ZERO- AND LOW-EMISSION VEHICLES IN U.S. CARSHARING FLEETS

IMPACTS OF EXPOSURE ON MEMBER PERCEPTIONS

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Table of Contents

ABSTRACT

The California Zero-Emission Vehicle (ZEV) Mandate, adopted in 1990, was aimed at increasing the sale and dissemination of low- or zero-emission vehicles throughout the California auto market. ZEVs include plug-in hybrid vehicles (PHVs) and all-electric vehicles (EVs). In an attempt to accelerate the exposure of ZEVs in the general population, in 2001, additional credits were allotted to automakers in return for placing ZEVs into transportation networks, such as carsharing fleets. This policy is set to end in 2018. This white paper presents the results of a study that evaluated the impacts of ZEV exposure on United States carsharing users. Two surveys were administered to members of several carsharing organizations that use PHVs or EVs in their fleet including: car2go, DriveNow, eGo, and Zipcar. One was a control group survey, which was comprised of 1,742 respondents, and the other was an experimental group survey, covering 1,920 respondents.

The results support that exposure to PHVs or EVs through carsharing has influenced customer ZEV perceptions to be more positive and has commensurately increased the propensity for an individual to buy a ZEV. Furthermore, the data suggest that certain socio-demographic groups, such as younger people and women, are more interested in purchasing these vehicles after using them in carsharing.

INTRODUCTION

The Zero Emission Vehicle (ZEV) Program has been a key component of proactive policies within the State of California that are designed to encourage the sale and dissemination of ZEVs. For many years, the policy preceded systems capable of delivering practical electric vehicles (EVs) accessible to the middle-class consumer market. Initial research suggested the linking of ZEVs and carsharing systems to accelerate the spread of these vehicles in the general population. In 2001, the California Air Resources Board approved a revision to the ZEV mandate allowing for additional incentives for placing EVs in "transportation systems" or carsharing and station car fleets (Shaheen et al., 2002). Today, EVs have emerged from major automotive manufacturers placing these vehicles in carsharing fleets (short-term vehicle access) and into consumer households. These early stages of growth in EV use are encouraging, but the overall market share remains small and mass consumer exposure remains limited.

At present, there are three forms of carsharing in the United States. The first type is roundtrip carsharing, in which users access and return vehicles from the same location and pay on an hourly basis. This can include free miles or come with a per-mile charge. The second form is one-way carsharing, in which individuals typically access vehicles on a per-minute basis and can return them to either designated or free-floating parking spaces throughout a selected area/city. The final model is peer-to-peer carsharing, where individuals place their own private vehicles into a carsharing fleet that is managed by a third-party operator. Use of low- and zero-emission vehicles in the first two models is the focus of this white paper.

Numerous studies have found carsharing to have notable impacts on travel behavior including: household vehicle ownership, vehicle miles traveled (VMT), and greenhouse gas (GHG) emissions. A multi-year University of California (UC) Berkeley study on users of San Francisco's City CarShare roundtrip carsharing service revealed that 17% of members surveyed had reduced vehicle ownership since joining (Cervero et al., 2006). An aggregate-level study, also from UC Berkeley (completed by the Transportation Sustainability Research Center (TSRC)), evaluated 6,281 users from ten roundtrip carsharing organizations across North America and found that the average number of vehicles per surveyed household dropped from 0.47 to 0.24, translating to 9 to 13 vehicles shed per carsharing vehicle (Martin and Shaheen, 2010). Martin and Shaheen (2011) found that the observed (due to sold vehicles) and full impact (due to sold and postponed vehicle purchases) on GHG emissions by roundtrip carsharing users was a reduction of 0.58 t to 0.84 t GHG/year per household, respectively (or a 34% to 41% decline in GHG emission reductions). They further observed a decline in VMT of 27% (observed) to 43% (full impact) overall across all households. Monthly household savings per U.S. member after joining carsharing range from $154 to $435 (Shaheen and Chan, 2015). It is important to note that aggregate-level data cannot necessarily be generalized on a city basis; the analysis reflects the combined impacts across the different study populations.

The California ZEV mandate defines a minimum percentage of ZEVs sold by an automaker in California. There are various methods that a manufacturer may choose to use to calculate their production

requirement. The percentages defining the ZEV credits (i.e., the percent applied to the calculated vehicles produced and delivered) are defined in Table 1 below.

Table 1: ZEV Credit Percentages Applied to Automaker* Vehicle Calculation

Model Years	Minimum ZEV Requirement
2009 through 2011	11%
2012 through 2014	12%
2015 through 2017	14%

*For large manufacturers

Based on the chosen method for calculating vehicle sales, the appropriate percentage is applied to determine the ZEV requirement. Companies may use the incentives provided by transportation systems to help meet the credit requirement. For the model years 2009-2011, a ZEV, an Advanced Technology (AT) PZEV, and a Partial ZEV (PZEV) placed in a transportation system (i.e., carsharing and carsharing linked to public transit) for two or more years were eligible for additional ZEV credits. For model years 2012-2017, ZEV and Transitional ZEV (TZEV) vehicles were eligible. ZEV credits can be traded among automakers that meet and do not meet the mandate, thereby providing them with intrinsic value. While the magnitude of the program's impact has been increasing, the transportation system ZEV policy is designed to sunset in model year 2017. **As the policy currently stands, any vehicle placed in a carsharing fleet after January 1, 2018 (even if produced and delivered before then), will not be eligible for any ZEV credits.**

At present, BMW, Daimler, Ford, and Toyota are among the leading major automakers deploying EVs in carsharing fleets. Other carsharing systems have incorporated plug-in hybrid vehicles (PHVs) and EVs from several manufacturers, including Toyota and Nissan, into their fleets of regular internal combustion engine vehicles. This incorporation of PHVs/EVs into shared vehicle fleets exposes this technology to a large array of potential customers that would otherwise have far less or no exposure.

