Electrifying Private Transport in California

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Abstract

With increasing automobile use, electrifying the private transportation sector is a key step in reducing California's environmental impact. This paper examines the viability of this solution, how it has been addressed at a policy level, and determines whether further action is needed to fully deploy electric vehicles. Using criteria generated from interviews with transportation experts, it identifies that all current legislation is productive in some way. Although time will tell which measures have had the most significant impact on vehicle uptake, the data revealed that equity-driven government outreach is one of the only remaining needs.

Table of Contents

Definitions

- (B)EV: (Battery) Electric vehicle
- CARB: California Air Resources Board
- CI: Carbon intensity
- GWP: Global warming potential
- HEV: Hybrid-electric vehicle
- HOV: High occupancy vehicle
- ICE(V): Internal combustion engine (vehicle), runs on gasoline or diesel
- LCA: Life cycle assessment, determines total environmental impact of electric car
- LCFS: Low Carbon Fuel Standard
- LEV: Low emission vehicle
- MPG: Miles per gallon (of fuel)
- PHEV: Plug-in hybrid electric vehicle, combines batteries with ICE technology
- (P)ZEV: (Partial) Zero emission vehicle

1: Introduction

While "three-quarters of all oil consumed and 40% of all greenhouse gases emitted are for the movement of goods and people" in California, the issue of the automobile's abundant carbon footprint is multifaceted (Sperling and Nichols 2012). Though it is without question that vehicle use contributes to climate change, many measures have been taken to lessen their impact, ranging from tire construction to the introduction of electric cars. Even prior to the electrification movement, trends had already begun to demonstrate a clear decline in vehicle emissions, according to a study from 1996 (Kahn 1996). California specifically has been the heart of this new shift, at least partially because its environmental problems are so severe (Sperling and Nichols 2012). Containing the top five cities with the worst air pollution in America (much of which stems from vehicle use), Southern California produced Tesla, arguably one of the most successful electric vehicle (EV) startups in the world ("Most Polluted Cities" n.d.).

The electric car "revolution," as some have dubbed it, is something every major auto manufacturer is scrambling to be a part of. Established companies such as Porsche, BMW, Mercedes, and Chevrolet are budgeting millions of dollars for the research and development of the next generation of automobiles (MacKenzie 2018). There has also been an onslaught of new brands, each fighting for the success Tesla has encountered in this new, future-proof industry. Within the past five years Rivian, Bollinger, Lucid Air, Fisker, and many more have each debuted what they promise will be Elon Musk's first legitimate challenger in the world of EVs (MacKenzie 2018). Though electric cars are not a flawless solution to the ongoing issue of

emissions and fossil fuel use, certain new legislation and policy amendments can help facilitate their role in mitigating the automobile's environmental impact.

The issues preventing consumers from purchasing EVs begin at the manufacturing level and span to a political level. Concerns of whether or not EV use can mitigate the environmental impacts of their production are abundant, and well founded. Moreover, high cost of development leads to prices considered unaffordable to most consumers, a problem that's exacerbated by public uncertainty regarding the new technology's infrastructure, longevity, and other factors. To combat buyer apprehension, state and federal governments have enacted policies that seek to either 1) encourage ownership through direct tax rebates (or a similar subsidy), or 2) penalize companies making vehicles exceeding certain emissions regulations (or related standards). In section three, the Literature Review, this paper will examine research covering the barriers facing EV infiltration of the vehicle market and policy solutions to address said barriers, ultimately determining that command regulation (fines, taxes, etc.) is only a partially effective technique by which to promote EV purchases. Supposing incentives are therefore a more reliable alternative, the logical question is then: how can the government continue to fund incentive programs, particularly for low and middle-income buyers? The paper will then proceed to conclusions resulting from interviews conducted with experts in this field, from which it will evaluate California's current and past policies, finally identifying remaining needs facing full EV deployment.

2: Background

As demand for mobility rises, so does demand for clean private transport. Developed countries are currently experiencing the highest growth rates in vehicle ownership, indicating an

impending rise in energy use and related greenhouse gases (Ma et al. 2012). Projected numbers show increases in these fields "by nearly 50% by 2030 and by more than 80% by 2050," demonstrating how crucial sustainable transportation options are to overall environmental health (Ma et al. 2012).

Electric vehicles are one measure in a multitude of auto-based efforts to achieve sustainable transportation. At the industry level, technological innovations such as the shift from carburetion to fuel injection, forced induction, and countless aerodynamic modifications have enabled more efficient energy use over the past century. At the political level, groups like the California Air Resources Board (CARB) are responsible for ensuring minimal air pollution (Sperling and Nichols 2012). At the legislative level, however, the state of California shines for having some of the most comprehensive environmental regulations in the transport sector today.

Since the mid-1960s, the state government has been actively involved in supervising automotive emissions levels (Brown et al. 1995). Their laws have been so progressive that they've set certain federal standards. California's Low Emission Vehicle (LEV) program, for instance, was adopted federally by the EPA with the exception of its ZEV mandate, despite harsh backlash from key players in and around the auto industry (Brown et al. 1995). Whereas that policy will be used in section 3 (the Literature Review) to compare the efficacy of command regulation to market-based measures, the following subsections will review other significant measures--both past and present--taken by the state government to encourage clean transportation. These efforts are part of a response to health and environmental impacts caused by emissions, and were selected for their relevance to EVs, equity, or both.

2.1: Senate Bill 350

Senate Bill 350 (SB 350) is known as the Clean Energy and Pollution Reduction Act. Signed into law on October 7, 2015, it "established California's 2030 greenhouse gas reduction target of 40 percent below 1990 levels" and 2050 target of 80 percent below 1990 levels ("Clean Energy & Pollution Reduction Act (SB 350)" n.d.). To achieve this, the bill specifies numerous goals and requirements. Section 32 outlines the need for "widespread transportation electrification," further prioritizing "increased access for disadvantaged communities, low- and moderate-income communities, and other consumers of zero-emission and near-zero-emission vehicles, and increased use of those vehicles in those communities and by other consumers to enhance air quality, lower greenhouse gases emissions, and promote overall benefits to those communities and other consumers" ("Bill Text - SB-350" n.d.). To complement this, SB 350 also plans to "increases California's renewable electricity procurement goal from 33 percent by 2020 to 50 percent by 2030," including energy generated from wind, solar, biomass, geothermal, and other sources ("Clean Energy & Pollution Reduction Act (SB 350)" n.d.). The Energy Commission worked closely with CARB to implement the bill, enlisting them to conduct the "Low-Income Barriers Study, Part B." Through direct engagement with residents, stakeholders, environmental groups, and community-based organizations, CARB identified that *permanent, long-term funding sources must be created* for ("Low-Income Barriers Study, Part B" n.d.):

> (1) Zero-emission and near zero-emission vehicles and supporting infrastructure for vehicle charging and fueling and safe biking and walking, (2) assessments to understand how funding can be used to better address low-income, community-based transportation and mobility needs, (3) increasing awareness for low-income residents by expanding education and outreach on clean transportation and mobility options, and (4)

maximizing economic opportunities and benefits for low-income residents from investments in clean transportation and mobility options.

2.2: Senate Bill 1275

Senate Bill 1275 (SB 1275), or the Charge Ahead California Initiative, was approved by the governor on September 21, 2014. It established a state goal of having "at least 1,000,000 zero-emission and near-zero-emission vehicles [in service] by January 1, 2023," and aimed "to increase access for disadvantaged, low-income, and moderate-income communities and consumers to zero-emission and near-zero-emission vehicles" ("Bill Text - SB-1275" n.d.). The bill acknowledges that "California's low-income and disadvantaged populations continue to face disproportionate impacts from substandard air quality in the form of higher rates of respiratory illnesses, hospitalizations, and premature death" ("Bill Text - SB-1275" n.d.). It directly addresses this problem with benefits that vary depending on income, such as monetary compensation towards replacement vehicles. Low-income motor vehicle owners qualify for compensation "no less than $2,500," while compensation for all other vehicle owners is required not exceed that amount ("Bill Text - SB-1275" n.d.).

