33nd Electric Vehicle Symposium (EVS33)
Portland, Oregon, June 14 - 17, 2020

Consumer Consideration of Electric Vehicles? Evidence from California

Kenneth S. Kurani[1]

[1]*Plug-in Hybrid & Electric Vehicle Center, University of California, Davis, 1590 Tilia Street Davis, CA 95616, USA, knkurani@ucdavis.edu*

Summary

To continue increasing electric vehicle (EV) sales requires increasing numbers of car buyers to consider EVs. Policy makers, automakers, and infrastructure providers continue spending on EV purchase and use incentives, increasing EV models, and expanding charging and fueling networks. Are increasing numbers of consumers aware of these actions and considering EVs? Survey results over multiple years indicate the answer is, "no," even in California, a state noted for its leadership. This paper describes stagnant levels of consumer engagement with, and consideration of, EVs and demonstrates the importance of prompting consideration by more households.

Keywords: BEV (battery electric vehicle), PHEV (plug-in hybrid electric vehicle), consumers, demand, market development

1 Introduction: Is the electric vehicle market in the United States growing?

Light-duty electric vehicles (EVs) are widely regarded as essential to limiting greenhouse gas emissions and improving local air quality [1, 2, 3, 4]. Given such social benefits, EV market growth goals have been stated such as California's 5 million zero emission vehicles (ZEVs) on-road by 2030 [5], regional initiatives of states and automakers have been created to promote EVs, e.g., [6], new states have joined the ranks of those with ZEV requirements, e.g., Colorado [7], and many automobile manufacturers have stated plans to electrify product lines. An essential feature of these goals, actions, and plans is their actual or implied timelines; the transition to electric drive must be made with some urgency. The need for a rapid and sustained transition to electric transportation mounts as climate change is happening not only faster than during any period in the historical record [8, 9, 10] but faster than thought it would as recently as 2014 [11]. However, it will take years to electrify the on-road fleet of vehicles. Simulations of vehicle fleet turnover for the U.S. show that given present trends in how long vehicles remain on road, even if every light-duty vehicle sold in the U.S. from today forward is an EV, it will take nearly 20 years before 90% of the on road fleet is an EV [12]. Given such long timelines and stipulating continuing improvements in EV cost and performance as well as increasing charging (for plug-in EVs (PEVs)) and fuelling (for hydrogen fuel cell EVs (FCEVs)) infrastructure leaves the question of demand: will rapidly increasing numbers of consumers consider and buy EVs rather than familiar ICEVs? This paper presents the case that such a trajectory has not yet started.

The start is to distinguish counting buyers from counting cars. The headline of the U.S. Department of Energy, Vehicle Technologies Office's Fact of the Week for 9 March 2020 announced, "U.S. All-Electric Vehicle Sales Level Off in 2019" [13]. Reading past the headline, while battery electric vehicle (BEV) sales in the U.S. were up in 2019 by 3,000 units over 2018, total EV sales (BEVs plus plug-in hybrid electric vehicles (PHEVs)) were down over 30,000 units—an approximately 10% decline from 2018. Annual U.S. EV sales dipped previously—by about four percent from 2014 to 2015. However, that small earlier decline might be excused as not unexpected in an early market for a new kind of automobile. The decline from 2018 to 2019 is more concerning for several reasons, including the decline occurred despite increasing variety of EV makes-models, spending on consumer incentives, and PEV charging infrastructure, as well as improving performance attributes such as BEV range.

Regardless of whether the decline in the number of EVs sold in the US from 2018 to 2019 reverses in 2020, counting cars is an incomplete measure of market demand during a transition when increasing the number of EV buyers is required to sustain and hasten a transition. This article focuses on household buyers because households buy or lease most of the light-duty cars and trucks in the U.S. Further, it will focus on households in the state of California as it is the single largest state market for automobiles in the US in general and EVs in particular. In 2019 California accounted for 11.3 percent of light-duty vehicle registrations and 11.7 percent of new sales as well as 47 percent of registrations and annual sales of EVs [14]. Twenty-five percent of all EV charging stations in the U.S. are in California [15]. Further, the state is the originator of zero emission vehicle policy in the US. As such, California serves as the test case for the thesis that household engagement with, and consideration of, EVs are not increasing at rates suggesting we are in a sustainable, rapid transition. If the thesis is supported, the decline in EV sales from 2018 to 2019, while still concerning, is not surprising.

2 Data and Measures

2.1 Household Survey Data

Primary data are from four surveys of car-owning households previously conducted under the direction of the author in the years 2014, 2017, and 2019. Though one of the two 2014 surveys included multiple U.S. states, the analysis in this article are solely from California households. Complete descriptions of individual studies may be found in [16, 17, 18]. Briefly, they are:

2014: All car-owning households, California: n ~ 1,700. June.
New-car buyers, California (and twelve other states): California subset, n~1,700. December.

2017 All car-owning households, California n ~ 1,700 ea. June.

2019 All car-owning households, California n ~ 3,600 stratified by air districts. March.

Supporting data to provide context for understanding survey responses over time such as public spending on incentives and charging infrastructure deployment are drawn from other sources noted in the results.

2.2 Measuring Consumer Engagement and Consideration

Consumer engagement as presented here is multi-dimensional. To be engaged with a new product is to be aware of it, seek (or at least perceive) information, accrue knowledge and possibly gain trial experience, form attitudes, establish and recognize norms, connect it to personal and social values, learn the signs of the new product and their meanings, and (perhaps) enter a purchase process that may iterate on all these. Thus, engagement with EVs is measured across multiple dimensions of whether, how, and to what extent a person or household is investing in becoming or being an EV owner. The measures of the dimensions of engagement discussed in this paper are presented here with their survey questions and possible responses:

Awareness: EV Name Recollection: "Can you name a [hybrid, battery electric, plug-in hybrid electric, hydrogen fuel cell electric] that is being sold in the US?" (For each of the bracketed options, the response is, No/Yes. If Yes, respondents complete text boxes for Make and Model.)

