
# FINAL REPORT

# Electric Vehicle Ownership Factors, Preferred Safety Technologies and Commuting Behavior in the United States

Date: February 2017

Z. Andrew Farkas, Ph.D., Morgan State University
Hyeon-Shic Shin, Ph.D., Morgan State University
Seyedehsan Dadvar, Morgan State University
Jessica Molina, Morgan State University

Prepared by:
Morgan State University
1700 E. Cold Spring Lane
Baltimore, MD 21251
Publication Number:

Prepared for:
Mid-Atlantic Transportation Sustainability University Transportation Center
University of Virginia
Charlottesville, VA 22904

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| **4. Title and Subtitle**<br><br>Electric Vehicle Ownership Factors, Preferred Safety Technologies and Commuting Behavior in the United States – Phase I | | **5. Report Date**<br>February 2017<br><br>**6. Performing Organization Code** |
| **7. Author(s)** Andrew Farkas, Hyeon-Shic Shin | | **8. Performing Organization Report No.** |
| **9. Performing Organization Name and Address**<br><br>Morgan State University<br>1700 E. Cold Spring Lane,<br>Baltimore, MD 21251-0001 | | **10. Work Unit No.**<br><br>**11. Contract or Grant No.**<br>DTRT13-G-UTC33 |
| **12. Sponsoring Agency Name and Address**<br>US Department of Transportation<br>Office of the Secretary-Research<br>UTC Program, RDT-30<br>1200 New Jersey Ave., SE<br>Washington, DC 20590 | | **13. Type of Report and Period Covered**<br><br>Final October 2014-January 2017<br><br>**14. Sponsoring Agency Code** |
| **15. Supplementary Notes** | | |

**16. Abstract**

Electric vehicles (EVs) are expected to reduce climate-changing greenhouse gas emissions, potentially reduce the ground-level ozone experienced during summers over the Mid-Atlantic's I-95 Corridor, and possibly reduce dependence on fossil fuels. EVs may also be an agent for diffusion of connected vehicle technologies and the resulting safety benefits. EVs are typically small size and light weight in order to achieve sufficient driving range, perhaps necessitating robust collision avoidance systems to allay fears of small vehicle vulnerability. The objectives of the research are to determine from online surveys applied nationally the factors that contributed to EV ownership and owners' commuting behavior and mode choice and to make recommendations for public investments in support of EV ownership. Research would also discern the expectations of EV owners regarding safety equipment and benefits. This research surveyed registered plug-in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV) owners and internal combustion engine vehicle (ICEV) owners nationwide regarding attitudes toward vehicle purchasing, demand for safety technologies, travel behavior, and mode choice for work trips before and after purchase. Statistical analyses of the survey results revealed that: EV owners are more affluent, older, more environmentally focused white males than ICEV owners; EVs were most popular among Democrats and least among those not interested in politics; Although EVs are generally equipped with more safety technologies than ICEVs, EV owners still care slightly more about safety features for their next vehicle; Owners use EVs for commuting to work, but transit is not a significant mode choice; EV owners have more traditional suburb-to-city and city-to-city commute patterns, while ICEV owners engage in slightly more dispersed trip-making; Among ICEV owners market penetration of EVs continues to be a challenge because of price.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| **17. Key Words** : EV ownership, safety technology, commuting behavior, attitudes toward EV | **18. Distribution Statement**<br>No restrictions. |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 48 | |

**Acknowledgements**

The authors wish to thank Mr. Scott Wilson of the Electric Vehicle Association of Greater Washington, DC, for promoting our EV survey to chapter members and for hosting information about the survey on the organization's website. We noted that there was great interest in our survey among EV owners nationally. EV owners appear to be enthusiastic about their vehicles and we greatly appreciate their responses and comments. We wish to acknowledge the valuable research assistance of Shilpi Bharti, graduate student in City and Regional Planning, and Ms. Nancy Jackson, NTC Editor, for her advice on survey questionnaires' formatting.

TABLE OF CONTENTS



## LIST OF FIGURES

## LIST OF TABLES

# ELECTRIC VEHICLE OWNERSHIP FACTORS, PREFERRED SAFETY TECHNOLOGIES AND COMMUTING BEHAVIOR IN THE UNITED STATES


## ABSTRACT

Electric vehicles (EVs) are expected to reduce climate-changing greenhouse gas emissions, potentially reduce the ground-level ozone experienced during summers over the Mid-Atlantic's I-95 Corridor, and possibly reduce dependence on fossil fuels. EVs may also be an agent for diffusion of connected vehicle technologies and the resulting safety benefits. EVs are typically small size and light weight in order to achieve sufficient driving range, perhaps necessitating robust collision avoidance systems to allay fears of small vehicle vulnerability.

The objectives of the research are to determine from online surveys applied nationally the factors that contributed to EV ownership and owners' commuting behavior and mode choice and to make recommendations for public investments in support of EV ownership. Research would also discern the expectations of EV owners regarding safety equipment and benefits.

This research surveyed registered plug-in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV) owners and internal combustion engine vehicle (ICEV) owners nationwide regarding attitudes toward vehicle purchasing, demand for safety technologies, travel behavior, and mode choice for work trips before and after purchase. Two different survey questionnaires were promoted to EV and ICEV owners through online sources, such as craigslist and back page, from May 2015 to February 2016. Statistical analyses of the survey results revealed that:

- EV owners are more affluent, older, more environmentally focused white males than ICEV owners.
- EVs were most popular among Democrats and least among those not interested in politics.
- Although EVs are generally equipped with more safety technologies than ICEVs, EV owners still care slightly more about safety features for their next vehicle.
- Owners use EVs for commuting to work, but transit is not a significant mode choice.
- EV owners have more traditional suburb-to-city and city-to-city commute patterns, while ICEV owners engage in slightly more dispersed trip-making.
- Among ICEV owners market penetration of EVs continues to be a challenge because of price.

Conclusions yielded public policy recommendations for promoting EV market share.


## INTRODUCTION

Electric vehicles (EVs) are expected to reduce climate-changing greenhouse gas emissions, potentially reduce the ground-level ozone experienced during summers over the Mid-Atlantic's I-95 Corridor, and possibly reduce dependence on fossil fuels. A recent study has suggested that EVs by emitting less heat than internal combustion engine vehicles (ICEVs) through their

exhausts could reduce temperatures from the "heat island" effect in urban areas (Li, 2015). EVs may also be an agent for diffusion of connected vehicle technologies and the resulting safety benefits. EVs are typically small size and light weight in order to achieve sufficient driving range, perhaps necessitating robust collision avoidance systems to allay fears of small vehicle vulnerability (Bayless et al., 2012).

The objectives of the research are to determine from online surveys applied nationally the factors that contributed to EV ownership and owners' commuting behavior and mode choice and to make recommendations for public investments in support of EV ownership. Research would also discern the expectations of EV owners regarding safety equipment and benefits.

**LITERATURE REVIEW**

Educational attainment, living in a detached home, and high household income (over $100,000) have been associated with EV purchases in California (Powers, 2014) (Tal & Nicholas, 2013). "Early adopters are generally wealthier, more educated, more comfortable with technology, and have a stronger environmental attitude … (than) the rest of society" (Lane et al., 2014). Individuals who feel strongly about reducing energy consumption and greenhouse gas emissions are more likely to consider purchasing an EV than those who do not (Krupa et al., 2014) (Carley et al., 2012). Verges and Chen, using data from all 50 states, found that the number of public charging facilities, concern for the environment, gasoline and electricity prices, education level, vehicle miles travelled, HOV lane access and the presence of purchase incentives were associated with EV market share in 2013 (2015). In Georgia there are more than 14,000 registered EVs, second only to California; EV owners receive the federal tax credit and (no longer) a state income tax credit up to $5,000 (The Economist). Without these incentives Georgia's GDP would decrease significantly, as vehicle owners purchase more ICEVs and spend more on motor fuels and vehicle maintenance (Keybridge, 2015).

According to a study of gender differences in automobile ownership choices in Toronto, women preferred practicality, safety and roominess in vehicles, while men preferred power and performance (Mohammadian, 2004). Women were also more sensitive to the price of automobiles than were men. A survey of plug-in hybrid electric vehicle (PHEV) acceptance in the U.S. indicated that women had different vehicle preferences, but had similar willingness-to-pay (WTP) for these advanced vehicles (Curtin et al., 2009). Shin et al. also found that men and women had similar WTP for safety technologies in connected vehicles, but women's budgets for vehicle purchase were less (Shin et al., 2015).

Among Japanese early adopters of EVs, women were more excited about purchasing new technologies and more environmentally conscious than men, willing to sacrifice some comfort for the sake of the environment (Radtke, P. et al., 2012). Caperello et al. on the other hand found women more likely to frame their PHEV ownership in practical terms, while men were more likely to frame their PHEV in terms of a research project (2014). Women spoke of their PHEV as a tool to use in their everyday lives. Men elaborated on their explorations of what PHEVs are,

how they work, and how they would like them to improve in range, decrease in price, and increase in style options.

Research has revealed geographic and mode choice patterns to EV ownership. Plotz et al. determined that EV buyers in Germany are middle-aged men living in rural or suburban multi-person households, while urban dwellers are less likely to purchase EVs because of their low vehicle-miles of travel and resulting small fuel-cost savings (2014). Another recent study reviewed the literature on EV use and attitudes in Europe and the U.S. and found that early adopters of EVs are middle aged, mostly men, have high education and income, live near cities and own more than one car (Hjorthol, R., 2013). The review also found that EV owners are for the most part former public transport commuters. Some reasons for this mode change are: availability of employer charging facilities, preferential parking, and access to HOV lanes, which make the EV trip more convenient than using transit.

Tal & Nicholas have found that in the California Bay Area the inner ring of the metropolitan area has a higher ratio of battery electric vehicles (BEVs) to PHEVs, while on the outer ring PHEVs have a higher ratio. This geographic pattern can be correlated with commute distance and income levels (November, 2013). BEVs in general have a smaller commuting range than do PHEVs.

The literature on EV purchasing behavior indicates that older, more affluent and environmentally conscious people have purchased EVs, but financial incentives are important to the decision to purchase. There is an urban orientation to EV ownership probably because of available charging infrastructure and concerns over air quality.

**METHODOLOGY**

This research surveyed registered PHEV and BEV owners and ICEV owners nationwide regarding attitudes toward vehicle purchase, demand for safety technologies, travel behavior, and mode choice for work trips before and after purchase. The ICEV survey also queried owners on their propensity to buy EVs. The research team promoted the two online survey questionnaires to appropriate social networks, such as craigslist and back page, and automobile ownership interest groups. Particular focus was on Leaf, Volt, Tesla and other EV owners. The survey questionnaires informed participants about giving consent and that they could end participation at any time. All information regarding participation in this survey was confidential. Only researchers at Morgan State University collected the survey responses, aggregated the data and conducted analyses. The individual survey responses were not shared with state agencies, insurance companies or other private organizations. The research team used descriptive analyses, cross tabs, ANOVA tests, and factor analysis to analyze the data. Data will be archived and preserved electronically.

The national survey results and statistical analyses of data yielded policy recommendations for promotion of EV purchases and attendant technologies and investment in public infrastructure.

The surveys and subsequent analyses could be a model for incorporating such data into state and local transportation planning processes.

**EV/ICEV Surveys**

The two online surveys were designed in Google Forms: the survey of EV owners (Figure 1) and the survey of internal combustion engine vehicle (ICEV) owners (Figure 2). The objectives of the surveys are two-fold. First, to identify socioeconomic characteristics, travel behaviors, and preferences of EV and ICEV owners. Second, to explore through comparative analysis based on descriptive and inferential statistics EV owners' characteristics distinguished from those of ICEV owners. Participants were asked about socioeconomic characteristics, vehicle features, current technology use, travel attributes, and preferences (see appendix).

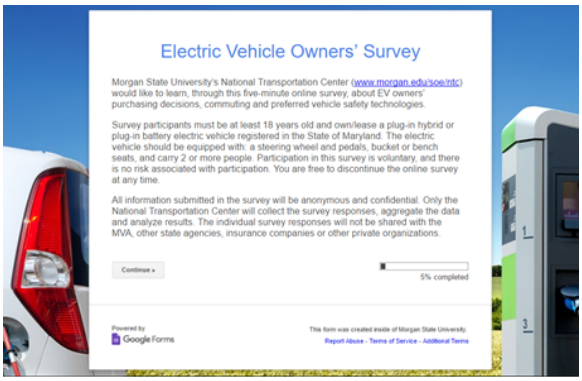



**Figure 1. EV Owner Survey**

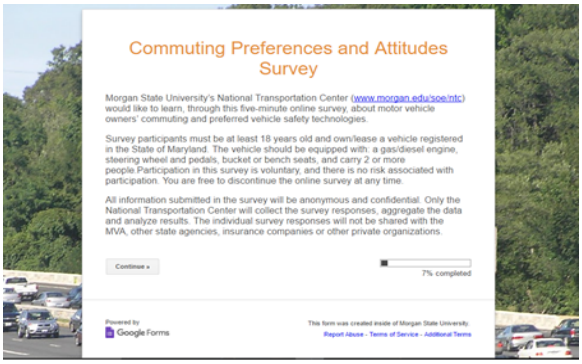



**Figure 2. ICEV Owner Survey**

The EV survey was administered from May 28, 2015, to February 19, 2016, and the ICEV survey from June 2, 2015, to January 17, 2016. Survey participants were recruited across the United States; responses from abroad were excluded.

