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Developing a Feasible Business Model for Expanding the EV Market to Lower-Income Californians

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CSUTC California State University Transportation Consortium

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16. Abstract Electric vehicles (EVs) are a valuable tool in addressing the climate and energy challenges placed on our transportation systems. However, while national and international market shares of EVs have been rising with exponential rates, access to EVs of low-income populations has been significantly slower. This research developed a business model for expanding the EV market to low-income Californians. The team developed the model from qualitative data from various stakeholders, including Electric and Solar Companies, Professional and Community-Based Organizations, State Agencies, research institutions, and more, which enabled insights regarding various barriers that hinder the adoption of EVs. The team also used a state-wide survey to understand the barriers from the point of view of lower income Californians. The business model created from this data can be used by state administrators, policy makers, and social emprises to mitigate the barriers faced by low-income Californians within the EV market.			
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1. Introduction

As climate change, air pollution, energy demand, and other challenges facing our transportation systems continue to intensify, electric vehicles (EVs) are seen as having high-value potential for addressing these challenges (Shaheen, Wright, & Sperling, 2002). Governments, public agencies, and researchers across the globe have been identifying, developing, and testing a plethora of different programs and policies to increase the adoption rates of EVs (Bernhart, Zhang, & Wagenleitner, 2010; Miao et al., 2016). Examples of these programs include customer and dealer rebate programs (Hardman & Tal, 2016; Johnson & Williams, 2017; Tal & Nicholas, 2016; Williams & Lipman, 2010), tax credit programs (Hardman & Tal, 2016; Johnson & Williams, 2017; Tal & Nicholas, 2016), battery lease programs (Hou, Du, & Wang, 2010; Li & Ouyang, 2011), carbon reduction credit policies (Williams & Lipman, 2010); and second life programs for EV batteries (Lidicker, Lipman, & Williams, 2011; Williams, 2012).

As a result of these extensive research efforts and the resulting policies and programs, EVs' regional, national, and international market shares have been rising exponentially. However, access to EVs for low-income populations has been significantly lower. Accordingly, as part of California's Senate Bill 350, the California Air Resource Board was tasked with conducting a study to "examine the barriers low-income residents must overcome to increase access to zero-emission and near zero-emission transportation and mobility options and develop recommendations on how to address these barriers" (California Air Resources Board, 2018). The study identified four fundamental types of barriers, namely: (i) barriers within a community, such as access, convenience, and safety; (ii) barriers in affordability; (iii) barriers in funding for clean transportation investments; and (iv) barriers in awareness of clean transportation and mobility options. Furthermore, the study concluded with six main recommendations for overcoming these barriers. However, what was beyond the scope of that comprehensive study was the development of a feasible business model that would be appealing for auto dealerships as well as low-income Californians (California Air Resources Board, 2018). Accordingly, this is what the present project aims to achieve.

Different business models have different impacts on the acceptance, appeal and adoption of EVs (Bernhart et al., 2010; Liao, Molin, Timmermans, & van Wee, 2018; Miao et al., 2016). Therefore, developing a feasible and attractive business model is a crucial step for the successful expansion of the EV market to lower-income Californians. The costs of used electric vehicles are highly competitive with internal combustion engine (ICE) vehicles. Yet, while the energy cost of EVs is much lower than that of ICE vehicles, the risk of needing to replace the high-cost battery could be one of many major hurdles for low-income Californians (Lidicker, Lipman, & Shaheen, 2010; Santini, Patterson, & Vyas, 2000). On the other hand, auto dealers do not appear to find it appealing to offer deals to low-income Californians.

The objective of this project is to develop a feasible business model for expanding the EV market to lower-income Californians. The model promises to address existing barriers that face low-income Californians.

2. Literature Review

Electric vehicles have come to the main stage of energy-efficient technologies and have become widely recognized by cities, businesses, and governments across the globe. Electric vehicles are a way to reduce greenhouse gas emissions, put the US back on top of energy security, and boost economic development by creating additional domestic jobs while improving the local air quality.

Electrification of transportation is the key to reaching global energy and climate policy goals. The transportation sector is responsible for very large portions of the CO_2 emissions stemming from fossil fuel consumption. According to the Environmental Protection Agency (2020), the transportation sector is the primary source of greenhouse gas emissions in the United States (e.g., 28.2% of 2018 greenhouse gas emissions).

In addition to tackling the environmental issue of greenhouse gas emissions and pollution, electric vehicles offer several advantages over traditional internal combustion engine vehicles. The advantages include economic savings through lower operational costs, reduction of noise pollution, better performance of electric vehicles (less vibration, less noise, and better acceleration), and the potential convenience of charging at home or work (Lance Noel, 2018).

Although there are a multitude of positive outcomes from the adoption of electric vehicles, there are still barriers to widespread adoption. According to existing literature sources, some of the major reasons people don't purchase electric vehicles include a lack of clear knowledge about electric vehicles, high upfront purchasing costs caused by high battery costs, limited range, concerns about the availability of charging infrastructure, and risk associated with the purchase or lease of electric vehicles (Ona Egbue, 2012). These barriers are compounded for low-income communities. Although each of these barriers can be significant in deterring individuals from purchasing an electric vehicle, there are many initiatives and current efforts to address each of these major concerns. The current efforts include public outreach, improvements in technology, rebates and incentives, and government initiatives which promote the sale of electric vehicles. The following sections present the current literature and research completed on the barriers to electric vehicle adoption, specifically addressing barriers to low-income communities.

2.1 Knowledge Barrier

One major reason the electric vehicle market hasn't taken off is the lack of information consumers have about EVs. The first popular electric vehicle, released by General Motors in 1996, was the EV1, which gained a cult following at the time. The next big boom in electric vehicles came with the Chevy Volt, the first available plug-in hybrid, followed by the Nissan LEAF, and the Tesla Model S (United States Department of Energy, 2014). Although EV have been around for more than an decade, there is still a large population of people who have little to no knowledge about electric vehicles or who have been exposed to misinformation and have incorrect notions.

2.1.1 Lack of Information and Exposure

One common finding has been that people lack information about the costs, benefits, charging infrastructure, and incentives surrounding electric vehicles. Although there are many websites, organizations, and advertisements which feature electric vehicles, much of the public still lacks awareness and knowledge. This barrier was found to be compounded for low-income individuals, who may have limited access to broadband internet service and can't access information on clean vehicles, incentives, or the locations of charging stations. In addition, community organizations and local transportation agencies may also lack awareness of clean transportation grant solicitations or other funding opportunities. These grants are offered by multiple sources and agencies, each with their own requirements and timelines.

Another reason people may have little knowledge about electric vehicles is that they have not been exposed to EVs in their community. This unfamiliarity with electric vehicles, combined with "not in my backyard" attitudes, can contribute to disinterest surrounding EVs. Further, residents may have some hesitation and distrust towards new technologies such as clean vehicles and may therefore be more reluctant to purchase them (California Air Resources Board, 2018).

The California Air Resources Board (CARB) convened an Environmental Justice Advisory Committee (EJAC) which consists of representatives from communities within California that experience the most significant exposure to air pollution, which are often the same communities with minority and/or low-income populations. The EJAC held a series of community-based meetings across California that were centered around the major topics and sectors of the climate plan, including industry, agriculture, and transportation. According to a summary of the seven meetings, San Bernardino, Oakland, and South Los Angeles each had a key takeaway about residents' lack of awareness and the need for more education and outreach centered around electric vehicles. The community-based meeting in Oakland further stated that residents had a lack of awareness and understanding of Climate Change Investment Programs, a source offering funding for consumers (California Air Resources Board, 2018).

Another set of community-based case studies was performed by CARB to study the barriers to clean transportation in each of the selected communities: Huntington Park, Huron, Redwood Valley, and North Richmond. In these communities, there were many people who reported a distrust of dealerships, e.g., that they were inflating prices, especially those of zero-emission vehicles and incentives. They also stated that they had uncertainty about electric vehicle technology or lacked knowledge on the technology. Specifically, some residents did not know about the car makes and models or their costs and charging capabilities. Some even stated they had misconceived notions about the prices of the vehicles and were surprised by how reasonably priced they were. Additionally, residents lacked knowledge on the programs, incentives, and funding offered by the state. Community members also recommended that clean transportation information be updated routinely and that the information be made available in Spanish (California Air Resources Board, 2018).

The California Vehicle Survey Report (2015–2017) also presented similar findings. This report included interviews with participants in residential and commercial focus groups in four areas: Fresno, Los Angeles, Sacramento, and San Francisco. Each focus group was made up of about 8–10 individuals recruited by firms that employed screening questions to recruit people with diverse backgrounds. These case studies included an interview component inviting individuals to discuss their alternative fuel knowledge and perceptions. Participants in the focus groups indicated that they had heard EVs were "slow" and "plastic-y" (RSG, 2018), which reflected lack of safety concerns.

2.1.2 Misinformation

In addition to the issue of inadequate information about electric vehicles, some reports against electric vehicles have been put out from oil-backed studies, which has contributed to a misinformation campaign against electric vehicles (Whitman, 2018). One claim is that "more electric cars and trucks will mean more pollution" which appeared in a story run by Politico and written by Jonathan Lesser, an energy industry consultant with the Manhattan Institute which is funded by Koch, Mercer, and Exxon (Lesser, 2018). This notion, however, has been disproven many times over. Another falsehood is that transportation is not the true culprit of polluting emissions. It has been shown, however, that about a third is attributable to cars and trucks (Dans, 2018). Such narratives may be muddling the public's perception on the value and effectiveness of electric vehicles.

Another target of misinformation is the electric vehicle battery, which many claim is made of scarce mineral sources, can't be recycled, and degrades quickly. Studies show, however, that batteries can be recycled and are reusable. In addition, batteries degrade at about 1% every 30,000 km (18,641 miles). This puts them at a higher efficiency than their internal combustion rivals. Similarly, some believe that maintenance is an issue. Electric vehicles have around 18 moving parts with low degradation, while internal combustion engines have more than 10,000 moving parts that require lubrication and periodic replacement. This causes much lower maintenance costs for electric vehicles (Dans, 2018).

In addition to the false information floating around about EV technology, there have also been some concerns about the safety of electric vehicles. In particular, fire-related EV accidents occurred in 2011 in both China and the United States. These accidents were covered very extensively in the media and have provoked skepticism and caution about the safety of the EV vehicles. These safety concerns have been addressed by a comprehensive evaluation which indicates that EVs do not have a higher risk of fire than internal combustion engine vehicles (Ghazale Haddadian, 2015).

2.1.3 Current Efforts to Mitigate Knowledge Barriers

Although there is plenty of skepticism and misinformation regarding EVs, there are also some initiatives which are aimed at informing the public. Significant progress has been made in the past

decade in increasing education and outreach efforts, completed through current laws and state programs.

Senate Bill 375 is the Sustainable Communities and Climate Protection Act, which sets regional targets for greenhouse gas emissions. These targets were established for 2020 and 2035 and have resulted in community planning. This includes an increase in public discussion about benefits, outreach, and public participation as well as coordination and funding allocation.

In addition, Senate Bill 1275 was passed in the State Legislature and signed by Governor Brown in 2014. The California Charge Ahead Initiative is a bill which supports consumer incentives and rebates to promote the state's goal of one million EVs in California before January 1, 2023. This law will also require that the programs will be targeted specifically to benefit low-income residents and disadvantaged communities. In addition, Assembly Bill 1550 sets the investment requirements for disadvantaged communities to higher levels than were previously set for clean transportation. Assembly Bill 2722 provides grants for disadvantaged communities to perform outreach and assess projects' environmental justice benefits.

The California Air Resources Board has conducted various interviews and studies which identified the need for outreach and education in low-income communities. Specifically, it was found that outreach should be broadened to multilingual programs in order to reach individuals in the predominant language spoken in the communities. Additionally, the outreach needs to be done on a routine schedule to ensure a consistent presence is established to build trust. Another tool they have promoted is a "one-stop-shop" hub of information which provides residents with all the information on clean energy, transportation, and housing projects in their area. This is a current project which develops a web-based application tool which can be used to inform consumers of whether they are pre-qualified for rebates or incentives (California Air Resources Board, 2018).

One program involving a low-income community in California is called The Bolt to College by the California Energy Commission CALSTRART, which offers door-to-door service for students to travel to Fresno City College (FCC) from Kerman and back in an electric vehicle free of charge. The Chevrolet Bolt is used in an effort to advance goals for cleaner air and less pollution in the Fresno area. Surveys were administered to students and drivers who participated in the program. The student surveys reflected positive feedback for the program including that a majority of the respondents would be "much more likely to use Ride-share / carpooling and electric vehicles" in the future after being exposed to this program. Although almost all of the riders knew the Chevrolet Bolt was an electric vehicle, most had not driven in an electric vehicle. There was a broad spectrum of how much knowledge the respondents had on electric vehicles prior to using the Bolt to College service. Some respondents also had concerns about battery life and were skeptical about the smoothness of electric vehicles, but many reported thinking that EVs are good for the environment and save money. About 47% of the respondents stated that using the Bolt to College service changed their opinion on electric vehicles, saying that it made them think EVs are good for the environment, reliable and effective, and competitive with gas vehicles, while a couple

people even said they would purchase one. These results indicate that people who are exposed first-hand to electric vehicles may form positive opinions of them and may even be inclined to purchase one.

2.2 Cost Barrier

Another reason electric vehicles haven't become more widespread across all income groups is the higher upfront costs of the vehicles compared to their internal combustion engine counterparts. Cost has made purchasing EVs unappealing, specifically for low-income customers who may not qualify for a low-interest loan or lease option. Also, many low-income residents don't have credit cards or bank accounts required to access an electric vehicle. In addition, residents have reported that they distrust dealerships and financial lenders because they have the perception that they inflate the price of electric vehicles (California Air Resources Board, 2018).

Buying a vehicle is heavily determined by one's budget. Whether considering a new or used vehicle, sale price is heavily dependent on the location, type of vehicle, and brand of the car. The average price of a four-door sedan that is gasoline-powered is $35,000 according to Kelly Blue Book. Electric vehicles, on the other hand, cost $55,000 on average. It is worth noting that this average price is skewed by luxury, high-end models such as the Tesla Model S and Model X. Other electric vehicles such as the Kia Soul, Nissan Leaf, and Chevy Bolt all cost below $35,000 (enelx, 2019).

One major reason the cost of electric vehicles is so high is the battery. Pesaran et al. (2007) estimated that advanced battery costs can range from $800 to $1000/kWh. This cost, however, is a target of the U.S. Department of Energy, and they have been trying to reduce the prices of high-energy, high-power batteries with the Vehicle Technology Program (Ona Egbue, 2012).

This high upfront cost may be minimized by purchasing used rather than new electric vehicles. Used, near-new electric vehicles are coming onto the market at a higher rate because many Americans prefer to lease an electric vehicle. A 2019 study by Cox Automotive found that Americans purchase used versus new vehicles at a ratio of 2:1 (Cox Automotive, 2019).

2.2.1 Auto Dealership Barrier

Auto dealerships play a major role in the sale of electric vehicles. Salespersons are not always qualified or knowledgeable enough to sell EVs and dealerships sometimes deter customers from EV purchases (Kress, 2015).. This is in large part because dealerships make larger profits from used vehicles, oil changes, and parts and services. Because EVs require fewer maintenance tasks such as part replacement and oil changes, dealerships sometimes push internal combustion engine (ICE) vehicles over electric vehicles (Kress, 2015).

Another reason dealerships may promote ICE vehicles over EVs is because they take less time to sell. According to a Nissan business development manager, a salesperson can sell a conventional vehicle in half the time it takes to sell a Nissan Leaf (an electric vehicle). This has also been

supported by other authors who state that dealers report much longer transaction times for sales of electric vehicles (Alkiviadis Tromaras, 2017). This may deter associates from selling EVs because they are required to put in more effort to sell a single car.

Knowledge of electric vehicles may be another hindrance of EV sales at auto dealerships. Consumer reports have shown that several salespeople did not have the correct information about battery life, warranties, tax incentives, charging requirements, and costs. These consumer reports also show that car shoppers were even discouraged from purchasing an EV in 35 out of 85 dealerships involved in the study. Too often, people intended to test drive an EV but instead were offered an ICE vehicle of a similar category (Consumer Reports, 2014).

2.2.2 Current Efforts to Mitigate Cost Barriers

There are plenty of initiatives and programs aimed at aiding individuals financially in the purchase or lease of electric vehicles. Many of these operate through the State Legislature as well as programs developed through these laws.

One example is Senate Bill 1275, in which Governor Brown signed the California Charge Ahead Initiative into existence. Senate Bill 1275 supports consumer incentives and rebates in order to achieve the target of 1 million EVs in California by January 2023. This requires that CARB create programs which are aimed at specifically benefitting low-income residents. Programs such as the Carl Moyer Memorial Air Quality Standards Attainment Program and the Clean Vehicle Rebate Project (CVRP) are led by CARB with the goal of promoting electric vehicles in low-income communities through implementing charging installation projects or offering incentives (California Air Resources Board, 2018).

There are also pilot projects funded by the state such as the Enhanced Fleet Modernization Program (EFMP) and the Financing Assistance for Lower-Income Consumers initiative. The EFMP is a vehicle retirement which provides $1,500 for low-income consumers to scrap older vehicles. There is also a vehicle retirement and replacement program which provides financial assistance for low-income consumers to retire and replace their vehicles with cleaner vehicles using more advanced technology. The Financing Assistance program provides vehicle buy-down grants, point of sale incentives, and low-cost consumer loans, which help lenders to be more flexible with offering loan assistance (California Air Resources Board, 2018).

One possible solution to EV battery cost is implementing a business model of reusing and recycling batteries. Reusing a battery for energy storage purposes after its useful vehicle life is one way to reduce waste while increasing the battery's total service life. By commercializing the "post-vehicle" market, additional revenue streams will be created, which can contribute to possible price reductions in EVs.

2.3 Convenience Barrier

A major reason people have not considered electric vehicles is because of EVs' lack of convenience in areas such as charging, limited range, and the limited models available for transporting multiple passengers and work equipment. These reasons are cited as some of the major deterrents of purchasing electric vehicles, and each issue is compounded even more for low-income individuals, who may live in multi-unit housing or in charging deserts.

2.3.1 Charging

In lower-income communities, a lack of access to public, workspace, and home charging has been found to be a major obstacle of electric vehicle adoption. These areas are more likely to be commercial "charging deserts" (California Air Resources Board, 2018), which are areas that lack charging capabilities.

Residential charging accounts for 80% of all charging in the United States (Office of Energy Efficiency and Renewable Energy, 2020). The Level 1 Charger at a 120-volt outlet charges at around 4 miles of range per hour. This means it would take over two full days of charging to completely charge an EV with a 240-mile range. Level 2 chargers are much faster, using a 220–240-volt outlet. This charger can achieve a full charge at around 9 hours for the same vehicle. The even more advanced DC Fast Chargers reduce charge times to can achieve a full charge at around an hour and a half, but they are not available for home charging (Toppin, 2020).

A Level 2 Charger can cost anywhere between $1,000 to $3,000 to install. In addition to this high cost, the home ownership rate in California also is a deterrent. California has the second-lowest home ownership rate in the Country (53.6%). People who rent are less likely to invest in their homes and install chargers (Toppin, 2020).

In addition to this residential charging issue, public charging infrastructure is also a barrier. This large issue is prevalent and reflects a chicken-and-egg problem in which employers, retailers, and municipalities are uncertain about installing charging infrastructure or investing in EV infrastructure. This uncertainty is in large part due to the unforeseen future of electric vehicles. Parties are not sure whether chargers will be utilized heavily. This creates a paradox which results in sparse charging stations, especially in low-income communities. This is a major reason there is not public charging available at the workplaces of many of these low-income residents.

One study reported that only 32% of a sample thought recharging a battery-powered electric vehicle was more convenient than fueling a gasoline vehicle (Ona Egbue, 2012). This sentiment can be attributed to long charge times which do not currently compare to the gas station model of fast fill-ups.

2.3.2 Range Anxiety

In a study by Ona Egbue (2012), for a technologically minded target group, electric vehicle battery range was cited as respondents' most prevalent concern. First-generation plug-in hybrid and battery electric vehicles generally have a range anywhere between 40 and 100 miles. The study reported that the minimum range required before considering the purchase of an electric vehicle was an average of 215 miles. Yet the majority of the respondents traveled fewer than 20 miles per day while 87% traveled fewer than 40 miles per day, which is consistent with findings from the 2011 National Household Travel Survey (Ona Egbue, 2012). There is a large disparity between expectation and the actual driving range of respondents. This is likely due to "range anxiety," which is the fear of running out of battery power before reaching a destination and becoming stranded.

Battery technology is constantly changing and improving in range. It is still typical, however, that electric vehicles offer about 20 percent of the range of a typical internal combustion engine vehicle. Vehicles with larger batteries, such as the 85kWh Tesla Model S, achieve a much higher range (compared to the Nissan LEAF, for example). Such cars, however, are much more expensive than lower-range electric vehicles, which discourages people from purchasing them (Ghazale Haddadian, 2015).

As discussed previously, "range anxiety" is compounded by "charging deserts" and not knowing where the existing charging infrastructure is located while travelling on longer trips.

