



Electric Vehicle Charging Survey Results

November 2023

TABLE OF CONTENTS

TABLE OF FIGURES.....	3
EXECUTIVE SUMMARY	4
INTRODUCTION	6
BACKGROUND	7
METHODOLOGY	8
Overall principles.....	8
Demographics	8
FINDINGS.....	9
Respondent demographics	9
Access to a vehicle.....	9
Experience with driving a plug-in electric vehicle	11
Experience with using public electric vehicle charging.....	13
Access to financial products and services	19
KEY FINDINGS AND RECOMMENDATIONS	25
Regarding charging reliability and the experience of EV drivers:	25
Regarding payments at EV charging stations:	26
NEXT STEPS	27
Appendix A Statistical Significance	28
Chi-square test.....	28
Appendix B Survey Questions	29
Appendix C Respondent Zip Code	33

TABLE OF FIGURES

- Figure 1: Access to a vehicle by gender 10
- Figure 2: Access to a vehicle by household income 10
- Figure 3: Access to a vehicle by race/ethnicity 11
- Figure 4: Experience driving a plug-in electric vehicle by gender 12
- Figure 5: Experience driving a plug-in electric vehicle by household income 12
- Figure 6: Experience driving a plug-in electric vehicle by race/ethnicity 13
- Figure 7: Experience using public EV charging by gender 14
- Figure 8: Experience using public EV charging by household income 14
- Figure 9: Experience using public EV charging by race/ethnicity 15
- Figure 10: Respondents who have experienced problems with public EV charging, by household income 16
- Figure 11: Access to a bank account by household income 19
- Figure 12: Use of financial products and services by gender 20
- Figure 13: Use of financial products and services by household income..... 21
- Figure 14: Use of financial products and services by race/ethnicity 22
- Figure 15: Access to a contactless tap payment option by gender 23
- Figure 16: Access to a contactless tap payment option by household income 23
- Figure 17: Access to a contactless tap payment option by race/ethnicity..... 24

- Table 1: Top 5 problems experienced with EV charging by household income 17
- Table 2: Payment-related problems actually experienced 18
- Table 3: Reasons for contacting customer service 18
- Table B1: Survey questions and response options provided to respondents 29

EXECUTIVE SUMMARY

By 2035, all new cars and light trucks sold in California must be zero-emission vehicles, or ZEVs. In preparation for the shift away from internal combustion engine vehicles, the California Air Resources Board (CARB) is researching a number of topics associated with the physical, financial, and technological accessibility of electric vehicle charging. In March 2023, in collaboration with the California Integrated Travel Project (Cal-ITP), CARB prepared and distributed a survey to understand how Californians pay for goods and vehicle fueling today, and how they would like to do so in the future. The findings – based on the responses from 2,676 completed surveys – can help to inform actions and programs that enable electric vehicle charging stations to be used by all Californians. Key findings include:

- **The experience of using public electric vehicle charging is not yet consistently reliable or satisfactory for most users.**
 - Among respondents with experience using public electric vehicle charging, two-thirds have encountered problems. The top five issues that respondents reported experiencing were:
 - The chargers were all in use (68% of respondents to this question)
 - Chargers were unresponsive (67%)
 - Chargers were physically damaged (59%)
 - Charging was too slow (48%)
 - Issues with the station accepting a user's form of payment (45%)
- **Concerns about public electric vehicle charging (among those who have never used it) typically focus on different problems than those reported by people who are users of public electric vehicle charging.**
 - Being unable to locate a charger was a concern among individuals who had never used public electric vehicle charging, but it was not reported as a problem by those who have. In contrast, unresponsive and damaged chargers, and problems with charging stations accepting users' payment, have been a reality for many public electric vehicle charging users; these technological/infrastructure issues are not anticipated by those who have never used public electric vehicle charging.
 - Nonetheless, the availability of chargers is both a concern *and* a reality when comparing the perceptions that individuals have about public electric vehicle charging with the challenges that are actually experienced.

- **Memberships act as a barrier to frictionless payments.**
 - Of the issues encountered that were payment-specific, the inability to pay unless you hold a membership was the most-cited problematic experience, followed by the payment card reader not functioning properly.
- **Drivers prefer interoperable and convenient ways to pay for public electric vehicle charging.**
 - The top two preferred ways to pay for public electric vehicle charging were “automatic billing from vehicle (Plug & Charge),” and “contactless tap credit or debit card or mobile wallet,” irrespective of gender, household income, or race/ethnicity. The least preferred options were “electric vehicle charging company issued card” and “dialing a 1-800 number.”
- **Contactless payment options are popular but not yet universal.**
 - Among all survey respondents, 87% have access to a contactless or “tap” payment option, whether that is a physical card, a smartphone with a contactless payment method, or both. Access varies significantly across income groups; roughly 23% of individuals with a household income under \$40,000 do not have a contactless payment option, compared with just 2% of individuals with a household income of \$115,000 or higher.

INTRODUCTION

In 2022, California surpassed one million electric vehicles sold, accounting for more than 40% of all zero-emission vehicles (ZEVs) across the United States and leading the nation's zero-emissions vehicles market.¹ Electric vehicles are one category of zero-emission vehicles, alongside hydrogen-powered vehicles. Both electric vehicles and hydrogen-powered vehicles produce no harmful emissions during operation and do not rely on fossil fuels for propulsion. Zero-emission vehicles' impact on the climate and public health is less severe than other vehicle types, including hybrid and traditional internal combustion engine vehicles, which produce carbon emissions and harmful air pollutants while consuming fossil fuels. The following report focuses only on fully electric vehicles and the electric vehicle charging infrastructure that supports them.

To speed up the uptake of zero-emission vehicles, both California's Advanced Clean Cars I and California's Advanced Clean Cars II build on the state's zero-emission vehicle regulation and impose increasing levels of low-emission and zero-emission vehicle standards for new vehicles. The Advanced Clean Cars 1 regulation has been in effect since 2012 and addresses model years 2015-2025, while the Advanced Clean Cars II regulation addresses model years 2026-2035. All new light- and medium-duty vehicles sold in the state must be zero-emission vehicles by 2035.² As a result, the number of zero-emission vehicles is expected to surge to 12.5 million in the next 10 years.³

While this is a phenomenal commitment to reduce greenhouse gas and air pollutant emissions and tackle their severe impacts on global climate and public health, recent studies find that communities in California with the highest concentrations of zero-emission vehicles are those that are most affluent. For example, Erica Yee from CalMatters reports that "the top 20 ZIP codes for percentage of electric cars [as a proportion of all light-duty vehicle registrations in a ZIP code] are all in the Bay Area and Los Angeles/Orange counties. All are at least 75% white and/or Asian, and the top 10 have typical home values over \$3 million."⁴

To bridge this gap and ensure a transition that is fair and just, the California Air Resources Board (CARB) is researching the different perceptions and experiences with electric vehicles and electric vehicle charging throughout the state. Doing so will help develop a deeper understanding of California residents and their current experiences with public electric vehicle charging, or lack thereof, informing strategies

¹ "[California Leads the Nation's ZEV Market, Surpassing 1 Million Electric Vehicles Sold](#)" (Office of Governor Gavin Newsom)

² McNamara "[Understanding California's Advanced Clean Cars II Regulations](#)" (2023)

³ Lopez and Yee, "[Who buys electric cars in California – and who doesn't?](#)" (Calatters.org)

⁴ Ibid.

and policies that can support those who are most disadvantaged by the transition. This work can ensure that everyone interested in moving over to electric vehicles – now and in the future, regardless of their income, race, or gender – is able to do so.

BACKGROUND

By 2035, all vehicles sold in California must be zero-emission vehicles to meet the state’s health-based air quality standards and greenhouse gas emission reduction goals. Making public charging stations more convenient and user-friendly is therefore critical to alleviate existing concerns and challenges. In 2019 CARB adopted the Electric Vehicle Supply Equipment (EVSE) Standards Regulation, pursuant to Senate Bill 454 (Corbett, Chapter 418, Statutes of 2013), to reduce access barriers to public charging stations. Based on CARB’s 2022 EVSE Standards Technology Review findings, it was determined that more work was needed to monitor the evolution of payment technologies and the use of different payment methods, including by drivers with varying levels of income and differential access to traditional banking services.

Therefore, CARB aims to better understand the experiences of individuals from various backgrounds with electric vehicle (EV) charging. A 23-question survey (see Appendix B | Survey Questions for the full list of survey questions) was shared with EV drivers, non-EV drivers, and non-drivers from various socioeconomic backgrounds living in the state of California.⁵ The questions were arranged to assess the different levels of experience with EVs (i.e., if respondents have previously driven an EV, or own an EV already), perceptions of and experienced barriers to public charging, and overall preferences for paying for goods and fueling. Survey results will serve as guidance for state agencies to understand ways to reduce barriers to accessing public charging stations. These learnings will help shape future iterations of regulations and provide advice for other types of government intervention.

⁵ EV drivers were asked to answer all survey questions. Non-EV drivers were asked to answer the financial, demographic and perception of EV charging questions. Non-drivers only answered financial and demographic questions.

METHODOLOGY

Overall principles

The design for the survey focused on three main principles:

- **Easy to answer** – A survey questionnaire that would take 6 minutes or fewer to complete.
- **Accessible** – Versions available in English and Spanish with compatibility through different media (browser, phone, tablet).
- **Multi-themed** – A survey questionnaire design that would include questions related to:
 - Access to financial services.
 - Payment preferences for electric vehicle charging and everyday activities.
 - Concerns about the electric vehicle public charging experience.
 - Electric vehicle charging experiences related to charging and payment.
 - Demographics: covering gender, age, race/ethnicity, household income, household size, and general location.

Demographics

Overall, the survey distribution aimed to target respondents who would have access to a vehicle for their activities.⁶ If the respondent indicated that they did not have access to a vehicle, then the survey would take them through the financial, electric vehicle charging concerns, and demographic sections.