2.3: Assembly Bill 118

Though it doesn't account for low-income communities with the same prudence that SB 350 and SB 1275 do, Assembly Bill 118 did consider "people of all races, cultures, and income levels, including minority populations and low-income populations of the state" while also seeking to further the state's progress towards its climate change policies ("Bill Text - AB-118" n.d.). Approved by the Governor on October 14, 2007, it sought to establish funding sources

("grants, loans, loan guarantees, revolving loans, or other appropriate measures") for public projects ("public agencies, businesses and projects, public-private partnerships, vehicle and technology consortia, workforce training partnerships and collaboratives, fleet owners, consumers, recreational boaters, and academic institutions") that aimed to "develop and deploy innovative technologies that transform California's fuel and vehicle types" ("Bill Text - AB-118" n.d.). Some of the funding for this program is derived from Assembly Bill 8, which collected extra fees from vehicle registrations, boat registrations, and tire sales ("Bill Text - AB-8" n.d.).

2.4: Assembly Bill 1493 and Related Legislation

Assembly Bill 1493 (AB 1493), the "Pavely" bill, "aimed to reduce GHG emissions [and improve fuel efficiency and reduce motorists' costs] in new passenger vehicles from 2009 through 2016" ("Climate Change for Mobile Sources" n.d.). According to CARB, the regulations combine "the control of smog-causing pollutants and greenhouse gas emissions into a single coordinated package of standards," including "efforts to support and accelerate the numbers of plug-in hybrids and zero-emission vehicles in California" ("Climate Change for Mobile Sources" n.d.). In reports of the bill's impact, the state board was required to consider "communities in the state with the most significant exposure to air contaminants or toxic air contaminants, or both, including, but not limited to, communities with minority populations or low-income populations, or both" ("Bill Text - AB-1493" n.d.).

Several policies are linked to the Pavely bill. Assembly Bill 32 (AB 32) takes a similar stance, also requiring a reduction in greenhouse gas emissions, but directs the order more broadly, to almost all sectors of the economy. This includes--in addition to emissions from cars and trucks--emissions from "electricity production, fuels, and other sources" ("Assembly Bill 32

- California Global Warming Solutions Act" n.d.). Senate Bill 375 (SB 375, the Sustainable Communities & Climate Protection Act) then refined the framework set by AB 32, declaring in 2008 that regional targets for these reductions must be set. In a progress report from November, 2018, CARB identified that areas with high displacement tend to have more miles driven per capita than areas with sedentary populations ("2018 Report - SB 375" n.d.). This information will ideally help future policymakers develop effective transportation-related environmental policies.

3: Literature Review

The shift towards electrification is a slow and reluctant process, with many manufacturers unwilling to surrender their internal combustion engine (ICE) technology (Fallah 2017). Governments and corporations alike are facing obstacles across the infrastructure, technology, and finance sectors when promoting the uptake of EVs. In an effort to expedite the adoption of plug-in hybrid and electric vehicles, many local governments use one of two fundamental policy strategies: incentivizing policy or forceful policy. In Quebec, consumers were enticed by direct rebates according to battery capacity (Mercier, Lanoie, and Leroux 2015). According to a cost-benefit analysis, the scheme proved advantageous for the city in terms of the reductions in emissions and gasoline use (Mercier, Lanoie, and Leroux 2015). California used a commanding approach to the same issue in 1990, when they adopted "a plan to encourage the development and use of zero emission vehicles" as part of the LEV Program (Calef and Goble 2007). By requiring manufacturers to abide by strict regulations, the state "spurred the development of innovative hybrid and fuel cell vehicles" very effectively (Calef and Goble 2007). These two approaches to increasing ownership will be thoroughly examined later, but it is important to first

discern the challenges facing both auto companies and local, state, or federal governments when promoting EV use.

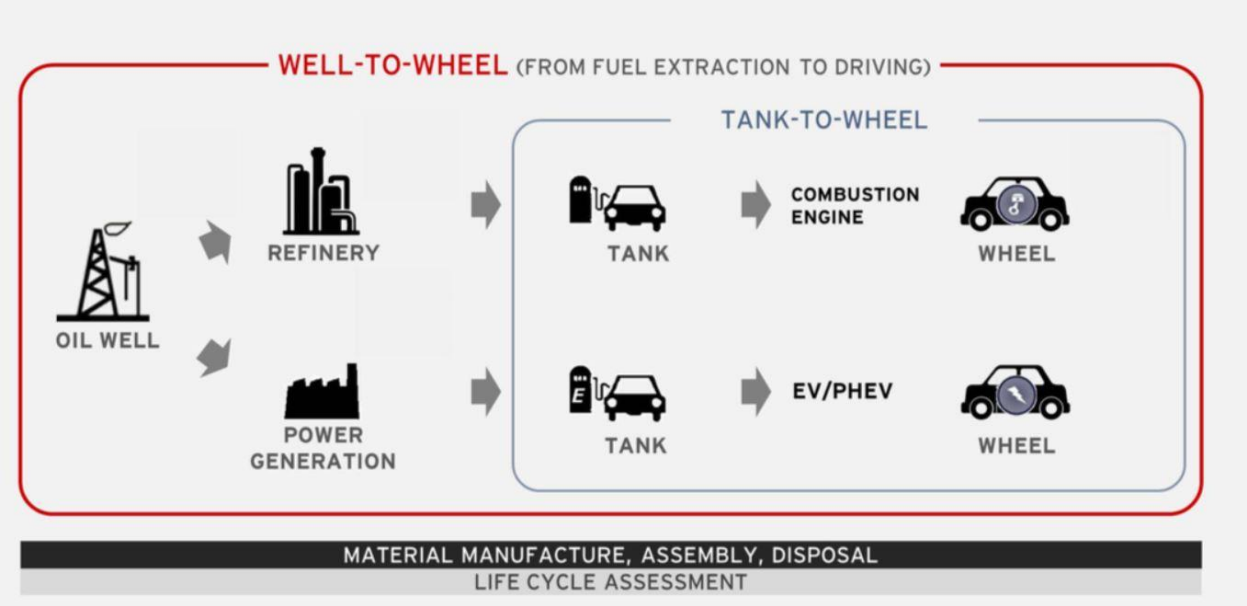
3.1: Barriers

The following sections (3.1.1, 3.1.2, and 3.1.3) present research on obstacles for producers and potential buyers of EVs. Though EVs generate appeal through their reduced tailpipe emissions, they are not flawless. The literature identified several prominent barriers facing the complete adoption of EVs, including the costs of production, energy sourcing, use, recycling, and finances.

3.1.1: Technological Considerations

Much of the literature points towards life cycle assessments (LCAs) as vital tools with which to gain a comprehensive understanding of the automobile's carbon footprint, which is needed to determine whether EVs are a viable way of reducing the environmental burden of the private transport sector. An LCA quantifies the resource use and pollution from the production to the disposal of a product (Hawkins, Gausen, and Strømman 2012). Several studies have outlined the "well-to-wheel" impacts of EVs as compared with internal combustion engine vehicles (ICEVs). Well-to-wheel refers to the total environmental effects resulting from the processes

between fuel extraction and the moving vehicle, or the fuel life cycle (Total 2017); see the following graphic for a rudimentary example:



(Total 2017)

In addition to well-to-wheel data, research by Hongrui Ma et al. indicates the importance of "cradle-to-grave" data, which incorporates the carbon footprint of the manufacturing process. One study, from the journal *Energy Policy*, examined both well-to-wheel and cradle-to-grave factors, looking specifically at energy intensity during vehicle use, battery charging, and production. It highlighted the importance of "marginal grid intensity/marginal electricity," which is the additional electricity that must be brought to the grid to meet the demand for EVs (Ma et al. 2012). The article claimed that until renewable energy production becomes more of a standard practice, battery-powered cars will struggle to lower their well-to-wheel greenhouse gas emissions (Ma et al. 2012). This finding is corroborated by three other studies (Hawkins, Gausen, and Strømman 2012; Hawkins et al. 2013; Faria et al. 2013).

This study from *Energy Policy* further noted the significance of driving style on energy use. The authors found that battery electric vehicles (BEVs) driving "at high speeds with heavy loads" leads to higher lifetime emissions than those of an ICEV on account of the increased frequency with which the BEV will have to recharge (Ma et al. 2012). In summary, EVs are most efficient--more so than conventional ICEVs or even plug-in hybrid electric vehicles (PHEVs)--in an urban setting, operating at relatively low speeds with low passenger and accessory loading. Features such as regenerative braking have a much larger effect in the city than on the highway, meaning hybrids and ICEVs are the ideal choice for long-distance trips (Ma et al. 2012; Hawkins, Gausen, and Strømman 2012). Keep in mind, however, that this relationship shifts as technology develops.

