Electric Vehicle Integration in San Francisco

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This Master’s Project

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by

Lisa Farmos

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Abstract

California’s Executive Order N-79-20 requires all new cars and passenger trucks sold in California to be zero-emissions by 2035. Electric vehicles (EVs) are the primary alternative fuel solution. However, there are widespread barriers to ownership, particularly for those in lower socioeconomic classes. A literature review of barriers to EV ownership shows the primary barrier is insufficient overnight charging infrastructure. Geospatial data of EV charging infrastructure and 2020 census tract data were used to map average income versus EV charging infrastructure in San Francisco. Data maps confirm the literature review findings: there is a positive correlation between income and EV charging infrastructure. Next, a comparative analysis of three groupings of neighboring San Francisco districts found districts with higher median household income were likely to have a higher concentration of EV charging infrastructure than districts with lower median household income. Discovered equity concerns were addressed using the Just Transition framework to assess how the City of San Francisco can develop an EV charging infrastructure that is beneficial to all San Francisco residents, regardless of income. Finally, five recommendations were developed to increase equity in the transition to an all electric fleet in San Francisco: 1) Develop curbside parking policy and infrastructure in neighborhoods that use residential street parking permits; 2) Equip existing street lights with public EV chargers; 3) Create City EV charger support or incentives for low-income residents; 4) Develop infrastructure grants for outdated apartment buildings with parking garages; and 5) Invest in Participatory Action Research in San Francisco neighborhoods.
1. Introduction

The increasing impact of anthropogenic climate change due to the high volume of carbon emissions has fueled the current global interest in shifting away from fossil fuels and towards renewable energies. In 2019, the transportation sector made up 29% of the United States total greenhouse gas (GHG) emissions (Figure 1) (EPA, 2021). When examining the source of GHG emissions within the transportation sector, light-duty vehicles (i.e., passenger and fleet cars) account for 58% of emissions (Figure 1) (EPA, 2021). Climate action plans (CAP) are being created at all levels of government to reduce the amount of GHG emitted into the atmosphere. CAPs typically cite reducing GHG through vehicle electrification as a key strategy to GHG reduction within the transportation industry.

On September 23, 2020, California Governor Gavin Newsom signed Executive Order N-79-20. The order does two things: 1) requires that 100% of sales of new passenger cars and trucks sold within the state be zero-emission by 2035; and 2) sets an ambitious goal that 100% zero-emission medium and heavy duty vehicles in California by 2045 for all operations (EDSC, 2020). Additionally, Executive Order B-48-18 (2018) set the goals to 1) deploy five million zero emission vehicles by 2030 and 2) to set up 250,000 public charging stations by 2025 (CPUC, 2021). As ambitious as this goal is for the state, the city of San Francisco set a similar goal in
2019 to make all transportation within the city emission-free by 2040 by requiring all new car sales be electric by 2030 and banning combustion engine vehicles in 2040 (SFDE, 2019).

The state of California has the highest concentration of electric vehicles (EV) in the country and is responsible for 41% of national EV sales (Bui et al., 2020). However, within the state the numbers tell a different story. EVs only make up 1.3% (369,364 total registered EVs) of all light-duty vehicles registered in California; if plug-in hybrid and fuel cell vehicles are included, low emission vehicles only account for 2.2% of registered light duty vehicles in California (CEC, 2020). For California to achieve its goal of five million EVs deployed by 2030, there will have to be approximately 500,000 EV sales annually, more than double the total EVs registered at the end of 2020. Executive order N-79-20 was written to help achieve the ambitious goal of 5 million deployed EVs by 2030.

Transitioning to EVs requires a complete restructuring of current transportation infrastructure to support charging needs. Traditional gas stations will become obsolete as charging stations slowly take their place. Unlike the average ten minute fill up at the gas station, a trip to a charging station will take at least 45 minutes (depending on the type of charger). Currently, the majority of the EV owners are able to charge their vehicles overnight in their driveways or garages, drastically reducing their reliance on public EV charge stations. Those who do not have access to residential overnight charging will continue to encounter charging burdens as the EV transition progresses, the heaviest burden in the transition in the form of long wait times at charging stations and the experience of range anxiety when they are unable to charge their vehicles (due to time constraints or public EV charger availability).