2.3.3 Limited Selection of Larger Models

Another complaint about electric vehicles by low-income communities is that they are not necessarily functional for transporting multiple passengers and work equipment because there is a lack of larger models (California Air Resources Board, 2018). Although this was a concern in 2018, this is being addressed two years later with many new larger models coming to the market. The new models include the General Motors electric Hummer, trucks from Ford and Chevrolet, and upstart vehicles from Rivian and Bollinger, some of which will be released in mid-2020. These larger models, however, may be similarly priced to luxury Tesla models at over $50,000. This is, in part, due to the key fact that it takes more battery power to motivate these larger vehicles (Ulrich, 2020). A large-model, affordable SUV is needed for low-income individuals to be able to fit in their budget.

2.3.4 Current Efforts to Mitigate Convenience Barriers

There are many current efforts to solving the electric vehicle charging infrastructure issue. They include state-funded programs which analyze communities and their location-based charging needs, Regional Electric Vehicle Infrastructure Planning Grants, and the Clean Energy in Multifamily Building Plan. In addition, there are many incentives available from state and local governments and from utility companies. There are also updates to building codes and permitting which can increase access to chargers.

Although not a permanent solution, some electric vehicle companies try to combat the range barrier by offering free conventional rental cars as an incentive. This is aimed at addressing the range anxiety for longer trips that surpass EVs' range (Ghazale Haddadian, 2015).

Currently, the best technology is believed to be the lithium-ion battery technology, but there is also talk about the Ultium batteries being researched by General Motors as well as South Korea's LG Chem (Ulrich, 2020). Improvements are aiming to increase mileage range and lifespan. This increase in battery performance will potentially reduce the price. Also, the prices of batteries are expected to fall by 70 percent by 2025 due to technological advancement and improvements in the energy density of batteries (Ghazale Haddadian, 2015).

2.4 Risk Barrier

The purchase of a vehicle is perceived to be relatively risky because it is one of the most expensive purchases made by households. For this reason, consumers generally tend to gravitate to what is known and familiar to them. For a purchase to occur, it must be established that the new technology offers many advantages which must be sufficient to offset the price differential and perceived risk when compared to the older technology. Although there are many benefits, there is still risk associated with purchasing an electric vehicle. This includes the unknown battery life and decay and the rapid technology advancements. For this reason, many people are choosing to lease electric vehicles.

2.4.1 Loss of Value

Due to technological advances, depreciation rates have increased. This rate is even higher for EVs. According to an AAA analysis, the value of electric vehicle falls by $5,250 per year, which is 30% more than other vehicle classes (Toppin, 2020). Although this is a potential opportunity for purchasing less expensive used electric vehicles, this fact does not help in the overall sales of electric vehicles.

The California Vehicle Survey Report (2015–2017) included interviews by current plug-in electric vehicle owners and leasers. Vehicle leasing was much more common amongst the group because they claimed that electric cars lose value quickly. Leasing is a way to mitigate the risk of new technology failing and plummeting in value (Mark Fowler, 2018). This issue is prevalent because of new battery technologies which increase vehicle range and battery longevity.

2.4.2 Current Efforts to Mitigate Risk Barriers

One possible solution to loss of value of electric vehicles is to separate the battery from the vehicle. This has been discussed in many journal articles as a "battery leasing" business model in which the battery can be swapped out at the end of the lease. This way, the risk for the consumer is minimized through a third party who may be responsible for the maintenance and replacement of the battery.

There are many opportunities for partnerships here, whether with battery manufacturers or with energy companies and independent operators offering services (Fabian Kley, 2011).

Another way the loss of value is minimized is through the assurance of a battery warranty. In California, the battery warranty requirement is a 10-year or 150,000-mile warranty (whichever comes first).

2.5 Barriers for Cities/Infrastructure

The emergence of electric vehicles will heavily depend on city and local government policies and infrastructure. Proper planning, infrastructure, and investments will be required to handle additional electric vehicles on the road. One very important necessity is the electric charging infrastructure and its effects on the electric grid, which may need adjustments in order to handle additional loads changing from a few to many electric vehicles in a neighborhood.

2.5.1 Electric Grid Considerations

As the demand for electric vehicle charging facilities continues to increase, the efficiency of the charging mechanism will come into question. The energy demand may require an upgrade in the distribution network which includes transformers, feeders, and distribution lines and cables. The challenge lies in addressing phase imbalances, harmonic injections, and protection system coordination (Ghazale Haddadian, 2015).

With EVs, there is some opportunity for electric vehicle companies to control the electric grid and increase utilization to increase cleaner energy usage. This is provided through flexibility of EVs to charge at different times throughout the day and at different locations. Electric companies can set prices according to their energy grid utilization such that wind energy or peak solar production is used. This pricing to ensure the energy grid is being used when capacity is available will help minimize costs for all users. Companies are currently testing ways to manage the charging strategies including through complementary approaches which integrate both renewable and distributed energy sources (Edison Electric Institute, 2018).

The electric companies also have an important role in organizing the placement of charging infrastructure to ensure the energy grid has the capacity to handle new charger installations. This will become especially important as high-powered DC fast chargers and chargers for large fleets are installed. The energy grid may be challenged without proper planning and partnerships with electric companies (Edison Electric Institute, 2018). This close coordination will also be important to ensure chargers are strategically placed to allow all owners and potential owners to access it.

2.5.2 Current Efforts to Mitigate Barriers for Cities

CEC awarded $1.8 million in funding from Alternative and Renewable Fuel and Vehicle Technology Program for nine cities to develop their strategic plans for electric vehicle charging infrastructure

It is important for local governments to establish an EV readiness strategy within their general plans which can help identify land-use requirements for potential charging sites. This collaboration can even expand across cities into regional transportation planning agencies and councils of governments to create regional plans. It should be considered in zoning classifications as an accessory to multi-family housing, commercial areas, etc. They can also reduce parking requirements to allow for use in charging instead or allow charging stations to count toward the parking minimums. Another way cities can have an impact is through their building codes. By ensuring the codes require EV wiring, cities can reduce the cost involved in retrofitting (Southern California Edison, 2019).

2.6 Business Model Barrier

Another barrier to widespread ownership of electric vehicles is the business aspect of selling to low-income individuals. In order to overcome the barriers facing electric vehicle adoption, a harmonized effort amongst stakeholders is required. In particular, there are many powerful stakeholders involved in the expansion of EVs. Some of the main players include auto makers, energy companies, governments, and the public. When trying to create business models, it is vital that stakeholders and their possible partnerships are considered.

There are challenges for businesses to create a model which targets low-income individuals, also referred to as the bottom of the pyramid or (BOP) of the income distribution. The BOP has been promoted as an untapped market for companies to grow profitably with an estimated potential of $13 trillion (Prahalad, 2004). In order to target the BOP, companies must change their business approach including every step in their supply chain. Because these business models would be complex and there would be high potential costs for these changes, this is a large hurdle for executives, and they must make decisions about whether the financial returns would justify the investments. In particular, multinational corporations (MNCs) are most equipped to target the BOP because they can draw from global resources and superior technology. This does, however, require MNCs to rethink and consider new resources and capabilities as well as creating a multitude of relationships and alliances with local BOP partners. Some of the major barriers for expanding the market to the BOP include a lack of resources and capabilities, complexity of the required business model, failed business alliances, and the need for cost cutting (Mair, 2007).

2.6.1 Resource Scarcity

It has been found that the BOP is "willing" to consume but not able to pay (Hart, 2004). This causes a major challenge for companies which requires them to rethink their whole supply chain to find ways to overcome the affordability obstacle (Prahalad, 2004). One of the major hurdles in expanding the market to the BOP is resource scarcity. The resources in BOPs may not be available or tradable, and if they are, the value of using them in new ways is generally hard to estimate (Denrell, 2003). For instance, allocation government resources to expand EVs' adoption among low-income individuals can be challenging as other pressing needs (e.g., food and shelter) also compete for such governmental resources.

2.6.2 Strategic Alliances

Because of these resource scarcity issues, research has suggested the need for BOP partnerships (Hart, 2004). Although this is recommended, partnerships that offer scalable and impactful soloutions to make EVs affordable to low-income individual still lacking.

3. Qualitative Study Methodology

This qualitative study was designed to identify the different objectives, priorities, preferences, challenges, and limitations of the different stakeholder groups involved with the EV market. This qualitative study aimed at investigating the current challenges faced by various stakeholders when it comes to expanding EVs to low-income Californians. It was designed to gain a greater breadth of understanding of how various stakeholders can contribute towards increased EV access among low-income Californians.

3.1 Design

The qualitative study used semi-structured interviews to gain a greater breadth of understanding of how companies and institutions can contribute towards increased EV access among low-income Californians. The interview questions were designed to capture the opinions and attitudes of various stakeholders—members of companies, institutions, and state agencies—regarding the barriers that low-income Californians face within the EV market as well as the obstacles related to the adoption of EVs that they face.

3.2 Procedure

Twenty-one in-depth interviews were conducted. Participants were recruited to participate in this qualitative study from various areas of California, including Northern California, the Greater Sacramento Area, San Joaquin Valley, Bay Area, and Southern California. Participants were told that their responses will be reported. The in-depth interviews with members of the different participating agencies were conducted to identify the different objectives, priorities, preferences, challenges, and limitations of the different stakeholder groups with respect to expanding EVs to low-income Californians.

First, questionnaires and discussion topics for the different stakeholder groups were prepared. Second, invitation emails were sent. These emails included the purpose of the study and a brief description of the potential value of the research project, and they were sent to recruit participants from different stakeholder groups, including (1) electric and solar companies, (2) financial and loan institutions, (3) professional and community-based organizations, (4) state agencies, and (5) various professionals in the field, including participants from research institutions, policy advocacy institutions, institutions concerned with air pollution, etc. Third, virtual interviews, due to the COVID-19 situation, were scheduled with the participants who agreed to join the study. Then, virtual interviews were conducted using a semi-structured method, whereby participants were presented with prepared questions, and relevant elaborations and conversations were also allowed to take place during the interviews. Finally, interviews were transcribed and analyzed.

3.3 Sample

For this qualitative study, a convenience sampling method was employed. The names and the organizations of the participants will not be reported to maintain their confidentiality and anonymity.

4. Qualitative Findings

A sample of qualitative quotes is included in this section and summarized in Table 1.

4.1 Knowledge Barriers

4.1.1 Electric & Solar Charging Companies

There seem to be an ongoing effort to **educate the public about the benefits of EV transportation**. This was illustrated in the interviews by multiple stakeholders in both electric companies and solar charging companies. Quotes supporting this notion included the following.

> *I think that what we're finding is that there's a wide spectrum of awareness and comfort with electric vehicle knowledge across our territory and customer types. So, we are wanting to develop and have developed some tools to help customers figure out what EVs are on the market, what is the total cost of ownership. But there are other ways to involve, like community-based organizations to help us spread the message and help us understand what is resonating with customers.*

> *We come at this [educating the public] in a couple different ways, our national brand neutral education awareness effort that the current campaign is called normal now. And this is a bilingual campaign. It's …English and Spanish.*

When it comes to **advertising rebates or reduced costs to customers who install charging equipment at their homes**, there seem to be some initiatives to communicate those benefits to potential EV customers. This was indicated by participants in both electric and solar charging companies. Specifically, a participant from a major electric company stated:

> *We have a variety of ways that our solutions marketing team engages with customers. So, our previous clean fuel rebate program was marketed [via] email and some of our … website content as well as using paid social media channels, you know, ads, or targeted research or through outreach. We're hoping to continue to expand upon that and continue to find either current EV owners that might also be interested in then installing, charging at home, also trying to leverage other existing programs and resources that help us figure out who, who was a newbie owner, or considering one, but we are also very reliant on word of mouth, and having other people share their experiences or these resources with, with their friends and family. So that is big—a big tool that we use as well.*

Another participant for a solar charging company mentioned a specific incentive tool:

> *The incentive advisor tool is specifically a tool where you can enter in your address and it's going to tell you know, based on your utility service territory and all these other factors, you know, what the different incentives are that you qualify for. And then the next sort of phase of functionality is to really hold people's hand through that incentive process by getting them onto the website where they can fill out the*

forms etc. So, I'm—that has been our major effort in in California is working on that incentive advisor tool to give people that information tip of their fingers.

4.1.2 Professional and Community-Based Organizations (CBOs)

An abundance of awareness and education programs offered in both Spanish and English was perceived as an important tool to overcome the knowledge barrier by participants from professional and community-based organizations.

As one participant indicated:

Targeted investment in outreach, Spanish and bilingual translation awareness and education, you know, making sure that that people are educated. And starting to do this, you know, to the masses, lots of events, lots of awareness, getting people in the cars.

Offering these awareness programs at work and schools seemed to emerge as a need.

EV educational programs that they've built into their work and trying to get their workforce educated about electric vehicles. So, I think that's a big way to increase awareness.

We really need to bring education [about EVs] in schools, particularly like in high schools, because kids coming up in high schools, they make up their minds, what they want to buy is their first car.

Participants from professional and community-based organizations also highlighted the need for **education regarding the low maintenance cost and the availability of free charging stations**.

More education that can definitely be done around the low maintenance costs and …charging infrastructure, there's still free chargers out there and available.

Further, the importance of source (the communicator) of the message that educated about and promotes the adoption of EVs was highlighted. Additionally, the importance of involving community leaders in raising awareness and education about EVs was strengthened. As one participant stated:

It's finding those community leaders who can help kind of spread the message, whether it's church leaders, or just community groups or something, principals, and the people in the communities who have the ear of others… I don't think it's as simple as like, finding the right messaging, I think it's more about finding the right messenger.

4.1.3 Financial & Loan Institutions

Outreach and communication with low-income Californians is perceived as a challenge by participants coming from financial and loan institutions. Specifically, translating the message to

the target audience native language seem to require further improvements. Also, engaging community leaders in communication and awareness campaigns could increase the effectiveness of communication messages aimed at overcoming the knowledge and awareness barriers.

> *Some of the challenges, I would say [is] the message… how does that translate to different languages? Because there's many different minorities existing in California… So, I would say outreach is a challenge… how is the state of California working with local leadership or local government to help residents… I don't think it [the message] trickles down… we don't see the marketing happening in local communities.*

4.1.4 State Agencies

State agency participants described the existence of awareness programs aimed at low-income Californians to educate them about the various aspects of EVs. As one participant indicated:

> *[There are] certain programs [that] have their own education and outreach teams. And those teams when they go up to the community are often targeting low-income… our agency has a compliance assistance and outreach branch that also is targeting low income [Californians] with outreach on electric vehicles and other things that can help low-income community members.*

Similarly, another participant indicated the presence of **current outreach programs** and emphasized that the acceptance of the communicated information will be enhanced if the local community-based organizations do the outreach.

> *Purchase incentive program administrators, they provide robust outreach, through in person events, printed collateral, social media updates, as well as through partnerships with community-based organizations. And so that's a lot of how we do a majority of our on the ground outreach throughout the state… But, you know, they don't always respond well, when there's a government employee in their neighborhood asking questions. And so, you know, leveraging the community-based organizations like relying on somebody that's from the neighborhood that's trusted, that speaks the language. That's been crucial with our outreach work.*

4.1.5 Professionals in the Field

The lack of knowledge and awareness about EVs among low-income communities was indicated as one of the main barriers by professionals in the field. As one participant indicated:

> *The most prevalent barrier is the education and the awareness there. Right now, these are not being marketed to low-income people. So, because of that, you know, you don't see a lot of electric vehicles in low-income and disadvantaged communities.*

One professional who works in campaigns related to EVs agreed about the lack of education. Specifically, this participant stated:

There is a lack of knowledge, the exciting response through our campaign work as we know there's a thirst for more education. We see that in our data.

A **language barrier** was also mentioned by professionals in the field as an obstacle when trying to raise awareness of EVs among low-income Californians. For example, it was stated:

Well, I think language is a big importance, language barriers in our region are vastly, probably one of the biggest barriers. So being able to translate a lot [or] just have someone who can speak to those in different languages is helpful.

It was also indicated that **dealerships may have been spreading negative information regarding EVs**, negatively affecting the perceptions of low-income Californians. Specifically, one participant indicated:

Lack of knowledge is definitely an issue. You know, people just don't know that they exist. And to be honest, in a lot of cases, if they've heard any messaging about EVs, it's usually been messaging coming from the conventional car industry during the decades that the conventional car industry opposed EVs, and, you know, told them EVs will never have enough power, they'll never have enough range, they're too expensive…

Professionals also indicated that **communication efforts** need to be adjusted to change perceptions among low-income Californians regarding the cost and the exclusivity of EVs. It was stated:

Electric Vehicles do have a reputation of being expensive and are popular with, you know, the white community… And so, minorities and low-income people don't see them as viable options. So, that's a question of education.

4.2 Cost Barriers

4.2.1 Electric & Solar Charging Companies

None of the participants from electric and solar charging companies were able to specify an **average cost to install charging infrastructure at a home**. It was obvious from participants' responses that the cost depends on many factors, such as the site, how old the building is, whether the building meets green building standards, whether service panels requires to be upgraded to allow the installation of chargers, and the amount of trenching or digging that may be needed for the installing of charging infrastructure. It was stated in the interviews:

It'd be hard to choose sort of a single cost figure here because there are a lot of different things that are involved if you need to do electrical work that can substantially increase the costs for a multi-unit dwelling if you need to do any kind of trenching digging up of your parking lot that can greatly increase costs. So, you know, I wouldn't commit to sort of a single number…

When asked about offering **reduced costs to customers who install charging equipment through financing solutions or rebates,** participants mentioned some available programs that help with reducing costs through financing and rebates, including programs that are aimed to support lower-income individuals. Specifically, a participant from a major electric company indicated:

> *Yeah… if we're doing option D, like you had earlier full ownership, we will finance a lot of the infrastructure and ask for like a participation payment from the customer. So, we'll finance quite a bit and then they'll pay a bit as well. And then we also through some of those programs offer rebates, it kind of depends on which specific program and which specific customer segment we're targeting. But we do offer both financing solutions and rebates for various customer types. And we tend to offer kind of along the theme of this discussion we tend to offer so financing solutions or rebates that are more for customers who fall into certain disadvantaged communities or low-income classifications.*

As for **decreasing the peak-hour usage by offering discounted prices during these times for electric vehicle charging,** participants from major electric companies indicated that they had observed some success with such initiatives. A participant from a major electric company stated:

> *They [initiatives aimed at decreasing the peak-hour usage] actually are doing pretty well… when I was in the contact center, customers that have EV have done their research on it… and they make it work for them.*

> *People become more and more aware of the advantages of being able to charge at home and take advantage of low pricing… So, comparing that to the cost of gasoline in California, that's a pretty attractive pricing.*

As for opinions on **offering rebates to customers who own or lease zero-emission vehicles,** it seems that there are some existing programs to offer rebates for those who have zero-emission vehicles. As one participant from a major electric company stated:

> *There's a program called the California Clean Fuel Reward. And that's really like pot of money that goes to fund that which is a discount off the sticker price of a zero-emission vehicle is funded by all the utilities in the state. And so, we contribute to that. And we also just propose to offer rebates on used EVs and so we support offering rebates and are hoping to expand our ability to do so.*

4.2.2 Professional & Community-Based Organization (CBOs)

Participants from various professional and community-based organizations indicated **cost as a main barrier for low-income Californians**. However, there is some optimism that this **cost will be lowered in the long term** as more models and used vehicles become available on the market.