The surveys were distributed via multiple venues in order to increase the number of participants. Given the difficulty in drawing a random sample, which is typical for online surveys, this was the best non-random sampling method (Trochim and Donnelly 2007). Researchers collected a total of 1,190 responses. Unfortunately, the response rate is not available, since Google Form does not provide the number of individuals who accessed the survey. Further data cleaning removed 63 incomplete responses; 1,127 usable surveys (379 EV responses and 748 ICEV responses) remained for analysis (Table 1).

**Table 1. Collected Surveys by Websites**

| Website | EV Responses | ICEV Responses | Total |
|---|---|---|---|
| Administration | 24 | 31 | 55 |
| Backpage | 0 | 4 | 4 |
| Craigslist | 0 | 691 | 691 |
| EVADC | 54 | 0 | 54 |
| EV Forums | 301 | 0 | 301 |
| ICEV Forums | 0 | 22 | 22 |
| Total | 379 | 748 | 1127 |

Note:

- Admin: Contacts and Facebook of National Transportation Center, Morgan State University
- Backpage: Free classified website (www.backpage.com)
- Craigslist: Free classified website (www.craigslist.org)
- EVADEC: Electric Vehicle Association of Greater Washington
- EV Forums: Various EV forums[1]
- ICEV Forums: Southern Maryland Community Forums (http://forums.somd.com)

## Survey Results

### Socioeconomic and Household Characteristics

This section summarized 10 questions that asked participants' socioeconomic and household characteristics. Marketing and behavioral economics research has found consumers' socioeconomic characteristics as predictors of new technology (Curtin, Shrago and Mikkelsen 2009, Shin, Callow, et al. 2015).

Socioeconomic characteristics are presented in Table 2. The table provides responses of EV and ICEV surveys for comparison. Also provided was the Census data to examine the representativeness of the collected information. Some of the variables appeared representative of the national data, while the majority was less representative. These results were not surprising; the study focused on drivers of EV or ICEV, not the general public. However, data sets of EV and ICEV owners' characteristics were not publicly available. Thus, a reliable test of data representativeness could not be performed.

[1] Speak EV (https://speakev.com); Electric Cars (https://electricforum.com): Tesla Motors Club (https://teslamotorsclub.com/tmc/); My Nissan Leaf (http://mynissanleaf.com); Nissan Infiniti Car Owners (http://forums.nicoclub.com); GM Volt (http://gm-volt.com); Chevy Volt Forum – Forums and Owners Club (http://www.voltforumz.com); My Chevy Spark EV (http://www.mychevysparkev.com); and My Kia Soul EV (http://www.mykiasoulev.com).

*Socioeconomic Characteristics*

Table 2 shows six individual characteristics. The graphical representation of each characteristic is presented in Figure 3. Two interesting observations are discussed below. First, males dominated among EV participants: 91.6% male vs 8.4% female. Among ICEV survey participants the genders were nearly in balance (male – 48.3% and female – 51.7%) and close to the national averages. Such a significant difference might come from the gender differences in adopting new technologies, risk-averse behavior, and financial resources (Shin, Callow, et al. 2015, Shin, Farkas, et al. 2014, Vrkljan and Anaby 2011, Croson and Gneezy 2009). A study of preferences of willingness-to-pay for connected vehicle (CV) technology (Shin, Callow, et al. 2015, Shin, Farkas, et al. 2014) provided explanations about such gender differences with new technologies. The study of connected vehicles found that women were less involved in advanced technology purchasing decisions. In addition, males considered social status when making car purchasing decisions. EV owners are older and more likely married or in domestic relationships, and have higher educational attainment than their ICEV counterparts. Over 80% of the EV respondents were 40 or older, compared to 62.5% of the ICEV respondents. Finally, nearly 77% of EV participants had bachelor's degrees or higher, while about 50% of ICEV participants did.

*Household Characteristics*

Household characteristics of participants are presented in Table 3. A chart of each variable is shown in Figure 4. First, EV owners had higher household income than ICEV owners. Approximately 20.1% of ICEV owners' household income was more than $100,000, similar to the national data (23.5%). The same income group of EV owners was more than three times larger than for ICEV owners: Just over 66% of EV owners' households made at least $100,000 annually. Second, the EV owners' average household size was larger, compared to ICEV owners. About 90% of EV survey participants had a household size over two and the average was about 2.6. On the other hand, the proportion of at least two-person households for ICEV respondents was 25%. Third, EV households living with children under 18 were larger by roughly 8% than ICEV households (33.1% vs 25%). Last, approximately 93.1% of EV owner households owned more than two vehicles, which is about 27% higher than ICEV owners. In addition, the average number of vehicles per EV households was much higher than the national average (2.6 vs 1.9).

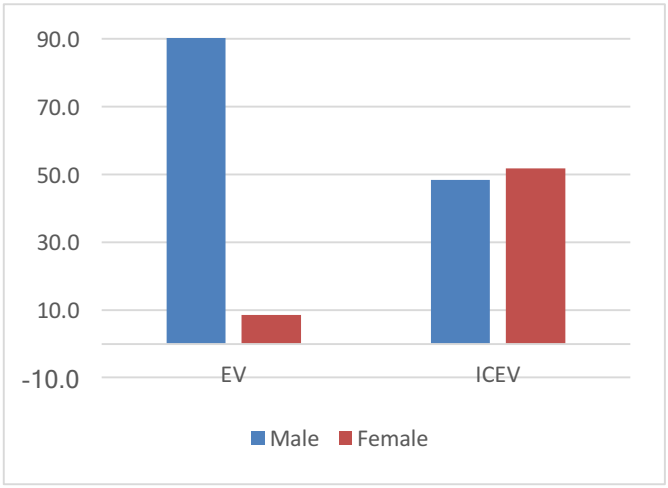
**Table 2. Socioeconomic Characteristics**

| Questions | | EV | | ICEV | | U.S. | |
|---|---|---|---|---|---|---|---|
| | | Count | (%) | Count | (%) | Count | (%) |
| Gender [1] (EV *N* = 379) (ICEV *N* = 748) | Male | 347 | 91.6 | 361 | 48.3 | 155,734,280 | 49.2 |
| | Female | 32 | 8.4 | 387 | 51.7 | 160,780,741 | 50.8 |
| Age over 18 [1] (EV *N* = 378) (ICEV *N* = 738) | <20 | 3 | 0.8 | 10 | 1.4 | 8,764,442 | 3.6 |
| | 20 - 24 | 1 | 0.3 | 71 | 9.6 | 22,604,232 | 9.3 |
| | 25 - 29 | 11 | 2.9 | 95 | 12.9 | 21,698,010 | 8.9 |
| | 30 - 39 | 56 | 14.8 | 111 | 15.0 | 41,039,421 | 16.9 |
| | 40 - 49 | 93 | 24.6 | 110 | 14.9 | 42,166,496 | 17.4 |
| | 50 - 59 | 109 | 28.8 | 177 | 24.0 | 43,527,437 | 17.9 |
| | 60 - 69 | 87 | 23.0 | 140 | 19.0 | 32,963,127 | 13.6 |
| | 70 + | 18 | 4.8 | 34 | 4.6 | 30,068,031 | 12.4 |
| Marital Status (EV *N* = 379) (ICEV *N* = 748) | Single | 65 | 17.2 | 353.0 | 47.5 | 132,361,248 | 51.8 |
| | Married or in domestic partnership | 314 | 82.8 | 390.0 | 52.5 | 123,059,987 | 48.2 |
| Race/Ethnicity [1] (EV *N* = 342) (ICEV *N* = 698) | White Alone | 298 | 87.1 | 565 | 80.9 | 157,100,990 | 67.9 |
| | Hispanic | 8 | 2.3 | 29 | 4.2 | 33,346,703 | 14.4 |
| | Black or African-American | 9 | 2.6 | 54 | 7.7 | 27,323,665 | 11.8 |
| | Asian | 21 | 6.1 | 20 | 2.9 | 11,288,995 | 4.9 |
| | American Indian/Alaska Native | 0 | 0.0 | 7 | 1.0 | 1,599,777 | 0.7 |
| | Native Hawaiian/Other Pacific Islander | 1 | 0.3 | 0 | 0.0 | 345,986 | 0.1 |
| | Other | 5 | 1.5 | 23 | 3.3 | 381,045 | 0.2 |
| Educational Attainment (EV *N* = 379) (ICEV *N* = 746) | Some high school | 3 | 0.8 | 13 | 1.7 | 4,426,790 | 3.7 |
| | High school diploma or GED | 46 | 12.1 | 192 | 25.7 | 4,194,315 | 3.5 |
| | Associate's degree | 36 | 9.5 | 174 | 23.3 | 22,398,437 | 18.5 |
| | Bachelor's degree | 156 | 41.2 | 228 | 30.6 | 24,747,846 | 20.5 |
| | Master's degree | 88 | 23.2 | 102 | 13.7 | 27,745,180 | 23.0 |
| | Doctoral or professional | 50 | 13.2 | 37 | 5.0 | 37,280,561 | 30.9 |
| Political Affiliation [2] (EV *N* = 375) (ICEV *N* = 739) | Democrat | 136 | 36.3 | 233 | 31.5 | na | 30.0 |
| | Republican | 53 | 14.1 | 149 | 20.2 | na | 30.0 |
| | Independent | 127 | 33.9 | 187 | 25.3 | na | 37.0 |
| | Not interested in politics | 59 | 15.7 | 170 | 23.0 | na | 3.0 |

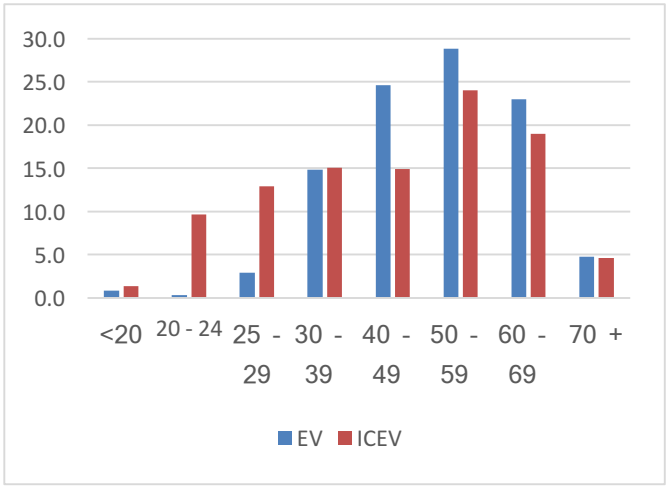
EV *N* – Number of EV survey responses; ICEV *N* – Number of ICEV survey responses

*Notes on the U.S. Data*

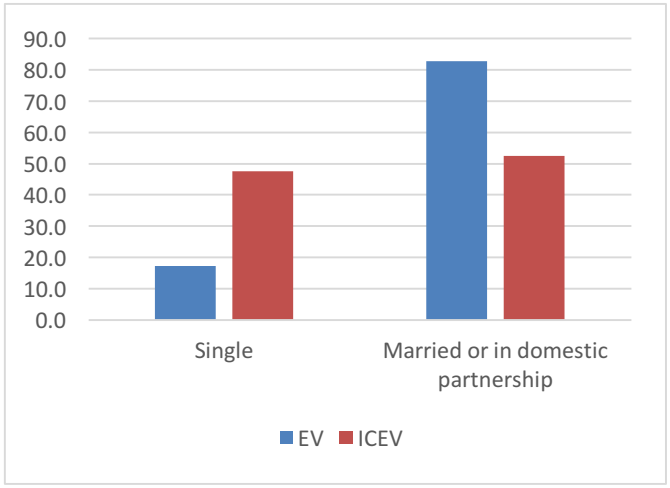
1. 2011-2015 American Community Survey 5 Year Estimates.
2. Gallop. "Party Affiliation," February 3 - 7, http://www.gallup.com/poll/15370/party-affiliation.aspx