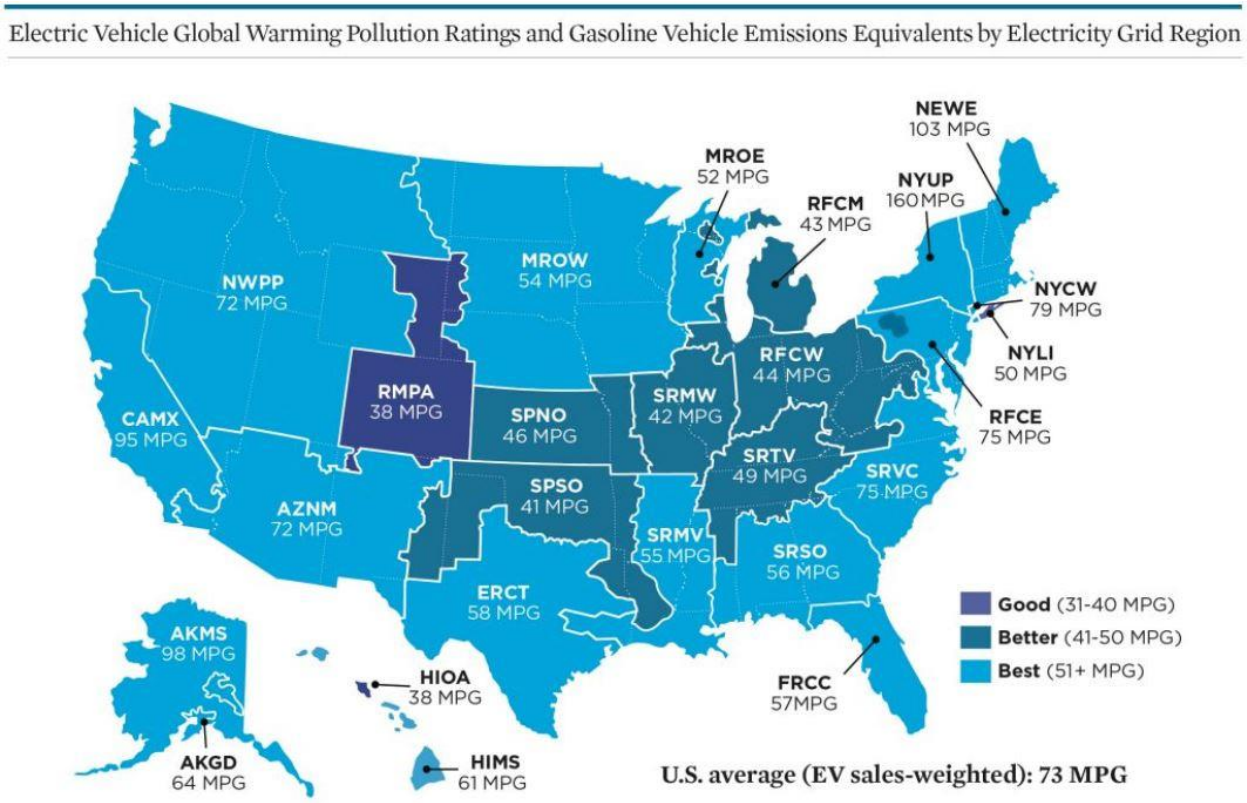
A separate, two-part study from the *International Journal of Life Cycle Assessment* by Troy Hawkins et al. came to similar conclusions, but also emphasized the substantial impacts associated with battery manufacturing. Using a literature review to determine the potential of recycling, the authors highlight that although many assume the consequences of production can be offset by reuse, this process of often infeasible: "not all materials in batteries, for example, can be reused in batteries given current material prices" (Hawkins, Gausen, and Strømman 2012). Another paper from 2006, however, found that when ignoring the financial perspective, recycling can counteract roughly half the carbon footprint of battery production (Van den Bossche et al. 2006). Hawkins et al. add that certain technology, like battery exchange systems, seem promising in regard to sustainability but would require industry standardization. They also acknowledge that such a system would prove unsuccessful because of 1) the generous size and weight of batteries, 2) prohibitive vehicle designs, and 3) safety concerns from manufacturers (Hawkins, Gausen, and Strømman 2012).

In the second part of the study, Hawkins et al. focus on the requirements necessary to balance the negative aspects of EV production. The general consensus was that the longer an individual owns/drives an EV, the lower its global warming potential (GWP) falls (Hawkins et al. 2013):

> Assuming a vehicle lifetime of 200,000 km [125,000 mi] exaggerates the GWP benefits of EVs to 27% to 29% relative to gasoline vehicles or 17% to 20% relative to diesel. An assumption of 100,000 km [62,000 mi] decreases the benefit of EVs to 9% to 14% with respect to gasoline vehicles and results in impacts indistinguishable from those of a diesel vehicle. Improving the environmental profile of EVs requires engagement around reducing vehicle production supply chain impacts and promoting clean electricity sources in decision making regarding electricity infrastructure.

These statistics represent a scenario in which the electricity used to charge the batteries is derived from renewable sources. Should the electricity be generated by coal-powered plants, EVs would lead to a 17-27% increase in GWP as compared to ICEVs (Hawkins et al. 2013). The following map demonstrates how EVs compare to ICEVs (in terms of equivalent miles-per-gallon (MPG) ratings) on a state-by-state basis as of 2017. Though it takes into account how

much of the grid is powered by renewable sources, it does not factor in the GWP from the production phase of EVs.



(Reichmuth 2017)

Hawkins et al. provide an analysis of the factors contributing to the GWP of the production phase for EVs, identifying batteries as the major subscriber (at 35-41% of the GWP), followed by battery cooling systems (16-18%), followed by the motor itself (at 7-8%) (Hawkins et al. 2013). Furthermore, the authors are careful to point out that there is uncertainty surrounding the human toxicity potential produced during the vehicle supply chain. Metals such as nickel, copper, and aluminum have a strong environmental acidification potential, again suggesting the need for manufacturing improvements (Hawkins et al. 2013).

The final LCA reviewed for this section was published by Ricardo Faria et al. in the journal *Renewable and Sustainable Energy Reviews*, and came to similar conclusions as the

others. It characterized the production of EVs as more energy-intensive than the production of ICEVs, and specified the battery's large role in that imbalance. When examining the use phase of an EV life cycle, Faria et al. reinforced the assertion that battery life can be prolonged (and thus their GWP mitigated) with smooth driving inputs. Using several real-world driving cycles, the authors determined that an aggressive driving profile can reduce the car's range by 90km as energy consumption consequently increases by 47% (Faria et al. 2013). Battery Management Systems are also able to lower an EV's GWP. The technology is able to avoid "working points that contribute to accelerated aging, for instance by controlling the battery pack temperature using active heating and cooling systems, as well as by avoiding the battery overcharge" (Faria et al. 2013). These kinds of advancements support the remarkable efficiency with which EVs operate. Compared with ICEVs, which lose around 80% of the available energy from fuel as heat (depending on speed), EVs lose just 15% (Faria et al. 2013). Faria et al. finished by asserting that overall environmental impacts associated with EVs would be reduced by giving their batteries a "second life" (recycling), a solution that could be accomplished by using them as energy storage for the grid (Faria et al. 2013).

3.1.2: Cost and Infrastructure Considerations

The research also found that another significant barrier hindering the total acceptance of EVs is their cost. Since EVs are still considered a luxury good, they are inaccessible to low-income communities. This issue is compounded by the fact that the technology is still young, which causes consumer uncertainty, thereby lowering the amount people are willing to pay (Sierzchula et al. 2014). Interestingly, socio-demographic variables like education level or concern for the environment were determined not to have a substantial role in determining the likelihood of adoption (Sierzchula et al. 2014). It is worth noting that the high initial fee for EVs

is counteracted by the relatively low operational costs made possible by simpler maintenance (Faria et al. 2013). Regardless, the point at which EV buyers are likely to break even on their investment (compared to buying and owning an ICEV) is estimated to be 9-10 years after the purchase (Faria et al. 2013). Prohibitively expensive prices are one of the leading reasons that EV market penetration is progressing much slower than it could be. Manufacturing optimization can address this problem (Faria et al. 2013).

