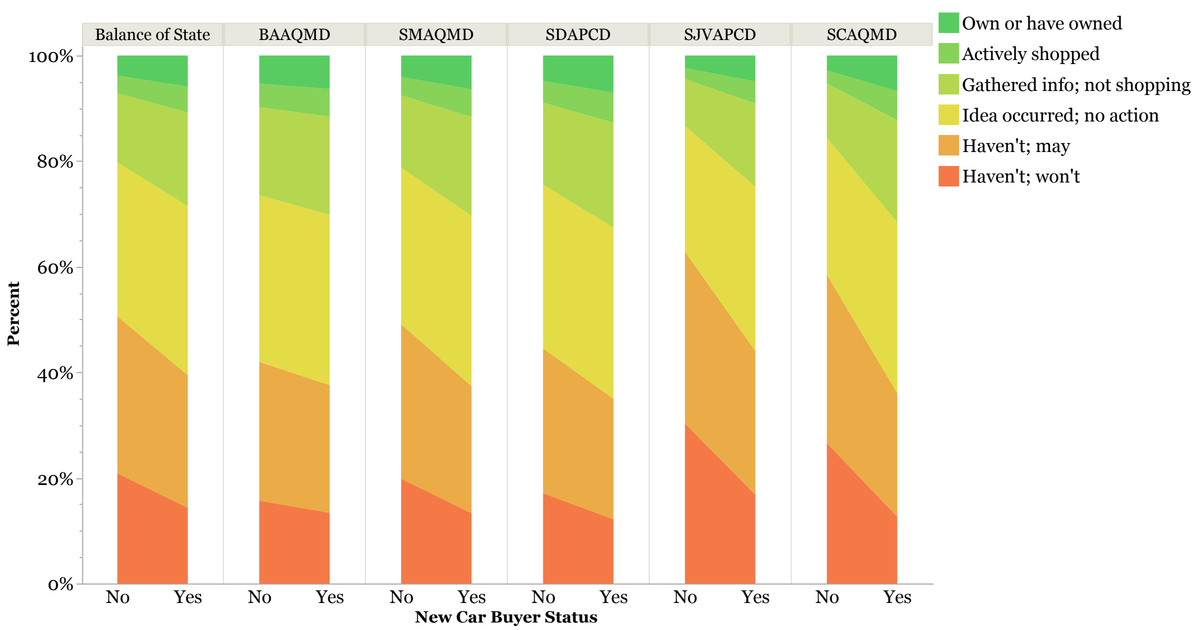


Figure 19: Estimated Probabilities of ZEV Consideration by six regions and new car buyer status, California, 2021; percent

3.2 Differences between 2014 and 2021: Six Regions

This section compares measures of ZEV awareness, knowledge, assessments, and consideration between 2019 and 2021 across the six regions of California defined by air districts. Unlike the multi-state comparative analysis in Volume 1 which compared 2014 to 2021, data for both the years analyzed here contain both New Car and non-New Car Buyers. So, while it is not strictly required to be able to test the differences between years, hypotheses pertaining to the relative familiarity with different vehicle types between New Car Buyers and non-New Car Buyers are sufficiently interesting to include the NCB variable here. However, because data from both 2019 and 2021 contain both values of the NCB variable, it does not have to be nested within Year as it had to be in the analyses in Volume 1. Thus, this section tests the general hypothesis of differences between regions and across years controlling for any possible differences between households who acquired new cars and those who did not. The independent variables required to do this are Year, Region, their interaction (Year*Region), and NCB.

3.2.1 Familiarity

As before, Familiarity 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 Region and Year in Figure 20. There are few substantive differences in average familiarity with different vehicle types between 2019 and 2021 within any region.

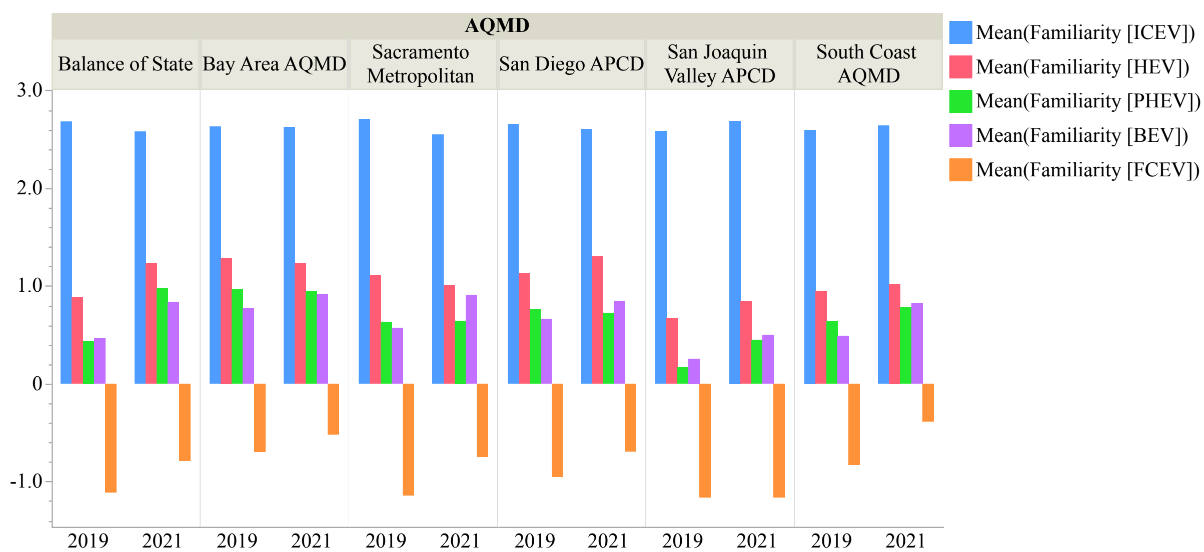


Figure 20: Familiarity with Vehicle Types in 2019 and 2021across Six Regions, CA, original scale -3 to +3; mean scores

Regression models are estimated on the five familiarity measures using Year, Region, New Car Buyer (NCB), as well as Year crossed with Region (Year*Region). The purpose of the models is to test whether there is reason to believe there are differences across time (controlling for the effects of Region and NCB) and between regions (controlling for Year and NCB). All five models provide a fit that is superior to fitting only the intercepts. The effect tests for all five models are summarized in Table 23 and parameter estimates in Table 24. Variables are assessed for their importance to the estimated values of familiarity scores assuming independent, resampled inputs.

Table 23: Significance of Effect Tests for Models of Familiarity with ICEV, HEVs, PHEVs, BEVs, and FCEVs between 2019 and 2021 across Six Regions, CA

Familiarity: ICEVs	Degrees of Freedom	Sum of Squares	F Ratio	Probability > F
Year	1	0.862	0.947	0.3306
Region	5	5.927	1.302	0.2599
NCB	1	8.783	9.647	0.0019
Year*Region	5	11.097	2.438	0.0324
HEVs				
Year	1	7.669	1.68	0.1949
Region	5	120.705	5.289	<0.0001
NCB	1	437.796	95.91	<0.0001
Year*Region	5	37.425	1.64	0.1458
PHEVs				
Year	1	22.261	4.6	0.0320
Region	5	191.19	7.901	<0.0001
NCB	1	547.549	113.135	<0.0001
Year*Region	5	73.083	3.02	0.0100
BEVs				
Year	1	89.863	18.187	<0.0001
Region	5	80.068	3.241	0.0063
NCB	1	398.821	80.717	<0.0001
Year*Region	5	12.853	0.52	0.7612
FCEVs				
Year	1	84.573	18.672	<0.0001
Region	5	79.932	3.53	0.0035
NCB	1	540.868	119.416	<0.0001
Year*Region	5	35.616	1.573	0.1641

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

3.2.1.1 Familiarity with ICEVs

- On average participants are very certain they are familiar enough with ICEVs to be able to consider one for their household in all regions, in both years, and whether they acquired any new cars in the seven years prior to completing their questionnaire.
- Controlling for Year, Region, and their interaction, households who did not acquire any new cars in the seven years prior to completing their questionnaire

are more familiar with ICEVs than are those who did acquire at least one new car over the same interval. Among Year, Region, and NCB, the distinction between New and non-New Car Buyers has the largest direct effect on ICEV Familiarity.

- Neither Year nor Region is statistically significant, but their interaction is.
  - The model suggests there is no difference in familiarity with conventional vehicles between years or regions—but there are statistically significant differences in how participants in different regions rate their familiarity at the two points in time (or how the Year cohorts score across regions). Specifically, ICEV familiarity scores for participants in the SMAQMD are lower in 2021 than in 2019; the opposite is true for those in the SJVAPCD.

3.2.1.2 Familiarity with HEVs

- Overall, participants' mean familiarity with HEVs is less than that for ICEVs in both years and all regions. The mean HEV Familiarity score of about +1.0 is interpreted as slightly familiar with HEVs.
- NCB is by far the most influential variable in estimating differences in familiarity with HEVs: New Car Buyers (1.22) rate themselves a half-point higher than non-New Car Buyers (0.73).
- There is no difference by Year, even allowing for its interaction with Region: familiarity with HEVs is not higher in 2021 than it was in 2019.
- There are significant differences between regions. Mean scores (across both years) are higher than 1.0 in the BAAQMD, SMAQMD, and SDAPCD but lower than 1.0 in the SCAQMD, Balance of State, and SJVAPCD. Estimated means range from a high of 1.24 for the BAAQMD to a low of 0.69 for the SJVAPCD.

3.2.1.3 Familiarity with PHEVs

- Participants' mean scores for familiarity with PHEVs, while positive, are less than for HEVs; the mean PHEV familiarity score is 0.65.
- Though all four effects (Year, Region, Year*Region, and NCB) are statistically significantly associated with differences in PHEV familiarity, NCB is the most influential. New Car Buyers' mean PHEV familiarity is estimated to be 0.83; non-New Car Buyers' is 0.29.
- The second most influential variable is Region. As with HEVs, participants from the BAAQMD have the highest estimated familiarity (0.90) and those in the SJVAPCD (0.18). The estimated means for the SDAPCD, SMAQMD, and SCAQMD are similar to each other (0.66 to 0.57), though of these three only the SDAPCD and SMAQMD are significantly higher than the SJVAPCD. Only the BAAQMD is statistically significantly higher than the Balance of the State (0.42).
- Though statistically significant, Year has the smallest effect on PHEV familiarity, even accounting for its interaction with Region. PHEV familiarity is estimated to be higher in 2021 (0.72) than in 2019 (0.56).
- The Year*Region interaction is such that the higher scores in the Balance of State in 2021 compared to 2019 are more different from each other than are the differences in other regions.

Table 24: Parameter Estimates for Regression Models of Familiarity with ICEV, HEVs, PHEVs, BEVs, and FCEVs between 2019 and 2021 across Six Regions, CA

	ICEV		HEV		PHEV		BEV		FCEV	
Term	Estimate	Prob>|t|	Estimate	Prob>|t|	Estimate	Prob>|t|	Estimate	Prob>|t|	Estimate	Prob>|t|
Intercept	2.642	<0.0001	1.003	<0.0001	0.599	<0.0001	0.535	<0.0001	-0.983	<0.0001
Year [2021-2019]	-0.023	0.3306	0.070	0.1949	0.119	0.0320	0.239	<0.0001	0.232	<0.0001
Region [BoS]	0.037	0.2870	-0.104	0.1862	-0.145	0.0724	-0.053	0.5137	-0.109	0.1623
Region [BAAQMD]	-0.010	0.7819	0.267	0.0008	0.345	<0.0001	0.219	0.0084	0.267	0.0008
Region [SMAQMD]	0.062	0.1774	0.112	0.2823	0.042	0.6924	0.041	0.7034	-0.150	0.1474
Region [SDAPCD]	0.014	0.6844	0.110	0.1571	0.144	0.0703	0.113	0.1610	0.014	0.8588
Region [SJVAPCD]	-0.062	0.0824	-0.298	0.0002	-0.391	<0.0001	-0.244	0.0035	-0.140	0.0796
Region [SCAQMD]	-0.042	0.1901	-0.087	0.2251	0.005	0.9471	-0.076	0.3069	0.119	0.0949
NCB[No]	0.037	0.0019	-0.259	<0.0001	-0.290	<0.0001	-0.247	<.0001	-0.288	<0.0001
NCB[Yes]	-0.037	0.0019	0.259	<0.0001	0.290	<0.0001	0.247	<.0001	0.288	<0.0001
Year [2021-2019]* Region [BoS]	-0.077	0.1377	0.255	0.0284	0.390	0.0011	0.106	0.3820	0.061	0.5971
Year [2021-2019]* Region [BAAQMD]	0.025	0.6384	-0.164	0.1614	-0.175	0.1481	-0.130	0.2885	-0.095	0.4157
Year [2021-2019]* Region [SMAQMD]	-0.128	0.0430	-0.216	0.1259	-0.156	0.2845	0.058	0.6939	0.113	0.4221
Year [2021-2019]* Region [SDAPCD]	-0.022	0.6654	0.064	0.5782	-0.199	0.0951	-0.092	0.4431	-0.015	0.8998
Year [2021-2019]* Region [SJVAPCD]	0.130	0.0141	0.083	0.4863	0.139	0.2543	-0.016	0.8942	-0.256	0.0305
Year [2021-2019]* Region [SCAQMD]	0.072	0.1449	-0.022	0.8447	0.000	0.9970	0.075	0.5174	0.191	0.0833

Notes: BoS = Balance of State.

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

3.2.1.4 Familiarity with BEVs

- Overall, familiarity with BEVs is similar to familiarity with PHEVs; the estimated mean BEV familiarity score is 0.63.
- The three main effects (Year, Region, and NCB) are all statistically significant; NCB is clearly the most important to estimating differences in BEV familiarity. New Car Buyers—while still only rating very slight familiarity—are estimated to have higher scores (0.71) than non-New Car Buyers (0.26).
- In contrast to PHEVs, Year is second most important, not Region. BEV familiarity is estimated to higher in 2021 (0.78) than in 2019 (0.49).
- The only statistically significant difference between regions is between the BAAQMD (0.68) and the SJVAPCD (0.27).

3.2.1.5 Familiarity with FCEVs

- FCEVs are the only vehicle type for which participants, on average, score themselves as unfamiliar; the overall mean score is -0.87.
- NCB is the effect that is most important to estimating differences: New Car Buyers are estimated to be less unfamiliar ((-0.75) than non-New Car Buyers (-1.29).
- Region is second most important, though as with BEVs only the difference between the BAAQMD (-0.76) and the SJVAPCD (-1.12) is statistically significant.
- Though Year is the least important variable to determining differences in FCEV Familiarity, familiarity with FCEVs is estimated to be higher in 2021 (-0.75) than in 2019 (-1.02).

3.2.2 Naming ZEVs

In 2019, participants who said they could name a BEV or PHEV were not asked if they could name in a second such vehicle as was asked in 2021. Therefore, the comparison of 2019 and 2021 samples' ability to name PEVs focuses only on naming one. Further, the distinction between simply stating one cannot name a PHEV or BEV on the one hand and saying you can but being wrong on the other is simplified; no answer and a wrong answer are both counted as not being able to provide a correct answer. The values of this version of the "name a BEV/PHEV" variable are:

Neither = able to name neither a PHEV nor a BEV,

PHEV or BEV = able to name a PHEV or a BEV, and

PHEV and BEV = able to name both a PHEV and a BEV.

Using the moderate rules (Table 3) for establishing right and wrong answers, the distributions for 2019 and 2021 are plotted in Figure 21 by Region. Any seeming differences between years within regions appear slight. Differences between regions suggest participants in the BAAQMD and SDAPCD may be more likely to name either a (PHEV or BEV) or (PHEV and BEV). The following analysis assesses whether these appearances amount to statistically significant differences while also controlling for differences by NCB.