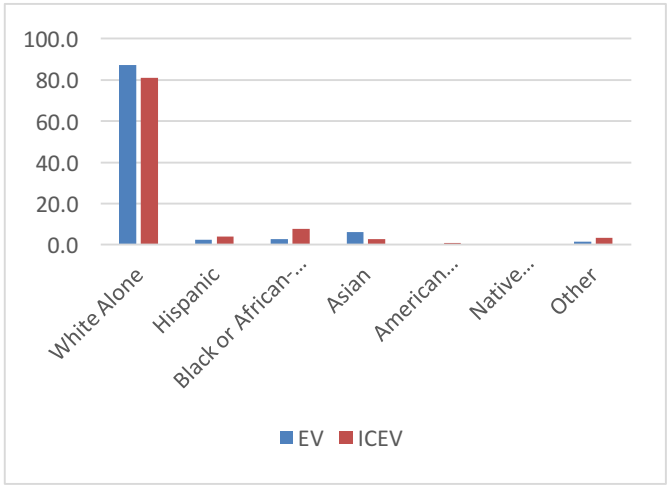

(a) Gender



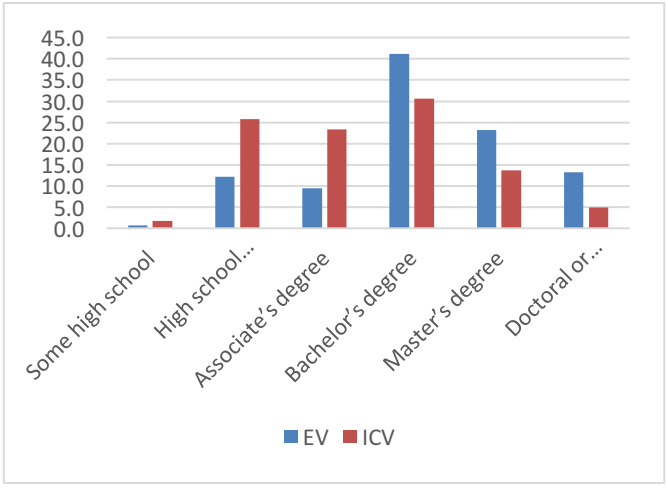

(b) Age



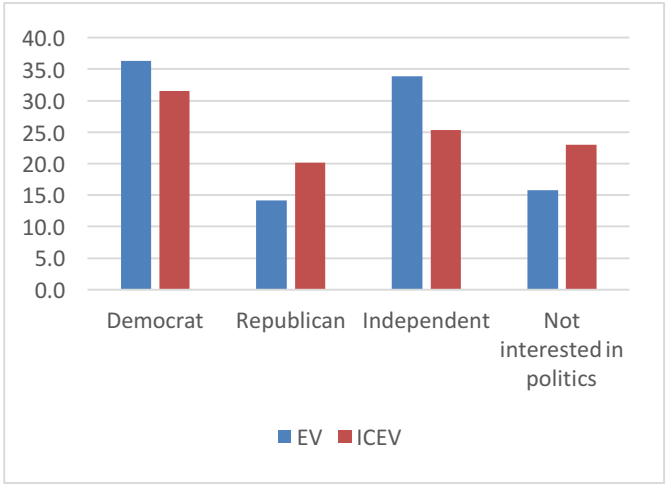

(c) Marital Status




(d) Race/Ethnicity




(e) Educational Attainment




(f) Political Affiliation

**Figure 3. Socioeconomic Characteristics of Survey Participants**

**Table 3. Household Characteristics**

| Questions | | EV | | ICEV | | U.S. | |
|---|---|---|---|---|---|---|---|
| | | Count | (%) | Count | (%) | Count | (%) |
| Annual Household Income (EV *N* = 328) (ICEV *N* = 672) | < $50,000 | 24 | 7.3 | 277 | 41.2 | 54,426,532 | 46.5 |
| | $50,000 – $74,999 | 35 | 10.7 | 165 | 24.6 | 20,827,239 | 17.8 |
| | $75,000 – $99,999 | 52 | 15.9 | 95 | 14.1 | 14,166,538 | 12.1 |
| | $100,000 – $199,999 | 141 | 43.0 | 118 | 17.6 | 21,366,958 | 18.3 |
| | $200,000 + | 76 | 23.2 | 17 | 2.5 | 6,139,038 | 5.3 |
| Household Size[1] (EV *N* = 377) (ICEV *N* = 745) | One | 38 | 10.1 | 557 | 74.8 | 32,316,130 | 27.6 |
| | Two | 163 | 43.2 | 154 | 20.7 | 39,347,586 | 33.7 |
| | Three or more | 176 | 46.7 | 32 | 4.3 | 45,262,589 | 38.7 |
| | Average household size | | 2.6 | | 2.3 | | 2.6 |
| # of Children under 18 [1] (EV *N* = 378) (ICEV *N* = 743) | None | 253 | 66.9 | 557 | 75.0 | 77,743,629 | 66.6 |
| | One or two | 112 | 29.6 | 154 | 20.7 | 30,524,371 | 26.2 |
| | Three or more | 13 | 3.4 | 32 | 4.3 | 8,448,292 | 7.2 |
| Number of Vehicles per Household (EV *N* = 379) (ICEV *N* = 746) | One | 26 | 6.9 | 249 | 33.4 | na | na |
| | Two | 186 | 49.1 | 272 | 36.5 | na | na |
| | Three or more | 167 | 44.1 | 225 | 30.2 | na | na |
| | Average # veh/HH | | 2.6 | | 2.1 | na | 1.9 |

EV *N* – Number of EV survey responses

ICEV *N* – Number of ICEV survey responses

*Notes on the U.S. Data*

1. 2011-2015 American Community Survey 5 Year Estimates.

2. The 2001 National Household Travel Survey, Table A-2: Mean number of drivers, vehicles, and bicycles per household.

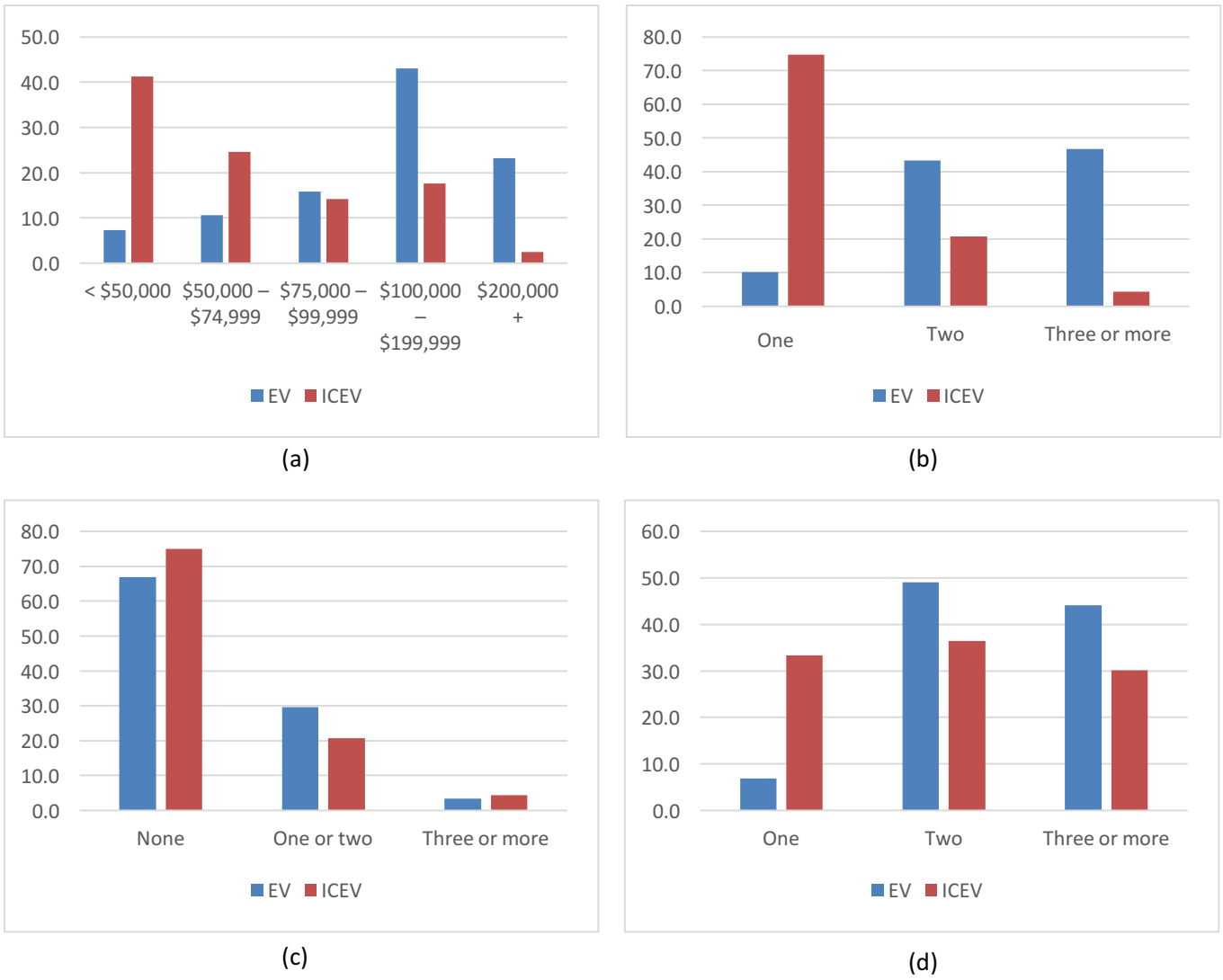



**Figure 4. Household Characteristics**

**Drivers' Preferences for EV/ICEV Purchasing/Leasing Decisions**

Drivers purchase/lease vehicles based on their preferences. However, vehicle purchasing decisions are made in such a way that a buyer considers various alternative bundles within given budget constraints. The following sections discuss the important factors for buying an EV or ICEV, including factors that may affect ICEV drivers' potential EV purchasing decisions. Participants were asked to choose three top reasons that influenced the vehicles they were driving at the time of taking the survey. For ICEV owners, two additional questions were asked. First, they chose three top reasons for considering buying an EV as their next car. Then, those who do not want an EV for their next vehicle purchase had to select three reasons for not purchasing an EV.

EV Owners' Preferences

Survey participants were asked to select the most important three reasons for purchasing/leasing an EV from 11 choices. The result is summarized in Figure 5. Roughly 21.4% of the participants (241 responses) chose *Environmental concerns* as one of the three most important reasons, followed by *Reduction in dependence on petroleum* (19.8% or 223 responses), and *Price of electricity vs gasoline* (17.6% or 198 responses). Only 8.5% of the participants purchased or leased an EV due to *Tax breaks and net price of vehicle.* This is not surprising considering that approximately 66% of EV owner households earned $100,000 or more annually, shown earlier in Figure 4. This income group's ability to buy an EV is much higher than for other income groups. Market penetration of EVs would have been faster if tax incentive programs had been designed to increase EV affordability for lower income groups.

ICEV Owners' Preferences

Figure 6 presents the primary reasons for ICEV owners to choose their current vehicles. *Price of vehicle* was the most decisive factor for owning an ICEV, which was chosen by nearly 22% of the respondents. Nearly similar importance was given to *Reliability of vehicle* (19.5%). The importance of vehicle price for ICEV owners makes sense, considering their household income compared to EV owners (Figure (a)). In contrast to EV owners (21.4%), only 2.1% of the ICEV owners chose *Environmental concerns.* However, ICEV owners' low environmental concerns as a primary purchasing decision factor does not necessarily reveal their real preferences. Instead, this may imply vehicle price is a primary barrier to buying an EV, as they chose *Price of Vehicle* as the first reason to buy an ICEV. Figure 6 shows the important decision preferences for current ICEV owners' future EV purchasing decision. The top three reasons are *Price of electricity vs gasoline* (25.6%), *Environmental concerns* (23.3%), and *Reduction in dependence on petroleum* (17.3%), which were the same as the top three reasons for current EV owners. EV prices as a barrier was pointed out as the first reason not to choose an EV (Figure 6). That said, current incentive policies may need to be revisited.