Using a workshop with expert policy-makers, Sjoerd Bakker and Jan Jacob Trip reviewed limiting factors affecting EV ownership, concluding that more developed charging infrastructure is needed to incentivize purchases. This issue is mentioned in almost every reading pertaining to the subject. Simply put, owning an ICE vehicle is easier than owning an EV. With the vast network of gas stations, *range anxiety* is a phenomenon specific to battery-powered cars. Between relatively young companies like EVgo, Blink, PlugShare, and ChargePoint, plug-in vehicle owners are comparatively underserved in terms of refueling choices; the newness of this market is reflected in its undeveloped infrastructure. According to a study from 2014 on factors that influence EV adoption, the charging network is the number one predictor of a country's EV market share (Sierzchula et al. 2014). In addition to making lives easier, expanding public charging locations could serve to increase the public visibility of EVs. This way of raising awareness could, in turn, "lower the barrier for people to buy an EV" (Bakker and Trip 2013).

3.1.3: Barriers--Conclusions

Though comprehensive EV adoption is contingent upon factors such as manufacturing, marketing, and use, much of the literature points to these vehicles as a viable method of reducing the carbon footprint of the private transportation sector. It is imperative to recognize that of the four reviewed LCAs, the most recent publication was from 2014. Hawkins et al., for instance,

used a standard battery capacity of 24kWh by which to make comparisons to ICEVs. In August of 2016, that capacity more than quadrupled with the introduction of the 100kWh battery by Tesla Motors (MacKenzie 2018). Since EVs are being so rapidly accepted by consumers, the technology behind their performance and production has improved at a remarkable rate (Randall 2016), meaning that apprehension surrounding their viability five years ago is less relevant today. Bigger batteries lead to longer vehicle lifetimes, thereby lowering the GWP of EVs through continued use. Moreover, as the electricity grid retrieves an increasing proportion of its energy from renewable sources, EVs will become more efficient (Ma et al. 2012; Hawkins, Gausen, and Strømman 2012; Hawkins et al. 2013; Faria et al. 2013).

Even if issues like inadequate charging infrastructure were resolved, what kind of policies would effectively tempt low- and middle-income buyers? Taxes on high-emission vehicles wouldn't work since disadvantaged communities can't justifiably be charged for not being able to afford EVs, but incentives like tax rebates are finite: federal funds must be budgeted appropriately. The following section, 3.2, will present the research regarding government intervention in the private transportation market.

3.2: Policy Debates

EVs will only have a meaningful impact if consumers use them, and the government, whether is local, state, or federal, has the capacity to put forth policies that will encourage their use. The two foremost EV-related policy approaches discussed in the literature were 1) command regulations and 2) incentives. Command regulations, as the name suggests, are strict requirements to be met by a given deadline (Brown et al. 1995). The most direct legislative response to increasing emissions from the private transportation sector in California today is the

Low Emission Vehicle (LEV) program with its Zero Emission Vehicle (ZEV) mandate. The LEV program will be used repeatedly in this section (and 3.2 subsections) because multiple sources cited it as an example with which to discuss the pros and cons of command regulation.

It emerged in 1990 primarily in response to poor air quality and subsequent health-related issues, rather than concerns of global warming or oil use (Collantes and Sperling 2008). Created by the California Air Resources Board (CARB), the program was developed in an almost entirely "politically independent" environment. Although Board appointments are made by the governor and the budget is set by the legislature, CARB does not report to either of these authorities for approval of its decisions (Collantes and Sperling 2008). Some view this autonomy as a positive attribute, since it inhibits interference from lobbyists for an agency focused maintaining healthy air quality, researching causes of pollution, and fighting pollution produced by motor vehicles (Collantes and Sperling 2008).

One factor influencing the successful implementation of the ZEV mandate was the debut of General Motor's *Impact* (later renamed the EV-1) on January 3rd, 1990 (Collantes and Sperling 2008). The EV-1 was designed to be one of the first commercially available electric vehicles, with the performance and range necessary to make it adequately competitive with ICEVs (Collantes and Sperling 2008). This idea of EVs as a method to combat rising emissions had already been considered in the late '80s, when officials began to recognize that EVs did not face the same problems that plague ICEVs; since ICEVs deteriorate with age, their contribution to greenhouse gases grows over time (Collantes and Sperling 2008). The EV-1 was significant for proving that ZEV technology was *feasible*. When CARB responded with the mandate, it was perceived as ambitious for attempting to regulate a new technology (of which little was known), the volume it was produced at, and the dates it was produced by (Collantes and Sperling 2008).

According to Daniel Sperling, who was appointed to the automotive engineering seat at CARB in February of 2007, CARB had seen technology-forcing regulations effectively bring catalytic converters (a previous method of mitigating emissions) to the market in the 1970s and thought, why wouldn't this technique work for ZEVs too (Collantes and Sperling 2008)? Though the LEV program isn't flawless, CARB was right.

3.2.1: Successful Instances of Command Regulation

Command regulation can be--and has been--effective. For example, when combined with increasing competition from foreign manufacturers, fuel economy standards implemented during the 1970s generated rapid technological advancement from US auto companies. Between 1975 and 1991, the average MPG of American passenger cars went from 15.7 to 27.8 (Brown et al. 1995). Beyond mileage standards, the ZEV mandate also presents a unique lens with which to examine the efficacy of command regulation.

A comparison of case studies in California and France highlighted the benefits and disadvantages associated with two policies aimed at reducing urban air pollution. Before any analysis, the authors established that environmental legislation is often accompanied by controversy in the US, especially compared to the reaction in France. The American response has historically included a substantial amount of impactful lobbying, resulting in policy overhauls and creating hostility between environmentalists and the majority of those involved in or closely related to the auto industry. CARB, for instance, allowed for the ZEV rules to be reviewed every two years, which resulted in the renegotiation of emissions standards (to make them less stringent) and delaying of deadlines (Calef and Goble 2007). Under amendments in 1998, the original goal of having 10% of all vehicles for sale by 2003 be ZEVs was reduced to 6% and revised to include partial zero emission vehicles (PZEVs) (Calef and Goble 2007). While this

was partially an answer to corporate pushback, it may also be indicative of a weak policy in the first place.

Despite a warm welcome from environmental organizations, the opposition to the LEV regulation from oil companies was more passionate and more forceful. Perceiving the requirements as a direct threat to their monopoly, a wave of strategic political contributions, study funding, and advertising ensued (Calef and Goble 2007).

> BP America, Exxon, Mobil Oil Co., Phillips Petroleum, Shell Oil Co. and Texaco donated a total of $1.1 million to legislative candidates in 1994 and in the first six months of 1995. During the same period, the auto industry donated $276,000. In particular, California's governor Pete Wilson received $325,000 and $76,000 from oil and auto industry groups, respectively. (Calef and Goble 2007).

Furthermore, the same oil companies exhibited deceptive lobbying. Employing tactful rhetoric to mimic grassroots movements, these corporations used names such as “Toward Utility Rate Normalization (TURN),” “Utility Consumer's Action Network,” “Californians Against Utility Company Abuse (CAUCA),” “Californians Against Hidden Taxes (CAHT)” and “the National Institute for Emergency Vehicle Safety” (Calef and Goble 2007). Advertising campaigns were released to reassure the public that the world still had plenty of oil, EV technology was inadequate, and to “stir up economic apprehension” about potential tax increases (Calef and Goble 2007).

Their efforts, however, were not as effective as they may have hoped. The ZEV mandate caused American, French and Japanese car companies to resume their interest in battery technology after neglecting it through the 1970s and ‘80s (Calef and Goble 2007). Moreover,

electric utility companies saw the legislation as an opportunity to expand their markets. Combined, these reactions helped to catalyze the development of hybrid vehicles which are so abundant in today's cities.

Did the lack of opposition in France enable a more robust adoption of EVs? Unfortunately not. The French policy was not command regulation--all goals were voluntary and no penalties were established. This then presents a unique argument in favor of command regulation: the American approach, which was more strict, was also more successful.

3.2.2: Problems with Command Regulation

While it has proven effective, command regulation can easily be over or under applied. Of the problems most frequently cited with regard to this type of policy, these two are the most frequent (Brown et al. 1995):

> Rather than forcing innovation, command regulation has sometimes inhibited innovation because it gives producers no incentive to go beyond the requirements of a specific regulation" and "command regulation actually gives producers the incentive to conceal any innovative environmental protection measures for fear that their new measure will become required by a new regulation.