Moreover, the survey aimed to get responses from all income groups, with special focus on lower-income populations. To achieve this goal, CARB and the California Integrated Travel Project (Cal-ITP) relied on their social media channels (LinkedIn and Twitter), and reached out to their partners, including local air quality districts, not-for-profit organizations, and community-based organizations, to distribute the survey through their own channels. This approach allowed responses from an extended set of urban and peri-urban (rural areas of the state that are becoming urbanized) parts of California (please see Appendix B).

⁶ The marketing information for the surveys noted an interest in learning more about consumers' overall electric vehicle charging experience but was ultimately agnostic to the fuel type of respondents' current vehicle(s).

FINDINGS

The findings are based upon the answers of 2,676 respondents who completed the entire survey. CARB staff was specifically interested in understanding if gender and income play a role in shaping or influencing an individual's experience or attitude toward electric vehicle charging. Therefore, the findings below apply the lens of gender and income level at the forefront of the analyses.

Respondent demographics

- **Residency:** Most respondents are residents of California (98%) with only 50 individuals residing outside of the state.⁷
- **Gender:** 65% of respondents identify as male, 30% identify as female, 4% prefer not to say, and 1% identify as other.⁸
- **Household income:** 30% of respondents reported a household income under \$40,000 while 18% of respondents reported a household income of \$150,000 or higher; 12% of respondents preferred to not report their household income.
- **Household size:** 24% of respondents live alone, while 29% of respondents live in a two-person household and 42% of respondents live in households of three or more.
- **Race and ethnicity:** 34% of respondents identify as White/Caucasian, 32% as Asian/Pacific Islander/Hawaiian, 14% as Hispanic/Latino, and 4% as Black/African American; 9% of respondents preferred not to say.
- **Age:** 16% of respondents were aged 25-34 at the time of the survey; 21% were aged 35-44; 19% were aged 45-54; 18% were aged 55-64 and 15% were aged 65+. A further 2% were 24 years old or under, and 9% preferred not to say. The average age of respondents was 49 years old.

Access to a vehicle

Respondents were asked whether they have access to a vehicle for their mobility needs and the majority (90%) responded that they always do. However, females, and respondents with an annual household income of \$40,000 or less, were significantly less likely than male respondents, and respondents from higher household income brackets respectively, to always have access to a vehicle. White/Caucasian

⁷ A negligible proportion of respondents (50 total) stated that they were not residents of California. However, their responses are included in the final analysis to gain additional insight into the experiences and perceptions of paying for goods and vehicle fueling.

⁸ Throughout this report, wherever differences are noted by gender, we compare between males and females only. The number of respondents stating "Other" is too small to provide meaningful comparisons and it is not possible to draw gender-related conclusions about those who "prefer not to say".

respondents were significantly more likely to always have access to a vehicle than respondents from any other racial or ethnic group.

Figure 1: Access to a vehicle by gender

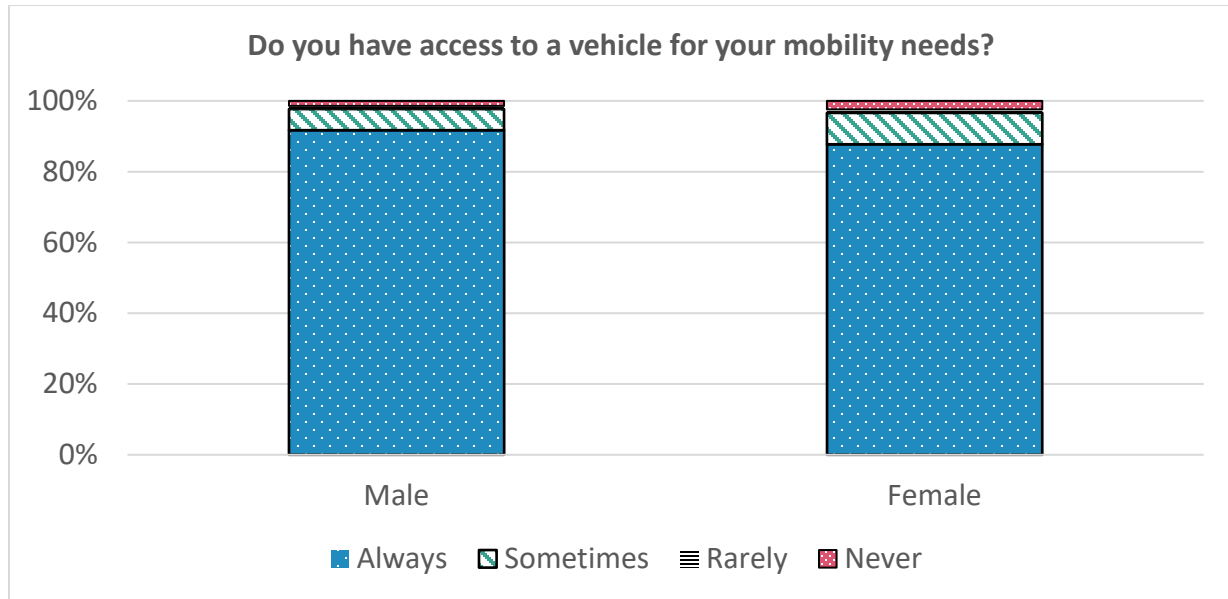


Figure 2: Access to a vehicle by household income

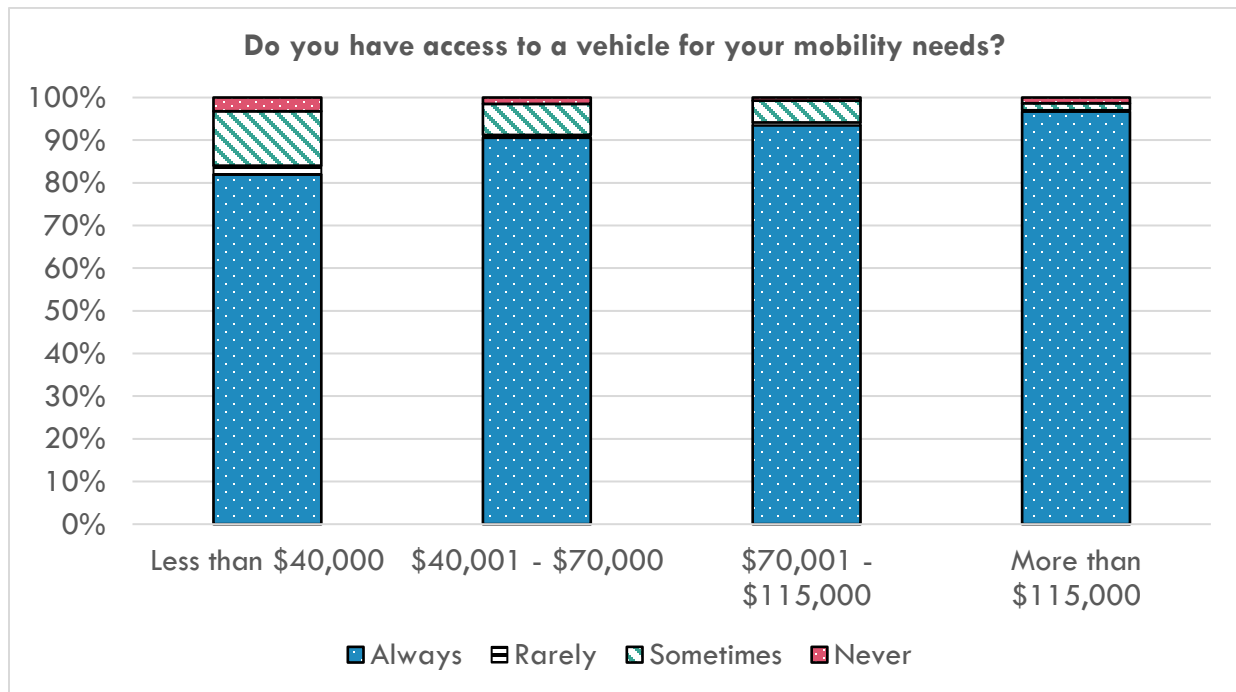
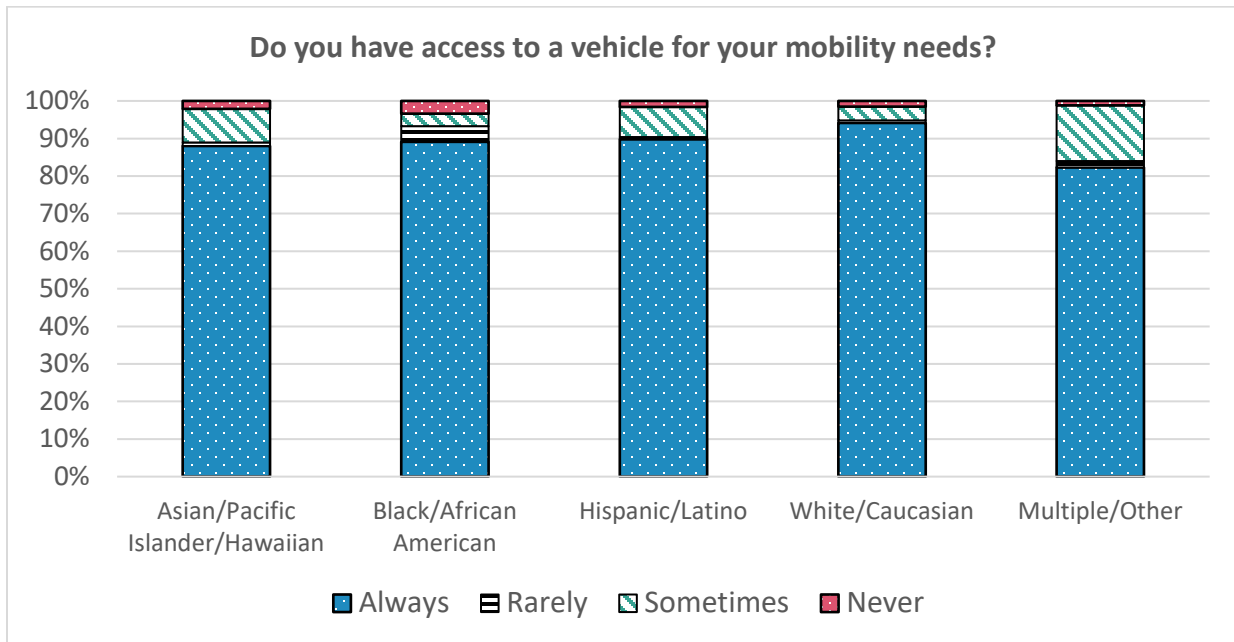


Figure 3: Access to a vehicle by race/ethnicity



Experience with driving a plug-in electric vehicle

Males, respondents with higher household incomes, and those identifying as white/Caucasian were significantly more likely to have experience driving a plug-in electric vehicle. Three-quarters of male respondents have driven or currently drive a plug-in electric vehicle, compared with roughly 60% of all female respondents. In addition, the survey results show a positive correlation between household income and experience driving a plug-in electric vehicle: the higher the income, the more likely the individual has experience with driving a plug-in electric vehicle. Finally, white/Caucasian respondents were significantly more likely to have experience driving a plug-in electric vehicle than respondents from any other racial or ethnic group.