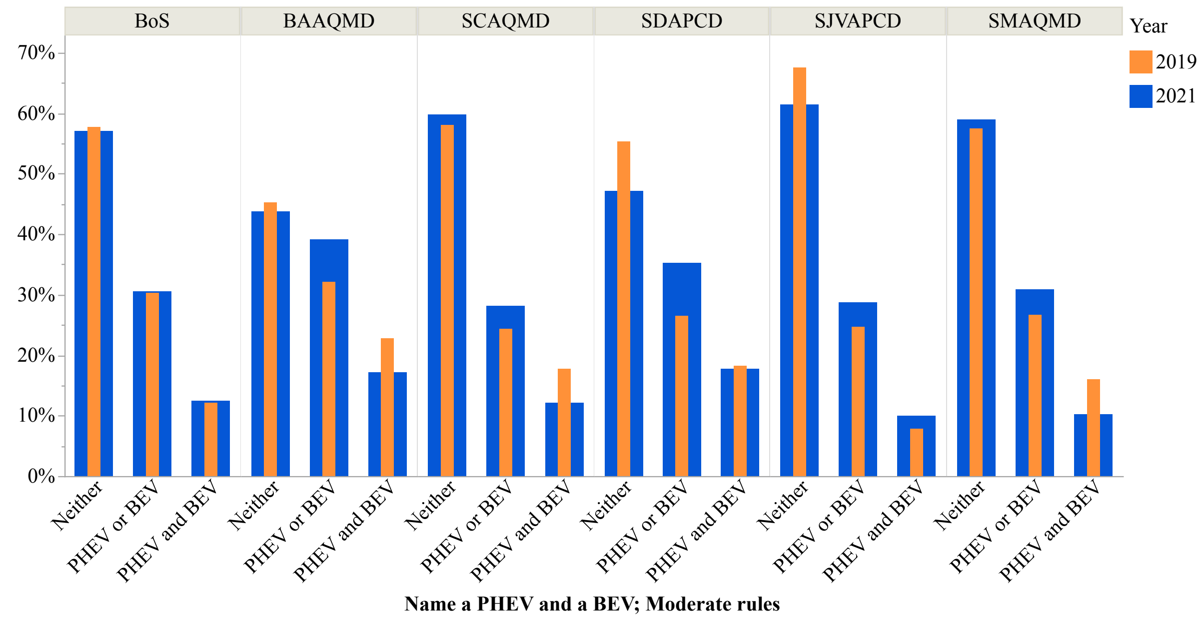


Figure 21: Simplified Measure of Ability to Correctly Name a PHEV or BEV between 2019 and 2021 Across Six Regions in California; Percent within Year and Region

A regression model is estimated on the measure for naming PHEVs and BEVs on Year, Region, New Car Buyer (NCB), and Year crossed with Region (Year*Region). The fitted model is in Table 24. The model's fit to the data is superior to fitting only the intercepts. All parameters are statistically significant. The model in Table 22 confirms there are statistically significant effects which support the initial impressions from Figure 20:

- The overall effect of Year is that fewer participants in 2021 are estimated to be able to correctly name PHEVs and/or BEVs than could do so in 2019.
- The model confirms differences between regions.
    - In both years and across New and non-New Car Buyers, participants in the BAAQMD are most likely to be able to name a PHEV and/or a BEV, followed closely by those in the SDAPCD.
    - Participants in the SJVAPCD are estimated to be least likely to be able to name a PHEV and/or a BEV.
- The interaction between Year and Region is such that instances of correctly naming a PHEV and/or a BEV increased most (or decreased least) from 2019 to 2021 in the SJVAPCD and SDAPCD.
    - There is no difference between 2019 and 2021 in the Balance of the State.
- New Car Buyers are estimated to be more likely to be able to name a PHEV and/or a BEV in both years and in all regions.

Table 25: Regression of Naming a PHEV and BEV, 2019 and 2021 across Six Regions, CA

Whole Model

Model	-LogLikelihood	DF	χ^2
Difference	116.989	24	233.978
			Prob > χ^2
Full	6300.627		
Reduced	6417.616		<0.0001

Parameter Tests

Source	DF	L-R χ^2	Prob> χ^2
Year	2	18.417	0.0001
NCB	2	56.838	<0.0001
Region	10	122.293	<0.0001
Year*Region	10	18.713	0.0441

Parameter Estimates

Term	Estimate	Std Error	χ^2	Prob> χ^2
Intercept: Neither/And	1.422	0.04	1275.90	<0.0001
Year[2019]	-0.069	0.039	3.141	0.0763
NCB[No]	0.280	0.038	55.163	<0.0001
Region[BoS]	0.139	0.086	2.647	0.1037
Region[BAAQMD]	-0.553	0.077	51.183	<0.0001
Region[SCAQMD]	0.037	0.078	0.221	0.6382
Region[SDAPCD]	-0.323	0.077	17.642	<0.0001
Region[SJVAPCD]	0.565	0.097	33.812	<0.0001
Year[2019]*Region[BoS]	0.074	0.085	0.754	0.3852
Year[2019]*Region[BAAQMD]	-0.076	0.077	0.960	0.3271
Year[2019]*Region[SCAQMD]	-0.148	0.078	3.548	0.0596
Year[2019]*Region[SDAPCD]	0.115	0.077	2.237	0.1347
Year[2019]*Region[SJVAPCD]	0.226	0.097	5.420	0.0199
Intercept: Or/And	0.791	0.043	340.100	<0.0001
Year[2019]	-0.164	0.042	15.341	<0.0001
NCB[No]	0.234	0.041	33.009	<0.0001
Region[BoS]	0.138	0.092	2.240	0.1345
Region[BAAQMD]	-0.153	0.081	3.593	0.0580
Region[SCAQMD]	-0.150	0.086	3.021	0.0822
Region[SDAPCD]	-0.208	0.083	6.325	0.0119
Region[SJVAPCD]	0.317	0.105	9.124	0.0025
Year[2019]*Region[BoS]	0.162	0.092	3.104	0.0781
Year[2019]*Region[BAAQMD]	-0.093	0.081	1.324	0.2500
Year[2019]*Region[SCAQMD]	-0.107	0.086	1.539	0.2148
Year[2019]*Region[SDAPCD]	-0.008	0.083	0.010	0.9214
Year[2019]*Region[SJVAPCD]	0.199	0.105	3.588	0.0582

3.2.3 Seeing PEV Charging

Statewide, there was an increase from 2019 to 2021 in the percentage of participants reporting they had seen "EV charging spots in the parking lots and garages I use." The percentage of people who reported they had not seen or were unsure if they had seen EV charging locations declined from 31% to 25% while almost all the countervailing increase was in people reporting they had seen EV parking in several locations, up from 26 to 32%. Plots of the high density regions (HDR) of the distributions of responses for each of the six regions in California are shown for both years in Figure 22. Comparing the top row of the figure (2019) to the bottom (2021) suggests most of the change occurred in the Balance of the State and SJVAPCD. The BOS distribution was strongly tri-modal in 2019 (as shown by the three non-contiguous dark blue regions) but showed a shift toward more people seeing charging (as indicated by the single dark blue region at the upper end of the scale). This conclusion is reinforced by the fact the mode of the density distribution for the BOS shifted from "no" to "yes, several." Similar changes are seen for the SJVAPCD, though there the mode did not shift as far, from "no" to "yes, a few." In contrast, the modes of the distributions are unchanged from 2019 to 2021 in the other four regions.

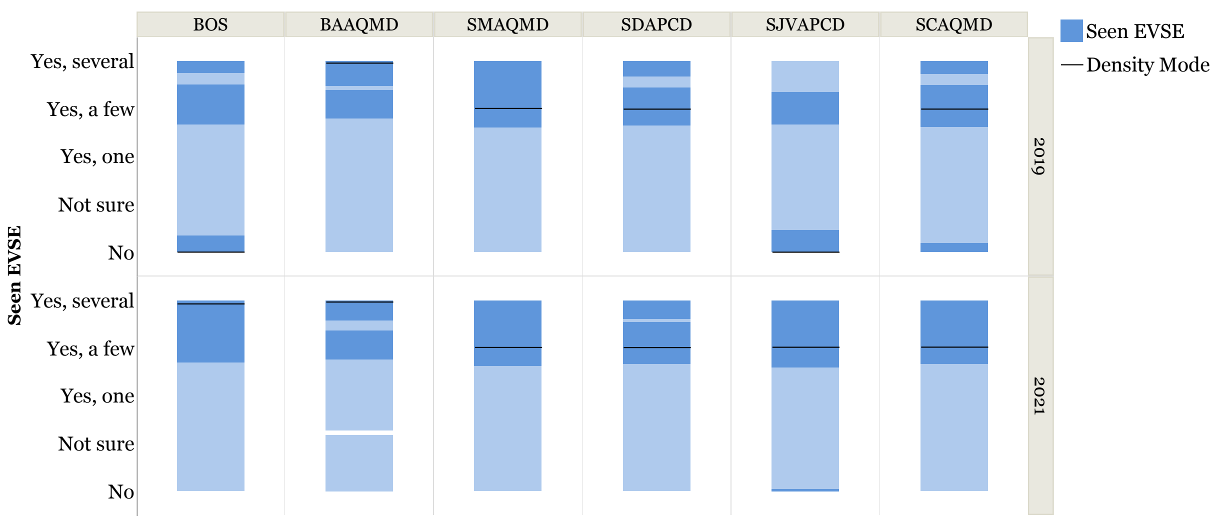


Figure 22: Distributions of "Have seen Electric Vehicle Charging Spots," between 2019 and 2021 Across Six Regions in California; Percent within Year and Region

An ordinal logistic regression equation is estimated on the responses to seeing EV charging: the explanatory variables are Year, Region, NCB, and a crossed effect between Year and Region. Following an initial model estimation on the full range of responses, the response categories "No" and "Not sure" were combined on the assumption there is little practical difference between not seeing charging and not being sure one has seen charging. The substantive interpretation of the model is unchanged by this simplification. The effect tests and parameter estimates based on the reduced response categories are summarized in Table 26.

Table 26: Significance of Effect Tests and Parameter Estimates for Ordinal Logistic Regression on Seeing Electric Vehicle Charging, 2019 and 2021 across Six Regions

Effect Tests	**Degrees of Freedom**	**Likelihood Ratio χ^2**		**Probability > χ^2**
Region	5	200..804		< 0.0001
Year	1	22.230		< 0.0001
NCB	1	58.311		< 0.0001
Year*Region	5	40.472		< 0.0001
Parameter Estimates	**Estimate**	**Standard Error**	**χ^2**	**Probability > χ^2**
Intercept [No; not sure]	-0.777	0.035	495.73	<0.0001
Intercept [Yes, one]	-0.362	0.034	114.79	<0.0001
Intercept [Yes, a few]	1.117	0.036	950.63	<0.0001
Year [2021-2019]	-0.217	0.046	22.13	<0.0001
NCB[No]	0.173	0.023	58.28	<0.0001
Region [Balance of State]	0.285	0.067	17.93	<0.0001
Region [BAAQMD]	-0.504	0.069	54.13	<0.0001
Region [SMAQMD]	-0.341	0.088	14.85	0.0001
Region [SDAPCD]	-0.318	0.066	23.06	<0.0001
Region [SJVAPCD]	0.791	0.071	125.15	<0.0001
Year [2021-2019]* Region [Balance of State]	-0.294	0.099	8.76	0.0031
Year [2021-2019]* Region [BAAQMD]	0.096	0.100	0.92	0.3387
Year [2021-2019]* Region [SMAQMD]	0.372	0.120	9.59	0.002
Year [2021-2019]* Region [SDAPCD]	0.244	0.099	6.12	0.0134
Year [2021-2019]* Region [SJVAPCD]	-0.488	0.103	22.64	<0.0001

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

Region, Year, NCB, and the interaction between Region and Year are all statistically significant; each is correlated with whether participants have seen EV charging locations controlling for the effects of the others. The results confirm the impression given in Figure 22: the interaction effect between Year and Region modifies the main effects of Year and Region.

- The main effect of Year is such that in 2021 across all regions and New and non-New Car Buyers, participants are estimated to be more likely to have seen EV charging at "several locations" and fewer are likely to say they have seen none or are unsure whether they have seen any than in 2019.

- The main effect of Region is such that in both years and across New and non-New Car Buyers, participants in the SJVAPCD and the Balance of the State are least likely to have seen EV charging in several places and more likely to say they have seen none or are unsure whether they have seen any.
- However, the interaction of Year and Region shows the greatest shift toward higher estimated probabilities of seeing EV charging in several places from 2019 to 2021 occurred in the SJVAPCD and the Balance of the State.
    - The SJVAPCD may still show the lowest percentage of participants who have seen several EV charging locations, but it also showed the greatest increase from 2019 to 2021.
    - In contrast, the BAAQMD is estimated to have no significant change in whether participants in that region have seen EV charging in the parking lots and facilities they use.
- The result for NCB suggests that people who acquired at least one new vehicle in the seven years prior to completing their questionnaire are more likely to have seen EV charging and to have seen more EV charging than those who acquired only used vehicles or no vehicles in the same interval.

3.2.4 Knowledge of Vehicle Fueling

Knowledge of how vehicles are fueled was ascertained for ICEVs, HEVs, PHEVs and BEVs. PHEVs and BEVs will be examined separately as will a new variable of their joint value, "PEV fueling." The new variable takes the value -1 if the participant incorrectly identifies how both PHEVs and BEVs are fueled, 0 if they get either one right but the other wrong, and +1 if both are correct. Across all six regions and both years, 56% of participants correctly identify PHEVs both fuel with gasoline and plug-in to charge with electricity, 73% correctly identify BEVs only plug-in to charge, and 51% correctly identify both. The remainder of this section examines the simultaneous effects of the variables Year, Region, Year*Region, and NCB on knowledge of fueling PHEVs and BEVs via logistic regression equations. The parameter effect tests for the three models are summarized in Table 27 and the parameter estimates in Table 28.

It is generally true that Year and Region are statistically significantly related to the percent of people who correctly understand how PHEVs and BEVs are fueled but that the interaction of Year and Region does not modify the main effects in any meaningful way. However, the results do not support a belief that knowledge of fueling of PHEVs and BEVs is getting better over time: the main effect of Year is to reduce the estimated percentage of participants who can correctly identify how PHEVs and BEVs fueled. The difference is approximately a five-percentage point reduction in the percent of correct answers for PHEVs and BEVs individually and a four-percentage point reduction in the percent correct answers for both PHEVs and BEVs jointly. The difference between the highest and lowest percentage correct responses by region is approximately ten-percentage points. In general, the SJVAPCD and SCAQMD score lower than the BAAQMD, BoS, and SMAQMD.

Table 27: Parameter Effect Tests for Knowledge of Fueling PHEVs, BEVs, and PEVs, Six Regions in CA, 2019 and 2021

Dependent Variable	Effect Tests	Degrees of Freedom	Likelihood Ratio χ^2	Probability > χ^2
Fueling: PHEV	Year	1	17.333	< 0.0001
	Region	5	18.743	0.0020
	Year*Region	5	5.423	0.4768
	NCB	1	0.000	0.9884
Fueling: BEV	Year	1	4.367	0.0366
	Region	5	18.223	0.0027
	Year*Region	5	3.530	0.6189
	NCB	1	4.847	0.0277
Fueling: PEV	Year	1	14.631	0.0001
	Region	5	26.480	<0.0001
	Year*Region	5	4.570	0.4705
	NCB	1	1.715	0.1903

Table 28: Parameter Estimates for Knowledge of Fueling PHEVs, BEVs, and PEVs, Six Regions in CA, 2019 and 2021; for log-odds Incorrect/Correct

Dependent Variable	Fueling PHEV		Fueling BEV		Fueling PEV	
Term	Estimate	Prob > χ^2	Estimate	Prob > χ^2	Estimate	Prob > χ^2
Intercept	-0.302	<0.0001	-1.038	<0.0001	(Neither) -1.350 (One right) -0.078	<0.0001 0.0021
Year [2019]	-0.107	<0.0001	-0.060	0.0366	-0.092	0.0001
Region [Balance of State]	-0.115	0.0387	-0.057	0.3663	-0.103	0.0487
Region [BAAQMD]	-0.129	0.0213	-0.208	0.0014	-0.178	0.0008
Region [SMAQMD]	-0.024	0.7175	0.013	0.8661	0.000	0.9991
Region [SDAPCD]	0.011	0.8358	-0.014	0.8234	-0.003	0.9487
Region [SJVAPCD]	0.177	0.0016	0.119	0.0553	0.170	0.0012
Year [2019]* Region[BoS]	0.000	0.9993	0.040	0.5243	-0.016	0.7615
Year [2019]* Region[BAAQMD]	-0.041	0.4664	0.011	0.8695	-0.028	0.5925
Year [2019]* Region[SMAQMD]	-0.042	0.5354	0.047	0.5326	-0.008	0.8961
Year [2019]* Region[SDAPCD]	0.071	0.1945	0.072	0.2439	0.079	0.127
Year [2019]* Region[SJVAPCD]	0.069	0.2161	-0.009	0.8806	0.042	0.4178
New Car Buyers [No]	0.000	0.9884	-0.062	0.0279	-0.031	0.1896

Only for the model of knowledge of fueling BEVs is the variable NCB statistically significant. The effect is such that those who had acquired new cars are less likely to correctly identify how BEVs are fueled. Though the parameter estimate for NCB is statistically significant, the resulting difference is substantively small—about a two-percentage point difference in estimated correct responses.

3.2.5 Assessments of ZEVs

3.2.5.1 BEV Assessments

The same nine assessment statements for BEVs, PHEVs, and FCEVs are used in the 2019 and 2021 studies. As was done previously for the 2021-only results, this comparison of 2019 and 2021 starts with a more detailed presentation of one of the nine assessments before moving on to comparing all of them. Figure 23 shows the density distributions by Region of participants' agreement scores with the statement, "My household would be able to plug in a battery electric vehicle to charge at home," (BEV [Plug in at home]) for 2021 (right) and 2019 (left). The question is, do any of the regional density distributions in 2021 differ from their corresponding distributions in 2019?