Awareness: Public Purchase and Use Incentives: "As far as you are aware, is [each of several options including the Federal Government and Your State Government] offering incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel?" (Yes; No; I'm not sure).

*Awareness: Charging Infrastructur*e: "Have you seen any electric vehicle charging spots in the parking garages and lots you use?" (Yes, in several places; Yes, a few places; Yes, one place; No; I'm not sure.)

Assessment: Availability of BEV Charging Infrastructure: "There are enough places to charge battery electric vehicles."

Assessment: BEV Driving Range: "Battery electric vehicles do not travel far enough before needing to be charged."

Assessment: BEV Driving Range and Purchase Price: "Battery electric vehicles cost more to buy than gasoline vehicles."

All assessment statements are rated on a scale: -3 = strongly disagree to +3 = strongly agree. Some of the original assessment statements were written so agreement, i.e., positive scores on the scale, indicate a favourable assessment of EVs, others such that positive scores indicated an unfavourable assessment of EVs. For analysis all statements were (re)coded so positive numbers favour EVs.

Knowledge: Basic Functionality, e.g., Fuelling: "From what you understand, which of these vehicles [hybrid, battery electric, plug-in hybrid electric] are fuelled with gasoline and which are plugged in to charge with electricity?" (Choose one: Only fuelled with gasoline; Only plugged in to charge; Both fuelled with gasoline and plugged in to charge with electricity; or, I don't know.)

Sources of Information; Social Network Effects: (New starting in 2017.) "Is there anyone you know by name who owns a BEV [PHEV]?" (I'm not sure, No, Yes)
If yes, "Have you spoken to this person, or these people, about their BEV [PHEV]?" (Yes, No).
If yes, "Have those conversations changed your thoughts or feelings about BEVs [PHEVs]?" (No; Yes, made me more favorable toward BEVs; Yes, made me less favorable toward BEVs [PHEVs])

Consideration as used here is broader than the idea of "consideration sets" common in choice modelling and decision research. Consideration describes where people are in relation to a purchase decision. For example, one may engage in information search about EVs without shopping for EVs; consideration connects information search to a purchase decision. An engaged consumer may consider an EV for purchase and decide not to purchase one. Thus, the measure of consideration for purchase allows both resistance to, as well as purchase of, an EV.

Consideration for Purchase: "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."

The question was repeated with appropriate changes for PHEVs and FCEVs. (Because there are so few FCEV make-models for sale and so few sales have as yet occurred, they are not considered further here).

Comparisons across years are not made by meta-analysis, a method common for articles reviewing several studies or data sets for which authors have access only to summary measures from multiple studies such as sample sizes, means, and variances. Further, in a meta-analysis the reviewed studies may vary in methods, measures, samples, and other ways that confound direct comparison. Here, the author has the data for all three years from a research process designed to produce comparable samples and data over time. Therefore, direct estimations of whether consumer engagement with and consideration of EVs changed from 2014 to 2019 are made.

3 Results

3.1 Awareness: EV Name Recollection

The ability to recall the name of an EV—whether from advertising, conversation, seeing a nameplate on a car, or any other source—suggests a person both recognizes the name as belonging to an EV and that names of EVs are salient enough to the person to be remembered. Respondents in all three years were asked if they could recall the name of a PHEV and a BEV. Reponses from text boxes for Make and Model are cleaned (for variations in spelling and capitalization) then scored for correctness. Data are presented in Figure 1 for BEVs based on a stricter set of rules for correct answers (notably, the name of a PHEV does not count as correct for the question about BEVs and vice versa). The ability of samples of all car-owners to name a BEV is shown in Figure 1 compared to the increasing number of possible right answers over time, that is, the cumulative number of BEV make-models that were sale at the time of each survey or had previously been for sale but no longer were.

The number of BEV make-models nearly doubled from June 2014 to March 2019 (counts on lower-axis of Fig.1); over the same period there is no substantive increase in the percentage of car-owning households who can name a BEV; the distributions of responses are independent across the years of the surveys ($\chi^2 = 83.335$, df = 10, n = 7,022, $p < 0.001$). Across all three years about 70 percent of households either say they can't name a BEV ("No") or say they can but provide an answer that is clearly wrong ("Yes: Wrong") (upper axis of Fig.1). Only Tesla (all models combined) and Nissan Leaf are recalled by more than a low single digit percentage of respondents. The Chevrolet Bolt was only distinguished from correct "Other" responses in 2019.

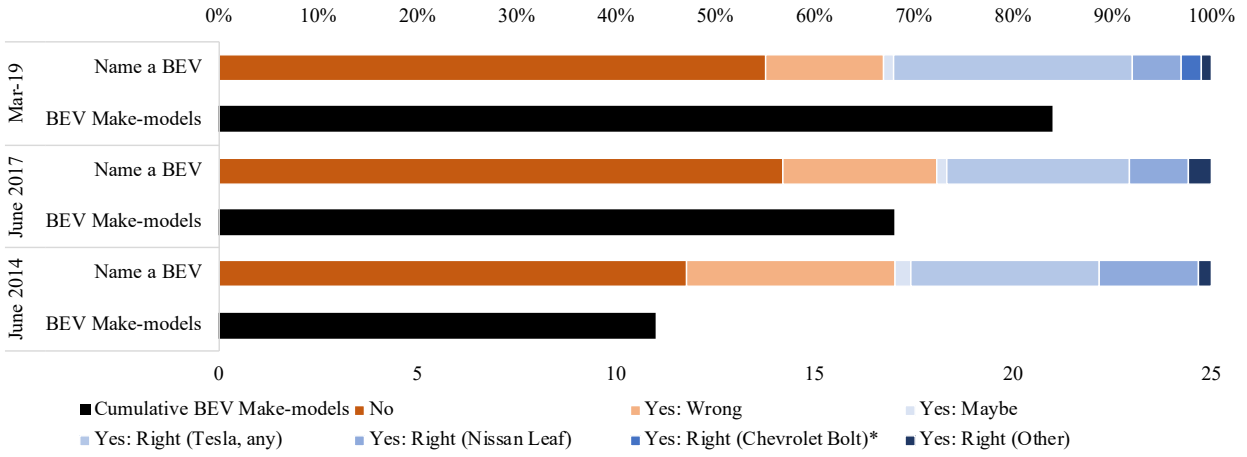

Figure 1: Cumulative Number of BEVs for Sale in the U.S. and Respondent Ability to Name such BEVs

Data on PHEV name recollection are not presented here but, shows name recollection is worse than for BEVs. The number of PHEVs that were or had been for sale in the U.S. at the time of each survey increased four-fold from eight in 2014 to 33 in 2019, yet in 2019 even more people (than for BEVs)—nearly three-fourths of respondents—said they could not name a PHEV or gave an answer that was unambiguously wrong.