Figure 4: Experience driving a plug-in electric vehicle by gender

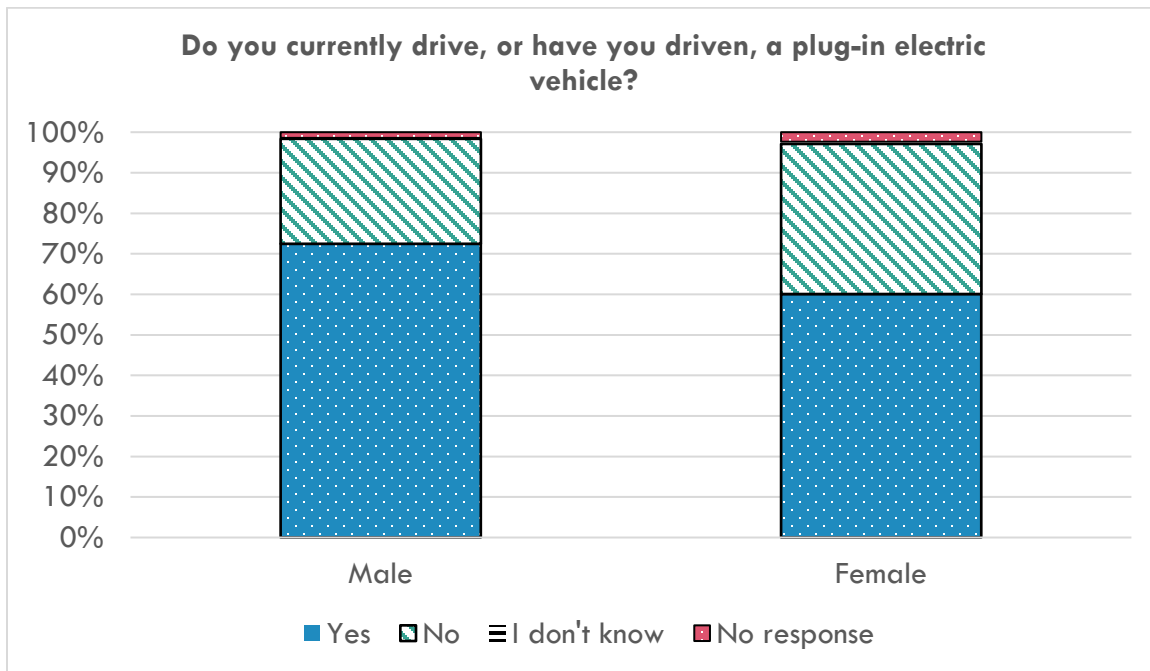


Figure 5: Experience driving a plug-in electric vehicle by household income

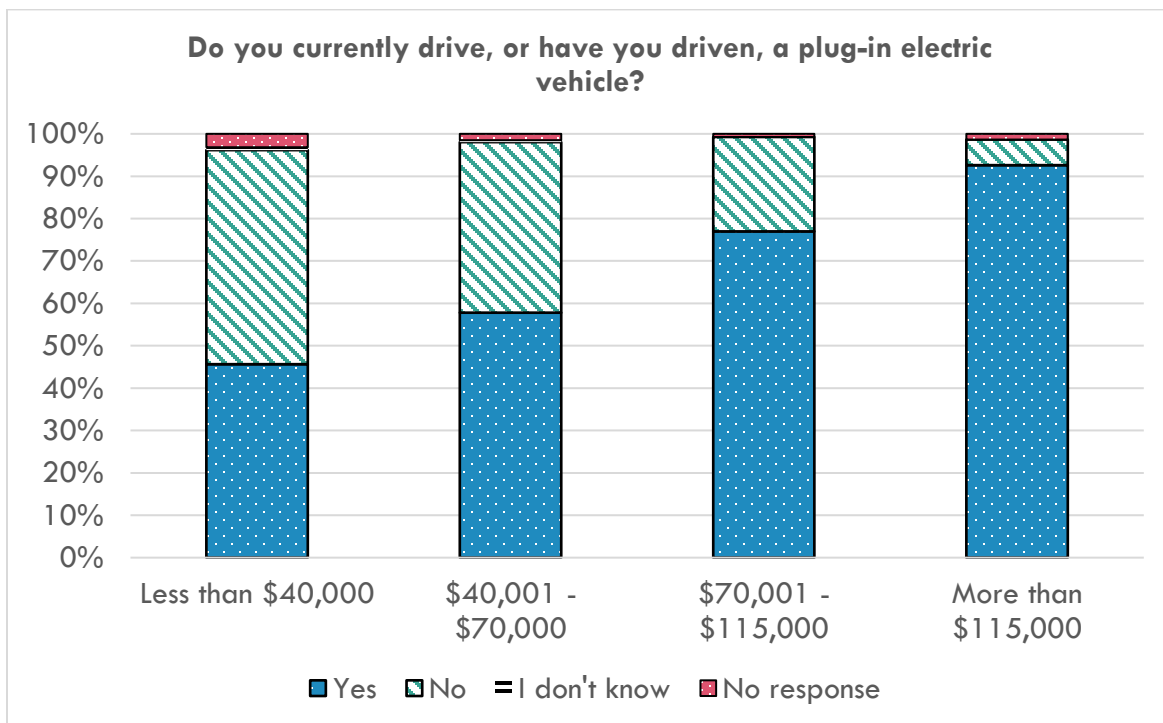
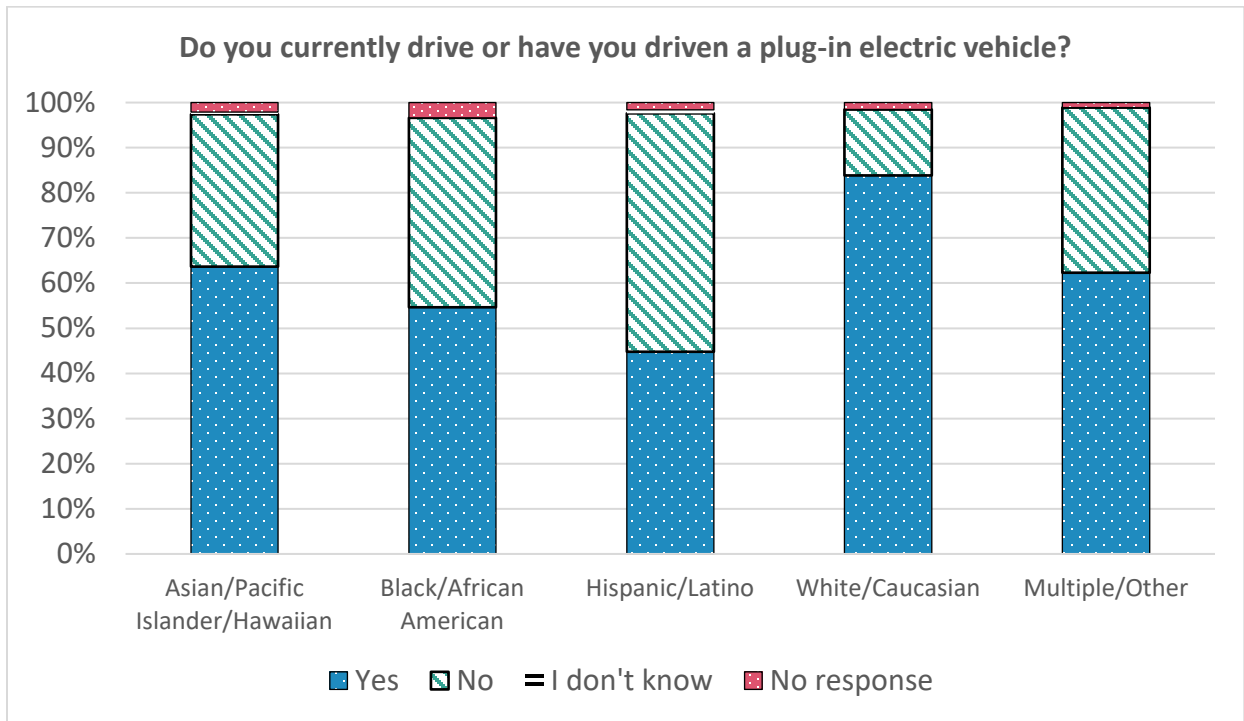


Figure 6: Experience driving a plug-in electric vehicle by race/ethnicity



Experience with using public electric vehicle charging

Roughly 4 in 5 respondents who currently drive or have driven an electric vehicle have used public electric vehicle charging. Males were slightly but significantly more likely to have used public electric vehicle charging than females, while those with higher household incomes were significantly more likely to have used public electric vehicle charging than those with lower household incomes; the likelihood increased by 26 percentage points between the lowest and highest household income brackets. Respondents identifying as Asian Americans/Pacific Islander/Hawaiian were less likely to have used public electric vehicle charging than respondents from all other racial or ethnic groups. With the exception of those identifying as Black/African American, this decreased likelihood was significant.

