State of the Plug-In Electric Vehicle Market: Report II

September 2018

A Research Report from the National Center for Sustainable Transportation

Kenneth S. Kurani, University of California, Davis

National Center for Sustainable Transportation

UC DAVIS

PLUG-IN HYBRID & ELECTRIC VEHICLE RESEARCH CENTER

of the Institute of Transportation Studies

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NCST

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Preface

Assembly Bill (AB) 118 (Nùñez, Chapter 750, Statutes of 2007), created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). The statute authorizes the California Energy Commission to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. AB 8 (Perea, Chapter 401, Statutes of 2013) re-authorizes the ARFVTP through January 1, 2024, and specifies that the Energy Commission allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The ARFVTP has an annual budget of approximately $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and non-road vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the ARFVTP, a project must be consistent with the Energy Commission's ARFVTP Investment Plan, updated annually. The Energy Commission issued Program Opportunity Notice (PON)-13-604 to evaluate emerging technologies based on lifecycle emissions and economic performance, consumer behavior, and the influence of new business models and regulatory and market policies on the pace of adoption of emerging technologies and the scale of their expansion. In response to PON-13-604, the recipient submitted an application which was proposed for funding in the Energy Commission's notice of proposed awards February 27, 2014 and the agreement was executed as ARV-13-020 on May 1, 2014.

Abstract

This is the second of two reports gauging the extent to which car-owning households in California have considered purchasing plug-in hybrid electric vehicles, battery electric vehicles, and fuel cell electric vehicles collectively, zero emission vehicles. It seeks insights into how to promote greater consideration across an increased number and broader variety of households. The analysis is based on two on-line surveys of car-owning households in California. The first was conducted in February (n = 1,681) and June 2017 (n = 1,706). Analysis of the February 2017 data is presented in the companion State of the Market Report 1. Nothing in the results for the June data contradicts the general findings from February. To quote the abstract of *State of the Market Report 1*:

> "The primary measure of interest is the extent to which respondents have already considered a zero emission vehicle for their household: 4-of-5 car-owning households in California had given either no or nearly no consideration to zero emission vehicles. Combined, less than 10 percent had given the highest two levels of consideration; active shopping or ownership. Other measures of awareness, name recognition, incentive knowledge, and driving experience were commensurately low. Relying on socio-economic and demographic variables to segment markets is unlikely to succeed. Variables describing respondents' decision contexts and resources are important, especially whether respondents can reliably access electricity at a home parking location. General attitudes regarding air quality, the relative public health and environmental effects of electricity vs. gasoline, and experience with hybrid electric vehicles add further explanatory power. Ultimately though, variables specific to zero emission vehicles are more strongly associated with zero emission vehicle consideration: interest in zero emission vehicle technology; familiarity with zero emission vehicles including name recognition, driving experience, and recognizing and recalling PEV charging, assessments of zero emission vehicle charging/fueling duration, driving range, purchase price, safety and reliability; and, whether people know a zero emission vehicle owner."

New results from additional analysis of the role of biological sex/social gender is based on a recommendation in the first State of the market report. The lower likeliness that female respondents have considered zero emission vehicles is solely for fuel cell electric vehicles. There appear to be some slight differences in how some explanatory variables are correlated to consideration between males and females: for females, it matters more that they live in a household that has flexible vehicle assignments; for males, it matters more whether they claim familiarity with internal combustion engine vehicles and experience with zero emission vehicles. Still, these differences are marginal and do not contravene the overall finding that across all respondents—female and male—few have paid much attention to any kind of zero emission vehicle.

Zero emission vehicle consideration is a multi-faceted concept and there are several ways in which it can be initiated: personal contact with zero emission vehicle drivers; making visible the signs of the transition, i.e., teaching people which vehicles they see on the road are zero emission vehicles, making visible not merely of specific charger locations but a growing charging network, and marketing the fact incentives exist to buy and use zero emission vehicles; and expanding the number and variety of opportunities to gain direct experience of zero emission vehicles. In doing so, consider differential possibilities to provide targeted messages at the majority of car-owning households who are not opposed to the idea of zero emission vehicles, but simply have paid them no attention.

Keywords: zero emission vehicles, plug-in hybrid, electric vehicles, consumers

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TABLE OF CONTENTS

Preface i
Abstract ii
TABLE OF CONTENTS iv
List of Figures v
List of Tables vi
EXECUTIVE SUMMARY vii
Recommendations xi
Chapter 1: Project Description 1
Purpose 1
Approach 1
Objectives 1
Framework Design 1
Chapter 2: Results 3
Sample Description 3
Modeling consideration of PEVs and FCEVs: June 2017 26
CHAPTER 3: Insights 43
Consideration of ZEVs by car owning households in California has been limited 43
Socio-economic and demographic measures alone are poor estimators of ZEV consideration. 43
The timing of future consequences and orientations toward the future may matter, but more specific measures matter more 44
Female and male respondents differ little in their consideration of ZEVs 45
CHAPTER 4: Conclusions 46
Recommendations 46
Acronyms 48

List of Figures

Figure ES-1. Consideration of Electric Vehicle Types; February 2017 viii
Figure 1. Consideration of PEVs and PEVs or FCEVs, percent.. 4
Figure 2. Comparisons of income distributions to the California Household Travel Survey.......... 6
Figure 3. Home parking location by reliable access to electricity, percent of total sample 8
Figure 4. Whether any vehicles were acquired as new since January 2010 by the number of vehicles owned or leased by household, percent 9
Figure 5. If for any reason we could no longer use gasoline and diesel to fuel our vehicles, what do you think would likely replace them? Choose up to three... 11
Figure 6. Familiarity with vehicle types, mean score; -3 (“No, I am not familiar…”) to +3 (“Yes, I am familiar…”) 11
Figure 7. Name recognition of battery electric vehicles “being sold in the US.” 13
Figure 8. Mean driving experience scores; -3 = never; +3 = daily 13
Figure 9. Knowledge of how vehicles are fueled, percent... 15
Figure 10. Incidence of knowing ZEV owners, having conversations with them about the car, and effects of such conversations, percent 16
Figure 11. BEV assessments, mean score; -3 (strongly disagree) to +3 (strongly agree) 17
Figure 12. FCEV assessments, mean score; -3 (strongly disagree) to +3 (strongly agree) 18
Figure 13. Heard of incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel, percent 18
Figure 14. Support for government incentives to consumers, percent 19
Figure 15. Reasons for buying a PEV or FCEV, percent.. 20
Figure 16. Histograms of the distributions for air pollution affected by individuals’ lifestyles, air pollution is a personal worry, and air pollution is a regional health threat 21
Figure 17. Joint distributions risk to human health risk and the environment of using electricity rather than gasoline; reverse coded so +3 = disagree electricity poses a greater risk than gasoline 22
Figure 18. Boxplots of rescaled total CFCS scores, scale 1 = motivated entirely by immediate consequences to 5 = motivated entirely by future consequences....................................... 25
Figure 19. Distributions of the mean respondent scores for past, present, and future temporal focus (TFS) scores... 26

List of Tables

Table 1. Respondent and household socio-economic and demographic distributions 5

Table 2. Residence Characteristics 6

Table 3. Vehicle purchase decision making roles within households, Percent 9

Table 4. Relative role of decision makers regarding motor vehicle purchases in multi-person households, Percent 10

Table 5. Items in CFC-I and CFC-F scales, means 24

Table 6. Temporal focus scales, June 2017; means and rotated factor loadings 25

Table 7. Complete list of explanatory variables in Models 1 through 6 27

Table 8. Progression of Models of Consideration of PEVs and FCEVs as New Variable Groups added to Model and models that minimize information criteria 29

Table 9. Statistically Significant Explanatory Variables in Models 1 through 4: Consideration of PEVs and FCEVs 30

Table 10. Statistically Significant Explanatory Variables in Models 5 (Minimum AIC_c); interactions with respondent sex identifier 31

Table 11. Explanatory Variables in Model 6 (Minimum BIC); Consideration of PEVs and FCEVs. 32

Table 12. Summary of explanatory variables in models 7a through 10b 38

Table 13. Comparison of February and June 2017; Progression of Models of Consideration of PEVs and FCEVs as New Variable Groups added to Model and models that minimize information criteria 40

Table 14. Statistically Significant Explanatory Variables in Models 7a through 10a: Consideration of PEVs and FCEVs 41

Table 15. Model of who are new car buyers, combined February and June 2017 42

State of the Plug-In Electric Vehicle Market: Report II

EXECUTIVE SUMMARY

The need to further improve energy efficiency and reduce greenhouse gas emissions motivates a shift to electric vehicles, including battery, plug-in hybrid, and fuel cell electric vehicles. Electric vehicle stakeholders, including governments, the auto industry, fuel suppliers, and consumers, face numerous challenges in developing a sustainable market at pace to meet the State's goals, e.g., as laid out in Assembly Bill 118. Further understanding of the electric vehicle markets is necessary in order to help guide California toward meeting California zero emission vehicle sales and emissions and air pollution reduction goals. (A note on nomenclature used in this report: the category of "plug-in electric vehicles" is taken to include battery electric vehicles and plug-in hybrid electric vehicles and the category "zero emission vehicles" is taken to include battery electric vehicles, plug-in hybrid electric vehicles, and fuel cell electric vehicles. Effort has been taken to use the correct acronym in each instance.)

The objective of Task 2.2 of research agreement ARV-13-020 is to implement a market research project with a recurring survey to advise California state agencies and electric vehicle stakeholders on the most effective ways to expand the market for electric vehicles in California and the US. To accomplish this objective a consumer data collection and analysis framework capable of tracking consumer awareness, knowledge, and consideration of zero emission vehicles over time was deployed. The framework requires consistency across a set of measures will allowing flexibility to test different hypotheses over in time.

Specifically, two surveys were conducted of the population of car-owning households in California. The surveys were conducted in February and June of 2017. The realized sample sizes were 1,681 (February) and 1,706 (June). The study approach was a repeated cross-section (different households in each survey) design to measure differences (within each survey sample) and infer changes over time (between samples). Each surveys' questionnaire collected information in these general categories:

- Household vehicle ownership and use;
- Awareness, knowledge, consideration, and action regarding zero emission vehicles;
- Awareness and support for policies and programs; and,
- Attitudinal, socio-economic, and demographic measures.

Examples of hypotheses tested within samples, but not across, include these:

- The role of orientation toward new vehicle technology and future consequences of present actions on consideration of zero emission vehicles (February 2017); and
- The role of future consequences of present actions and orientation toward the past, present, or future (June 2017).

This *State of the Market Report II* describes the June 2017 survey as well as comparative analysis of the February and June 2017 data sets.

The primary measure of interest is the extent to which respondents had already considered any zero emission vehicle—battery electric vehicle, plug-in hybrid electric vehicles, or fuel cell electric vehicle—for their household at the time of their questionnaire. The result from February and June 2017 is that nearly 4-of-5 car-owning households in California have given no to nearly no consideration to any type of zero emission vehicle. Combined, less than eight percent had given the highest levels of consideration: active shopping for or ownership of a zero emission vehicle. Further we note, that people who had actively shopped had generally decided not to buy (or lease) a zero emission vehicle at the time they shopped (Figure ES-1).

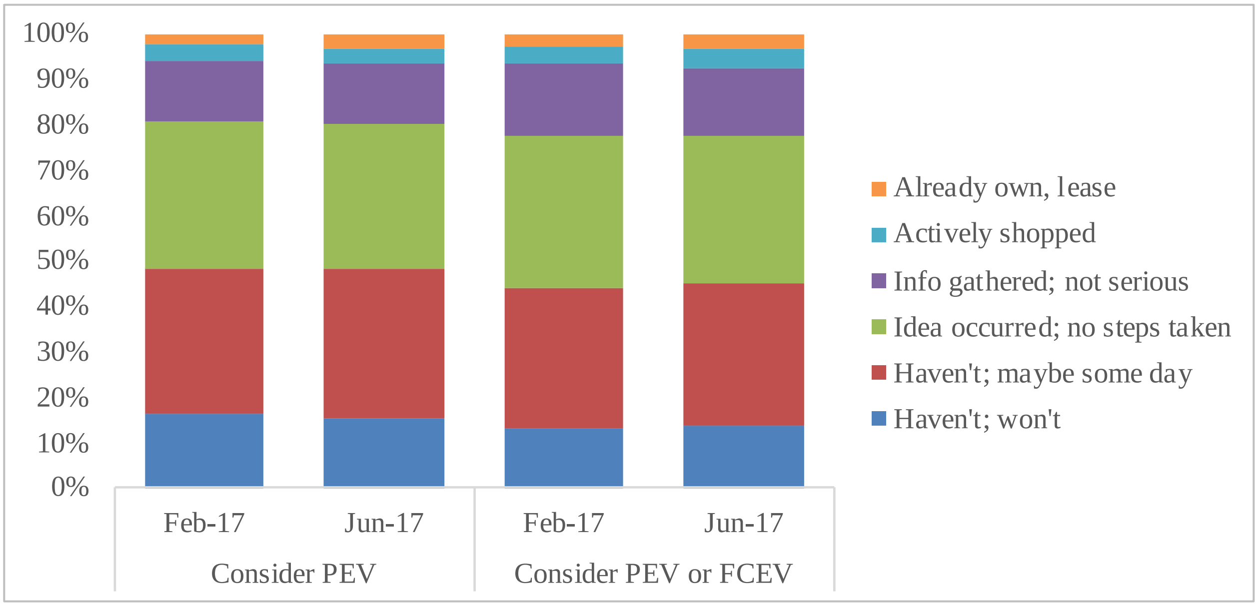

Figure ES-1. Consideration of Electric Vehicle Types; February 2017
Source: Kurani, Kenneth. University of California, Davis.

In both samples, all other measures of awareness, vehicle name recognition, incentive awareness, and driving experience are commensurate with these low levels of consideration. Assessments of battery electric vehicle and fuel cell electric vehicle charging and fueling, performance, price, reliability, and safety are correlated with zero emission vehicle consideration—but those assessments are based on the same low levels of awareness, knowledge, and experience just cited. Thus, these assessments are susceptible to change from increased awareness, knowledge, and experience.

Relying on socio-economic and demographic variables alone to attempt market segmentation for improved information and outreach to people at levels of no to low zero emission vehicle consideration is unlikely to succeed. The results for June 2017 and the combined analysis for February and June 2107 indicate that while simple socio-economic and demographic measures—age, sex, education, and household income in this case—can be statistically correlated to zero emission vehicle consideration, by themselves they are not particularly powerful descriptors of who had and who had not considered zero emission vehicles as of the first half of 2017. While no model estimated for the February, June, or combined data performs well describing who has already shopped for or owned a zero emission vehicle (the two highest levels of consideration), this is in part because, so few households in the population of car-owning households were at these high levels. For June 2017, the only socio-economic or demographic measure to consistently appear across all models of zero emission vehicle consideration is respondent age. Younger people, specifically those age 30 to 39 are consistently estimated to be at higher levels of zero emission vehicle consideration than any other age bracket; probability of having considered zero emission vehicles is estimated to decline as age categories shift toward older respondents.

Every model that included additional variables did a better job than one including only socio-economics and demographics. Measures of household context and resources improve the estimation of zero emission vehicle consideration, especially whether the household has reliable access to electricity at home parking location. While it is true that access to electricity at a parking location is more likely for households that live in single family homes rather than multi-unit dwellings, measures of residence type, i.e., single family home vs. multi-unit dwelling don't enter any model as statistically significant. This suggests creating reliable access to electricity, regardless of building type or ownership, may allow households who have not considered zero emission vehicles (or at least, plug-in electric vehicles) to do so.

Another improvement in understanding the extent to which car-owning households have already considered zero emission vehicles is made if measures of general attitudes toward public health and the environment are known, in particular as these relate to the effects of substituting electricity for gasoline and diesel. People who believe substituting electricity for gasoline, "in the region where I live," is better for human health and the environment are more likely to be at higher levels of zero emission vehicle consideration.

Ultimately, the variables that provide the biggest improvement to estimating zero emission vehicle consideration are specific to the technology, market, and policy context of zero emission vehicles:

- Seeing plug-in electric vehicle charging;
- Knowing how plug-in electric vehicles are fueled;
- Knowing of federal and California incentives;
- Supporting the idea of government incentives;
- Knowing a zero emission vehicle owner;
- Having an interest in zero emission vehicle technology;
- Being able to name a plug-in electric vehicle offered for sale;
- Feeling sufficiently familiar with zero emission vehicles;
- Experience driving zero emission vehicles; and

- Assessments of battery electric vehicles on these related measures:
  - Duration of charging and driving range; and,
  - Safety and reliability compared to conventional vehicles.

The inference is that affecting these measures broadly across the population of car-owning households—because they are all generally low across the population—builds a broader base of zero emission vehicle consideration. While the modeling here is of differences between people, not of changes to people over time, the suggestion is that to start to increase zero emission vehicle market growth it would be productive to increase peoples' awareness and knowledge, provide them with a basis to form more informed assessments, and thus prompt consideration of zero emission vehicles for their households. Certainly, we should not expect all of the people who have so far paid no-to-little attention will be or can be quickly converted to zero emission vehicle shoppers and owners. However, there seems very little prospect to grow the zero-emission vehicle market very far, very fast unless the vast majority of car-owning households in California who are not paying attention can be engaged in the transition to electric-drive.