An article detailing how to bring about innovation through environmental policy established three crucial rules for legislators: 1) providing sufficient time for new developments, 2) enforcing regulation in a "gradual and predictable" way, and 3) ensuring that the new technology will be profitable for the industry (Brown et al. 1995). Interestingly, Ford's offer to support the ZEV mandate specifically called for CARB to abide by the first two rules, and further asserted that ZEVs should be considered a goal instead of a requirement (Collantes and

Sperling 2008). As far as CARB was concerned, however, the severity of the mandate was needed to accelerate innovation (Collantes and Sperling 2008). Such conflicting ideologies indicate that command regulation can be a very finicky legislative tool with which to govern: too strict and it can lead to litigation, but too lenient and it won't produce meaningful results.

3.2.3: Incentives and Other Alternatives

An article from 2009 detailing the impact of government incentives on the sales of hybrid-electric vehicles (HEVs) highlighted that the level of environmental concern expressed by the buyer and the potential savings on gas are two prominent motivators influencing the purchase of clean cars (Diamond 2009). The piece claimed that states typically associated with high environmental awareness, such as California, Washington, Maine, Oregon, Vermont, and Massachusetts were among the highest ranking in HEV market share, with "large clusters" in neighboring states showing similar trends (Diamond 2009). The cost of refueling, however, had an even stronger effect on the likelihood of purchase: "A 10% increase in average gas prices would result in, on average, a 72–93% increase in state hybrid market share, depending on the vehicle" (Diamond 2009). Since gas use increases in direct proportion to the miles traveled in a car, longer trips also proved to have a positive effect on HEV sales: "a 10% increase in average per-capita miles traveled would result in an 8–15% increase in state hybrid market share, depending on the hybrid model" (Diamond 2009).

As for less influential factors, federal and state monetary incentives vary in their efficacy. Monetary incentives were shown to primarily benefit higher income consumers who were already likely to purchase an HEV (Diamond 2009). In fact, the article found that doubling the average rebate would produce an 18% increase in market share for HEVs, while additional

government expenditures would rise by over one million dollars per state (Diamond 2009). The study concluded by theorizing that such incentives may not have a strong effect because they do not "affect the up-front price that the consumer pays for the vehicle." This indicates that the psychological impact of an incentive can determine how persuasive it actually is.

Other sources found incentives to be a more reliable approach. Sjoerd Bakker and Jan Jacob Trip's previously mentioned study identified that measures such as subsidies upon purchase, free parking for EVs in city centers (only viable as long as the number of EVs is limited), toll road exemption, or access to high occupancy vehicle (HOV) lanes can all be determining factors in consumer choices (Bakker and Trip 2013). The research highlighted, however, two specific options. Bakker and Trip proposed that a city or local government can facilitate the adoption of EVs to business fleets either with--again--direct subsidies, or with advising. Helping a company calculate the costs of transitioning and/or simply informing them of the benefits made possible by electrification (such as brand recognition) has been a very persuasive method to influence sustainable practices (Bakker and Trip 2013). The final suggestion was to support the introduction of EVs into the vehicle fleets of ride-sharing initiatives. The article states that these programs are "almost by definition, used to and supportive of alternative and green mobility systems" (Bakker and Trip 2013). In other words, minimal effort would be required to initiate such a shift.

Multiple readings cited the political decision to lead by example as a key factor for increasing consumer demand for EVs. The government carries enormous influential power, meaning should they decide to employ all-electric fleets for official purposes, the public response would be to follow suit (Bakker and Trip 2013; Ewing and Sarigöllü 2000, Michaelis 1995). In doing this, authorities would demonstrate sincerity about promoting sustainable practices.

Effective environmental regulation is generally very difficult for the US government to produce, particularly when it's up against the increasingly prevalent deregulation sentiment (Brown et al. 1995).

A study from the *Journal of Public Policy and Marketing* that sought to assess consumer preferences for vehicles arrived at a similar claim. Results showed that without government intervention at the industry level, government intervention at the consumer level would be ineffective. Performance characteristics such as range, acceleration and recharging rate make EVs more attractive alternatives to conventional ICEVs than a direct subsidy after purchase (Ewing and Sarigöllü 2000; Levinson 2014). To assist in the production of improved vehicle technology, the government could instead subsidize research and development for EV manufacturers. Regardless of the level at which an incentive is provided, much of the literature agrees that they are more reliable than disincentives (e.g. taxes or fines) when it comes to producing new technology.

3.2.4: Policy Debates--Conclusions

While the LEV program in California was an example of effective command regulation, help from other policies and other factors were instrumental in its success. Overall, the literature specifically points towards market-based mechanisms as the most predictable tools with which to promote EV ownership, while acknowledging that regulatory measures are only circumstantially effective (their efficacy depends on a multitude of external factors) (Gass, Schmidt, and Schmid 2014). Taxes without complementary motivational policies are not only held in contempt by companies and citizens alike, but are also a finicky instrument with which to encourage EV use. To actually change individual and company practices, taxes would need to be much higher than

what public tolerance allows for (Gass, Schmidt, and Schmid 2014). In the context of green transportation, command regulation can be shortsighted, overlooking the question of how to get EVs into the lives of low-income consumers. To address this issue, incentives are a much more reliable solution than penalizing legislation.

3.3: Literature Review Conclusions

The research has stated that for EVs to successfully reduce the carbon footprint of private transportation in California, they must be driven correctly (lighter loads, slower speeds, etc.), they must be charged with electricity produced by renewable sources, they must cost less (which can be achieved through efficient manufacturing practices), their supporting infrastructure must be developed, and the state government can more reliably promote their purchase with a greater emphasis on incentive programs than on command regulation. The literature review has highlighted that while the LEV program with its ZEV mandate in California has been effective, there is still a need for supporting legislation to address the social barriers prohibiting complete EV adoption. In theory, EVs are a viable measure to reduce the carbon footprint of the private transportation sector. The question remains, however, how can the California government continue to incentivize their adoption for low and middle-income consumers?

4: Methodology

To address the question of how policy makers can ensure the continuation of consumer incentives for EV purchases in disadvantaged communities, I collected qualitative data through interviews. My subjects consisted of researchers who have written extensively on the subject, public officials, and members of EV-related advocacy groups, all of whom helped me gain

professional insight as to what kinds of private transportation policies best address the needs of low- and middle-income communities, and how to continue and/or expand them.

Of my eight subjects, four had written studies that contributed to the Literature Review for this paper: Mark Brown (teaches political theory at California State University in Sacramento), Troy Hawkins (an energy analyst for Argonne National Laboratory, which is operated by the University of Chicago and owned by the US Department of Energy), Daniel Sperling (currently on the board at CARB), and David Reichmuth (who writes for the Union of Concerned Scientists).

Three of my subjects (including Sperling) were current or former members of CARB. Hector De La Torre is a former California State Assembly member who was appointed to the board at CARB in June of 2018. Eileen Tutt served on the board at CARB for ten years, and is now the executive director at the California Electric Transportation Coalition (CalETC), a group that addresses environmental issues by targeting emissions and fossil fuel use in the transportation sector. My final two subjects also currently work for nonprofit organizations; Bahram Fazeli has been the director of research and policy at Communities for a Better Environment (CBE) for 18 years, and Max Baumhefner works for the Natural Resource Defense Council (NRDC) on the Clean Vehicles and Fuels team within the Climate and Clean Energy program

Reaching out at first by email, telephone, and Linkedin, I arranged semi-structured interviews for each subject to be conducted between January and February of 2019. The full list of questions can be found at the end of this paper, in the Appendix. As probing questions were used to elicit more information on a particularly relevant topic, the final questions varied for each subject.