3.2 Awareness: Public Purchase and Use Incentives

As purchase incentives for new PEVs would be most salient to buyers of new vehicles generally, we use the new car buyer sample from 2014 and select the sub-sets of people from the 2017 and 2019 samples who meet the definition of new car buyer used in the 2014 new car buyer study. As of this writing, the U.S. federal income tax credit for purchasing a PEV is expiring for vehicles from the manufacturers of the most popular selling PEVs.

Still, through March 2019 qualifying households in California were eligible for some level of a federal tax credit for PEVs and a California Clean Vehicle Rebate (CVR). PEV (and FCEV) buyers in California were eligible for other incentives, too, but as the federal tax credit and CVR are both large one-time monetary purchase incentives uniformly available and valuable across the state (unlike local incentives), the analysis focuses on them.

Figure 2 shows the cumulative number of CVRs (in thousands) and spending on CVRs (current US$ millions) as areas with values on the left-hand y-axis [19]. Though most years are represented by full calendar years of data, for 2010 data only starts in mid-March and as of the writing of this article data for December 2019 were not yet available. For the new car buyers, columns at the survey years show the percent of respondents (on the right-hand y-axis) who affirm they had heard the federal and California state governments offer "incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel." Any change over time in the percent of new car buyers who are aware of federal incentives is a decrease (Somers' D (treating Year as the explanatory variable)) = -0.079, n = 4,492, $\alpha = 0.01$). For California, there is no statistically significant change in the percentage who affirm they are aware California provides incentives (Somers' D (treating Year as the explanatory variable = -0.009, n = 4,491, $\alpha = 0.45$). On the interval from the 2014 to 2019 surveys, California spent over half-a-billion dollars on CVRs and while this subsidized the purchase of a quarter-million EVs, neither it nor the federal tax credit created any greater awareness of EV purchase incentives among new car buyers.

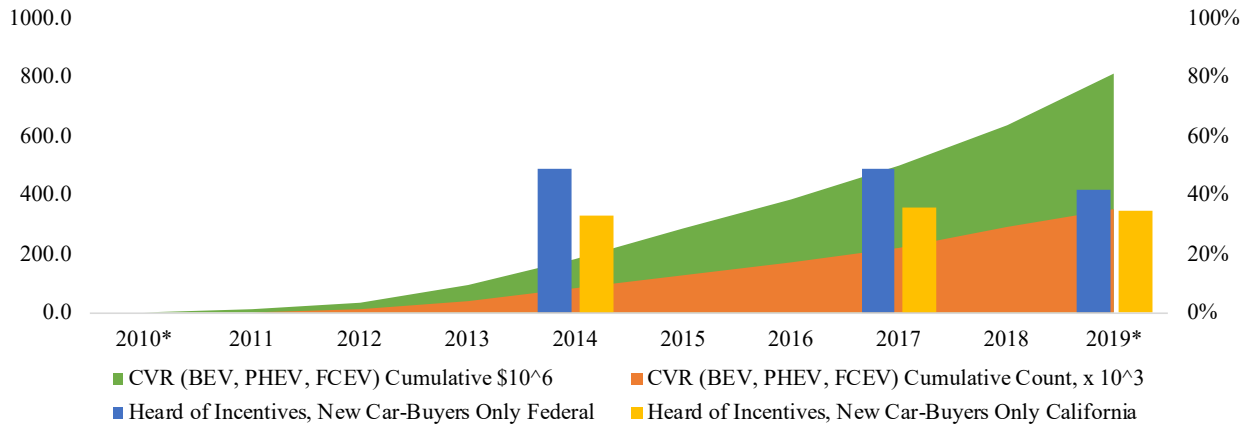

Figure 2: California Clean Vehicle Rebate Counts (10^3) and Spending (Current US$ 10^6); Percent of New Car Buyers who have Heard of Federal and California Incentives.

3.3 Awareness: Charging Infrastructure

EV charging infrastructure is described as necessary for many EV owners and as an important sign to all car owners of EVs. However, for the latter to be true a higher percentage of all car owners should both report seeing EV chargers and seeing them in more places over time as more EV charging is deployed. The survey data indicate neither is happening across all car-buyers, supporting similar conclusions from workshops conducted with EV and non-EV owners [18]. Figure 3 shows counts of EV charging locations in California shortly after three surveys [20] and the percent of respondents in each of survey who report seeing EV charging "in the parking garages and lots you use." Responses from 2014 are from the sample of new car buyers as this question was not asked in the survey of all car-owning households that year while all responses from 2017 and 2019 were used. From 2014 to 2019, the number of EV charging locations tripled but there was no substantive change in the percentages of respondents who report seeing EV charging either at all or in more locations. Somers' D C|R (treating Year as the explanatory variable) = -0.009, which while negative (indicating sightings of charging are going down over time as more charging is deployed) is not significantly different from zero $\alpha < 0.01$.