It is less clear if understanding people's orientation toward past, present, and future timeframes and whether people feel their present actions are affected more by immediate or future consequences adds any real power to explanations of zero emission vehicle consideration. These measures improve the model containing only socio-economic and demographic descriptors. The results indicate that both a greater attention to future consequences of present behavior and spending more time thinking about the future are associated with higher levels of zero emission vehicle consideration. However, when variables describing household context and resources as well as environmental and public health attitudes are included, they supplant measures of effects of future consequences and orientation towards time.

The one set of models in which orientation toward time appear as statistically significant is the model examining differences between female and male respondents. In models exploring differences between female and male respondents, the variable for respondent's sex identifier does not itself enter as a statistically significant variable, but the interaction of this variable with four other variables does:

- Daily flexibility to assign cars to drivers;
- Familiarity with conventional gasoline- or diesel-fueled internal combustion engine vehicles;
- Consideration of Future Consequences-Immediate, that is, the degree to which people rate their present actions as being affected more by future or immediate consequences; and,
- Experience driving zero emission vehicles.

These interaction effects indicate that women living in a household with flexible assignment of vehicles to drivers are more likely to be at a higher level of zero emission vehicle consideration.

For all respondents, higher levels of familiarity with internal combustion engine vehicles and more experience driving zero emission vehicles are associated with higher probability of being at higher levels of zero emission vehicle consideration; the interaction with respondent sex identifier is such that these effects are stronger for male respondents than for female respondents.

The overall effect of consideration of future consequences-immediate is that people who score themselves as being more motivated in the present by immediate consequences (than by future consequences) are more likely to be at *lower* levels of zero emission vehicle consideration. The interaction between respondent sex identifier and consideration of future consequences-immediate indicates the general effect is not modified among female respondents, but that among male respondents the effect is slightly reduced.

Recommendations

The effect of any efforts to increase consumer engagement in the electric-drive transition can best be gauged by instituting and funding consumer research on an ongoing basis and within a consistent framework. This study is one in what can best be described having been carried out in a consistent framework but at unpredictable intervals as new funding must be found for each new (set of) surveys.

Social marketing of the electric-drive transition itself is required, not just of the vehicles. Consumer engagement requires motivation. It matters that people imagine why they would consider electric-drive vehicles in general to create the motivation to shop for one in particular. Among respondents who can give no reason why they would buy a battery electric vehicle more than half say they haven't and won't consider a battery electric vehicle for their household. Among respondents who can give a reason why they might buy a battery electric vehicle, only seven percent say they haven't already considered one and won't do so in the future.

A stronger distinction between female and male respondents was evidenced in the February 2017 data than in the June 2017 data. However, the difference was a matter of degree, not existence. The conclusion is supported by both samples that levels of consideration of zero emission vehicles are generally low among female and male respondents but the messages, media, and mechanisms for encouraging greater consideration by women and men may differ. Further research should be designed to more specifically address gender differences not only in zero emission vehicle consideration, but also in zero emission vehicle purchase and use.

Finally, the samples used for State of the Market I and II were representative of the state as a whole. As the analysis of these data suggest, but cannot themselves prove, to the extent some differences between people may vary systematically by regions, for example Air Quality Management Districts and Air Pollution Control Districts or electric utility service areas, future studies of consumer engagement in the electric-drive transition should consider collecting survey samples specifically designed to test for and study such regional variation in zero emission vehicle consideration, purchase, and use.

Chapter 1: Project Description

Purpose

The purpose of this research is to help the State of California accelerate the transition toward zero-emission vehicles (ZEVs) through a greater understanding of why car-buying households in California are—or are not—interested in buying ZEVs. This market research is conducted as two surveys of independent samples separated in time reported in two State of the Market Reports. The first State of the Market report describes the basic research approach and summarizes the results of the first survey. The second report will report the results of the later survey and compare and contrast the results of the two surveys implemented as part of Research Agreement ARV-13-020; Task 2.2.

Approach

Two surveys of car-owning households were conducted in California during 2017, one in February and another in June. Past research on consumer response to zero emission vehicles (ZEVs), a category that for purposes of this report will subsume plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs) (collectively, plug-in electric vehicles (PEVs), and fuel cell electric vehicles (FCEVs)) does not build on an ongoing record to monitor change. Past studies—even if designed to project markets for ZEVs and their fuels over time—were typically conducted as one-off studies. It could be argued that some replication has occurred across disparate studies. However, there is little reason to believe studies by different authors using differing conceptual models of human behavior, studying different populations, sampled by different methods, queried by different means, and analyzed by different techniques add to a consistent view over time of consumer behavior with respect to ZEVs.

Objectives

Within this approach, the project has these objectives:

- Implement a consumer data collection and analysis framework capable of accomplishing the following:
    - Track consumer awareness, knowledge, and consideration of ZEVs over time within a consistent frame;
    - Allow flexibility within the framework to test different hypotheses over time; and,
    - Provide input to strategies for ZEV market growth and infrastructure deployment.

Framework Design

This project assembles a framework for policy makers to understand whether or not consumer behavior is changing in such a way that health, environment, and energy goals for ZEVs will be achieved on their stipulated timelines. The framework should allow legislators, policy makers, and administrating agencies to better understand the effectiveness of supporting programs and investments. It implements a single, flexible, conceptual model of consumer behavior grounded in decades of prior research. A single population is studied and for the term of this project that population is repeatedly, independently sampled by the same method. The data over time are analyzed in the same way, with an emphasis on interpretability and applicability of the results.

Sampling

The approach is a repeated cross-section (different households in each sample) study to measure differences (within each cross-sectional sample) and infer changes over time (between samples). The population of study is all California households that own or lease light-duty automobiles for their private use. This population differs from much past work on consumer response to ZEVs that has focused on how to initiate markets for ZEVs and thus studied the population of new car buyers. As the purpose of the project is to establish a framework for ongoing feedback to policy and program design and implementation, the framework accounts for the eventual development of a market for used ZEVs by including all households that own or lease light-duty vehicles regardless of whether they tend to acquire vehicles new or used.

Questionnaire design

The questionnaire assesses parameters required to assess differences between survey samples and test hypotheses both between survey samples as well as within each survey sample. These are the general categories of questions:

- Household vehicle ownership and use;
- Awareness, knowledge, consideration, and action regarding ZEVs;
- Awareness and support for policies and programs; and,
- Attitudinal, socio-economic, and demographic measures.

Examples of hypotheses tested within samples, but not across, include these:

- The role of orientation toward new vehicle technology and future consequences of present actions on consideration of ZEVs (February 2017); and
- The role of future consequences of present actions and orientation toward the past, present, or future (June 2017).

Activities Performed

Associated literature reviews were made to support the study of consumer orientation to new automotive technology, consequences of future actions, and orientation toward past, present, or future time periods. Two surveys were conducted for this project in order to evaluate any changes in consumer orientation over time. Sample size for the February 2017, n = 1,681; for June 2017, n = 1,706. This report covers the February and June surveys.

Chapter 2: Results

Sample Description

Results presented here show those from June 2017 in comparison to those from February 2017. Results are presented in the following order. The first section describes the central description of consumer engagement with ZEVs: the extent to which they have already considered buying one for their household. Then, the variables that will be used in multivariate modeling are presented. These variables include measures of households and respondents on socio-economics and demographics, followed by measures of respondents' awareness, knowledge, and assessments of the PEVs and FCEVs. There follows a description of environmental and health attitudes and orientations toward new technology and immediate vs. future consequences of present-day actions. After that, the multivariate modeling is presented.

Consideration of PEV and ZEVs for purchase

The primary measure of interest in ZEVs is the extent to which respondents had already considered one for their household. This is the question for BEVs:

> "Battery electric vehicles (BEVs) run only on electricity; they plug-in to charge their batteries. Have you considered buying a BEV for your household? Please choose only one of these:
>
> ☐ 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 a BEV."

The question is also asked for PHEVs and FCEVs with the following substitutions for the opening descriptive sentence:

- PHEVs: "Plug-in hybrid vehicles (PHEVs) run on electricity and gasoline; you can both plug them in to charge their batteries and refuel them at a gasoline station."
- FCEVs: "Hydrogen fuel cell electric vehicles are powered by an electric motor. Electricity is created on the vehicle using hydrogen (refueled at a fuel station much like a gasoline station) and oxygen (from the air)."

The distributions are shown in Figure 1 for PEVs and PEVs or FCEVs. The values are the highest consideration assigned to any vehicle type in the combination. Even in the l most permissive combination (PEV or FCEV), about seven percent of the sample of car-owning households in California says they own (~three percent) or have shopped (~ four percent) a PEV or an FCEV. Even allowing for respondents who say they have started to gather information about any PEV or FCEV but aren't "serious yet" still leaves four out of five car-owning households in California who were not paying attention to the transition to electric drive in the light duty automotive sector. Any apparent differences between the two surveys are within in sampling errors.

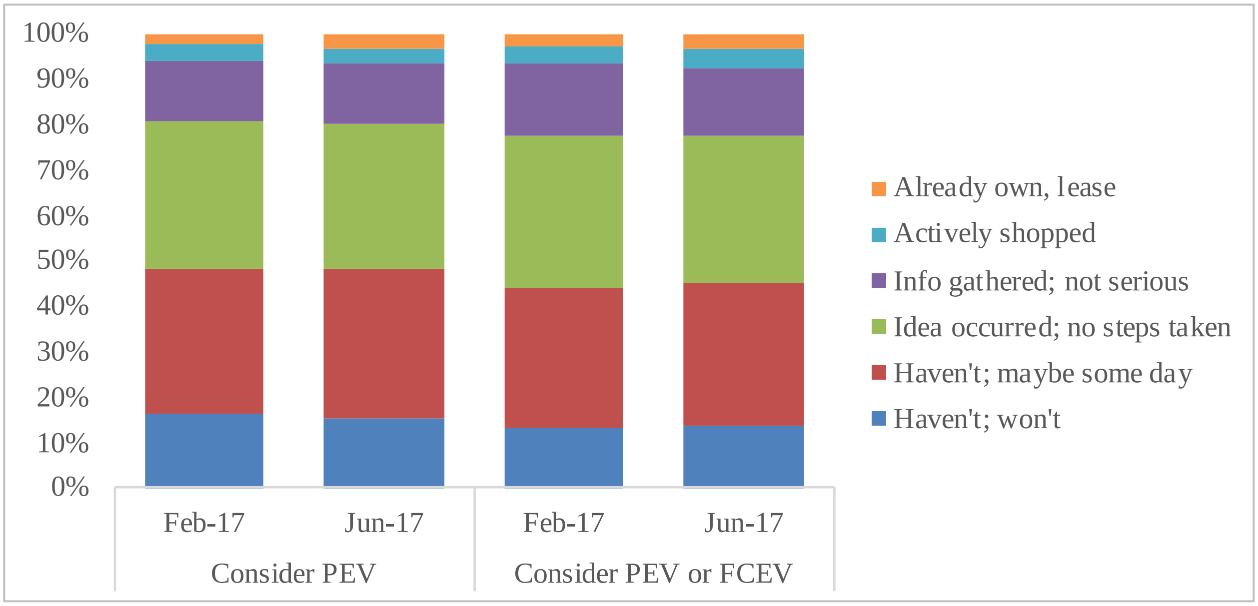

Figure 1. Consideration of PEVs and PEVs or FCEVs, percent
Source: Kurani, Kenneth. University of California, Davis.

Description of respondents and households

Socio-economic and demographic distributions of the February and June 2017 UCD samples are in Table 1 and Figure 2; characteristics of their residences are in Table 2. Comparative data are shown from the 2010-12 California Household Travel Survey (CAHTS). The distributions shown for the CAHTS are based on the subset who meet the age and vehicle ownership requirements of the UCD surveys: older than 18 years old (for reasons primarily related to requirements for consent) and live in households that own automobiles. Also, personal descriptors—age, sex, employment status, and education—are limited to the person identified as the head of household in each CAHTS household. In general, the two samples appear much alike on most of the selected measures. The two variables with different distributions are age and home ownership. Both UCD samples have a much higher percentage of respondents age 19 to 39 and lower percentage aged 59 and above than the CAHTS sample; the UCD samples also have fewer (though still a large majority) of respondents who own their residence.

The household income categories used in the February 2017 sample are tied eligibility for the California Clean Vehicle Rebate program's increased rebate for low income households. Since this question was asked in fixed categories, it is difficult to map a precise comparison of income distributions into other data with different categories. Because of this difficulty in comparison to other samples, an answer format that allows mapping into any categories was used for the June 2017 UCD survey. The income distributions in the two UCD samples are similar except for the higher non-response rate in June. An approximate comparison to the income distribution in the CAHTS data is in Figure 2; the income categories have been aggregated to create the closest possible comparisons between the CAHTS and the February 2017 samples. The patterns across income categories are similar for all three samples.

Table 1. Respondent and household socio-economic and demographic distributions

Variable	Categories	Feb. 2017 UCD, %	June 2017 UCD, %	CAHTS, %
Respondent Age	19 to 29	23	18	3
	30 to 39	24	22	10
	40 to 49	13	16	16
	50 to 59	16	19	28
	60 to 69	16	16	27
	70 and older	7	9	15
Respondent Sex	Female	52	50	54
	Male	48	50	46
Respondent Employment Status	Employed	61	57	61
	Family Caregiver	7	4	6
	Unemployed	7	9	9
	Retired	18	21	23
	Student	6	7	1
	Other	2	2	0
Respondent Education	≤ High school/GED	11	12	20
	≤ Undergrad deg.	66	64	57
	≤ Grad. degree	23	24	23
Household Income	$35,640 or less	19	17	[1]
	$35,641 to $48,060	9	8	
	$48,061 to $60,480	13	10	
	$60,481 to $72,900	8	6	
	$72,901 to $85,320	9	8	
	$85,321 to $97,740	7	6	
	$97,741 to $110,190	8	6	
	$110,191 to $122,670	5	3	
	$122,671 to $150,000	7	9	
	$150,001 to $204,000	6	9	
	$204,001 to $300,000	3	7	
	Greater than $300,000	2	1	
	Prefer not to answer	4	9	
People in Household	1	23	23	22
	2	33	37	39
	3	19	15	17
	4	15	14	14
	5	7	6	6
	6 or more	3	3	3
Number of Licensed Drivers In Household	1	28	30	27
	2	55	53	56
	3	12	11	13
	4 or more	6	6	4

Source: Kurani, Kenneth. University of California, Davis.

1 See Figure 2 for comparison between the 2017 UCD samples and the 2010-12 CAHTS data.

Table 2. Residence Characteristics

Variable	Categories	Feb. 2017 UCD, %	June 2017 UCD, %	CAHTS, %
Own-Rent Residence	Own	65	61	78
	Rent	35	39	22
Residence Building[2]	Detached Home	69	66	81
	Attached Home	12	12	10
	Large Multi-Unit Dwelling	20	22	9
Solar electricity on residence	Yes	14	13	—
				—

Source: Kurani, Kenneth. University of California, Davis.

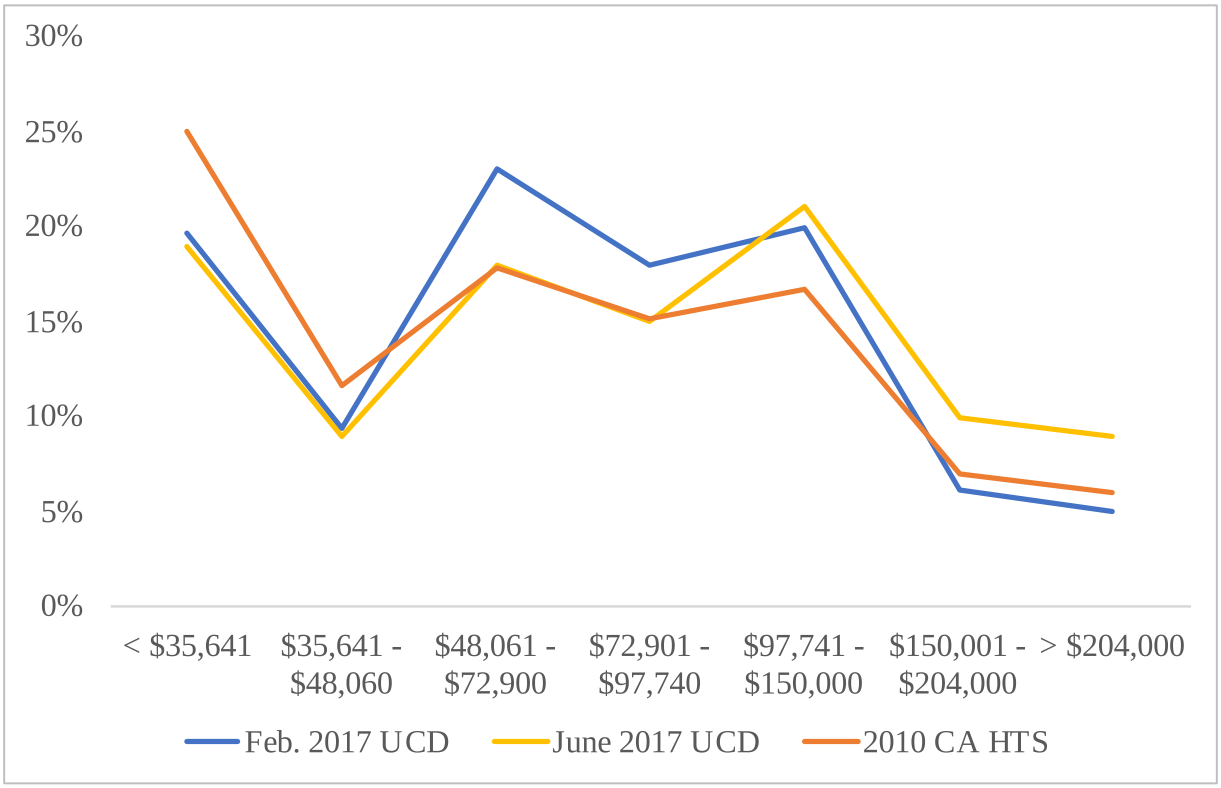

Figure 2. Comparisons of income distributions to the California Household Travel Survey

Note: Points are plotted at mid-points of categories of varying width.