As stated by one participant:

> *Purchase price is one [barrier] and I think that will continue to fall as there's more and more models available as the used vehicle market becomes expanded and there's more options out there.*

The **upfront cost**, rather than the total cost of ownership, was indicated as the main issue. Specifically, one participant stated,

> *The upfront cost is a barrier. The lower maintenance cost is not something that most people even recognize [when] they're considering a purchase, and [it's] all about the upfront cost… So, the upfront cost is your problem… most people don't even consider reduce maintenance. They don't even think of a total cost of ownership model.*

4.2.3 Financial & Loan Institutions

From the perceptive of financial professionals, **grants and rebates are not enough to overcome the income and cost barriers** when helping low-income Californians to get an EV. One participant stated:

> *Low-income Californians cannot easily access a vehicle because of their income status alone… despite grants and rebates [it] is still can be very difficult to attain.*

4.2.4 State Agencies

Some of the existing programs try to alleviate the cost barrier by offering **incentives and rebates**. Specifically, one participant indicated:

> *We offer increased incentive amounts to income eligible Californians to help address the cost barrier that many low-income consumers face when moving to EBS. The statewide clean vehicle rebate project offers post purchase rebates of up to $7,000 for the purchase or lease of a new eligible EV. We also have a state— the statewide Clean Vehicle Assistance Program or statewide financing assistance program that provides low interest rate loans and purchase grants of up to $5,000.*

There seem to be **loan guarantee programs** to support low-income Californians with their EV purchases. As one participant from a state agency stated:

> *[There]'s a loan guarantee program… It's called the Clean Vehicle Assistance Program. It says it was launched in 2018, through a partnership between beneficial state Foundation, which is often beneficial state bank, and the California Air Resources Board… ultimately, they provide loans to consumers who wouldn't otherwise qualify.*

As for efforts to increase rebates, the current programs seem to have a high-income cap that does not suit low-income Californians. However, there are some discussions about **lowering the income cap** over time. As one participant from a state agency stated:

> *I know that the clean vehicle rebate project had a meeting last week to talk about changes that they're contemplating. And the income cap's pretty high. I think it's 150,000, singly or 300,000. Married filing jointly. And I think that they are thinking about moving the income cap down over time, so that it would ultimately be strictly low-income program. And so that means that, of course, they would be able to incentivize a lot more low-income consumers, but currently, the demand from low-income consumers has not been there.*

Also, it seems that rebate amounts are the same for purchasing and leasing an EV. Hence, the rebate amounts does not make leasing an EV significantly more appealing than purchasing. As one participant mentioned:

> *My understanding is that there is no difference that whether you're leasing or purchasing a vehicle, the value of the rebate is the same.*

There are some financing options available for low-income Californians to purchase a new or used EV with loans that are capped to approximately 8%. As one participant from a state agency stated:

> *Applicants that go through our statewide financing Assistance Program do have the option to use the programs lender, which is beneficial state bank to obtain a low interest car loan that's capped at I believe, 8%. And so that's open to folks who wouldn't otherwise be able to qualify for financing at a dealer or through a different lending foundation.*

Several incentives available to low-income Californians can be stacked, but this process seem to be difficult. As one participant indicated:

> *[We are] looking for ways to streamline, so folks don't have to go to two or three different entities and fill out two or three different applications with different eligibility requirements. So that's something that we're looking at currently, to help on that effort.*

One recommendation is to **subsidize charging costs** for low-income Californians when they charge their EVs in a public charging station. One participant specifically stated:

> *I think that the way you address cost is … that you subsidize drivers in these communities. We talked about whether or not you issue them a credit card or something, but you ensure that they're not paying more than they would have paid if they had level two charging accessible in their in their community.*

4.2.5 Professionals in the Field

Professionals in the field named cost as one of the main barriers for EV adoption among low-income Californians. One participant stated:

> *Cost [is a main barrier] … still generally speaking, [EVs are] slightly more expensive than a conventional vehicle of the same class.*

Specifically, the **upfront cost** was indicated as the main cost barrier for low-income Californians. As one participant stated:

> *I would say that upfront cost is certainly one of the biggest challenges for low-income folks.*

The **rebate structure** was indicated as a main contributor to the cost barrier. It was stated:

> *The upfront cost is varied. I mean, that goes back to how the rebates are structured, the incentives, the tax credits, and the rebates, those need to be given at point of sale. And if you cannot issue them at point of sale, and you have to have somebody turn in a form and then wait seven weeks to be issued a refund, that in itself is a big barrier because not everybody can come up with $7,000, right, and then wait for a couple of months to get their $7,000 bonus.*

A leasing model was recommended as a possible solution to overcome the cost barrier. One participant stated:

> *Leasing makes it much more affordable. And then, after three years, you can turn it back in and— and start all over. So, yeah, leasing is definitely a good option for a lot of low-income folks.*

As one participant stated:

> *Leasing may have an advantage from the standpoint that it may reduce the barriers of entering the EV market… If [low-income Californians] cannot come up with that down payment, or with that higher monthly payment, perhaps the leasing option may be a viable alternative.*

4.3 Charging Infrastructure

4.3.1 Electric & Solar Charging Companies

As for **incentivizing property owners to install charging stations on their property**, there seem to be existing and forthcoming programs aimed at expanding charging stations at public housing.

A participant from a major electric company indicated the availability of a specific program that encourages owners of public housing to install charging stations by offering incentives. Specifically, this participant stated:

We offer to pay for infrastructure at multi-unit buildings. And we're also about to propose a successor program to that— so that we can continue to offer that to our multi-unit dwelling customers. And we also just recently proposed a program where we would incentivize customers that like smaller, multi-unit dwellings to install charging infrastructure where they have panel capacity. So, where it's like pretty cost effective, and if they're smaller, multi-unit dwelling, they tend to sometimes not meet some of our cost effectiveness requirements for our larger programs. So those are two ways that we are incentivizing installation of charging stations and multi-unit dwelling properties.

Rather than incentivizing the owners of public housing to install charging stations on their property, participants mentioned other approaches that aim at increasing access to super-fast charging stations. These solutions involved building fast charging station in convenient locations (such as the parking lots of grocery stores) to integrate charging into EV owners' daily routine.

As on participant indicated:

The way that you really expand EV charging to everybody is to have ubiquitous public charging at really convenient locations. You know, it's not an extra trip, if you're going to the grocery store once a week anyway, if you put a charger there, you can charge up your vehicle, and with the ranges of the modern vehicles, and with most people's driving habits, you know, it's very realistic in many cases, that that's going to last you until your next trip to the grocery store.

When it comes to **the likelihood that a home in a low-income community will have outlet capacity for electric vehicle charging**, there seems to be a lack of solid knowledge among participants from electric and solar charging companies. Answers came along the lines of "I have no idea" and "I don't know if we know how likely it is."

Importantly, when asked about the **factors that prevent low-income Californians from having an outlet capacity for electric vehicle charging**, a variety of reasons came to the surface, including home condition, the existing electrical system, transformer capacity, etc., and these barriers do increase the cost.

As a participant from a major electric company indicated:

It's really dependent on the condition of the home and the electrical system… the transformer capacity… So, there's a lot of different variables.

Usually, the homes are older… they just don't have that outlet, like the newer builds do, it's a requirement that they be put in there. Now, so it's really as simple as popping a little panel and then getting it installed, compared to the older structures where you have to rewire— you have to get everything done from fresh.

It really just depends on how the home was designed. And, any issues that could show up in terms of getting an electrician out there to run a new line… if the panel capacity is constrained for some reason,

or if it's really difficult to get a wire from the panel out to where the resident is looking to install their charger… those would be barriers, definitely not insurmountable, you could, but they could increase the cost.

As for solutions to **decrease the cost of having a charging outlet available for low-income Californians**, responses generated from the electric and solar charging participants indicated the lack of existing solutions and an openness to recommendations.

For example, one participant from a major electric company, when asked to provide recommendations and solutions to increase the adoption of EVs among low-income Californians, stated:

I don't know if we have an answer to that. But I would say we're very interested in any recommendations you all come up with as you do some of this research because one of the things that we kind of consistently are trying to do is find ways that provide low-cost solutions to advance EV adoption. And so, this is definitely a question that we kind of constantly grapple with and are trying to find, trying to find different solutions. So open to anything that you open to learning more about what you find out.

One recommendation was made to further educate low-income Californians about available rebates, tax credits, and incentives, and to promote public fast charging stations.

Rebates for the purchase and installation of home charging infrastructure are a strategy that is has been pursued by state governments by utility is, you know, the Federal alternative fuel infrastructure, tax credit, etc. So, rebates could easily be part of the solution. But then making sure that you connect people with those, and they understand how to take advantage of them. That's certainly part of it. And depending on the cost of the operation, you know that to come and do the electrical work, maybe there's rebates and incentives aren't set at the right level to really cover enough of that cost that it makes it a possibility for a low-income individual. So, I mean, public charging is another option, if it is, you know, so expensive to do the electrical work at your house and purchase the unit especially if you rent your home, or you don't know you're going to be living there for the long term.

4.3.2 Professional and Community-Based Organizations (CBOs)

The availability of charging infrastructure seems to be a crucial factor to successfully expanding EV use among low-income Californians. As one participant indicated:

EV charging infrastructure being located at both multi-unit dwellings and businesses and just making sure that that's accessible to everybody is going to make you know, especially for lower income communities, make electric vehicles more and more accessible.

It was also highlighted that the presence of charging stations at work or other convenient locations may aid with solving the accessibility issue.

If you can't charge at home, there's a lot less of an incentive to own an electric vehicle. And, same thing with the workplace. Maybe if you don't have charging at home, you can— you can get away with it if you have chargers at work, or somewhere that you conveniently go to.

If people can charge at work, it's going to be — huge for incentivizing them to get an electric vehicle.

We've kind of seen examples where people actually will use a work charger as their main charger. And then even if their house they don't charge at home, they're charging at work.

Also, one participant highlighted the importance of the role of the government in investing in charging stations:

I think it really just comes down to getting multi-unit dwellings to install charging infrastructure, or potentially, you know, other options like curbside charging, and having cities and counties and local governments invest in those technologies to be able to offer those services to low-income individuals.

4.3.3 Financial & Loan Institutions

From the perspective of professionals in financial and loan institutions, there is a disparity in the availability of charging stations among different communities, which creates an access problem for low-income Californians. As one participant stated:

There are communities that don't have the same access for electric vehicles as other communities do. And this is due to the lack of charging stations.

Also, professionals from financial and loan institutions emphasized that the state should prioritize increasing the accessibility to charging stations and direct funds and efforts towards ensuring that those charging stations are located appropriately. Specifically, one participant stated:

The [state's] focus [should be] solving the charging stations [issues]… that takes a lot of thinking about where to locate them [and] getting access to them, getting approval from local zones. There's just so many components to actually building a charging station.

4.3.4 State Agencies

As for the availability of chargers to low-income Californians, **there seem to be some doubts regarding appropriate locations and accessibility**. As one participant from a state agency indicated:

We have an intern who's working for us this summer is actually looking at the density of charging and low-income communities to see if it's sufficient to meet demand… the more important question, and what our student is trying to determine is, are the Chargers that are actually placed in low-income communities placed in such a way that they're accessible to low-income drivers? I mean, are they

actually in the low-income neighborhoods or does the driver have to get on the freeway and go somewhere else to access? So, they're there, but they may not be as accessible.

One main challenge facing low-income Californians is the lack of charging stations in the multi-family dwellings and the hardship associated with convincing the property owner to install charging stations. Specifically, one participant stated:

The problem is that multi-family units or multi-family dwellings, the cost to add charging infrastructure to existing facilities is exorbitant, and you require buy in by the property owner, or property manager. And it's too difficult. And I think that, instead, you need to have a situation where the consumer is already familiar with going to a gas station to fuel up, if they can go to an electric station that happens to be co located with a convenience store. They can take care of, or you know, laundry or whatever, they take care of some of their other pressing needs while they refuel.

4.3.5 Professionals in the Field

The lack of charging stations is perceived as a major barrier among professionals in the field. As one participant stated:

We have people [from low-income communities] who maybe are interested in loading in electric vehicles, however, there isn't the charging infrastructure in place. So, you know, they, if they want to buy one, they don't know where they could charge. You know, I can tell you, the community I live in the nearest charging station is, I don't know anywhere from, you know, seven to 15 miles away.

Electric vehicle charging infrastructure is a key to the successful deployment and penetration of electric vehicles among the low-income community, because, you know, hypothetically speaking, let's assume that we solved the pricing problem, and we were able to make it attractive to the low-income community. Well, once they purchase that vehicle, they need to charge it. And if they are living in an apartment complex, well, they won't have the ability to charge the vehicle until and unless that apartment building it stalls an EV charger, so addressing that is extremely important.

The importance of having conversations with local communities to find the most convenient locations for public chargers was emphasized by professionals in the field. It was stated:

The important thing to keep in mind when thinking about deploying public charging infrastructure for the purpose of solving this specific problem, is to make sure that you're talking to the people who would be using it, so that you know, what would actually be the most useful to them. I think probably what you'll find, when you have those conversations, is that putting that public charging, actually out there, at the places they go most often, like work, or other, you know, place in the community here regularly, we go to like the grocery store or possibly church or a kid school or something like that would probably be what most people would tell you would help them the most.

4.4 Opinions Regarding Potential Business Models

4.4.1 Electric & Solar Charging Companies

As for perceptions about the battery swap plan, in which the ownership of the vehicle and battery are separated and consumers would pay a monthly subscription fee for battery recharging/swapping, the need of easy to install swap batteries was indicated.

As one participant from a major electric company indicated,

> *It just has to be modeled safely, where a regular consumer [who] doesn't have much knowledge on it can go ahead and swap out a battery, without hurting themselves or other. That would be awesome… Hopefully the batteries aren't like a size of an engine. But if they were smaller, accessible and safe, I think that would be awesome, actually.*

Other participants described the complexity of the battery swapping model:

> *Battery swapping technology is pretty complicated to begin with. There's been a few companies that looked in earnest at doing battery swapping and they were looking at sort of more rapid than just at the end of the lease like you know… depending on your vehicle that might be more or less realistic from sort of an engineering perspective.*

The warranty emerged as another factor relevant to promoting EV leasing. As one participant from an electric company indicated:

> *When you purchase or lease a new vehicle, the battery comes with like an eight-year at least warranty on it. And so, if you're looking at a typical, maybe a 36-month lease or something like that, your battery is already is still going to be under warranty.*

One recommendation made by a participant from an electric company is to have **strong communication channels between dealerships and the organizations offering incentives**, as this will allow the dealership to have solid knowledge and communicate about available options:

> *Dealerships, it's really important to have communication and collaboration with the folks who are offering rebates, because that's another thing that we hear from dealerships when I did dealership engagement work in the northeast was, dealerships, really, they don't want to be in the position of promising customer something, and then having it not be true. So having that kind of coordination between the dealerships and the folks who are implementing these programs, that's crucial… I think that the state should continue to look at ways to get these vehicles into the hands of more people.*

4.4.2 Professional & Community-Based Organizations

Leasing was a valid solution in the eyes of some participants from professional and community-based organizations, **especially if the upfront cost can be decreased or eliminated altogether**. As stated by one participant:

> *I think with low-income individuals, specifically, this [leasing and EVs] can be a really good way to get into the EV market… I've heard firsthand from folks who have been able to lease a vehicle for no money down*

> *I think it's a fantastic idea [to lease an EV]. And I would love to see that, try it out and see how that works… If you can take that burden away from people, I think you're really relieving, you know, a huge amount of anxiety for, you know, potential costs.*

One hindrance for leasing seemed to be the credit score of low-income Californians, so it was suggested that dealers adopt a leasing model where credit score does not impact getting approved to lease an EV. Specifically, one participant indicated:

> *So… if the leasing program is not based on their FICO score, or their [low-income Californians] credit score, and it could be something where even if they don't have good credit, there's a way for them to get an opportunity to lease a car? I think that's— that could be a solution for some.*

4.4.3 Financial & Loan Institutions

Current programs aimed at providing financing options to low-income Californians seem to be restricted due to limited funding. Hence, obviously, more funds are needed. As one participant indicated:

> *Currently, our program has a reservation list, which means that we're able to continue to give out grants until participants either [decide] to redeem their grant or not. And then the following participant would receive a grant or not. So, I think starting with enough funding to keep our program open, can contribute to increasing EVs.*

Advertising the available financial options and programs to reach broader audiences seems to be necessary. As one participant indicated:

> *Another idea is … broadcasting our program through the radio, through TV channels, to be able to access broader community and just more people in California.*

4.4.4 State Agencies

State agencies seem to be willing to partner with financial institutions to help low-income Californians get access to low-interest loans. One participant stated:

I think the precedent is already there… Essentially, we are doing it. And you know, we support it, and it probably could be done with other entities as well.

Car dealerships that low-income Californians patronize are not engaged in promoting used EVs to low-income Californians. As one participant indicated:

I think that low-income consumers are going to… dealerships that deal with much cheaper vehicles. But I don't think that dealerships that are selling used cars [promote EVs], dealerships already complain about the extra effort needed to educate consumers on EVs, and that's on a new car… I don't think their level of engagement is going to be great.

Partnerships with transport network companies seem to be an important aspect for expanding EVs among low-income Californians, as transport network companies offering rideshare services (e.g., Uber and Lyft) in California will be mandated by 2030 to have a fully electric fleet. Since some low-income Californians would be working for these transport network companies, they would have to drive an EV. As one participant from a state agency indicated:

One of the things we recently passed a regulation, or, you know, we adopted a regulation and it'll become law. And it's called the clean miles standard. And the clean mile standard will require transport, or they call the transport network companies or companies like Uber and Lyft will have to have a greater level of electric vehicle. A greater portion of their fleet will have to be EV is over time, eventually. Uber and Lyft are both committed to be fully electric, I think either by 2030, or 2035. But the majority of Uber and Lyft drivers are low-income drivers. And there are a lot of programs right now to get ease into the hands of those drivers, [such as] a [proposed] incentive for low income, transportation network company drivers or Uber Lyft drivers. And what happens then is every Uber and Lyft driver, you know, if I go out with my Tesla, I can go out and talk to one person here, one person there. But Uber and Lyft drivers talk to dozens of people a day. And those who who've gotten electric vehicles so far have become evangelists for the technology.

Battery swap programs do not have an appeal among Californians due to the lack of standardization in the battery specifications. One participant stated:

So, battery swap can work if you have one or two cars that have a common battery architecture, so that you can do the swaps. But here in the US and here in California, where consumers want a plethora of choices when it comes to vehicles, there's no way that we don't envision that there's ever going to be a consolidation or an agreed upon battery structure, or size, shape or form factor that would make it easier for vehicles to do battery swap. So over, you know, maybe a generation from now, but in the near term, I don't I don't see it, lending itself as a as a cost-effective means of getting low-income consumers into vehicles.

4.4.5 Professionals in the Field

The availability of used EVs need to be addressed. It was perceived by professionals in the field that used EV supply is not enough to meet potential demand among low-income Californians given that purchasers from other income levels also compete for the used EVs. As one participant stated:

> *And, you know, the only V's that are available are really new there. The second hand, EV market, you know, they don't last long, once one tries to sell used EV, somebody usually buys it pretty quick. So, there's just not enough supply.*

> *The lack of used electric vehicles is a big problem… buying a new electric vehicle is something that low-income individuals probably can't afford.*

One integrative platform that is designed with low-income Californians' demographics in mind is needed. The platform needs to overcome language barriers and streamline the process of stacking all available rebates and incentives for low-income Californians. It was stated:

> *There are these financial programs out there that can assist [low-income Californians get an EV], you know, with the state rebates and with the air pollution rebates and PG&E rebates. It can pencil out, but if you know. But if somebody* ***doesn't put that whole package together for resident who doesn't speak English very well****, right, and they're having to have a translator or their children translate for them, or they're having to go and dig through all these government programs to try to find where these incentives… you just immediately lose people. And so, to be able a very clean package of: if you hold in this income category and you want to buy a car, here's everything that you're going to get for it. And this is your advice, that I think that simplicity makes it so much more palatable.*

Dealerships need to have incentives from government subsidies to sell EVs rather than gas vehicles. Traditionally, a significant part of their revenues came from maintenance packages for gas cars. It was stated:

> *I would say [dealerships] do prefer to sell the gas vehicles. And the main reason is that most dealerships earn I think the statistic is somewhere around 30 to 40% of their revenue from service. And electric vehicles just don't have that kind of come for service. And so that's probably the biggest thing a dealership knows what where their income comes from.*

5. Quantitative State-Wide Survey Methodology

5.1 Design

A state-wide survey was designed to quantitatively assess the different objectives, preferences, priorities, challenges, and limitations of low-income Californians in the different regions of the state. The survey enabled an assessment of various barriers for the adoption of EVs by low-income Californians, including knowledge barriers, misinformation barriers, convenience barriers, and cost barriers. Additionally, the survey investigated low-income Californians' perceptions regarding the advantages of EVs and quantitively assessed their concerns that may hinder their willingness to purchase or lease an EV. Further, the survey explored low-income Californians' willingness to purchase an EV in the next three, five, and ten years. Using a projection technique, the survey addressed how low-income Californians perceive current EV owners. The general thoughts and attitudes of low-income Californians towards EVs are also measured.

The survey was designed not only to offer descriptive statistics, but also, importantly, to allow for inferential statistics methods to be employed, in this report, to identify statistical significance and hence allow for evidence-based decision making. The survey design also took into account the insights generated from the qualitative study and various conversations the researchers had with major stakeholders to provide more robust insights. The survey design ensured the inclusion of low-income Californians across various regions and counties and collected various demographic factors.

5.2 Sample

Sampling was designed to ensure that participants are low-income Californians. To that end, the research team built a sampling frame whereby the state of California is divided into nine main regions, and after that, some of the most populous counties in those regions were selected to geographically target. In addition to geographic sampling, the research team imposed a household income level screen to ensure that only low-income Californians would be included. The income levels, required for inclusion in this study, were designed taking into account the number of people per household and the county where a participant life (as the cost of living differs from one county to another). The research team used the level of income that is considered low for each county, according to the size of the household, as indicated in 2020 state income levels publication by the Department of Housing and Community Development, Division of Housing Policy Development. Some counties had the same income level brackets and were hence grouped together. Quota sampling was conducted with efforts to make the percentages in the sample relevant to the population percentages in these regions. The sampling frame for income, geographical region (including counties), and the number of people in the household is presented in Table 1. The sampling efforts resulted in 1,450 complete responses. Sample characteristics related to age, political orientation, marital status, education, employment, and so on can be found in Table 2.

5.3 Procedure

First, to abide by the sampling framing and criteria, participants completed screening questions to determine the age, county, income level, and the number of people who live in the respondent's household. Participants who were identified as low-income Californians according to the sampling criteria proceeded to take the survey.

Questions regarding past adoption of hybrid and fully electric vehicles were introduced along with a question aiming to determine the sources by which survey participants first learned about EVs.

Participants then completed a set of questions designed to determine the knowledge barriers that might exist. Questions included how much knowledge they have on EVs, how much positive information they have heard about EVs, and how much negative information they heard about EVs (1–7 scale anchored on 1 = "None at all" and 7 = "A great deal"). As the level of knowledge can be associated with past weighing of purchasing or leasing EVs, participants were asked to indicate whether they had previously considered purchasing or leasing either hybrid or fully electric vehicles (1–7 scale anchored on 1 = "Definitely not" and 7 = "Definitely yes").