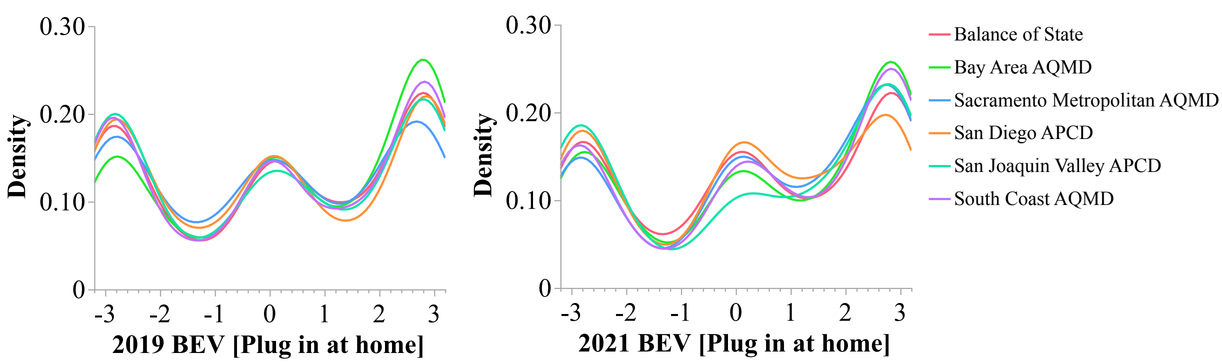


Figure 23: Density Distributions for Participants' Assessments of their Capability to Charge a BEV at Home across Six Regions, California, 2019 (left) and 2021 (right)

The regional mean agreement scores are shown in Figure 24 by Region, Year, and NCB. The figure appears to show:

- On average New Car Buyers are more likely to agree they would be able to charge a BEV at home than are non-New Car Buyers (comparing orange and green columns.
- Average agreement among those who are New Car Buyers is higher in 2021 than it was in 2019 (comparing green columns, top and bottom)
- There is little difference between the two years among those who are non-New Car Buyers (comparing the orange columns between the top and bottom).

The regional patterns appear similar in the two years. A regression equation on the variable BEV:[Plug in at home] is used to address the questions of whether there are grounds to conclude these distributions are different. The variables Year, Region, Year*Region, and NCB are tested. Similar regressions are also run for the other eight BEV Assessments. The effect tests for all nine models are shown in Table 29. As assessment items differed as to whether positive agreement favored BEVs, those statements for which scales were inverted so that positive agreement favor BEVs are indicated with the leading letter "i" in the name.

Figure 24: Mean Agreement Scores for Ability to Charge a BEV at Home across Six Regions in California by New Car Buyer, 2019 and 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Based on the statistically significant effects in Table 29, the parameter estimates for each model, and tests of Variable Importance for each model (not shown), the results for each BEV Assessment Statement are as follows:

- Charge a BEV at Home: While there are statistically significant differences between regions and across years, by far the greatest part of the differences in participants' assessment of whether they can charge a BEV at home is associated with whether they are a New or non-New Car Buyer.
  - The least square mean agreement score for New Car Buyers is 0.72; for non-New Car Buyers, -0.05.
    - The interaction between Year and NCB is such that the difference between New and non-New Car Buyers is larger in 2021 than 2019. The least square means for New and non-New Car Buyers in 2021 were 0.91 vs. -0.04, respectively and 0.53 vs. -0.06 in 2019.
  - The differences between Regions are less than the difference due to NCB; the high estimated mean is in the BAAQMD (0.53) and the low in the SDAPCD (0.18).

- Enough BEV Charging Locations: The overall assessment is one of slight disagreement there are enough places to charge BEVs. Year has the greatest effect on differences followed in order by NCB and Region.
    - The least square means for Year show lower average disagreement, in 2021 (-0.12) than in 2019 (-0.76).
    - Neither New nor non-New Car Buyers have average scores greater than zero, i.e., neither agrees on average there is enough BEV charging.
    - The same is true for Region; no region shows positive mean agreement.
    - The effect of the interaction Year*Region is such that differences between regions are less in 2021 than they were in 2019.
        - The only statistically significant differences in Year-by-Region least square means in 2021 are the higher means in the BAAQMD and SMAQMD compared to the Balance of the State.
- Charging Duration: Participants' assessments of the amount of time to charge BEVs differs by NCB and Region; there is no statistically significant effect of Year on agreement whether "BEVs take too long to charge." Keeping in mind the scale for this assessment has been inverted so that positive values favor BEVs,
    - New Car Buyers have worse assessments of BEV charge duration (-0.95) than non-New Car Buyers (-0.71) and on average, the worst assessment is from participants in the BAAQMD (-0.97).
        - The regional differences are large enough that the mean assessment of BEV charge duration in the BAAQMD is statistically significantly worse than the Balance of the State (-0.77), SDAPCD (-0.77), and the SJVAPCD (-0.74).
- Driving Range: Participants' assessments of the driving range of BEVs differ by Year, Region, and NCB, including an interaction between Year and Region—but are generally slightly negative no matter the year, region, or new car buyer status.
    - On average, participants disagree less strongly in 2021 than in 2019 that "Battery electric vehicles do not travel far enough before needing to be charged." Parsing the double-negative, participants in 2021 agree a little more strongly that BEVs do travel far enough before needing to be charged than did participants in 2019.
    - However, at neither time nor in any region do participants on average register actual positive agreement BEVs can be driven "far enough" before charging.
    - On average New Car Buyers' assessments of BEV driving range are worse than those of non-New Car Buyers.
- BEV Purchase Cost: In both years, all regions, and among New and non-New Car Buyers, there is no statistically significant difference in the average assessment BEVs cost more to buy than conventional vehicles. On average, participants register modest *disagreement* (least square means range from -1.25 to -1.57) that BEVs *don't* cost more, i.e., they do agree BEVs cost more than ICEVs.

Table 29: Significant Explanatory Variables in Regression Equations of Nine Assessments of BEVs in Six Regions of California, 2019 and 2021

Vehicle Type [Assessment]	Parameter tests				
	Term	DF	Sum of Squares	F Ratio	Prob. > F
BEV [Charge at home]	Year	1	63.526	12.732	0.0004
	Region	5	80.803	3.239	0.0064
	NCB	1	954.846	191.371	<.0001
	Year*Region	5	52.239	2.094	0.0631
	Year*NCB	1	50.666	10.155	0.0014
BEV [Enough charging]	Year	1	626.641	163.033	<.0001
	Region	5	183.715	9.559	<.0001
	NCB	1	492.498	128.133	<.0001
	Year*Region	5	77.773	4.047	0.0011
	Year*NCB	1	11.19	2.911	0.088
iBEV [Too long to charge]	Year	1	8.06	3.061	0.0802
	Region	5	45.986	3.493	0.0037
	NCB	1	89.153	33.863	0.0000
	Year*Region	5	28.108	2.135	0.0583
	Year*NCB	1	5.831	2.215	0.1367
iBEV [Range too short]	Year	1	30.832	11.294	0.0008
	Region	5	48.259	3.536	0.0034
	NCB	1	49.424	18.105	0.0000
	Year*Region	5	59.175	4.335	0.0006
	Year*NCB	1	0.179	0.066	0.7978
iBEV [Higher price]	Year	1	4.75	1.917	0.1663
	Region	5	24.034	1.94	0.0844
	NCB	1	1.481	0.597	0.4396
	Year*Region	5	25.345	2.046	0.0692
	Year*NCB	1	0.311	0.125	0.7232
iBEV [Safety]	Year	1	85.802	29.522	0.0000
	Region	5	112.429	7.737	0.0000
	NCB	1	12.549	4.318	0.0378
	Year*Region	5	6.809	0.469	0.8000
	Year*NCB	1	20.276	6.976	0.0083
iBEV [Reliability]	Year	1	3.139	1.182	0.2770
	Region	5	66.85	5.034	0.0001
	NCB	1	9.246	3.481	0.0621
	Year*Region	5	22.506	1.695	0.1322
	Year*NCB	1	6.573	2.475	0.1157
BEV [Environment impact]	Year	1	1.865	0.66	0.4165
	Region	5	103.432	7.324	0.0000
	NCB	1	5.725	2.027	0.1546
	Year*Region	5	23.852	1.689	0.1335
	Year*NCB	1	0.958	0.339	0.5603
BEV [Market ready]	Year	1	273.457	96.278	0.0000
	Region	5	123.722	8.712	0.0000
	NCB	1	175.295	61.717	0.0000
	Year*Region	5	34.97	2.462	0.0309
	Year*NCB	1	8.059	2.837	0.0921

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

- Vehicle Safety: Average assessments of the relative safety of battery electric and gasoline vehicles differ by Year, Region, and NCB.
    - Assessments of the relative safety of battery electric and gasoline vehicles were less favorable to BEVs in 2021 than in 2019.
    - The average assessment is more favorable in the SDAPCD than in any other region, still even in the SDAPCD the mean assessment score is barely better than zero (on the -3 to +3 scale).
    - On average New Car Buyers have worse assessments of the relative safety of BEVs compared to conventional vehicles than do non-New Car Buyers.
- Vehicle Reliability: Average assessments of the relative reliability of battery electric and conventional gasoline vehicles differ significantly only by Region but everywhere favor conventional gasoline vehicles.
    - Across all participants (both years, all regions, both New and non-New Car Buyers) the average assessment is modest agreement that conventional gasoline cars are more reliable than BEVs; the mean score is -0.83.
    - The effect of Region is such that participants in the SDAPCD (-0.70), BAAQMD (-0.75) and Balance of the State (-0.79) have better average assessments of BEV reliability compared to conventional gasoline vehicles than do participants in the SJVAPCD (-1.00). Further, participants in the SDAPCD favor the reliability of BEVs more so than those in the SCAQMD (-0.91).
- Environmental Impact: As with reliability, assessments of the relative environmental damage caused by BEVs and ICEVs differs only by Region. Everywhere in both years and among both New and non-New Car Buyers BEVs draw moderate average agreement they are less damaging to the environment (1.33).
    - Participants in the BAAQMD, SDAPCD, and SCAQMD have higher average agreement scores than those in the Balance of the State. Further, participants in the BAAQMD and SCAQMD have higher average scores than those in the SJVAPCD.
- Market Ready: Across both years, all regions, and New and non-New Car Buyers there is modest agreement BEVs are “ready for mass market”, though this assessment differs by Year, Region, and NCB.
    - The average assessment is higher in 2021 (0.73) from 2019 (0.43).
    - The BAAQMD has the highest mean score.
        - It was statistically significantly higher than the Balance of the State, SMAQMD, and SJVAPVD in 2019.
    - Only in the SMAQMD and SCAQMD is the more favorable assessment in 2021 enough larger than in 2019 for the difference to be statistically significant.
    - New Car Buyers’ average agreement is higher than non-New Car Buyers’.

3.2.5.2 PHEV Assessments

Participants assess PHEVs via nine similar statements as those by which they assess BEVs. The scales are the same, ranging from -3 to +3. Since some assessment states are written to favor PHEVs and others to favor conventional gasoline vehicles, some answer scales have been inverted so positive scores always favor PHEVs. As was done for comparing BEV assessments between 2019 and 2021, this comparison of PHEV assessments starts with a more detailed presentation of one of the nine assessments before moving on to comparing all of them. Figure 25 shows the density distributions by Region of participants' agreement scores regarding the statement, "My household would be able to plug in a plug-in hybrid electric vehicle to charge at home," (PHEV[Plug in at home]) for 2019 (left) and 2021 (right). The densities show distinct modes at the minimum, center, and maximum values, though the highest mode in both years and all regions is at the highest level of agreement. It appears possible that in all regions but SDAPCD, this high level of agreement is shifted slightly higher in 2021 than in 2019, i.e., perhaps a few more people are certain they could charge a PHEV at home.

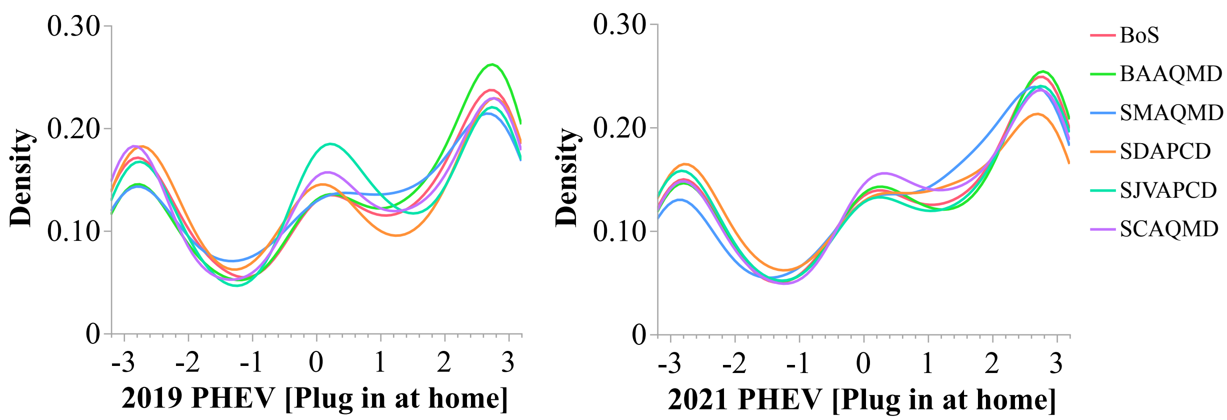


Figure 25: Density Distributions for Participants' Assessments of their Capability to Charge a PHEV at Home across Six Regions, California, 2019 (left) and 2021 (right)

The regional mean agreement scores are shown in Figure 26 by Region, Year, and NCB. The figure appears to show similar results as for BEVs in Figure 24:

- On average agreement is higher among New Car Buyers than non-New Car Buyers (comparing orange and green columns.
- Average agreement among those who are New Car Buyers is even higher in 2021 than it was in 2019 (comparing green columns, top and bottom)
- There is little difference between the two years among those who are non-New Car Buyers (comparing the orange columns between the top and bottom sets of columns).

A regression equation on the variable PHEV[Plug in at home] is used to address the questions of whether there are grounds to conclude these distributions are different. The variables Year, Region, Year*Region, NCB, and Year*NCB are simultaneously tested. Similar regressions are also run for the other eight PHEV Assessments. The effect tests for all nine models are shown in Table 30. As for BEVs, assessment statements differed as to whether positive agreement favored PHEVs, those statements for which their scales where inverted so that positive agreement does favor PHEVs are indicated with the leading letter "i" in the name of the PHEV Assessment.

Figure 26: Mean Agreement Scores for Ability to Charge a PHEV at Home across Six Regions in California by New Car Buyer, 2019 and 2021; scale -3 (strongly disagree) to +3 (strongly agree)

Based on the statistically significant effects in Table 30, the parameter estimates for each model, and tests of Variable Importance for each model (not shown), the results for each PHEV Assessment Statement are as follows:

- Charge a PHEV at Home: On average across all participants, there is slight average agreement they would be able to charge a PHEV at home (0.45). Participants' assessments of their ability to charge a PHEV at home differ by Year, Region, the interaction Year*Region, and NCB.
    - NCB is by far the most important variable in estimating participants' assessments of their ability to charge a PHEV at home.
        - New Car Buyers have higher mean estimated scores (0.71) than non-New Car Buyers (0.13).
    - Even including their interaction, the practical effect of Year and Region on differences in participants assessments of their capability to charge a PHEV at home are slight.
        - The least square mean agreement score is slightly higher in 2021 (0.53) than in 2019 (0.42).
        - No differences in least square means by Region or Region*Year are statistically significant (Tukey's Honestly Significant Difference, α = 0.05).

Table 30: Significant Explanatory Variables in Regression Equations of Nine Assessments of PHEVs in Six Regions of California, 2019 and 2021

Vehicle Type [Assessment]	Parameter tests				
	Term	**DF**	**Sum of Squares**	**F Ratio**	**Prob. > F**
PHEV [Charge at home]	Year	1	21.111	4.588	0.0322
	Region	5	57.035	2.479	0.0299
	NCB	1	296.685	64.48	<0.0001
	Year*Region	5	30.428	1.323	0.2512
	Year*NCB	1	22.227	4.831	0.0280
PHEV [Enough charging]	Year	1	523.495	147.922	<0.0001
	Region	5	134.253	7.587	<0.0001
	NCB	1	133.081	37.604	<0.0001
	Year*Region	5	55.901	3.159	0.0075
	Year*NCB	1	11.848	3.348	0.0673
iPHEV [Too long to charge]	Year	1	13.658	5.927	0.0149
	Region	5	2.619	0.227	0.9508
	NCB	1	21.254	9.224	0.0024
	Year*Region	5	24.907	2.162	0.0554
	Year*NCB	1	6.485	2.814	0.0935
iPHEV [Range too short]	Year	1	3.958	1.391	0.2382
	Region	5	22.479	1.58	0.1619
	NCB	1	12.548	4.41	0.0358
	Year*Region	5	89.423	6.286	<0.0001
	Year*NCB	1	7.371	2.591	0.1075
iPHEV [Higher price]	Year	1	6.693	3.133	0.0767
	Region	5	13.477	1.262	0.2774
	NCB	1	0.883	0.414	0.5202
	Year*Region	5	18.765	1.757	0.1181
	Year*NCB	1	0.234	0.11	0.7405
iPHEV [Safety]	Year	1	62.405	24.265	<0.0001
	Region	5	43.582	3.389	0.0046
	NCB	1	0.151	0.059	0.8085
	Year*Region	5	15.268	1.187	0.3126
	Year*NCB	1	29.462	11.455	0.0007
iPHEV [Reliability]	Year	1	19.499	7.705	0.0055
	Region	5	55.755	4.407	0.0005
	NCB	1	0.564	0.223	0.6368
	Year*Region	5	31.028	2.452	0.0315
	Year*NCB	1	17.205	6.799	0.0091
PHEV [Environment impact]	Year	1	3.504	1.508	0.2195
	Region	5	41.308	3.555	0.0033
	NCB	1	4.471	1.924	0.1654
	Year*Region	5	9.652	0.831	0.5275
	Year*NCB	1	0.871	0.375	0.5405
PHEV [Market ready]	Year	1	99.398	36.226	<0.0001
	Region	5	70.829	5.163	<0.0001
	NCB	1	92.357	33.66	<0.0001
	Year*Region	5	13.085	0.954	0.4448
	Year*NCB	1	0.033	0.012	0.9127