Current EV infrastructure development has heavily relied on market mechanisms for infrastructure development (Hardman et al., 2020). EV infrastructure is primarily built in proximity to EV owners to ensure profitability for the companies building the charging stations. For the transition to EVs to be successful in its scale up to a 100% EV fleet, infrastructure must be designed to account for the margins. In regards to EV charging, this means designing EV charging infrastructure to be beneficial for those who do not have access to overnight residential charging infrastructure.
1.1 San Francisco Case Study
San Francisco is one of the leading cities in EV infrastructure development in California and has continued to move towards its long term goal of a carbon neutral city by 2050 by setting a mid-range goal to allow only the sale of EVs beginning in 2030 and a long range goal to make all transportation in San Francisco emission-free by 2040 (SFDE, 2019). Figure 2 is a visualization of San Francisco’s struggle to increase the percentage of EVs on the road. For context, in 2018, 1.63% (10,648) of the approximately 420,000 registered vehicles in San Francisco were EVs, varying widely by neighborhood (California Energy Commission, 2021), but by the end of 2020 (two years later), the percentage of EVs in San Francisco had increased to 2.6% of the approximately 404,243 vehicles registered in 2020 (California Energy Commission, 2021). Additionally the total number of vehicles registered in San Francisco decreased, so the percentage may have only increased due to the decrease in total vehicles registered. For San Francisco to meet its vehicle electrification goals, it will have to substantially increase the number of electric vehicles on the road.

![Electric vehicle population increase in San Francisco for the past 10 years](www.energy.ca.gov/zevstats).

To address the slow implementation of EVs, the Electrical Vehicle Working Group (EVWG) was established by Mayor Ed Lee. The objective of the EVWG is to identify policies and actions to
facilitate the continued growth of EVs in San Francisco and develop recommendations and solutions that result in the transition to EVs in both the municipal fleet and private sector (SFMTA, 2017). Working with the EVWG, San Francisco Municipal Transportation Authority (SFMTA) developed three long term strategies in the form of implementation actions to support and accelerate the transition to an all electric fleet (SFMTA, 2017). Figure 3 highlights these actions, their benefits and estimated costs.

Figure 3. SFMTA’s long term strategies to meet the City’s goal to increase the number of zero emission vehicles by 2025 in both the public and private sectors and to improve access to charging infrastructure. Source: SFMTA, 2017.

EVI-1 (as shown in Figure 3) develops a roadmap that prioritizes decisions and investments that relate to the electrification of the transportation sector. This action focuses on engaging the city partners, the private sector, the public and key stakeholders in developing a plan for EVs. EVI-1 is led by SFMTA, EVWG and SF environment. The goal of EVI-2 is to implement EV pilot projects and high priority recommendations from San Francisco’s zero emission vehicle strategy. The projects are to be implemented in coordination with key stakeholders, the public, and city partners. EVI-2 is led by SF environment and SFMTA. EVI-3 focuses on the development of action plans to guide the conversation surrounding the transition of the paratransit and taxi fleet along with school buses and non-revenue municipal fleet to EVs. EVI-3 is led by SF Environment and SFMTA. The following research questions were developed by imagining what it would look like to have a 100% EV fleet in San Francisco and how accessibility issues may impede the city from hitting its goal of zero combustion engine vehicles on the road after 2040.
1.2 Research Questions
Due in part to the infrastructure needs of those who rely on street parking or live in multi-unit dwellings (MUD) the rate of EV adoption in San Francisco (and the state of California as a whole) has been very slow. Current EV goals set by the City appear to be somewhat unrealistic and perhaps unachievable. In an effort to understand how San Francisco will achieve its ambitious goal to allow only the sale of EVs beginning in 2030 and to make all transportation in San Francisco emission-free by 2040, I developed three research questions to answer my primary question of what the successful implementation of EV infrastructure would look like in San Francisco.

To answer my main research question I first assessed what the primary barriers to electric vehicle adoption are regarding both EV technology and infrastructure. I then researched if initial accessibility to EVs has long term implications in terms of equity in the distribution of EVs and EV infrastructure. To answer my final question regarding how equity is being addressed in EV infrastructure and development in San Francisco, I conducted an analysis of different city and statewide EV infrastructure policies and I conducted a case study of current EV infrastructure trends regarding its development and implementation within the city of San Francisco.