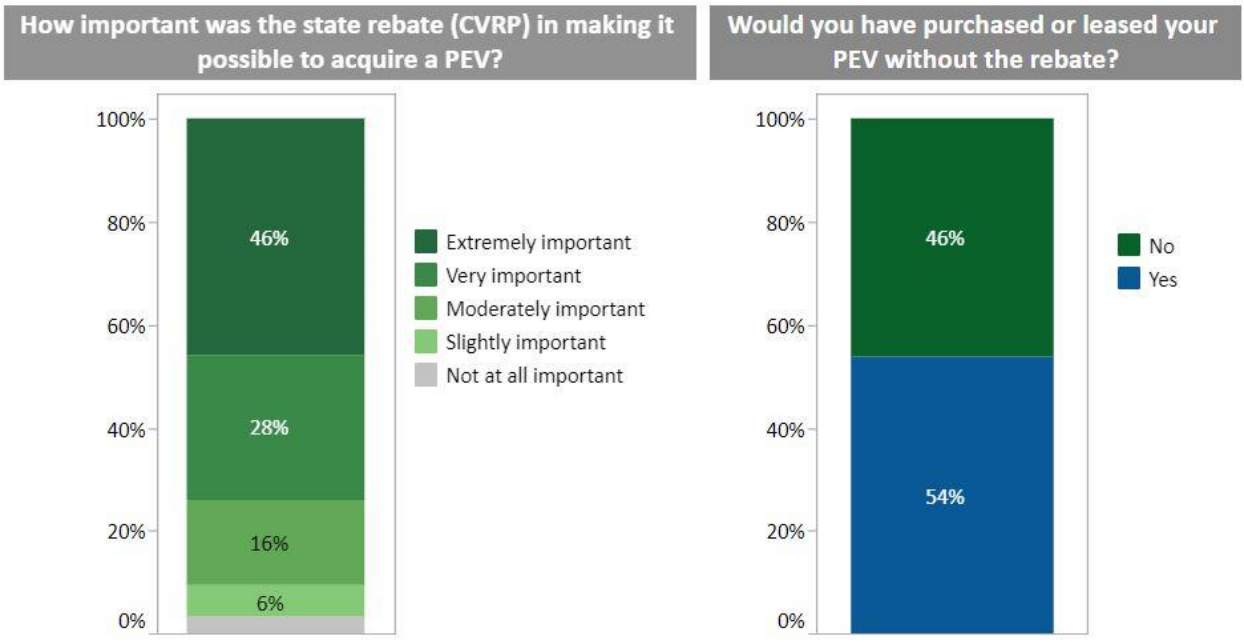
Of the eight interviews completed, two were conducted electronically (via email) on account of time constraints. The others were completed over the phone, as many of my subjects either 1) weren't easily accessible for an in-person interview, or 2) didn't have the time to meet me face-to-face. All interviewees completed the consent form under HSRRC Proposal number Teve-F18120. My questions sought to identify the qualities of effective EV-related policy. The criteria found from each interview will be used later to evaluate the efficacy of past programs in California.

5: Findings--Necessary Components of Effective Policy

The following subsections will be arranged according to the key takeaways from the interview process. They describe three components--incentives, mandates, and infrastructure--of effective policy that each subject mentioned when asked how to address the issue of inadequate EV adoption among low- and middle-income communities in California.

5.1: Incentives Influence Consumer Decisions

All but two subjects (Eileen Tutt and Max Baumhefner), both of whom work for nonprofits and own EVs, referenced some sort of incentivizing technique while explaining California's most effective measures for promoting EV adoption. The following data, collected by the Clean Vehicle Rebate Project (CVRP), reinforces this support for incentives:



("EV Consumer Survey Dashboard" 2016)

Aside from Daniel Sperling and David Reichmuth, the remaining interviewees provided examples. Hector De La Torre specified that the supply and demand model (supply side: manufacturers have to meet corporate fuel economy standards, demand side: incentive programs for the purchase of clean vehicles) has worked particularly well, while Mark Brown only cited the method of "providing financial incentives and tax rebates." Brown concluded his interview by stating "there's a long history of taxes being implemented on the backs of poor people. With rebates of various kinds those effects can be avoided." He proposed that revenue collected from taxing gasoline or gas-powered cars could fund rebates for low-income communities.

Troy Hawkins mirrored this point, reasoning that an incentive works because it "hits at the point of sale when the price difference can influence a consumer's decision... I think it's like anything else: people look at the economics of owning a vehicle and if it makes sense they will do it." Hawkins elaborated by highlighting the difference between a rural buyer, who may need a long-range vehicle, and an urban buyer, who may be looking for something that charges quickly.

"There seems to be very little appetite for any kind of tax but if you were going to give an incentive it has to come from somewhere. Incentives are good for first adopters but once you get to a certain share of ownership you have to look for something else."

Mark Brown and Bahram Fazeli also highlighted the importance of appropriate implementation. Brown stressed how retrogressive "half-hearted" measures can be, claiming "subsidies have to be high enough to make EVs competitive in the market in terms of cost, otherwise people won't buy them until the price comes down." Fazeli built off of this point, asserting that "incentives are definitely important, but it's imperative to consider how you distribute those incentives. One could argue that someone making $300,000 annually probably doesn't need a $2,500 rebate to incentivize them to buy a $70,000 Tesla. I agree that incentives should continue, but they should be more equitable." He reiterated that the "trickle down" model, which doesn't sufficiently prioritize disadvantaged communities when deploying EVs, is "a very slow [and wasteful] process," one that "is not a good example of public policy. A bottom-up approach is better."

5.2: Mandates Influence Corporate Decisions

The two interviewees who did not emphasize the efficacy of incentives were Eileen Tutt and Max Baumhefner. Tutt got straight to the point. "The Low Carbon Fuel Standard [LCFS, which establishes fuel standards to be met by fuel providers] is the most effective governmental regulation for promoting EV ownership... The LCFS addresses two of the biggest barriers to EVs, the monopoly oil holds on the transportation fuels sector and the cost of EVs in the early stage of the EV market." She then back-peddled, stating: "it is really the suite of CA policies that have brought the success of the EV market in CA thus far." (It is important to note that David

Reichmuth took the opposite stance on the LCFS, describing it as containing a "financial incentive that arrives much too late to influence the purchase decision." He did mention, however, that this program is changing to a point-of-purchase rebate.)

Baumhefner, alternatively, specified the ZEV mandate and the Charge Ahead California Initiative (SB 1275), both of which target automobile manufacturers. He labeled the mandate as "the bedrock of California's policy framework," citing it as the reason "why we see so many different EVs on the market now." Regarding SB 1275, Baumhefner described the bill as aiming to "democratize the EV market [by making sure] every Californian gets the benefit from the transition to EVs." All of the aforementioned bills will be analyzed in section 6: Discussion.

5.3: Infrastructure Influences Everyone

Infrastructure, which includes both physical developments and organized programs/initiatives, is the criteria Bahram Fazeli referenced when he cited the need to "create an equal playing field." Fazeli posited that "the oil industry has had a head start for about 100 years." Creating an equal playing field therefore means making opportunities for the emergence of a non-fossil fuel economy. This can be accomplished by addressing issues like workforce training, which requires heavy investment from the government.

Mark Brown, alternatively, noted the significance of "environmental efforts to fund and promote [charging stations] and access to HOV lanes." David Reichmuth supported this, reasoning that "many potential EV owners don't own a single-family home with garage/off-street parking. Having shared public fast chargers can help make EVs useable for those without a place to charge at home." Hector De La Torre also agreed, asserting further that "all the projections show that we're in good shape to [electrify our transportation]." He explained how "we have an

oversupply of energy almost all the time, except during a heatwave." De La Torre later reported that all other policy measures currently in place are additional steps in the right direction for the state government.

Several interviewees mentioned how effective a suite of infrastructure programs can be. Troy Hawkins specified the high rate of EV ownership in Norway, which is a result of policies such as free charging, unrestricted access to city centers, and dedicated street parking. Eileen Tutt and Daniel Sperling suggested pairing ride sharing initiatives with more free or reduced-cost charging, as well as programs that allow individuals to exchange old/dirty vehicles for vouchers that can be applied to the purchase of clean replacement vehicles. Max Baumhefner and Hector De La Torre also mentioned trade-in programs, but their final recommendations focused elsewhere.

De La Torre has been pushing for EVs to have a stronger secondary market. "Low-income people don't normally buy new cars. Lower-income people usually buy used cars, sometimes they are the third or fourth owner of a vehicle, not even the second. We need to do more to promote that second and third buyer of these vehicles." Max Baumhefner's solution does not factor in how to get disadvantaged communities to *own* EVs, but it does present a way for residents to reap some of the benefits of the technology. He advocated for the electrification of medium and heavy duty vehicles, contending that they are responsible "for a disproportionate share of local air pollution."

6: Discussion

When discussing each component--incentives, mandates, and infrastructure--of policies that effectively promote EV ownership and use, the interviewees provided specific examples. For

mandates, Eileen Tutt and Max Baumhefner mentioned bills that establish efficiency standards aimed at auto manufacturers. For infrastructure, subjects highlighted charging stations, lane/road access, ride sharing initiatives, and other measures. The following figure (Figure 1) outlines these examples and uses them to evaluate the bills introduced in section 2 (Background). Each example selected mirrors some concept or program described as effective during the research process; in other words, an example from the interviews was only chosen for the policy analysis if it was corroborated by the literature review. Figure 1 isolates the most and least productive bills, what makes one better than another, and ultimately presents a discrepancy between my literature review and my findings. This section concludes with remaining concerns of policy implementation and this study's limitations.