Next, participants completed a set of questions designed to assess the perceived importance of various aspects of EVs, including reducing greenhouse gas emissions, reducing operating costs, reducing noise pollution, increasing performance over gas vehicles, and offering convenience of charging at home or work. The perceived importance of each of these aspects was assessed using a 1–7 scale anchored on 1 = "Not at all important" and 7 = "Extremely important."

Afterwards, participants were presented with a set of questions to assess the misinformation barriers. Participants' perceptions of availability of EVs in their area, mileage range, charging infrastructure, charging time, battery life, and re-sale value were assessed using a 1–7 scale, anchored on 1 = "None at all" and 7 = "A great deal."

Convenience barriers, including rebates and government subsidies offered for EVs, mileage range, various types of charging for EVs, and how long EVs take to charge, were measured using a 7-point scale. Additionally, to further understand these convenience concerns, participants were given questions related to how much mileage they expected to gain after charging an EV for an hour and how many miles would they want on a single charge of EV before purchasing one. The availability and type of chargers at participants' current residential properties and work sites were also investigated using dichotomous yes/no questions.

Cost barriers were then measured, including perceptions regarding EVs' upfront purchasing cost, maintenance cost, operating cost, and insurance cost, using a 1–7 scale anchored on 1 = "None at all significant" and 7 = "Extremely significant." Since comparing the costs associated with EVs to those associated with gas vehicles is a common step in the decision-making process when considering an EV purchase, participants were asked to indicated if they would consider

purchasing a new EV, purchasing a used EV, or leasing an EV if the price were comparable to that of a gas-powered vehicle, using a likelihood scale anchored on 1 = "Extremely unlikely" and 7 = "Extremely likely."

The likelihood of purchasing an EV in the future was then assessed for three time frames (the next 3 years, the next 5 years, and the next 10 years) using a 1–7 scale anchored on 1 = "Extremely unlikely" and 7 = "Extremely likely." Then, the questionnaire measured the conditional likelihood of purchasing an EV in the future using "if statements" where some of the barriers, one at a time, are addressed and some other conditions are imposed. Specifically, participants were asked to indicate their likelihood of purchasing an EV under these hypothetical conditions: (a) if more charging stations were available in one's area, (b) if replacement batteries were easier to find, (c) if rebates and/or subsidies for EV were doubled, (d) if vehicle warranty were doubled, (e) if the cost of gasoline were to be doubled, (f) if total cost of ownership were less than or equal to that of a gas-powered vehicle, and (g) if more people drove electric vehicles. Participants indicated the likelihood of purchasing an EV under each of these conditions, using a likelihood scale anchored on 1 = "Extremely unlikely" and 7 = "Extremely likely."

The general thoughts/attitudes regarding EVs' different aspects, including whether they are good for the environment, safe, modern, reliable, convenient, fun to drive, easy to maintain, and not too expensive to operate, were assessed using a 1–7 scale. This was followed by assessing respondents' perceptions regarding EVs' current owners. Participants were asked to indicate their expectations of the satisfaction level of EV owners and whether those EV owners are perceived as more successful, using a 1–7 scale. Finally, we collected demographic information including age, marital status, political orientation, employment, education, house ownership, and so on.

6. Quantitative State-Wide Survey Findings

6.1 Current and Past Adoption of Hybrid and Fully Electric Vehicles

Only 13% of study participants have owned a hybrid vehicle and 7% have leased one. Approximately 12% of the participants currently own a hybrid vehicle. Only 6% of the sample has owned a fully electric vehicle, and around 5% has leased one. Current ownership or leasing of fully electric vehicles was around 6.5% of the study participants. These numbers support the aim of this study, namely, to address the very low adoption rate of EVs among low-income Californians. Interestingly, 40% of the sample has previously ridden in an EV.

6.2 Initial Exposure to EVs

Approximately 12% of participants indicated that they had no prior knowledge of EVs and another 12% indicated that they are not sure how they first learned about EVs. Only 5% first learned about in EVs in school and another 2.3% at work; 21% first learned about EVs via TV, almost 18% had the internet as their first source, and 8% indicated social media. A further 12% first learned about EV through word of mouth, and 6% did so via advertising. Only 3% indicated other sources, such as family, friends, or a salesperson (see Table 4 and Figure 1).

6.3 Knowledge Barriers

Low-income Californians indicated a low level of perceived knowledge regarding EVs with a mean significantly lower than the midpoint of the scale. Specifically, they indicated that the amount of negative information they had heard about EVs was low, but the amount of positive information they heard about EVs did not significantly differ from the midpoint of the scale. These finding indicate that the amount of information available to low-income Californians regarding EVs is not enough to promote the adoption of EVs.. Since the amount of negative information they had received about EVs appeared to be minimal, the knowledge barrier appears to manifest in the lack of knowledge rather than the presence of negative information (see Table 5 and Figure 2).

As their current level of knowledge can be associated with their past consideration of purchasing or leasing EVs, participants indicated their previous consideration or purchasing or leasing hybrid or fully electric vehicles. More participants had considered purchasing or leasing a hybrid vehicle compared to fully electric vehicles. The means for past considerations of purchasing or leasing a hybrid or a fully electric vehicle did not significantly differ from the midpoint of the scale (see Table 5).

6.4 Perceived Importance of Various Aspects of EVs

To further examine participants' knowledge regarding the various advantages of EVs, low-income Californians indicated their perceptions of the importance of EVs in reducing greenhouse gas

emissions, reducing operating costs, reducing noise pollution, increasing performance over gas vehicles, and offering convenience of charging at home or work. Findings indicated that participants believe that EVs can offer all the aforementioned benefits with all means significantly higher than the midpoint of the scale. Results indicated the following descending order of perceived importance: (1) offering convenience of charging at home or work, (2) reducing operating costs, (3) reducing greenhouse gas emissions, (4) increasing performance over gas vehicles, and lastly (5) reducing noise pollution. Since the mean scores of all these benefits occupied a very narrow range (from 4.72 to 5.01) and did not show a meaningful variation, the ranking of these advantages is unwarranted. Rather, in general, when participants are prompted with the advantages of EVs, they tend to perceive those advantages positively. This further supports the findings under the knowledge barrier section as it indicates that the potential problem is the lack of information available to low-income Californians regarding EVs, rather than the availability of negative information (see Table 6 and Figure 3).

6.5 Misinformation Barrier: Concerns with EVs

When promoted with common negative perceptions regarding EVs and asked to indicate their level of concern with issue potential negative perception, results showed a low concern level with the availability of EVs in participants' area with a mean that is statistically lower than the midpoint of the scale. This indicated that distribution does not seem to be a factor hindering EV purchasing. Interestingly, the concern level regarding re-sale value was also lower than the midpoint of the scale with marginal statistical significance. Hence, re-sale value does not seem to be a hindering factor for EV purchasing. On the other hand, concern levels for battery life, charging time, charging infrastructure, and limited mileage range were all significantly higher than the mid-point of the scale and ranked in this order (see Table 7 and Figure 4).

6.6 Convenience Barriers

Low-income Californians indicated low levels of familiarity with various convenience aspects of EVs. In particular, the level of awareness of rebates and government subsidies offered for EVs was significantly lower than the midpoint of the scale. Similarly, the awareness of mileage range, various types of charging, and the duration of charging were all significantly low. These findings were line with the major concerns regarding battery life, mileage range, and the charging infrastructure, indicated under the misinformation barrier section (see Table 8 and Figure 5).

To further understand these convenience concerns, participants were asked questions related to how much mileage they expect to gain after charging an EV for an hour: 40% of participants chose 60+ miles, 10% indicated 50–60 miles, 16% indicated 41–50 miles, and 15% indicated 31–40 miles. Only 20% of the sample had the expectation of 30 miles or less after a one-hour charge. Also, when asked about how many miles they would want on a single charge of an EV before purchasing one, almost 18% were satisfied with a range of 100–200 miles, whereas 28% and 25% of

participants indicated the need to have 201–300 and 301–400 miles, respectively. Approximately 28% of participants indicated the need for 401–500 miles (see Table 9 and Figures 6 and 7).

Importantly, we investigated the availability of chargers at participants' current residential properties and work locations. Among those who live in a house, 60% indicated that they are able to charge an EV at their house; 76% indicated that they have a standard outlet and almost 23% indicated that they have a 220 outlet. Among those who live in an apartment, only 10% indicated that they have EV chargers at their apartment complex. Hence, the availability of charges seems to be a major hindrance for those who live in apartments. Almost 18% indicated the availability of chargers at their work and 46% indicated that they have access to a charger at a nearby public structure.

6.7 Cost Barriers

Comparing the costs associated with EVs to those associated with gas vehicles is a commonly used strategy in the decision-making process when considering an EV purchase. Low-income Californians indicated that they would consider purchasing a new EV if prices were comparable to those of a gas-powered vehicle with a mean score that is significantly higher than the midpoint of the scale. The same positive indications were found for purchasing a used EV, if prices were comparable to that of a gas-powered vehicle. However, the opposite was true for leasing an EV. In fact, low-income Californians indicated that they would not consider leasing an EV even if the price was comparable to that of a gas-powered vehicle, with a mean significantly lower than the midpoint of the scale. This indicated a general resistance to leasing an EV (see Table 10 and Figure 8).

Further, the various aspects that contribute to the overall cost were investigated. Maintenance cost, upfront purchasing cost, insurance cost, and operating cost were all perceived to be significant costs for low-income Californians (with means significantly higher than the midpoint of the scale). This indicates the importance of lowering some of these costs to encourage low-income Californians to consider purchasing EVs (see Table 10 and Figure 8).

6.8 Likelihood of Purchasing an EV in the Future

Low-income Californians indicated a significantly low likelihood of purchasing an EV within the next three years and the next five years, with means significantly lower than the mid-point of the scale. However, within the next ten years, low-income Californians indicated a significantly higher likelihood of purchasing an EV, with a mean that is significantly higher than the mid-point of the scale. This finding indicates that for the short term, on average, low-income Californian are not considering an EV purchase, arguably due to the aforementioned concerns and barriers (see Table 11 and Figure 9).

6.9 Conditional Likelihood to Purchase an EV in the Future

Participants were prompted to think about "if statements" where some of the barriers are addressed and some other conditions are imposed and then indicate their likelihood of purchasing an EV under these hypothetical conditions. If more charging stations were available in one's area, replacement batteries were easier to find, vehicle warranty were doubled, or rebates and/subsidies for electric vehicles were doubled, participants indicated a high likelihood of purchasing an EV, under each of these conditions, with means significantly higher than the midpoint on the scale. Also, if the cost of gasoline were to be doubled, or the total cost of ownership were less than or equal to that of a gas-powered vehicle, participants indicated a high likelihood of purchasing an EV. However, if EVs became more popular and more people drove electric vehicles, this would not seem to affect low-income Californians' likelihood of purchasing an EV (see Table 12 and Figure 10).

6.10 Willingness to Pay to Own or Lease an EV

When asked about how much they would be willing to pay on a monthly basis to own or lease an EV, almost 54% of participants indicated that they are willing to pay $199 or less, 32% are willing to pay $200–$299, and 9% are willing to pay $300–$399. Only 3% were willing to pay $400–$499 and 2% are willing to pay $500–$599. This indicates the possibility of capturing the interest of around 30% of low-income Californians if monthly costs are between $200 and $299 (see Table 13 and Figure 11).

6.11 General Thoughts Regarding EVs

The general thoughts regarding EVs were significantly positive in all the presented aspects. EVs were perceived as good for the environment, safe, modern, reliable, convenient, fun to drive, easy to maintain, and not too expensive to operate, with all means significantly higher than the midpoint of the scale. This indicated that the general attitudes towards EVs among low-income Californians are positive. This comes in line with the low scores for negative information received regarding EVs. However, as previously indicated in this report, some specific barriers and concerns are still preventing low-income Californians from considering or purchasing EVs (see Table 14 and Figure 12).

6.12 Perceptions Regarding EV Owners

Applying the projection technique, participants were asked to indicate their expectations of the satisfaction level of EV owners and whether those EV owners are perceived as more successful. Low-income Californians indicated that EV owners are expected to be satisfied with their EVs and they tend to be perceived as more successful, with means significantly higher than the midpoint of the scale. This indicates that low-income Californians have a positive image of EV ownership and assume that such people are satisfied (see Table 15 and Figure 13).

7. Insights to Direct the Business Model

7.1 Insights from the Qualitative Findings

In this section, we present highlights from the insights captured by the qualitative in-depth interviews. These insights are related to various barriers identified and the involvement of different stakeholders in dealing with those barriers to expand the adoption of EVs, specifically among low-income Californians. These insights should aid in the development of the business model aimed at increasing the odds of purchasing or leasing an EV for low-income Californians.

7.1.1 Electric & Solar Charging Companies Insights

- There is an ongoing effort by electric and solar charging companies to educate the public on the benefits of EV transportation and to develop tools to advertise rebates or reduced costs to customers who install charging equipment at their home.

- There is an understanding and a growing interest among electric and solar charging companies to develop tools to advertise rebates and reduced costs for customers who install chargers at home.

- There are some available programs involving electric companies that help with reducing costs through financing and rebates, including programs that target lower-income individuals.

- The average cost to install charging infrastructure at a home is hard to specify, and the actual cost varies significantly depending on many variables.

- There is success in decreasing the peak-hour usage by offering discounted prices during these times for electric vehicle charging.

- There are some existing programs to offer rebates for those who have zero-emission vehicles, such as the California Clean Fuel Reward program.

- There are existing and forthcoming programs that aim at expanding charging stations at public housing by incentivizing the owners of public housing to install charging stations on their property.

- Building fast charging station in convenient locations (such as the parking lots of grocery stores) to integrate charging in EV owners' daily routine is a valid solution to overcome the availability of charging outlets where low-income Californians live.

- Factors that prevent low-income Californians from having an outlet capacity for electric vehicle charging include home condition, the existing electrical system, transformer capacity, and so on, and these barriers increase the cost.

- There is a lack of existing solutions offered by electric companies to lower the cost of having a charging outlet available for low-income Californians.

7.1.2 Professional & Community-Based Organizations Insights

- Awareness and education programs that are offered in both Spanish and English are important to provide accessible information.

- Awareness programs at work and schools are needed.

- Education programs should focus on the low maintenance cost and the availability of free charging stations.

- The involvement of community leaders in raising awareness and educate about EVs was perceived a useful strategy that resonates with local communities.

- Cost is a main barrier for low-income Californians. The cost will be lowered in the long term as more models and used vehicles become more available on the market.

- The upfront cost is the main issue rather than the total cost of ownership.

- The availability of charging infrastructure is a crucial factor to successfully expand EVs among low-income Californian.

- The presence of charging stations at work or other convenient locations will aid in solving the accessibility issue.

- The government needs to invest in charging stations in low-income neighborhoods.

- Leasing is a valid solution to increase the adoption of EVs among low-income Californians, especially if the upfront cost can be decreased or eliminated altogether.

- One hindrance for leasing seems to be the credit score of low-income Californians; a leasing model where the credit score does not impact approval to lease an EV can be successful.

7.1.3 Financial & Loan Institutions

- The outreach to communicate available financial programs to low-income Californians is a challenge.

- Both the language and the source of the message require further improvements in engaging community leaders, and messages should be bilingual.

- From the perspective of financial professionals, grants and rebates are not enough to overcome the income and cost barriers and help low-income Californians get an EV.

- There is a disparity in the availability of charging stations among different communities, which creates an access problem for low-income Californians.

- The state needs to prioritize increasing the accessibility of charging stations and should direct funding and efforts towards making those charging stations abundant and located appropriately.

- Current programs aimed at providing financing options to low-income Californians seem to be restricted due to limited funding. Hence, more funds are needed.

- There need to be more advertising placements to communicate financial options and programs to a broader audience of low-income Californians.

7.1.4 State Agencies

- There are awareness programs aimed at low-income Californians to educate them about the various aspects of EVs.

- The acceptance of the communicated information will be enhanced if the local community-based organizations do the outreach.

- Some of the existing programs try to alleviate the cost barrier by offering incentives and rebates.

- There are loan guarantee programs to support low-income Californians with their EV purchases.

- There are some available financing options for low-income Californians to purchase a new or used EV with loans that are capped to approximately 8%.

- Some current rebate programs have a high income cap that does not suit low-income Californians. However, there are some discussions of lowering the cap over time.

- The rebate amounts are the same for purchasing and leasing an EV.

- Several incentives available to low-income Californians can be stacked, but this process seem to be hard as they need to fill multiple applications on a variety of platforms.

- There are doubts regarding the appropriate locations of chargers to promote access among low-income Californians.

- There is a lack of charging stations in the multi-family dwellings and hardship in convincing the property owner to install charging stations.

- State agencies are willing to partner with financial institutions to help low-income Californians get access to low interest loans.

- Car dealerships that low-income Californians patronize are not engaged in promoting used EVs to low-income Californians.

- Partnerships with transport network companies seem to be an important aspect for expanding EVs among low-income Californians, as transport network companies will be mandated to have a fully electric fleet. Any low-income Californians working as drivers for these transport network companies would then have to drive an EV.

- Battery swap programs do not have an appeal among Californians due to the lack of standardization in the battery specifications.

7.1.5 Professionals in the Field

- The lack of knowledge and awareness about EVs among low-income community members was identified as a main barrier.

- Language barrier is an obstacle when trying to raise awareness of EVs among low-income Californians.

- Dealerships may have been spreading negative information regarding EVs, negatively affecting the perceptions of low-income Californians.

- Communication efforts need to be adjusted to change perceptions among low-income Californians regarding the price and exclusivity of EVs.

- Cost is a main barrier to EV adoption among low-income Californians: specifically, the upfront cost.

- The rebate structure is main contributor to the cost barrier since low-income Californians cannot pay upfront and then wait for a rebate.

- A leasing model is a possible solution to overcome the cost barrier.

- The lack of charging stations is a major barrier.

- It is important to have conversations with local communities to find the most convenient locations for public chargers.

- The supply of used EVs is not enough to meet potential demand among low-income Californians as purchasers from other income levels also compete for the used EVs.

- One integrative platform that is designed with low-income Californians' demographics in mind is needed. The platform needs to overcome language barriers and streamline the process of stacking incentives.

- Dealerships need to have incentives to sell EVs rather than gas vehicles because a significant part of their revenues comes from maintenance packages for gas cars.

7.2 Insights from the Quantitative Findings

In this section, we present highlights of the insights captured from the state-wide quantitative survey. These insights should aid in the development of the business model aimed at increasing the odds of purchasing or leasing an EV by low-income Californians.

- The current adoption rate for EVs is very low among low-income Californians: only 6% of the sample has owned a fully electric vehicle and around 5% has leased one.

- Interestingly, 40% of the sample has previously ridden in an EV and hence had at least a minimal level of exposure to EVs.

- More people had considered purchasing or leasing a hybrid vehicle compared to a fully electric vehicle.

- Only 5% had first learned about in EVs in school and another 2.3% at work.

- The amount of negative information that low-income Californians received about EV is not concerning.

- The knowledge barrier appears to manifest in the lack of knowledge rather than the presence of negative information.

- When low-income Californians are presented with the advantages of EVs, they tend to perceived those advantages positively. Hence, the potential problem resides in the lack of available information to low-income Californians regarding EVs, rather than the availability of negative information.

- There is a low concern level among low-income Californians with the availability of EVs in their area. This indicated that the availability of EVs in dealerships does not seem to be a hindering factor for EV purchasing.

- Re-sale value does not seem to be a hindering factor for EV purchasing among low-income Californians.

- Battery life, charging time, charging infrastructure, and limited mileage range are significant concerns among low-income Californians.

- The awareness of mileage range, various types of charging, and the duration of charging is lacking among low-income Californians. These match with major concerns low-income Californians have regarding battery life, mileage range, and charging infrastructure, indicated under the misinformation barrier section of this report.

- The availability of chargers seems to be a major hindrance for low-income Californians who live in apartments.

- There is a low level of familiarity with various rebates and government subsidies offered for EVs among low-income Californians.

- If more charging stations were available, replacement batteries were easier to find, or rebates and vehicle warranty duration were doubled in time, low-income Californians would be more willing to purchase an EV.

- Low-income Californians would consider purchasing a new or used EV if prices were comparable to those of gas-powered vehicles.

- There is a general resistance to leasing an EV among low-income Californians even if the price were comparable to the cost of leasing a gas-powered vehicle.

- Maintenance cost, upfront purchasing cost, insurance cost, and operating cost were all perceived to be significant costs for low-income Californians.

- For the short term, within the next three years and the next five years, low-income Californian are not considering an EV purchase.

- Within the next ten years, low-income Californians are willing to purchase an EV.

- From the study sample, 30% of participants are interested to buy or lease an EV if monthly payments are between $200 and $299.

- The general attitudes towards EVs among low-income Californians are positive, which is in line with the low amount of negative information received regarding EVs. However, there are still some specific barriers and concerns hindering the purchasing of EVs among low-income Californians.