A key hypothesis of the study discussed in this white paper is that carsharing programs, which feature PHVs and EVs, are providing access to individuals who would otherwise **not** had access to them. To ascertain the effect of PHVs and EVs in carsharing (e.g., impacts on user perceptions and desire to purchase EVs), TSRC researchers administered two surveys between November 2014 and February 2015 to members of several carsharing organizations that use PHVs or EVs in their fleet including: car2go, DriveNow, eGo, and Zipcar. As an incentive to complete the survey, respondents were placed into a drawing for 25 Amazon gift cards per survey, each valued at $50. One of the two surveys was for the control group, which was administered to those members who had been active carsharing users in the 18 months prior to taking the survey but had **not** used a PHV or EV through their carsharing provider despite having access to them in the fleet they use. The control survey was administered to all operators except eGo (as they had employed a similar member survey previously and did not want to repeat it). The other was an experimental group survey, whose respondents were defined as those who had used a PHV or EV through their carsharing provider in the last six months. Of the 1,921 experimental

respondents, a vast majority (78%) had been exposed to full battery EVs as a driver or passenger through carsharing, and about 635 (25%) had also been exposed to PHVs in a similar way. It is important to note that two of the operators, car2go and DriveNow, are one-way carsharing operators. At the time of the survey, DriveNow exclusively deployed dedicated a full EV fleet in the San Francisco Bay Area. The car2go cities surveyed included both dedicated EV fleets (San Diego) and mixed fleets (Portland and Austin). Zipcar and eGo operate as roundtrip operators, and researchers surveyed members in the following cities: Boston, New York City, and Boulder. Table 2 below provides an overview of the two surveys.

Table 2: Survey Overview

Control Survey		Experiment Survey	
Launched	Dec 4, 2014	Launched	Nov 7, 2014
Closed	Feb 18, 2015	Closed	Feb 15, 2015
Avg. Completion Time	14 minutes	Avg. Completion Time	15 minutes
Total Completions	1,742	Total Completions	1,920
Completion Rate	77%	Completion Rate	74%
Participating Programs	car2go, Zipcar	Participating Programs	car2go, Zipcar, DriveNow, eGo
Cities Surveyed	Portland, Austin, New York City, Boston	Cities Surveyed	Portland, San Diego, Austin, New York City, Boston, San Francisco Bay Area, Boulder

Exposure to PHVs or EVs through carsharing has influenced customer EV perceptions to be more positive and has commensurately increased the propensity for an individual to buy an EV (see analysis discussion below). Furthermore, the data suggest that certain socio-demographic groups, such as younger people and women, are more interested in purchasing these vehicles after using them in carsharing.

This white paper first examines issues pertaining to access of ZEVs across the survey respondents. A discussion follows on the demographic profile of the experimental population exposed to PHVs/EVs. Finally, this paper analyzes the impact of PHV/EV exposure on attitudes toward ZEV use and ZEV purchasing decisions.

ZEV ACCESSIBILITY

Figure 1 supports the hypothesis that carsharing programs that feature PHVs and EVs are providing access to those who would otherwise not had access to such vehicles. Of the survey respondents that

own personal vehicles, 96% to 98% do not own a PHV or an EV. The rates of PHV and EV ownership are almost equally low among the experimental and control respondents.