2. Methods
The paper will consult a body of research to examine current accessibility trends in EV infrastructure development and implementation using Van Dijk’s (2017) framework for accessibility. A Dutch Communication Scientist, Van Dijk’s (2017) study of the digital divide in technology created a 5 step framework for analyzing accessibility trends to new technologies (i.e., the internet). I found that his robust framework can be applied to any emergent technology and tailored his framework to the parameters of the adoption of EVs as a replacement for internal combustion engine vehicles to assess accessibility concerns within the current transition to EVs.

I conducted a case study of San Francisco EV infrastructure using maps created by ArcGIS from 2015 census data layers found on datasf.org and EV station GIS data from the U.S Department of Energy. An equity analysis was then conducted using the Just Transition framework laid out by McCauley & Heffron (2018) which defines a Just Transition as a “fair and equitable process of
moving towards a post-carbon society.” The equity analysis was done by examining the demographics of three different districts of San Francisco and comparing the integration of EV infrastructure for each of the districts.

To assess the distribution of EVs in San Francisco, I selected three groupings of San Francisco districts, 1) Inner Mission and Castro; 2) South of Market and Potrero; and 3) Bayview and Hunters Point, grouped together by proximity (neighboring districts) and median household income to form three communities of varying income for analysis (Figure 4). Bayview and Hunters Point were chosen to represent the lowest earning districts with a combined median household income of $76,838; South of Market and Potrero represent the middle earning districts with a combined median household income of $93,767; and Inner Mission and Castro districts represent the highest earning districts with a median household income of $150,715 (Data USA, 2019). An analysis is conducted of the following for each grouping of districts: 1) average vehicle ownership per household; 2) housing type; 3) on- or off-street parking and 4) existing EV charging infrastructure.

![Figure 4](image)

Figure 4. A. Inner Mission/Castro districts; B. South of Market/Potrero districts; and C. Bayview-Hunters Point district. Data Source: Clean Cities SF, 2021.

Projected 2030 public, work, and home charging need estimates were taken from Hsu et al. (2020). Public charging infrastructure needs (to include level 2 and DC fast chargers) were projected by dividing daily energy demand projections by the maximum amount of energy that is supplied by the chargers. Needed home chargers were estimated by dividing the total number of EVs by the average number of vehicles in a household with the assumption that the same household would share a single charger (Hsu et al., 2020). Finally, workplace charging needs
were projected based on the total workplace charging needs per day for inner-city and out of city commuters (Hsu et al., 2020). Using the given information, I examined what the equitable distribution of EV infrastructure would look like within each group.

3. Primary Barriers to EV Adoption
The resistance to EV adoption largely comes from limitations in battery technology, primarily charge time and miles per charge (Jensen and Mabit, 2017). Additional concerns are related to driving range and charging station accessibility. Consumers consistently list charging time as a main concern as they equate charging time with lost time in which they are foregoing some amount of independence and freedom of movement (Koffman et al, 2016). When surveying California drivers, urban motorists were found to experience the highest levels of anxiety regarding charge station accessibility (Asensio et al, 2020). Access to charging infrastructure relies heavily on infrastructure in place. Currently there is no nation-wide policy regarding the development or financing of charging infrastructure, leaving the responsibility to fall on the private sector or state and local governments (Granoff et al., 2016). Large-scale adoption of EVs is in danger of stagnation unless lawmakers prioritize barriers to access.

3.1 Battery Life
Battery technology is a limiting factor in the transition to EV’s. In the first generation of EVs, the substantial cost of batteries made it difficult for automakers to create a cost effective EV. In 2010, Tesla Motors achieved a breakthrough in battery technology with the introduction of the lithium ion battery. The new battery greatly reduced cost per kilowatt hour (kWh) and effectively doubled the production of EVs. The cost of batteries declined industry wide by 14% annually between 2007 and 2014 (Nykvist and Nilsson 2015). Figure 5 shows the price reduction of EV batteries from 2005 with projections into 2030. Battery production costs continue to fall resulting in lower production costs for market leaders. One hundred and fifty dollars per kWh is regarded as the commercialization point for EVs (Nykvist and Nilsson 2015). As of 2020 the average cost of battery prices fell to $137 per kWh and is projected to reach $100 per kWh by 2024 (Edelstein, 2021).
As battery costs continue to fall the primary barrier to EV adoption still remains: battery range. The energy capacity of EV batteries has increased in the past ten years from 80-100 watt-hours per kilogram (Wh/kg) to 200-250Wh/kg (Varga et al., 2019). However, the primary concern of consumers regarding EVs is still the range per charge of the vehicle (Asensio et al., 2020). Range anxiety is the worry that the battery will not have enough charge to reach its destination.