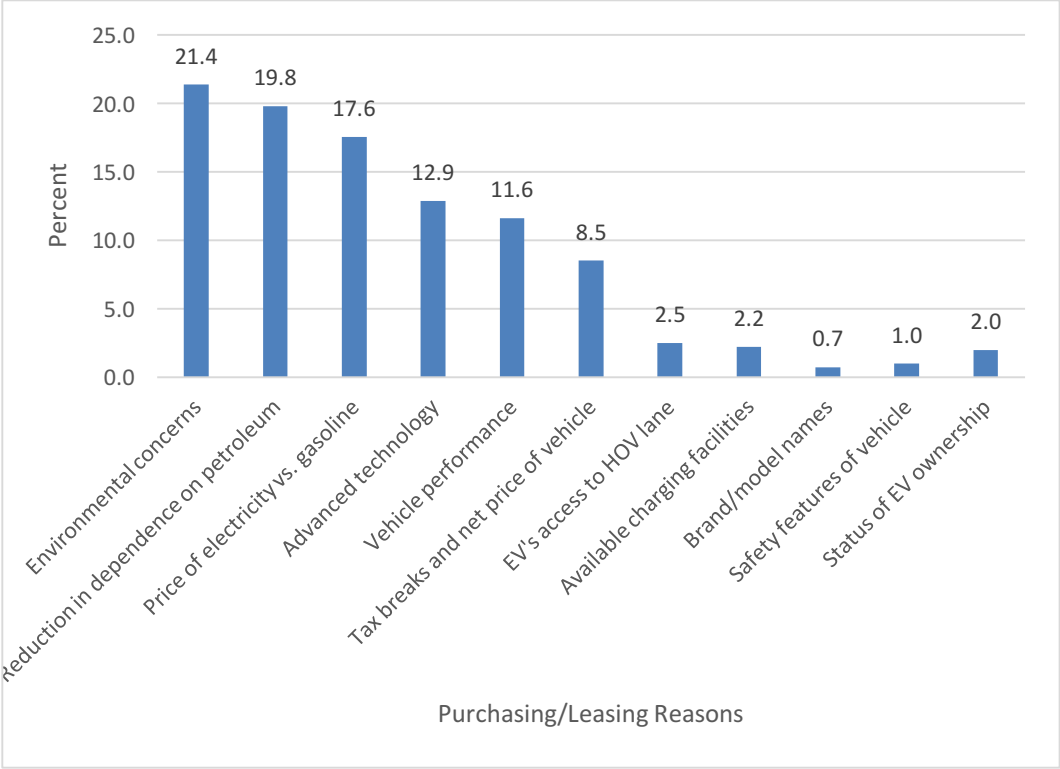



**Figure 5. Reasons for Purchasing/Leasing an EV**

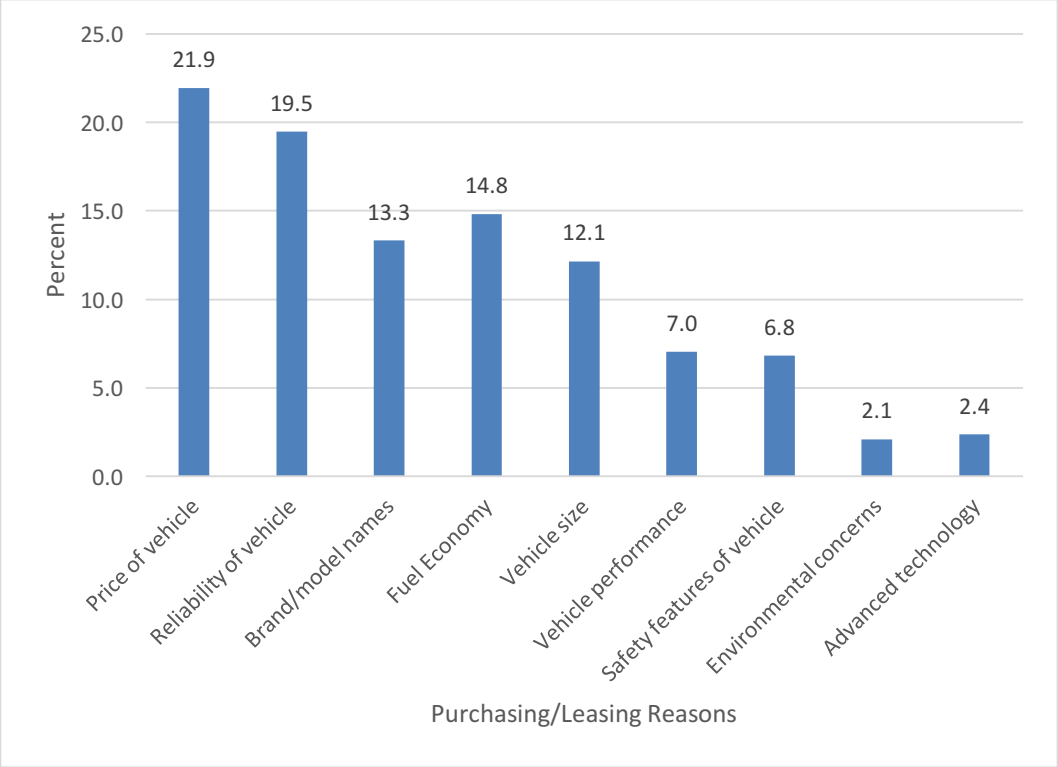



**Figure 6. Reasons for Purchasing/Leasing an ICEV**

## Reasons to Purchase/Lease EV and Political Affiliation

Table 12 shows differences between different political affiliations and purchase or lease of an EV, but the only statistically significant one (99.99%) was the 1st reason ($X(30) = 81.893$, $p = 0.000$), *Environmental concerns*. Democrats were the only affiliation with the highest 1st reason of "*Environmental concerns, e.g., air quality, pollution*"; the first choice of all other affiliations was "*Price of electricity vs. gasoline.*"

**Table 4. Top Three Reasons to Purchase/Lease the EV and Political Affiliation**

| 1st Reason to Purchase/Lease the EV | All | Democrat | Republican | Independent | Not Interested in Politics |
|---|---|---|---|---|---|
| Environmental concerns, e.g., air quality, pollution | 25.99% | 43.70% | 15.09% | 17.46% | 15.25% |
| Reduce dependence on petroleum | 21.22% | 22.96% | 13.21% | 23.81% | 18.64% |
| Price of electricity vs. gasoline | 19.63% | 10.37% | 30.19% | 23.81% | 23.73% |
| Advanced technology | 13.26% | 7.41% | 26.42% | 15.08% | 10.17% |
| Vehicle performance | 9.28% | 5.19% | 7.55% | 13.49% | 8.47% |
| Tax breaks and net price of vehicle | 5.04% | 4.44% | 7.55% | 2.38% | 10.17% |
| Single occupant access to HOV lane | 2.92% | 2.96% | 0.00% | 2.38% | 6.78% |
| Available charging facilities | 1.59% | 2.22% | 0.00% | 0.79% | 3.39% |
| Vehicle make or model | 0.53% | 0.00% | 0.00% | 0.00% | 3.39% |
| Safety features of vehicle | 0.27% | 0.00% | 0.00% | 0.79% | 0.00% |
| Status of EV ownership | 0.27% | 0.74% | 0.00% | 0.00% | 0.00% |
| **2nd Reason to Purchase/Lease the EV** | **All** | **Democrat** | **Republican** | **Independent** | **Not Interested in Politics** |
| Environmental concerns, e.g., air quality, pollution | 22.02% | 25.00% | 17.31% | 22.22% | 16.95% |
| Reduce dependence on petroleum | 20.95% | 27.94% | 17.31% | 18.25% | 13.56% |
| Price of electricity vs. gasoline | 15.12% | 11.76% | 15.38% | 14.29% | 25.42% |
| Advanced technology | 12.20% | 12.50% | 15.38% | 10.32% | 11.86% |
| Vehicle performance | 11.67% | 8.82% | 11.54% | 15.87% | 10.17% |
| Tax breaks and net price of vehicle | 10.88% | 7.35% | 13.46% | 12.70% | 13.56% |
| Available charging facilities | 1.86% | 2.94% | 3.85% | 0.79% | 0.00% |
| Single occupant access to HOV lane | 1.59% | 1.47% | 1.92% | 0.79% | 3.39% |
| Safety features of vehicle | 1.33% | 0.00% | 0.00% | 3.17% | 1.69% |
| Status of EV ownership | 1.33% | 1.47% | 3.85% | 0.00% | 1.69% |
| Vehicle make or model | 1.06% | 0.74% | 0.00% | 1.59% | 1.69% |
| **3rd Reason to Purchase/Lease the EV** | **All** | **Democrat** | **Republican** | **Independent** | **Not Interested in Politics** |
| Price of electricity vs. gasoline | 17.91% | 23.53% | 17.31% | 14.40% | 12.28% |
| Reduce dependence on petroleum | 17.11% | 13.97% | 19.23% | 17.60% | 22.81% |
| Environmental concerns, e.g., air quality, pollution | 16.04% | 13.24% | 7.69% | 21.60% | 19.30% |
| Vehicle performance | 13.90% | 13.97% | 15.38% | 12.80% | 14.04% |
| Advanced technology | 13.10% | 14.71% | 15.38% | 10.40% | 12.28% |
| Tax breaks and net price of vehicle | 9.63% | 11.03% | 7.69% | 11.20% | 5.26% |
| Status of EV ownership | 4.28% | 5.15% | 5.77% | 2.40% | 5.26% |
| Available charging facilities | 3.21% | 1.47% | 3.85% | 4.00% | 5.26% |
| Single occupant access to HOV lane | 2.94% | 2.21% | 7.69% | 2.40% | 1.75% |
| Safety features of vehicle | 1.34% | 0.00% | 0.00% | 2.40% | 1.75% |
| Vehicle make or model | 0.53% | 0.74% | 0.00% | 0.80% | 0.00% |

Notes: Tables are sorted based on "All." "Green" refers to highest percentage and "Red" to the lowest percentage. "No response" to this question was excluded. Four participants did not answer the "Political Affiliation" question.

## EV Charging

This section summarizes vehicle attributes for EV and ICEV owners, as well as ICEV owners' preferred attributes for an EV if they were to buy one.

EV Ownership Types, Range Concerns, and Charging Facilities

Table 5 summarizes EV attributes. The majority of the respondents (68.8%) owned an EV. The EV owners seem to prefer plug-in battery EV to plug-in hybrid EV (66.4% vs 33.6%). EV owners are charging EVs at home more than at work. Ninety-six percent of the participants charged at home and nearly 37% at work. In addition, 85.2% of those who drive an EV to work answered that their main charging location is home. This preference for home as a charging location would be related to a high ownership of a level 2 charger (79.1%). Another speculation would be safety and a longer charging possibility at home. Interestingly, the majority of EV owners do not have concerns or no opinion regarding *Driving Range*.

**Table 5. EV Ownership, Vehicle Types, Range Concerns, and Charging Facilities**

| | | Responses | Percent |
|---|---|---|---|
| Purchase/Lease (*N*=378) | Purchased the EV | 260 | 68.8 |
| | Leased the EV | 118 | 31.2 |
| EV Type (*N*=378) | Plug-in hybrid electric, (e.g., Chevy Volt) | 127 | 33.6 |
| | Plug-in battery electric (e.g., Nissan Leaf) | 251 | 66.4 |
| Charging EV at Home (*N*=378) | Yes | 363 | 96.0 |
| | No | 15 | 4.0 |
| Charging EV at Work (*N*=260) | Yes | 96 | 36.9 |
| | No | 163 | 62.7 |
| | Don't know (Not sure) | 1 | 0.4 |
| Owning Level 2 Charger (*N*=363) | Yes | 287 | 79.1 |
| | No | 76 | 20.9 |
| Main Charging Location (*N*=256) | Home | 218 | 85.2 |
| | Work | 28 | 10.9 |
| | Don't know (Not sure) | 10 | 3.9 |
| | Both | 0 | 0.0 |
| EV Range Concern (*N*=379) | Yes | 55 | 14.5 |
| | No | 205 | 54.1 |
| | No response / Not Applicable | 119 | 31.4 |

ICEV Ownership

Nearly 96% of ICEV drivers owned a vehicle (Table 6), which is much higher than EV drivers (roughly 68% owned an EV). Nearly 60% of the ICEV respondents owned either a coupe or sedan; SUVs accounted for 32%. More specifically, a majority owned a small coupe or sedan (40.7%), followed by a small SUV (22%), large coupe or sedan (17.5%), large SUV (10%), and pickup truck (9.8%).

**Table 6. ICEV Ownership and Vehicle Types**

| | | Responses | Percent |
|---|---|---|---|
| Purchase/Lease (*N*=737) | Purchase | 704 | 95.5 |
| | Lease | 33 | 4.5 |
| Vehicle Type (*N*= 737) | Small coupe or sedan | 300 | 40.7 |
| | Large coupe or sedan | 129 | 17.5 |
| | Small SUV | 162 | 22.0 |
| | Large SUV | 74 | 10.0 |
| | Pickup truck | 72 | 9.8 |

**EV Preferences for ICEV Owners**

Table 7 summarizes EV preferences for ICEV owners. Only 18.6% of ICEV owners are likely to own an EV in the future. However, the likeliness increased when asked whether they will buy an EV if a charging facility is provided at work (36.5%) or rail station (30.9%). It appears not many participants know what types of EVs are available in the market. Only about 11% knew what types of EV they are likely to buy. However, such a low knowledge level is probably due to their low interest in buying an EV, as stated earlier. Another aspect of low acceptance would be low visibility of EVs and/or charging stations. Less than half of the respondents (43.2%) stated they have seen EV charging stations, but those who have never seen one was slightly higher (44.4%). Even more, 12.3% of the ICEV owners did not know what an EV charging facility looks like.

**Table 7. EV Preferences for ICEV Owners**

| | | Responses | Percent |
|---|---|---|---|
| Purchasing EV in Future (*N*=748) | Yes | 139 | 18.6 |
| | No | 604 | 80.7 |
| | No response | 5 | 0.7 |
| EV Type (*N*=772) | Plug-in battery electric (e.g., Nissan Leaf) | 41 | 5.3 |
| | Plug-in hybrid electric (e.g., Chevy Volt) | 43 | 5.6 |
| | Don't know (Not sure) | 79 | 10.2 |
| | No response | 609 | 78.9 |

| | | | |
|---|---|---|---|
| Purchasing EV if charging provided at work (*N*=748) | Yes | 273 | 36.5 |
| | No | 470 | 62.8 |
| | No response | 5 | 0.7 |
| Purchasing EV if charging provided at rail station (*N*=748) | Yes | 231 | 30.9 |
| | No | 512 | 68.4 |
| | No response | 5 | 0.7 |
| Seen public EV charging station (N=*748)* | Yes | 323 | 43.2 |
| | No | 332 | 44.4 |
| | I don't know what an EV charging facility looks like. | 92 | 12.3 |
| | No response | 1 | 0.1 |

## Reasons to Purchase/Lease EV in Future and Political Affiliation

Table summarizes purchase/lease an EV in the near future by political affiliation. Figure 7 also depicts the same information. Democrats (25%) considered purchasing/leasing an EV in the future more than the rest, followed by Independents (23%). Only 14% of Republicans expressed interest in purchasing/leasing an EV in future, and participants who were not interested in politics showed the least interest (11%). The differences were statistically significant at 99.99% (X(3) = 15.683, p = 0.001) and indicated a significant association between purchasing or leasing an EV in the future and political affiliation.

**Table 8. Purchase/Lease an EV in Future by Political Affiliation**

| Political Affiliation | Purchase/Lease an EV in Future | | | |
|---|---|---|---|---|
| | Yes | | No | |
| | # | % | # | % |
| Democrat | 57 | 24.57% | 175 | 75.43% |
| Republican | 20 | 13.51% | 128 | 86.49% |
| Independent | 42 | 22.58% | 144 | 77.42% |
| Not interested in politics | 19 | 11.31% | 149 | 88.69% |
| **All** | **139** | **18.71%** | **604** | **81.29%** |

Notes: "No response" to this question was excluded (5 participants). "All" row includes participants with "No response" to "Political Affiliation" question (9 participants).