Source: Kurani, Kenneth. University of California, Davis.

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2 For the 2010-12CAHTS data, "detached home" is the sum of "single family unattached" and "mobile home"; "attached home" is the sum of "single family attached" and "MUD 2 to 4 unit"; and, "large Multi-unit dwelling" is the sum of "MUD 5 to 19 units" and "MUD > 20 units."

Home vehicle parking

As the ability to charge a PEV at home facilitates PEV ownership and use, households were asked to describe where they park vehicles at home and whether they have access to electricity at those locations. This information is ascertained for at most two vehicles in a household. As the information is for 1) the only vehicle, 2) the only two vehicles, or 3) the most recently acquired vehicle and the vehicle that is otherwise driven most, it is likely the data capture frequently used home parking locations even if a household owns more than two vehicles.

For the February and June 2017 samples, the percentage of households parking at least one vehicle in specific types of location are similar. For February, 46 percent of households park at least one vehicle in a garage attached to the residence; 58 percent in a garage or carport; and 86 percent in a garage, carport or driveway. These percentages are nearly identical for June 2017: 46%, 58%, and 89%. Across these parking arrangements in February, 31 percent say they either don't have reliable access to any electricity or don't know if they do, 45 percent say they have reliable access to a 110/120V outlet, and 23 percent say they have access to either 220/240V outlet or an EVSE. Again, the percentages for June are nearly identical: 33%, 47%, and 20%.

Combining these data within each sample (Figure 3) shows how the percentage of households who might be able to charge a PEV at home increases as we relax constraints like weather protection (from enclosed garages, to carports, to driveways) and reduce the power required to charge (from 220/240 volts or an EVSE, to include 110/120 volt). Only 13-14% of households both parks at least one car in a garage and believes they have reliable access to 220/240V electrical service (or an EVSE). At the other extreme, a combined 64% park in a garage, carport or driveway and have access to 110/120V, 220/240V, or an EVSE.

Household vehicle transactions

All households in the UCD samples own at least one car. There is a clear positive correlation between the number of vehicles owned and whether any vehicles were acquired as new since January 2010 (Figure 4). While only 3% of households that own (or lease) only one vehicle had purchased two or more vehicles as new since January 2010, nearly one-third of households that own (or lease) three or more vehicles had done so.

The survey does not ask for a complete description of all vehicles in households that own more than two vehicles; if the household owns more than two vehicles, descriptions are elicited for the most recently acquired vehicle and the remaining vehicle that "is driven most often." Even given this limit, since the incidence of ZEVs is still so low in the population, it is unlikely the following results underestimate ZEVs in any substantively important way. For February 2017, the vast majority of household (89%) own or lease only internal combustion engine vehicles (ICEVs); seven percent own or lease at least one ICEV and at least one hybrid electric vehicle (HEV); and just over one percent (1.4%) own or lease two (or more) HEVs. Of the remaining, 1.2% own a PHEV (and either an ICEV or HEV) and 1.5% own a BEV (and either an ICEV or HEV). No household owns or leases only a PHEV, a BEV, a PHEV and a BEV, or an FCEV in combination with any other vehicle. All told, two to three percent of households in the February and June 2017 samples own a PEV. (Data from other sources do show households with two or more PEVs, but as noted, the overall incidence of PEV ownership is still so low, it is not surprising that no multiple-PEV households appear in this sample.)

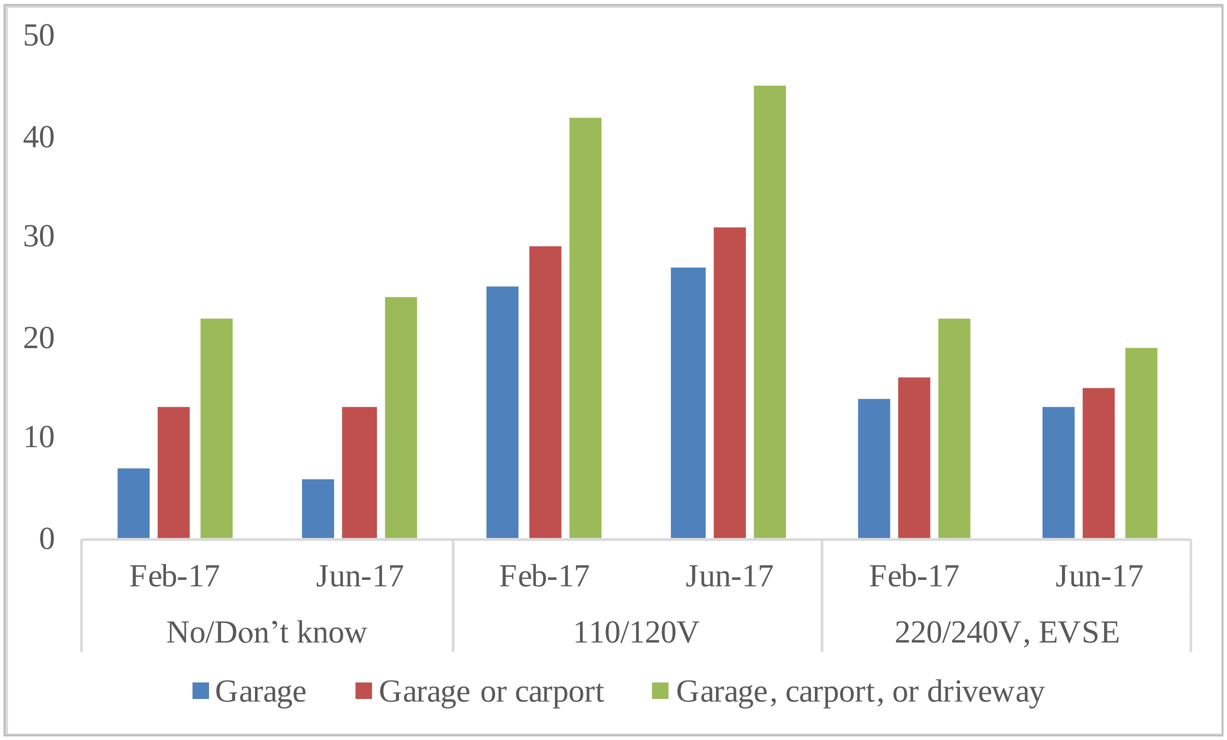

Figure 3. Home parking location by reliable access to electricity, percent of total sample
Source: Kurani, Kenneth. University of California, Davis.

Household vehicle decision making

A set of question asks about how households make decisions about buying vehicles (Table 3). The large majority of respondents are evenly divided between whether they are the sole decision maker regarding household vehicle purchases or whether they are one of such decision makers. Only a small percentage of respondents say they play no role in household vehicle purchases and only a slightly larger percentage say household vehicle purchase decisions involve people living outside their household. As expected, if single-person households are excluded, the balance shifts toward respondents being one of, rather than the sole, decision maker. Within these overall observations, the June sample contains more households in which members make joint decisions about vehicle purchases rather than one person being the sole decisionmaker than the February's.

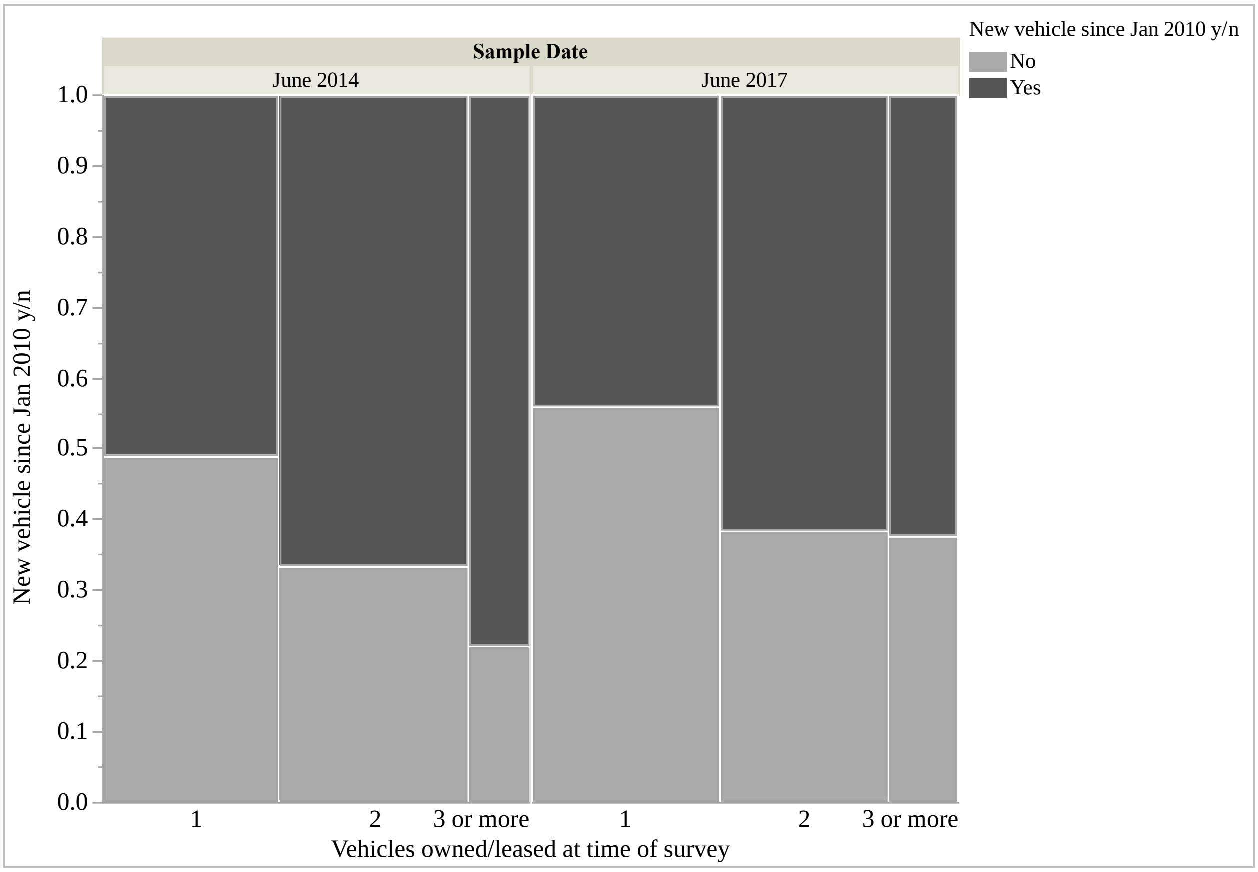

Figure 4. Whether any vehicles were acquired as new since January 2010 by the number of vehicles owned or leased by household, percent

Source: Kurani, Kenneth. University of California, Davis.

Table 3. Vehicle purchase decision making roles within households, Percent

	February 2017		June 2017	
Statement	All hhlds, %	Multi-person hhlds, %	All hhlds, %	Multi-person hhlds, %
I don't take part in decisions about whether my household buys motor vehicles.	2	2	3	4
I am one of the people in my household to decide about motor vehicle purchases.	47	59	52	66
I am the only decision maker in my household regarding motor vehicle purchases.	46	32	41	25
I make these decisions with one or more people who don't live in my household.	5	6	4	5
n =	1681	1295	1652	1307

Source: Kurani, Kenneth. University of California, Davis.

Looking only at households in which vehicle purchase decisions are shared in some way, a follow-up question asked about the relative role the respondent typically plays in decisions about vehicle purchases. The distributions for June and February are similar, though there are fewer respondents in June who claim to share decisions equally (Table 4). Perhaps reflecting some bias toward interest in automobiles in general among the survey respondents, if one household member is reported to play a larger role in vehicle purchase decisions, respondents are three times more likely to claim that larger share of decision making for themselves than they are to assign that larger role to someone else in the household.

Table 4. Relative role of decision makers regarding motor vehicle purchases in multi-person households, Percent

Statement	February 2017, %	June 2017, %
I generally play a larger role in these decisions, with some input from others.	23	22
We share decisions about motor vehicles together equally.	60	56
I generally play a smaller role in these decisions, providing input to someone else who plays the larger role.	10	11
We make most of these decisions independently, for example, I buy my vehicles and they buy theirs.	7	11
n =	809	919

Source: Kurani, Kenneth. University of California, Davis.

Electricity most commonly viewed as replacement for gasoline and diesel

In an abstract sense, most respondents believe that "should we need to replace gasoline and diesel for any reason," electricity and/or hydrogen are more likely than the other possibilities offered them in the survey, i.e., natural gas, bio-fuels (ethanol and bio-diesel), propane, "none," and "I have no idea." This finding holds for both the 2017 samples (Figure 5). The question was asked in two stages: respondents first picked three replacements they thought likely, then of those three selected the one they thought most likely.

Familiarity with types of drivetrains follows an expected pattern

Moving toward more specific questions about ZEVs, data on familiarity, knowledge, experience, and consideration of these vehicles are presented next. Familiarity is first assessed with this question:

> *"Are you familiar enough with these types of vehicles to make a decision about whether one would be right for your household?"*

The question was asked for "gasoline" ICEV, "battery electric" (BEV), "hybrid" (HEV), "plug-in hybrid" (PHEV), and hydrogen fuel cell electric vehicles. Answers are on a scale from -3 (No) to +3 (Yes). The mean responses for each vehicle type for February and June 2017 are plotted in Figure 6.

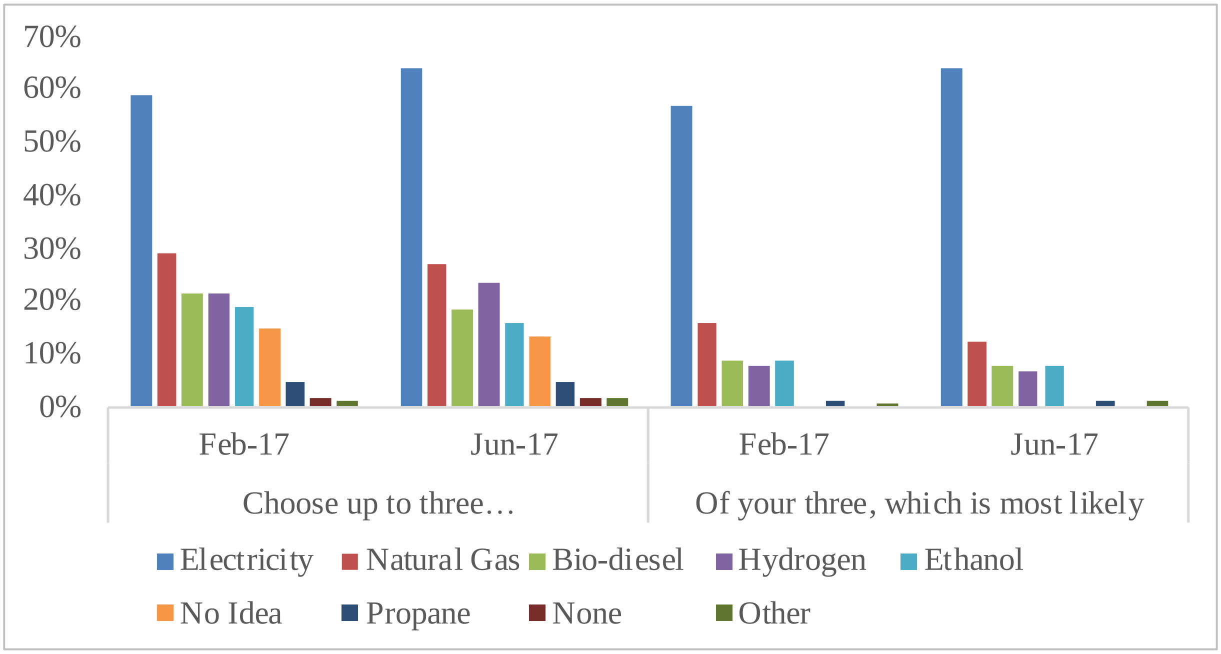

Figure 5. If for any reason we could no longer use gasoline and diesel to fuel our vehicles, what do you think would likely replace them? Choose up to three.
Source: Kurani, Kenneth. University of California, Davis.