6.1: CA Policy Analysis According to the Interviews' Criteria for Effective Policy

	SB 350	SB 1275	AB 118	AB 1493 +
Efficiency standards	✓	✓		✓
Lane/Road Access	*N/A	*N/A	*N/A	*N/A
Parking	*N/A	*N/A	*N/A	*N/A
Charging Stations	✓	✓	✓	
Ride Sharing		✓		
Vehicle Exchange		✓		
Secondary Market		✓		
Workforce Training	✓		✓	
Dedicated Funding	✓	✓	✓	
Rebates		✓		
Outreach	✓	✓	✓	
Consumer Variety				

(Figure 1: Policy Analysis. Color indicates type of criteria: the red row is a mandate, blue rows are infrastructure, yellow rows are incentives, and green rows are implementation. Note that "Lane/Road Access" and "Parking" categories are addressed through other policies, such as Assembly Bill 544)

None of the bills discussed in section 2 (Background) manage to address *every* measure deemed effective by the interviewees, but each one successfully complements the rest of the suite of policies. Three of them successfully meet the majority of the criteria from Figure 1 and even use equitable implementation strategies. This analysis will progress from the most to the least comprehensive bill, starting with SB 1275 and concluding with AB 1493.

SB 1275, the Charge Ahead California Initiative, was easily the most effective policy reviewed. It established California's goal of having one million zero-emission and near-zero-emission vehicles on the road by 2023, accomplishing this though requirements such as (1) the "deployment of charging infrastructure in multiunit dwellings in disadvantaged communities to remove barriers to zero-emission and near-zero-emission vehicle adoption," (2) "increased partnerships and outreach with community-based organizations," and (3) an "increased emphasis on the reduction of greenhouse gas emissions through increased vehicle efficiency or transit and car sharing use" ("Bill Text - SB-1275" n.d.). SB 1275 also satisfies the vehicle exchange and secondary market criteria with its numerous equity-driven programs. The Enhanced Fleet Modernization Program (EMFP) provides the previously discussed need-based vouchers for replacement vehicles, but "program participants can also get an additional $2,000 for the purchase and installation of a charging station for battery electric cars at their homes" ("Bill Text - AB-118" n.d.). Moreover, "if participants scrap an old clunker, but don't want to replace it, they can get between $2,500 and $4,500 (depending on income level) in vouchers for public transit passes and car-sharing" (Magavern, n.d.). The Low-Income Electric Car-sharing Pilot Project was "designed to increase the visibility and use of EVs, improve mobility, economic opportunity, and air quality in the neighborhoods most impacted by pollution and poverty" (Magavern, n.d.).

AB 118 and SB 350 also met much of the criteria established during the interviews. Both bills demonstrate attributes of effective policy through their emphasis on infrastructure, outreach, and workforce training, but each one contains unique, additional benefits. In establishing funding sources for "alternative and renewable fuel infrastructure, fueling stations, and equipment," AB 118 stressed the need for actions that expedite the development of the non-fossil fuel economy in

areas that are disproportionately impacted by it. These actions include projects aimed at improving medium- and heavy-duty vehicle technology to "create higher fuel efficiencies" ("Bill Text - AB-118" n.d.). SB 350, the Clean Energy and Pollution Reduction Act, set targets for reducing greenhouse gas levels 40% below 1990 levels in 2030 and 80% below 1990 levels by 2050 ("Bill Text - AB-118" n.d.). In setting standards for vehicle efficiency, the bill focuses on equity by "considering unintended consequences of targeted investments in clean transportation projects and programs, such as the potential for physical or economic displacement of people or businesses" ("Low-Income Barriers Study, Part B" n.d.).

Assembly Bill 1493 (and its supporting legislation) serves as the weakest example of EV-promoting policy, only meeting one of the criteria established for effective policy. In setting greenhouse gas emissions standards, it not only exemplifies the problems typically associated with command regulation, but it also does nothing to incentivize EV purchase or use. Without supplementary legislation, AB 1493's requirements would not impact lane/road access, charging infrastructure, parking availability, tax rebates, outreach/education, ride sharing, vehicle exchange programs, the secondary market, or any other project aimed at making EVs a more convenient and prolific option. Moreover, the bill was poorly implemented. After being "threatened by automaker lawsuits," it was amended to allow vehicle manufacturers "compliance flexibility" ("Climate Change for Mobile Sources" n.d.). Apprehension regarding over/under enforcement is also relevant for SB 350. Are the standards it sets strict enough to generate innovation? Or will they be lowered and/or pushed back by litigation from industry lobbyists?

6.2: Literature Review and Findings Discrepancies

Aside from the conditions under which EVs can successfully reduce the environmental impact of the private transport sector, the major finding from the literature review was that command regulation is not as reliably effective as market-based mechanisms. The interviews, however, revealed that AB 1493 is one of the least effective EV-promoting policies *because* it is not supported by a mandate.

Since the California government has finite resources, certain policies--like rebates upon purchase--are volatile. President Donald Trump has already threatened to eliminate subsidies for EV purchases (*Reuters* 2018). Policies that have a dedicated funding stream (from tax/fee revenue), then, are much more sustainable. SB 1275 uses money from the Greenhouse Gas Reduction Fund (cap-and-trade), AB 118 uses money from AB 8 (which collects money from vehicle registrations, tire sales, etc.), and SB 350 has an entire study that identifies the need for "permanent, long-term funding sources" for equitable EV distribution in disadvantaged communities.

Another measure brought up during the interviews, the Low Carbon Fuel Standard (LCFS), epitomizes self-sustaining legislation in this field. The LCFS was approved to "reduce the carbon intensity (CI) of transportation fuel used in California by at least 10% by 2020 from a 2010 baseline" ("LCFS Basics" n.d.). In doing so, it reduces petroleum dependency and achieves the air quality goals established under AB 32. The LCFS sets CI standards on all forms of transportation fuels, including electricity and other clean sources of energy ("LCFS Basics" n.d.). Producers of fuels that fall below the CI standards receive credits from high CI fuel producers, which these parties are then mandated to distribute to their customers ("LCFS Basics" n.d.). The electric utility company Southern California Edison (SCE), for example, created a Clean Fuel

Rewards Program using credits collected from the LCFS. Under this program, “SCE customers driving new, used, or leased electric vehicle, may be eligible to receive a $450 rebate” (“LCFS Utility Rebate Programs | Low Carbon Fuel Standard Program” n.d.). The Sacramento Municipal Utility District (SMUD) offers a similar incentive, in which they offer either a “$599 incentive or a free level 2 charger for purchasing or leasing a new plug-in electric vehicle” (“LCFS Utility Rebate Programs | Low Carbon Fuel Standard Program” n.d.).

Policies with dedicated funding streams are significantly less vulnerable to phase-outs than those operating on predetermined budgets, meaning they can have a more meaningful and longer-lasting impact on EV adoption.

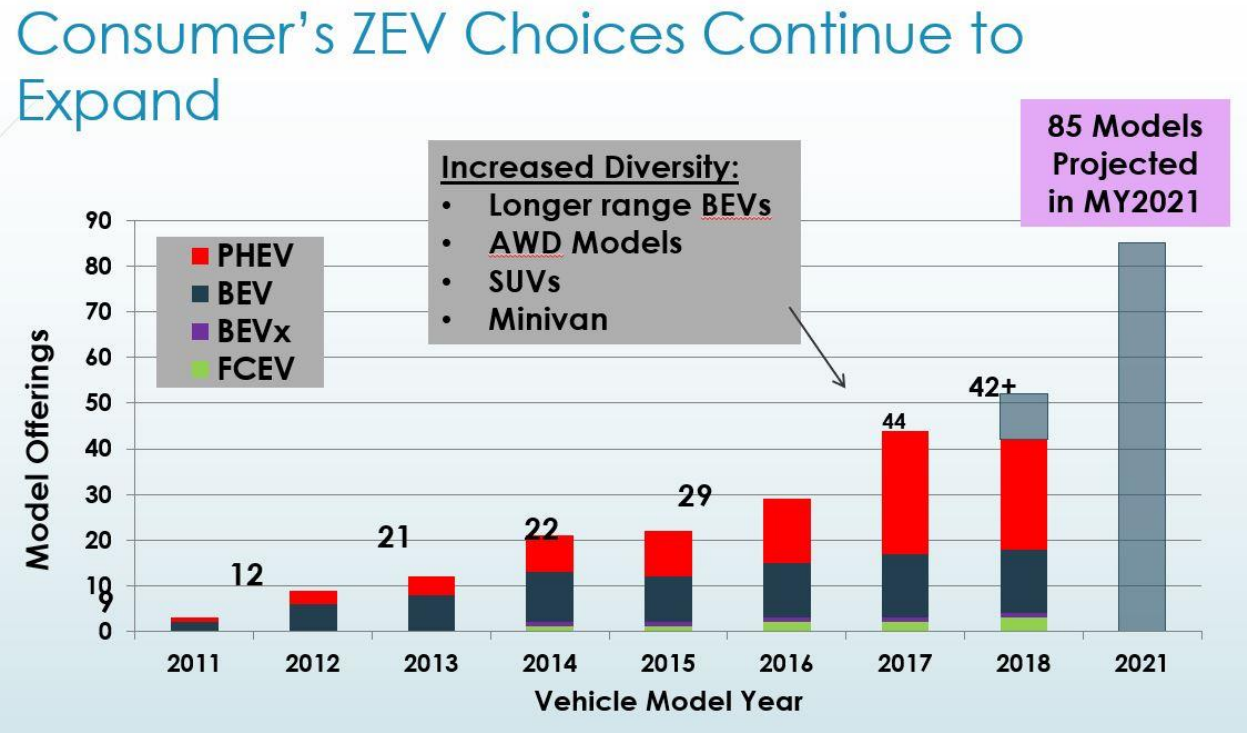
6.3: The Importance of Strategic Implementation