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

- Enough Charging Locations: On average across all participants (both years, all regions), there is slight average disagreement there are enough places to charge PHEVs (-0.24). The effects Year, Region, the interaction Year*Region, and NCB are all statistically significant.
    - Year is the most important variable in estimating differences, producing a shift from slight *disagreement* in 2019 (-0.46) to even slighter *agreement* in 2021 (0.11).
    - The result of the variables Year, Region, and Year*Region are such that lease square mean agreement scores are higher in all six regions in 2021 than in 2019.
        - The difference is large enough that the least square means all switch signs from negative to positive except in the Balance of the State for which there remains slight disagreement, on average, there is enough charging.
    - New Car Buyers are estimated to have higher agreement scores than non-New Car Buyers.
- Too Long to Charge PHEVs: Across all participants' there is modest agreement PHEVs take too long to charge. Inverting the scale so positive values favor PHEVs, the mean is score (-0.69). There are differences between participants based on Year and NCB, with NCB being the more important.
    - New Car Buyers have, on average, a worse assessment of how long PHEVs take to charge (-0.73) than do non-New Car Buyers (-0.58).
    - Assessments are worse in 2021 (-0.75)than they were in 2019 (-0.66).
- Range too Short: On balance, participants assess PHEV driving range negatively (-0.54). Assessments differ by Year and Region (though only through their interaction) and NCB. The interaction of Year and Region elevate the importance of these two variables above that of NCB.
    - The BAAQMD had the best (though still negative) assessment of PHEV range of any region in 2019 but the worst in 2021. The decrease is large enough that in 2021, the assessment of PHEV range in the BAAQMD is significantly lower than in the SMAQMD and SDAPCD.
- PHEV Higher Price: The strongest of all the PHEV assessments across all participants is their negative assessment of PHEV purchase price (-1.36). It is also the only PHEV assessment that does not differ over time, between regions, or between New and non-New Car Buyers.
- Vehicle Safety: Across all participants there is slight agreement that gasoline vehicles are safer than PHEVs (-0.26). Differences between participants are due to Year, Region, and the interaction Year*NCB. Though the main effect of Year and Region are similar, the additional effect of Year through its interaction with NCB makes Year the most important variable.
    - The assessment of the comparative safety of PHEVs and conventional gasoline vehicles is worse in 2021 (-0.37) than it was in 2019 (-0.17).
    - The best assessment of PHEV safety was in the SJAPCD (-0.04) and the worst in the SJVAPCD (-0.32).
    - The interaction Year*NCB is such that New Car Buyers in 2021 have worse assessments of PHEV safety compared to conventional vehicles than non-

New Car Buyers in the same year and both New and non-New Car Buyers in 2019.

- Vehicle Reliability: Over all participants the assessment of PHEV reliability compared to conventional gasoline vehicles is negative (-0.62). Differences are due to Year, Region, Year*Region, and NCB but only through the interaction Year*NCB. Year and Region are nearly equally important—though mostly through their interaction—and both much more important than NCB.
    - The assessment of PHEV reliability is worse in 2021 (-0.70) than in 2019 (-0.59).
    - Differences in the assessment of PHEV reliability are somewhat greater across regions: the BAAQMD (-0.43) and SDAPCD (-0.46) have the highest (though still negative) least square mean assessment scores and the SJVAPCD (-0.79) and Balance of State (-0.66) have the worst.
    - The interaction Year*Region is such that no individual region has a least square mean assessment score that is worse in 2021 than it was in 2019. Further, differences between regions appear to have diminished between 2019 and 2021 such that differences that were significant in 2019 are no longer so in 2021.
        - For example, in 2019 the BAAQMD had a higher score than the SJVAPCD and SCAQMD but by 2021 the BAAQMD score was higher than no other region.
        - Similarly, in 2019 the SDAPCD had a higher score than the SCAQMD, but by 2021 the SDAPCD's score was no higher than any other region.
- Environmental Impact: Across all participants, PHEVs garner moderate agreement they are less damaging to the environment than are conventional gasoline vehicles (1.20). Only Region accounts for differences between participants, i.e., as differences are not associated with Year this positive evaluation was sustained from 2019 to 2021 but did not get stronger.
    - Participants from the BAAQMD are estimated to have higher agreement scores (that PHEVs are less damaging to the environment) (1.35) than participants are from the Balance of State (1.11), SMAQMD (1.10), and SJVAPCD (1.05).
    - Participants from the SDAPCD (1.27) are also estimated to have higher scores than those from the SJVAPCD.
- Ready for Mass Market: Across all participants there is slight average agreement that PHEVs are "ready for mass market" (0.85). There are differences by Year, Region, and NCB, the last being the most important.
    - While both groups register slight agreement that PHEVs are ready for mass market, New Car Buyers have higher least square mean values (0.87) than do non-New Car Buyers (0.55).
    - This assessment of PHEVs is improved in 2021 (0.96) over 2019 (0.71).
    - The assessments of market readiness are higher in the BAAAMD (0.90), SCAQMD (0.82), and SDAPCD (0.77) than in the SJVAPCD (0.49). The BAAQMD is also higher than the Balance of State (0.60).

3.2.5.3 FCEV Assessments

There is one fewer assessment statement for FCEVs than for BEVs and PHEVs as the possibility of home fueling of FCEVs is precluded. As was done for assessments of BEVs and PHEVs, the participants' assessments of FCEVs are tested for differences between 2019 and 2021, across the six regions defined for this study, and between New and non-New Car Buyers. Parameter significance tests are summarized in Table 31. These along with an examination of the importance of the variables Year, Region, and NCB in any differences in assessments and of the least square means estimated by each assessment model are the basis for the following results.

- FCEV Enough Fueling Locations: Across all participants there is moderate disagreement there are enough places to fuel FCEVs (-1.12) though this disguises that the median value is even more negative (-1.60), i.e., half of all participants disagree much more strongly there are enough fueling locations. There are differences by Year, Region, NCB, and Year*NCB; Year is the most important in estimating differences, followed by NCB.
    - The assessments of FCEV fueling in 2021 (least square mean = -0.70) is higher than 2019 (-1.38)
    - Across both years and all regions, the assessments of New Car Buyers are less unfavorable (-1.25) than are those of non-New Car Buyers (-1.49).
    - The interaction Year*NCB is such that New Car Buyers have higher (less negative) scores than non-New Car Buyers in both years and both groups of buyers have higher scores in 2021 than they did in 2019.
        - New Car Buyers in 2021 only slightly disagree, on average, there are enough places to fuel FCEVs (-0.32)
    - Though the effect of Region is statistically significant, the differences between regions are substantively small. The only statistically significant differences are the worse assessments offered in the Balance of the State compared to the SCAQMD and SJVAPCD.
- FCEV Fueling Duration: Across all participants, there is a slight negative assessment of how long they believe it takes to fuel an FCEV (-0.17). There are differences by Year, both through the main effect and the interaction with NCB. The result is that Year is the most important variable in estimating assessments of FCEV fueling time.
    - Participants in 2021 offered worse assessments of FCEV fueling duration (-0.36) than those in 2019 (-0.09) though in both years the estimated mean assessment is in the range of slight agreement that FCEVs take too long to refuel.
    - New Car Buyers in 2021 are estimated to have worse assessments of FCEV fueling duration (-0.49) than New Car Buyers in 2019 (-0.12) and worse than non-New Car Buyers in 2021 (-0.22) and 2019 (-0.07).

Table 31: Significant Explanatory Variables in Regression Equations of Eight Assessments of FCEVs in Six Regions of California, 2019 and 2021

Vehicle Type [Assessment]	Parameter tests				
	Term	DF	Sum of Squares	F Ratio	Prob. > F
FCEV [Enough Fueling Locations]	Year	1	708.634	200.747	0.0000
	Region	5	53.734	3.044	0.0095
	NCB	1	51.159	14.493	0.0001
	Year*Region	5	37.464	2.123	0.0598
	Year*NCB	1	106.847	30.269	0.0000
iFCEV [Too long to fuel]	Year	1	105.994	47.255	0.0000
	Region	5	23.977	2.138	0.0580
	NCB	1	2.078	0.926	0.3359
	Year*Region	5	9.232	0.823	0.5329
	Year*NCB	1	19.795	8.825	0.0030
iFCEV [Range too short]	Year	1	30.185	14.296	0.0002
	Region	5	18.912	1.791	0.1110
	NCB	1	6.971	3.302	0.0693
	Year*Region	5	25.734	2.438	0.0324
	Year*NCB	1	5.935	2.811	0.0937
iFCEV [Higher price]	Year	1	0.327	0.153	0.6956
	Region	5	6.756	0.632	0.6750
	NCB	1	2.810	1.315	0.2515
	Year*Region	5	26.594	2.490	0.0292
	Year*NCB	1	0.561	0.263	0.6082
iFCEV [Safety]	Year	1	90.140	39.561	0.0000
	Region	5	22.559	1.980	0.0782
	NCB	1	2.982	1.309	0.2526
	Year*Region	5	20.173	1.771	0.1152
	Year*NCB	1	51.173	22.459	0.0000
iFCEV [Reliability]	Year	1	19.499	6.316	2.939
	Region	5	55.755	23.428	2.180
	NCB	1	0.564	0.359	0.167
	Year*Region	5	31.028	18.441	1.716
	Year*NCB	1	17.205	20.528	9.552
FCEV [Environment impact]	Year	1	20.122	9.159	0.0025
	Region	5	77.706	7.074	0.0000
	NCB	1	12.017	5.470	0.0194
	Year*Region	5	34.876	3.175	0.0073
	Year*NCB	1	5.439	2.476	0.1157
FCEV [Market ready]	Year	1	360.179	123.907	0.0000
	Region	5	86.829	5.974	0.0000
	NCB	1	29.510	10.152	0.0014
	Year*Region	5	17.739	1.221	0.2965
	Year*NCB	1	23.006	7.915	0.0049

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

- FCEV Driving Range: Across all participants there is a slight negative assessment of how far FCEVs travel between fueling (-0.39). There are differences by Year and Region, though the latter is primarily through the interaction Year*Region. As such, Year is the variable that is most important.
    - On average, assessments of FCEV driving range are worse in 2021 (-0.51) than in 2019 (-0.37) though both register as slight disagreement that FCEVs travel far enough between fueling.
    - In no region is the 2021 assessment better than it was in 2019 though only in the SCAQMD is the assessment in 2021 (-0.61) so much more negative as to be statistically significantly more negative than in 2019 (-0.28).
- FCEV Higher (Purchase) Price: Across all participants there is a moderate negative assessment of FCEV purchase prices (-1.25), i.e., they believe FCEVs cost more to buy than conventional vehicles. Year and Region appear to be related to differences in these assessments though through their interaction Year*Region.
    - There are no significant differences between by Year, Region, NCB, Year*Region, or Year*NCB. The moderate agreement that FCEVs cost more to buy than conventional vehicles is similar in both years, across all regions, and among New and non-New Car Buyers.
- Gasoline Vehicles Safer (than FCEVs): Across all participants there is a slightly negative assessment of the safety of FCEVs compared to conventional gasoline vehicles (-0.54). Differences are due to Year and NCB, though the latter through the interaction Year*NCB. As such, Year is the variable that is most important.
    - The least square mean for vehicle safety is more negative for 2021 (-0.67) than 2019 (-0.43).
    - The effect of Year*NCB is such that New Car Buyers in 2021 are estimated to have the worst assessment of the safety (-0.82) compared to non-New Car Buyers in 2021 (-0.52), and both New Car Buyers (-0.40) and non-New Car Buyers (-0.46) in 2019.
- Gasoline Vehicles More Reliable: Across all participants there is disagreement that FCEVs are more reliable than gasoline vehicles (-0.80). This assessment does not differ by Year, Region, or NCB.
- Environmental Impact: The average assessment across all participants is modest agreement that FCEVs have lower environmental impact than gasoline vehicles (1.05). Differences are due to Year, Region, NCB, and Year*Region; Region is assessed to be most important to these differences.
    - Participants in the BAAQMD are estimated to have a higher average assessment of the environmental impact of FCEVs (1.18) than participants anywhere except the SDAPCD (1.13). The lowest assessment is in the SJVAPCD (0.74).
    - Estimated mean scores are slightly higher in 2021 (1.09) than 2019 (0.98).
    - The interaction Year*Region is such that no region shows a year-to-year change, but the SJVAPCD is estimated to have the lowest mean assessment compared to most other regions in both years.
    - New Car Buyers are estimated to have higher assessments (1.04) than non-New Car Buyers (0.92).

- FCEVs Read for Mass Market: Overall, participants slightly disagree FCEVs are ready for mass marketing (-0.25). Differences due to Year, Region, NCB, and Year*NCB. Year is assessed to the most important.
    - Participants in 2021 are estimated to be, on average, more likely to agree FCEVs are ready of mass market than were participants in 2019. The difference is one of shifting from modest disagreement in 2019 (-0.46) to indifference in 2021 (0.02).
    - Regionally, the Balance of the State (-0.67) lags the SCAQMD (-0.23), SJVAPCD (-0.37), and BAAQMD (-0.38). The SJAPCD (-0.54) and SMAQMD (-0.59) also lags the SCAQMD.
    - New Car Buyers (-0.37) are more favorable than non-New Car Buyers (-0.55).
    - The interaction Year*NCB is such that is magnifies the main effects, making all differences by Year and NCB larger. One result is that New Car Buyers in 2021 are estimated to modestly agree FCEVs are ready for mass market (0.23).

3.2.6 Incentives for ZEVs

All participants in the 2019 and 2021 samples live in similar policy contexts regarding federal and state incentives such as the federal tax credit for PEVs and the state's Clean Vehicle Rebate for ZEVs. Additional, differing incentives are offered by Air Districts. The San Joaquin Valley has been a focus for additional incentives. For example, the State of California funds an additional consumer incentive for ZEVs in the SJVAPCD; the DriveClean! Rebate is on par with the amount of the statewide Clean Vehicle Rebate. From the perspective of consumers, the DriveClean! Rebate appears as a separate incentive for which application must be made to the District (in addition to a separate application for a CVR). The Voluntary Vehicle Retirement Incentive is available to residents of the SJVAPCD and SCAQMD if they replace older vehicles with more fuel-efficient vehicles including ZEVs. The amount of the incentive is also on par with the statewide Clean Vehicle Rebate. Other regional incentives are or have been available in other air districts at different times.

In practice, not all participants have equal opportunity to take advantage of incentives. PEV availability, i.e., PEVs offered for sale and available at a local automobile dealership, has not been uniform across California. Sales of PEVs and leases of FCEVs show regional differences such that people who have not acquired a ZEV but live in a region with higher ZEV sales may have more opportunity to encounter people who have knowledge of incentives. Actively shopping for any new car may reveal information about the existence of PEV and ZEV incentives. Whether any more participants report hearing about federal, state, or regional incentives for "vehicles that are powered by alternatives to gasoline and diesel" in 2021 than in 2019, across regions—which show spatial correlation to ZEV sales and leases—and between New and non-New Car Buyers are evaluated here.

3.2.6.1 Federal Incentives

Distributions of awareness of federal government incentives are shown in Figure 27 by region and year. The assumption is made that "No" and "Not sure" are functionally equivalent and the two responses are combined into one. There appear to be differences between regions. The analysis addresses this as well as whether there are differences between the two survey years and between New and non-New Car Buyers. Testing for the existence and significance of any differences by Year, Region, and NCB is done via nominal logistic regression. The parameter estimates are presented in Table 32. Based on these there are significant effects of Year, Region, and NCB, but not from either of the tested interactions. Based on tests of variable importance and the odds-ratios, NCB is most important, followed by Region and Year.

Figure 27: Awareness of Federal Incentives across Six Regions, CA, 2019 and 2021; percent

Table 32: Significance of Explanatory Variables in Regression of Awareness of Federal Incentives in Six Regions, CA, 2019 and 2021

Dependent Variable	**Effect Tests**			
	Term	**DF**	**Likelihood Ratio Chi-Square**	**Prob. > F**
Incentive Awareness [Federal]	Year	1	17.182	< 0.0001
	Region	5	28.917	< 0.0001
	NCB	1	42.884	< 0.0001
	Year*Region	5	9.675	0.0850
	Year*NCB	1	3.475	0.0623

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

The statistically significant odds ratios for pairs of regions are summarized in Table 33. The ratio of the odds a New Car Buyer has heard of federal incentives to the odds a non-New Car Buyer has heard is 1.578 ($p \le 0.001$); in short, New Car Buyers are more likely to have heard of federal incentives than not as are non-New Car Buyers. Participants from the BAAQMD and SDAPCD were more likely to have heard of incentives than those from the Balance of the State, SMAQMD, SJVAPCD, and SCAQMD. The odds ratio for whether a participant from 2021 has heard of federal incentives to the odds a participant from 2019 has heard is 1.243 ($p \le 0.001$).

Table 33: Statistically Different Odd-Ratios for Awareness of Federal Incentives between Pairs of Regions in CA controlling for Year and NCB, $\alpha \le 0.05$

	BoS	BAAQMD	SMAQMD	SDAPCD	SJVAPCD	SCAQMD
BoS	—	0.660		0.792		
BAAQMD	1.515		1.705		1.669	1.517
SMAQMD		0.586		0.703		
SDAPCD	1.263		1.422		1.391	1.265
SJVAPCD		0.599		0.719		
SCAQMD		0.659		0.791		

Notes: "BoS" = Balance of State. Shading indicates significance; $\alpha \le 0.01$, $0.01 < \alpha \le 0.05$. Blank cells indicate non-significant odds ratios.