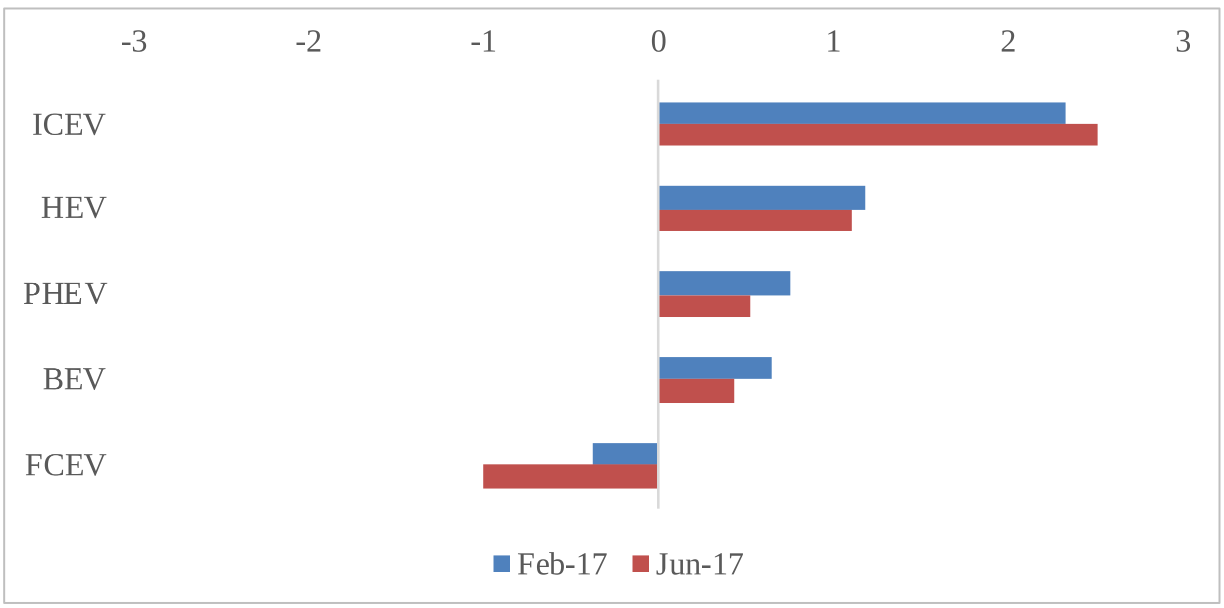

Figure 6. Familiarity with vehicle types, mean score; -3 ("No, I am not familiar…") to +3 ("Yes, I am familiar…")
Source: Kurani, Kenneth. University of California, Davis.

As would be expected, respondents report high familiarity with conventional, gasoline-fueled, ICEVs. Considering HEVs have been for sale for nearly twenty years and their comparative popularity in California over this period, it may be a surprise that respondents self-rated familiarity with HEVs is so much lower than for ICEVs. The samples have lower average familiarity with PHEVs, BEVs, and especially, FCEVs. It may be of some concern that mean familiarity scores for BEVs, PHEV, and FCEVS are lower in the June compared to February, however the difference may be due to the specific format of the answer, which was changed between the two samples to reduce the incidence of "I don't know" responses. It is possible that people who previously would have given such a reply are systematically more likely to register lower familiarity.

Name recognition is limited to a few makes and models of PEVs

Respondents were asked if they could name a "battery electric vehicle that is being sold in the US." Any BEV offered in the US has also been offered for sale in California. Respondents were asked to name only one. The question was repeated for "hybrid," "plug-in hybrid," and "hydrogen fuel cell electric" vehicles. Name recognition for BEVs is shown in Figure 7. The ability—or inability—of car-owning households in California to name a BEV for sale is stable between the two samples. Only the distribution of responses for BEVs is shown as there are no substantively different conclusions to be drawn from the other vehicle types: few people successfully name a BEV and only a few BEVs are named.

By 2017, 14 different vehicle manufacturers offered or had offered 17 different BEVs for sale in California.[3] BEVs that had been offered for sale (or lease) at any time leading up to the survey were counted as correct responses. Thus, despite the actual survey question wording, the allowed answers make the question about whether people recall the name of any BEV offered at any time leading up to the survey, not a test of their knowledge of the specific vehicle offerings at the time of the survey. Three-fourths of respondents either simply state they can't name a BEV or attempt to name one but provide an answer that is clearly wrong. Only Tesla (Roadster, Model S, and Model X) was named by a double-digit percentage (18%) of respondents. Nissan (Leaf) was a distant second (5%), but their BEV was still named by more people than named the other 12 manufacturers' vehicles combined. Compared to the 56% of respondents who said they could not name a BEV, 62% said they could not name of PHEV. As Tesla and Nissan Leaf dominate name recognition of BEVs, Toyota Prius and Chevrolet Volt (assuming people accurately distinguish between the plug-in and non-plug-in variants of the Prius) dominate name recognition of PHEVs.

3 These are the BEV names counted as correct (in alphabetical order): BMW i3, BMW MINI-e, Chevrolet Bolt, Fiat 500e, Ford Focus Electric, Honda Fit EV, Hyundai Ioniq, Kia Soul EV, Mercedes-Benz B-class Electric, Mitsubishi iMEV, Nissan Leaf, Smart fortwo EV, Tesla Roadster, Tesla Models S, Tesla Model X, Toyota RAV4-EV, and VW e-Golf. The Toyota Scion eQ was not mentioned by any respondent, nor is it included in the list of correct answers as only a few of these vehicles were ever brought to California and then only to fleets.

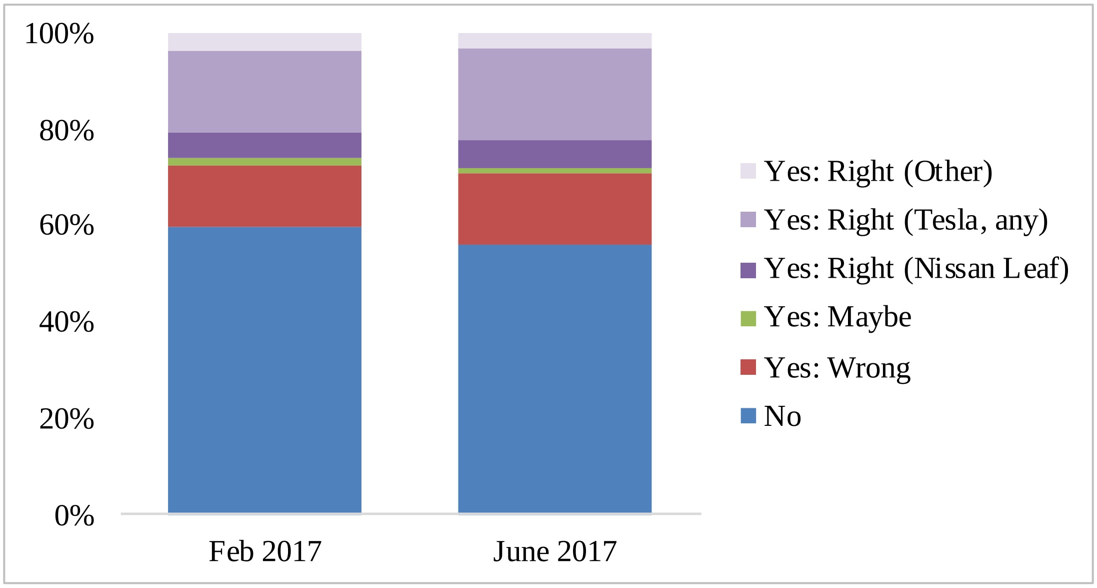

Figure 7. Name recognition of battery electric vehicles "being sold in the US."
Source: Kurani, Kenneth. University of California, Davis.

Driving experience is low for HEVs and virtually absent for PEVs and FCEVs

Driving experience with HEVs, PHEVs, BEVs, and FCEVs is assessed on a scale from -3 = "I have never driven one" to +3 = "I drive one daily." The mean scores for all four drivetrain types are negative in both samples (Figure 8). This is certainly not surprising for FCEVs, and perhaps not for BEVs and PHEVs. However, that the mean score for HEVs should still be negative some 20 years since they were introduced to the automotive market hints that the "market" itself may not create ZEV driving experience across the population of car-owning households very quickly.

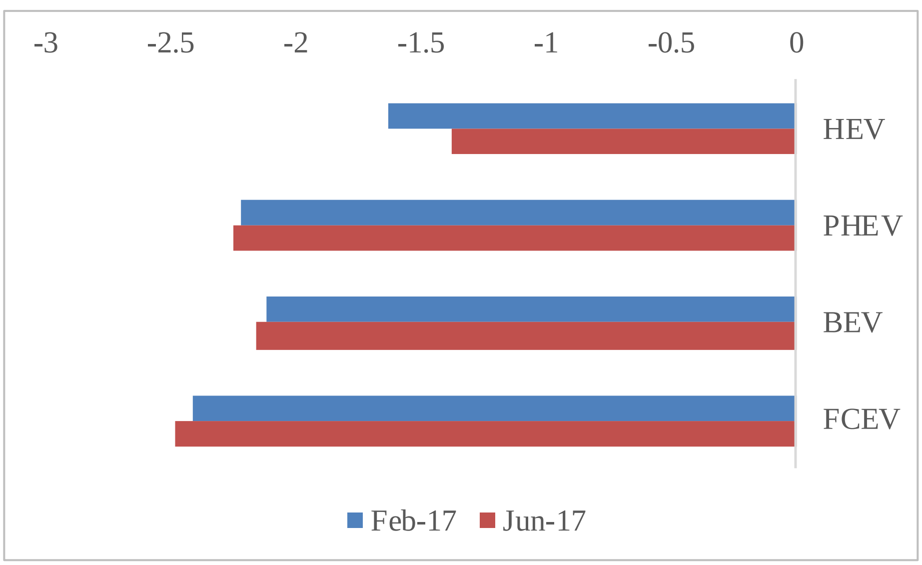

Figure 8. Mean driving experience scores; -3 = never; +3 = daily
Source: Kurani, Kenneth. University of California, Davis.

Charging for PEVs seems to be visible to a majority of respondents.

Approximately seventy percent of both the February and June 2017 samples report seeing at least one “electric vehicle charging spot” in the parking garages and lots they use; most (~60% of the total) report seeing charging for PEVs at “a few” or “several” places. A new question in June 2017 ascertains that 13% of respondents claim they’ve have seen PEV charging infrastructure at their workplaces.

Knowledge of how different vehicles are fueled is mixed; people are confused about the difference between HEVs and PHEVs.

As a test of basic knowledge about the different vehicle drivetrain types and how vehicles in each type operate, respondents are asked,

> *“From what you understand, which of these vehicles are fueled with gasoline and which are plugged in to charge with electricity?”*

They are then presented the four drivetrain types and options as to how they are fueled. The distributions of responses from both samples are shown in Figure 9. While large majorities provide the correct response for ICEVs and BEVs, only a bare majority correctly responds that PHEVs are both fueled with gasoline and plugged in to charge. Clearly indicating confusion about HEVs, barely one-quarter of respondents correctly state HEVs are only fueled with gasoline; more than twice as many say HEVs are both fueled with gasoline and plugged in to charge. In fact, more people *incorrectly* say HEVs both fuel with gasoline and plug in to charge with electricity than correctly say this about PHEVs in both samples. Across HEVs, BEVs, and PHEVs, barely one-in-ten respondents in the February sample correctly identified how all three are “fueled” and one-in-eight did so in the June sample.

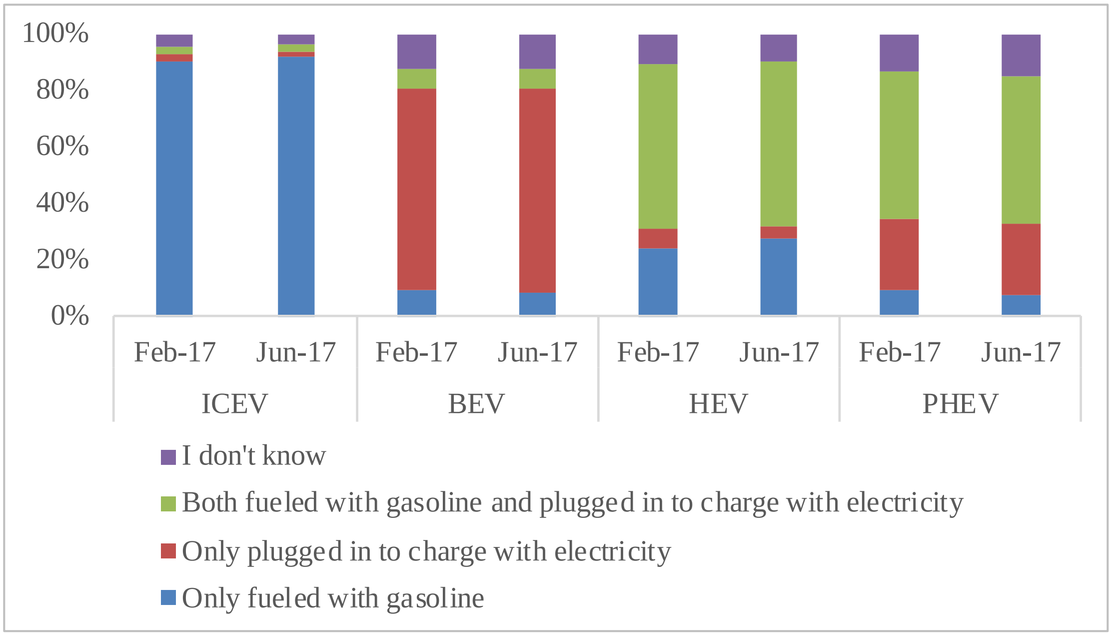

Figure 9. Knowledge of how vehicles are fueled, percent
Source: Kurani, Kenneth. University of California, Davis.

The "Neighbor" Effect: Do respondents know people with PEVs or FCEVs

The "neighbor" effect has been variously defined depending whether it requires physical and/or social proximity; here it is defined in the social sense. Respondents were first asked if there is anyone they now by name who owns a BEV. If so, they were then asked if they had spoken to that person about their BEV. Again if so, they were asked whether those conversations had affected their "thoughts or feelings about BEVs." The series of three questions was repeated for PHEVs and FCEVs. Figure 10 shows the responses for all three drivetrains; results are similar for both samples.

PHEVs were the subject of the most conversations, still only 11 to 12 percent of respondents had a conversation with someone they know by name who has a PHEV (regardless of the outcome of such a conversation). In general, two-thirds to three-fourths of such conversations led to the non-PEV/FCEV owner having more favorable thoughts or feelings about the subject vehicle type. More hopefully, aggregated across all three drivetrain types about one-in-four respondents said they knew someone by name who had a PHEV, BEV, or FCEV.

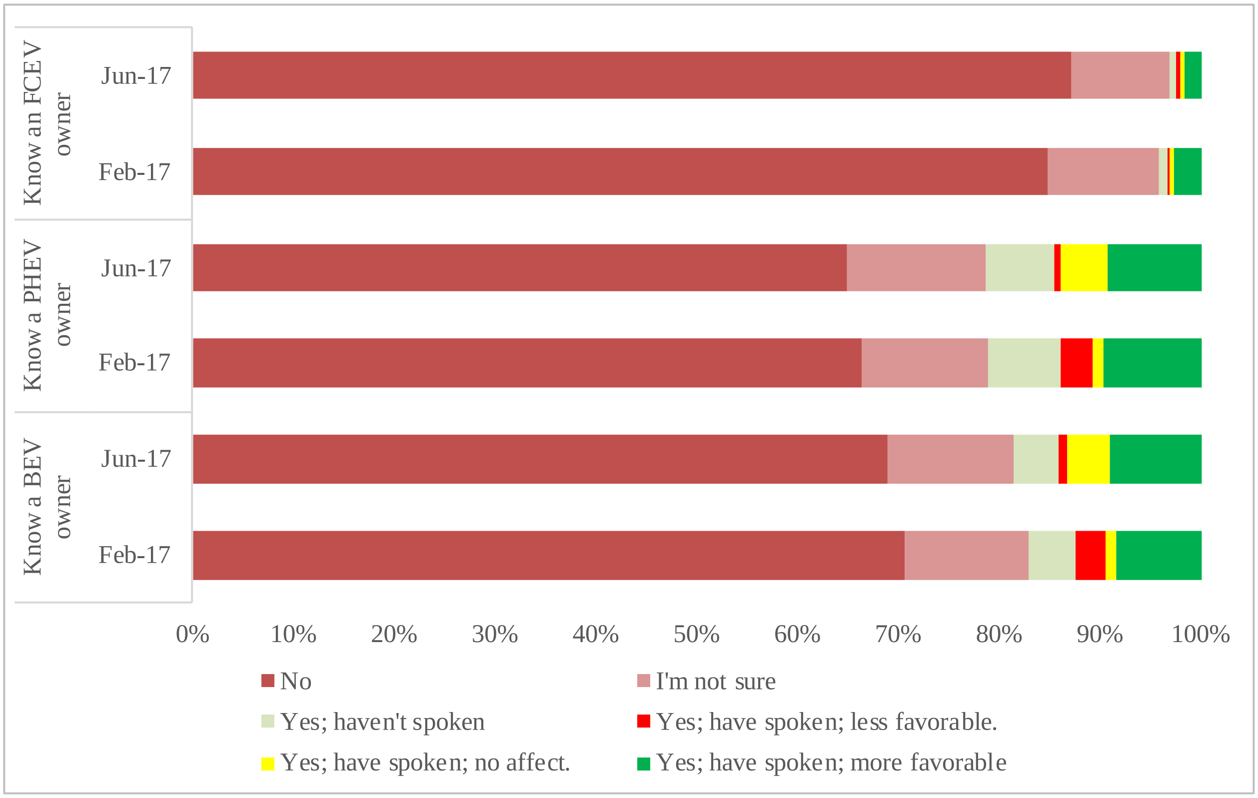

Figure 10. Incidence of knowing ZEV owners, having conversations with them about the car, and effects of such conversations, percent
Source: Kurani, Kenneth. University of California, Davis.