8. Business Model

The proposed business model and ideas can be considered for implementation by state programs, state agencies, or new social enterprises (e.g., startups). The business model builds on foundational entrepreneurial concepts that foster innovation, leverage resources, and invest in partnerships. The business model canvas can be found in Appendix A.

8.1 Situational Analysis

In the situational analysis, opportunities and threats that stem from external factors are identified. The business model goal is to leverage opportunities and mitigate threats to help expand EV adoption among low-income Californians.

Table 1. Business Model Opportunities and Threats

Opportunities	Threats
• The general attitudes towards EVs among low-income Californians are positive • Little negative information and perceptions about EVs within the minds of low-income Californians • Implementation of education and awareness programs in both Spanish and English and across educational institutions and work, involving community leaders and focusing on low maintenance cost, the availability of free charging stations, cost, and the future of EVs, which will be monitored by local community-based organizations • Low running and maintenance costs of EVs in the long term, making them a better investment for drivers • Electric companies are attracting increasing interest in offering and advertising programs that offer rebates to EV users • Building charging stations in common high-traffic areas such as grocery shop parking lots • Existing and forthcoming programs aimed at expanding charging stations at public housing by incentivizing the owners of public housing to install charging stations on their property which would in turn make charging more accessible and affordable than gas • Building charging stations at workplaces or other convenient locations spread out across low-income neighborhoods, sponsored by the government for higher accessibility • Provide tax benefits for property owners when they install charging stations for multi-family dwellings	• Lack of knowledge, education, and awareness regarding the benefits of EV transportation among low-income Californians • Significant concern among low-income Californians regarding battery life, charging time, charging infrastructure, and limited mileage • Gaps in engaging community leaders and bilingual messages • Language barriers in existing information and programmes • Resistance against leasing which limits ownership options • Lack of solutions to decrease price of available charging outlets • Lack of existing solutions offered by electric companies to decrease the cost of charging outlets • Scarcity of charging stations creates a state of fear towards EVs • Existing infrastructure preventing low-income Californians from having an outlet capacity for electric vehicle charging • Improper infrastructure which inhibits the installation of charging stations and is very costly to fix • Vagueness and ambiguity in criteria and price set for purchase of home charging infrastructure • Lack of charging stations at work or other convenient locations • High upfront cost for EV purchase • Perceptions of higher costs of EVs compared to gas-powered vehicle along with maintenance cost, upfront purchasing cost, insurance cost, and operating cost could push prospects to reconsider purchase • Available financial incentives are not readily accessible to target market due to a rigorous application process • Some current rebate programs have a high income cap that is not suitable for target market

Opportunities	Threats
• Capitalizing on leasing as it removes the burden of the full cost of ownership • Expanding the option of leasing an EV to decrease/eliminate high upfront payment, based on buyer's credit score • Existence of loan guarantees programs to support low-income Californians with their EV purchases • Create a platform to act as an intermediary between state agencies and financial institutions in order to provide low-income Californians low-interest loans • Have a single platform with a single application for applicants to fill in order to gain several incentives upon purchase • Provide incentives, such as tax reductions, for car dealerships to promote used EVs to low-income Californians • Create partnerships with transport network companies (e.g., Uber & Lyft) to promote the use of EVs among low-income Californians. • Partner with third-party organizations to partake in sponsoring charging stations installments and spreading awareness • Create more rewards program for EV purchases	• Incentive stacking process is tiring and time consuming which puts users off • Lack of payment plans to facilitate payment for low-income Californians • Property owners are not convinced and are refusing to install charging stations on their property

8.2 Business Model

The business model focuses on generating revenue to cover the costs associated with the services offered to low-income Californians to ease their adoption of EV. Several revenue streams are identified to allow for the sustainability of the model and decrease the need for state funds.

8.2.1 Value Proposition

The program/startup aims to increase EV usage amongst lower-income Californians by making information and services more accessible and bridging cost barriers. A collection of **integrated services** will be offered including accessible and convenient charging stations at a subsidized cost, easy access to financial options and incentives, free educational programs, and awareness campaigns/event. The program/startup will offer a one-stop platform, including an inclusive knowledge database and programs, financial and leasing access and assistance, a loyalty program and promotions, and charging subscriptions and bundles.

Charging Stations

In collaboration with **electric and solar companies**, the program/startup will invest in building public charging stations in convenient locations that are accessible to low-income Californians, including grocery store parking lots. The charging stations' impact will be two-fold. First, they will allow low-income Californians to charge EVs at subsidized rates. Second, and importantly, the charging stations will be designed with the ability to feature short commercials on a screen. When an EV owner decides to watch the commercial (maximum 30 seconds), they receive a discount on their charge. **The premiums charged to businesses in order to feature their ads will contribute as a revenue stream** to subsidize the cost of charging and contribute to mitigating the initial investment put into building the charging stations. The option of watching a commercial to receive a subsidized/discounted rate will be exclusive to low-income Californians. To access this feature, called "Watch and Save," low-income Californians will have to use the program's/startup's mobile application (which will be discussed later).

E-Charging Wallet & Loyalty Programs

Through the e-charging wallet we will partner up with charging companies (power/solar companies) such as EVGO (Wire, 2022) in order to provide charging bundles/subscriptions. EVGO allocates a budget towards increasing stations within lower-income areas in California, as noted in Wire (2022). Through these bundles, users will pay in advance for several charges for a price benefit. Through using the e-wallet they will receive occasional discounts and benefits. Benefits can include getting one charge for free after completing a certain number of charges. In addition to that, through our partnership with partner retailers such as Target and Walmart, we aim to provide occasional discounts for charging after a certain number of purchases from our partner retailers.

Facilitating the Financial Process

In collaboration with **state agencies and financial institutions**, the program/startup will **integrate and streamline several application processes for various incentives** and rebates to ease the hurdles that low-income Californians face and ensure they can stack up the available incentives in an easy fashion. All applications will be easily accessible through the mobile application, and advisors will be available to answer low-income Californian's concerns.

To **overcome the upfront cost**, funds will be allocated to provide **interest-free loans equivalent to the rebates**. This way, low-income Californians will not be burdened by the upfront cost and can pay these interest-free loans back when they receive the rebates.

A **leasing feature** will be offered with partner banks through which users can lease a car via our mobile application. The leasing feature aims to provide simplified information on how to get approved for an EV alongside easy-to-follow steps in Spanish and English. Longer payment features and a lower price will also help to decrease the upfront cost.

Awareness and Education Programs

In collaboration with **state agencies and community-based organizations,** the program/startup will invest in organizing events and conduct awareness campaigns to increase awareness regarding EVs and help clarify misconceptions about EVs that may exist among low-income Californians. The impact will be two-fold.

First, the awareness and education programs will allow low-income Californians free access to information that is designed specifically for them, taking in consideration their concerns, language preferences, and so on. The awareness and education program will provide beneficial and simplified information on EVs **in Spanish and in English**. Such information will be provided through video content that is developed with **community leaders**. The video content will cover several concerns such as different EVs available in the market, how to get a loan for a car through the application, the cost benefits of having an EV, how to charge, access to rebates, and so on. The awareness and education program will mitigate the lack of engagement of dealerships and their lack of willingness to explain and promote EVs to low-income Californians. The awareness and education program will include events and campaigns as well as a repository library of resources available on the program's/startup's mobile application (which will be discussed later). The content (e.g., events, campaigns designed for specific local communities, etc.) will be **geographically categorized** and displayed to its intended target audience, featuring the **relevant community leader**, capitalizing on the **geolocation** feature in the mobile application. Also, the program will include **outreach to schools and workplaces** to increase awareness about EVs.

Second, and importantly, the awareness and education program will be conducted using paid sponsorships for the events and the content on the mobile app. **The paid sponsorships charged to**

businesses will contribute as a revenue stream to subsidize the cost of running the awareness and education program.

Training Program

A training program will be designed in collaboration with professionals in the field and offered for free for auto dealerships and community partners. The training program will be designed to deliver a better understanding of low-income Californians' consumption behaviors, how they access information, their decision-making process in the market, etc. The training program will equip several stakeholders (e.g., dealership personnel, community leaders) with the knowledge and the skills required to promote EVs among low-income Californians.

Inventory of Used EVs for Purchase and Lease

In collaboration with car dealerships, the inventory of used EVs available for purchase and lease will be included on the mobile application to allow low-income Californians a one-stop shop to find available EVs. This will offer low-income Californians ease of access to EVs available on the market. The inventory will be **geographically categorized**, capitalizing on the **geolocation** feature in the mobile application.

Integrated Platform (Mobile Application)

A one-stop mobile app as well as a website will be developed and offered to low-income Californians, including access to all the above-mentioned tools and services. The integrated platform will include an inclusive knowledge database, an EV blog, the e-charging wallet, financial assistance, an event and trainings calendar, announcements, and an inventory of available used EVs for purchase or lease.

The integrated platform will provide the benefit of simplified information on EVs in Spanish and in English. Such information will be provided through our video content in partnership with community leaders. The video content will cover several aspects such as information about different EVs available on the market, how to get a loan for a car through the application, the cost benefits of having an EV, access to rebates, and so on. Through this platform we aim to provide the benefit of access to reliable information and knowledge of EV models and to provide a place to share concerns.

The integrated platform will also include a feature to locate either all charging stations nearby and **charging stations that we have partnerships with (e.g., charging station with discounts and loyalty programs)** in order to reduce the charging cost and facilitate access to other loyalty benefits.

As mentioned above, the integrated platform will **integrate and streamline several application processes for various incentives** and guide low-income Californians to stack up all incentives.

Also, the app provides offers and promotional codes that are related to our partners' products, such as: grocery stores, Uber, Lyft, car-share services, insurance discounts, and EV charging discounts.

8.2.2 Customer Segments

The target customer segments are low- and middle-income Californians. Middle-income Californians are included to widen the scope of our application. Middle-income Californians can find great benefits in the proposed integrated mobile application.

People between the ages of 16 and 25 will receive focus as an important target market since they are most likely to have not yet purchased or leased their first vehicle, and hence, getting them in an EV as their first vehicle is a promising target to pursue.

8.2.3 Revenue Streams

B2B advertisement service: B2B advertisement service for various business sectors on both the **mobile application** and **the charging station** streams will be a source for revenue.

Sponsorships: Paid sponsorships for the awareness and educational programs as well as events will be designed to generate revenues.

Signing Bonuses: When users finalize a lease or a purchase deal through our application in partnership with EV dealerships.

Transaction Fees: Transaction fees will be received from purchases done through our e-commerce shop. We will also place a small transaction fee on the charging bundles through our charging e-wallet to generate revenue.

Freemium Model for Middle-Income Californians: As we will expand access to some services provided by the mobile app to middle-income Californians, a subscription option for a premium user experience will be included. This will allow users to have zero ads, access to special features on our blog, and access to deals.

Research Services: Low-income Californians may participate in research studies in order to receive incentives (e.g., free charging for a certain period of time). These research omnibus studies will generate **reports** that will be made available for interested parties for a **subscription fee.**

8.2.4 Key Activities

- Collaborate with electric and solar companies to make charging stations more available in low-income neighborhoods.

- Develop a subsidized program with electric and solar companies

- Develop partnership with media buying agencies to promote and secure commercials to be displayed
- Manage the advertising feature on the charging station
- Create informational video content in English and Spanish in partnership with community leaders
- Create a sponsorship program to utilize in holding various awareness events where sponsorships help mitigate/cover the cost of the campaign events.
- Partner up with banks and financial initiations to manage the rebate/incentives and lease processes
- Develop a digital financial assistant tool to integrate all incentives and rebate applications
- Develop a training program to equip several stakeholders (e.g., dealership personnel, community leaders, etc.) with the knowledge and skills required to promote EVs among low-income Californians
- Partner with auto dealerships to display inventories of used EVs for purchase and lease
- Develop and launch the mobile application
- Community outreach in schools and workplaces

8.2.5 Channels

Customer Segment Reach: Through the following channels, the program will reach and create contact points with target audience to develop long-term relationships that are fostered in care and trust.

The channels will include:

- Tailored free educational programs and awareness campaigns/events
- One-stop platform (mobile app and website), including an inclusive knowledge database and programs, financial and leasing access and assistant, loyalty program & promotions and charging subscriptions & bundles
- Advisors will be available to answer low-income Californians' concerns
- Community leader ambassadors

- Outreach to schools and workplaces

- Research services, low-income Californians may participate in research studies to receive incentives as a compensation for their participation in research studies.

Most of the channels (knowledge database, an EV blog, the e-charging wallet, financial assistance, an event and trainings calendar, announcements, and an inventory of available used EVs for purchase or lease) are integrated through the mobile application and website.

The outreach with local community leaders will be one of the best ways to understand customers and provide a convincing message. Specifically, community reach, in collaboration with community leaders/ambassadors, will be key to raise awareness regarding the integrated digital platform and the services offered. Further efforts will be dedicated to supporting dedicated leaders in each community who are trained and possess the knowledge required to expand the understating and adoption of EV among their local community.

The use of the mobile application is deemed a cost-efficient channel because it can reach so many people with the same fixed cost. Given the significant time spent on cell phones, the mobile app will be integrated into the lifestyle of the targeted segment.

Table 2. Summary of Qualitative Quotes

	Barriers			
Stakeholders	**Knowledge Barrier**	**Cost Barrier**	**Charging/Infrastructure Barrier**	Business Model Barrier
Electric & Solar Charging Companies	*I think that what we're finding is that there's a wide spectrum of awareness and comfort with electric vehicle knowledge across our territory and customer types. So, we are wanting to develop and have developed some tools to help customers figure out what EVs are on the market, what is the total cost of ownership. But there are other ways to involve, like community-based organizations to help us spread the message and help us understand what is resonating with customers.*	*It'd be hard to choose sort of a single cost figure here because there are a lot of different things that are involved if you need to do electrical work that can substantially increase the costs for a multi-unit dwelling if you need to do any kind of trenching digging up of your parking lot that can greatly increase costs. So, you know, I wouldn't commit to sort of a single number*	*We offer to pay for infrastructure at multi-unit buildings. And we're also about to propose a successor program to that, so that we can continue to offer that to our multi-unit dwelling customers. And we also just recently proposed a program where we would incentivize customers that like smaller, multi-unit dwellings to install charging infrastructure where they have panel capacity. So, where it's like pretty cost effective, and if they're smaller, multi-unit dwelling, they tend to sometimes not meet some of our cost effectiveness requirements for our larger programs. So those are two ways that we are incentivizing installation of charging stations and multi-unit dwelling properties.*	*It just has to be modeled safely, where a regular consumer that doesn't have much knowledge on it can go ahead and swap out a battery, without hurting themselves or other. That would be awesome…Hopefully the batteries aren't like a size of an engine. But if they were smaller, accessible and safe, I think that would be awesome, actually.*
	We come at this [educating the public] in a couple different ways, our national brand neutral education awareness effort that the current campaign is called normal now. And this is a bilingual campaign. It's an English and Spanish.	*Yeah…if we're doing option D, like you had earlier full ownership, we will finance a lot of the infrastructure and ask for like a participation payment from the customer. So, we'll finance quite a bit and then they'll pay a bit as well. And*	*The way that you really expand EV charging to*	*Battery swapping technology is pretty complicated to begin with. There's been a few companies that looked in earnest at doing battery swapping and they were looking at sort of more rapid than just at the end of the lease like you know…depending on your vehicle that might be more or less realistic from sort of an engineering perspective.*

	Barriers			
Stakeholders	**Knowledge Barrier**	**Cost Barrier**	**Charging/Infrastructure Barrier**	Business Model Barrier
		then we also through some of those programs offer rebates, it kind of depends on which specific program and which specific customer segment we're targeting. But we do offer both financing solutions and rebates for various customer types. And we tend to offer kind of along the theme of this discussion we tend to offer so financing solutions or rebates that are more for customers who fall into certain disadvantaged communities or low-income classifications.	*everybody is to have ubiquitous public charging at really convenient locations. You know, it's not an extra trip, if you're going to the grocery store once a week anyway, if you put a charger there, you can charge up your vehicle, and with the ranges of the modern vehicles, and with most people's driving habits, you know, it's very realistic in many cases, that that's going to last you until your next trip to the grocery store.*	*When you purchase or lease a new vehicle, the battery comes with like an eight year at least warranty on it. And so, if you're looking at a typical, maybe a 36-month lease or something like that, your battery is already is still going to be under warranty*
	We have a variety of ways that our solutions marketing team engages with customers. So, our previous clean fuel rebate program was marketed [via] email and some of our web website content as well as using paid social media channels, you know, ads, or targeted research or through outreach. We're hoping to continue to expand upon that and continue to find either current EV owners that might also be interested in then installing, charging at home, also trying to leverage other existing programs and resources that help us figure out who, who was a newbie owner, or considering one, but we are also very reliant on word of mouth,	*They [initiatives aimed at decreasing the peak-hour usage] actually are doing pretty well… when I was in the contact center, customers that have EV have done their research on it… and they make it work for them.*	*Usually, the homes are older… they just don't have that outlet, like the newer builds do, it's a requirement that they be put in there. Now, so it's really as simple as popping a little panel and then getting it installed, compared to the older structures where you have to rewire you have to get everything done from fresh.*	*Dealerships, it's really important to have communication and collaboration with the folks who are offering rebates, because that's another thing that we hear from dealerships when I did dealership engagement work in the northeast was, dealerships, really, they don't want to be in the position of promising customer something, and then having it not be true. So having that kind of coordination between the dealerships and the folks who are implementing these programs, that's crucial…I think that the state should continue to look at ways to*

	Barriers			
Stakeholders	**Knowledge Barrier**	**Cost Barrier**	**Charging/Infrastructure Barrier**	Business Model Barrier
	and having other people share their experiences or these resources with, with their friends and family. So that is big a big tool that we use as well.	*People become more and more aware of the advantages of being able to charge at home and take advantage of low pricing… So, comparing that to the cost of gasoline in California, that's a pretty attractive pricing.*	*It really just depends on how the home was designed. And, any issues that could show up in terms of getting an electrician out there to run a new line…if the panel capacity is constrained for some reason, or if it's really difficult to get a wire from the panel out to where the resident is looking to install their charger…those would be barriers, definitely not insurmountable, you could, but they could increase the cost.*	*get these vehicles into the hands of more people.*
	The incentive advisor tool is specifically a tool where you can enter in your address and it's going to tell you know, based on your utility service territory and all these other factors, you know, what the different incentives are that you qualify for. And then the next sort of phase of functionality is to really hold people's hand through that incentive process by getting them onto the website where they can fill out the forms etc. So, I'm that has been our major effort in in California is working on that incentive advisor tool to give people that information tip of their fingers.	*There's a program called the California Clean Fuel Reward. And that's really like pot of money that goes to fund that which is a discount off the sticker price of a zero-emission vehicle is funded by all the utilities in the state. And so, we contribute to that. And we also just propose to offer rebates on used EVs and so we support offering rebates and are hoping to expand our ability to do so.*	*Rebates for the purchase and installation of home charging infrastructure are a strategy that is has been pursued by state governments by utility is, you know, the Federal alternative fuel infrastructure, tax credit, etc. So, rebates could easily be part of the solution. But then making sure that you connect people with those, and they understand how to take advantage of them. That's certainly part of it. And*	

	Barriers			
Stakeholders	**Knowledge Barrier**	**Cost Barrier**	**Charging/Infrastructure Barrier**	Business Model Barrier
			depending on the cost of the operation, you know that to come and do the electrical work, maybe there's rebates and incentives aren't set at the right level to really cover enough of that cost that it makes it a possibility for a low-income individual. So, I mean, ***public charging*** *is another option, if it is, you know, so expensive to do the electrical work at your house and purchase the unit especially if you rent your home, or you don't know you're going to be living there for the long term.*	
Professional and Community-Based Organizations (CBOs)	*Targeted Investment in outreach, Spanish and bilingual translation awareness and education, you know, making sure that that people are educated. And starting to do this, you know, to the masses, lots of events, lots of awareness, getting people in the cars.*	*Purchase price is one [barrier] and I think that will continue to fall as there's more and more models available as the used vehicle market becomes expanded and there's more options out there.* *The upfront cost is a barrier. The lower*	*EV charging infrastructure being located at both multi-unit dwellings and businesses and just making sure that that's accessible to everybody is going to make you know, especially for lower income communities, make electric vehicles more and more accessible.*	*I think with low-income individuals, specifically, this [Leasing and EV] can be a really good way to get into the EV Market…I've heard firsthand from folks who have been able to lease a vehicle for no money down* *I think it [leasing an EV]'s a fantastic idea. And I would love to see that, try it out and see how that works…If you can take that burden away*

	Barriers			
Stakeholders	**Knowledge Barrier**	**Cost Barrier**	**Charging/Infrastructure Barrier**	Business Model Barrier
	EV educational programs that they've built into their work and trying to get their workforce educated about electric vehicles. So, I think that's a big way to increase awareness.	*maintenance cost is not something that most people even recognize [when] they're considering a purchase, and [it's] all about the upfront cost…So, the upfront cost is your problem…most people don't even consider reduce maintenance. They don't even think of a total cost of ownership model.*		*from people, I think you're really relieving, you know, a huge amount of anxiety for you know, potential costs.*
	We really need to bring education [about EVs] in schools, particularly like in high schools, because kids coming up in high schools, they make up their minds, what they want to buy is their first car.		*If you can't charge at home, there's a lot less of an incentive to own an electric vehicle. And, same thing with the workplace. Maybe if you don't have charging at home, you can you can get away with it if you have chargers at work, or somewhere that you conveniently go to.*	*So…if the leasing program is not based on their FICO score, or their [low-income Californians] credit score, and it could be something where even if they don't have good credit, there's a way for them to get an opportunity to lease a car? I think that's that could be a solution for some.*
	More education that can definitely be done around the low maintenance costs and …charging infrastructure, there's still free chargers out there and available.		*If people can charge at work, it's going to be it's going to be huge for incentivizing them to get an electric vehicle We've kind of seen examples where people actually will use a word charger as their main charger. And then even if their house they don't charge at home, they're charging at work.*	
	It's finding those community leaders who can help kind of spread the message, whether it's			