3.2.6.2 State Incentives

The distributions of awareness that the California state government offers incentives to consumers to purchase vehicles powered by alternatives to gasoline and diesel are shown in Figure 28 by region and year. There appear to be differences between regions in each year and a higher percentage of participants who have heard of California incentives in 2021. Testing for the existence and significance of differences by Year, Region, and NCB is done via nominal logistic regression. The parameter estimates are presented in Table 34. Based on these there are significant effects of Year, Region, and NCB, but not from either of the tested interactions. Based on tests of variable importance and the odds-ratios (Table 35), Region is most important, followed by Year and NCB.

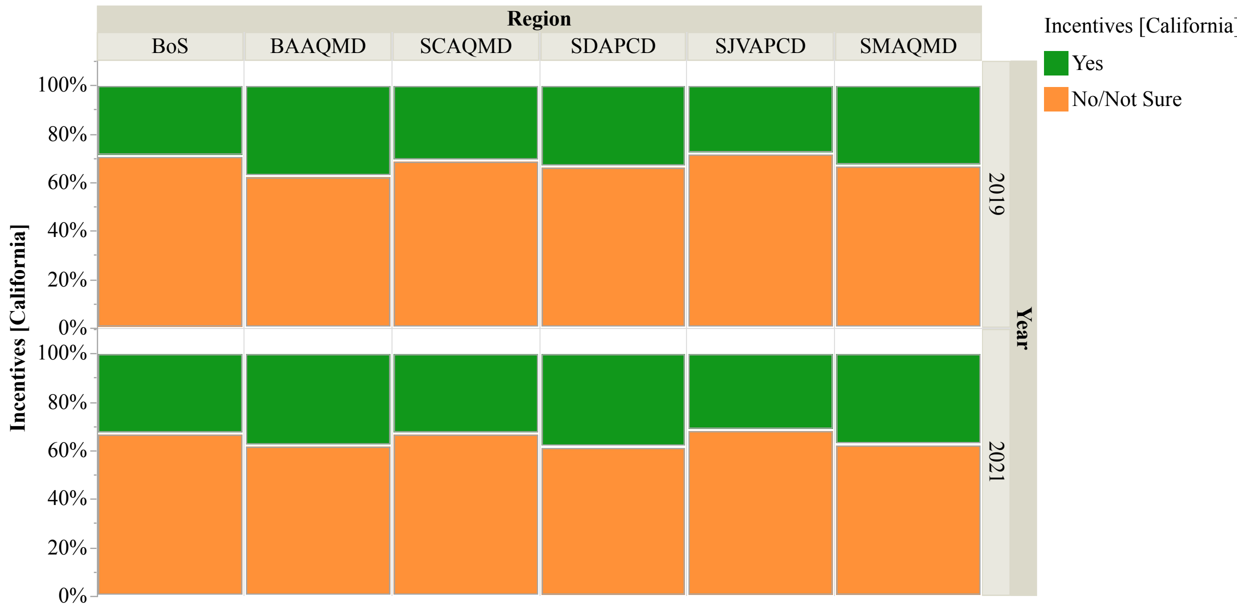


Figure 28: Awareness of California Incentives across Six Regions, 2019 and 2021; percent

Table 34: Significance of Explanatory Variables in Regression of Awareness of California Incentives in Six Regions, 2019 and 2021

Dependent Variable	Effect Tests			
	Term	DF	Likelihood Ratio Chi-Square	Prob. > F
Incentive Awareness [California]	Year	1	12.025	0.0005
	Region	5	21.758	0.0006
	NCB	1	4.097	0.0430
	Year*Region	5	1.683	0.8910
	Year*NCB	1	2.469	0.1161

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

The ratio of the odds a participant in the BAAQMD or SDAPCD has heard of state incentives to the odds a participant from the SCAQMD, SJVAPD, or BoS has heard range from approximately 1.2 to 1.4 ($0.0003 \leq p \leq 0.03$), i.e., participants in the BAAQMD and SDAPCD are more likely to have heard of state incentives than to not have heard than are participants in all other regions except the SMAQMD. The odds-ratio for 2021 to 2019 is similar to the lower end of this range, about 1.2 ($p = 0.005$), i.e., more participants in 2021 were more likely to have heard of state incentives than not than those in 2019. The odds ratio for whether a New Car Buyer has heard of California incentives to the odds a non-New Car Buyer has heard is about 1.1 ($p = 0.043$).

Table 35: Statistically Different Odd-Ratios for Awareness of California Incentives between Pairs of Regions in CA controlling for Year and NCB, $\alpha \leq 0.05$

	BoS	BAAQMD	SMAQMD	SDAPCD	SJVAPCD	SCAQMD
BoS	—	0.772		0.769		
BAAQMD	1.384	—			1.355	1.278
SMAQMD			—			
SDAPCD	1.301			—	1.274	1.199
SJVAPCD		0.738		0.785	—	
SCAQMD		0.784		0.834		—

Notes: "BoS" = Balance of State. Shading indicates significance; $\alpha \leq 0.01$, $0.01 < \alpha \leq 0.05$. Blank cells indicate non-significant odds ratios.

3.2.6.3 Regional: Air District Incentives

The distributions of awareness that regional agencies such as air districts offer incentives to consumers to purchase vehicles powered by alternatives to gasoline and diesel are shown in Figure 29 by region and year. There appears to be a higher percentage of participants who have heard of regional incentives in 2021 with perhaps the biggest change in the SJVAPCD. Testing for the existence and significance of differences by Year, Region, and NCB is done via nominal logistic regression. The parameter estimates are presented in Table 36. Based on these there are significant effects of Year and NCB, but not Region. Neither interaction effect is significant. Based on tests of variable importance and the odds-ratios (Table 37), Year is most important followed by NCB, then Region.

The results support the conclusion awareness of regional incentives is higher in 2021 than 2019; the odds ratio is 1.343 ($p < 0.0001$). It is also the case that New Car Buyers are more likely to have heard of regional incentives than non-New Car Buyers; the odds ratio is 1.241 ($p = 0.0006$). Though the effect test indicates Region is not statistically significantly related to awareness of regional incentives, examination of the odds ratios between pairs of regions indicates that ten of the 30 odds ratios are statistically significantly different from zero: all ten involve the SJVAPCD and all ten indicate higher awareness of regional incentives in the SJVAPCD than in all five other regions.

Figure 29: Awareness of Regional Incentives across Six Regions, 2019 and 2021; percent

Table 36: Significance of Explanatory Variables in Regression of Awareness of Regional Incentives in Six Regions, 2019 and 2021

Dependent Variable	Effect Tests			
	Term	DF	Likelihood Ratio Chi-Square	Prob. > F
Incentive Awareness [Regional: Region]	Year	1	21.144	< 0.0001
	Region	5	9.506	0.9050
	NCB	1	11.994	0.0005
	Year*Region	5	2.926	0.7114
	Year*NCB	1	0.902	0.3422

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

Table 37: Statistically Different Odd-Ratios for Awareness of Regional Incentives between Pairs of Regions in CA controlling for Year and NCB, $\alpha \leq 0.05$

	BoS	BAAQMD	SMAQMD	SDAPCD	SJVAPCD	SCAQMD
BoS	—				0.801	
BAAQMD		—			0.798	
SMAQMD			—		0.730	
SDAPCD				—	0.777	
SJVAPCD	1.249	1.252	1.370	1.287	—	1.238
SCAQMD					0.808	—

Notes: "BoS" = Balance of State. Shading indicates significance; $\alpha \leq 0.01$, $0.01 < \alpha \leq 0.05$. Blank cells indicate non-significant odds ratios.

3.2.6.4 Support for Government Incentives

Distributions of participants' support for government incentives for hydrogen and electricity are shown in Figure 30.There may be more support in 2021 than in 2019 and there may be differences between regions. These impressions are assessed in Table 38. The model results confirm statistically significant higher support for incentives in 2021 than 2019 only for those who support either electricity *or* hydrogen but not those who support both. While it is still true in 2021 that most participants support incentives for both electricity and hydrogen, the increase in support is mostly from people who believe one or the other should be incentivized. This result is produced in part by the interaction between Year and NCB: New Car Buyers in 2021 show the largest increase in support for electricity or hydrogen at the expense of support for both. Support is higher in the BAAQMD and lower in the BoS and SJVAPCD.

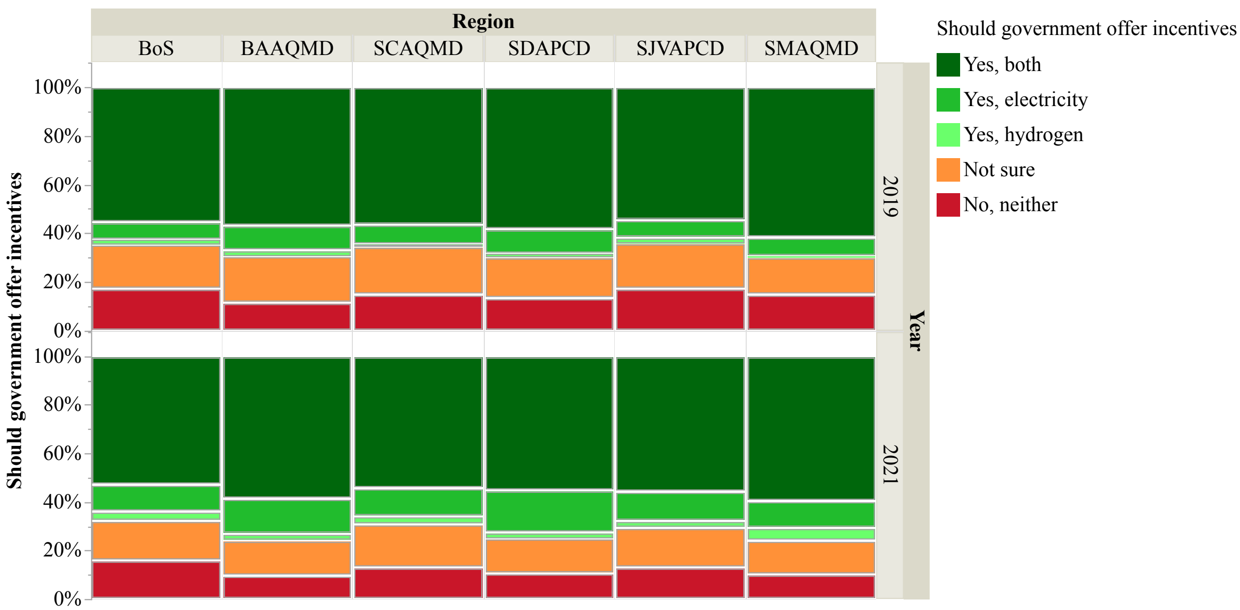


Figure 30: Support for Government Incentives, Six Regions, CA, percent

Table 38: Significance of Explanatory Variables in Regression of Support for Government Incentives, Six Regions, CA, 2021

Dependent Variable	Effect Tests			
	Term	**Degrees of Freedom**	**Likelihood Ratio χ^2**	**Prob. > χ^2**
Support for Government Incentives	Year	4	50.794	< 0.0001
	Region	20	51.583	0.0001
	NCB	4	49.436	< 0.0001
	Year*Region	20	18.983	0.5236
	Year*NCB	4	11.100	0.0255

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

3.2.7 Consideration of ZEVs

Participants' consideration of PHEVs, BEVs, PEVs, FCEVs, and ZEVs are evaluated in that order. The analysis will be conducted as others to this point. Note that because sales (and leases) of all ZEVs are still dominated by new vehicle transactions there is still some reason to expect that New Car Buyers would be at higher levels of Consideration than non-New Car Buyers even in 2021. Moreover, the description and interpretation of any differences by Region, Year, or NCB must be made within the larger context that very few car owning households in California are at high levels of Consideration of PHEVs, BEVs, PEVs, FCEVs, or ZEVs regardless which year they completed the survey, where they live, or whether they buy new cars.

3.2.7.1 PHEV Consideration

The distribution of PHEV Consideration by Region and Year is shown in Figure 31, from which it appears there may be some differences between years, but differences that vary by region. Parameter tests and estimates from the ordinal logistic regression on PHEV Consideration are in Table 39.

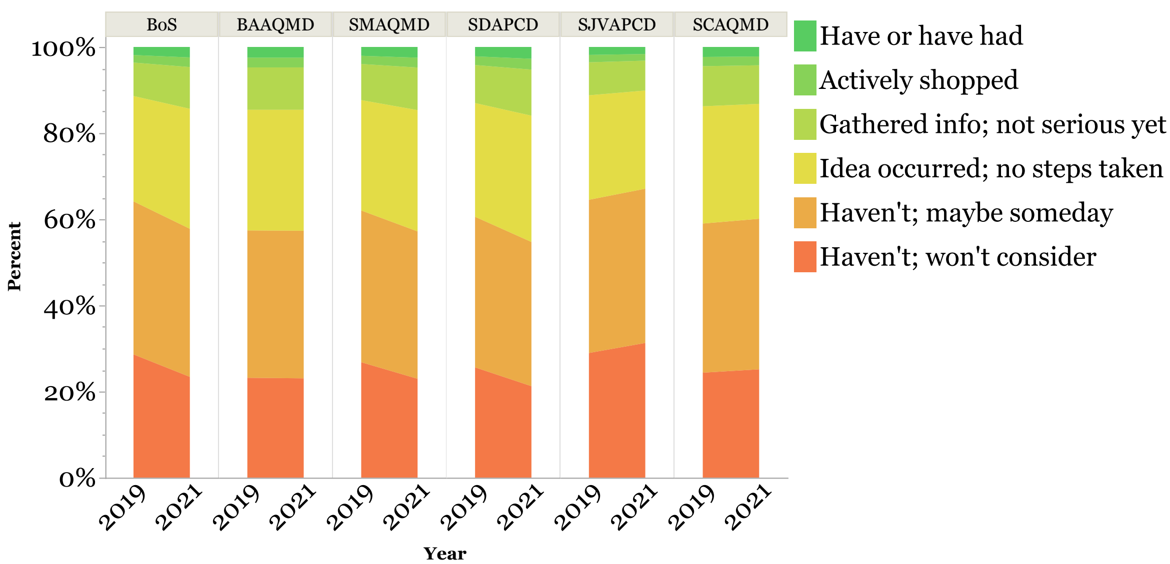


Figure 31: PHEV Consideration by Six Regions, 2019 and 2021, percent

NCB and Region are significant and of the two, the difference between New and non-New Car Buyers has the larger effect on PHEV Consideration (as it's parameter estimate has the largest absolute value). New Car Buyers are more likely to be at higher levels of PHEV Consideration than are non-New Car Buyers. Participants from the BAAQMD are most likely to be at higher levels of PHEV Consideration, those from SCAQMD, SDAPCD, and SMAQMD are somewhat less likely to be at higher levels, and those from the BoS and SJVAPCD are least likely to be at higher levels of PHEV Consideration. Year is related to PHEV consideration but primarily through its interaction with Region. The effect of the interaction term is such that in most regions it reinforces the conclusion of no difference in PHEV Consideration between 2019 and 2021. However, in the SJVAPCD the interaction is in the direction of lower Consideration and is strong enough for us to conclude that PHEV Consideration declined in that region from 2019 to 2021.

Table 39 Significance of Effect Tests and Parameter Estimates for Ordinal Logistic Regression on PHEV Consideration, 2019 and 2021 across Six Regions

Parameter	**Degrees of Freedom**	**Log-Likelihood χ^2**		**Prob. > χ^2**
Year	1	2.532		0.115
Region	5	12.148		0.0328
NCB	1	32.922		< 0.0001
Year * Region	5	11.781		0.0379
Year * NCB	1	0.503		0.4782
Term	**Estimate**	**Std Error**	**χ^2**	**Prob. > χ^2**
Intercept[Haven't; won't consider]	-1.036	0.036	846.46	< 0.0001
Intercept[Haven't; maybe someday]	0.471	0.034	196.95	< 0.0001
Intercept[Idea occurred; no action]	1.948	0.043	2068.40	< 0.0001
Intercept[Gathered info; not serious]	3.181	0.065	2391.50	< 0.0001
Intercept[Actively shopped]	3.857	0.087	1981.60	< 0.0001
Year[2021-2019]	-0.073	0.046	2.53	0.1116
Region[BoS]	0.117	0.067	3.08	0.0793
Region[BAAQMD]	-0.161	0.068	5.65	0.0174
Region[SMAQMD]	0.022	0.088	0.06	0.8017
Region[SDAPCD]	-0.024	0.066	0.14	0.7086
Region[SJVAPCD]	0.125	0.068	3.35	0.0672
NCB[No]	0.172	0.030	32.36	< 0.0001
Year[2021-2019]*Region[BoS]	-0.191	0.098	3.75	0.0529
Year[2021-2019]*Region[BAAQMD]	0.094	0.099	0.91	0.3409
Year[2021-2019]*Region[SMAQMD]	-0.094	0.119	0.62	0.4309
Year[2021-2019]*Region[SDAPCD]	-0.152	0.098	2.42	0.1198
Year[2021-2019]*Region[SJVAPCD]	0.208	0.101	4.24	0.0395
Year[2021-2019]*NCB[No]	-0.032	0.045	0.50	0.4778

3.2.7.2 BEV Consideration

The distribution of BEV Consideration by Region and Year is shown in Figure 32. There appears to be differences between 2019 and 2021 that vary by region. Despite these, the differences between region appear to persist, e.g., the BAAQMD persists in having the lowest level of outright resistance and the SJVAPCD, the highest. These appearances are tested in the ordinal logistic regression whose parameter significance tests and estimates are in Table 40. The significance tests indicate there are statistically significant differences by Region, Year, NCB, and Year*NCB.