Baseline Assessments of BEV and FCEV Attributes

Given their low familiarity and even lower experience with PEVs and FCEVs, what assessments will people offer when asked to do so. Respondents were asked to rate their agreement with nine statements related to “battery electric vehicles (cars and trucks powered only by batteries that must be plugged in to recharge)” on a scale from -3 = strongly disagree to +3 = strongly agree (Figure 11).

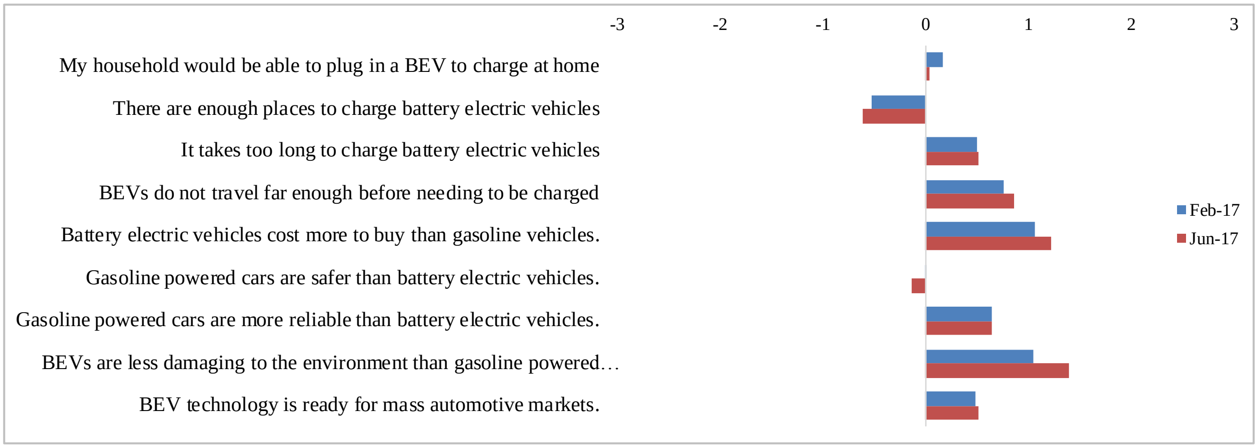

Figure 11. BEV assessments, mean score; -3 (strongly disagree) to +3 (strongly agree)
Source: Kurani, Kenneth. University of California, Davis.

The average assessments offered by the two samples are broadly similar. However, the June sample is slightly less favorable regarding charging—less likely on average to agree they could charge at home and more likely to disagree there are enough places to charge BEVs—but more favorable regarding the comparative safety and environmental effects of BEVs compared to gasoline-powered ICEVs.

Assessments of FCEV attributes are summarized in Figure 12. The general pattern is the same as for BEVs (noting though that no question was asked about home refueling of hydrogen). There is modest average disagreement that there are enough places to fuel with hydrogen—and this disagreement is higher in the June sample than in February's. There slight to modest agreement the FCEVs don't travel far enough between fueling, cost more but are better for the environment than gasoline cars; there is modest agreement gasoline cars are safer and more reliable than FCEVs. The mean score for whether hydrogen FCEV technology is ready for mass markets is zero in February—respondents were not willing to agree or disagree; in June the mean score indicates slight disagreement.

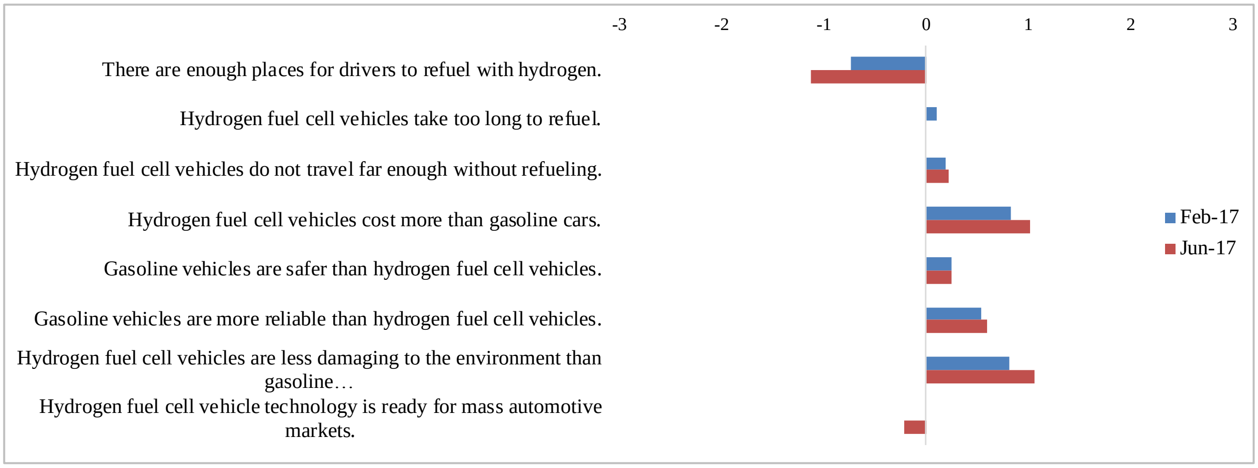

Figure 12. FCEV assessments, mean score; -3 (strongly disagree) to +3 (strongly agree)
Source: Kurani, Kenneth. University of California, Davis.

Awareness of incentives

Respondents were not queried about specific incentives, e.g., the federal alternative fuel vehicle tax credit and California's Clean Vehicle Rebate. Rather, they were asked more generally whether they had heard specific entities were "offering incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel?" A minority of respondents in both samples are aware of incentives from any government, business, or their electric utility (Figure 13). Respondents were mostly likely to say they are aware of incentives from the federal government; one-third said they were aware of incentives from California.

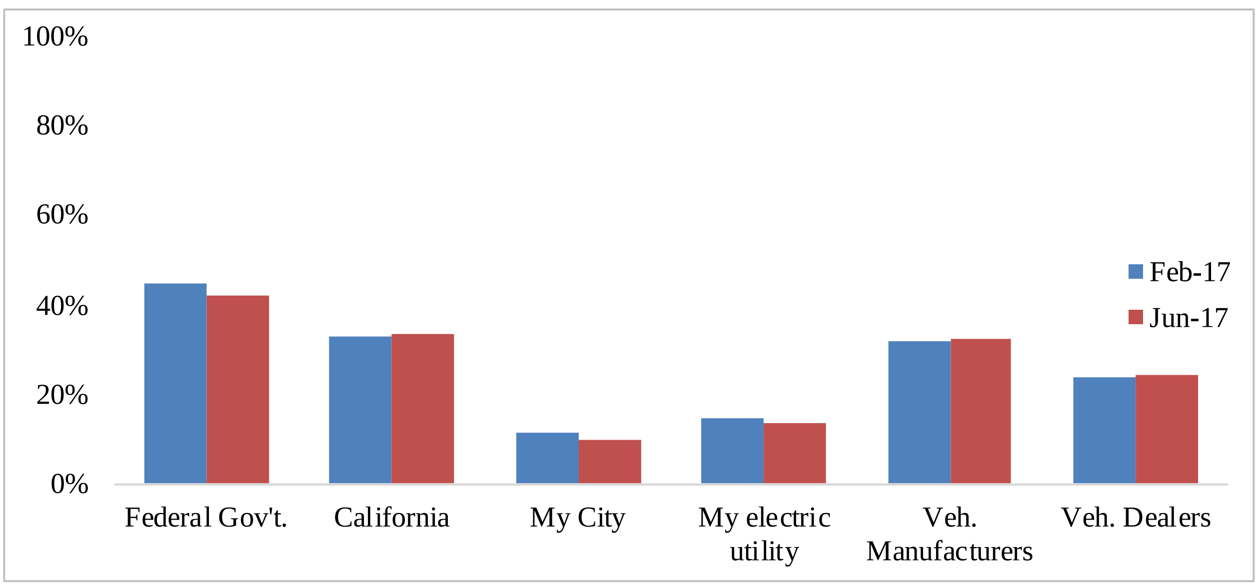

Figure 13. Heard of incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel, percent
Source: Kurani, Kenneth. University of California, Davis.

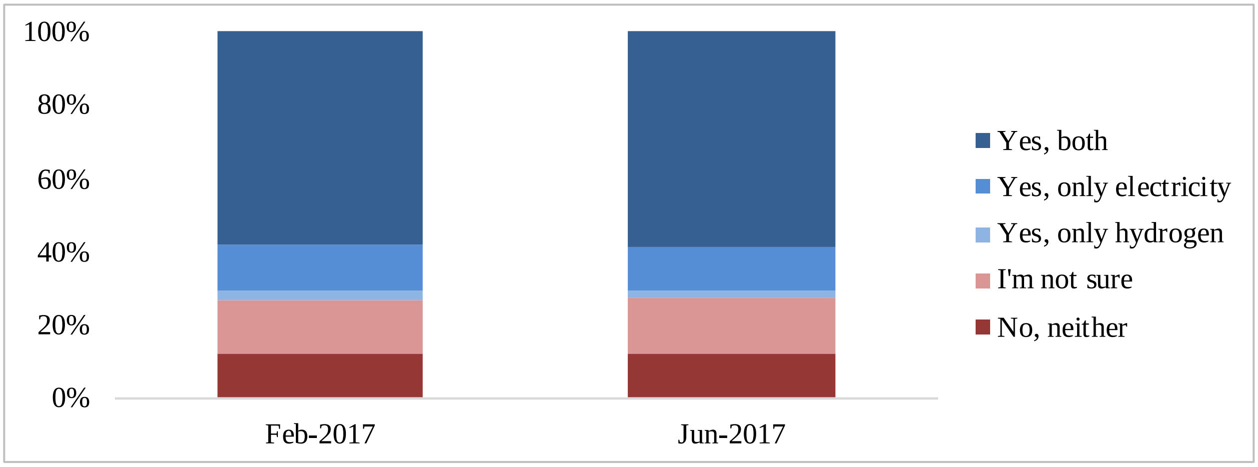

Figure 14. Support for government incentives to consumers, percent
Source: Kurani, Kenneth. University of California, Davis.

To gauge their level of support for the idea of government incentives, respondents were asked whether they thought governments should "offer incentives to consumers to buy and drive vehicles that run on electricity or hydrogen." A three-fourths majority of both the February and June 2017 samples support the idea of government subsidies (Figure 14), with clear majorities supporting incentives for both electricity and hydrogen.

Reasons why respondents might consider PEVs and FCEVs

Respondents were asked whether they can imagine reasons why they would buy a PEV or an FCEV; they were presented a list of possible reasons from which to choose They could choose as many as they wished. The list included an option to explicitly state they can't imagine any reason. The percent of respondents selecting each potential reason is shown in Figure 15. Given the opportunity to respond they can't imagine a reason, one-fifth (June) to one-fourth (February) of indicate they can't imagine why they would buy a PEV and a bit more than one-third to two-fifths say they can't imagine why they would buy an FCEV. The affirmative reasons for buying a PEV that are given by more people than can't imagine reason are: to save money, to reduce the effects of their driving on air quality and climate change, and to reduce the amount of money they pay to oil producing companies or nations. Among those who can give no reason why they would buy a BEV, more than half say they haven't and won't consider a BEV for their household. Among people who can give even one reason why they might buy a BEV, only seven percent say they haven't already considered one and won't do so in the future.

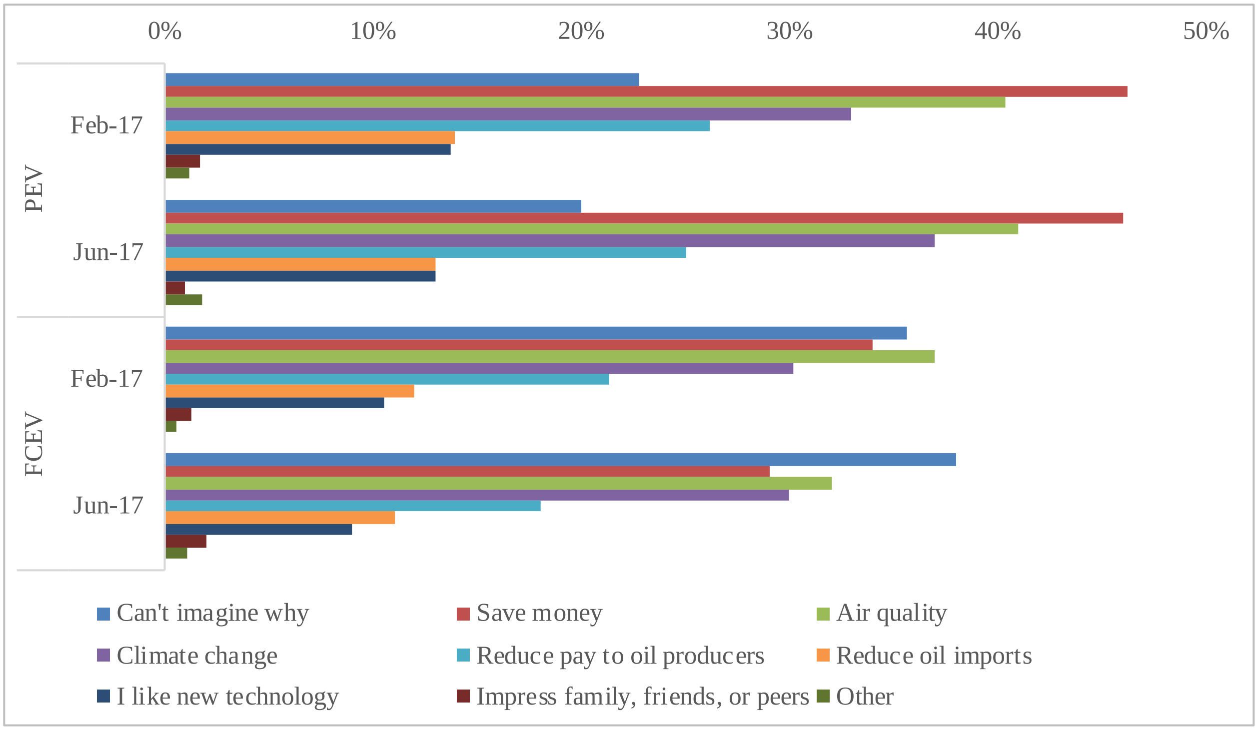

Figure 15. Reasons for buying a PEV or FCEV, percent
Source: Kurani, Kenneth. University of California, Davis.

Air pollution: public health and environmental risk

Attitudes toward air pollution and opinions about whether electricity represents an opportunity to address public health and environmental risk compared to gasoline were assessed in a set of five questions. First, a response from -3 = strongly disagree to +3 = strongly agree were elicited for these three statements:

- Air pollution can be reduced if individuals make changes in their lifestyle|
- I personally worry about air pollution
- Air pollution is a health threat in my region

Histograms of the distributions of responses for both samples are shown in Figure 16. The three measures are distributed similarly in the two samples. All six distributions show large majorities register a belief that air pollution can be reduced through changes in personal lifestyle, that respondents personally worry about air pollution, and believe air pollution to be a health threat in the region in which they live: 90% of respondents have a score higher than zero and thus agree to some extent that personal lifestyle affects air pollution. For the questions about personal worry and regional health threat, as the zero point is the 25th percentile, 75% of the sample registers at least some agreement that they personally worry about air pollution and 75% (though not necessarily the same 75%) agrees air pollution is a health threat in their region.