	Barriers			
Stakeholders	**Knowledge Barrier**	**Cost Barrier**	**Charging/Infrastructure Barrier**	Business Model Barrier
	church leaders, or just community groups or something, principals, and the people in the communities who have the ear of others… I don't think it's as simple as like, finding the right messaging, I think it's more about finding the right messenger.		*I think it really just comes down to getting multi-unit dwellings to install charging infrastructure, or potentially, you know, other options like curbside charging, and having cities and counties and local governments invest in those technologies to be able to offer those services to low-income individuals.*	

	Barriers			
Stakeholders	**Knowledge Barrier**	**Cost Barrier**	**Charging/Infrastructure Barrier**	Business Model Barrier
Financial & Loan Institutions	*Some of the challenges, I would say [is] the message…how does that translate to different languages? Because there's many different minorities existing in California… So, I would say outreach is a challenge… how is the state of California working with local leadership or local government to help residents… I don't think it [the message] trickles down… we don't see the marketing happening in local communities.*	*Low Income Californians cannot easily access a vehicle because of their income status alone…despite grants and rebates [it] is still can be very difficult to attain.*	*There are communities that don't have the same access for electric vehicles as other communities do. And this is due to the lack of charging stations.* *The [state's] focus [should be] solving the charging stations [issues]…that takes a lot of thinking about where to locate them [and] getting access to them, getting approval from local zones. There's just so many components to actually building a charging station.*	*Currently, our program has a reservation list, which means that we're able to continue to give out grants until participants either decides to redeem their grant or not. And then the following participant would receive a grant or not. So, I think starting with enough funding to keep our program open, can contribute to increasing EVs.* *Another idea is like broadcasting our program through the radio, through TV channels, to be able to access broader community and just more people in California.*

Table 3. Sample Framing for the Quantitative Study

Region	County	Number of people	Low income: Household Income less than or equal to	Sample Collected
Northern CA	Tehama Trinity Glenn Shasta Siskiyou	1	39150	69
		2	44750	
		3	50350	
		4	55900	
		5	60400	
		6	64850	
		7	69350	
		8	73800	
SJ Valley	Fresno Merced Madera Kings Kern Tulare	1	39150	210
		2	44750	
		3	50350	
		4	55900	
		5	60400	
		6	64850	
		7	69350	
		8	73800	
Sac Valley	Sacramento	1	48350	157
		2	55250	
		3	62150	
		4	69050	
		5	74600	
		6	80100	
		7	85650	
		8	91150	

Region	County	Number of people	Low income: Household Income less than or equal to	Sample Collected
Desert	San Bernardino Riverside	1	42200	188
		2	48200	
		3	54250	
		4	60250	
		5	65100	
		6	69900	
		7	74750	
		8	79550	
Central Coast	San Luis Obispo	1	54350	118
		2	62100	
		3	69850	
		4	77600	
		5	83850	
		6	90050	
		7	96250	
		8	102450	
	Monterey County	1	54250	
		2	62000	
		3	69750	
		4	77500	
		5	83700	
		6	89900	
		7	96100	
		8	102300	

Region	County	Number of people	Low income: Household Income less than or equal to	Sample Collected
Napa Valley	Sonoma County	1	63650	55
		2	72750	
		3	81850	
		4	90900	
		5	98200	
		6	105450	
		7	112750	
		8	120000	
LA	Los Angeles County	1	63100	261
		2	72100	
		3	81100	
		4	90100	
		5	97350	
		6	104550	
		7	111750	
		8	118950	
	Orange County	1	71750	
		2	82000	
		3	92250	
		4	102450	
		5	110650	
		6	118850	
		7	127050	
		8	135250	
Bay Area	Contra Costa County	1	73100	216
		2	83550	

Region	County	Number of people	Low income: Household Income less than or equal to	Sample Collected
		3	94000	
		4	104400	
		5	112800	
		6	121150	
		7	129500	
		8	137850	
	San Francisco County San Mateo County	1	97600	
		2	111550	
		3	125500	
		4	139400	
		5	150600	
		6	161750	
		7	172900	
		8	184050	
San Diego	San Diego County	1	64700	176
		2	73950	
		3	83200	
		4	92400	
		5	99800	
		6	107200	
		7	114600	
		8	122000	
Total				1450

Table 4. Sample Characteristics of Quantitative Study

Sample Characteristics					
Characteristic	**Percentage**	**Characteristic**	**Percentage**	**Characteristic**	**Percentage**
Political Party		**Ethnicity**		**Education**	
Republican	21.7	American Indian or Alaska	1.2	Less than high school	4.2
Democrat	41	Native	20.4	High school graduate (or GED)	21.7
Independent	21.7	Hispanic/Latino	7.5	Vocational or technical training	4.8
Other	2.3	Black or African American	1.1	Some college (No degree)	25.7
No preference	13.3	Native Hawaiian or		Two-year college degree	12.6
		other Pacific Islander	56.1	(Associate's, etc.)	22.6
		White or Caucasian	6.8	Bachelor's degree	6.6
		Asian	3.5	Master's degree	1.8
		Multiracial	1.7	Doctoral degree (PhD, JD, MD,	
		Other	1.7	etc.)	
		Prefer not to answer			
Age		**Total Annual Household**		**Employment Status**	
18 to 29	29.9	**Income**	34.5	Working full-time	28.8
30 to 44	24.1	Less than $30,000	23	Working part-time	13.5
45 to 59	17.1	$30,000 to $49,999	23.4	Self-employed	6.8
60 or older	28.9	$50,000 to $74,999	10.3	Homemaker or stay-at-home	5.2
		$75,000 to $99,999	3.8	parent	5.1
		$100,000 to $124,999	1.9	Student	7.9
		$125,000 to $149,999	1.6	Out of work, but looking for work	1.6
		$150,000 to $199,999	.6	Out of work, but not looking for	6.1
		$200,000 to $249,999	1	work	0.1
		$250,000 or more		Unable to work (e.g., disability)	0.0
				Military	
				Retired	
Marriage Status		**House vs. Apartment**		**Average Driving Miles per Day**	
Married	30.1	House	66.4	0-10 miles per day	38.6
Single (Never	45.4	Apartment	33.6	11-20 miles per day	23
married)	15.6			21-30 miles per day	17.4
Divorced	3.1			31-40 miles per day	9.7
Separated	5.8			41-50 miles per day	4.8

Sample Characteristics					
Characteristic	**Percentage**	**Characteristic**	**Percentage**	**Characteristic**	**Percentage**
Widowed				51+	6.6
Children Yes No	 44.3 55.7	**Homeowner** Yes No	 45.1 54.9	**Number of Vehicle per Household** One Vehicle Two Vehicles Three Vehicles Four Vehicles Five Vehicles or more	 53.7 31.7 9.1 3.3 2.2

Table 5. Initial Source to First Learn about EVs

Initial Source to First Learn about EVs		
	Frequency	Percent
I had no prior knowledge	177	12.2
Unsure	174	12
School	73	5
Work	33	2.3
TV	305	21
Internet	257	17.7
Social Media	111	7.7
Advertisement	96	6.6
Word of Mouth	177	12.2
Other	47	3.2

Table 6. Knowledge Barriers: One Sample T Test – Comparing the Means to Mid-Point of the Scale

Knowledge Barriers					
	Mean	Std. Deviation	Mean Difference	T	Sig.
Knowledge Regarding EV	3.4	1.812	-0.603	-12.67	<.001
Negative Information about EV	3.02	1.788	-0.979	-20.846	<.001
Positive Information about EV	4.04	2.03	0.044	0.828	0.408
Past Consideration of Buying or Leasing a Hybrid Vehicle	4.05	2.213	0.052	0.89	0.374
Past Consideration of Buying or Leasing a Fully Electric Vehicle	3.82	2.21	-0.176	-3.031	0.002

Table 7. Perceived Importance of Various Aspects of EVs: One Sample T Test – Comparing the Means to Mid-Point of the Scale

Perceived Importance of Various Aspects of EVs					
	Mean	Std. Deviation	Mean Difference	T	Sig.
Importance of EVs in Reducing Greenhouse Gas Emissions	4.88	2.095	0.878	15.96	<.001
Importance of EVs in Reducing Operating Costs	4.95	1.934	0.952	18.737	<.001
Importance of EVs in Reducing Noise Pollution	4.72	1.992	0.718	13.722	<.001
Importance of EVs in Increasing Performance over Gas Vehicles	4.84	1.97	0.839	16.209	<.001
Importance of EVs in Offering Convenience of charging at Home or Work	5.01	1.979	1.014	19.505	<.001

Table 8. Misinformation Barrier: Concerns with EVs: One Sample T Test – Comparing the Means to Mid-Point of the Scale

Misinformation Barrier: Concerns with EVs					
	Mean	Std. Deviation	Mean Difference	T	Sig.
Concern Level with Availability of EV in their Area	3.41	1.997	-0.592	-11.295	<.001
Concern Level with Limited Mileage Range	4.35	2.048	0.349	6.49	<.001
Concern Level with Charging Infrastructure	4.42	2.035	0.423	7.911	<.001
Concern Level with Charging Time	4.47	2.019	0.469	8.846	<.001
Concern Level with Battery Life	4.54	2.025	0.543	10.218	<.001
Concern Level with Re-sale Value	3.9	1.975	-0.095	-1.835	0.067

Table 9. Convenience Barriers: One Sample T Test – Comparing the Means to Mid-Point of the Scale

Convenience Barriers					
	Mean	Std. Deviation	Mean Difference	T	Sig.
Awareness of Rebates and Government Subsidies offered for EVs	2.59	2.045	-1.407	-26.192	<.001
Awareness of Mileage Range for EVs	3.31	2.003	-0.688	-13.069	<.001
Awareness of Various Types of Charging for EVs	2.8	1.856	-1.198	-24.576	<.001
Awareness of How Long EVs take to charge	2.87	1.906	-1.13	-22.565	<.001

Table 10. Mileage Expectation

Mileage Expectation after One Hour of Charge			Mileage Expectation after One Full Charge		
	Frequency	Percent		Frequency	Percent
10-20 miles	177	12.2	100-200 miles	258	17.8
21-30 miles	174	12	201-300 miles	409	28.2
31-40 miles	73	5	301-400 miles	373	25.7
41-50 miles	33	2.3	401-500 miles	410	28.3
51-60 miles	305	21			
60+ miles	257	17.7			

Table 11. Cost Barriers: One Sample T Test – Comparing the Means to Mid-Point of the Scale

Cost Barriers					
	Mean	Std. Deviation	Mean Difference	T	Sig.
Consideration of Purchasing a New EV If Prices were Comparable to that of a Gas-Powered Vehicle	4.42	2.004	0.417	7.916	<.001
Consideration of Leasing an EV If Prices were Comparable to that of a Gas-Powered Vehicle	3.66	2.046	-0.338	-6.289	<.001
Consideration of Purchasing a USED EV If Prices were Comparable to that of a Gas-Powered Vehicle	4.13	2.009	0.132	2.496	0.013
Perceptions Regarding EVs' Up-front Purchasing Cost	4.72	1.946	0.718	14.05	<.001
Perceptions Regarding EVs' Maintenance Cost	4.73	1.911	0.731	14.567	<.001
Perceptions Regarding EVs' Operating Cost	4.58	1.911	0.584	11.639	<.001
Perceptions Regarding EVs' Insurance Cost	4.63	1.949	0.626	12.238	<.001

Table 12. Likelihood to Purchase an EV in the Future: One Sample T Test – Comparing the Means to Mid-Point of the Scale

Likelihood to Purchase an EV in the Future						
		Mean	Std. Deviation	Mean Difference	T	Sig.
Likelihood to Purchase an EV	Within the next 3 years	3.44	1.993	-0.557	-10.633	<.001
	Within the next 5 years	3.66	2.08	-0.344	-6.301	<.001
	Within the next 10 years	4.11	2.169	0.108	1.901	0.058

Table 13. Conditional Likelihood to Purchase an EV: One Sample T Test – Comparing the Means to Mid-Point of the Scale

Conditional Likelihood to Purchase an EV						
Likelihood to Purchase an EV **IF**		Mean	Std. Deviation	Mean Difference	T	Sig.
	more charging stations were available in one's area	4.14	1.982	0.143	2.743	0.006
	cost of gasoline doubled	4.54	1.979	0.541	10.404	<.001
	replacement batteries were easier to find	4.52	1.962	0.518	10.052	<.001
	rebates and/or subsidies for electric vehicles doubled	4.53	1.992	0.53	10.124	<.001
	vehicle warranty doubled	4.53	1.994	0.532	10.166	<.001
	total cost of ownership was less than or equal to that of a gas-powered vehicle (upfront cost, plus maintenance, plus cost to charge, minus resale value).	4.58	2.009	0.575	10.904	<.001
	more people drove electric vehicles	4.08	1.864	0.08	1.634	0.102

Table 14. Willingness to Pay Monthly to Own or Lease an EV

Willingness to Pay Monthly to Own or Lease an EV		
	Frequency	Percent
$199 or less	778	53.7
$200 - $299	460	31.7
$300 - $399	132	9.1
$400 - $499	48	3.3
$500 - $599	32	2.2
$600 or more	778	53.7

Table 15. General Thoughts Regarding EVs: One Sample T Test – Comparing the Means to Mid-Point of the Scale

General Thoughts Regarding EVs					
	Mean	Std. Deviation	Mean Difference	T	Sig.
Safe	4.64	1.702	0.641	14.337	<.001
Convenient	4.41	1.813	0.412	8.662	<.001
Reliable	4.41	1.706	0.41	9.16	<.001
Easy to maintain	4.21	1.722	0.21	4.651	<.001
Less expensive to operate	4.15	1.875	0.15	3.039	0.002
Fun to drive	4.38	1.827	0.377	7.85	<.001
Cool / Modern	4.61	1.889	0.612	12.346	<.001
Good for the environment	5.3	1.849	1.295	26.668	<.001

Table 16. Perceptions Regarding EVs' Owners: One Sample T Test – Comparing the Means to Mid-Point of the Scale

Perceptions Regarding EVs' Owners					
	Mean	Std. Deviation	Mean Difference	T	Sig.
Satisfaction with their EV	4.64	1.558	0.645	15.758	<.001
More Successful	4.45	1.478	0.448	11.547	<.001