Figure 7: Experience using public electric vehicle charging by gender

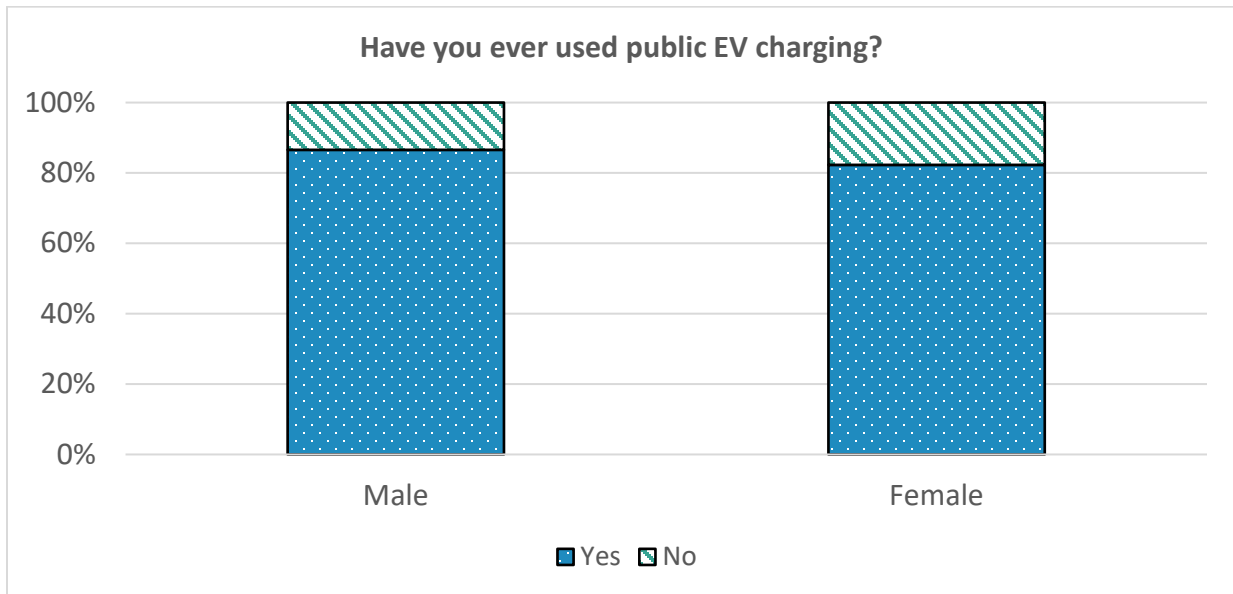


Figure 8: Experience using public electric vehicle charging by household income

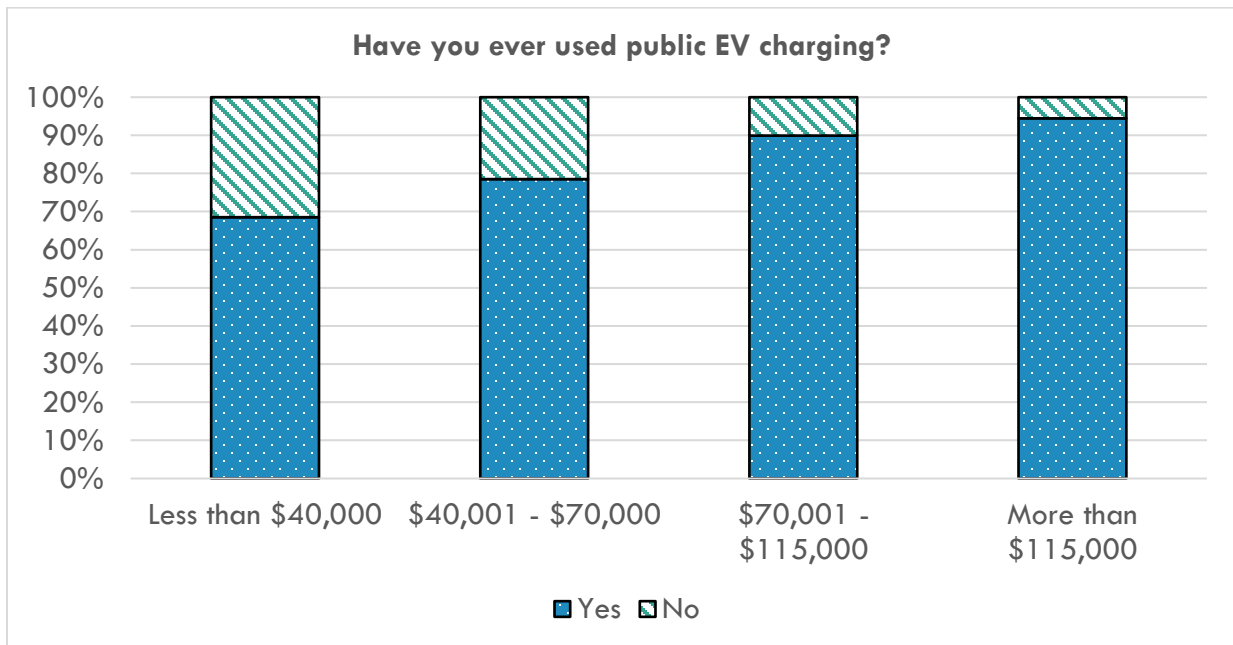
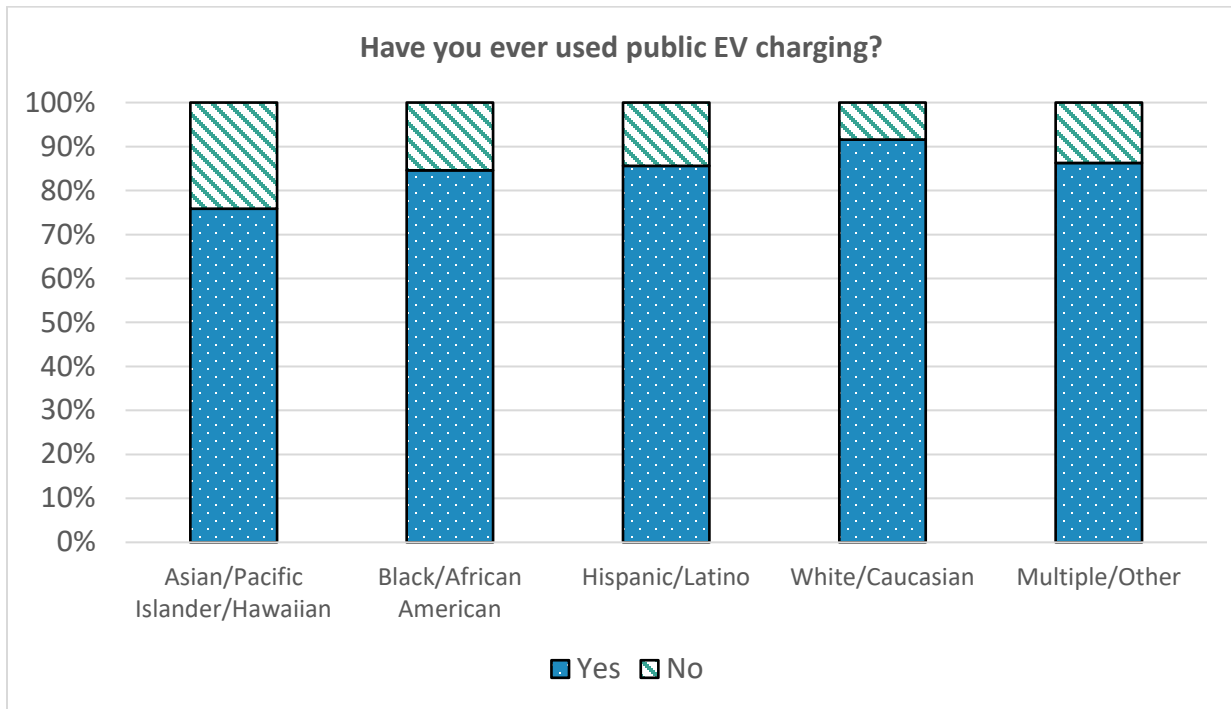


Figure 9: Experience using public electric vehicle charging by race/ethnicity



Concerns surrounding electric vehicle charging (perceived barriers)

Respondents who had never experienced driving a plug-in electric vehicle or using an electric vehicle charging station (combined, 40% of all respondents) were split 50-50 between those who were worried about problems at electric vehicle charging stations and those who were not.

The top five situations that respondents⁹ were worried about encountering with electric vehicle charging were:

- Charging is too slow (cited by 49% of respondents to this question)
- Chargers are all in use (47%)
- I am unable to locate a charger (40%)
- Charging is too expensive (40%)
- I need to become a member of a charging company in order to access a session (29%)

⁹ Respondents were invited to answer this question only if they responded 'Yes' to Question 10 "Are you worried about problems at EV charging stations?" Of the 1,076 individuals who responded to Question 10, 546 responded 'Yes.'

Overall, these concerns speak to the speed of charging, demand for energy, geographic convenience of charging stations, charging affordability, and membership-restricted access to charging.