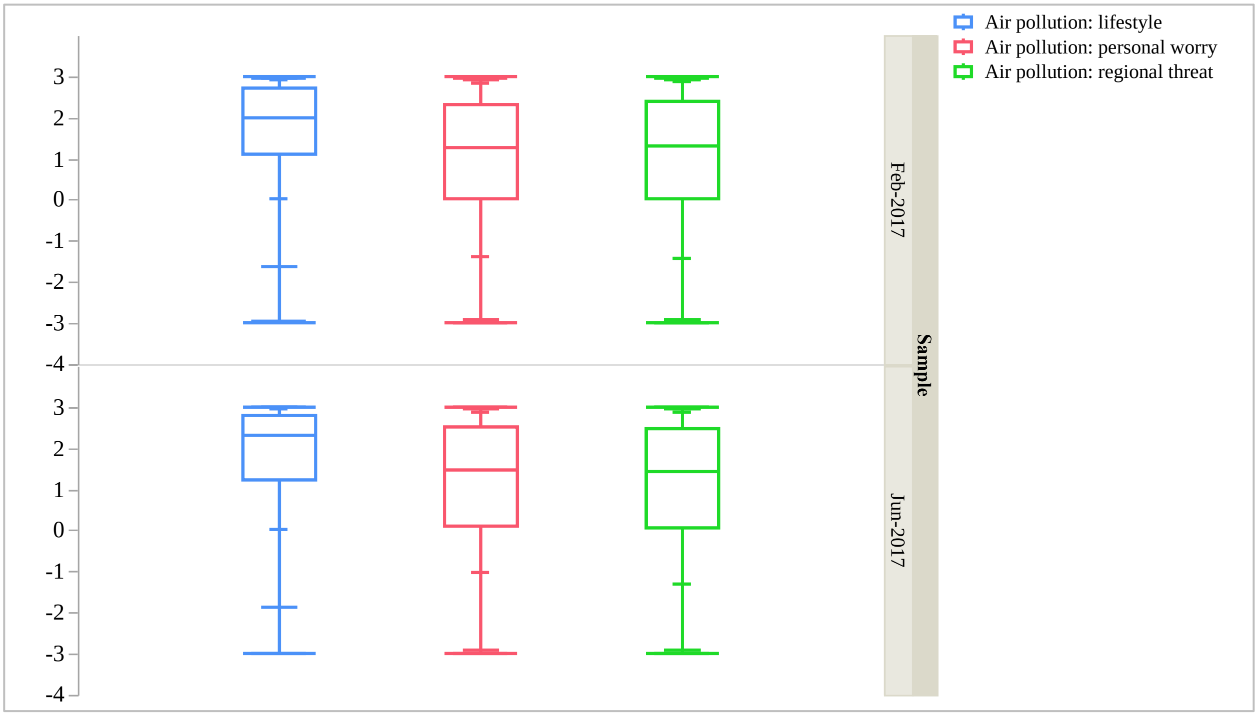

Figure 16. Histograms of the distributions for air pollution affected by individuals' lifestyles, air pollution is a personal worry, and air pollution is a regional health threat

Note: Rectangles show interquartile ranges, i.e., from the 25% to the 75% percentiles. The line bisecting the rectangles marks the median (50% percentile); the score at which half the sample has a lower score and half a higher score. The progressively longer lines outside the rectangles mark (in this case) the 10%/90%, 5%/95%, 2.5%/97.5%, and 0%/100% percentiles.

Source: Kurani, Kenneth. University of California, Davis.

Second, without specifying the specific risks, respondents were asked whether powering vehicles with electricity rather than gasoline would pose less or more risk to human health and the environment. The original scale was -3 = electricity poses less risk; +3 = electricity poses more risk. So that the signs of all variables used in subsequent modeling have consistent interpretations (all positive effects favor electricity and electric vehicles) the scores on these scales are inverted. These two questions reveal similar distributions in both samples: large majorities (75%) of respondents believe powering vehicles with electricity rather than gasoline poses less risk to human health and the environment. The correlation coefficient is greater than 0.80 in both samples. This can be seen in Figure 17 in which the scores for environmental risk and human health risk are plotted as a density map; darker colors indicate more respondents. The clear pattern of positive correlation is seen in that most respondents lie along the diagonal from lower left to upper right and that most respondents agree electricity poses less risk than gasoline to both human health and the environment is seen by the larger, darker area at the top right. (Though clearly, there is also a distinct grouping at the 0-points of both scales, too.)

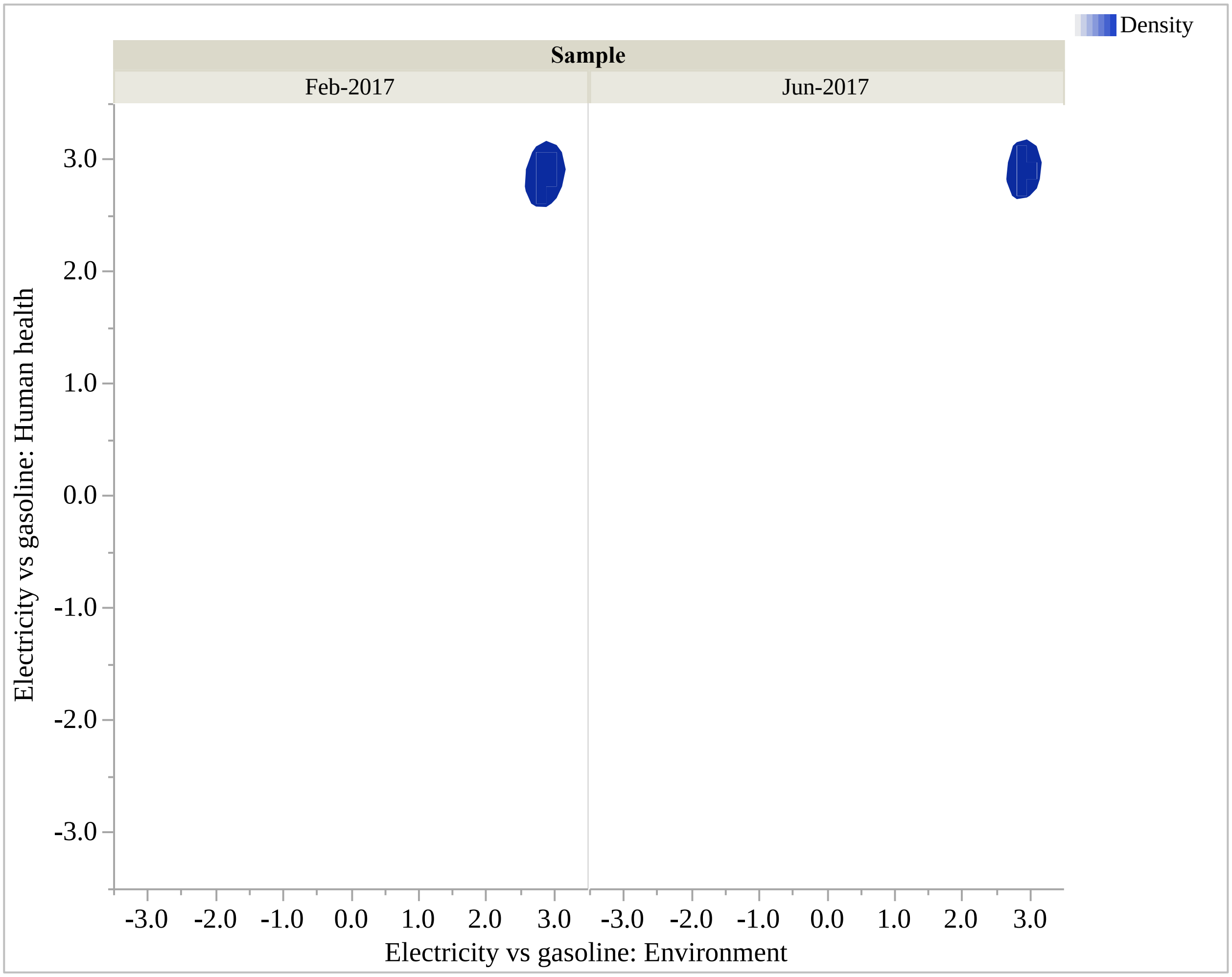

Figure 17. Joint distributions risk to human health risk and the environment of using electricity rather than gasoline; reverse coded so +3 = disagree electricity poses a greater risk than gasoline

Source: Kurani, Kenneth. University of California, Davis.

Other concepts hypothesized to explain who has already considered ZEVs

New Technology

The suite of questions based on a modified Exploratory Buying Behavior Tendencies (EBBT) scale that was used for the February 2017 survey was not repeated in June 2017. The conclusions reported in the State of the Market Report I indicated that specific measures of interest in ZEV technology performed better than generalized measures of interest in new automotive technology in describing who had or had not considered a ZEV for their household.

Consideration of Future Consequences

Several possible explanations for who might be more attracted to buying PEVs and FCEVs are plausibly related to whether people are prone to being more influenced by immediate or farther future consequences of their present actions. The consideration of future consequences (CFCS) scale is used here to test this idea. The mean values of the fourteen items (seven each related to immediate (CFC-I) or future (CFC-F) consequences are presented in Table 5 for both samples and the total score on all items (as will be used in the subsequent multivariate analysis) is shown in Figure 16. All CFC-I and CFC-F items are summed to a single measure such that larger scores indicate a greater orientation toward future consequences and lower scores a greater orientation toward immediate consequences. (Respondents score all items on the same scale. However, the signs of responses to the CFC-I items are switched before summing.)

Because 1) there are seven items in both the CFC-I and CFC-F, 2) the original scale ranges from 1 = not at all like me to 5 = very much like me, and 3) because the items in the CFCS-I subset have their signs switched to negative before the total sum is computed, the total CFCS scale ranges from -28 = completely oriented toward immediate consequences to +28 = completely oriented toward future consequences. Simply to make the distribution of the total scores easier to compare to the individual item scores, the total values are re-scaled to 1 to 5 before being plotted in Figure 18. The sample mean score of 3.35 for February and 3.32 for June indicates that, on average, the samples describe themselves as slightly more motivated by farther future consequences of their present actions than by immediate consequences.

Temporal Focus Scale

Another perspective on people's orientation toward time is Temporal Focus: "the allocation of attention to past, present, and future." Applied here, the original 12 statements (four each for past, present, and future focus) of the Temporal Focus scales were reduced to nine (three each for past, present and future focus). Statements were rated on a 7-point scale describing the frequency with which the respondent thought about the time frame indicated by the item (1 = never; 3 = sometimes; 5 = frequently; 7 = constantly). The individual statements are shown in Table 6 along with their mean scores rotated factor loading. A confirmatory factor analysis was performed to assure the reduced set of nine items still formed a three-fold (past, present, future) description of temporal focus. The results support the conclusion the reduced set constitute a three-fold description and that all nine items group together in their respective categories of past, present, or future.

The distributions of mean past, present, and future focus scores (rescaled to match the 1 to 7 scale of the individual items) is shown in Figure 19. The mean values for all time focus items and the three categories all indicate that on average, people report as likely to be frequently focused on all three time periods.

Table 5. Items in CFC-I and CFC-F scales, means

Consequences of future actions—immediate: CFC-I	**Feb-2017**	**Jun-2017**
3. I only act to satisfy immediate concerns, figuring the future will take care of itself.	-2.69	-2.77
4. My behavior is only influenced by the immediate (i.e., a matter of days or weeks) outcomes of my actions.	-2.82	-2.92
5. My convenience is a big factor in the decisions I make or the actions I take.	-3.53	-3.45
9. I generally ignore warnings about possible future problems because I think the problems will be resolved before they reach crisis level.	-2.62	-2.69
10. I think that sacrificing now is usually unnecessary since future outcomes can be dealt with at a later time.	-2.75	-2.81
11. I only act to satisfy immediate concerns, figuring that I will take care of future problems that may occur at a later date.	-2.75	-2.89
12. Since my day-to-day work has specific outcomes, it is more important to me than behavior that has distant outcomes.	-3.24	-3.33
Consequences of future actions—future: CFC-F		
1. I consider how things might be in the future and try to influence those things with my day to day behavior.	3.66	3.73
2. Often I engage in a particular behavior in order to achieve outcomes that may not result for many years.	3.34	3.38
6. I am willing to sacrifice my immediate happiness or wellbeing in order to achieve future outcomes.	3.47	3.57
7. I think it is important to take warnings about negative outcomes seriously even if the negative outcome will not occur for many years.	3.74	3.78
8. I think it is more important to perform a behavior with important distant consequences than a behavior with less important immediate consequences.	3.43	3.47
13. When I make a decision, I think about how it might affect me in the future.	3.93	3.90
14. My behavior is generally influenced by future consequences.	3.57	3.56

Source: Kurani, Kenneth. University of California, Davis.

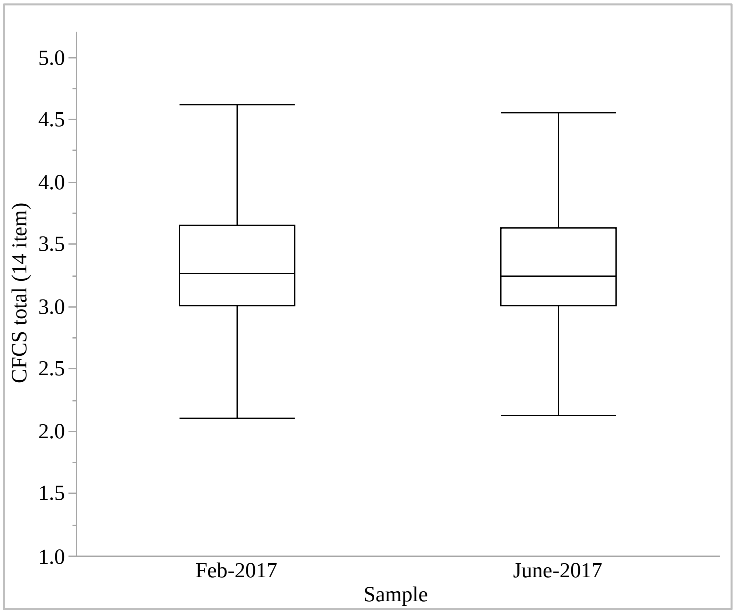

Figure 18. Boxplots of rescaled total CFCS scores, scale 1 = motivated entirely by immediate consequences to 5 = motivated entirely by future consequences

Source: Kurani, Kenneth. University of California, Davis.

Table 6. Temporal focus scales, June 2017; means and rotated factor loadings

Item (enumerated in order asked in the questionnaire but grouped according to time period)	Mean	Rotated factor loading; Variance explained, %
Past		
1. I think about things from my past.	4.63	0.795
6. I replay memories of the past in my mind.	4.63	0.843
9. I reflect on what has happened in my life.	4.98	0.665
Mean of the temporal focus items:	4.75	21.3%%
Present		
2. I live my life in the present.	5.12	0.784
4. I focus on what is currently happening in my life.	5.44	0.618
8. My mind is on the here and now.	5.06	0.748
Mean of the resent temporal focus items:	5.21	20.7%
Future		
3. I think about what my future has in store.	5.25	0.848
5. I focus on my future.	5.20	0.671
7. I imagine what tomorrow will bring for me.	5.07	0.701
Mean of the future temporal focus items	5.17	18.3%

Source: Kurani, Kenneth. University of California, Davis.

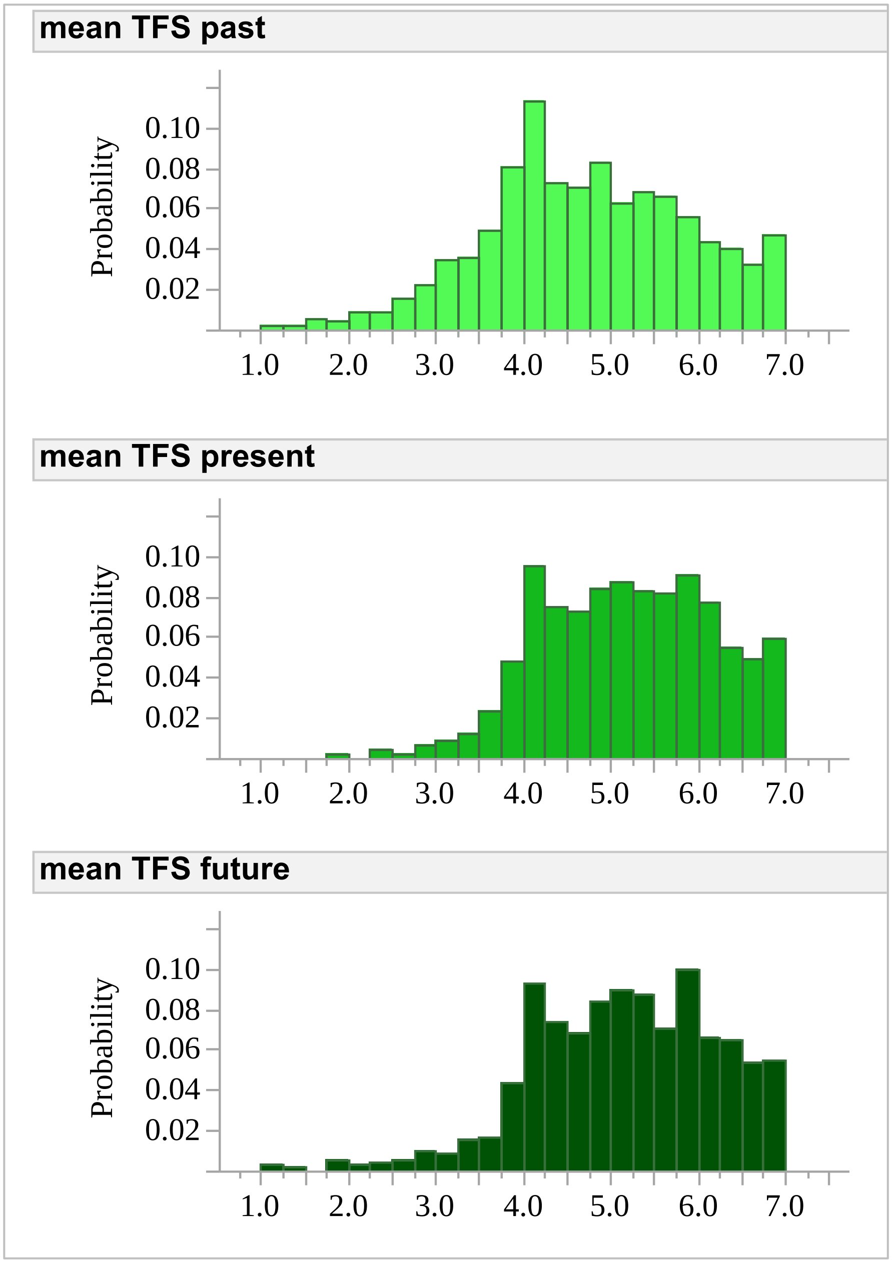

Figure 19. Distributions of the mean respondent scores for past, present, and future temporal focus (TFS) scores

Source: Kurani, Kenneth. University of California, Davis.