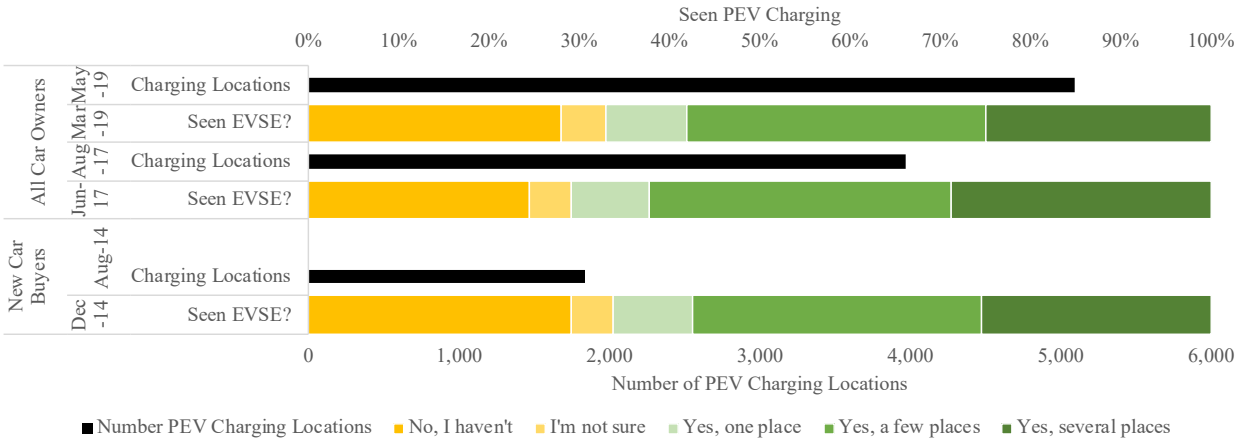

Figure 3: Number of Public Level 2 and DC Fast Charging Locations in California and Percent of Respondents who Report Seeing EV Charging

3.4 Assessment: Availability of EV Charging

As the number of EV charging locations increased from 2014 to 2019 yet awareness of EV charging infrastructure among car-owning households did not, car-owning households were shifting toward more negative assessments of the availability EV charging. Respondents in the three surveys of all-car owners were asked to rate their agreement with the statement, "There are enough places to charge battery electric vehicles" (-3 = strongly disagree to +3 = strongly agree). The mean scores declined from -0.51 in 2014, to -0.61 in 2017, to -0.73 in 2019. The 2017 mean is statistically significantly lower (worse) than the 2014 mean and the 2019 mean is less than the 2017 (Wilcoxon each pair test: 2017-2014 $Z = -2.07$, $p = 0.038$; 2019-2017 $Z = -2.06$, $p = 0.038$). Thus, with even greater certainty the average assessment of whether there are enough EV charging locations is worse in 2019 than in 2014 (Wilcoxon each pair test, 2019-2014 $Z = -5.13$, $\alpha < 0.01$). Further, examining the probability densities of the BEV charging assessments (Fig. 4) shows that in later years as the number EV charging locations increases, so too did the probability respondents more strongly disagree there are enough compared to earlier respondents who offered their assessment of a smaller number of charging locations. The pattern shows people shifting from uncertainty (peak density at a score of 0 for 2014) toward the ends of the scales but especially toward the negative end: the percentage of people rating the strongest disagreement (-2.75 to -3) there are enough places to charge BEVs nearly doubles from 2014 (13 percent) to 2019 (24 percent).

3.5 Assessment: BEV Driving Range and Purchase Price

From 2014 to 2019, increasing percentages of respondents from the surveys of all car-owners gave the most negative assessment of BEV driving range and BEV purchase price compared to conventional gasoline vehicles (Fig. 5). Over the time period covered by the surveys, more BEVs offered longer driving range [21]. Despite this, the highest point on the probability density curve for the assessment of BEV driving range in 2019 is -3 (strongest [dis]agreement that "BEVs do [not] travel far enough before needing to be charged," whereas the highest point for both 2014 and 1027 is at zero. Further, the mean assessment of BEV range declined from 2104 to 2017 (Wilcoxon each pair test: 2017-2014 $Z = -6.75$, $p < 0.01$) and again from 2017 to 2019 (Wilcoxon each pair test: 2019-2017 $Z = -7.30$, $p < 0.01$).

Prices for BEVs may not yet show a downward trend, but from 2014 to 2019 there was a shift toward more negative assessments of the price of BEVs compared to gasoline vehicles on the part of all car-owning households; the year-to-year declines are statistically significant from 2014 to 2017 (Wilcoxon each pair test: 2019-2017 $Z = -6.75$, $p < 0.01$)and from 2017 to 2019 (Wilcoxon each pair test: 2019-2017 $Z = -7.06$, $p < 0.01$).

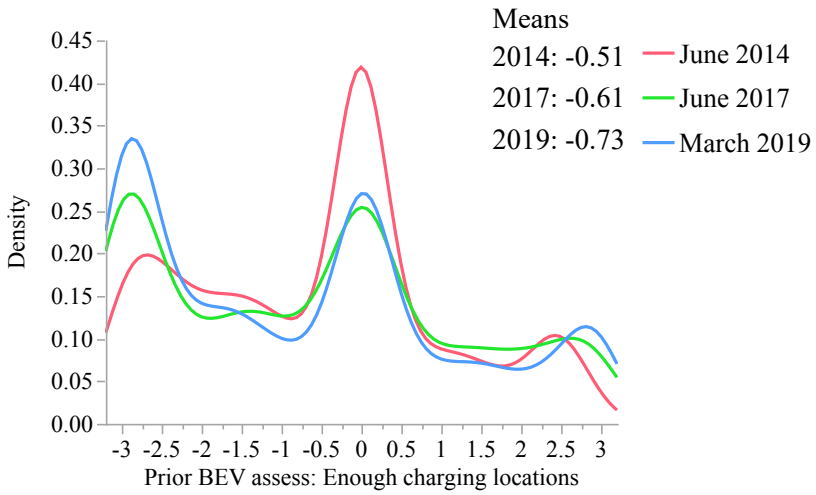

Figure 4: Means and Probability Densities of Agreement Scores: Assessment of the number of BEV charging locations