Figure 1: Share of Households with EVs or PHVs

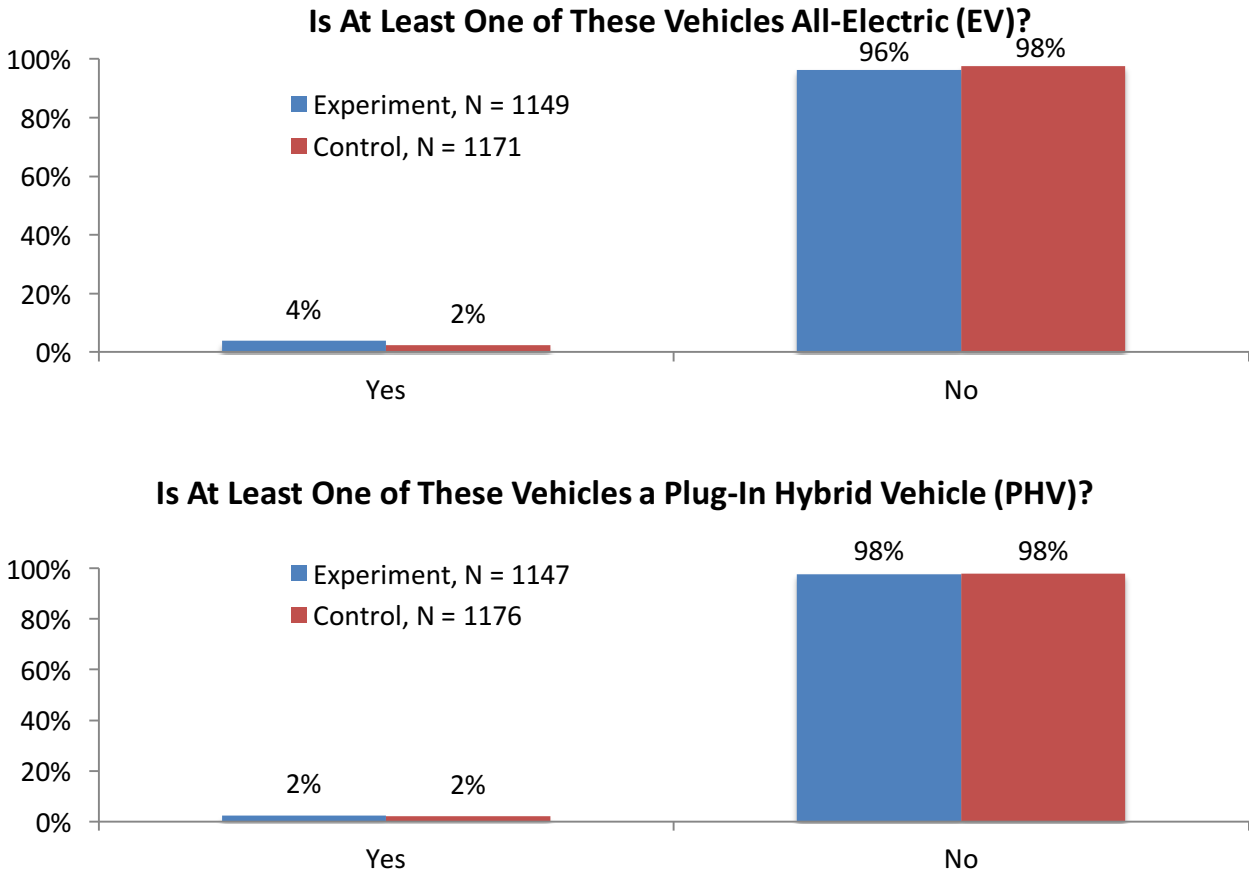
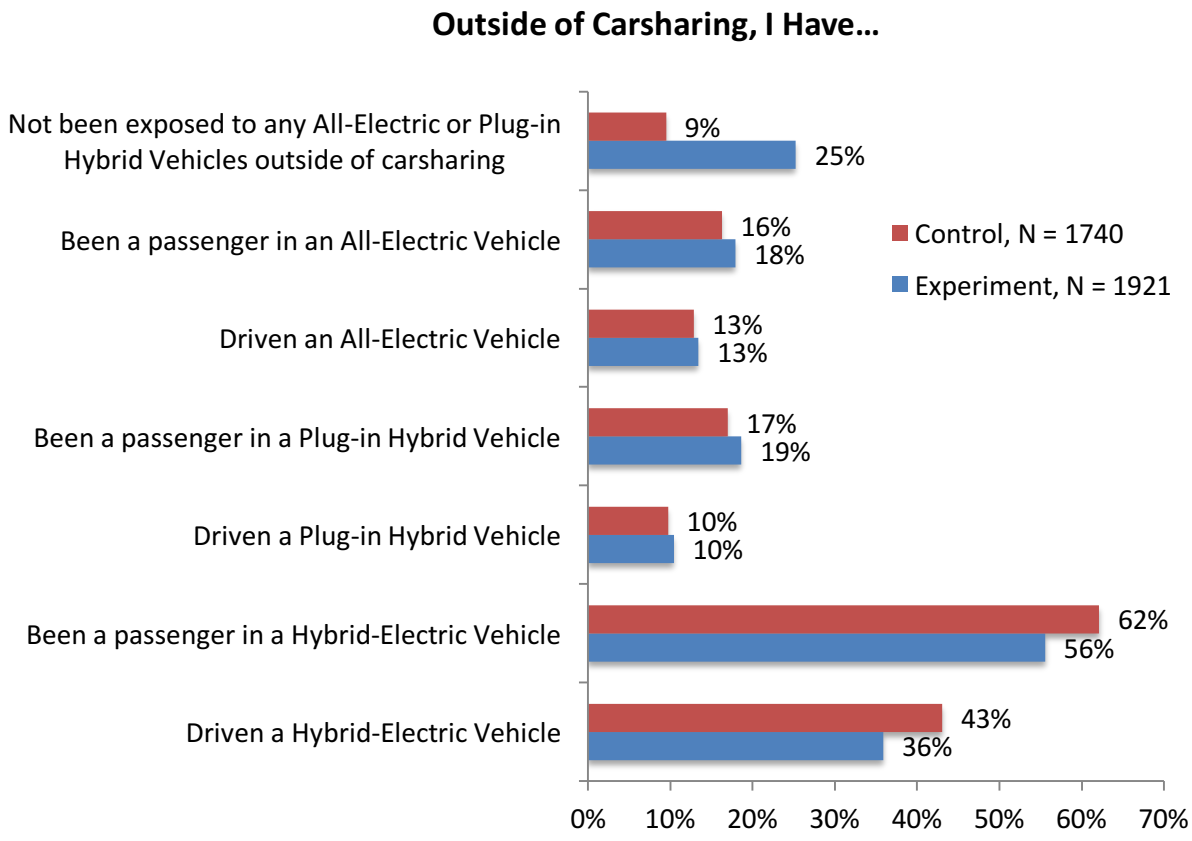


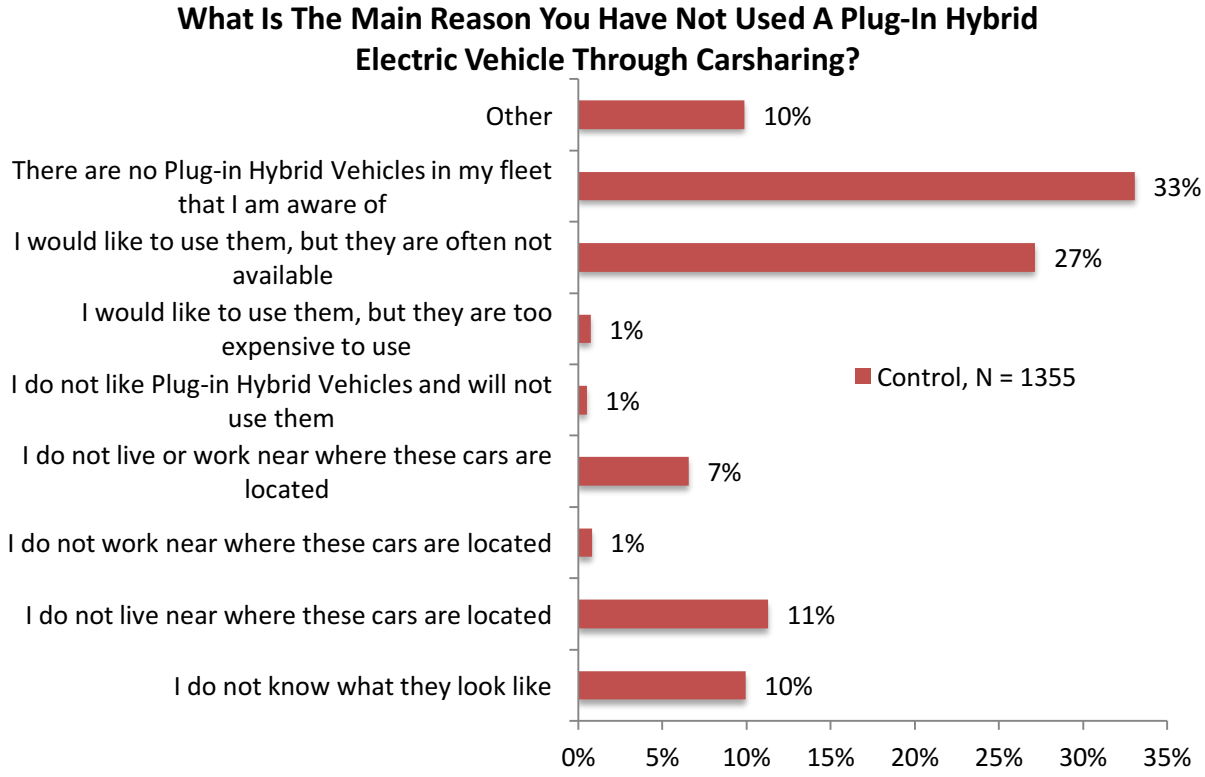
Figure 2 shows that for about one-fourth of the experimental population, carsharing has been the sole method of PHV and EV exposure. While this means that three-fourths of the experimental respondents have in some way been exposed to such vehicles, Figure 2 also shows that outside of carsharing use, respondents are more likely to be passengers in these vehicles (e.g., traveling in a friend's car) rather than drivers.