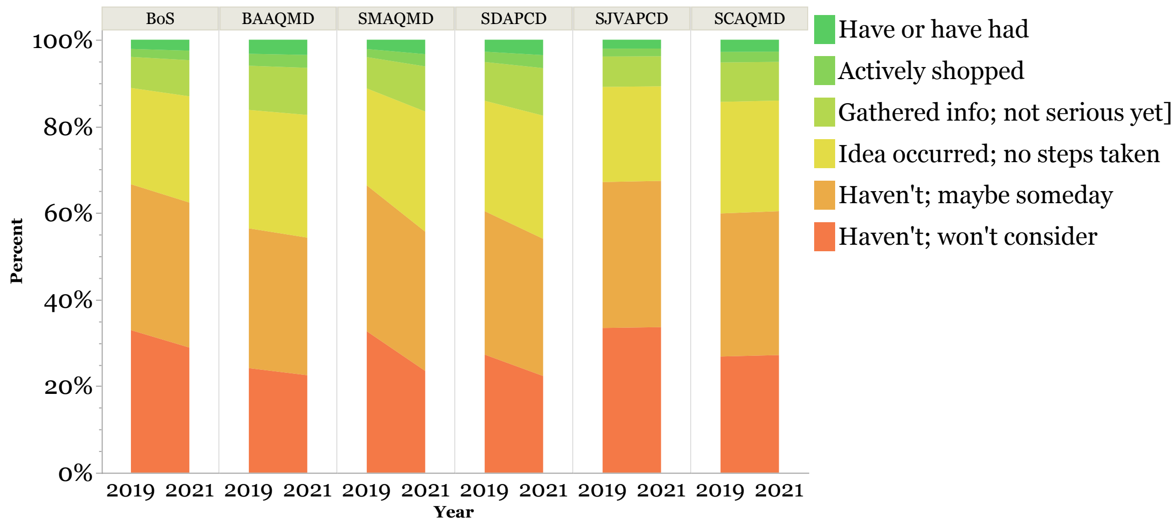


Figure 32: BEV Consideration by Six Regions, 2019 and 2021, percent

Table 40: Parameter Estimates and Significance, Ordinal Logistic Regression on BEV Consideration, 2019-2021, CA

Parameter	**Degrees of Freedom**	**Log-Likelihood χ^2**		**Prob. > χ^2**
Year	1	7.879		0.0050
Region	5	29.990		< 0.0001
NCB	1	63.029		< 0.0001
Year*Region	5	11.228		0.0470
Year*NCB	1	0.269		0.6039
Term	**Estimate**	**Std Error**	**χ^2**	**Prob. > χ^2**
Intercept[Haven't; won't consider]	-0.878	0.035	631.17	< 0.0001
Intercept[Haven't; maybe someday]	0.544	0.034	259.29	< 0.0001
Intercept[Idea occurred; no action]	1.943	0.043	2085.80	< 0.0001
Intercept[Gathered info; not serious]	3.056	0.061	2519.10	< 0.0001
Intercept[Actively shopped]	3.701	0.079	2185.30	< 0.0001
Year[2021-2019]	-0.128	0.046	7.89	0.0050
Region[BoS]	0.158	0.067	5.61	0.0179
Region[BAAQMD]	-0.269	0.067	15.89	0.0001
Region[SMAQMD]	0.142	0.088	2.59	0.1075
Region[SDAPCD]	-0.097	0.065	2.22	0.1366
Region[SJVAPCD]	0.17	0.068	6.17	0.0130
NCB[No]	0.238	0.030	61.90	< 0.0001
Year[2021-2019]*Region[BoS]	-0.049	0.099	0.24	0.6218
Year[2021-2019]*Region[BAAQMD]	0.081	0.099	0.67	0.4145
Year[2021-2019]* Region[SMAQMD]	-0.273	0.119	5.24	0.0221
Year[2021-2019]*Region[SDAPCD]	-0.108	0.098	1.23	0.2675
Year[2021-2019]*Region[SJVAPCD]	0.171	0.101	2.87	0.0901
Year[2021-2019]*NCB[No]	-0.023	0.045	0.27	0.6032

Though the parameters for Region and NCB are larger in absolute value than that for Year, the effect of Year is increased via its interaction with Region. Thus, while Region accounts for the largest share of the variation in BEV Consideration, Year and NCB account for smaller but similar shares in their importance to BEV Consideration. BEV Consideration is estimated to be highest in the BAAQMD and lowest in the SJVAPCD and higher in 2021 than in 2019. The interaction between Year and Region indicates the increase from 2019 to 2021 was not uniform across the regions: SMAQMD, SDAPCD, and the BoS are estimated to have higher levels of BEV Consideration in 2021 though only in the SMAQMD is the increase from 2019 large enough to be statistically significant. BEV Consideration is unchanged between 2019 and 2021 in the BAAQMD, SJVAPCD, and SCAQMD. In both years and in all six regions, New Car Buyers are estimated to be at higher levels of than non-New Car Buyers.

3.2.7.3 PEV Consideration

Recalling PEV Consideration is defined as the higher of PHEV and BEV Consideration, its distribution by Region and Year is shown in Figure 33. Because PEV Consideration "biases" Consideration upwards and combines two measures, Figure 33 shows higher percentages of participants at higher levels (more green and less orange areas than Figure 31 or Figure 32), accentuates differences common to the two measures, e.g., the (non-significant) difference between survey years for PHEVs plus the significant difference for BEVs combine to create an impression of higher Consideration of PEVs in 2021 than in 2019, and reduces differences they don't share, e.g., the interaction Year*Region. These are tested in the ordinal logistic regression whose parameter significance tests and estimates are in Table 41. The significance tests indicate there are statistically significant differences by Region, Year, NCB, and Year*NCB.

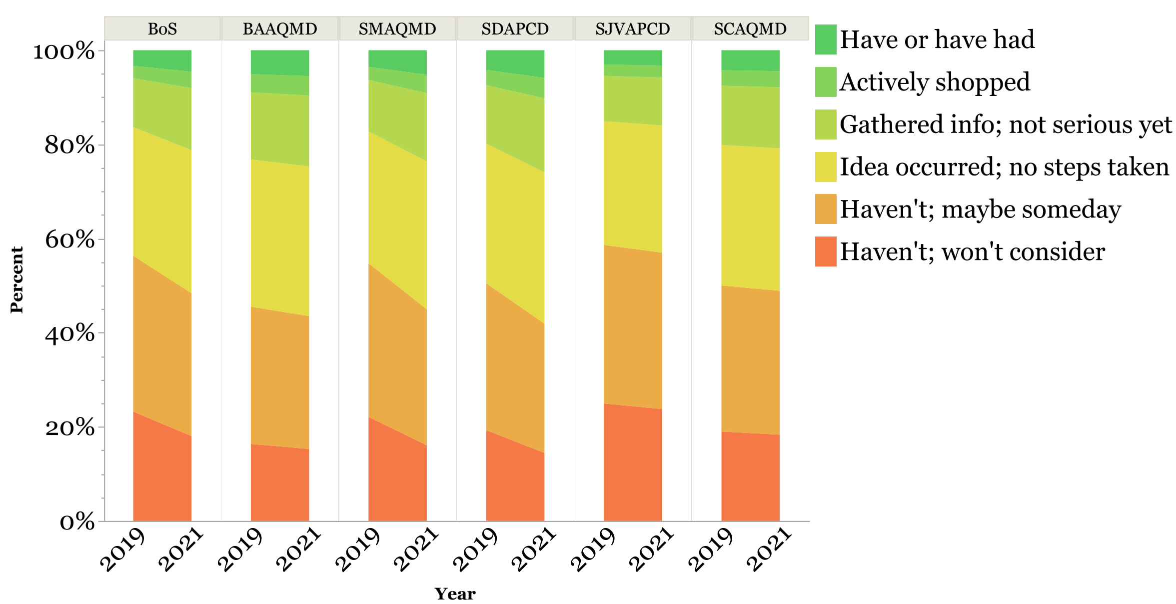


Figure 33: PEV Consideration by Six Regions, 2019 and 2021, percent

Table 41: Parameter Estimates and Significance, Ordinal Logistic Regression on PEV Consideration, 2019-2021, CA

Parameter	Degrees of Freedom	Log-Likelihood χ^2		Prob. > χ^2
Year	1	13.992		0.0002
Region	5	32.585		< 0.0001
NCB	1	67.684		< 0.0001
Year*Region	5	11.041		0.0506
Year*NCB	1	0.084		0.7724
Term	**Estimate**	**Std Error**	**χ^2**	**Prob. > χ^2**
Intercept[Haven't; won't consider]	-1.353	0.038	1290.60	< 0.0001
Intercept[Haven't; maybe someday]	0.117	0.033	12.43	0.0004
Intercept[Idea occurred; no action]	1.512	0.038	1546.20	< 0.0001
Intercept[Gathered info; not serious]	2.645	0.052	2573.90	< 0.0001
Intercept[Actively shopped]	3.251	0.065	2492.20	< 0.0001
Year[2021-2019]	-0.170	0.045	13.96	0.0002
Region[BoS]	0.144	0.066	4.72	0.0299
Region[BAAQMD]	-0.286	0.067	18.18	0.0000
Region[SMAQMD]	0.073	0.087	0.70	0.4027
Region[SDAPCD]	-0.077	0.065	1.42	0.2341
Region[SJVAPCD]	0.227	0.068	11.22	0.0008
NCB[No]	0.245	0.030	66.42	< 0.0001
Year[2021-2019]*Region[BoS]	-0.141	0.098	2.08	0.1492
Year[2021-2019]* Region[BAAQMD]	0.139	0.098	1.99	0.1584
Year[2021-2019]* Region[SMAQMD]	-0.160	0.119	1.82	0.1778
Year[2021-2019]* Region[SDAPCD]	-0.144	0.097	2.21	0.1370
Year[2021-2019]*Region[SJVAPCD]	0.14	0.100	1.96	0.1618
Year[2021-2019]*NCB[No]	0.013	0.045	0.08	0.7720

The variables Year, Region, NCB, and Year*Region are statistically significant, but not the interaction Year*NCB. NCB and Region are the more influential effects. New Car Buyers are estimated to be at higher levels of PEV Consideration than non-New Car Buyers. Participants from the BAAQMD are estimated to be at higher levels of PEV Consideration than participants from any of the other five regions and those from the SVJAPCD are estimated to be at the lowest. The effect of Year is such that PEV Consideration is estimated to be higher, i.e., more participants are at higher levels of Consideration, in 2021 than in 2019. Despite the fact the interaction Year*Region is statistically significant in both the PHEV and BEV Consideration models, it is not so in the PEV Consideration model likely because the effect of the interaction is in the opposite direction for the individual vehicle types. In the PHEV Consideration model, the interaction effect reduces PHEV Consideration (in the SJVAPCD) while in the BEV Consideration model, the effect increases BEV Consideration (in the SMAQMD).

3.2.7.4 FCEV Consideration

The distribution of FCEV Consideration by Region and Year is shown in Figure 34. The figure gives some reason to expect FCEV Consideration is slightly higher in the BAAQMD and is higher in 2021 than in 2019 in the BoS, SMAQMD, and SCAQMD. These appearances are tested in the ordinal logistic regression whose parameter significance tests and estimates are in Table 42.

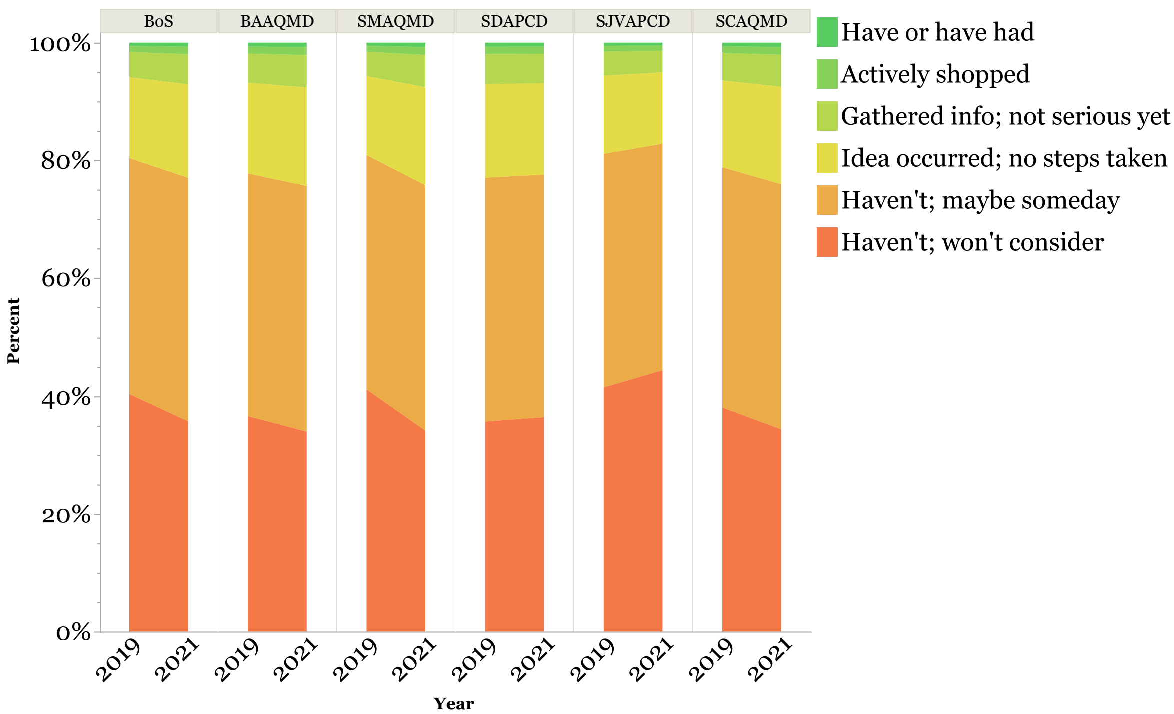


Figure 34: FCEV Consideration by Six Regions, 2019 and 2021, percent

The significance tests indicate there are statistically significant differences only by NCB. New Car Buyers are estimated to be more likely to be at higher levels of FCEV Consideration than non-New Car Buyers. The model provides no evidence that FCEV Consideration is higher in the BAAQMD than in any other region (nor that any region is different from the others). The interaction Year*Region is not statistically significant. However, the individual parameter for Year[2021-2019]*Region[SJVAPCD] is and its sign and magnitude indicate it is less likely participants from the SCVAPCD are at higher levels of FCEV Consideration in 2021 than 2019.

Table 42: Parameter Estimates and Significance, Ordinal Logistic Regression on FCEV Consideration, 2019-2021, CA

Parameter	Degrees of Freedom	Log-Likelihood χ^2		Prob. > χ^2
Year	1	3.459		0.0629
Region	5	7.715		0.1726
NCB	1	11.94		0.0005
Year*Region	5	8.333		0.1388
Year*NCB	1	0.684		0.4083
Term	**Estimate**	**Std Error**	**χ^2**	**Prob. > χ^2**
Intercept[Haven't; won't consider]	-0.456	0.034	181.24	< 0.0001
Intercept[Haven't; maybe someday]	1.352	0.038	1279.50	< 0.0001
Intercept[Idea occurred; no action]	2.718	0.055	2459.60	< 0.0001
Intercept[Gathered info; not serious]	4.066	0.095	1821.10	< 0.0001
Intercept[Actively shopped]	5.119	0.156	1073.90	< 0.0001
Year[2021-2019]	-0.087	0.047	3.45	0.0633
Region[BoS]	0.055	0.068	0.65	0.4208
Region[BAAQMD]	-0.089	0.069	1.67	0.1968
Region[SMAQMD]	0.092	0.090	1.04	0.3081
Region[SDAPCD]	-0.131	0.067	3.79	0.0516
Region[SJVAPCD]	0.094	0.070	1.82	0.1775
NCB[No]	0.106	0.031	11.69	0.0006
Year[2021-2019]*Region[BoS]	-0.099	0.101	0.96	0.3270
Year[2021-2019]* Region[BAAQMD]	-0.007	0.102	0.00	0.9474
Year[2021-2019]* Region[SMAQMD]	-0.191	0.123	2.44	0.1182
Year[2021-2019]*Region[SDAPCD]	0.143	0.100	2.03	0.1545
Year[2021-2019]* Region[SJVAPCD]	0.213	0.104	4.19	0.0406
Year[2021-2019]*NCB[No]	0.038	0.046	0.68	0.4081

3.2.7.5 ZEV Consideration

As with PEV Consideration, ZEV Consideration takes on the highest value of multiple measures, in this case consideration of PHEVs, BEVs, and FCEVs. As such it is subject to the same upward "biasing" of scores and to both complementary and competing effects on its three explanatory measures. The distribution of ZEV Consideration by Region and Year is shown in Figure 35 and the parameter significance tests and estimates of a regression on Year, Region, their crossed effect, and NCB are in Figure 35: ZEV Consideration by Six Regions, 2019 and 2021, percent.