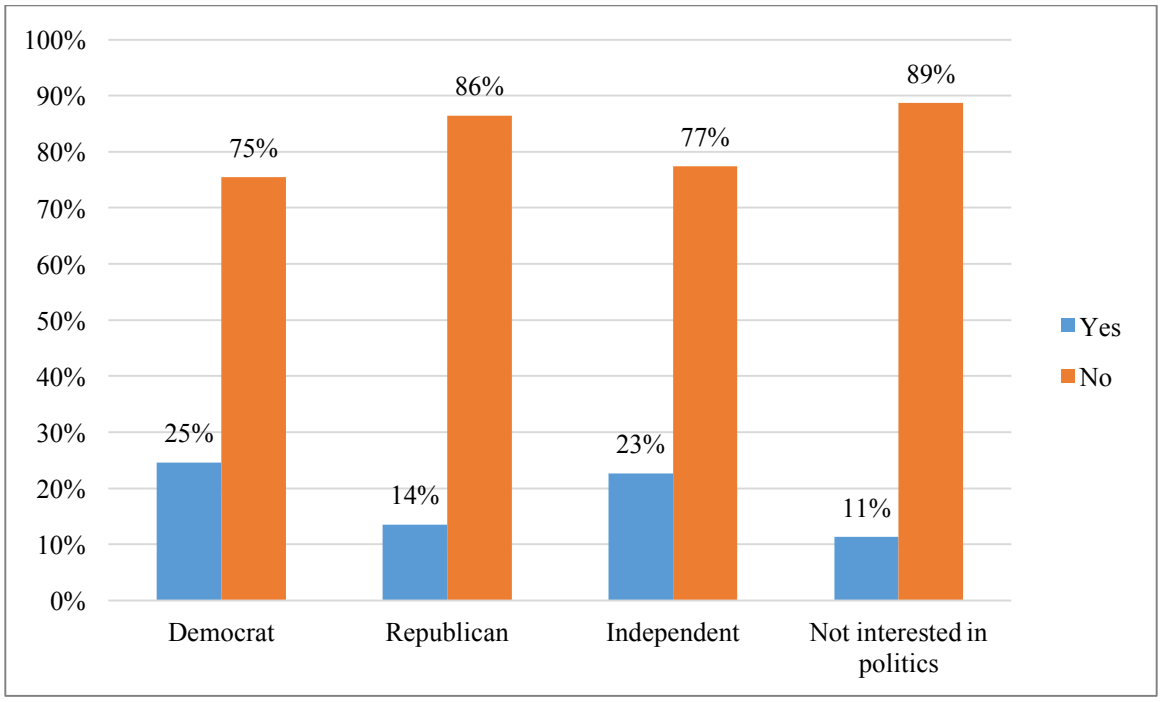



**Figure 7. Purchase/Lease an EV in Future by Political Affiliation**

## Current Technology and Wanted Safety Technology

Current high-technology device adoption is known to have positive associations with early adoption of new innovation (Hauser, Tellis and Griffin 2006, Rogers 2003, Im, Bayus and Mason 2003). A recent study on the acceptance of connected vehicle technology found that such association could be found in vehicle technology preferences and willingness-to-pay (Shin, Callow, et al. 2015). EV and ICEV survey participants were asked to choose their current in-vehicle technology use from the provided list. Their answers and comparison are presented in the following radar chart (Figure 8). The figure shows clear differences in current technology usage between EV and ICEV drivers, indicating a higher adoption of new technology by EV owners. However, the figure should be interpreted carefully because such in-vehicle devices are usually found in high-end vehicles; that is, the current usage of new devices relates closely to income levels. Further analysis should be carried out.

### EV Ownership and Socioeconomic Characteristics

Table 9 summarizes the EV purchase in association with gender for ICEV owners. In terms of purchasing or leasing an EV in the future, no significant association was found, but there were significant associations among the factors that might impact purchase behavior and gender. Women are more likely to buy an EV if charging is provided at work (12% more than men) or at a rail station (9% more than men). The Chi-square test was statistically significant at $\alpha = 0.01$.

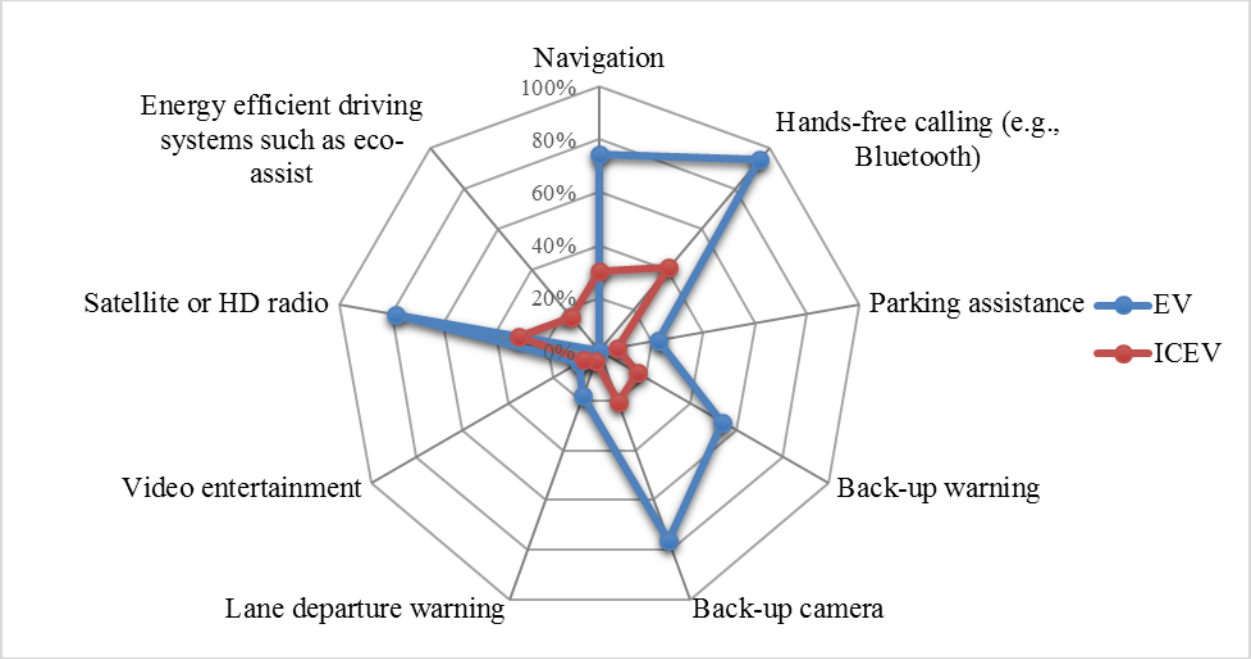



**Figure 8. Current Technology Usage**

**Table 9. EV Purchase Association with Gender for ICEV Owners**

| | | Male | | Female | | Chi-Square |
|---|---|---|---|---|---|---|
| | | # | % | # | % | |
| Purchasing EV in Future | Yes | 62 | 17.3 | 77 | 20.1 | 0.582 |
| | No | 297 | 82.7 | 307 | 79.9 | |
| Purchasing EV if charging provided at work | Yes | 109 | 30.3 | 164 | 42.8 | 0.001 |
| | No | 251 | 69.7 | 219 | 57.2 | |
| Purchasing EV if charging provided at rail station | Yes | 94 | 26.1 | 137 | 35.8 | 0.007 |
| | No | 266 | 73.9 | 246 | 64.2 | |

**Vehicle Use and Travel Behavior**

Participants were asked to provide their primary vehicle uses (work vs. non-work), commuting distances, experiences with congestion during commuting trips, and rail transit use. EV drivers were also asked about the role of charging stations in rail station parking lots. Table 10 is a summary of the responses. More than 70% of the EV drivers and nearly 64% of the ICEV drivers drove their cars for the commute to work. Most of the respondents were primary vehicle users in the household. The percentage of participants who experienced congestion during work trips was

lower than expected. Approximately 38% of the EV owners and 31% of ICEV owners experienced congestion.

There are several interesting observations. First, well-known "range concerns" about EVs are not likely an issue in reality. The difference in average commuting distance between the EV and ICEV drivers was not statistically significant ($p < 0.05$); in fact, EV owners' commuting distance is on average 2 miles longer. Second, the EV owners' rail transit use before and after EV purchase/lease and their experience with charging facilities in rail stations suggested that rail transit is not a desired option for a portion of the commute trip. The percentage of EV drivers who used rail transit after driving an EV was 2.6%, a 2.3% drop from their past usage. Certainly, if charging (and preferential parking) is available at home and work, then using rail transit may be inconvenient. A popular public initiative of installing charging facilities on rail station parking lots may not be as effective as expected. In addition, no EV owners charged their cars at rail stations and the availability of charging facilities at rail stations had almost no effect on EV buying decisions.

As presented in Figure 9, approximately 52% of the EV owners chose two reasons for not using rail transit: *Driving is faster* (27.6%) and *Transit service is inconvenient* (24.1%). Concerns about potential crime were nearly 15%. The observations from Table 10 and Figure 9 provide critical implications for integrative policy designs building inter-agency collaboration. First, public agencies need to examine the effectiveness of existing public outreach efforts for promoting the visibility of public EV charging stations at rail parking lots. Second, improving the transit level of services and remaking brand image are critical to success in attracting drivers to rail stations.

**Table 10. Vehicle Use and Trip Characteristics**

| | | EV | | ICEV | |
|---|---|---|---|---|---|
| | | Responses | Percent | Responses | Percent |
| Primary vehicle use | Work | 260 | 70.1 | 475 | 63.7 |
| | Non-work | 111 | 29.9 | 271 | 36.3 |
| Primary work trip driver | Myself | 235 | 90.7 | 404 | 85.6 |
| | Other household members | 24 | 9.3 | 68 | 14.4 |
| Congestion to work | Yes | 100 | 37.5 | 141 | 30.5 |
| | No | 167 | 62.5 | 321 | 69.5 |
| Commuting Distance (miles) | Min. | 1 | | 0 | |
| | Max. | 120 | | 400 | |
| | Average | 18.84 | | 16.82 | |
| Using rail in past | Yes | 13 | 4.9 | 46 | 9.7 |
| | No | 255 | 95.1 | 426 | 90.3 |
| Using rail now | Yes | 7 | 2.6 | 18 | 3.8 |
| | No | 261 | 97.4 | 458 | 96.2 |
| Nearby rail station | Yes | 39 | 15.2 | 50 | 11.5 |
| | No | 217 | 84.8 | 383 | 88.5 |
| | Don't know | 0 | 0.0 | 0 | 0.0 |
| Charging at Rail Station | Yes | 0 | 0.0 | - | |
| | No | 7 | 1.8 | - | |
| | Don't know | 0 | 0.0 | - | |
| | No response / Not Applicable | 372 | 98.2 | - | |
| Charging facility at rail station influence on using rail | Yes | 5 | 1.3 | - | |
| | No | 34 | 9.0 | - | |
| | No response / Not Applicable | 340 | 89.7 | - | |

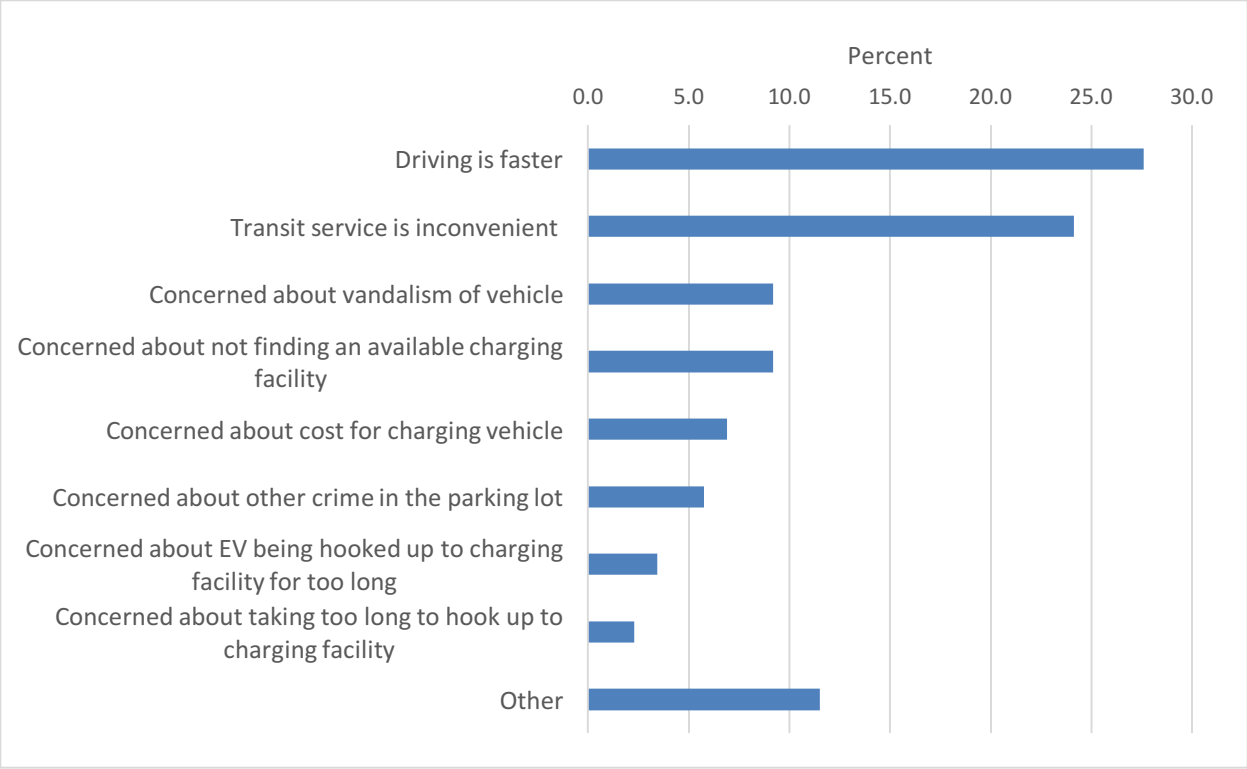



**Figure 9. Reasons Not to Use Rail Transit and Charging Facility**

## State-Level Analyses

Participants by State in the EV and ICEV Owners Survey

A total of 374 EV owners from 38 states participated in the EV survey. Figures 10 and 11 present EV survey participants by state. The most participants (83 or 22.2%) lived in California. Sixty-four Marylanders (17.1%) completed the survey, followed by Texas (5.6%), Washington (5.1%), and Massachusetts (4.5%).