Figure 2: Exposure to PHVs and EVs Outside of Carsharing



The data suggest that a key reason that members of the control group have not yet used a PHV or EV in a carsharing fleet is related to vehicle access.

Figure 3: Reasons for Not Using a Plug-In Hybrid (PHV) or Electric Vehicle (EV)



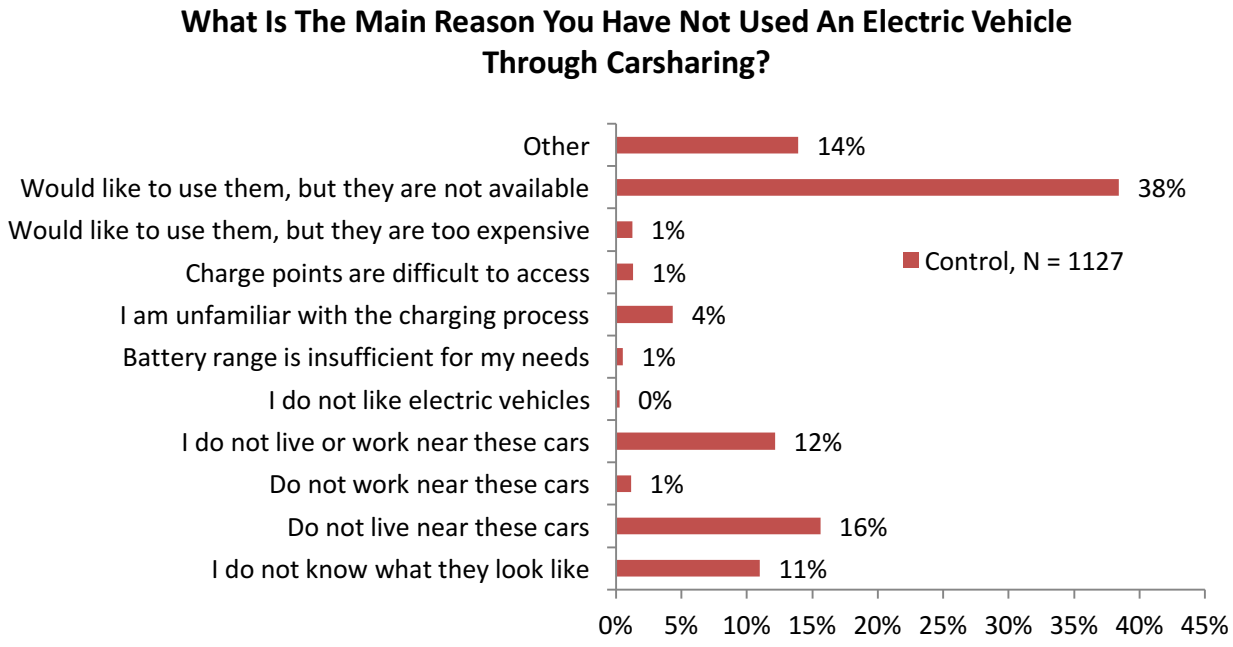


Figure 3 shows that limited availability or access to PHVs accounts for at least 79% of the control group's reason for having not yet used a PHV through their carsharing operator. Nineteen percent of the control group stated that their work and/or residence location prevented them from accessing PHVs; 27% have limited availability; and 33% said that they were not in the fleet. **This suggests that the primary reason that members of the control group do not use EVs and PHVs is due to lack of access and exposure versus a self-selection away from these vehicles. Only 2% of the same stated that they did not like these vehicles or that they were too expensive.**

DEMOGRAPHICS AND MARKET PENETRATION

Carsharing appears to be exposing more women as well as younger individuals to PHVs/EVs relative to the traditional demographic profile of PHV/EV owners. A May 2013 survey sponsored by the California Air Resources Board of owners of PHVs found that 79% of the respondents were male and 71% were over the age of 45 (CCSE, 2014). In contrast, the TSRC survey of PHV/EV carsharing users found that only 59% of respondents were male, and 18% were over the age of 45. This shows a 20% greater representation of women using PHV and EVs in carsharing, as well as a greater proportion of younger people. **In fact, only 6% of the owners surveyed in the May 2013 study were between 25 and 34 years of age, whereas this age group made up 50% of the experimental respondents in the TSRC PHV/EV carsharing survey (CCSE, 2014).** These comparisons between the two surveys are outlined in Table 3 below. **The greater exposure by younger members is notable, as this could accelerate the acceptance of PHV/EV technology across this population and among future vehicle buyers.** Those between the ages of 25 and 34 are likely to purchase their first vehicle within those years and so having greater favorability toward zero-emission vehicles could lead to a shift in the purchasing patterns of today's younger generation.