The results indicate differences depend on Year, Region, and NCB, but there is no reason to expect differences between regions or between New and non-New Car Buyers differ between 2019 and 2021.

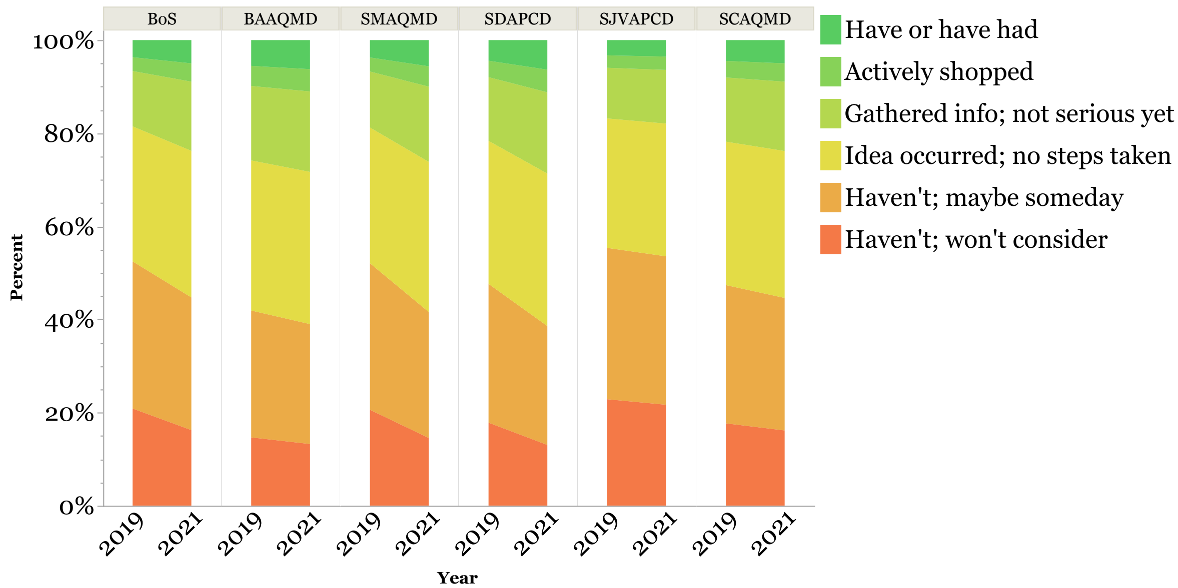


Figure 35: ZEV Consideration by Six Regions, 2019 and 2021, percent

Table 43: Parameter Estimates and Significance, Ordinal Logistic Regression on ZEV Consideration, 2019-2021, CA

Parameter	Degrees of Freedom	Log-Likelihood χ^2		Prob. > χ^2
Year	1	18.251		< 0.0001
Region	5	31.848		< 0.0001
NCB	1	66.606		< 0.0001
Year*Region	5	9.372		0.0951
Year*NCB	1	0.472		0.4922
Term	**Estimate**	**Std Error**	**χ^2**	**Prob. > χ^2**
Intercept[Haven't; won't consider]	-1.462	0.039	1437.70	< 0.0001
Intercept[Haven't; maybe someday]	-0.012	0.033	0.12	0.7263
Intercept[Idea occurred; no action]	1.387	0.038	1366.80	< 0.0001
Intercept[Gathered info; not serious]	2.557	0.050	2565.90	< 0.0001
Intercept[Actively shopped]	3.182	0.063	2544.00	< 0.0001
Year[2021-2019]	-0.194	0.045	18.19	< 0.0001
Region[BoS]	0.115	0.066	3.01	0.0828
Region[BAAQMD]	-0.306	0.067	20.75	< 0.0001
Region[SMAQMD]	0.094	0.087	1.15	0.2830
Region[SDAPCD]	-0.065	0.065	1.00	0.3183
Region[SJVAPCD]	0.221	0.068	10.66	0.0011
NCB[No]	0.243	0.030	65.44	< 0.0001
Year[2021-2019]*Region[BoS]	-0.107	0.098	1.21	0.2717
Year[2021-2019]*Region[BAAQMD]	0.125	0.098	1.62	0.2033
Year[2021-2019]*Region[SMAQMD]	-0.163	0.118	1.88	0.1699
Year[2021-2019]*Region[SDAPCD]	-0.142	0.097	2.13	0.1442
Year[2021-2019]*Region[SJVAPCD]	0.159	0.100	2.54	0.1113
Year[2021-2019]*NCB[No]	0.031	0.045	0.47	0.4919

Participants from 2021 are estimated to be more likely to be at higher levels of ZEV Consideration than are those from 2019 though Year has the least effect of the three variables. Participants from the BAAQMD are estimated to be more likely to be at higher levels of ZEV Consideration than participants from the other regions and those in the SJVAPCD to be more likely to be at lower levels. The distinction between New and non-New Car Buyers is nearly as important to differences in ZEV Consideration as is Region. New Car Buyers are estimated to be more likely to be at higher levels of ZEV Consideration than are non-New Car Buyers.

4. Conclusions

There is very little evidence in these results of a rapidly growing consumer base from 2019 to 2021 to support accelerating ZEV sales toward the goal of 100% ZEV sales in new vehicles in California by 2035. Across several measures there is no consistent evidence of greater awareness, better knowledge, more positive assessments, or increased consideration of any type of ZEV by car-owning households in California. Whether participants were New Car or non-New Car Buyers is associated with differences in awareness, knowledge, assessment, and consideration of ZEVs in both 2019 and 2021. The results most often are that non-New Car Buyers are less aware, less knowledgeable, and have worse assessments than New Car Buyers. Non-New Car Buyers are less likely to have given higher levels of consideration given less consideration to acquiring ZEVs for their households and are more likely to be outright resistant to ZEVs. Thus, an additional barrier to 100% sales of ZEVs is non-New Car Buyers—who must be willing, even eager, to buy used ZEVs—are even less prepared to do so than are New Car Buyers. There are differences between regions in California defined by air districts that generally reflect the differing levels of ZEV sales and PEV charging infrastructure deployment: where sales are higher and PEV charging more prevalent, measures of awareness, knowledge, assessment, and consideration generally are more favorable toward ZEVs than in regions with lower sales and less charging infrastructure.

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. For all five drivetrain types—ICEVs, HEVs, PHEVs, BEVs, and FCEVs—the distinction between New and non-New Car Buyers is the most important effect in estimating differences between participants—not region or year. Only for ICEVs are non-New Car Buyers estimated to have higher familiarity scores than New Car Buyers; they are estimated to have lower familiarity for all types of ZEVs.

Differences in familiarity by regions defined by air districts and differences between 2021 and 2019 were second or third most important across vehicle types. For HEVs, PHEVs, and FCEVs, regional differences are larger than differences between years; only for BEVs are differences between years larger than differences between regions. Still, statistically significant regional differences most consistently exist across HEVs, PHEVs, BEVs, and FCEVs between the BAAQMD (higher familiarity) and the SJVAPCD (lower familiarity). Though the variable distinguishing 2019 from 2021 may be less important to understanding the variation in participants' familiarity with vehicle types, it is the case for PHEVs, BEVs, and FCEVs that familiarity scores are estimated to be higher in 2021 than in 2019.

Compared to ICEVs, participants everywhere in California in both years rate themselves as much less familiar with all drivetrain types—even HEVs which had been for sale in the US for over 20 years by the time the 2021 survey was conducted. This may be explained by HEVs continued low market share; the California New Car Dealers Association reported in the 3rd quarter of 2019 the year-to-date hybrid vehicle share of new vehicle sales was five percent statewide. Participants from the SDAPCD, BAAQMD, and Balance of the State rate themselves to be statistically significantly more familiar with HEVs than do those in the SJVAPCD; no other pairs of regional means are different.

The case of HEV Familiarity, i.e., more than 20 years after HEVs first became available for sale familiarity with them remains far lower than for ICEVs, suggests it may take households a long time to become familiar with PHEVs, BEVs, and FCEVs in the absence of a concerted and pervasive effort to create interest on their part to increase their familiarity. In 2021, only 25% of participants in the six regions of California examined here are quite sure they are familiar enough with HEVs to "decide if one is right for my household" compared to 75% for ICEVs.

4.2 Naming ZEVs

Controlling for differences between regions and New and non-New Car Buyers, the data indicate fewer participants in 2021 can name a BEV or PHEV for sale than could participants in 2019. Differences across regions are slight: participants in the BAAQMD and SDAPCD are slightly more likely to be able to name either a BEV or a PHEV than those in the SJVAPCD. However, the higher instances of correctly naming BEVs and PHEVs in the BAAQMD and SDAPCD is much less than one might expect given the much higher sales of such vehicles, especially in the BAAQMD. The interaction between Year and Region is such that instances of correctly naming a PHEV and/or a BEV decreased least from 2019 to 2021 in the SJVAPCD and SDAPCD. New Car Buyers are estimated to be more likely to be able to name a PHEV and/or a BEV in both years and in all regions.

Starting in 2021, participants' knowledge of up to two names PHEVs, BEVs, and FCEVs is assessed. New Car Buyers are more likely than non-New Car Buyers to be able to name BEVs and PHEVs and more likely to be able to name more than one of either. Only in the BAAQMD is knowledge of PHEV and BEV names linked, that is, in the BAAQMD there is a slight positive correlation between naming PHEVs and BEVs that is not observed in any other region. Participants in the Sacramento region are more likely than participants almost anywhere else to be able to name more than one PHEV, BEV, or both.

4.3 Seeing PEV Charging

Statewide, there was an increase from 2019 to 2021 in the percentage of participants reporting they had seen "EV charging spots in the parking lots and garages I use." The percentage of people who reported they had not seen or were unsure if they had seen EV charging locations declined from 31% to 25%; there is a similar percentage point increase in people reporting they had seen EV parking in several locations, up from 26 to 32%.

Around these statewide estimates there are variations by Region, Year, NCB, and the interaction between Region and Year. The variable Region is of most importance to estimating whether participants see EVSE, followed by Year and NCB. The main effect of Year is that compared to 2019, participants in 2021 are estimated to be more likely to have seen EV charging at "several locations" and fewer are likely to say they have seen none or are unsure whether they have seen any. The main effect of Region is that participants in the SJVAPCD and the Balance of the State are estimated to be least likely to say they had seen EV charging. However, the interaction of Year and Region shows the greatest difference between 2019 and 2021 in whether participants report seeing EV charging occurred in the SJVAPCD and to a lesser extent across the Balance of the State. The overall result is that while the SJVAPCD is estimated to have the lowest percentage of participants who have seen several EV charging locations, it is also estimated to have the greatest difference from 2019 to 2021. New Car Buyers are estimated to be more likely to have seen EV charging and to have seen more EV charging than non-New Car Buyers.

4.4 Knowledge of Vehicle Fueling

Of HEVs, BEVs, and PHEVs, participants are most likely to correctly report how BEVs are fueled: statewide nearly three-quarters of all participants (over both years and all regions) understand BEVs only plug-in to charge. Just over half understand PHEVs may both plug in to charge and fuel with gasoline. Just barely half understand how both BEVs and PHEVs are fueled.

There are differences between 2019 and 2021 and across regions. However, the results indicate knowledge of fueling of PHEVs and BEVs is, at best, not getting better over time: the main effect of Year is to reduce the estimated percentage of participants who can correctly identify how PHEVs and BEVs are fueled. The difference is approximately a five-percentage point reduction in the percent of correct answers for PHEVs and BEVs individually and a four-percentage point reduction in the percent correct answers for both PHEVs and BEVs jointly. The difference between the highest and lowest percentage correct responses by region is approximately ten-percentage points: the SJVAPCD and SCAQMD score lower than the BAAQMD, BoS, and SMAQMD. Only for fueling BEVs does the distinction between new and non-new car buyers matter. The effect is such that those who had acquired new cars in the seven years prior to their survey are less likely to correctly identify how BEVs are fueled though the difference is substantively small—about a two-percentage point reduction in estimated correct responses.

4.5 Assessments of ZEVs

Assessments of PHEVs, BEVs, and FCEVs are measured on nine items. Some items address the relationship between the capabilities and requirements of each vehicle type and each participant's context, such as residence type, access to electricity at their residential parking location, travel patterns, and mobility tools. Examples of this type of statement include those that ask participants to assess whether they could charge a BEV or PHEV at their home, whether they think there is enough BEV or PHEV charging or FCEV fueling, whether the driving range of ZEVs is long enough, and whether they think fueling ZEVs takes too long. Other assessments are made compared to conventional vehicles, such as those pertaining to purchase price, safety, reliability, and environmental effects. The final item asks for a summary assessment of whether ZEVs are ready to be sold to a mass market.

It is a general feature of almost all assessments offered for all three ZEV types that their density distributions have three distinct peaks at the points of greatest disagreement and agreement, as well as at the mid-point. That is, across the various ways participants were asked to assess PHEVs, BEVs, and FCEVs a general feature of their collective assessment is the participants tend to be segmented into those who have either the strongest negative assessment, strongest positive assessment, or are unable to offer either negative or positive assessments with any conviction.

Given these general shapes of the distributions, average values cannot be construed to describe most participants. However, model estimated averages are useful as an indicator of how important different variables are to differences in the assessments. In this sense, model estimated means, i.e., least square means, illustrate direction and magnitude of change. For example, in estimating whether participants from 2019 and 2021 differ in any assessment, the least square means provide examples of the difference in values between the two years.

The detailed descriptions of each of the nine (eight in the case of FCEVs) assessment items for BEVs, PHEVs form the basis for generalized conclusions about whether assessments of ZEVs are improved in 2021 compared to 2019 as well as whether those assessments differ between regions and between households who buy new cars and those who don't. Table 44 summarizes prior results as to which variables—Year, Region, or NCB—are most important to estimated differences in participants' assessments. The importance listings apply only within each vehicle type-assessment combination, for example, they do not support conclusions about whether NCB is more important to Home Charging than it is to Charging/Fueling Duration. No importance rating is shown for Higher Price since none of the three variables has a statistically significant relationship to assessments of the relative prices of BEVs, PHEVs, or FCEVs compared to conventional vehicles. Where two variables are listed, their importance is similar but the more important one is listed first. The importance ratings include the effects of interactions with the variable Year.

The variable Year, i.e., differences between 2019 and 2021, is not uniformly most important in differences in participants' assessments of BEVs and PHEVs, appearing as important in four of nine assessments. Further as discussed in the summaries of each vehicle type that follow, the assessments for which Year is most important do not uniformly result in better assessments of ZEVs in 2021 compared to 2019.

The assessments that are, on average, higher in 2021 than in 2019 for each vehicle type are these:

- BEVs: whether there is enough charging/fueling, driving range, and whether BEVs are ready for mass markets,
- PHEVs: enough charging and ready for mass markets, and
- FCEVs: enough fueling, better for the environment, and ready for mass markets.

The assessments that do not differ between 2021 and 2019 are:

- BEVs: charging duration, purchase price, reliability, and better for the environment,
- PHEVs: driving range, purchase price, and better for the environment, and
- FCEVs: driving range.

The assessments that are lower in 2021 than in 2019 are these:

- BEVs: safety,
- PHEVs: charging duration, safety, and reliability, and
- FCEVs: fueling duration, driving range, safety, and reliability.

Table 44: Most Influential Variables in Least Squares Estimations of BEV, PHEV, and FCEV Assessments

	Vehicle Type		
Assessment	**BEV**	**PHEV**	**FCEV**
Home Charging	NCB	NCB	na
Enough Charging/Fueling	Year	Year	Year, NCB
Charging/Fueling Duration	NCB	NCB	Year
Driving Range	Region, Year	Year, Region	Year, Region
Higher Price	—	—	—
Safety	Year, Region	Year, Region	Year
Reliability	Region	Year, Region	Year, Region
Environment	Region	Region	Region
Ready for Mass Market	Year	NCB	Year, Region

na—not applicable.

4.5.1 BEV Assessments

Participants offer slight average agreement they can charge a BEV at home. As just discussed, all the assessment density distributions have three modes. Thus, the average obscures that many people are quite convinced they can charge a BEV at home, many—if somewhat fewer—are just as convinced they cannot, and a bit fewer don't know. While there are statistically significant differences between regions and across years, by far the larger part of differences between participants is due to New Car Buyers being much more likely to assess they can charge a BEV at home than do non-New Car Buyers. The interaction between Year and NCB is such that the difference between New and non-New Car Buyers is even greater in 2021 than in 2019. While there is some regional variation, Region explains less of the variation in BEV home charging assessments than does NCB: the mean assessment is highest in the BAAQMD and lowest in the SJVAPCD.

The overall assessment of whether there are enough BEV charging locations is one of slight disagreement. Year has the greatest effect on differences: participants in 2021 are more likely to have more favorable assessments than participants in 2019. Further, differences between regions are less in 2021 than in 2019. The difference between regions is less in 2021 than in 2019 because regions with the worst assessments in 2019 had the most improved (though still negative) assessments in 2021. However, there is no difference between 2019 and 2021 in the BAAQMD, the region with the highest assessment of the amount of BEV charging.

Participants' assessments of the amount of time to charge BEVs differ by NCB and Region; there is no statistically significant effect of Year. Keeping in mind the scale for this assessment has been inverted so that positive values favor BEVs, New Car Buyers have worse assessments of BEV charge duration than non-New Car Buyers. The regional differences are large enough that the BAAQMD mean is statistically significantly worse than the Balance of the State, SDAPCD, and the SJVAPCD.