Figures 12 and 13 summarize ICEV survey participants by state; 747 ICEV owners from 48 states and the District of Columbia, completed the survey. Approximately 22.5% or 168 responses were Maryland drivers. Pennsylvania had the second-largest group of participants, 6.8% or 51 responses, followed by California, with about 5.6% or 42 responses.

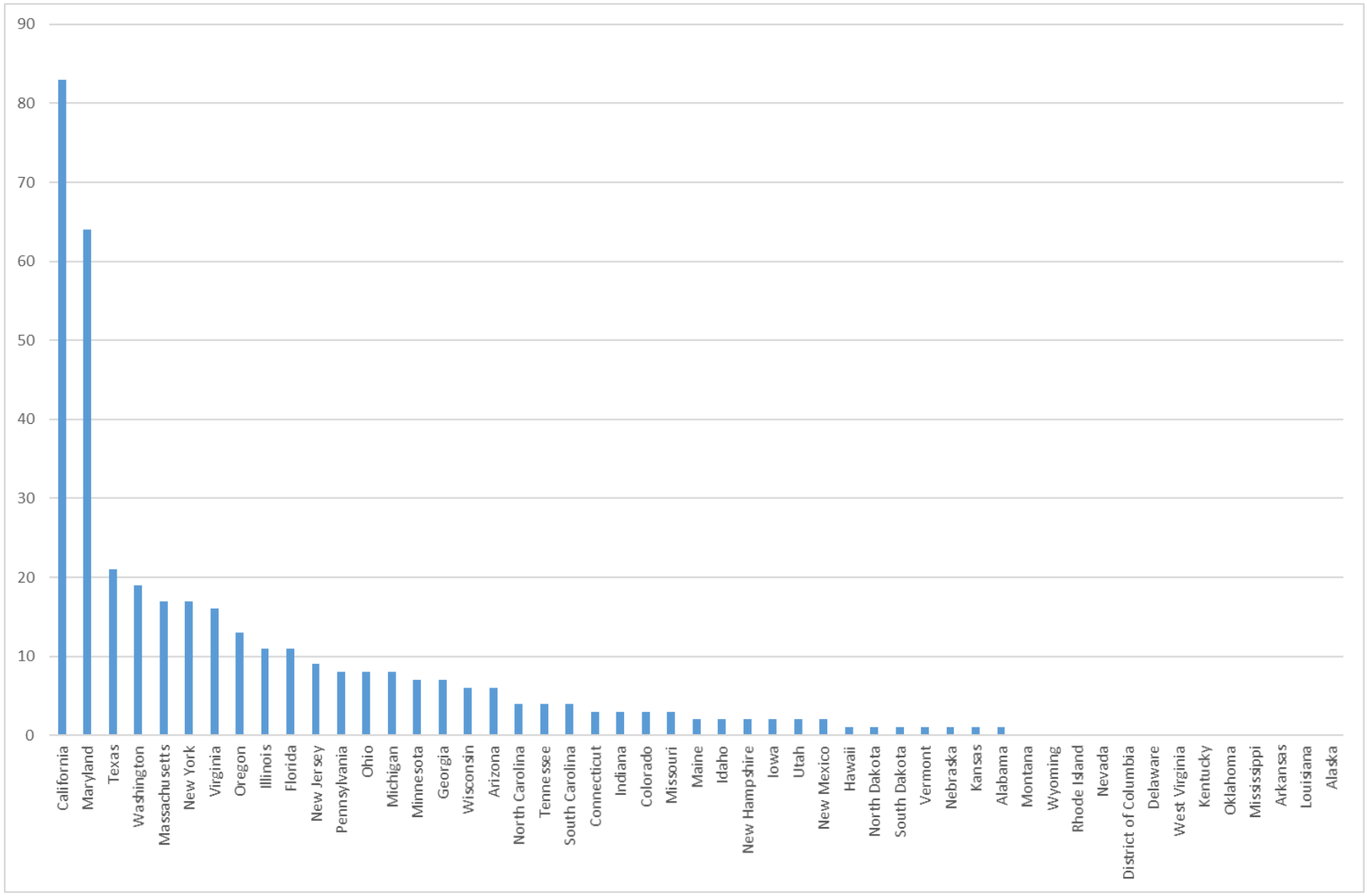



**Figure 10. EV Owner Survey Participants by State**

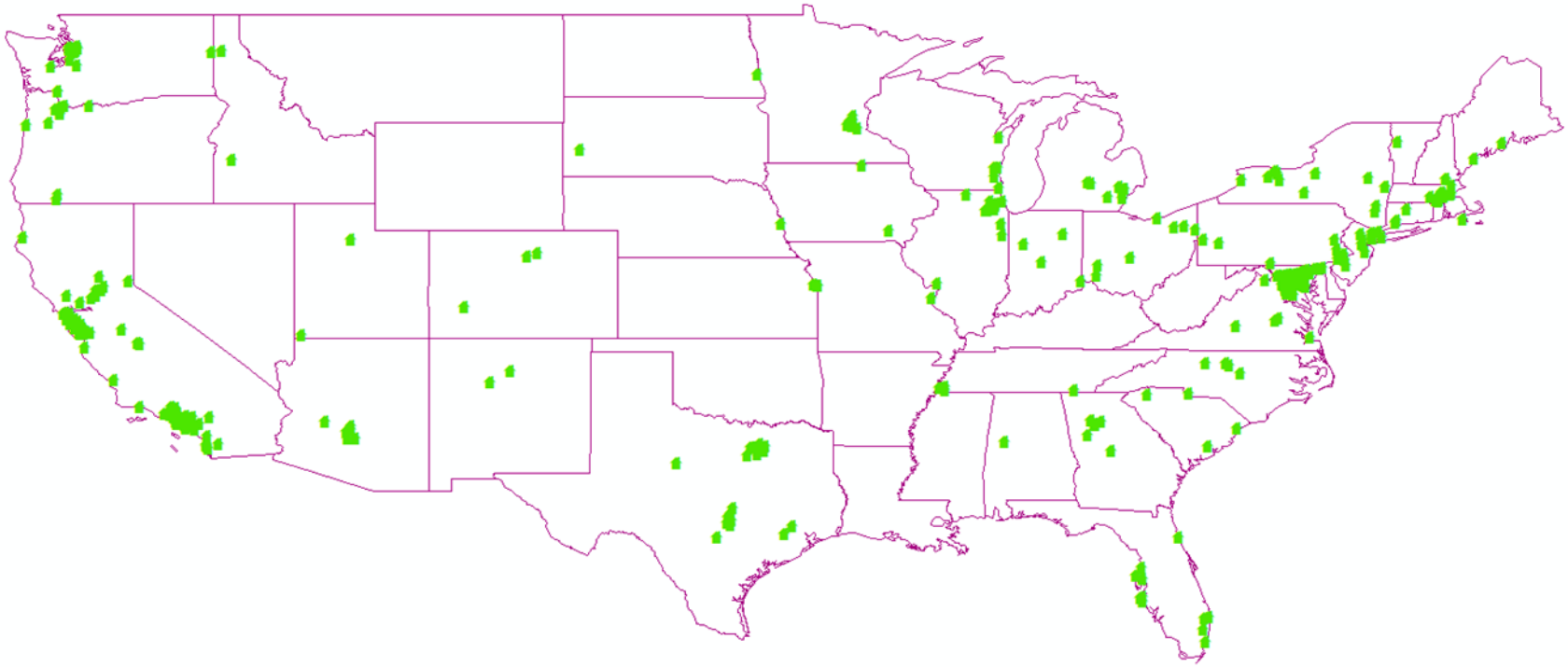


**Figure 11. Geographical Distribution of EV Owners Survey Participants**

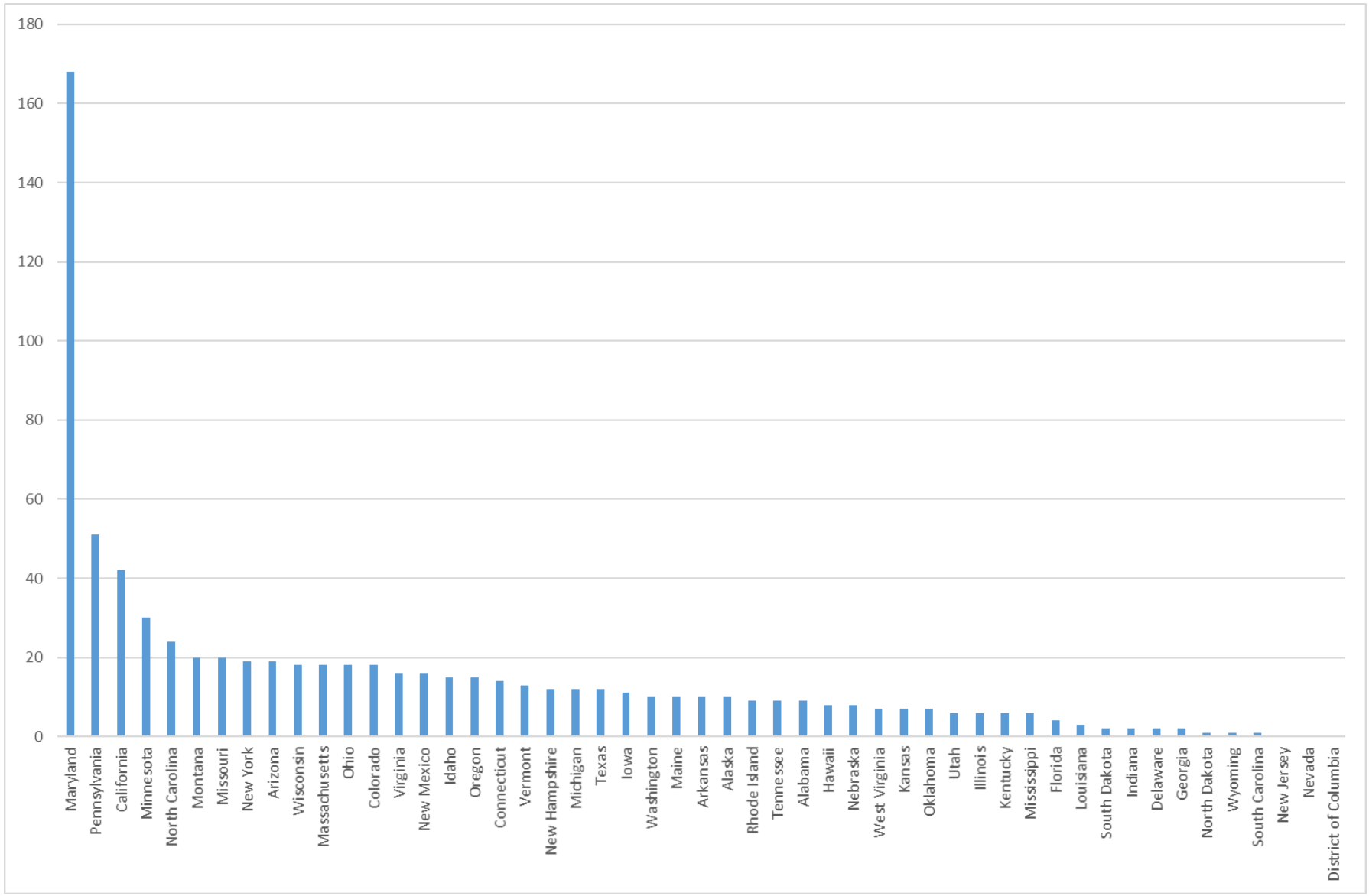



**Figure 12. ICEV Owner Survey Participants by State**

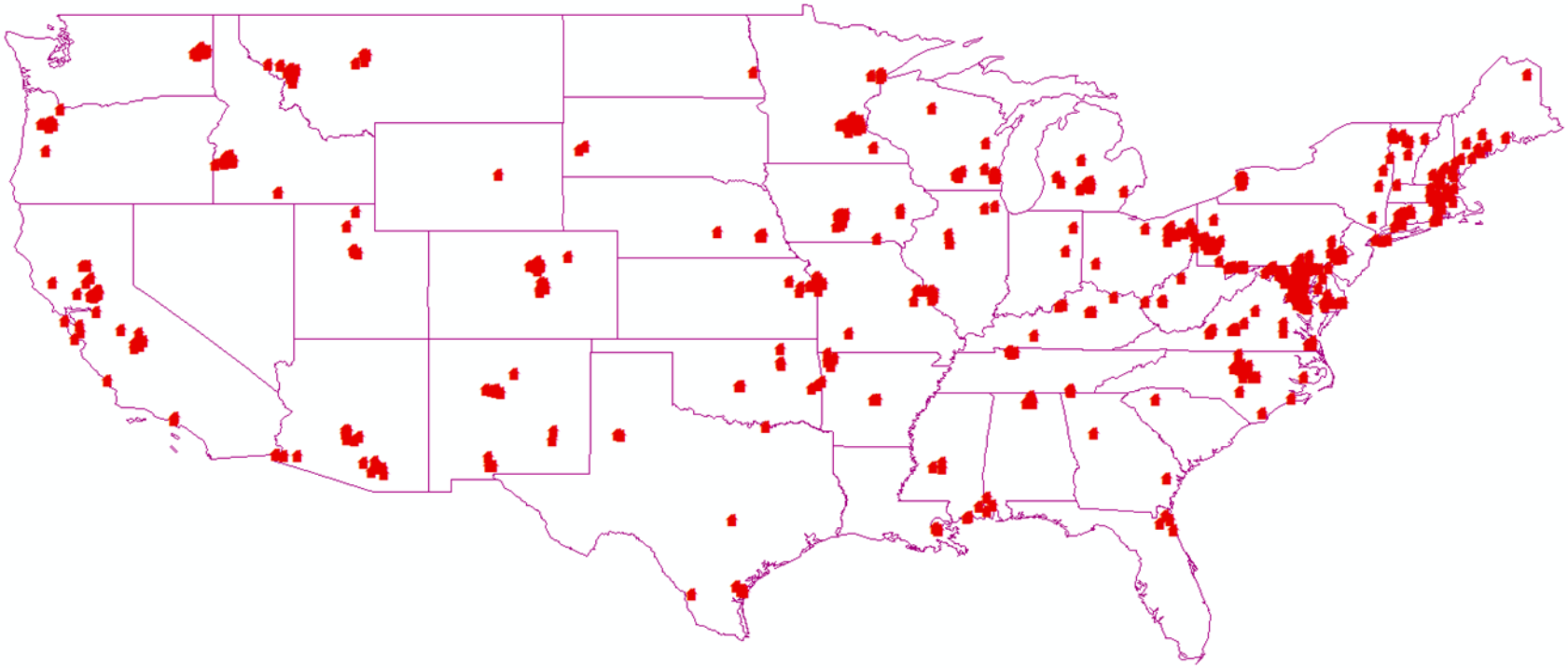


**Figure 13. Geographical Distribution of ICEV Owners Survey Participants**

**Travel Patterns: Maryland and the District of Columbia**

To investigate travel patterns and also commute types of the participants, GIS layers for Metropolitan Statistical Areas (MSA) and Principal Cities were downloaded from "TIGER/Line® Shapefiles and TIGER/Line® Files" of the United States Census Bureau (United States Census Bureau 2015). MSAs and principal cities in Maryland, Delaware, Washington, D.C., and Northern Virginia area are shown in Figure 14 (shaded in orange). Please note that MSAs in this study indicate the area less principal cities. This definition indicates "more" urbanized suburbs that mostly share borders with the principal city. A PYTHON Code was used to categorize origin (home) and destination (work) zip codes of the participants into either *principal city*, *MSA*, or *Rural*. A total of 245 commuting O-D pairs of EV drivers and 451 pairs for ICEV drivers were identified, and classified into nine pairs. The results are shown in Table 11. For both vehicle owner groups, the most prevalent commuting pattern is between MSAs: nearly 40% of the EV owners and just over 44% for ICEV, confirming trends of recent decades of increased suburb-to-suburb journey-to-work trips. The second most common type for EV owners is MSA-city commuting, and then intra-city commuting. The three commuting types accounted for 97.6% and 93.3% of EV and ICEV drivers, respectively. EV owners seemed to have more commute trips starting or ending in 'City" in comparison with ICEV owners (58% to 49%), so it appears that ICEV owners have slightly more dispersed commuting patterns.

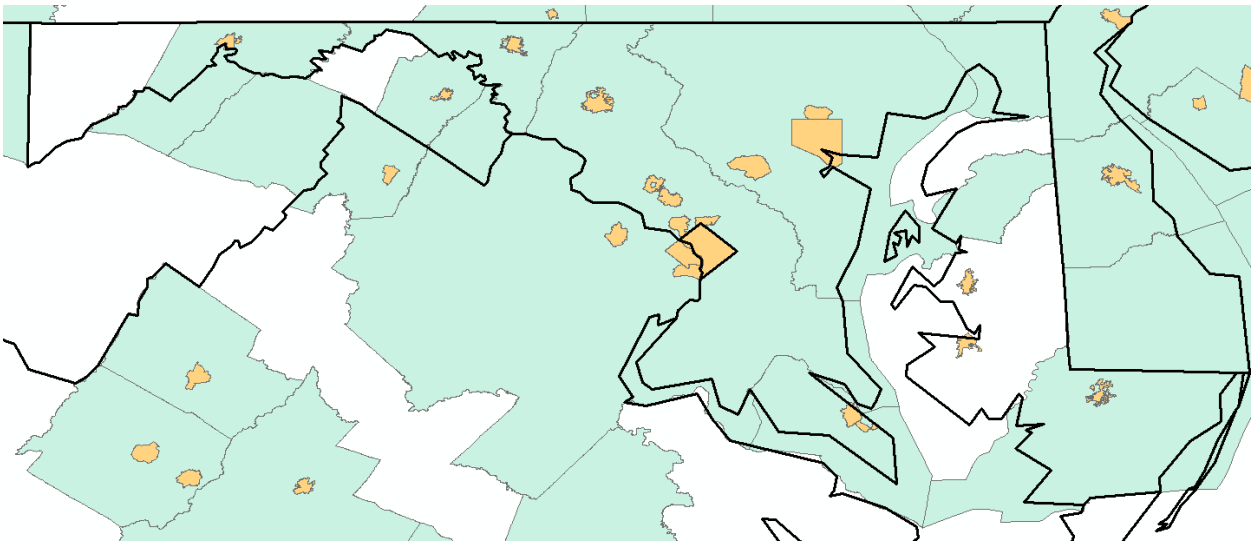


**Figure 14. MSAs and Principal Cities in Maryland, Delaware, Washington, D.C., and Northern Virginia**

**Table 11. Commute Type by Survey Participants**

| Commuting O-D Pairs | | EV Owners | | ICEV Owners | |
|---|---|---|---|---|---|
| | | O-D Pairs | Percent | O-D Pairs | Percent |
| 1 | City - City | 64 | 26.1 | 123 | 27.3 |
| 2 | City - MSA | 26 | 10.6 | 32 | 7.1 |
| 3 | City - Rural | 0 | 0.0 | 2 | 0.4 |
| 4 | MSA - City | 53 | 21.6 | 66 | 14.6 |
| 5 | MSA - MSA | 96 | 39.2 | 200 | 44.3 |
| 6 | MSA - Rural | 1 | 0.4 | 1 | 0.2 |
| 7 | Rural - City | 1 | 0.4 | 0 | 0.0 |
| 8 | Rural - MSA | 1 | 0.4 | 4 | 0.9 |
| 9 | Rural - Rural | 3 | 1.2 | 23 | 5.1 |
| Total | | 245 | 100.0 | 451 | 100.0 |

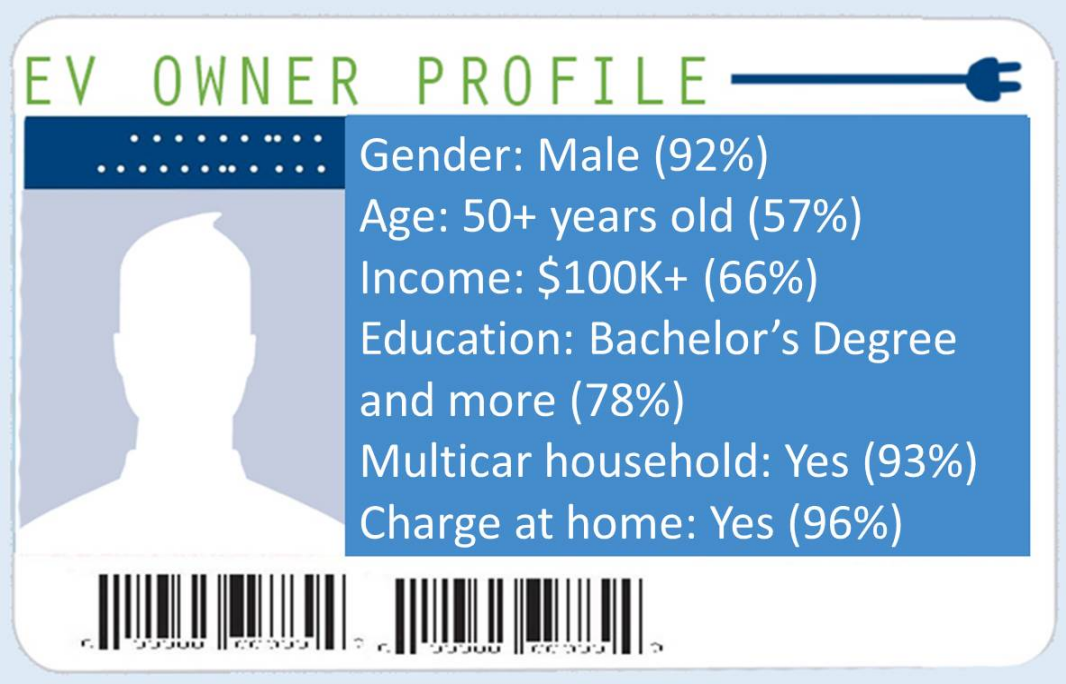
## Text Analysis – EV Owners Survey

In Figure 15 in response to "*Are you satisfied with your EV? Why or why not?*" some relevant words are bold, such as "*yes,*" "*satisfied,*" and "*love,*" and show that the majority of EV owners were satisfied with their EV; however, appearance of "*range*" might refer to some range anxiety.


**Figure 15. Word Cloud for "*Are you satisfied with your EV? Why or why not?*"**

## CONCLUSIONS

The surveys could not be applied to random samples, so the responses and analytical results are merely suggestive of vehicle owners' attitudes and behaviors. However, the results are consistent with previous research.