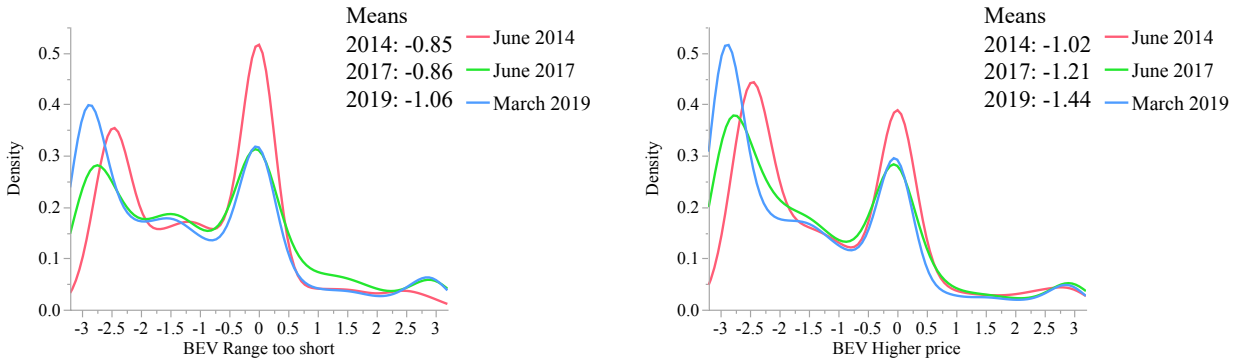

Figure 5: Means and Probability Densities of Agreement Scores: Assessments of BEV Driving Range and Purchase Price

3.6 Knowledge of Basic Functionality: Fuelling

In contrast to assessments which tap into respondents' subjective evaluations, measures of knowledge test objective facts, e.g., how different types of vehicles are fuelled. Respondents were asked to indicate whether hybrid electric vehicles (HEV), BEVs, and PHEVs are "only fuelled with gasoline," "only plugged in to charge with electricity," both, or, "I don't know." Distributions of responses for all three years are shown in Figure 6: correct responses for each vehicle type are emphasized and incorrect responses are pale. Summarizing across vehicle types, on average three-fourths of respondents across the three surveys know BEVs only plug-in to charge. Fewer, but still a majority (60%), know PHEVs both plug-in to charge and refuel with gasoline. Despite the fact HEVs have been available for purchase since 1999, barely one-fifth of respondents in any year understand they are only fuelled with gasoline; rather, the majority—about 60 percent in all three years—believe HEVs fuel with gasoline and must be plugged in to charge with electricity, too. From 2014 to 2019 there are no progressive shifts toward higher percentages of respondents knowing how HEVs, PHEVs, or BEVs are fuelled. A measure of association between fuelling knowledge and ear of the survey, an asymmetric λ (that takes Year to be the explanatory variable) = 0.00 (α = 0.01) for HEVs, PHEVs, and BEVs; knowing which year a car-owner is from does nothing to improve predicting whether they know how these vehicle types are fuelled.

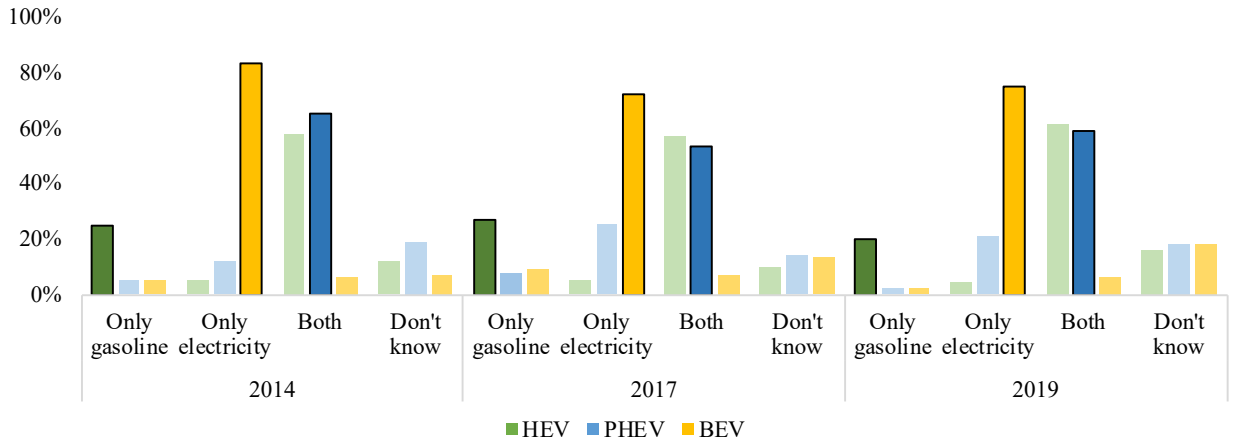

Figure 6: Knowledge of how HEV, PHEVs, and BEVs are fuelled, percent

3.7 Social Effects: Conversations with EV Owners

Data on conversations that all car-owners may have had with BEV and PHEV owners they "personally know" were collected only 2017 and 2019. The number of registered EVs in California increased from June 2017 (303,973) to March 2019 (545,315). It is uncertain how many more EV owners this represents, but allowing there were some more EV owners in 2019 and also with the passage of nearly two years, it is plausible that in 2019 car-owning households would have had greater opportunity to talk about EVs with an EV owner than in 2017. Further, it is plausible that with increasing variety of EV make-models, increasing BEV driving range, and more extensive charging infrastructure that more of such conversations would favourably impress non-EV owners. Neither of these seems to have occurred (Figure 7). For both BEVs and PHEVs, the asymmetric λ (treating Year as the explanatory value) = 0.00 (α = 0.01); knowing which year respondents are from does nothing to improve predicting whether they know a BEV or PHEV driver, spoke to so such person, or what effect such conversations had on respondents' "thoughts and feelings" about BEVs or PHEVs. The sum of percentages for, "I don't know a BEV [PHEV] owner" and "I'm not sure if I know a BEV [PHEV] owner" for 2017 and 2019 cluster about 68 to 70 percent. Among those few respondents reporting conversations with BEV or PHEV owners, there is no difference in how many of those conversations made the non-EV owners more (or less) favourable toward EVs.