Modeling consideration of PEVs and FCEVs: June 2017

Here we present multivariate models of respondents' consideration of ZEVs (Figure 1). Seven models are presented which collectively inform the discussion of what explanatory variables are correlated with consideration of ZEVs. Models 2 through 5 progressively add variables and interactions to each prior model (taking Model 1 as the starting point) as summarized in Table 7. These models are constructed as tests of specific hypotheses. Explanatory variables are included to test whether groups of variables, individual variables within each group, and interactions with the respondents' sex identifier are statistically significant. Testing the variable for respondents' sex identifier follows a recommendation from State of the Market Report I.

Table 7. Complete list of explanatory variables in Models 1 through 6

Model	Incrementally added variables
Model 1: Socio-economic and demographic descriptors	• Respondent age, sex, and education; household income
Model 2a: Model 1 plus Contextual and Resource descriptors such as characteristics of the residence, household vehicles, and daily and weekly driving:	• Own or rent residence • Acquired any new vehicles since Jan. 2010 • Access to electricity at home parking location • Authority to install new electricity at home • Flexibility assigning vehicles to household drivers • Number of days per week respondent drives • Does respondent commute to a workplace
Model 2b: Model 1 plus Consideration of Future Consequences (CFCS) and Temporal Focus Scales (TFS):	• CFCS-Immediate • CFCS-Future • TFS Past • TFS Present • TFS Future
Model 3: Model 2a plus general attitudes and orientations, including CFCS and TFS	• Air quality: personal worry and regional health risk • Assessment whether in their region electricity presents a lower or higher risk to public health and the environment than gasoline • Whether electricity, hydrogen, or both are imagined to be likely replacements for gasoline and diesel • CFCS: immediate and future • TFS: past, present, and future • Familiarity with conventional ICEVs • Experience with HEVs
Model 4: Model 3 plus measures of specific awareness, knowledge, experience and assessments of PHEVs, BEVs, and FCEVs	• Name a PHEV and BEV • Know incentives offered by federal and CA governments • Should governments incent electricity and hydrogen • Respondent's interest in ZEV technology • Familiarity with HEVs, PHEVs, BEVs, and FCEVs • Experience driving ZEVs • Whether respondent has seen PEV charging infrastructure • Assessments of performance, charging, and price of BEVs • Assessments of performance, fueling, and price of FCEVs • Whether the respondent knows someone who owns a PEV or FCEV

Model	Incrementally added variables
Models 5 and 6: Model 4 plus interactions between respondent sex and a subset of variables Model 5: Minimum AIC_c Model 6: Minimum BIC	• Respondent sex by: ○ Daily flexibility to assign cars to drivers ○ Familiarity with ICEVs ○ CFCS-Immediate ○ Experience driving ZEVs

Source: Kurani, Kenneth. University of California, Davis.

Table 8. Progression of Models of Consideration of PEVs and FCEVs as New Variable Groups added to Model and models that minimize information criteria

	Model 1	Model 2a	Model 2b	Model 3	Model 4	Model 5: min. AIC_c	Model 6: min. BIC
Whole Model							
-LogLikelihood							
Difference	43.96	69.05	62.60	180.58	311.77	324.18	324
Full	2322.36	2297.27	2303.72	2185.73	2054.56	2042.15	2065.28
Reduced	2366.32	2366.32	2366.32	2366.32	2366.32	2366.32	2366.32
Degrees of Freedom	10	26	15	41	51	45	32
Chi-Square	87.92	138.10	125.20	361.17	623.54	648.35	602.08
Prob > Chi-Square	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Entropy R^2	0.02	0.03	0.03	0.08	0.13	0.14	0.13
Misclassification Rate	0.66	0.66	0.65	0.63	0.60	0.58	0.60
AICc	4675.04	4657.85	4648.00	4466.36	4225.39	4187.7	4206.43
BIC	4754.90	4822.23	4754.34	4709.33	4520.41	4451.53	4402.32

Source: Kurani, Kenneth. University of California, Davis.

Table 9. Statistically Significant Explanatory Variables in Models 1 through 4: Consideration of PEVs and FCEVs

Variable Group	Model 1	Model 2a	Model 2b	Model 3	Model 4
Socio-economic, demographic	• Age • Sex • Education • Income	• Age • Education	• Age • Sex • Education • Income	• Age	• Age • Sex
Context: Residence, vehicles, weekly and daily travel	—	• Home parking electricity; • Daily driving variability	• —	• Home parking electricity	—
Attitudes: environment, health, future consequences, new technology	—	—	• CFCS-Future • TFS-Future	• Replace gasoline with electricity or hydrogen • Air quality • Electricity vs. gasoline health and environment risk • Familiarity with ICEVs • Experience driving HEVs	• Replace gasoline with electricity or hydrogen • HEV driving experience • Electricity vs. gasoline health and environment risk
PEV-and FCEV-specific awareness, knowledge, experience, assessments	—	—		—	• Seen PEV charging • Know fueling for BEVs or PHEVs • Know federal or CA incentives • Should gov't offer incentives • Know a ZEV owner • Interest in ZEV tech • Name a BEV or PHEV • ZEV driving experience • BEV assessment: safety, reliability

Source: Kurani, Kenneth. University of California, Davis.

Table 10. Statistically Significant Explanatory Variables in Models 5 (Minimum AIC_c); interactions with respondent sex identifier

Variable Group	Model 5: Interaction w/ respondent sex identifier
Socio-economic, demographic	• Age
Context: Residence, vehicles, weekly and daily travel	• Respondent Sex by ○ Daily flexibility to assign cars to drivers

Attitudes: environment, health, future consequences, new technology	• Replace gasoline with electricity or hydrogen
	• Air quality attitude
	• Electricity vs. gasoline: health and environment
	• Temporal Focus: present
	• Familiarity with ICEVs
	• Experience driving HEVs
	• Respondent sex by:
	  ○ CFCS Immediate
	  ○ Familiarity with ICEVs

PEV- and FCEV-specific awareness, knowledge, experience, assessments	• Seen PEV charging
	• Know fueling for BEVs or PHEVs
	• Knows of federal or California incentives
	• Should gov't offer incentives
	• Know a ZEV owner
	• Interest in ZEV technology
	• Name a BEV or PHEV for sale
	• Familiarity with ZEVs
	• Experience driving ZEVs
	• BEV assessment:
	  ○ Charging, home and away
	  ○ Safety and reliability
	• Respondent sex by:
	  ○ Experience driving ZEVs

Source: Kurani, Kenneth. University of California, Davis.

Table 11. Explanatory Variables in Model 6 (Minimum BIC); Consideration of PEVs and FCEVs

Variable Group	Model 6: minimum BIC
Socio-economic, demographic	• Age
Context: Residence, vehicles, weekly and daily travel	—
Attitudes: environment, health, future consequences, new technology	• Replace gasoline with electricity or hydrogen • HEV driving experience
PEV- and FCEV-specific awareness, knowledge, experience, assessments	• Interest in ZEV technology • Experience driving ZEVs • Knows how BEVs or PHEVs are fueled • Knows of federal or CA incentives • Governments should incent consumers • Knows ZEV owner • PEV/FCEV driving experience • PEV assessment: charging, home and away • PEV assessment: reliability and safety

Source: Kurani, Kenneth. University of California, Davis.

Models 5 and 6 are built as statistically strong as possible using the fewest variables. The measures of “statistically strong” are the corrected Akaike’s Information Criteria (AIC_c) and the Bayesian Information Criteria (BIC). The BIC imposes a larger penalty for adding variables than does AIC_c so the BIC results in models with fewer variables. Overall model tests are shown in Table 8. The explanatory variables that are statistically significant ($\alpha \leq 0.05$) for Models 1 through 4 are shown in Table 9 and those for Models 5 that add interactions with respondent sex are in Table 10. The significant explanatory variables for Model 6 are in Table 11.

How much ZEV consideration can be explained by which variables?

Models 1 through 4 are motivated by the question of how much improvement can be made in understanding who is considering PEVs and ZEVs by knowing more about households than a few socio-economic and demographic descriptors. The overall message is that knowledge (by researchers, policy makers, vehicle and charging providers, and other stakeholders) of consumers’ specific awareness, knowledge, experience, familiarity, and assessments of ZEVs almost entirely supplants not only socio-economics and demographics but also many measures of households’ context (residences, vehicle holdings and usage), and even most measures of general attitudes and beliefs regarding new technology and the environment.

Because high levels of ZEV consideration, i.e., active shopping and vehicle acquisition, remain such low incidence events across the general population of car-owning households, no model accurately estimates which respondents have already given the highest consideration to a ZEV for their household. However, collectively Models 1 through 5 suggest we do a rather poor job identifying who has expressed any interest in the transition to ZEVs by relying solely on socio-economic and demographic measures. Investing in information about household decision contexts, attitudes regarding air quality and beliefs about the relative ability of electricity (compared to gasoline and diesel) to remedy air pollution problems, and car owners’ perceptions, experiences, and assessments of ZEVs, we can more accurately establish who has already considered ZEVs. More importantly, these results suggest, though do not by themselves prove, ways in which those who have not considered ZEVs might be prompted to do so.

Model 1 starts with basic socio-economic and demographic measures of respondents and their households: sex, age, education, and income. All appear to be statistically significantly correlated with ZEV consideration. The estimated parameters for these models indicate the following generalization: men age 30 to 39 with graduate degrees who live in households with above median incomes are more likely than others to be at higher levels of ZEV consideration.

Despite the results from Model 1, neither the variables for respondent sex nor household income are statistically significant in Model 2a. Model 2a includes variables describing respondents’ residences, their vehicle holdings, their day-to-day use of vehicles, i.e., the context within which households might consider whether they could charge and use a PEV as well as use an FCEV. Of these Contextual and Resource descriptors listed in Table 7, the ones that are statistically significant in Model 2a are shown in Table 9: whether the household has reliable access to electricity (and differences in the power of that electrical service) at a location where they park at least one household vehicle and the amount of day to day variability in how far the respondent drives on weekdays. Access to electricity and to higher power electricity are associated with a higher likeliness the respondent's household has already considered a ZEV. Some daily variation in travel distances is associated with a higher likeliness to have already consider a ZEV than are no variation or a lot of variation.

Model 2b tests for whether consideration of future consequences or temporal focus are correlated with ZEV consideration, controlling for the four socio-economic and demographic measures. Both higher CFCS scores (more influenced by farther future consequences) and the TFS-future score are statistically significant; the past or present measures are not. People who indicate a stronger effect of future consequences on their present actions and those who rate themselves as spending more time thinking about the future are estimated to be more likely to be at higher levels of ZEV consideration.

Notably, when these time measures or the contextual and resource measures are added to the model, respondent sex and household income (though retained in Model 2a and 2b) are no longer statistically significant. Age and education retain their same statistically significant effect; younger respondents with more formal education are estimated to be more likely to be at higher levels of ZEV consideration, even controlling for CFCS and TFS.

Model 3 adds more information about respondents' environmental beliefs and attitudes that are generally hypothesized to be related to interest in ZEVs as well as measures of their familiarity with conventional vehicles and experience driving HEVs. Of the measures listed in Table 7, those that are statistically significant in Model 3 are listed in Table 9:

- If gasoline and diesel have to be replaced, does the respondent believe electricity or hydrogen are likely replacements (if so, the respondent is more likely to be at higher levels of ZEV consideration);
- Air quality is measured by a factor score that relates respondents' answers to three separate questions about air quality; lower factor scores indicate lower concern about air pollution and lower belief that individual lifestyles affect air quality (higher scores are associated with higher probability of higher levels of ZEV consideration);
- Electricity vs. gasoline health and environment risk is a factor score indicating whether the respondent believes that electricity poses lower public health and environmental risk than does gasoline; (higher scores indicate electricity is a lower health and environmental risk and are associated with higher probability of higher levels of ZEV consideration);
- Familiarity with ICEVs (higher familiarity is associated with higher probabilities of higher levels of ZEV consideration); and
- HEV driving experience (those with more experience driving HEVs have higher probabilities of higher ZEV consideration).

With the addition of these explanatory variables, another socio-economic variable—respondent education—becomes non-significant, leaving only respondent age. Also note, that daily driving distance variability is no longer statistically significant either, leaving reliable access to electricity as the only statistically significant measure of respondents' contexts and resources.

Model 4 adds variables related to ZEVs specifically: what do respondents already believe and know specifically about ZEVs and how do these measures correlate to whether respondents have already considered a ZEV? Of these measures listed in Table 7, these are the ones that are statistically significant in Model 4:

- Seeing PEV charging in the parking garages and facilities the respondent uses (not seeing PEV charging is associated with lower probability of higher levels of ZEV consideration);
- Know how BEVs or PHEVs are "fueled" (those who do know are more likely to be at higher levels of ZEV consideration);
- Know the federal or California state government offer incentives to consumers to buy vehicles powered by alternatives to gasoline and diesel (those who do know are more likely to be at higher levels of ZEV consideration);
- Believes governments should be providing incentives for electricity and hydrogen (those who do believe are more likely to be at higher levels of ZEV consideration, especially if they believe both electricity and hydrogen should be subsidized):
- Know a PEV or FCEV owner carries the stipulation the respondent know a PHEV, BEV, or FCEV owner "by name" (not knowing anyone by name that owns a PHEV, BEV, or FCEV is associated with lower probability of higher levels of ZEV consideration).
- Respondent interest in ZEV technology (higher interest in ZEV technology associated with higher probability of higher levels of ZEV consideration, though the relationship is not linear, that is, those with the highest level of interest are not the most likely to have the highest levels of ZEV consideration);
- Name a BEV or PHEV "presently for sale" (those who do know are more likely to be at higher levels of ZEV consideration);
- ZEV driving experience is also a factor score, this time summarizing three measures (PHEV, BEV, and FCEV) of driving experience (lower driving experience is associated with lower probability of higher levels of ZEV consideration); and
- Comparative BEV-ICEV safety and reliability is a factor score combining respondents' assessments of whether FCEVs are safer and more reliable than ICEVs (lower scores, i.e., less favorable ratings of FCEVs compared to ICEVs, are associated with lower probability of higher levels of ZEV consideration); and

Neither consideration of future consequences (CFCS) nor any of the three Temporal Focus Scale (TFS) scales are statistically significant. Other context, resource, and general attitude variables that previously were significant but are not in Model 4 include attitudes about air quality and the measure of access to electricity at a home parking location.

The variable for respondent sex identifier re-enters Model 4 as statistically significant; further analysis of this variable is conducted in Model 5. The starting point is to add interaction effects between the sex identifier variable and the other variables in Model 4. Because models with so many variables are difficult to interpret and have many variables and interactions that are estimated to have no effect on the overall quality and performance of the model of ZEV consideration, the model is trimmed of such variables and interactions. The stopping point for this process of eliminating variables for Models 5 is the minimum value of AIC_c. The resulting model (Table 10) includes four interactions between respondent sex identifier and other explanatory variables:

- Daily flexibility to assign cars to drivers;
- Familiarity with ICEVs;
- Experience driving ZEVs; and,
- CFCS-Immediate.

The first two of these are contextual and resource measure: how much flexibility regarding the assignment of vehicles for daily travel do the respondent household's practice and familiarity with conventional vehicles. The answers to flexibility of vehicle assignment within the household range from none at all (either because there is only one driver in the household or because the household makes rigorous assignments of vehicles to specific drivers) to households who decide everyday who will take which vehicle. The overall effect of this variable is that households who decide everyday who takes which car are estimated to be more likely to have higher levels of ZEV consideration than households in which there are stricter assignments of vehicles. The interaction effect with respondent's sex adjusts this general effect: greater flexibility of vehicle assignment within a household increases the probability a female respondent is at a higher-level ZEV consideration, whereas flexibility of vehicle assignment has comparatively little effect on male respondents' ZEV consideration.

Familiarity with ICEVs is self-rated on a scale of whether the respondent is, "familiar enough with these types of vehicles to make a decision about whether one would be right for your household?" The overall effect of this variable is slight but indicates higher familiarity with ICEVs is associated with higher probabilities of higher levels of ZEV consideration. The interaction effect with respondent sex indicates that for males, this effect is amplified but for female respondents there is no adjustment to the general effect. Model 5 produces a similar result to model 2b regarding the main effect of consideration of future consequences:

- People who considered future consequences more than immediate consequences were more likely to be at higher levels of ZEV consideration.