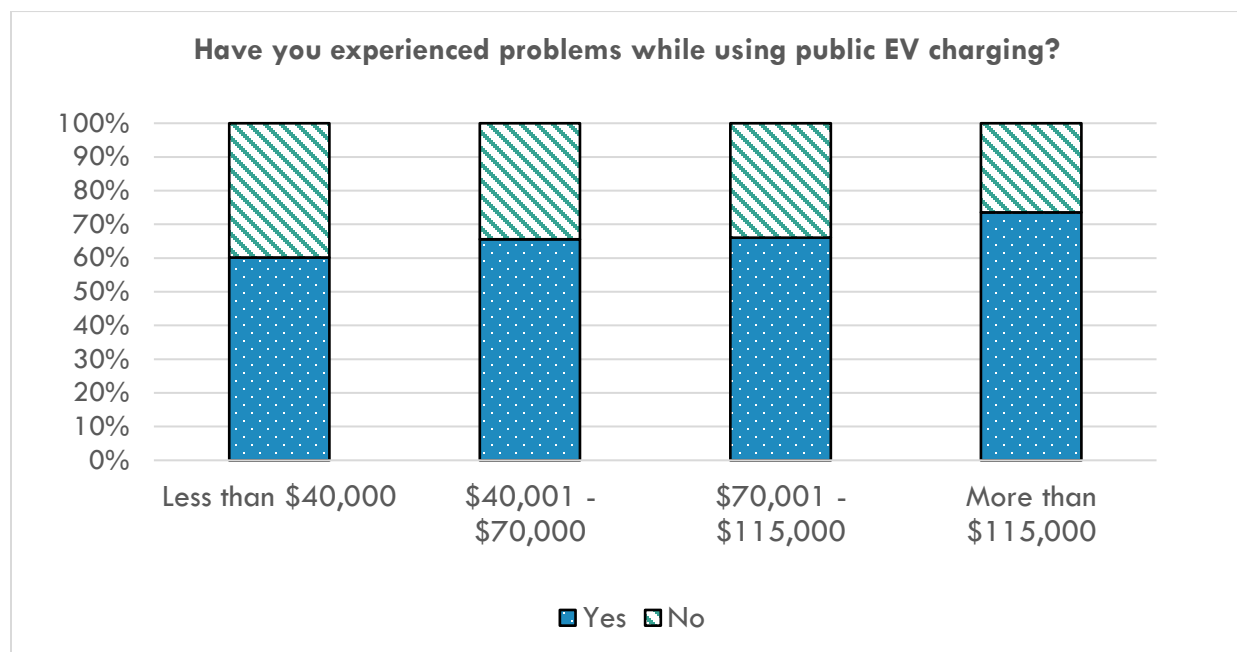
There was no difference in top-ranked concerns as differentiated by gender, annual household income, or race/ethnicity.

Among respondents who provided an open-text response to elaborate on their concerns with using public electric vehicle charging stations, a common theme was the lack of access to electric vehicle chargers in high-density residential complexes/apartment buildings.

Problems encountered with electric vehicle charging (actual barriers)

Of those with experience using public electric vehicle charging, two-thirds have encountered problems. Respondents earning more than \$115,000 were more likely to report having experienced problems with public electric vehicle charging (three-quarters) versus respondents with an income of \$40,000 or less (three-fifths). This question controlled for whether an individual had used public electric vehicle charging before, but not how many months/years they have been using public electric vehicle charging, or how regularly in an average week.

Figure 10: Respondents that have experienced problems with public electric vehicle charging, by household income



The top five issues that respondents reported having experienced were:

- The chargers were all in use (68% of respondents to this question)
- Chargers were unresponsive (67%)
- Chargers were physically damaged (59%)
- Charging was too slow (48%)
- Issues with the station accepting a user’s form of payment (45%)

The top problems faced at public electric vehicle charging stations are the same regardless of gender, income level, or race/ethnicity, albeit with slight deviations in the percentage of respondents picking a particular problem. Table 1 shows that respondents from households with an income under \$40,000 cited payment acceptance issues with the station and the price of charging sessions as their fourth and fifth most cited problems, respectively. Whereas those with an income of \$115,000 or more cited the problems of the charging being too slow and having a hard time reading the screen/blank screen.

Table 1: Top 5 problems experienced with electric vehicle charging by household income

Top cited problems actually experienced (Less than \$40,000)	Top cited problems actually experienced (More than \$115,000)
1. Chargers were all in use	1. The charger was unresponsive
2. The charger was physically damaged	2. Chargers were all in use
3. The charger was unresponsive	3. The charger was physically damaged
4. Issues with the station accepting my payment	4. Charging was too slow
5. Charging was too expensive	5. Hard to read screen/blank screen

It is clear that availability of chargers is both a concern *and* a reality when comparing the perceptions that individuals have about public electric vehicle charging with the challenges that are actually experienced. Being unable to locate a charger was a concern that does not seem to be borne out by data from those who have used public electric vehicle charging. In contrast, unresponsive and damaged chargers, and problems with charging stations accepting users’ payment, have been a reality for many public electric vehicle charging users; these technological/infrastructure

issues are not anticipated by those who have never used public electric vehicle charging.

Among respondents who provided an open-text response to further describe the problems they have experienced at public electric vehicle charging stations, a commonly reported problem was that internal combustion engine vehicles were blocking the electric vehicle-only parking spaces. Drivers also reported discovering that the charging plugs were not always compatible with their model of electric vehicle, or that the charging cable was too short – both rendering the charging stations unusable for these individuals.

Of the issues encountered that were payment-specific, not being able to pay without a membership was the most-cited problematic experience, followed by the payment card reader not functioning properly. The ranking of payment-related problems was the same regardless of gender, household income level, or race/ethnicity. Table 2 below lists these payment-related issues, from most common to least common. Approximately one in five respondents stated they have never experienced a problem while paying for electric vehicle charging.

Table 22: Payment-related problems actually experienced

1. I couldn't pay without a membership
2. The payment card reader was not functioning properly
3. The payment process was too complex
4. I did not have the right type of payment card
5. I was not charged the correct amount

Contacting customer service

Approximately 40% of all respondents reported having contacted customer service about a public electric vehicle charging session. There was no significant difference between males and females, or individuals of different annual household income brackets. However, individuals who identified as Asian American/Pacific Islander/Hawaiian were significantly less likely to have contacted customer service than individuals of any other racial or ethnic group. The most reported reasons for contacting customer service are described in Table 3.

Table 33: Reasons for contacting customer service¹⁰

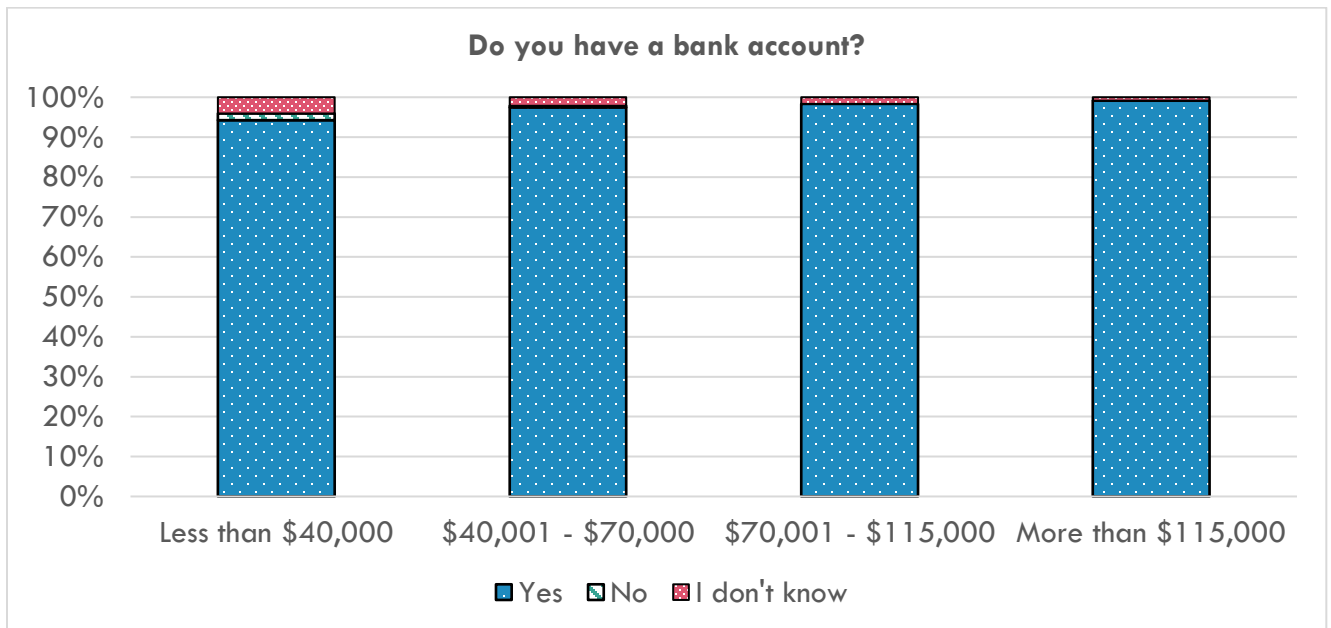
1. Chargers or payment equipment was not working
2. Connector was broken
3. The charger shut off during charging session
4. No way to pay with my payment card on the charger
5. Not a member of the network

¹⁰ These issues were ranked the same regardless of gender, household income or race/ethnicity.

Access to financial products and services

Most respondents have a bank account (96%). Females were slightly but significantly less likely to have a bank account than males, and individuals from households who earn less than \$40,000 per year were significantly less likely to have access to a bank account than individuals from higher income brackets. There were no significant differences between racial or ethnic groups. Of the few respondents who said they do not have a bank account, the most cited reason was that they don't want one, followed by bank fees being too high and not trusting banks.

Figure 11: Access to a bank account by household income



Respondents were asked which of the following financial products or services they (or someone in their household) use:

- Checking or savings account
- Prepaid or reloadable debit card
- Credit card (Visa, Mastercard, Discover, American Express)
- Check cashing somewhere other than a bank
- Payday loan or advance services somewhere other than a bank (Advance America, ACE Cash Express)
- Peer-to-peer payments (Venmo, Cash App, others)
- Wire transfer (Wester Union)
- Mobile wallet (Apple Pay, Google Pay, Samsung Pay)
- Other
- I don't know

Of these products/services, checking or savings accounts were the most used among all respondents. Females were slightly but significantly less likely to use a credit card than males, while respondents with a household income of less than \$40,000 were significantly less likely to report using a credit card, peer-to-peer payment methods, or mobile wallets than respondents from any other household income bracket. Having less access to credit as a deferred payment option may also be contributing to the experience of electric vehicle charging being more unaffordable/expensive for lower-income households.