The issue of misplaced rebates has already been discussed, but several other ineffective techniques to promote EV ownership were also highlighted. Troy Hawkins was the only subject to consider the timing of the “ramp-up” of EVs in his answers. When determining the impact these vehicles may have, he used this criteria to examine factors such as where the grid draws its electricity from and what developmental stage the technology is in. Hawkins spoke on the pros and cons of deploying EVs, stating that while it would be better to “inject vehicles into the fleet” once the technology is more advanced, doing it now helps the public understand new innovations. Max Baumhefner, alternatively, referenced an instance in which the government spent money poorly, installing Level 2 stations (240v, faster than Level 1--120v--but much slower than DC Fast Charging) at places where people wouldn’t park long enough to get a useful charge.

Of the remaining concerns cited in the interviews, outreach and education stood out. In Mark Brown's interview, he dubbed it "the power of publicity." Brown discussed how CARB doesn't devote enough of its resources towards public education. He posited that surveys to raise awareness of driving styles could have informed consumers that "even a limited-range EV can satisfy their needs." He summarized this argument by saying "government can play a role in helping people think more cautiously about transportation and their own habits. There's such a strong cultural connection to gas-powered cars that there's a need for cultural work to change that image and create a place for EVs." While Daniel Sperling and Hector De La Torre concurred, De La Torre advocated for government outreach to inform the public how this technology works, because "obviously [people] are not going to buy something they don't understand." Eileen Tutt lamented that government has never been very good at outreach and education efforts.

Aside from education, De La Torre expressed concern about consumer variety--or lack thereof--which is the only other issue left unaddressed by the reviewed legislation. De La Torre is "convinced consumers want… to be able to shop for a zero-emission vehicle the way they would shop for anything else." He acknowledged that as options multiply, "a lot of people, including myself, [will be convinced] to get into [EVs]." It can be argued that SB 1275 encourages EV research and development from manufacturers, but a mandate for the number of ZEVs on the road can be achieved through sales action, and does not necessarily require the production of entirely new vehicles. Regardless of whether or not there is direct government intervention, this issue will inevitably be addressed over time, as the market for EVs grows. As

evidenced by the figure below, ZEV choices have more than quadrupled in the past 7 years alone:



(CARB 2018)

California has done a remarkably good job at promoting EV ownership thus far. Policy makers have taken a relatively bottom-up approach and addressed virtually every component of what this study's interviewees consider effective policy. Incentives, infrastructure, and mandates to fund the incentives have been implemented. The only remaining need, and therefore the only recommendation to make, is for improved government outreach and education.

6.4: Limitations

The primary limitation regarding this research is that there currently is not enough data to know which policies promote a meaningful increase in EV adoption. While there have been

studies detailing EV sales over time, none present the data accounting for factors like vehicle availability. In other words, a bill that caused an increase in EV sales in 2015 is not necessarily more effective than a bill that had a negligible impact on sales in 2003. Moreover, if two bills were introduced simultaneously, how does one determine which measure had a more substantial impact? It's difficult to quantitatively compare the efficacy of, for example, SB 375 and AB 32. The interviews were only able to reveal which type of bill was *generally* more progressive and productive; the subjects reported that 1) there is a remaining need for additional government outreach and education, specifically for low- and medium-income consumers, and 2) that incentive programs can be prolonged if they are amended to favor disadvantaged buyers.

7: Conclusions and Next Steps

As demand for private transport increases, the government must fight to mitigate the automobile's heavy environmental toll, which disproportionately affects disadvantaged communities. EVs present a viable solution to this sector's overwhelming carbon footprint. In response to the question of how to encourage EV adoption in California, this study was able to determine that equity-driven, market-based mechanisms that have a dedicated funding stream are most effective. In other words, incentives for low- and middle-income consumers that are funded by taxes or fees are both reliable and sustainable. While California's existing policies meet this standard through their relatively progressive bottom-up approach, time will tell whether or not full deployment of the technology requires additional measures. Because EVs are a relatively new technology, it is tough to determine how the current legislation will impact/has impacted disadvantaged communities. Sales and usage data must be collected before one is able to recommend ending, continuing, or amending a certain bill. Though the interviews revealed a

remaining need for government outreach and education, California policy makers have done good job at promoting EV ownership thus far.

8: Appendix

Guiding interview questions:

1. Can you tell me a little bit about what you do?
2. Do you drive an electric vehicle (EV)? Why or why not?
3. Why have you devoted time to this topic?
4. Do you think that California could benefit from increased EV ownership? Why or why not?
5. What do you think is the most effective governmental technique for promoting EV ownership?
    a. Why do you think this was/is so successful?
6. What do you think is the least effective governmental technique for promoting EV ownership?
    a. Why do you think this was/is so unsuccessful?
7. What policy measures do you think could encourage EV adoption specifically in low-income communities?
8. Is there anyone you recommend talking to about this topic?
9. Any final thoughts?
10. Do you have questions for me?

Interviewee Motivation:

- Of the subjects who didn't cite environmental concerns as the primary motivating factor behind their involvement in EV-related work, all three were researchers. Mark Brown chose to investigate this field because he found it to be an interesting case study of the role of experts in politics. He explained that the testimonies made by competing interest groups (lobbyists from the auto industry, environmental groups, etc.) were especially compelling. Troy Hawkins' works were commissioned by the Norwegian Research

Council while he was living in Norway (around 2011). He described the country as a "special situation" for EVs because of "the high percentage of hydroelectricity in the grid and strong political and social will to reduce carbon emissions." Daniel Sperling, on the other hand, noted the historical relevance of EVs, calling them "the biggest change that's happened to transportation in 50 years, [one that is] going to have a huge impact on our cities, our lifestyle, equity, and the environment."

- The other four subjects agreed that climate concerns fueled their work, but two of them specified additional rationale. Eileen Tutt emphasized that her concern for our oil-dependent economy, which "suffers as a result of the unpredictability of the cost of oil and the massive fluctuations in the price of gasoline and diesel" has driven many of her efforts. Bahram Fazeli, alternatively, focused on equity, stating that he has aimed to "enhance access to clean mobility options for low-income communities of color" since he started at CBE.
- Each interviewee revealed that he/she saw increased EV adoption as beneficial to the state of California for the technology's environmental potential, but four participants mentioned supplementary reasoning. Tutt's argument built off of her answer to the previous question (why have you devoted time to this topic?). She stated that the shift from oil to electricity is economically logical, explaining that "the price of electricity has remained stable for over 30 years and, particularly if the EV is charged at times that help stabilize the electricity grid, electricity is much cheaper than gasoline or diesel." Max Baumhefner paralleled this point of view, contending that "when you switch to electricity you switch to a cleaner and cheaper fuel, so you reap billions [of dollars] in public health benefits and you stop sending billions [of dollars] to international oil conglomerates, and you keep that money in the economy instead." Bahram Fazeli also recognized the public health angle, acknowledging that air pollution exacts a heavy toll in certain areas.

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