Table 3: Comparison of Demographics Between California PHV Owners and PHV/EV Carsharing Users

Respondent Category	CCSE 2013 Survey	TSRC 2014-2015 Survey
Ages 65 and over	12%	<1%
Ages 55 – 64	25%	6%
Ages 45 – 54	34%	12%
Ages 35 – 44	23%	26%
Ages 25 – 34	6%	50%
Ages 18 – 24	<1%	4%
Males	79%	59%
Females	21%	41%

Figure 4 and Figure 5 demonstrate that exposure to PHVs and EVs in carsharing fleets are having a positive impact toward user desires to own such vehicles in the future. **The desire to own these vehicles is either greater or much greater for more than 40% of those that used these vehicles through carsharing (i.e., the experimental respondents). Reasons for this change in inclination vary including**

enjoyment of driving the vehicles themselves, greater appreciation of the emission benefits, and better understanding of the vehicle range. Less than 5% of the experimental respondents felt less inclined to own zero- or low-emission vehicles after carsharing use. The two most common reasons given among this subsample were concerns regarding vehicle range, as well as not enjoying driving the vehicle.

Figure 4: Impact of Exposure to PHVs on Desire to Own These Vehicles

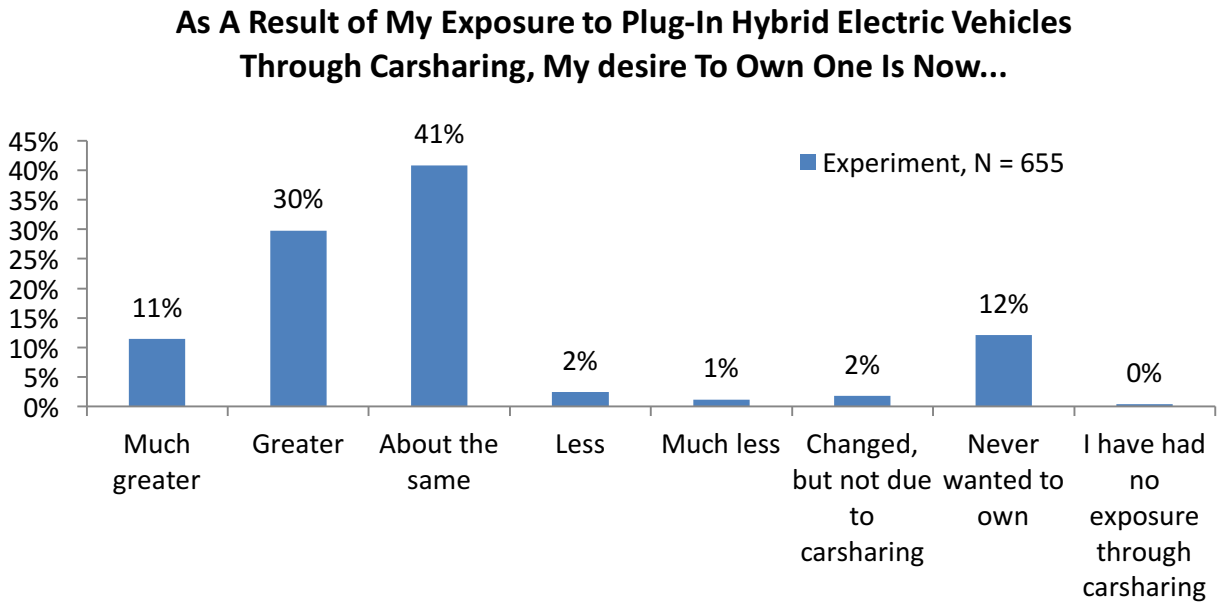
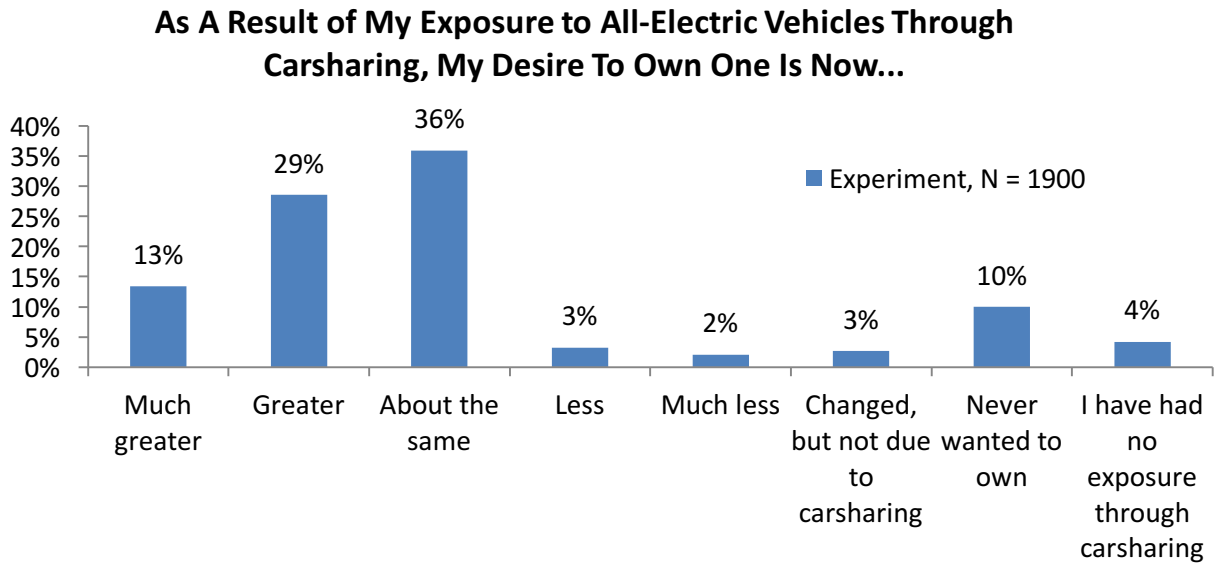
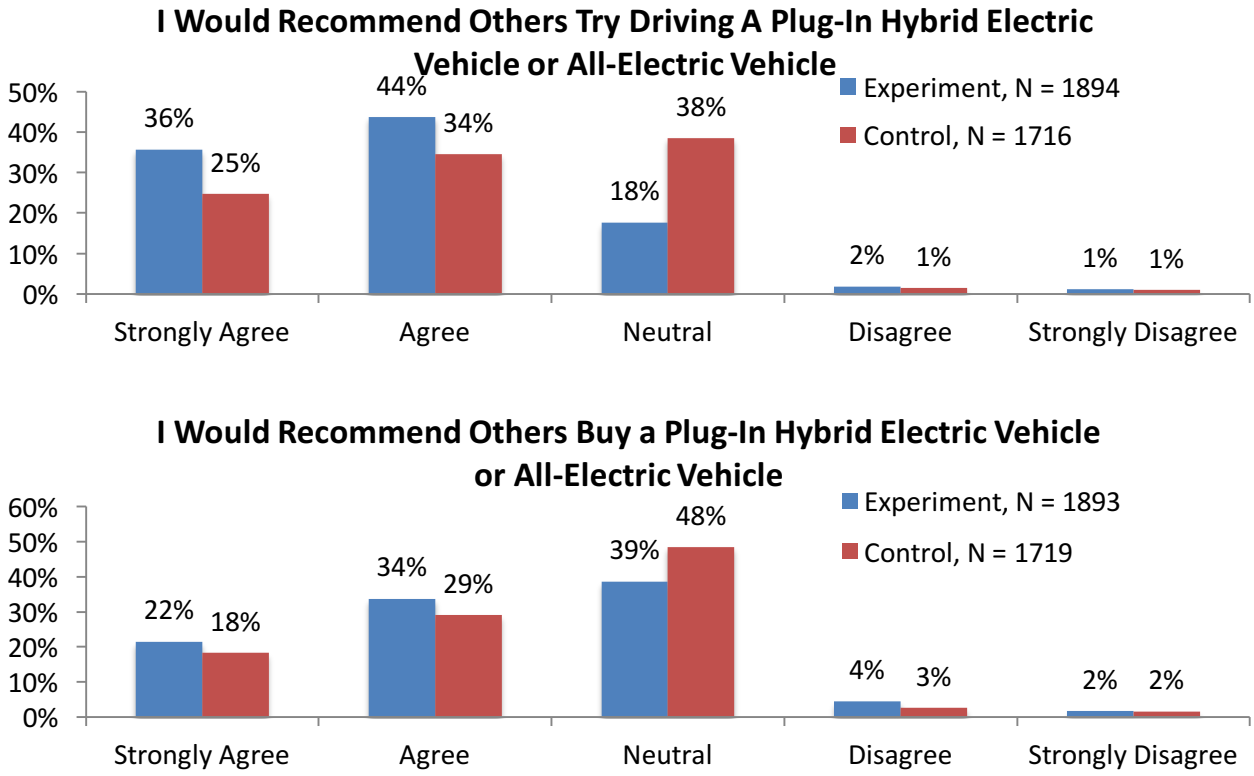