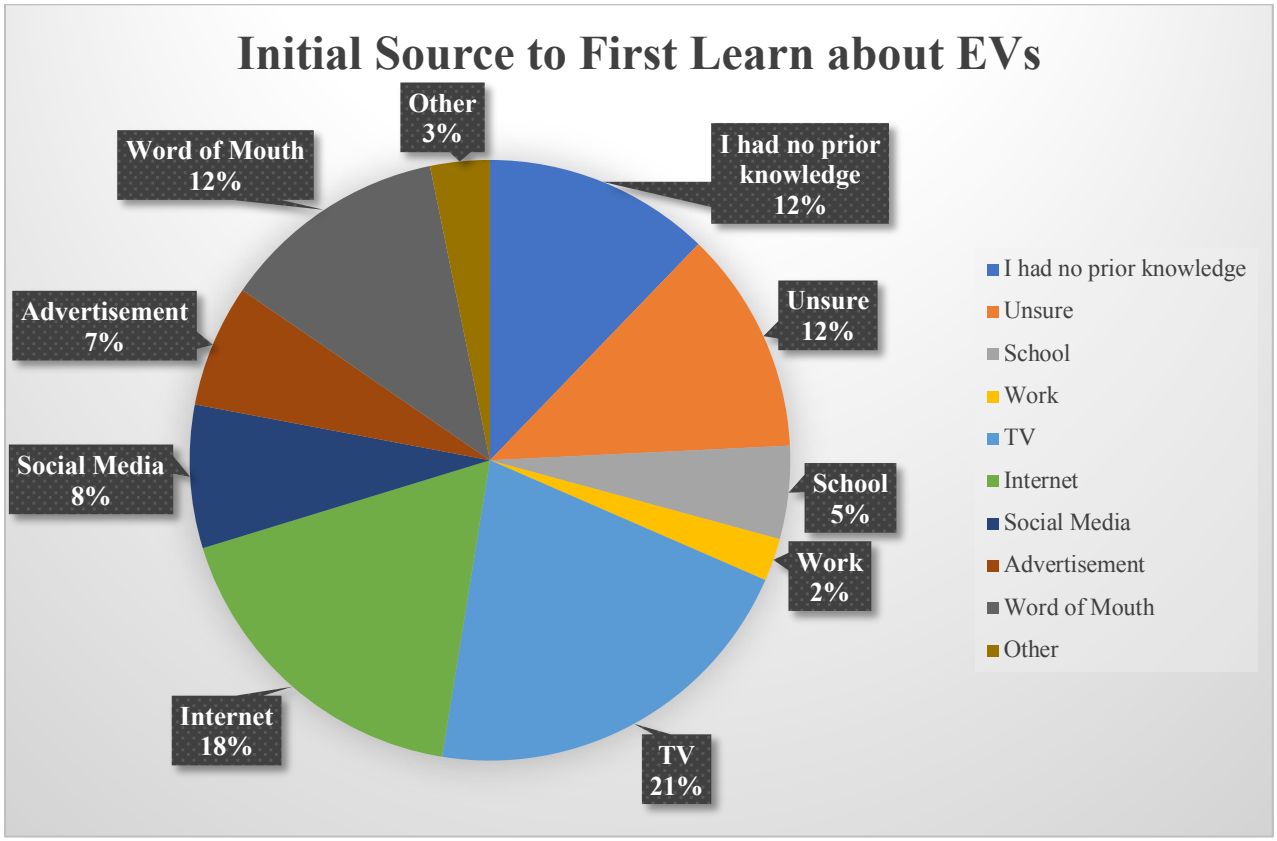

Figure 1. Initial Source to First Learn about EVs

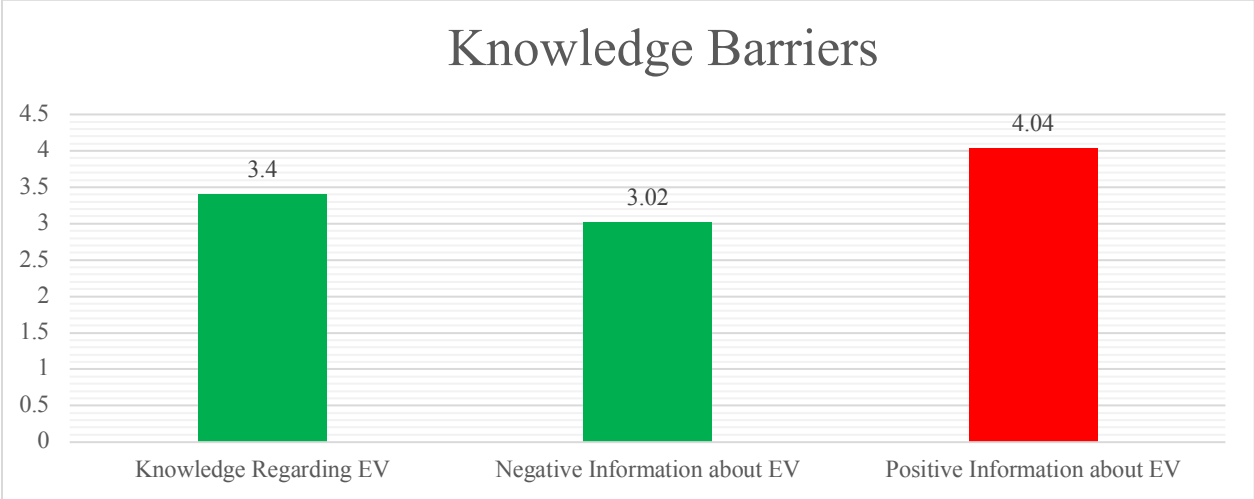

Figure 2. Knowledge Barriers

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

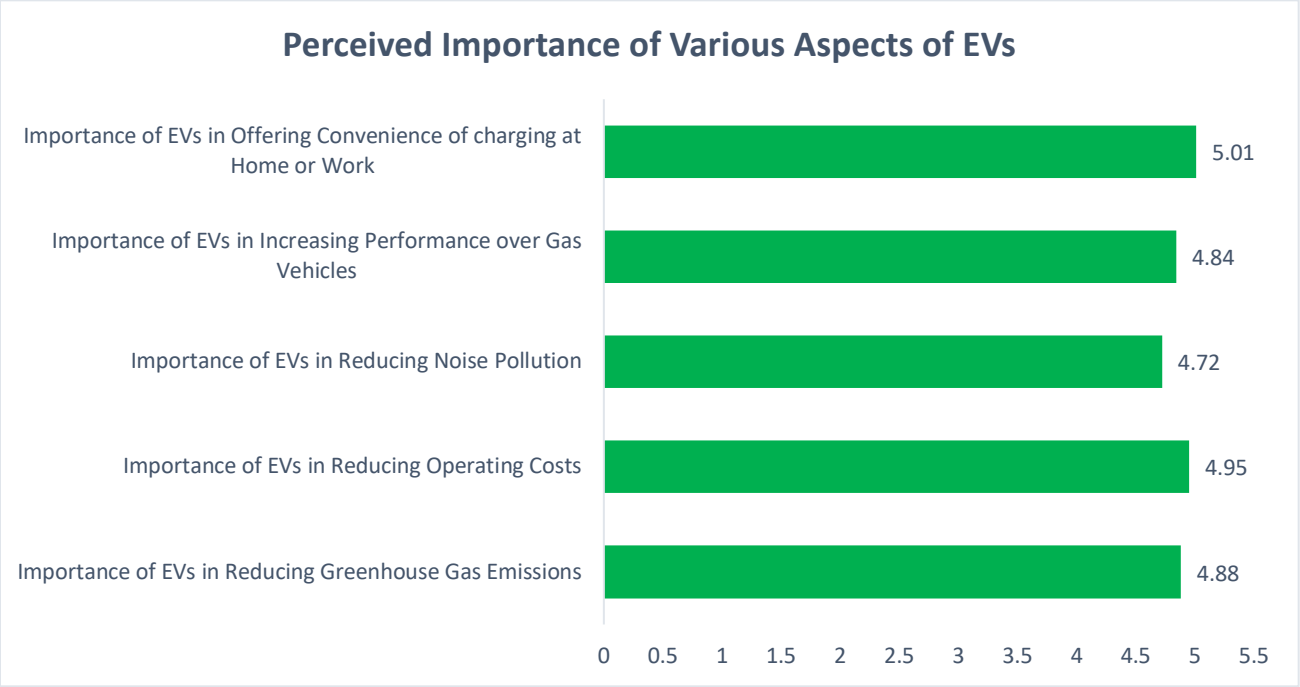

Figure 3. Perceived Importance of Various Aspects of EVs

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

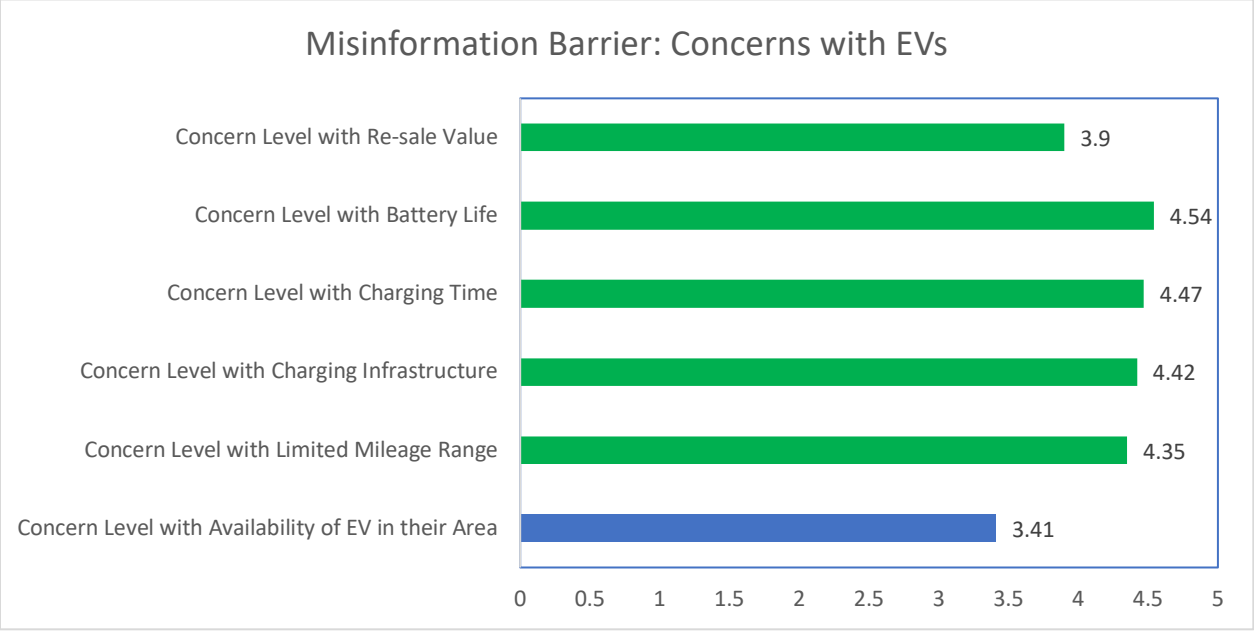

Figure 4. Misinformation Barrier: Concerns with EVs

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

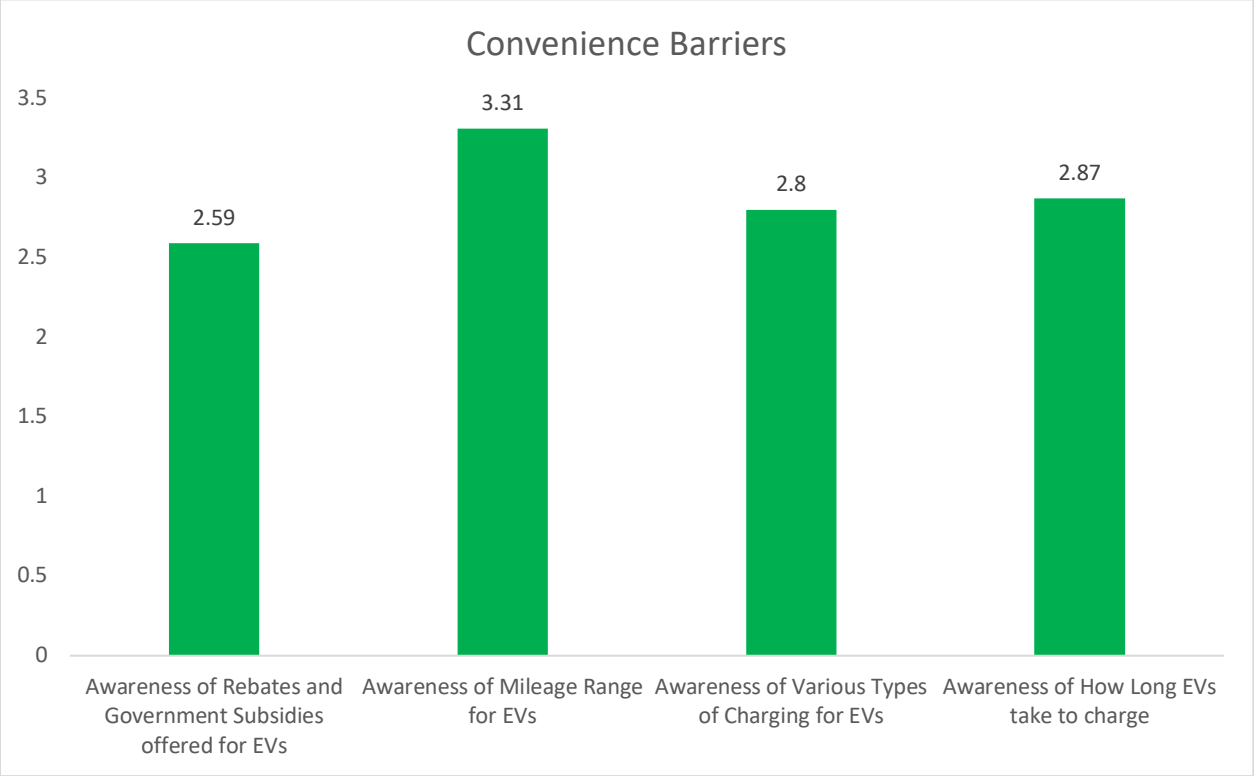

Figure 5. Convenience Barriers

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

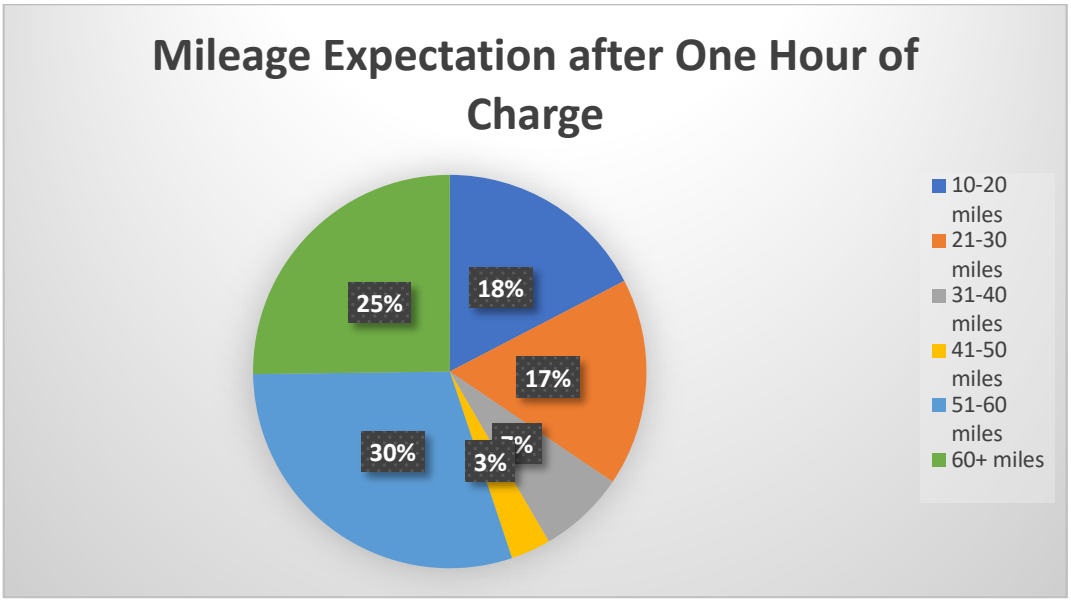

Figure 6. Mileage Expectations after One Hour of Charge

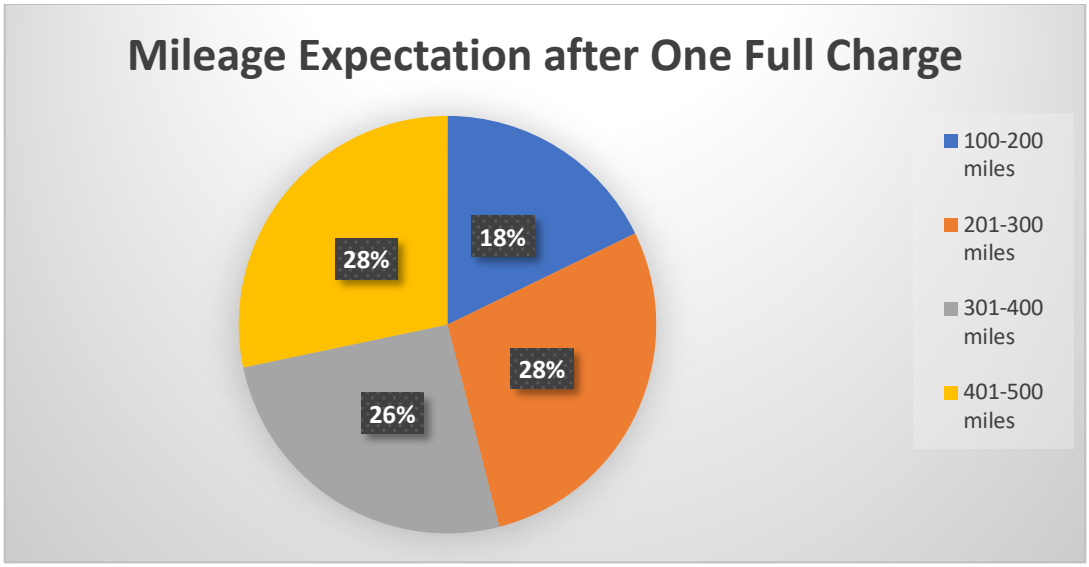

Figure 7. Mileage Exppectation after One Full Charge

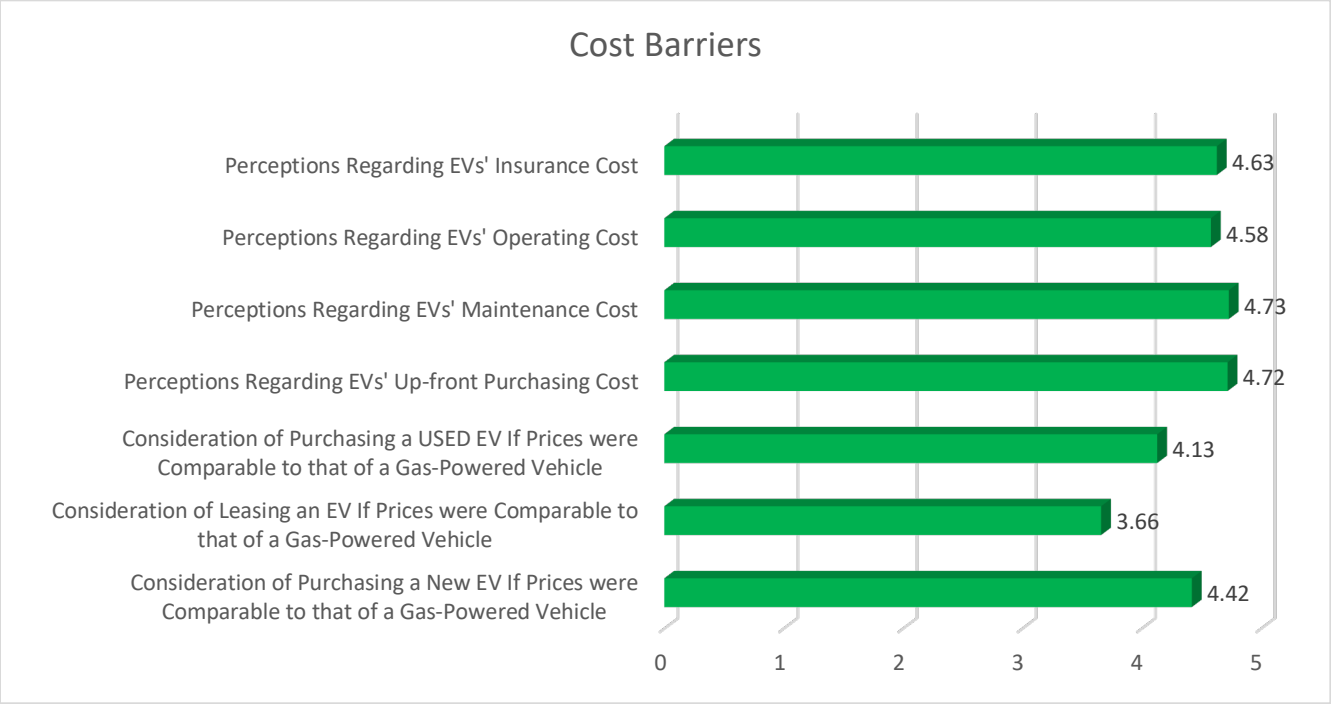

Figure 8. Cost Barriers

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

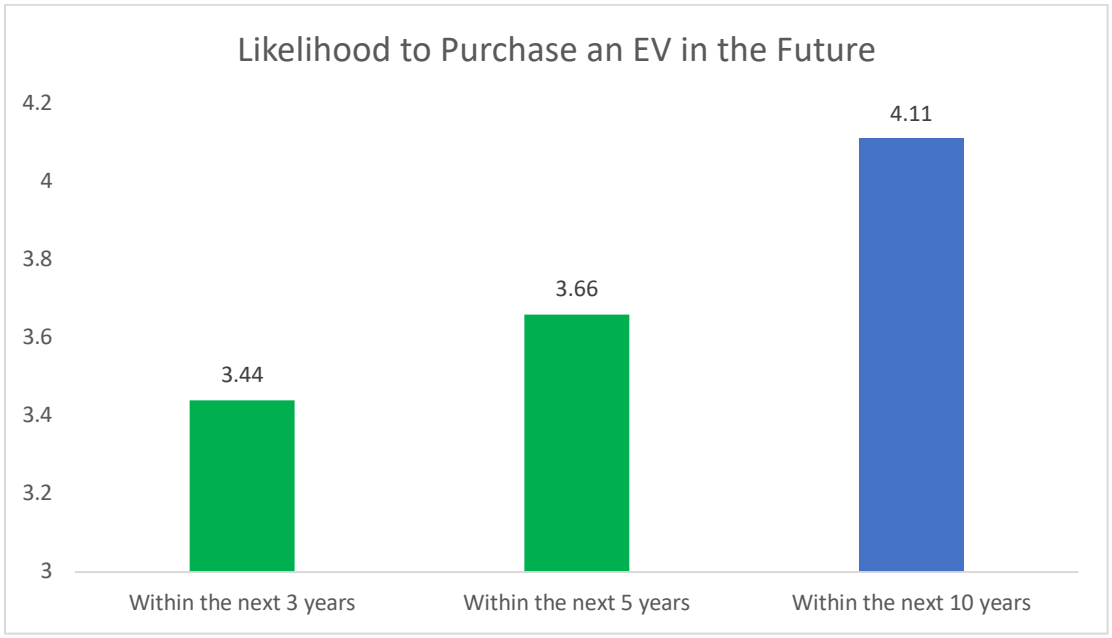

Figure 9. Likelihood to Purchase an EV in the Future

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

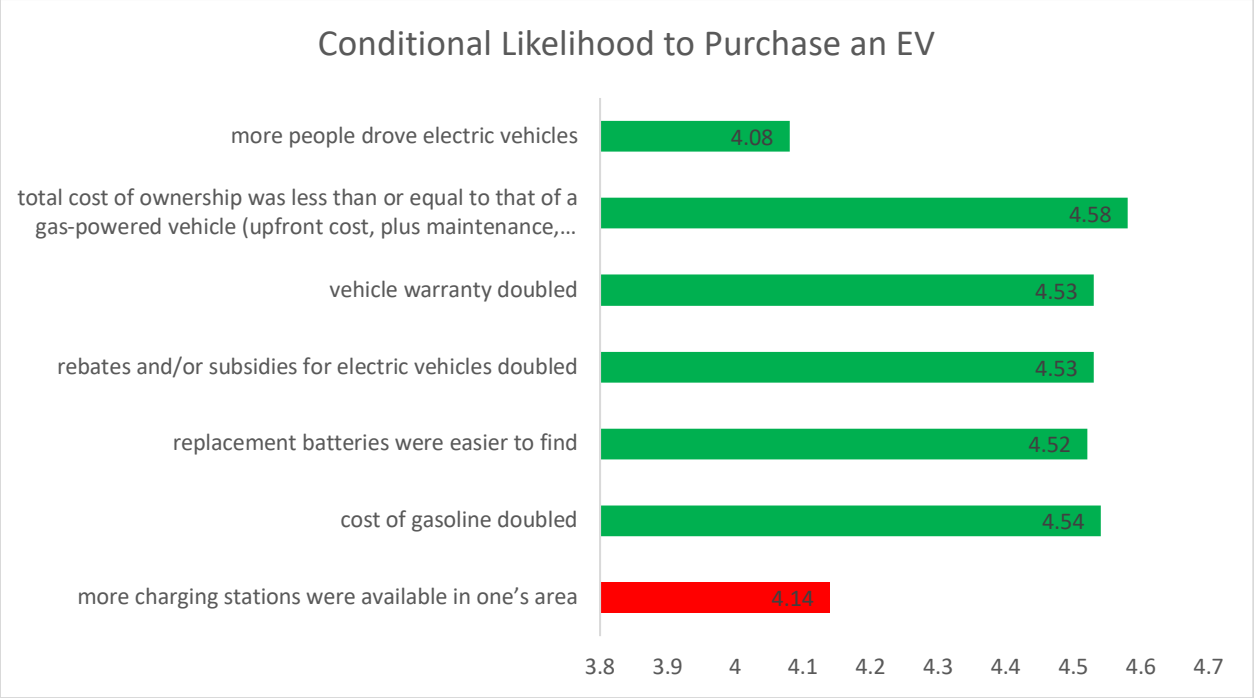

Figure 10. Conditional Likelihood to Purchase an EV

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

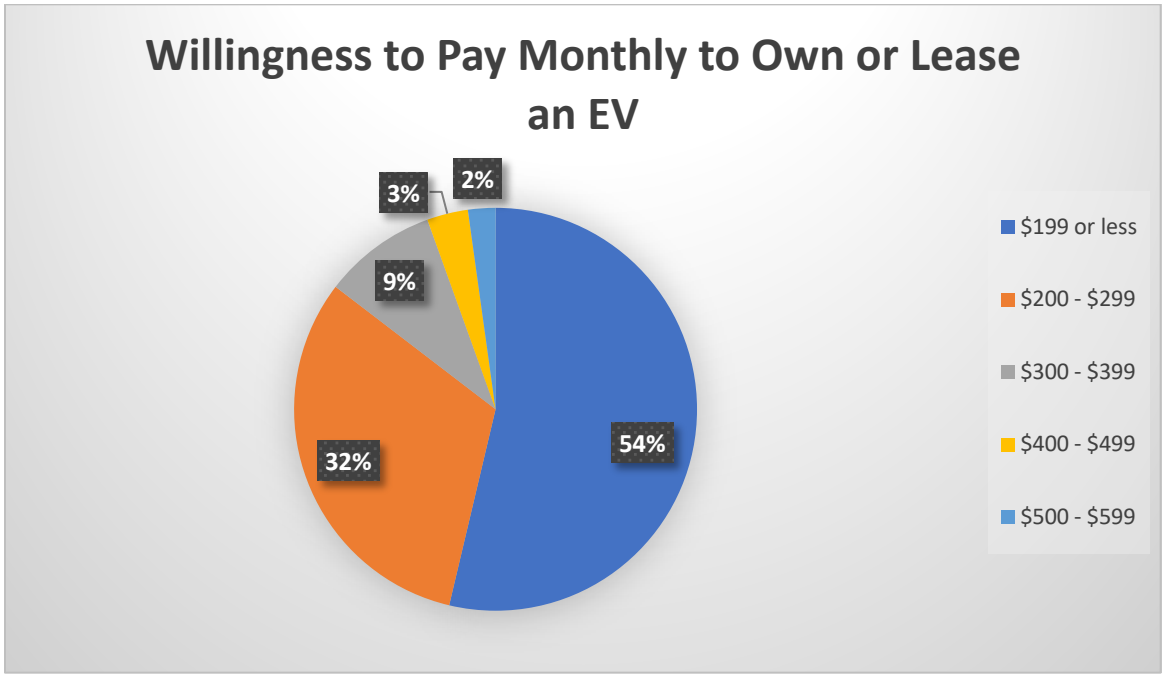

Figure 11. Willingness to Pay Monthly to Own or Lease an EV

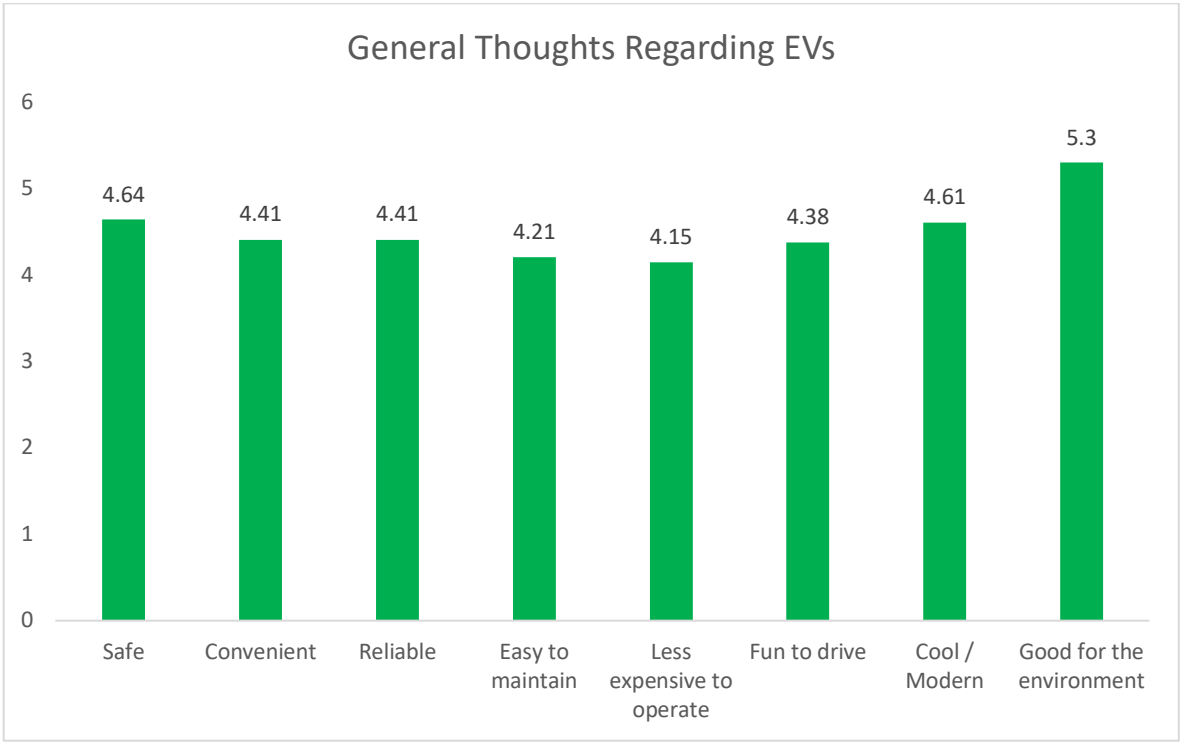

Figure 12. General Thoughts Regarding EVs

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

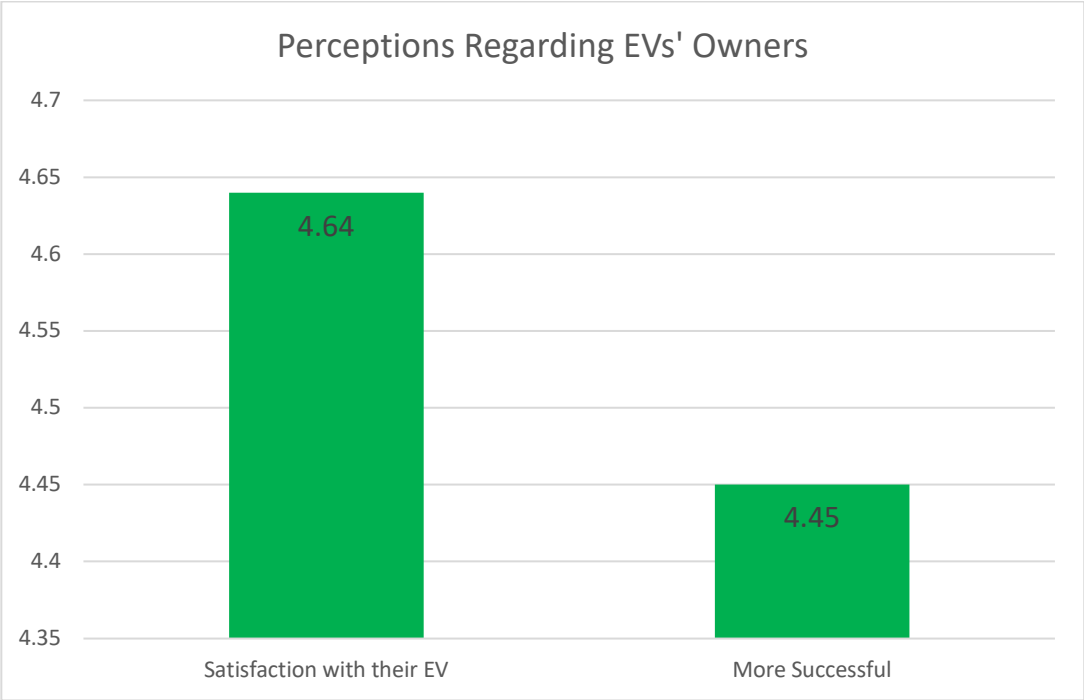

Figure 13. Perceptions Regarding EVs' Owners

One-sample t-test: Means that are significantly higher than the mid-point of the scale ($p < 0.05$) are in green, means with marginal significance ($p < 0.1$) are in blue, and insignificant means ($p \geq 0.1$) are in red.

9. Summary & Conclusions

The objective of this project is to develop a feasible business model for expanding the EV market to lower-income Californians. The model developed here addresses existing barriers that hinder the adoption of EVs by low-income Californians using a data-driven and evidence-based research approach. This research employed a combination of qualitative and quantitative designs. A state-wide survey was designed to quantitatively assess the different objectives, preferences, priorities, challenges, and limitations of low-income Californians in the different regions of the state. The survey aimed to assess various barriers to the adoption of EVs by low-income Californians, including knowledge barriers, misinformation barriers, convenience barriers, and cost barriers. This qualitative study aimed at investigating the current challenges faced by various stakeholders when it comes to expanding EVs to low-income Californians. It was designed to gain a greater breadth of understanding of how various stakeholders (e.g., companies, institutions, and state agencies) can contribute towards increased EV access among low-income Californians.

The findings presented the barriers perceived by low-income Californians and statistically tested for significant barriers. It also presented the perspectives of various stakeholders that play an important role in the EV market. Generally, there is willingness among stakeholders to engage with new ideas and creative solutions to change the dynamics within the EV market, overcome its obstacles, and serve low-income Californians. As for low-income Californians, it seems that the lack of adoption of EVs stems from existing barriers mainly related to cost, convenience, charging infrastructure, and financing options, and if these issues are addressed, residents' willingness to purchase or lease an EV will be positively impacted.

Insights from both the qualitative and quantitative studies were used to develop a business model that can be utilized to expand the EV market among low-income Californians. The business model can be used by state administrators, policy makers, and social enterprises to mitigate the barriers faced by low-income Californians within the EV market.

The expansion of the EV market to low-income Californians is a challenging task that requires the collaboration of multiple stakeholders. Currently, programs that aim to avail low-income Californians of EVs require a higher level of integration and new synergies to more effectively overcome the existing barriers. Hence, the integrative business model offered here attempts to create such an integration and include some revenue streams to aid the sustainability of this expansion.

Appendix A: Business Model Canvas

Key Partners	Key Activities	Value Proposition	Channels & Customer Relationships	Customer Segments
• Financial and loan institutions • Electric and solar companies • Community-Based Organizations • Community leaders • State Agencies • Car dealerships • Transport network (Uber, Lyft, etc.) • Partner Retailers such as Target/Walmart	• Collaborate with Electric and Solar Companies to avail charging stations • Develop a subsidized program with Electric and Solar Companies • Develop partnership with media buying agencies to promote and secure commercials to be displayed • Manage the advertising feature on the charging station • Create informational video content in English and in Spanish in partnership with community leaders • Create a sponsorship program to utilize in holding various awareness events • Partner up with Banks and Financial	• The Program/Startup aims to increase EV usage amongst lower income Californians by making information and services more accessible and bridging cost barriers. • A collection of integrated services will be offered including accessible and convenient charging stations at a subsidized cost, easy access to financial options and incentives, and free educational programs & awareness campaigns/event. • The Program/Startup will offer a one stop platform, including an inclusive	• Tailored free educational programs & awareness campaigns/event • One stop platform (Mobile app and Website); including an inclusive knowledge database and programs, financial and leasing access and assistant, loyalty program & promotions and charging subscriptions & bundles • Advisors will be available to answer low-income Californian concerns • Community Leader Ambassadors • Outreach to schools and workplaces • Research Services, Low-income	• Middle-Low Income Californians (to widen scope) • Middle-income Californians (to widen scope of services and potential revenue streams) • Age: 16 years and above

Key Partners	Key Activities	Value Proposition	Channels & Customer Relationships	Customer Segments
	initiations to manage the rebate/incentives and lease processes • Develop the digital financial assistant tool to integrate all incentives and rebate applications • Develop a training program to equip several stakeholders (e.g., dealership personnel, community leaders, etc.) with the knowledge and the skills required to promote EVs among low-income Californians • Partner with auto dealership to display inventory of Used EVs for Purchase and Lease • Develop and launch the mobile application • Community outreach in Schools and Workplaces.	knowledge database and programs, financial and leasing access and assistant, loyalty program & promotions and charging subscriptions & bundles.	Californians may participate in research studies, in lieu of receiving incentives	

<table>
<tr><td>Key Partners</td><td>Key Activities</td><td colspan="2">Value Proposition</td><td>Channels & Customer Relationships</td><td>Customer Segments</td></tr>
<tr><td colspan="3">Cost Structure

• One time cost: create the application and the website
• Application and website maintenance and updates costs
• Awareness campaigns and educational programs
• Charging Subsidies provided
• Events
• Administrative & Personnel Costs</td><td colspan="3">Revenue Streams

• B2B Advertisement Service: on app and charging stations: commercial premiums paid by businesses to advertise on platforms
• Sponsorships: Paid Sponsorships for the awareness and educational programs as well as events
• Signing Bonuses: when leasing or purchasing occurs through the app with partner dealerships
• Transaction Fees: when something is bought through E-commerce shop or on charging E-wallets for charging bundles