Finally, respondents who identified as white/Caucasian were significantly more likely to use a credit card than respondents identifying as any other race or ethnicity. White/Caucasian respondents were also more likely to use peer-to-peer payment methods or mobile wallets when compared with all other groups except respondents identifying with multiple or other racial or ethnic groups. Black/African American respondents were significantly more likely to make use of prepaid reloadable debit cards than either Asian American/Pacific Islander/Hawaiian respondents or white/Caucasian respondents.

Figure 12: Use of financial products and services by gender

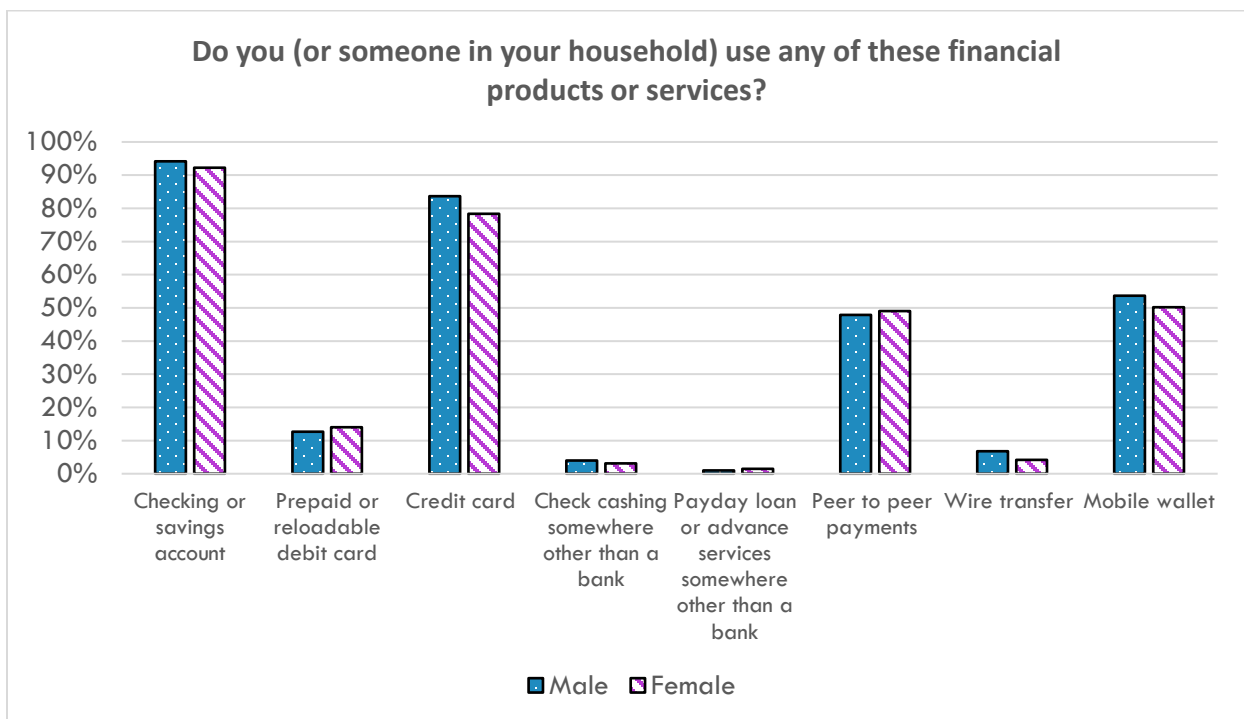


Figure 13: Use of financial products and services by household income

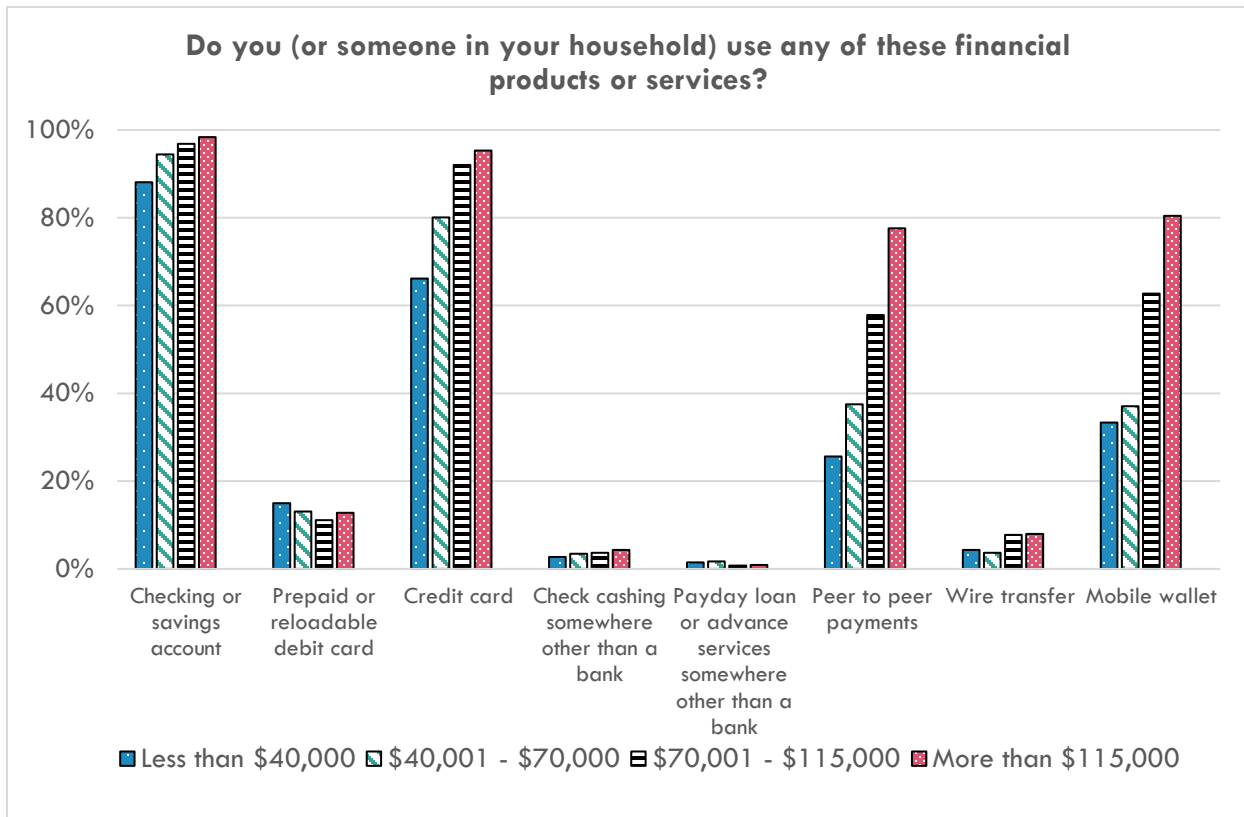
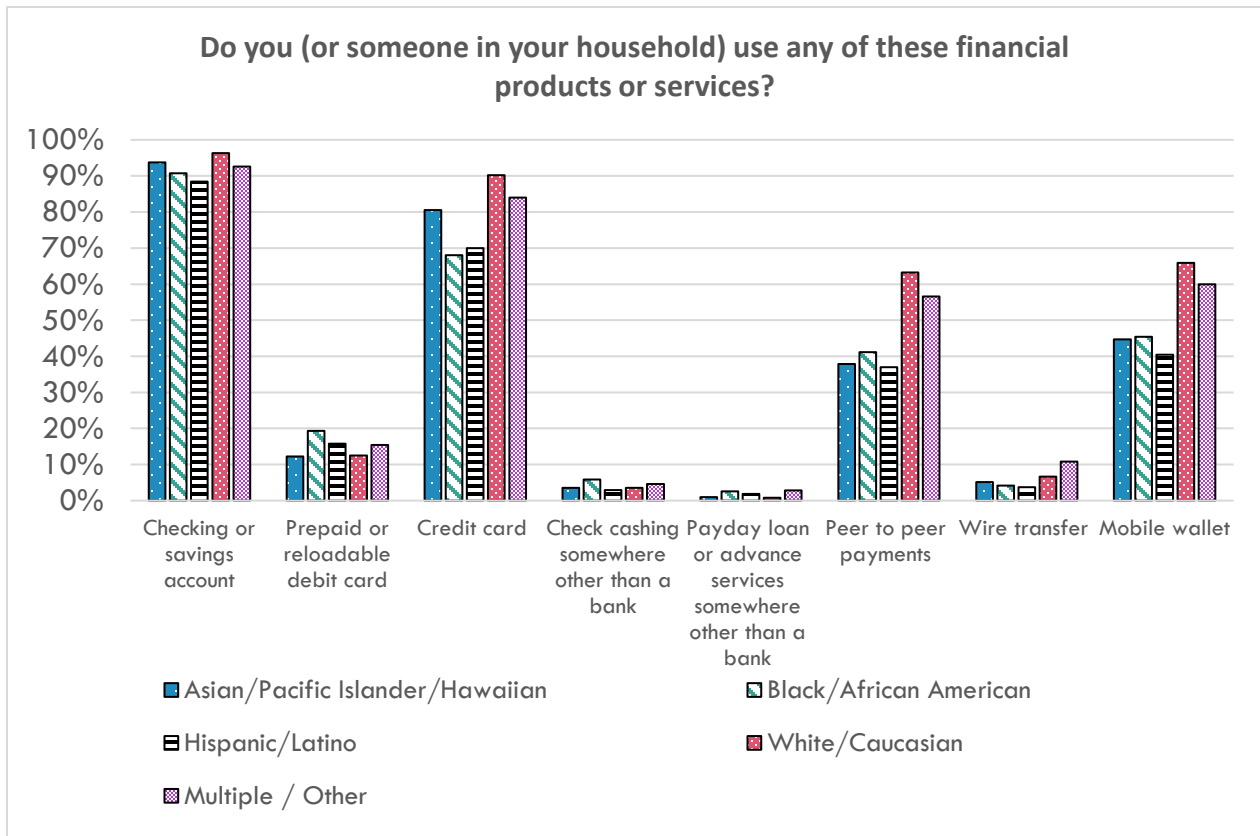


Figure 14: Use of financial products and services by race/ethnicity



Contactless payments

Among all survey respondents, 87% had access to a contactless tap payment option, whether that was a physical card; a smartphone with a contactless payment method, or both. Females were slightly but significantly less likely to have a contactless tap payment option available to them than males. In addition, roughly 23% of individuals with a household income under \$40,000 do not have a contactless payment option, compared with only 2% of individuals with a household income of \$115,000 or higher – a statistically significant difference. Finally, white/Caucasian respondents were significantly more likely to have a contactless tap payment option than respondents from all other racial or ethnic groups except for Black/African American respondents.