- EV owners are more affluent, older, more environmentally focused white males than ICEV owners.
- EVs were most popular among Democrats and least among those not interested in politics.
- Although EVs are generally equipped with more safety technologies than ICEVs, EV owners still care slightly more about safety features for their next vehicle.
- Owners use EVs for commuting to work, but transit is not a significant mode choice.
- EV owners have more traditional suburb-to-city and city-to-city commute patterns, while ICEV owners engage in slightly more dispersed trip-making.
- Among ICEV owners market penetration of EVs continues to be a challenge because of price.
- Continued EV market penetration depends on more financial incentives for less affluent households.
- More charging stations may be needed at suburban commute trip destinations.

**REFERENCES:**


Bayless, S., Neelakantan, R. and Guan, A. (2012). *Connected vehicle assessment: Vehicle electrification and the smart grid.* Technology Scan Series 2012-2014, Washington, DC: The Intelligent Transportation Society of America. Retrieved on March 25, 2015, from http://www.itsa.org/knowledgecenter/technology-assessment/electric-vehicle-and-smart-grid.

Caperello, N., Hageman, J., and Kurani, K. (2014). Engendering the Future of Electric Vehicles: Conversations with Men and Women. Institute of Transportation Studies, University of California, Davis, Working Paper UCD-ITS-WP-14-02

Carley, S., Krause, R., Lane, B. and Graham, J. (2012) Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cities. *Transportation Research Part D,* 18, 39-45.

Croson, R., & Gneezy, U. (2009). Gender differences in preferences. *Journal of Economic Literature, 47*(2), 448-474.

Curtin, R., Shrago, Y. and Mikkelsen, J. (2009). *Plug-in hybrid electric vehicles.* Ann Arbor, MI: University of Michigan.

Hauser, J., Tellis, G., & Griffin, A. (2006). Research on innovation: A Review and Agenda for Marketing Science. *Marketing Science, 25*(6), 687-717.

Hjorthol, R. (2013). *Attitudes, ownership and use of electric vehicles: A review of literature.* Oslo: Norwegian Centre for Transportation Research.

Im, S., Bayus, B. L., & Mason, C. H. (2003). An empirical study of innate consumer innovativeness, personal characteristics and new-product adoption behavior. *Journal of the Academy of Marketing Science, 31*(1), 61-73.

Keybridge Public Policy Economics. (2015). *Impact of elimination of the electric vehicle tax credit on the Georgia state economy: Summary of results.* Washington, DC: Securing America's Future Energy.

Krupa, J., Rizzo, D., Eppstein, M., Lanute, D., Gaalema, D., Lakkaraju, K., and Warrender, C. (2014). Analysis of a consumer survey on plug-in hybrid electric vehicles. *Transportation Research Part A,* 64, 14-31.

Lane, B., Sherman, C., Sperl, J., Krause, R., and Carley, S. (2014). Beyond early adopters of plug-in electric vehicles? Evidence from fleet and household users in Indianapolis. *TRB 2014 Annual Meeting,* Washington, DC, January 2014.

Li, C., Cao, Y., Zhang, M., Wang, J., Liu, J., Shi, H. and Geng Y. (March 19, 2015). Hidden benefits of electric vehicles for addressing climate change. *Scientific Reports 5*, retrieved on April 6, 2015, from http://www.nature.com/srep/2015/150319/srep09213/full/srep09213.html.

Mohammadian, A. (2004). Gender differences in automobile choice behavior. *Research on Women's Issues in Transportation: Report of a Conference, Vol. 2 Technical Papers*, *Transportation Research Board of the National Academies, Conference Proceedings 35,* 41-48.