3.8 Consider Purchasing an EV

As with all prior results, the distribution of the extent to which people have already considered either or both a BEV and PHEV showed no substantive increase from June 2014 to June 2017 and on to March 2019 (Figure 8). In 2014, the question phrasing allowed respondents to consider either BEVs or PHEVs in a single question. For 2017 and 2019, distinct questions were asked for BEVs and PHEVs; for those years the data in the figure takes the higher value of the two responses. For example, someone who owns or had owned a BEV [PHEV] may say they haven't and won't consider a PHEV [BEV]; they are plotted as "Have or have had a BEV and/or PHEV." The only way a respondent in 2017 or 2019 is counted as "Haven't and won't consider a BEV or PHEV" is to select "haven't and won't" for both BEVs and PHEVs. This outright resistance is near 20 percent of car-owning households across the three samples. Somers' D C|R (treating Year as the explanatory variable) = -0.033, (α < 0.01) indicating a substantively slight, but nevertheless downward, shift over time in the percent of car-owning households who have considered an EV for purchase for their household.

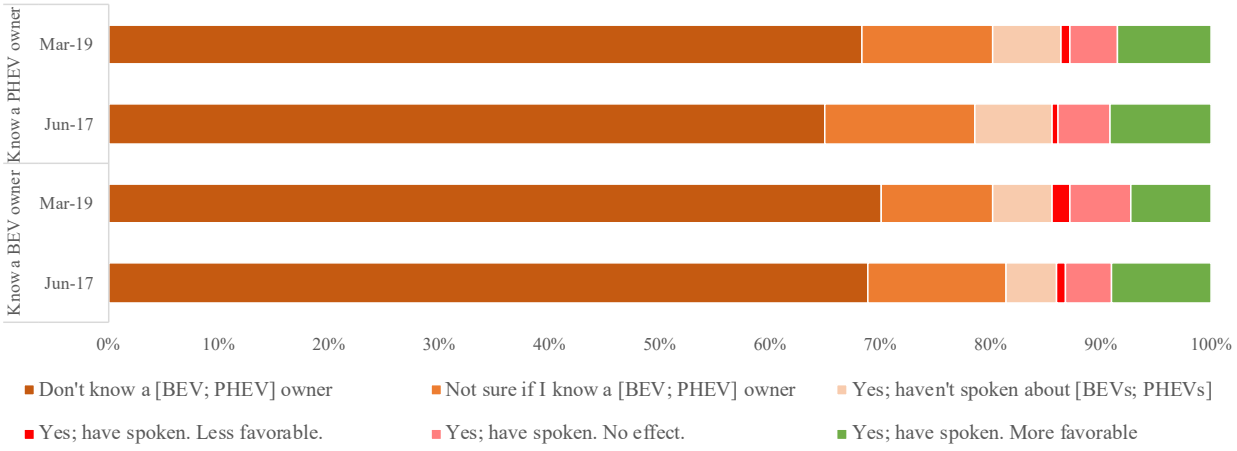

Figure 7: Incidence of Respondents' Conversations with EV owners and
Whether such Conversations made Respondents More or Less Favourable toward EVs

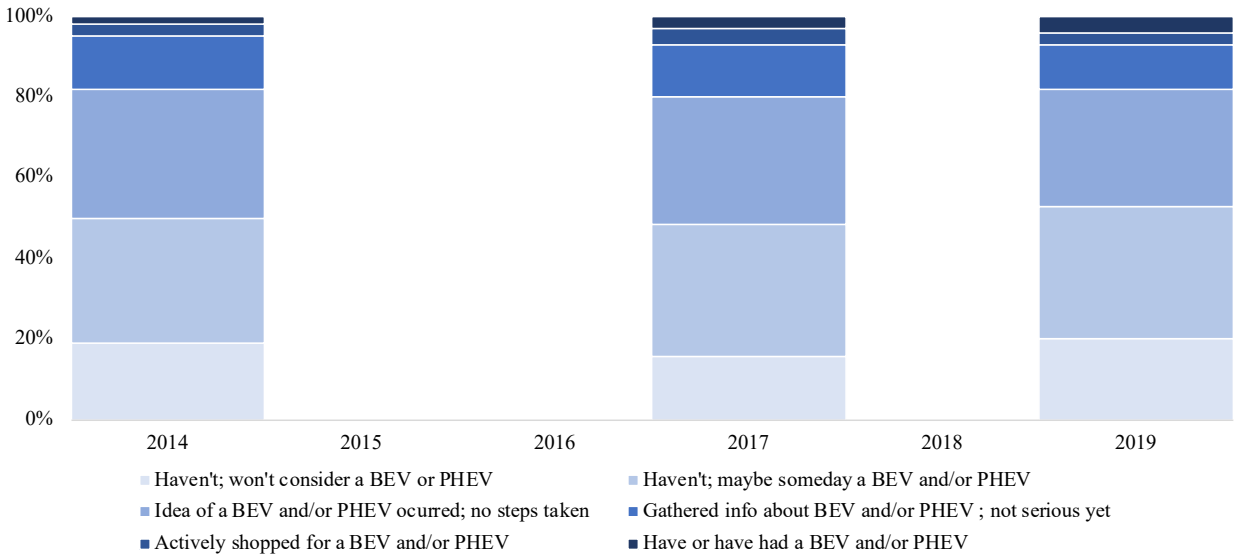

Figure 8: Consideration of BEVs and PHEVs for Purchase across Time, percent.

4 Discussion

No measure here of California car-owners' awareness, assessments, knowledge, conversations with EV owners, or consideration of EVs shows any sign of a growing base of consumers to support continuing EV market growth. In short, the majority of car-owning households in California are not engaged with EVs. The results for EV charging awareness and assessment are instructive. Reconciling the result that on average from 2014 to 2019 car-owners' were no more likely to agree there were enough EV charging locations—and worse, the percentage of respondents who offered the most negative assessment doubled—with the fact that at the same time the number of charging locations was increasing can be done by hypothesizing that in those few instances a non-EV owner notices an EV charger they don't add it to a "mental map" [23] of EV charging, rather, they see a reminder they

don't think there is enough EV charging. This hypothesis is supported by other evidence from a study across regions of California with differing levels of EV market and infrastructure development: EV drivers were keenly aware of the presence and absence of EV charging; non-EV drivers were not particularly aware of either the presence or absence of EV charging infrastructure [19].