Figure 5: Impact of Exposure to EVs on Desire to Own These Vehicles



Not only is exposure to low- and zero-emission vehicles in carsharing making users more inclined to own such vehicles, the data show that this exposure is also making them more likely to recommend to others to buy or at least try driving these vehicles**. In Figure 6, buying a PHV/EV would be recommended by 56% of the experimental group and by 47% of the control group.** While very few respondents of the experimental group (3%) and control group (2%) indicated they would not recommend driving these vehicles, the control group was found to be less likely to recommend these vehicles for driving (59% would recommend in control group versus 80% in experimental) and more likely to feel indifferent about them (38% neutral in control group versus 18% in experimental). This propensity among the experimental group to be more likely to recommend both driving and buying these vehicles is statistically significant. **This suggests an impact of carsharing on advancing the broader market for these vehicles, as those exposed to PHV and EV vehicles may play an influencer role among their own social circles in spreading the use of these vehicles.** Exposure through carsharing seems to increase the number of people who would be willing to play that role.

Figure 6: Distribution of Recommendations to Driving or Buying PHEV or EV vehicles



It is important to note that the control respondents appear to view PHV/EVs favorably even though they had not used these vehicles in their respective carsharing fleets. Indeed, 91% of the control group had been exposed to PHV/EVs outside of carsharing (e.g., riding in a vehicle with a friend). This result may also be due to the growing acceptance of ZEVs, especially among individuals who choose to join

carsharing programs. The visibility of PHV/EVs in vehicle fleets could also be playing a role in perceptions even if the control group respondents do not use these vehicles.

Tables 4 and 5 show the effect that greater frequency of ZEV use has on opinions toward ZEVs and on the desire to own them. Respondents were specifically asked how often they use PHVs and EVs, respectively, and were given the following options: never, less than once a month, once a month, twice a month, and one through seven times a week. They were then asked how their exposure to PHVs and EVs had affected their perceptions toward these respective vehicle types. **The above tables show that the more frequent users of PHV/EVs (i.e., those that used the vehicles more than once a month) had an improved opinion of ZEVs as well as a greater desire to own ZEVs.** In Table 4, there is a positive shift of 16% and 17% toward an improved or greatly improved opinion of PHVs and EVs, respectively, between low and high frequency users. Similarly, Table 5 shows a 19% and 14% increase in those with a greater or much greater desire to own PHVs and EVs, respectively, between low and high frequency users. These shifts are statistically significant.