Participants' assessments of the driving range of BEVs are generally slightly negative no matter the year, region, or new car buyer status but means differ by Year, Region, and NCB, as well as an interaction between Year and Region. On average, participants in 2021 agree a more strongly that BEVs do travel far enough before needing to be charged than did participants in 2019—though in neither year is their assessment positive. This difference is evident in all six regions. The difference is large enough that in the BAAQMD, which has the highest assessment of BEV range, the average assessment is essentially zero, i.e., the balance point between unfavorable and favorable assessment, in 2021. On average New Car Buyers' assessments of BEV driving range are estimated to be worse than those of non-New Car Buyers.

In both years, all regions, and among New and non-New Car Buyers, there is no statistically significant difference in the average assessment that BEVs cost more to buy than conventional vehicles.

The average assessment of the relative safety of battery electric and gasoline vehicles is slightly negative: participants assess conventional gasoline vehicles to be safer than BEVs. These assessments differ by Year, Region, and NCB. Assessments of the relative safety of battery electric and gasoline vehicles are less favorable to BEVs in 2021 than in 2019. The average assessment is more favorable in the SDAPCD than in any other region, barely registering a better assessment of BEVs than conventional vehicles. On average New Car Buyers have worse assessments of the relative safety of BEVs compared to conventional vehicles than do non-New Car Buyers.

Average assessments of the relative reliability of battery electric and conventional gasoline favor conventional vehicles; these assessments differ significantly only by Region. The effect of Region is such that participants in the SDAPCD, BAAQMD, and Balance of the State offer better (though still unfavorable) average assessments of BEV reliability compared to conventional gasoline vehicles than do participants in the SJVAPCD. Further, participants in the SDAPCD favor the reliability of BEVs more so than those in the SCAQMD.

On average, participants offer moderate agreement BEVs are better for the environment than are conventional gasoline vehicles. Assessments of the relative environmental damage caused by BEVs and conventional vehicles differ only by Region. Participants in the BAAQMD, SDAPCD, and SCAQMD have higher average agreement scores than those in the Balance of the State. Further, participants in the BAAQMD and SCAQMD have higher average scores than those in the SJVAPCD.

Across both years, all regions, and New and non-New Car Buyers there is modest agreement BEVs are “ready for mass market”, though this assessment differs by Year, Region, and NCB. The BAAQMD has the highest mean score. It was statistically significantly higher than the Balance of the State, SMAQMD, and SJVAPVD in 2019. Only in the SMAQMD and SCAQMD is the assessment in 2021 enough higher than in 2019 for the difference to be statistically significant. New Car Buyers’ average agreement is higher than non-New Car Buyers’.

Overall, BEVs garner broadly unfavorable assessments regarding charging availability, driving range, and price, safety, reliability vis-à-vis gasoline vehicles. Despite these, BEVs also garner slight agreement to a summary assessment that BEVs “are ready for mass marketing.” Almost 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 while they don’t register affirmative agreement, their disagreement with whether 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 though for neither 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, that is reversed BEV charging duration and driving range as well as the relative safety and reliability of BEVs and conventional vehicles.

4.5.2 PHEV Assessments

Across all participants, there is slight average agreement they would be able to charge a PHEV at home. Participants’ assessments of their ability to charge a PHEV at home differ by Year, Region, the interaction Year*Region, and NCB. NCB is by far the most important variable: New Car Buyers have higher mean estimated scores than non-New Car Buyers. Even including their interaction, the practical effect of Year and Region on differences in participants assessments of their capability to charge a PHEV at home are slight.

On average across all participants, there is slight average disagreement there are enough places to charge PHEVs. The effects Year, Region, the interaction Year*Region, and NCB are all statistically significant. Year is the most important variable in estimating differences, producing a shift from slight *disagreement* in 2019 to even slighter *agreement* in 2021. The improvement is seen in all regions though in the Balance of the State the improvement is not large enough to shift the average assessment from negative to positive. New Car Buyers are estimated to have higher assessments of the amount of charging for PHEVs than are non-New Car Buyers.

Across all participants' there is modest agreement PHEVs take too long to charge. There are differences between participants based on Year and NCB, with NCB being the more important. New Car Buyers have, on average, a worse assessment of how long PHEVs take to charge than do non-New Car Buyers. Assessments are worse in 2021 than they were in 2019.

On average, participants assess PHEV driving range negatively; assessments differ by Year and Region (though only through their interaction) and NCB. The interaction of Year and Region does not produce a clear pattern of differences though the BAAQMD went from the best (though still negative) assessment of PHEV range in 2019 to the worst in 2021. The drop is large enough that in 2021, the assessment of PHEV range in the BAAQMD is significantly lower than in the SMAQMD and SDAPCD.

The strongest of all the PHEV assessments across all participants is the negative assessment of PHEV purchase price. It is also the only PHEV assessment that does not differ over time, between regions, or between New and non-New Car Buyers.

Across all participants there is slight agreement that gasoline vehicles are safer than PHEVs. Year is the most important variable in understanding differences: the assessment of the comparative safety of PHEVs and conventional gasoline vehicles is worse in 2021 than it was in 2019. The interaction Year*NCB is such that New Car Buyers in 2021 have worse assessments of PHEV safety compared to conventional vehicles than non-New Car Buyers in the same year and worse than both New and non-New Car Buyers in 2019.

Over all participants, the assessment of PHEV reliability compared to conventional gasoline vehicles is negative. Year and Region are nearly equally important to these differences—though mostly through their interaction—and both are much more important than NCB. The assessment of PHEV reliability is worse in 2021 than in 2019. Again, the interactions between Year and Region do not produce a clear pattern of differences.

Across all participants, PHEVs garner moderate agreement they are less damaging to the environment than are conventional gasoline vehicles. Only Region is associated with for differences between participants, i.e., as differences are not associated with Year this positive evaluation was sustained from 2019 to 2021 but did not get stronger. Participants from the BAAQMD are estimated to have higher agreement scores than participants from the Balance of State, SMAQMD, and SJVAPCD. Participants from the SDAPCD are also estimated to have higher scores than those from the SJVAPCD.

Averaged over all participants there is slight average agreement that PHEVs are "ready for mass market." There are differences by Year, Region, and NCB, the last being the most important. New Car Buyers have higher least square mean values than do non-New Car Buyers. This assessment of PHEVs is improved in 2021 over 2019. The assessment of market readiness is on average higher in the BAAAMD, SCAQMD, and SDAPCD than in the SJVAPCD. The BAAQMD is also higher than the Balance of State.

4.5.3 FCEV Assessments

Against a background of almost no hydrogen fueling anywhere except the BAAQMD, SCAQMD, and SMAQMD and only a few available FCEV make-models at the time of either survey, assessments of FCEVs are generally worse in 2021 than they were in 2019.

Across all participants there is moderate disagreement there are enough places to fuel FCEVs though this disguises that the median value is strongly negative, i.e., half of participants disagree much more strongly than "average" there are enough fueling locations. Despite the strong regionality of FCEV and hydrogen fueling availability, Year is most important in estimating differences, followed by NCB. Average assessment of the number of FCEV fueling locations is higher in 2021 than 2019. The assessments of New Car Buyers are more favorable than those of non-New Car Buyers in both years and both groups have higher scores in 2021 than they did in 2019. That the BAAQMD and SCAQMD have "high" hydrogen fueling availability is only in comparison to other regions, not an absolute measure, assessment is reflected in the results for Region. Though the effect of Region is statistically significant, the differences between regions are substantively small. The only statistically significant differences are the worse assessments offered in the Balance of the State compared to the SCAQMD and SJVAPCD.

Across all participants, there is a slight negative assessment of how long they believe it takes to fuel an FCEV. Year is the most important variable in estimating assessments of FCEV fueling time. Participants in 2021 offer worse assessments of FCEV fueling duration than those in 2019: in both years the estimated mean assessment is in the range of slight agreement that FCEVs take too long to refuel. New Car Buyers in 2021 are estimated to have worse assessments of FCEV fueling duration than in 2019 and worse than non-New Car Buyers in both 2021 and 2019.

Across all participants there is a slight negative assessment of how far FCEVs travel between fueling, i.e., FCEV driving range is too short. Year is the variable that is most important to estimating differences. On average, assessments of FCEV driving range are worse in 2021 than in 2019; both years register slight disagreement that FCEVs travel far enough between fueling. In no region is the 2021 assessment better than it was in 2019 though only in the SCAQMD is the assessment in 2021so much more negative as to be statistically significantly more negative than in 2019.

Over all participants there is a moderate negative assessment of FCEV purchase prices, i.e., they believe FCEVs cost more to buy than conventional vehicles. There are no significant differences between any pairs of least square means for Year, Region, or NCB; the moderate agreement that FCEVs cost more to buy than conventional vehicles is similar in both years, across all regions, and among New and non-New Car Buyers.

Across all participants there is a slightly negative assessment of the safety of FCEVs compared to conventional gasoline vehicles. Year is the variable that is most important to estimating differences. The assessment of the relative safety of FCEVs is worse in 2021 than in 2019 and New Car Buyers in 2021 are estimated to have the worst average assessment compared to non-New Car Buyers in 2021 and both New Car Buyers and non-New Car Buyers in 2019.

Across all participants there is disagreement that FCEVs are more reliable than gasoline vehicles (-0.80). This assessment does not differ by Year, Region, or NCB.

The average assessment across all participants is modest agreement FCEVs have lower environmental impact than gasoline vehicles. Region is assessed to be most important to any differences. Participants in the BAAQMD are estimated to have higher assessments of the environmental impact of FCEVs than participants anywhere else except the SDAPCD. The lowest assessments are in the SJVAPCD. This assessment is improved in 2021 compared to 2019: estimated mean scores are higher for 2021 than for 2019. New Car Buyers are estimated to have higher assessments than non-New Car Buyers.

Overall, participants slightly disagree FCEVs are ready for mass marketing (-0.25). Year is assessed to the most important to estimating differences. Participants in 2021 are estimated to be, on average, more likely to agree FCEVs are ready of mass market than were participants in 2019. The difference is one of shifting from modest disagreement in 2019 to indifference or indecision in 2021. Regionally, the Balance of the State lags the SCAQMD, SJVAPCD, and BAAQMD. The SJVAPCD and SMAQMD also lag the SCAQMD. New Car Buyers are more favorable than non-New Car Buyers. The interaction Year*NCB is such that New Car Buyers in 2021 are estimated to slightly agree FCEVs are ready for mass market.

4.6 Awareness of and Support for Incentives

Participants are not queried about specific incentives, but about whether they have heard of whether different potential sources offer incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel. For participants residing in California, the relevant potential sources include federal and state government as well as "Air quality districts or other regional government agencies."

Statewide, 38 percent of participants across both 2019 and 2021 say they are aware of incentives from the federal government. There are significant differences by Year, Region, and NCB: NCB is most important, followed by Region and Year. New Car Buyers are more likely to have heard of federal incentives than non-New Car Buyers. Participants from the BAAQMD are more likely to have heard of federal incentives than participants in the Balance of State and SJVAPCD. Participants from 2021 are more likely to have heard of federal incentives than participants from 2019.

Statewide, 33 percent of participants across both 2019 and 2021 say they are aware of incentives from the State of California. There are significant direct effects of Year, Region, and NCB. Based on tests of variable importance and the odds-ratios Region is most important to estimating differences in awareness of incentives from California, followed by Year and NCB. As with awareness of federal incentives, participants in the BAAQMD, as well as those in the SDAPCD, are more likely to have heard of California incentives than are those from the SJVAPCD and BoS, as well as the SCAQMD. However, all these differences are less than their corresponding effects for federal incentives, i.e., there is less difference by year, region, or new car buyer status for state incentives.

Statewide, 21 percent of participants say they are aware of incentives from Air Districts. There are significant differences of Year, NCB, and in a way, Region. Awareness of regional incentives is higher in 2021 than 2019. It is also the case that New Car Buyers are more likely to have heard of regional incentives than non-New Car Buyers. The effect of Region indicate is that participants in the SJVAPCD are statistically significantly more likely to have heard of regional incentives than participants in any of the five other regions. The SJVAPCD is the focal region for the DriveClean! Rebate Program administered by the air district; it was not the only local ZEV incentive administered by an air district in the State.

Most participants in California support the idea of government providing incentives for consumers to purchase vehicles fueled by electricity and/ or hydrogen. There was a statistically significant increase in support for incentives from 2019 to 2021 but increasing support for only electricity *or* hydrogen but not both. While it is true in 2021 most participants support incentives for both electricity and hydrogen, the increase in support for one or the other is higher. New Car Buyers in 2021 show the largest increase in support for electricity or hydrogen at the expense of support for both. Support is higher in the BAAQMD and lower in the BoS and SJVAPCD.

4.7 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. Large majorities of participants throughout California say they have given no consideration to any ZEV. Outright resistance—a person has not and would not consider a ZEV—is stated by 26% of participants for PHEVs, 28% for BEVs, and 38% in California in the 2021 analysis. Yet for the combined measure of PEV Consideration, that is PHEVs *or* BEVs, outright resistance averages 19%: some people who are resistant to PHEVs are not resistant to BEVs and vice versa. Adding FCEVs, ZEV Resistance (PHEVs, BEVs, *or* FCEVs) was 19% in California in 2021. 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 any ZEV. At the opposite end of the scale, small single digit percentages of participants (5%) are at the highest levels of consideration: actively shopped or ownership (present or prior) no matter how many types of ZEVs are included.

4.7.1.1 PHEV Consideration

PHEV Consideration is a function New Car Buyer status and region. New Car Buyers are more likely to be at higher levels of PHEV Consideration than are non-New Car Buyers. Participants from the BAAQMD are most likely to be at higher levels of PHEV Consideration, those from SCAQMD, SDAPCD, and SMAQMD are somewhat less likely to be at higher levels, and those from the BoS and SJVAPCD are least likely to be at higher levels of PHEV Consideration. The only differences between 2019 and 2021 are in the SJVAPCD: the direction is toward lower PHEV Consideration and is strong enough to conclude that PHEV Consideration is lower in 2021 than in 2019.

4.7.1.2 BEV Consideration

There are statistically significant differences in BEV Consideration by Region, Year, NCB, and Year*NCB. Because of the interaction between Year and NCB, they have similar importance to variation in BEV Consideration as does Region. BEV Consideration is estimated to be highest in the BAAQMD and lowest in the SJVAPCD. BEV Consideration is estimated to be higher in 2021 than it was in 2019. However, the interaction between Year and Region indicates BEV Consideration is not uniformly higher in 2021 than in 2019 across the six regions. Three regions—SMAQMD, SDAPCD, and the BoS—are estimated to have higher BEV Consideration in 2021 though only in the SMAQMD is the increase enough to be statistically significant. BEV Consideration is not different in 2019 and 2021 in the BAAQMD, SJVAPCD, and SCAQMD. In both years and in all six regions, New Car Buyers are estimated to be at higher levels of BEV Consideration than non-New Car Buyers.

4.7.1.3 PEV Consideration

Recalling PEV Consideration is defined as the higher level of PHEV and BEV Consideration. PEV Consideration accentuates differences that are common to the two individual measures of PHEV and BEV Consideration, e.g., because the non-significant difference between survey years for PHEVs and the significant difference for BEVs are in the same direction they combine to create a distinct impression of higher Consideration of PEVs in 2021 than in 2019. Similarly, combining the highest values of the two measures into one reduces differences they don't share, e.g., the interaction Year*Region.

The variables Year, Region, NCB, and Year*Region are statistically significant: NCB and Region are the more important effects. New Car Buyers are estimated to be at higher levels of PEV Consideration than non-New Car Buyers. Participants from the BAAQMD are estimated to be at higher levels of PEV Consideration than participants from any of the other five regions and those from the SVJAPCD are estimated to be at the lowest. PEV Consideration is estimated to be higher, i.e., more participants are at higher levels of Consideration, in 2021 than in 2019. Despite the fact the interaction Year*Region is statistically significant in both the PHEV and BEV Consideration models, it is not so in the PEV Consideration model likely because its effect is in the opposite direction for the individual measures.

4.7.1.4 FCEV Consideration

The only statistically significant differences in FCEV Consideration are due to NCB. New Car Buyers are estimated to be more likely to be at higher levels of FCEV Consideration than non-New Car Buyers. The model provides no evidence that FCEV Consideration is higher in the BAAQMD than in any other region (nor that any region is different from the others). There is evidence that participants from the SCVAPCD are at lower levels of FCEV Consideration in 2021 than 2019.

4.7.1.5 ZEV Consideration

As with PEV Consideration, ZEV Consideration takes on the highest value of multiple measures, in this case consideration of PHEVs, BEVs, and FCEVs. As such it is subject to the same upward "biasing" of scores and to both complementary and competing effects on its three constituent measures. Differences in FCEV Consideration depend on Year, Region, and NCB, but there is no reason to expect differences between regions or between New and non-New Car Buyers differ between 2019 and 2021. Participants from the BAAQMD are estimated to be more likely to be at higher levels of ZEV Consideration than participants from the other regions and those in the SJVAPCD to be more likely to be at lower levels. New Car Buyers are estimated to be more likely to be at higher levels of ZEV Consideration than are non-New Car Buyers. Participants from 2021 are estimated to be more likely to be at higher levels of ZEV Consideration than are those from 2019.