The pervasive and persistent misunderstanding of how HEVs are fuelled has likely slowed their sales since their introduction. This study does not estimate the size of such an effect, but given how questions about BEV charging—"Where can I charge? How far can I drive? What happens when I run out of charge?"—are routinely posed as problems, it seems plausible demand for HEVs would have been higher if people understood they solely fuel with gasoline and do not have to plug in. The lesson for EV market development is that so long as the large majority of car-owning households remain unaware and inattentive to EVs, any possibility of rapidly shifting them toward greater consideration and purchase of EVs will be hampered by existing (mis)perceptions and (mis)information.

This paper started with a distinction between counting buyers and counting cars, arguing increasing the number of buyers is paramount to sustaining a rapid transition. A thought experiment along these lines is offered in Figure 9. The figure columns show counts of US EV sales as often reported [13]; the line in Figure 9 illustrates a hypothetical re-imagining of the last few years of EV sales based on the experience of Tesla Model 3 buyers. Hundreds-of-thousands of people committed to buy the Model 3 starting early in 2016 as a waiting list grew to nearly 200,000 commitments in two days (31 March to 1 April 2016) and to over 455,000 by August 2017 (net of the number of refunded reservations estimated to be 12 percent [24]). The alternative view assumes half the Model 3 waiting list was US residents and that 88 percent (100 percent minus 12 percent) of people on the list as of August 2017 ultimately bought a Model 3. It then apportions actual Model 3 sales that occurred in 2018 and 2019 across the years 2016 to 2019 as if Tesla had been able to fill demand on a timeline approximating when people made (an admittedly non-binding) commitment to buy. This alternative view reframes the last four years of EV sales. In a count of vehicle sales (figure columns), there was a one-year decline from 2018 to 2019; in the alternative view, total EV "sales plus fulfilled commitments" have been declining since 2016. This alternative view is consistent with lack of growth in the number of people who are becoming EV buyers as seen in the unchanging percentage of all car-owning households who had considered buying an EV from 2014 to 2019.

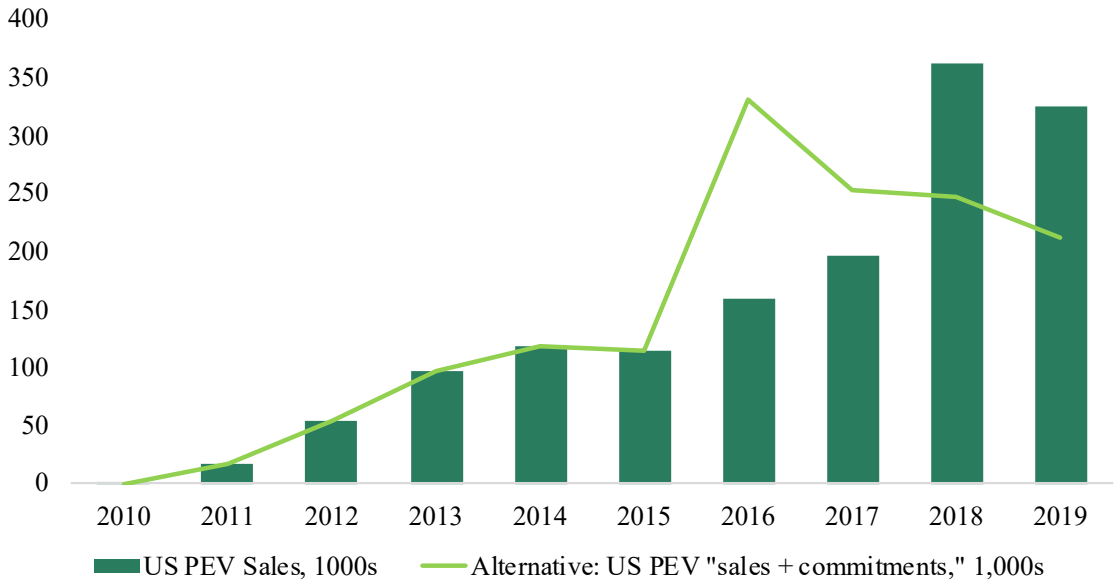

Figure 9: 2010 to 2019 US PEV Sales; two views

5 Conclusions

The thesis that consumer engagement with, and consideration of, EVs did not increase from 2014 to 2019 in California is supported. In 2019 most car-owning households in California were as unaware of improvements in key EV performance attributes, ongoing purchase incentives, and increasing charging infrastructure as they were in 2014. No more households had or were considering a BEV or a PHEV for purchase in 2019 than in 2014. If the number of people considering EVs for purchase does not grow, neither will the number of people who buy EVs and thus any transition to fully electrify the light duty fleet will take decades longer than it already will. Reconciling these results with what appears to be increasing EV sales is done by recognizing 1) many EVs are being purchased by the same people and 2) much of what appears to be an increase in vehicle sales over the past three years is due to one vehicle manufacturer essentially filling back-orders from 2016.

For all that has been accomplished over the past ten years to electrify light-duty transport, one thing that has not is the creation of a growing and engaged consumerate. Salience seems a prerequisite to two things broadly lacking among car-owning households, even in California: 1) recognition and attention to the signs and symbols of EVs, and 2) motivation to engage in considering EVs over familiar gasoline-powered cars and trucks. Salience is taken to refer to more than an attribute that "stands out among the good's attributes" [25]. Rather, salience is taken to mean the relationship between (potential and actual) buyers and the attributes of EVs and ICEVs, a relationship that expands not only the range of values of familiar (and unfamiliar) attributes but introduces new attributes that allow EVs to appeal to people for new reasons. Solutions to creating greater awareness and increasingly positive assessments of EVs and EV charging infrastructure—as real improvements are made—include making EVs salient to all car-owning households so, for example, they recognize, understand, and recall the signs, e.g., they recognize EVs when they see them on the roads and in parking locations and form, remember, and add to their own mental maps of EV charging.