Figure 15: Access to a contactless tap payment option by gender

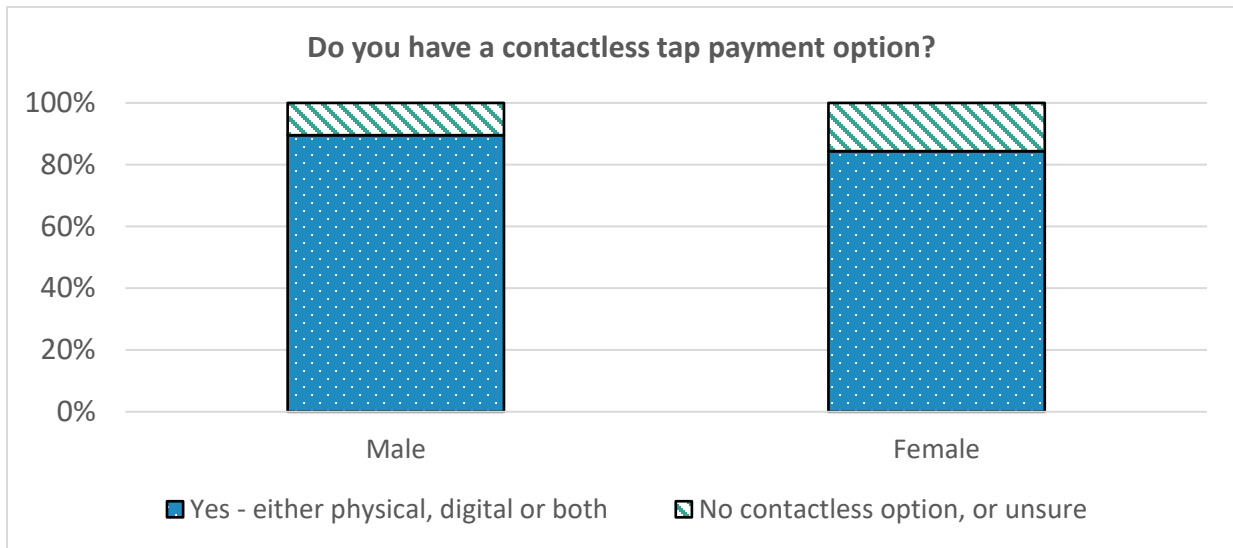


Figure 16: Access to a contactless tap payment option by household income

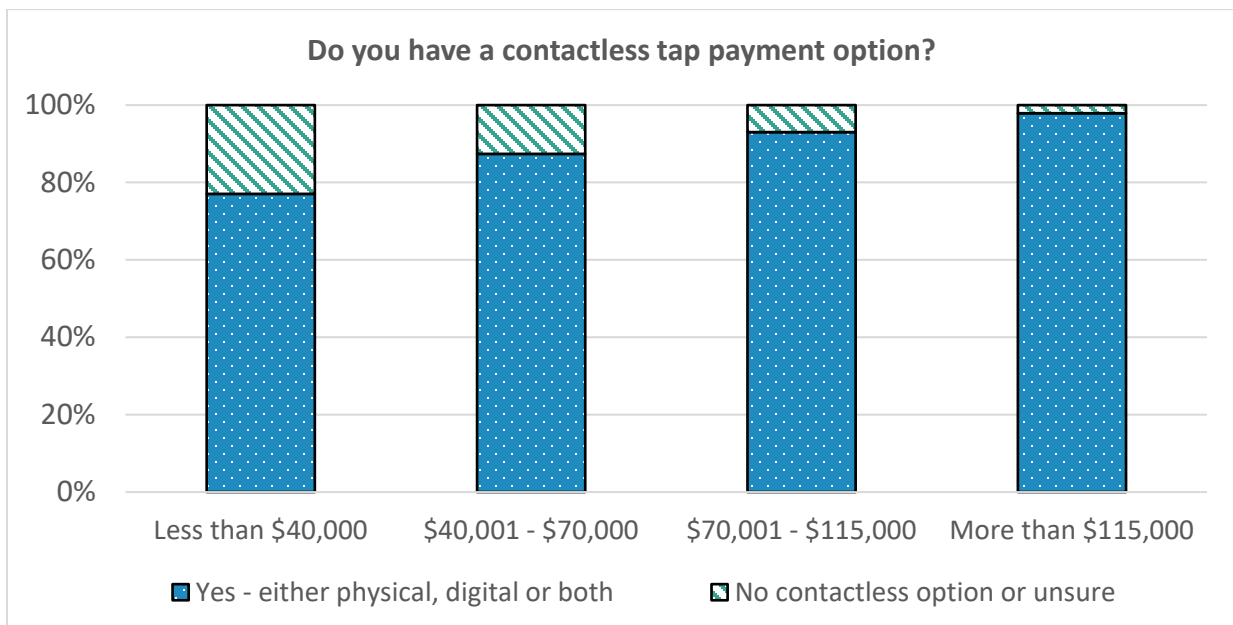
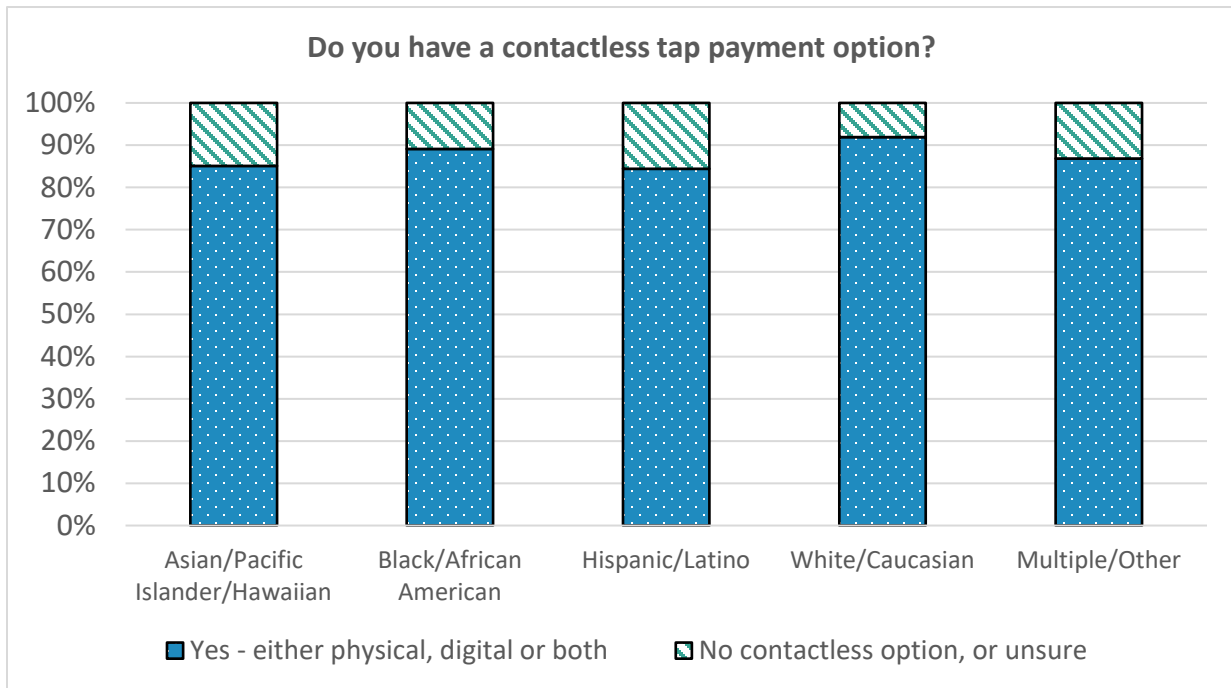


Figure 17: Access to a contactless tap payment option by race/ethnicity



Proportionally, there was little difference between males and females in their propensity to use contactless payment options with roughly two-thirds using their contactless payment cards “always” or “most of the time.” The propensity to use a contactless tap payment option “always” or “most of the time” increases (marginally but significantly) with household income from roughly 60% among the lowest income bracket to 70% among the highest income bracket. There was no significant difference in the frequency of contactless payment usage between different racial or ethnic groups.

Payment preferences

Finally, respondents were asked which of the following payment options they would prefer to use to pay for public electric vehicle charging:

- Contactless tap credit or debit card or mobile wallet
- Credit, debit, or prepaid card (with chip)
- Mobile phone application from charging provider
- 1-800 number
- QR code on mobile phone
- Electric vehicle charging company-issued card
- Automatic billing from vehicle (Plug & Charge)

The top two preferred ways to pay for public electric vehicle charging were “automatic billing from vehicle (Plug & Charge),” and “contactless tap credit or debit

card or mobile wallet”, irrespective of gender, household income, or race/ethnicity. The least preferred options were “electric vehicle charging company issued card” and “dialing a 1-800 number”, again irrespective of gender, household income, or race/ethnicity. Dialing a 1-800 number was ranked lowest by almost half of all respondents.

KEY FINDINGS AND RECOMMENDATIONS

Learnings from this survey can help to inform strategies and shape policy for increasing the accessibility and usability of electric vehicles and electric vehicle charging.