Table 4: Cross-Tabulation of ZEV Use Frequency with Change in Opinion of ZEVs

			How has your exposure to PHV/EVs through carsharing changed your opinion of them?					
Type of ZEV	**N**	**Frequency of ZEV use**	It has greatly improved	It has improved	My opinion has not changed	It has gotten worse	It has gotten much worse	Not applicable
PHV	395	Once a month or less	10%	45%	38%	3%	1%	4%
	87	More than once a month	28%	44%	24%	2%	1%	1%
EV	926	Once a month or less	14%	43%	33%	7%	2%	1%
	568	More than once a month	24%	50%	21%	3%	1%	1%

Table 5: Cross-Tabulation of ZEV Use Frequency with Change in Desire to Own a ZEV

			As a result of my exposure to PHV/EVs through carsharing, my desire to own a PHV/EV in the future is now…							
Type of ZEV	**N**	**Frequency of ZEV use**	Much greater	Greater	About the same	Less	Much less	Desire has changed, not due to carsharing.	Did not want to own before or now.	Have not been exposed through carsharing
PHV	282	Once a month or less	10%	29%	42%	2%	1%	3%	11%	1%
	73	More than once a month	18%	40%	29%	3%	0%	1%	10%	0%
EV	924	Once a month or less	12%	29%	36%	5%	3%	4%	10%	1%
	570	More than once a month	20%	35%	31%	2%	1%	2%	9%	1%

Figure 7 and Figure 8 show that exposure to PHVs/EVs in carsharing is also having an impact on vehicle purchasing decisions. Figure 7 shows the type of car that respondents expected to buy before the survey, while Figure 8 shows the type of vehicle that respondents next expected to buy at the time of the survey. Figure 7 shows that 5% of the experimental group and 7% of the control group expected to buy a PHV or EV before joining carsharing. **Figure 8 shows that 17% of the experimental group and 12% of the control group expected to buy a PHV or EV next.** The share of the experimental group interested in these vehicles increased by 12 percentage points (a statistically significant increase over the control group), while the share of the control group increased by five percentage points. Some of this movement in both groups is the result of time, as the market for these vehicles has grown, and the costs of ZEVs have declined. But Figure 7 and Figure 8 notably show that the experimental group had a slightly lower share of respondents interested in these vehicles before carsharing as compared to the control group and a modestly higher share after carsharing exposure. This difference between the control and experimental groups in movement shows the unique impact of PHV and EV exposure through carsharing. To summarize, exposure to PHV/EVs in carsharing is causing a visible shift toward these vehicle types with respect to planned vehicle purchases.