Plotz, P., Schneider, U., Globisch, J., Durschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transportation Research Part A,* 67, 96-109.

Powers, C. (December 2014). *Supporting the Plug-In Electric Vehicle Market: Best Practices from State Programs.* Washington, DC: Georgetown Climate Center.

Radtke, P., Krieger, A., Kirov, S., Maekawa, A., Kato, A., Yamakawa, N. and Henderson, D. (2012). *Profiling Japan's early EV adopters: A survey of the attitudes and behaviors of early electric vehicle buyers in Japan.* McKinsey & Company.

Rogers, E. (2003). *Diffusion of Innovations* (5th ed. ed.). New York: Free Press.

Shin, H., Callow, M., Dadvar, S., Lee, Y., and Farkas, Z. (2015). User acceptance and willingness to pay for connected vehicle technologies: Adaptive choice-based conjoint analysis. *Transportation Research Record 2531,* 54-62.

Shin, H., Farkas, Z., Lee, Y., Callow, M., and Dadvar, S. (2014). Women's acceptance of and willingness-to-pay for connected vehicles. *Women's Issues in Transportation - 5th International Conference* (pp. 439-451). Paris: Transportation Research Board.

Tal, G., & Nicholas, M. (2013). Studying the PEV Market in California: Comparing the PEV, PHEV and Hybrid Markets. *EVS27 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium*. Barcelona, Spain. November 17-20, 2013, 1-10.

Trochim, W., & Donnelly, J. P. (2007). *The Research Methods Knowledge Base* (3rd ed.). Maxon, OH: Atomic Dog.

United States Census Bureau. (2015). *TIGER/Line® Shapefiles and TIGER/Line® Files*. Retrieved July 15, 2016, from https://www.census.gov/geo/maps-data/data/tiger-line.html

US Department of Energy. (2016). *Alternative Fuels Data Center*. Retrieved October 3, 2016, from http://www.afdc.energy.gov/data_download/

Vergis, S. and Chen, B. (2015). Understanding variations in U.S. plug-in electric vehicle markets. *TRB 2015 Annual Meeting,* Washington, DC, January 2015.

Vrkljan, B., & Anaby, D. (2011). What vehicle features are considered important when buying an automobile? An examination of driver preferences by age and gender. *Journal of Safety Research, 42*(1), 61-65.

*The Economist.* (2015, March 21). Sparks fly: Georgia's breaks for electric vehicles may be too good to last. Retrieved on March 24, 2015, from http://www.economist.com/news/united-states/21646758-georgias-breaks-electric-vehicles-may-be-too-good-last-sparks-fly.

## APPENDIX A. SURVEY QUESTIONNAIRES

### Electric Vehicle Owners' Survey

Morgan State University's National Transportation Center (www.morgan.edu/soe/ntc) would like to learn, through this five-minute online survey, about EV owners' purchasing decisions, commuting and preferred vehicle safety technologies.

Survey participants must be at least 18 years old and own/lease a plug-in hybrid or plug-in battery electric vehicle registered in the State of Maryland. The electric vehicle should be equipped with: a steering wheel and pedals, bucket or bench seats, and carry 2 or more people. Participation in this survey is voluntary, and there is no risk associated with participation. You are free to discontinue the online survey at any time.
All information submitted in the survey will be anonymous and confidential. Only the National Transportation Center will collect the survey responses, aggregate the data and analyze results. The individual survey responses will not be shared with the MVA, other state agencies, insurance companies or other private organizations.

What is your gender?

- Male
- Female

What is your age?

- Under 20
- 20 to 24 years old
- 25 to 29 years old
- 30 to 39 years old
- 40 to 49 years old
- 50 to 59 years old
- 60 to 69 years old
- 70 and older

How many people are in your household (including you)?

- One
- Two
- Three or more

How many children (under 18) currently live with you in your household?

- None
- One or Two
- Three or More

How many vehicles does your household have?

- One
- Two
- Three or more

Which zip code do you live in?

What were the top three reasons for your household purchasing or leasing an electric vehicle (EV)?

- Environmental concerns, e.g., air quality, pollution
- Price of electricity vs. gasoline
- Tax breaks and net price of vehicle
- Single occupant access to HOV lane
- Advanced technology
- Safety features of vehicle
- Status of EV ownership
- Available charging facilities
- Vehicle performance
- Reduce dependence on petroleum
- Make or model of vehicle

Did your household purchase or lease the EV?

- Purchased
- Leased

What kind of EV does your household own/lease?

- Plug-in hybrid electric, such as a Chevy Volt
- Plug-in battery electric, such as a Nissan Leaf

Is EV charged at home?

- Yes
- No

Do you have a level 2 charger (240 volts)?

- Yes
- No

Why don't you charge at home?

What is the primary purpose for using the EV?

- Trip to work destination

- Trip to non-work destination

Who drives the EV to work primarily?
- I do
- Other household member does

How many days per week is the EV usually driven to work?
- 1 day
- 2 days
- 3 days or more

Does the primary driver have any concerns over the EV's battery range?
- Yes
- No

Does the primary driver have access to a charging facility at the work location?
- Yes
- No
- Don't know (Not sure)

Where does the primary driver charge the EV mostly?
- Home
- Work
- Both
- Don't know (Not sure)

Which zip code does the primary driver work in?

How far is the one-way commute to work?
(in miles)

Does the primary driver frequently encounter severe congestion or run late when commuting to work?
- Yes
- No
- Don't know

Before you purchased/leased the EV did the primary driver use public rail transit at least once or twice a week to commute to work?
- Yes
- No

Does the primary driver use rail transit now for part of the commute trip with the EV?
- Yes

- No

Is a charging facility available at the rail station?

- Yes
- No
- Don't know

Does the primary driver use the facility to charge the EV?

- Yes
- No

What are the reasons for not using the charging facility at the rail station?

- Concerned about vandalism of vehicle
- Concerned about other crime in the parking lot
- Concerned about not finding an available charging facility
- Concerned about taking too long to hook up to charging facility
- Concerned about cost for charging vehicle
- Concerned about EV being hooked up to charging facility for too long
- Other

Is there a rail transit station located on the way to work that the primary driver could use to get to work?

- Yes
- No
- Don't know

Would access to a charging facility influence the driver to use rail transit?

- Yes
- No

What are the reasons for not using a charging facility and taking rail transit for the rest of the commute?

- Concerned about vandalism of vehicle
- Concerned about other crime in the parking lot
- Concerned about not finding an available charging facility
- Concerned about taking too long to hook up to charging facility
- Concerned about cost for charging vehicle
- Concerned about EV being hooked up to charging facility for too long
- Transit service is inconvenient
- Driving is faster
- Other

Please indicate whether you have any of the following technologies in your current EV. (Select all that apply)

- Navigation
- Hands-free calling (e.g., Bluetooth)
- Parking assistance
- Back-up warning
- Back-up camera
- Lane departure warning
- Video entertainment
- Satellite or HD radio

What types of safety technologies would you like to have in your next vehicle? (Select all that apply)

- Front collision warning
- Side collision warning
- All around collision warning
- Do not pass warning
- Pedestrian and cyclist alert
- Control loss warning
- Other

What is your highest level of formal education?

- Some high school
- High school diploma or GED
- Associate's degree
- Bachelor's degree
- Master's degree
- Doctoral or professional degree

What is your annual household income?

- Less than $50,000
- $50,000 – $75,000
- $75,000 – $100,000
- $100,000 – $200,000
- More than $200,000
- Prefer not to answer

What is your marital status?

- Single
- Married or in domestic partnership

What is your race/ethnicity?

- White (non-Hispanic)
- Hispanic
- Black or African-American
- Asian
- American Indian or Alaska Native
- Native Hawaiian or other Pacific Islander
- Other
- Prefer not to answer

What is your political affiliation?

- Democrat
- Republican
- Independent
- Not interested in politics

Are you satisfied with your EV? Why or why not?

Other comments

If you have any questions or if you are interested in knowing the study results, please contact:
Principal Investigators:
- Dr. Z. Andrew Farkas, Morgan State University
andrew.farkas@morgan.edu or 443-885-3761
- Dr. Hyeon-Shic Shin, Morgan State University
hyeonshic.shin@morgan.edu or 443-885-1041
Thank you! Your response has been recorded.

ICEV Owners

**Commuting Preferences and Attitudes Survey (Non-EV Survey)**

Morgan State University's National Transportation Center (www.morgan.edu/soe/ntc) would like to learn, through this five-minute online survey, about motor vehicle owners' commuting and preferred vehicle safety technologies.

Survey participants must be at least 18 years old and own/lease a vehicle registered in the State of Maryland. The vehicle should be equipped with: a gas/diesel engine, steering wheel and pedals, bucket or bench seats, and carry 2 or more people. Participation in this survey is voluntary, and there is no risk associated with participation. You are free to discontinue the online survey at any time.

All information submitted in the survey will be anonymous and confidential. Only the National Transportation Center will collect the survey responses, aggregate the data and analyze results. The individual survey responses will not be shared with the MVA, other state agencies, insurance companies or other private organizations.

What is your gender?

- Male
- Female

What is your age?

- Under 20
- 20 to 24 years old
- 25 to 29 years old
- 30 to 39 years old
- 40 to 49 years old
- 50 to 59 years old
- 60 to 69 years old
- 70 and older

How many people are in your household (including you)?

- One
- Two
- Three or more

How many children (under 18) currently live with you in your household?

- None
- One or Two
- Three or More

How many vehicles does your household have?

- One
- Two
- Three or more

Which zip code do you live in?

What were the top three reasons for your household purchasing or leasing your last vehicle?

- Environmental concerns, e.g., air quality, pollution
- Miles per gallon
- Price of vehicle
- Advanced technology
- Safety features of vehicle
- Reliability of vehicle
- Vehicle size
- Vehicle make or model
- Vehicle performance

Did your household purchase or lease the vehicle?

- Purchase
- Lease

What kind of vehicle did you purchase/lease?

- Small coupe or sedan
- Large coupe or sedan
- Small SUV
- Large SUV
- Pickup truck

What is the primary purpose for using the vehicle?

- Trip to work destination
- Trip to non-work destination

Who drives the vehicle to work primarily?

- I do
- Other household member does

How many days per week is the vehicle usually driven to work?

- 1 day
- 2 days
- 3 days or more

Which zip code does the primary driver work in?

How far is the one-way commute to work?
(in miles)

Does the primary driver frequently encounter severe congestion or run late when commuting to work?

- Yes
- No
- Don't know

Before you purchased/leased the vehicle, did the primary driver use public rail transit at least once or twice a week to commute to work?

- Yes
- No

Does the primary driver use rail transit now for part of the commute trip?

- Yes
- No

Is there a conveniently located rail transit station that the primary driver could use to get to work?

- Yes
- No
- Don't know

Are you considering buying/leasing an electric vehicle (EV) in the near future?

- Yes
- No

What type of electric vehicle (EV)?

- Plug-in hybrid electric, such as a Chevy Volt
- Plug-in battery electric, such as a Nissan Leaf
- Don't know (Not sure)
- Other

What would be the top three reasons for your household purchasing or leasing an EV?

- Environmental concerns, e.g., air quality, pollution
- Price of electricity vs. gasoline
- Tax breaks and net price of vehicle
- Single occupant access to HOV lane
- Advanced technology
- Safety features of vehicle
- Status of EV ownership
- Availability of charging facilities
- Vehicle performance
- Reduce dependence on petroleum

What would be the primary reason for not buying/leasing an EV in the near future?

- Price of vehicle
- Driving range of vehicle
- Price of gasoline
- Safety issues with the technology
- Other

Would you buy/lease an EV if your employer provided a charging facility on-site?

- Yes
- No

Would you buy/lease an EV and use rail transit if a charging facility were available at a convenient rail station?

- Yes
- No

Have you recently seen a public EV charging facility?

- Yes
- No
- I don't know what an EV charging facility looks like.

Please indicate whether you have any of the following technologies in your current vehicle. (Select all that apply)

- Navigation
- Hands-free calling (e.g., Bluetooth)
- Parking assistance
- Back-up warning
- Back-up camera
- Lane departure warning
- Video entertainment
- Satellite or HD radio
- Energy efficient driving systems such as eco-assist

What types of safety technologies would you like to have in your next vehicle? (Select all that apply)

- Front collision warning
- Side collision warning
- All around collision warning
- Do not pass warning
- Pedestrian and cyclist alert
- Control loss warning
- Other

What is your highest level of formal education?

- Some high school
- High school diploma or GED
- Associate's degree
- Bachelor's degree
- Master's degree
- Doctoral or professional degree

What is your annual household income?

- Less than $50,000
- $50,000 – $75,000
- $75,000 – $100,000
- $100,000 – $200,000
- More than $200,000
- Prefer not to answer

What is your marital status?

- Single
- Married or in domestic partnership

What is your race/ethnicity?

- White (non-Hispanic)
- Hispanic
- Black or African-American
- Asian
- American Indian or Alaska Native
- Native Hawaiian or other Pacific Islander
- Other
- Prefer not to answer

What is your political affiliation?

- Democrat
- Republican
- Independent
- Not interested in politics

Comments

If you have any questions or if you are interested in knowing the study results, please contact:
Principal Investigators:
- Dr. Z. Andrew Farkas, Morgan State University
andrew.farkas@morgan.edu or 443-885-3761
- Dr. Hyeon-Shic Shin, Morgan State University
hyeonshic.shin@morgan.edu or 443-885-1041
Thank you! Your response has been recorded.