The interaction between respondent sex identifier and CFCS in Model 5 indicates the general effect is not modified among female respondents, but that among male respondents the effect of being more focused on immediate consequences is reduced from the main effect. Finally, the main effect of ZEV experience driving is that higher experience associated with a higher probability of being at higher levels of ZEV consideration. The interaction between respondent sex and experience driving ZEV does not appear to modify the main effect for female respondents, but to amplify the effect among male respondents.

Model 6 is produced by continuing to reduce the number of variables in model 5 until the minimum BIC value is reached. Because the emphasis of Model 6 is on statistical strength and parsimoniousness rather than hypothesis testing, Model 6 produces overall measures of fit as strong as the model with the highest number of potential explanatory variables (Model 4) but with far fewer variables. Compared to Model 5, neither the variable for respondent sex identifier nor any interaction with it are present. The reduced set of variables in Model 6 simply reinforces the larger message:

- Few socio-economics or demographics explain which car-owning households in California have considered a ZEV if we know more about whether they believe electricity is better for human health and the environment where they live and their awareness, knowledge, experience, and assessment of ZEVs specifically.

Modeling ZEV consideration: Comparing February and June 2017

The next set of models combines the February and June 2017 data and tests for differences in ZEV consideration. Modeling proceeds in a similar fashion as in the previous section, each subsequent model builds on the previous model (Table 12). As before the first model starts with socio-economic and demographic descriptors of the respondent. In this case, an initial model includes a variable designating to which sample each respondent belongs. A test is then conducted of whether adding interactions between the sample identifier and the other explanatory variables results in an improvement over the first model. For example, Model 7a includes a sample identifier and four socio-economic and demographic descriptors; Model 7b includes those five variables plus four more that allow the effects of the socio-economic and demographic descriptors to be different for each sample.

The overarching result is there is no reason to believe that anything fundamentally changed between February and June 2017. In no “a” model is the variable identifying the sample statistically significant—and thus there is no statistically significant difference in ZEV consideration between the samples. Further, no “b” model including interactions between the sample identifier and other explanatory variables in the model is better than its corresponding “a” model that excludes such interactions (Table 13).

The results of progressively adding suites of related explanatory variables to the combined data sets from February and June 2017 (Table 14) produces the same general result as the independent models of February (see State of the Market I) and June (see previous section) 2017. While consideration to date of ZEVs is correlated with basic socio-economic and demographic descriptors of the respondents and their households, we not only supplant most all socio-economic and demographic measures, we do a better job of identifying who has, and who has not, already considered a ZEV for their household the more we know about:

1. The context in which they live and resources they have available;

2. The attitudes they have toward the environment, public health (and the comparative effects of electricity and gasoline on these) and new technology; and,
3. Their awareness, experience, knowledge, and assessments of ZEVs specifically.

Further, since the same socio-economic and demographic descriptors correlated to ZEV consideration are also correlated to purchase of any new car (Table 15), relying on such measures amounts to trying to sell ZEVs to people who buy new cars and tells us nothing about how to shift new car buyers who are not considering ZEVs to consider ZEVs.

Table 12. Summary of explanatory variables in models 7a through 10b

Model 7a: Sample; Socio-economic and demographic descriptors	• Sample identifier • Respondent age • Respondent sex • Respondent education • Household income
Model 7b: Model 7a plus:	• Sample identifier crossed with all other variables in 7a, i.e., ○ Respondent age ○ Respondent sex ○ Respondent education ○ Household income
Model 8a: Model 7a plus Contextual and Resource Descriptors	• Own or rent residence • Acquired any new vehicles since Jan. 2010 • Access to electricity at home parking location • Authority to install new electricity at home • Flexibility assigning vehicles to household drivers • Number of days per week respondent drives • Does respondent commute to a workplace
Model 8b: Model 8a plus:	• Sample identifier crossed with all additional variables in 8a: ○ Own or rent residence ○ Acquired any new vehicles since Jan. 2010 ○ Access to electricity at home parking location ○ Authority to install new electricity at home ○ Flexibility assigning vehicles to household drivers ○ Number of days per week respondent drives ○ Does respondent commute to a workplace

Model 9a: Model 8a plus general attitudes and orientations	• Air quality: personal worry and regional health risk • Assessment whether in their region electricity presents a lower or higher risk to public health and the environment than gasoline • Whether electricity, hydrogen, or both are imagined to be likely replacements for gasoline and diesel • Consideration of Future Consequences Scale (CFCS): immediate and future • Familiarity with conventional ICEVs, HEVs • Experience with HEVs
Model 9b: Model 9a plus	• Sample identifier crossed with all the new variables in model 9a
Model 10a: Model 9a plus measures of specific awareness, knowledge, experience and assessments of PHEVs, BEVs, and FCEVs	• Name a PHEV and BEV • Know incentives offered by federal and CA governments • Should governments incent electricity and hydrogen • Respondent's interest in ZEV technology • Familiarity with HEVs, PHEVs, BEVs, and FCEVs • Experience driving ZEVs • Whether respondent has seen PEV charging infrastructure • Assessments of performance, charging, and price of BEVs • Assessments of performance, fueling, and price of FCEVs • Whether the respondent knows someone who owns a ZEV
Model 10 b: Model 10a plus	• Sample identifier crossed with all the new variables in model 10a.

Source: Kurani, Kenneth. University of California, Davis.

Table 13. Comparison of February and June 2017; Progression of Models of Consideration of PEVs and FCEVs as New Variable Groups added to Model and models that minimize information criteria

	Model 7a	Model 7b	Model 8a	Model 8b	Model 9a	Model 9b	Model 10a	Model 10b
Whole Model								
-LogLikelihood								
Difference	68.74	76.89	223.93	232.55	328.88	332.09	565.68	588..95
Full	4289.41	4281.27	4134.22	4125.61	4029.28	4026.07	3792.48	3769.21
Reduced	4358.16	4358.16	4358.16	4358.16	4358.16	4358.16	4358.16	4358.16
Degrees of Freedom	11	21	32	53	39	46	66	100
Chi-Square	137.49	153.78	447.87	465.10	657.76	664.17	1131.35	1177.91
Prob > Chi-Square	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Entropy R^2	0.02	0.02	0.05	0.05	0.08	0.07	0.13	0.14
Misclassification Rate	0.65	0.65	0.62	0.62	0.61	0.61	0.570	0.56
AICc	8611.02	8615.03	8343.44	8369.65	8147.96	8156.02	7730.62	7756.47
BIC	8706.22	8769.54	8563.03	8713.00	8408.87	8458.19	8150.25	8374.39

Source: Kurani, Kenneth. University of California, Davis.

Table 14. Statistically Significant Explanatory Variables in Models 7a through 10a: Consideration of PEVs and FCEVs

	Statistically Significant Variables			
Variable Group	**Model 7a**	**Model 8a**	**Model 9a**	**Model 10a**
Socio-economic, demographic	• Age • Sex • Education • Income	• Age	• Age • Sex	• Age
Context: Residence, vehicles, weekly and daily travel	—	• Purchased new vehicles • Daily driving variability • Home parking electricity; • Park in garage or carport • Residence has solar • Familiarity with HEVs	• Purchased new vehicles • Daily driving variability • Home parking electricity • Authority to install electricity • Residence has solar • Familiarity with HEVs	• Home parking electricity
Attitudes: environment, health, future consequences, new technology	—	—	• Replace gas w/ electricity or hydrogen • Air quality • Electricity vs. gasoline health and environment risk • Familiarity with ICEVs • Experience driving HEVs • CFCS-Future	• Replace gas w/ electricity or hydrogen • Air quality • Electricity vs. gasoline health and environment risk
PEV-and FCEV-specific awareness, knowledge, experience, assessments	—	—	—	• Seen PEV charging • Know fueling for PEVs • Know federal and CA incentives • Should gov't offer incentives • Know a ZEV owner • Interest in ZEV tech. • Name a PEV • Familiarity with ZEVs • Experience driving ZEVs • BEV assessments: ○ long charge, short range ○ safety, reliability

Source: Kurani, Kenneth. University of California, Davis.

Table 15. Model of who are new car buyers, combined February and June 2017

Whole Model Test				
	-LogLikelihood	Degrees of Freedom	Chi-Square	Prob > Chi-Square
Difference	154.48	10	308.95	<0.001
Full	1821.34			
Reduced	1975.82			
R^2	0.08			
AICc	3664.78			
BIC	3730			
Lack of Fit				
	-LogLikelihood	Degrees of Freedom	Chi-Square	Prob > Chi-Square
Lack of Fit	39.30	84	76.6	0.70
Saturated	1783.04	94		
Fitted	1821.34	10		
Parameter Estimates				
Respondent Sex		1	27.89	<0.001
Respondent Age		5	60.94	<0.001
Respondent Education		3	24.83	<0.001
Median Income		1	146.66	<0.001

Source: Kurani, Kenneth. University of California, Davis.

CHAPTER 3: Insights

Consideration of ZEVs by car owning households in California has been limited

This study focused on describing whether the households who own cars have already considered a ZEV for their household. The basic measure was shown in Figure 1. Nothing in June 2018 data nor in the joint modeling of the February and June 2017 data indicates there was any change in ZEV consideration in that interval detectable by samples of the size used here. Allowing for the possibility that respondents may have considered PHEVs, BEVs, and FCEVs independently (rather than as a single group or type of vehicle), half of all car-owning households have paid no attention to ZEVs and a total of 80% have paid no or scant attention. Less than eight percent of households in either February or June of 2017 indicated they had actively shopped for or already owned (or had owned) a PHEV, BEV, and/or FCEV.

Socio-economic and demographic measures alone are poor estimators of ZEV consideration.

The results for June 2017 and the combined analysis for February and June 2107 indicate that while simple socio-economic and demographic measures—age, sex, education, and household income in this case—can be statistically correlated to the measure of ZEV consideration used in this study, by themselves they are not particularly powerful descriptors of who had and who had not considered ZEVs as of the first half of 2017, nor do these descriptors distinguish consideration of ZEVs from the purchase of any new car. While no model estimated in Tables 8 or 13 performs well describing who has already shopped for or owned a ZEV (the two highest levels of consideration), this is in part because, so few households were at these high levels. Of the socio-economic and demographic descriptors, only respondent age appears consistently across all models of ZEV consideration. Younger people, specifically those age 30 to 39 are consistently estimated to be at higher levels of consideration than any other age bracket; probability of having considered ZEVs is estimated to decline as respondents are older and older.

It is the case that every model that included additional variables did a statistically significantly better job of estimating ZEV consideration than the model based only on socio-economics and demographics. Three sets of additional measures were tested: 1) respondents' context and resources, 2) attitudes toward public health, environment, and new technology generally, as well as assessments of whether present behaviors are influenced more by immediate or future consequences and orientations toward past, present, and future, and 3) knowledge, experience, and assessments of ZEVs specifically. Measures of household decision context and resources improve the estimation of household consideration of ZEVs, especially whether the household has reliable access to electricity at a location where they park at least one vehicle at home. It is true that access to electricity at a home parking location is more likely to occur for households that live in single family homes rather than multi-unit dwellings and who park at least one car in a garage or carport attached to their residence. However, the fact these other measures don't themselves enter any model as statistically significant suggests that creating reliable access to electricity at home—regardless of building type and ownership—may allow households who have not considered ZEVs (or at least, PEVs) to do so.

Another improvement in understanding the extent to which car-owning households have already considered ZEVs is made if measures of general attitudes toward air quality, public health, and the environment are known, and in particular if those are known in how they relate to the effects of substituting electricity for gasoline and diesel. Generally speaking there is some evidence that respondents with a greater orientation toward the future are also more likely to be at higher levels of ZEV consideration. However, these measures will be put into their proper context in the next section.

Ultimately, the variables that provide the most information to explain ZEV consideration are specific to the technology, market, and policy context of ZEVs:

- Seeing PEV charging;
- Knowing how PEVs are fueled;
- Knowing of federal and California incentives;
- Supporting the idea of government incentives;
- Knowing a ZEV owner;
- Having an interest in ZEV technology;
- Being able to name a PEV offered for sale;
- Feeling sufficiently familiar with ZEVs;
- Experience driving ZEVs; and
- Assessments of BEVs on these related measures:
    - Duration of charging and driving range; and
    - Safety and reliability compared to conventional vehicles.

The timing of future consequences and orientations toward the future may matter, but more specific measures matter more

It is less clear if understanding people's orientation toward past, present, and future timeframes and whether they feel their present actions are affected more by immediate or farther future consequences adds any real power to explanations of ZEV consideration. These measures improve a model containing only socio-economic and demographic descriptors and indicate that both a greater effect of future consequences on present behavior and spending more time thinking about the future are associated with higher levels of ZEV consideration. However, when variables describing context and resources as well as environmental and public health attitudes generally are included, they supplant measures of orientation towards time.

The one set of models in which orientation toward time appear as statistically significant is in the models examining differences between female and male respondents, the topic to which this discussion turns next.

Female and male respondents differ little in their consideration of ZEVs

In models exploring differences between female and male respondents, the variable for respondent's sex identifier does not itself enter as a statistically significant variable, but the interaction of this variable with four other variables does:

- Daily flexibility to assign cars to drivers;
- Familiarity with ICEVs;
- Experience driving ZEVs; and,
- CFCS-Immediate (whether present actions are more affected by immediate than far future consequences.

The interaction effects indicate that women living in a household with flexible assignment of vehicles to drivers are estimated to have a higher probability of being at a higher level of ZEV consideration than are women in households with strict assignments of household vehicles to particular drivers. For all respondents, higher levels of familiarity with ICEVs and more experience driving ZEVs are associated with higher probability of being at higher levels of ZEV consideration. The interaction of familiarity with ICEVs with respondent sex identifier is such that these effects are stronger for male respondents than for female respondents. The overall effect of CFCS-Immediate is that people more motivated by immediate consequences are more likely to be at *lower* levels of ZEV consideration. The interaction between respondent sex identifier and CFCS-Immediate indicates the general effect is not modified among female respondents, but that among male respondents the effect is slightly reduced.

The slight differences in consideration of ZEVs between female and male respondents (in a sample from a population that consists mostly of households who have not yet acquired a ZEV) raises the question of why much larger gender imbalances exist ZEV sales to date. The model results here suggest there is little reason for such an imbalance to persist (based on any prior differences in consideration of ZEVs) if the causes for the observed imbalance in sales are identified and corrected.

CHAPTER 4: Conclusions

As of the first half of 2017, the degree to which car-owning households have already considered a PHEV, BEV, or FCEV for their household is limited; fewer than eight percent of households are estimated to be at the highest levels of consideration—active shopping or ownership (or leasing). Four-of-five households are estimated to have paid no to scant attention to any transition to electric-drive light-duty vehicles. All other measures of awareness, vehicle name recognition, incentive awareness, and driving experience are commensurate with these low levels of consideration. Assessments of BEV and FCEV charging, performance, price, reliability, and safety are associated with consideration—but those assessments are based on the same low levels of awareness, knowledge, and experience just cited.

While the modeling done here is of differences between people at a point in time not of changes to people over time, still the suggestion would be that to start to increase ZEV market growth it would be productive to increase peoples' awareness, knowledge, assessments, and thus, consideration. Certainly, we should expect that not all of the people who have so far paid no or little attention will be or can be quickly converted to ZEV shoppers and owners. However, there seems very little prospect to grow the ZEV market very far, very fast unless the vast majority of car-owning households in California who are not paying attention can be engaged in the transition to electric-drive.

Recommendations

Social marketing of the electric-drive transition itself is required, not just of the vehicles. Sustained consideration, i.e., engagement, requires motivation. It matters whether people can imagine why they would consider electric-drive vehicles in general to create the motivation to shop for one in particular. Recall that among those who can give no reason why they would buy a BEV more than half say they haven't and won't consider a BEV for their household. Among people who can give even one reason why they might buy a BEV, only seven percent say they haven't already considered one and won't do so in the future.

The effect of any efforts to increase consumer engagement in the electric-drive transition can best be gauged by instituting and funding consumer research on an ongoing basis and within a consistent framework.

A stronger distinction between female and male respondents was evidenced in the February 2017 data than in the June 2017 data. However, the difference was a matter of degree, not existence. That is, differences between female and male respondents were found in both samples. Both samples support the conclusion that overall consideration of ZEVs is generally similar among female and male respondents but the messages, media, and mechanisms for encouraging greater consideration by women and men may differ. Further research should be designed to more specifically address gender differences not only in ZEV consideration, but also in ZEV purchase and use.

Finally, the samples used for State of the Market I and II were representative of the state as a whole. Just as the analysis of these data suggest, but cannot themselves prove, ways to increase the number of households that are considering ZEVs, it also suggests that to the extent some differences between people may vary systematically by geography, additional resources should be put towards survey samples specifically designed to test for and study such regional variation in ZEV consideration, and ultimately ZEV purchase and use.

Acronyms

Akaike's information criteria, corrected (AIC_c)

Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)

Assembly Bill (AB)

battery electric vehicles (BEVs)

Bayesian information criteria (BIC)

California Energy Commission (Energy Commission)

consideration of future consequences (CFCS)

fuel cell electric vehicles (FCEVs)

future temporal focus (TFS)

hybrid electric vehicle (HEV)

internal combustion engine vehicles (ICEVs)

plug-in electric vehicles (PEVs)

plug-in hybrid electric vehicles (PHEVs)

program opportunity notice (PON)

zero emission vehicles (ZEVs)