Acknowledgments

Funding was provided by the California Energy Commission, California Air Resources Board, Northeast States for Coordinated Air Use Management, and the Plug-in & Hybrid Electric Vehicle Research Center.

References

[1] H. Ma, F. Balthasar, N. Tait, X. Riera-Palou, A. Harrison, *A new comparison between the life cycle greenhouse gas emissions of battery electric vehicles and internal combustion vehicles*, Energy Policy 44 (2012) 160–173, https://doi.org/10.1016/j. enpol.2012.01.034

[2] U. Nopmongcol, J. Grant, E. Knipping, M. Alexander, R. Schurhoff, D. Young, J. Jung, T. Shah, G. Yarwood, *Air quality impacts of electrifying vehicles and equipment across the United States*, Environ. Sci. Technol. 51 (2017) 2830–2837, https://doi.org/10.1021/acs.est.6b04868.

[3] W. Ke, S. Zhang, X. He, Y. Wua, J. Hao, *Well-to-wheels energy consumption and emissions of electric vehicles: mid-term implications from real-world features and air pollution control progress*, Appl. Energy 188 (2017) 367–377, https://doi.org/ 10.1016/j.apenergy.2016.12.011.

[4] United States Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015*. EPA 430-P-17-001, https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-201

[5] *Office of Governor Brown, Executive Order B-62-18,* https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html Accessed on 2020-03-20.

[6] *Drive Change. Drive Electric.* https://driveelectricus.com/ Accessed on 2020-03-20.

[7] *Office of Governor Polis, Executive Order B2019 002,* https://www.colorado.gov/governor/sites/default/files/inline-files/b_2019-002_supporting_a_transition_to_zero_emissions_vehicles.pdf Accessed on 2020-03-20.

[8] *Climate is always changing. Why is climate change of concern now?* https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/question-6/ Accessed 2020-03-09.

[9] *Climate Change. How do we know?* https://climate.nasa.gov/evidence/ Accessed on 2020-03-09.

[10] *How is Today's Warming Different from the Past?* https://earthobservatory.nasa.gov/features/GlobalWarming/page3.php Accessed on 2020-03-09.

[11] Y. Xu, V. Ramanathan, and D. G. Victor. *Global Warming will happen faster than we think*, Nature 564, 30-32 (2018) https:/doi.org/10.1038/d41586-018-07586-5

[12] D.R. Keith, S. Houston, S. Naumov *Vehicle fleet turnover and the future of fuel economy* 2019 *Environ. Res. Lett.* 14 (2019) 021001. https:/doi.org /10.1088/1748-9326/aaf4d2

[13] United States Department of Energy, Office of Energy Efficiency & Renewable Energy. *Fact of the Week #1124*. https://www.energy.gov/eere/vehicles/articles/fotw-1124-march-9-2020-us-all-electric-vehicle-sales-level-2019 Accessed 2020-03-09.

[14] Auto Alliance. *U.S. and California Fact Sheets*. https://autoalliance.org/resource-center/ Accessed 2020-03-13.

[15] U.S. Department of Energy, *Alternative Fueling Station Counts by State.* https://afdc.energy.gov/stations/states Accessed on 12020-03-014.

[16] K.S. Kurani. *State of the Plug-In Electric Vehicle Market: Report II*. (2018) National Center for Sustainable Transportation, University of California, Davis. https://escholarship.org/uc/item/8rp9h6fb

[17] K.S. Kurani, N. Caperello, Jennifer TyreeHageman. *New Car Buyers' Valuation of Zero-Emission Vehicles: California*. (2016) Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-16-05 https://itspubs.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2682

[18] K.S. Kurani, N. Caperello, J. TyreeHageman, J. Davies *Symbolism, signs, and accounts of electric vehicles in California*. Energy Research and Social Science 46 (2018): 345–355. https://doi.org/10.1016/j.erss.2018.08.009

[19] Center for Sustainable Energy. *California Air Resources Board Clean Vehicle Rebate Project, Rebate Statistics*. Data last updated February 3, 2020. https://cleanvehiclerebate.org/eng/rebate-statistics Accessed 2020-03-15.

[20] United States Department of Energy, Alternative Fuels Data Center. *Alternative Fueling Station Locator*. https://afdc.energy.gov/stations#/analyze Accessed 2014-08, 2017-08, and 2019-05.

[21] D. Gohlke and Y. Zhou. *Impacts of Electrification of Light-Duty Vehicles in the United States, 2010 - 2017*. United States: N. p., 2018. https:/doi.org/10.2172/1418278

[22] Auto Alliance. *Advanced Technology Vehicle Sales Dashboard*. https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/ Accessed 2020-03-17.

[23] D. Dingemans, D. Sperling, R. Kitamura. *Mental Maps and the Refueling Behavior of Vehicle Drivers.* Transportation Research Record 1092 (1986) http://onlinepubs.trb.org/Onlinepubs/trr/1986/1092/1092-001.pdf

[24] K. Gessner. *Tesla faces accelerating rate of Model 3 refunds.* (2018) Second Measure Data Points. https://secondmeasure.com/datapoints/tesla-faces-accelerating-rate-of-model-3-refunds/ Accessed 2020-03-19.

[25] P. Bordalo, Nn. Gennaioli, and A. Shleifer. Salience and Consumer Choice. Journal of Political Economy 121 (2103) 51: 803-43.

Author

Ken Kurani is a Professional Researcher at the University of California, Davis Institute of Transportation Studies and Plug-in & Hybrid Electric Vehicle Center. Dr. Kurani's research is located at the intersection of lifestyle, automobility, energy, and the environment. He focuses on how citizen/consumers may use new technologies to (re)shape their lives and how these participants inform efforts to promote, operate, and regulate (auto)mobility systems. Presently, he is organizing his research around identity narratives, for example, framing studies around questions such as, "Do systems of electric/shared/automated vehicles help me to tell a better story about myself?"