Figure 7: Vehicle Purchase Expectations Before Carsharing

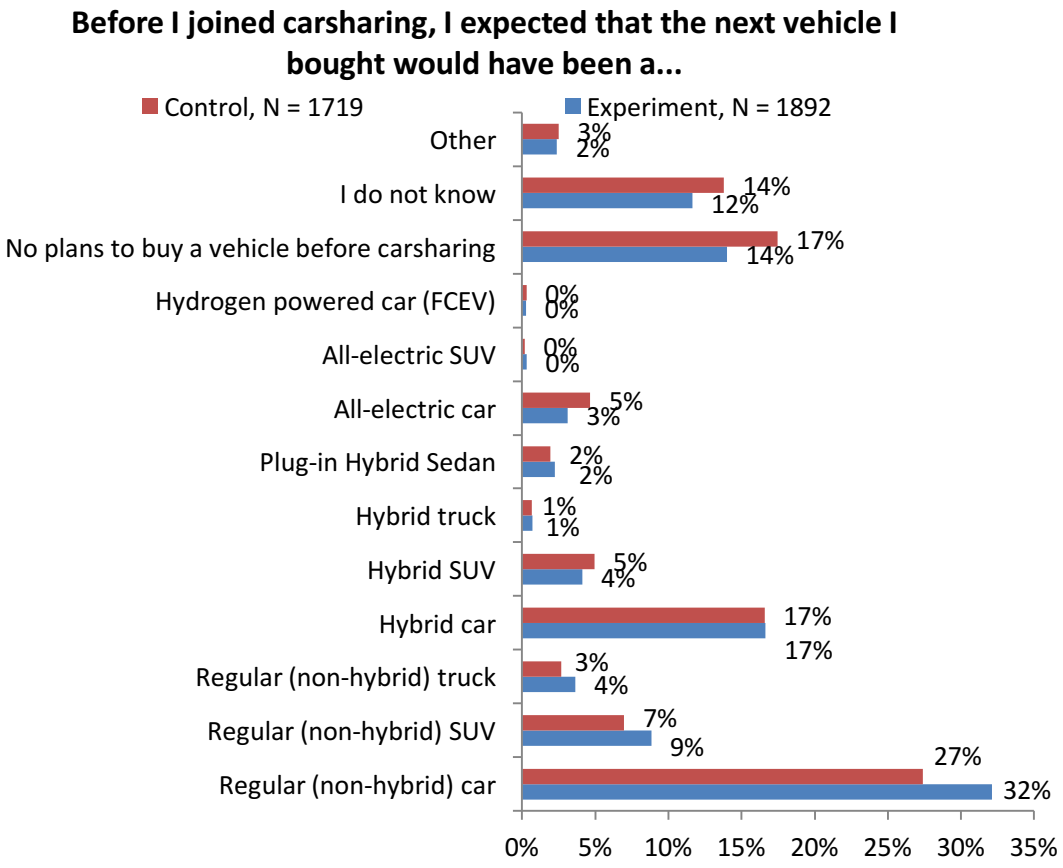


Figure 8: Vehicle Purchase Expectations with Carsharing

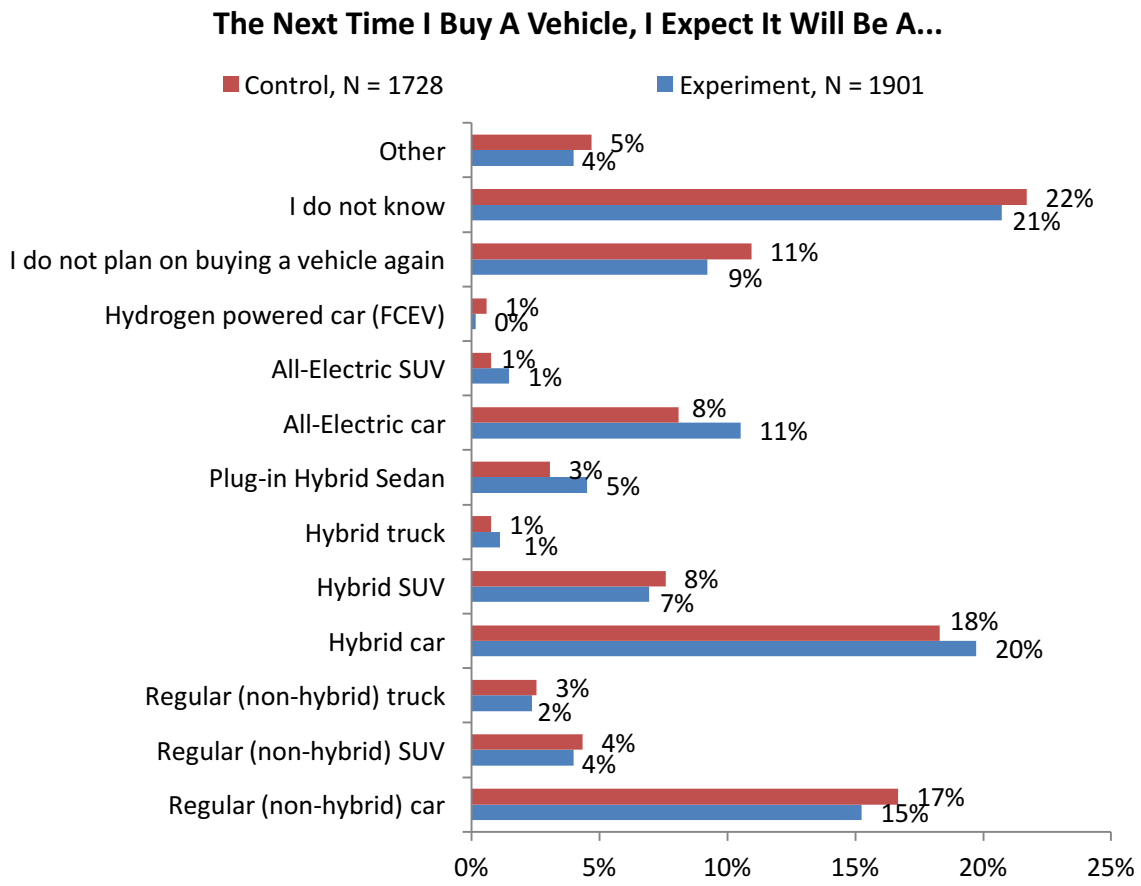
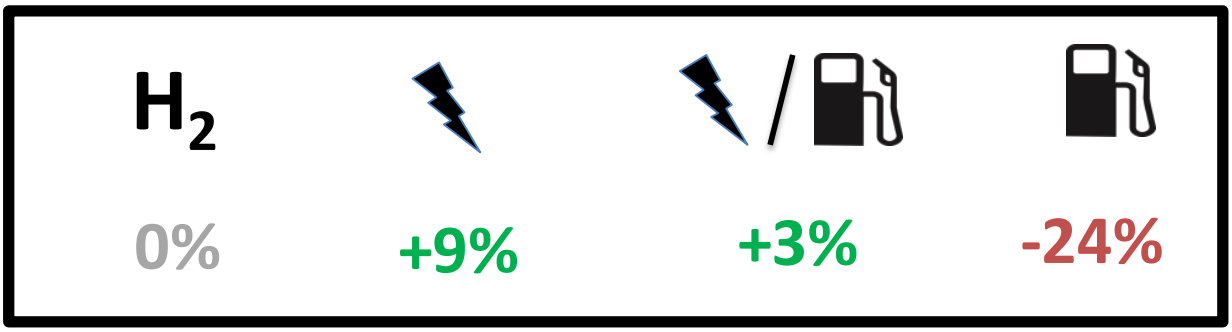


Figure 9 shows a simplified breakdown in the shift occurring among the experimental population. Notably, the favorable shift toward EVs is six percentage points greater than the shift toward plug-in hybrid sedans. Also, it is important to note the effect that PHV/EV carsharing has had on user likelihood of acquiring a regular (non-hybrid) vehicle; there is a sharp drop of 24% in this category, demonstrating a shift toward more sustainable vehicle purchases by ZEV carsharing users.

Figure 9: Changes in Percent of Experimental Population Expecting to Purchase Various Vehicles After EV Carsharing Exposure



CONCLUSION

The data from these surveys generally suggest that carsharing programs with PHVs and EVs within their fleets play a role in promoting greater adoption of these technologies. This is in addition to the other favorable impacts of carsharing explained in the introduction, such as facilitating reduced vehicle ownership and overall driving. In light of current model availability and EV costs, these programs provide exposure to a demographic that otherwise has a lower propensity to own such vehicles. The result of this access is an improved impression of ZEVs and a stronger affinity toward ZEV technology. This is apparent from key survey responses as well as side-by-side comparisons to carsharing users who have not been exposed to these vehicles. The presence of the control survey results are notable—91% of the control population had been exposed to gasoline-electric hybrids, PHVs, and EVs outside of carsharing, but the greater impact on perceptions toward PHVs and EVs was seen in the experimental population. This demonstrates that use of these vehicles through carsharing has had a distinct impact.

On a long-term basis, carsharing programs could act as gateways to improving market penetration of PHVs and EVs. Carsharing members exposed to these vehicles are also likely to recommend them to peers and assist in breaking down misconceptions that may exist among current nonusers (e.g., limited range concerns). Thus, carsharing programs that include low- and zero-emission vehicles in their fleets could be a valuable tool in diffusing these technologies to other population segments. These study results suggest that the California Air Resources Board consider incentivizing the placement of PHVs and EVs in carsharing fleets via the ZEV transportation system credit structure beyond 2018.

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