• Subscription Fee: fee paid for the premium version of the app with premium features
• Research Services: fees paid for research reports written by low-income Californians</td></tr>
</table>

Source: adapted from: www.businessmodelgeneration.com

Bibliography

A. Pesaran, T. M. *Battery requirements for plug-in hybrid electric vehicles: Analysis and rationale.* Anaheim, CA: International Electric Vehicle Symposium and Exposition, 2007.

Alkiviadis Tromaras, A. A. "Car Dealerships and their Role in Electric Vehicles' Market Penetration: A Greek Market Case Study." *Transportation Research Procedia* 24 (2017): 259-266.

Bernhart, W., J. Zhang, & J. Wagenleitner. EV/PHEV – CHANGING REVENUE & PROFIT POOLS IN THE AUTOMOTIVE VALUE CHAIN REQUIRE NEW BUSINESS MODELS. *World Electric Vehicle Journal* 4, no. 1 (2010): 104-109. https://www.mdpi.com/2032-6653/4/1/104

Brown, Jr., Edmund G. *2016 ZEV Action Plan.* Governor's Interagency Working Group on Zero-Emission Vehicles, 2016.

California Air Resources Board. *Low-Income Barriers Study, Part B: Overcoming Barriers to Clean Transportation Access for Low-Income Residents*. 2018.

Consumer Reports. "Dealers not always plugged in about electric cars, Consumer Reports' study reveals." *Consumer Reports*, April 22, 2014. https://www.consumerreports.org/cro/news/2014/04/dealers-not-always-plugged-in-about-electric-cars-secret-shopper-study-reveals/index.htm

Cox Automotive. *Car Buyer Journey 2019.* Autotrader, Kelley Blue Book, Dealer.com. 2019.

Dans, E. "The Misinformation Around Electric Vehicles." *Forbes*, July 3, 2018. https://www.forbes.com/sites/enriquedans/2018/07/03/electric-vehicles-and-disinformation/#15147431e587

Denrell, F. &. "The Economics of Strategic Opportunity." *Strategic Management Journal* (2003): 977-990.

Edison Electric Institute. *Accelerating Electric Vehicle Adoption.* Washington, D.C., 2018.

enelx. *Electric Cars vs. Gas Cars Cost*. October 7, 2019. https://evcharging.enelx.com/news/blog/570-electric-cars-vs-gas-cars-cost

Fabian Kley, C. L. "New Business Models for Electric Cars: A Holistic Approach." *Energy Policy* (2011): 3392-3403.

Ghazale Haddadian, M. E. "Accelerating Global Adoption of Electric Vehicles: Barriers and Drivers." *The Electricity Journal* (2015): 53-68.

Hardman, S., & G. Tal. "Exploring the Decision to Adopt a High-End Battery Electric Vehicle: Role of Financial and Nonfinancial Motivations." *Transportation Research Record* 2572, no. 1 (2016): 20-27. doi:10.3141/2572-03

Hart, T. L. "Reinventing Strategies for Emerging Markets: Beyond the Transnational Model." *Journal of International Business Studies* (2004): 350-370.

Hou, C., J. Du, & H. Wang. "The Living Space Analysis in the Battery Leasing Business." *World Electric Vehicle Journal* 4, no. 4 (2010): 870-879. https://www.mdpi.com/2032-6653/4/4/870

Johnson, C., & B. Williams. "Characterizing Plug-In Hybrid Electric Vehicle Consumers Most Influenced by California's Electric Vehicle Rebate." *Transportation Research Record* 2628, no. 1 (2017): 23-31. doi:10.3141/2628-03

Kress, R. "Why Car Dealerships Struggle With Selling Electric Vehicles." *The Fuse*, December 8, 2015. http://energyfuse.org/why-car-dealerships-struggle-with-selling-electric-vehicles/

Lance Noel, G. Z. "Beyond Emissions and Economics: Rethinking the Co-Benefits of Electric Vehicles (EVs) and Vehicle-to-Grid (V2G)." *Transport Policy* (2018): 130-137.

Lesser, J. "The Agenda." *Politico*, June 15, 2018. https://www.politico.com/agenda/story/2018/05/15/are-electric-cars-worse-for-the-environment-000660/

Li, Z., & M. Ouyang. "A Win–Win Marginal Rent Analysis for Operator and Consumer Under Battery Leasing Mode in China Electric Vehicle Market." *Energy Policy* 39, no. 6 (2011): 3222-3237. https://doi.org/10.1016/j.enpol.2011.03.014

Liao, F., E. Molin, H. Timmermans, & B. van Wee. "The Impact of Business Models on Electric Vehicle Adoption: A Latent Transition Analysis Approach." *Transportation Research Part A: Policy and Practice* 116 (2018): 531-546. https://doi.org/10.1016/j.tra.2018.07.008

Lidicker, J., T. Lipman, & B. Williams. "Business Model for Subscription Service for Electric Vehicles Including Battery Swapping, for San Francisco Bay Area, California." *Transportation Research Record* 2252, no. 1 (2011): 83-90. doi:10.3141/2252-11

Lidicker, J. R., T. E. Lipman, & S. A. Shaheen. "Economic Assessment of Electric-Drive Vehicle Operation in California and Other U.S. Regions." *Transportation Research Record* 2191, no. 1 (2010): 50-58. doi:10.3141/2191-07

Mair, C. S. "Profitable Business Models and Market Creation in the Context of Deep Poverty: A Strategic View." *Academy of Management Perspectives* (2007): 49-63.

Mark Fowler, T. C. *2015-2017 California Vehicle Survey Report.* California Energy Commission, 2018.

Miao, R., W. Huang, D. Pei, X. Gu, Z. Li, J. Zhang, & Z. Jiang. "Research on Lease and Sale of Electric Vehicles Based on Value Engineering." *International Journal of Production Research* 54, no. 18 (2016): 5361-5380. doi:10.1080/00207543.2015.1081709

Na Jiao, S. E. "Secondary use of Electric Vehicle Batteries and Potential Impacts on business Models." *Journal of Industrial and Production Engineering* (2016): 348-354.

Nicholas, P. S. *Expanding access to electric mobility in the United States.* ICCT, 2017.

Office of Energy Efficiency and Renewable Energy. *Electric Vehicles Charging at Home.* Energy.Gov, 2020. https://www.energy.gov/eere/electricvehicles/charging-home

Ona Egbue, S. L. "Barriers to Widespread Adoption of Electric Vehicles: An Analysis of Consumer Attitudes and Perceptions." *Energy Policy* (2012): 717-729.

Parry, S. The Practical PEV: Removing Barriers to Plug-In Electric Vehicle Charging and Ownership. Pomona Senior Theses, Paper 93, Clarement Colleges, 2011.

Prahalad, C. K. *The Fortune at the Bottom of the Pyramid: Eradicating Poverty through Profits.* Upper Saddle River: Wharton School Publishing, 2004.

RSG. *2015-2017 California Vehicle Survey.* California Energy Commission, 2018.

Santini, D. J., P. D. Patterson, & A. D. Vyas. "Importance of Vehicle Costs, Fuel Prices, and Fuel Efficiency in Hybrid Electric Vehicle Market Success." *Transportation Research Record* 1738, no. 1 (2000): 11-19. doi:10.3141/1738-02

Shaheen, S. A., J. Wright, & D. Sperling. "California's Zero-Emission Vehicle Mandate: Linking Clean-Fuel Cars, Carsharing, and Station Car Strategies." *Transportation Research Record* 1791, no. 1 (2002): 113-120. doi:10.3141/1791-17

Southern California Edison. *EV-Ready Communities Paving the way for electric vehicles.* 2019.

Tal, G., & M. Nicholas. "Exploring the Impact of the Federal Tax Credit on the Plug-In Vehicle Market." *Transportation Research Record* 2572, no. 1 (2016): 95-102. doi:10.3141/2572-11

Toppin, P. *Used EV White Paper Stakeholder Draft: Driving Towards Equity: Getting the Most Out of Used ZEVs.* 2020.

Ulrich, L. "New Breed of Pickups Mixes Horsepower and Battery Power." The *New York Times*, May 7, 2020. https://www.nytimes.com/2020/05/07/business/electric-pickup-trucks.html

United States Department of Energy. *Timeline: History of the Electric Car*. energy.gov, 2014. https://www.energy.gov/timeline/timeline-history-electric-car

United States Environmental Protection Agency. *Sources of Greenhouse Gas Emissions*. 2020. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Whitman, C. T. "Oil industry is 'peddling misinformation' about electric vehicles." *CNBC*, June 29, 2018. https://www.cnbc.com/2018/06/26/electric-vehicles-will-prevail-despite-oil-industry-misinformation.html

Williams, B. "Second Life for Plug-In Vehicle Batteries: Effect of Grid Energy Storage Value on Battery Lease Payments." *Transportation Research Record* 2287, no. 1 (2012): 64-71. doi:10.3141/2287-08

Williams, B. D., & T. E. Lipman. "Strategy for Overcoming Cost Hurdles of Plug-In–Hybrid Battery in California: Integrating Post-Vehicle Secondary Use Values." *Transportation Research Record* 2191, no. 1 (2010): 59-66. doi:10.3141/2191-08

Wire, B. "Yahoo is part of the Yahoo family of brands." finance.yahoo.com, 2022. https://finance.yahoo.com/news/evgo-selected-state-california-proposed-120000665.html (accessed February 11, 2022).

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