Regarding charging reliability and the experience of EV drivers:

Key finding 1: The experience of using public electric vehicle charging is not yet consistently reliable or satisfactory for most users.

Among respondents with experience using public electric vehicle charging, two-thirds have encountered problems. The top five issues that respondents reported experiencing were:

1. The chargers were all in use (68% of respondents to this question)
2. Chargers were unresponsive (67%)
3. Chargers were physically damaged (59%)
4. Charging was too slow (48%)
5. Issues with the station accepting a user’s form of payment (45%)

Key finding 2: Concerns about public electric vehicle charging (among those who have never used it) typically focus on different problems than those reported by public electric vehicle charging users.

Being unable to locate a charger was a concern among individuals who had never used public electric vehicle charging, but it was not reported as a problem by those who have. In contrast, unresponsive and damaged chargers, and problems with charging stations accepting a user’s payment, have been a reality for many public electric vehicle charging users and yet these technological/infrastructure issues are not anticipated by those who have never used public electric vehicle charging.

Nonetheless, availability of chargers is both a concern *and* a reality when comparing the perceptions that individuals have about public electric vehicle charging with the challenges that are actually experienced.

Recommendation: Advocate for the increased quality and reliability of public electric vehicle charging infrastructure.

Engaging with charge point operators (charging providers) will be key to achieving more consistent and reliable experiences at public electric vehicle charging stations.

Areas of focus should include the need for routine maintenance schedules; active charge point error tracking and resolution; and standardizing on payment options.

Other challenges, which overlap with the mandates of other state or local entities, include solving for an anticipated increase in demand for charging (including in the vicinity of high-density residential buildings); and deterring/preventing internal combustion engine vehicles from parking in electric vehicle-only designated charging spaces.

Regarding payments at EV charging stations:

Key finding 1: Memberships act as a barrier to frictionless payments.

Of the issues encountered that were payment-specific, not being able to pay without a membership was the most-cited problematic experience, followed by the payment card reader not functioning properly

Key finding 2: Drivers prefer interoperable and convenient ways to pay for public electric vehicle charging.

The top two preferred ways to pay for public electric vehicle charging were “automatic billing from vehicle (Plug & Charge),” and “contactless tap credit or debit card or mobile wallet,” irrespective of gender, household income, or race/ethnicity. The least preferred options were “electric vehicle charging company issued card” and “dialing a 1-800 number.”

Key finding 3: Contactless payment options are popular but not yet universal.

Among all survey respondents, 87% have access to a contactless tap payment option, whether that is a physical card; a smartphone with a contactless payment method, or both. Access varies significantly across income groups; roughly 23% of individuals with a household income under \$40,000 do not have a contactless payment option, compared with just 2% of individuals with a household income of \$115,000 or higher.

Recommendation: Continue to advocate for consistency and interoperability between public electric vehicle charging stations.

CARB’s Electric Vehicle Supply Equipment Standards Regulation (2019) requires contactless or contactless chip-enabled payments to be made at all public charging stations in the state of California,¹¹ thereby ensuring that drivers will not be required to pay a subscription fee or become a member to use a charging station.

¹¹ New installations must have the required EMV card technology by Jan 1, 2022, for public direct current fast charging (DCFC) and July 1, 2023, for public Level 2 chargers. Existing installations must be retrofitted by July 1, 2033.

Looking ahead, drivers continue to emphasize their desire for hassle-free payments. They want the ease of being billed automatically via Plug & Charge or to use their contactless payment card or their mobile wallet. The current regulation specifically ensures more universal charging access through standardizing of the most ubiquitous form of card payment. Future policies and regulations will likely need to focus on the interoperability of the Plug & Charge standard.

NEXT STEPS

Survey results will be shared with CARB's peer network and with key stakeholders. The conclusions from this survey offer data-driven insights to inform actions, including future iterations of regulations or other types of government intervention, that aim to increase equitable access to, and use of, zero-emission vehicles throughout the state of California.

Appendix A | Statistical Significance

In this report, statistical tests were performed to determine whether participants' responses varied significantly by gender, annual household income, or race/ethnicity (categorical variables). The tests, called Chi-square, are described below.

Chi-square test

The Chi-square test of independence checks whether two variables are likely to be related or not. Crucially, it does not tell us that one variable *causes* the other, simply that there is a relationship between the two.

When the test statistic is less than the critical value (or if the p-value is less than the chosen significance level), then there is a significant association between the two variables (e.g., being in a low-income household and having access to a credit card). If the test statistic is greater than the critical value (or if the p-value is greater than the chosen significance level), then there is no significant association between the two variables.

To avoid affecting the accuracy of the significance tests, categories with very low sample sizes were not included for analysis. The chosen significance level was 0.05 (5%).

Appendix B | Survey Questions

Table B14: Survey questions and response options provided to respondents

1.	Do you live in California? (Yes/No)
2.	Do you have access to a vehicle for your mobility needs? <ul style="list-style-type: none"> • Always • Sometimes • Rarely • Never
3.	Do you currently drive, or have you driven, a plug-in electric vehicle (the vehicle has an electrical plug for charging)? (Yes/No/I don't know)
4.	Do you have a bank account? (Yes/No/Prefer not to say)
5.	Are there any specific reasons why you do not have a bank account? <ul style="list-style-type: none"> • Don't trust banks • Bank account minimum balance requirements too are high • Bank account fees are too high • Bank account fees are too unpredictable • Bank locations are inconvenient • Bank hours are inconvenient • Banks do not offer products or services I need • I don't have the right personal identification documents to open a bank account • I don't want a bank account • Other (open text response)
6.	Do you (or someone in your household) use any of these financial products or services? <ul style="list-style-type: none"> • Checking or savings account • Prepaid or reloadable debit card • Credit card (Visa, Mastercard, Discover, Amex) • Check cashing somewhere other than a bank • Payday loan or advance services somewhere other than a bank (Advance America, ACE Cash Express) • Peer-to-peer payments (Venmo, Cash App, others) • Wire transfer (Western Union) • Mobile wallet (Apple Pay, Google Pay, Samsung Pay) • Other (open text response) • I don't know

7.	<p>Do you have a contactless tap payment option to pay for goods and/or vehicle fueling?</p> <ul style="list-style-type: none"> • Yes, I have at least one contactless tap payment • Yes, I have a smartphone with a contactless tap payment option • I don't know • No
8.	<p>How often do you use the contactless tap payment option to pay for goods and/or vehicle fueling?</p> <ul style="list-style-type: none"> • Always (i.e., more than 75% of the time) • Most of the time (i.e., 51-74% of the time) • Sometimes (i.e., 11-50% of the time) • Rarely (i.e., less than 10% of the time) • Never
9.	<p>Have you ever used public EV charging? (Yes/No)</p>
10.	<p>Are you worried about problems at EV charging stations? (Yes/No)</p>
11.	<p>What problems are you worried about experiencing at public EV charging stations?</p> <ul style="list-style-type: none"> • The chargers are constantly physically damaged • The chargers are unresponsive when I use them • Charging is too complicated • Charging is too expensive • I'm unable to locate a charger • Need to become a member of the charging company • Have the right form of payment • Issues with the station accepting my payment • Hard to read screen / blank screen • No / unclear instructions on how to start a charging session • Charging is too slow • Chargers are all in use • Other (open text response) • I don't know
12.	<p>Have you experienced problems while using public EV charging? (Yes/No)</p>
13.	<p>What problems have you experienced with public EV charging?</p> <ul style="list-style-type: none"> • The charger was physically damaged • The charger was unresponsive • Charging was too complicated

	<ul style="list-style-type: none"> • Charging was too expensive • Unable to locate a charger • I was not a member • I did not have the right form of payment • Issues with the station accepting my payment • Hard to read screen / blank screen • No / unclear instructions on how to start a charging session • Charging was too slow • Chargers were all in use • Other (open text response) • I don't know
14.	<p>What problems have you experienced specifically with paying for public EV charging?</p> <ul style="list-style-type: none"> • Couldn't pay without a membership • Payment card reader was not functioning properly • I was not charged the correct amount • I did not have the right type of payment card • Payment process too complex • I haven't experienced any problems • Other (open text response)
15.	<p>Have you ever had to contact customer service? (Yes/No)</p>
16.	<p>Why did you have to contact customer service?</p> <ul style="list-style-type: none"> • Charger or payment equipment not working • Not a member of the network • No way to pay with my payment card on the charger • Insufficient cell service to download mobile app • The connector was broken • Charger shut off during charging session • Other (open text response)
17.	<p>What payment options would you prefer to use if you were to use a public EV charger? (Respondents are asked to rank from 1 [highest] to 7 [lowest])</p> <ul style="list-style-type: none"> • Contactless tap credit or debit card or mobile wallet • Credit, debit, or prepaid card (with chip) • Mobile phone application from charging provider • 1-800 number • QR-code on mobile phone • EV charging company issued card • Automatic billing from vehicle (Plug & Charge)
18.	<p>With which gender do you identify?</p>

	<ul style="list-style-type: none"> • Male • Female • Other (open text response) • Prefer not to say
19.	What is your birthday year?
20.	<p>Which race/ethnicity do you most closely identify with?</p> <ul style="list-style-type: none"> • Asian/Pacific Islander/Hawaiian • Black/African American • Hispanic/Latino • Native American • White/Caucasian • Prefer not to say • Other (open text response)
21.	<p>Which of the following categories contains your approximate annual household income before taxes?</p> <ul style="list-style-type: none"> • Less than \$25,000 • \$25,000 to \$40,000 • \$40,001 to \$55,000 • \$55,001 to \$70,000 • \$70,001 to \$85,000 • \$85,001 to \$100,000 • \$100,001 to \$115,000 • \$115,001 to \$125,000 • \$125,001 to \$150,000 • \$150,000 or more • Prefer not to say
22.	<p>What is your household size?</p> <ul style="list-style-type: none"> • One • Two • Three • Four • Five • Six • Seven or more • Prefer not to say
23.	What is your ZIP code?

Appendix C | Respondent Zip Code