Continued development of battery technology to extend the range of EVs on a single battery charge will help to reduce the barrier of battery limitations.

One major setback in EV batteries is the direct influence temperature has on the range of the battery. Increased temperatures while charging negatively affects battery cells, making them unstable and consequently severely reduces the range and lifespan of the battery (Varga et al., 2019). Using the EVs climate control system has shown to cause significant reductions in range in both summer and winter months. In summer months the additional load from running the air conditioning causes a range reduction of 17.2 - 37.1%, whereas in winter the additional load from heating has been shown to cause a range reduction of 17.1 - 54.0% (Varga et al., 2019). The development of robust EV charging infrastructure will alleviate current range limitations of EV batteries as technology is still being developed to address battery shortcomings. While
limitations in battery range are a significant barrier to the adoption of EVs, this paper will focus on another primary barrier to EV adoption: charging infrastructure.

3.2 EV Infrastructure

In regards to EV charging infrastructure there are three primary types of charging station: level 1, 2, and 3 (also known as DC fast charging). Table 1 delineates the differences in types of charge stations. Level 1 charge stations are slow charge alternating current (AC) chargers that are most commonly used for at home charging. These charge stations can take 12-24 hours to fully charge a vehicle. Slow charging is the preferred method of charging due to the low thermal load associated with slower charging times (Varga et al., 2019). Level 2 charging stations are also considered slow charge stations with an average charge time of 4-6 hours. These charge stations are more common as public charging stations in workplace parking facilities and other areas where cars are typically parked for an extended period of time. Finally, the level 3 Direct Current (DC) charge stations (also known as quick charge stations) average a charge time of 45 minutes. Level 2 and 3 stations are the types of charging stations that will make up the majority of future public charging infrastructure. The main drawback of these types of stations is that increasing the speed of charge increases the thermal load put on the battery, which (as noted earlier) results in reduced battery performance and lifespan (Varga et al., 2019). Low-Power overnight home charging is the most beneficial because it reduces overall grid upgrade costs while also providing demand management flexibility for utility companies (Hsu et al., 2020).

A level 1 or 2 slow charging station is ideal for preserving the lifespan of the battery. The slow charging process reduces the thermal effect on battery cells, which increases the life of the battery and equalises electrical potential of the cells (Varga et al., 2019). In an urban environment like San Francisco, the ideal method of charging would be to slow charge the vehicle based on the daily use of the driver. Driving long distances outside of the city would be the ideal time to use a fast charging station, primarily for user comfort to get quickly to their destination. The next section will examine the challenges in building a robust infrastructure for EVs.
Table 1. The differences in the three types of EV charging stations (Bahrami, 2020).

<table>
<thead>
<tr>
<th>EV charging Station Types:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 (AC)</td>
</tr>
<tr>
<td>Typically used for at home charging. Conducted when the car is idle, this slow AC charge takes 12 or more hours to completely charge a battery.</td>
</tr>
<tr>
<td>Level 2 (AC)</td>
</tr>
<tr>
<td>Usually found in public charge stations, or workplace parking facilities. Takes 4-6 hours to fully charge. These stations are more common in areas where cars are parked for long periods of time.</td>
</tr>
<tr>
<td>Level 3 (DC Fast)</td>
</tr>
<tr>
<td>More expensive chargers. The average charge time for a 100 mile range battery is ~45 minutes.</td>
</tr>
</tbody>
</table>

4. Equitable Integration of EVs: Through the Lens of the Digital Divide

Shifting from conventional fossil fuel vehicles to electric vehicles requires a fundamental change in how we view infrastructure around “refueling.” Gasoline is a commodity shipped around the world to gas stations where it is resold to vehicle owners who can then forget about their gasoline needs for the next 300 miles or when the refuel light dings as a reminder to drive to the next corner gas station for a five minute refuel. EVs, however, require a place where they can be plugged into the electricity grid to charge, whether it be a slow overnight charge in a homeowners garage, or a “quick” 45 minute charge from a public EV charging station. Thus far, EV infrastructure build-out for public charging stations has relied on the conventional model of refueling stations in an attempt to mimic the infrastructure as a replacement for corner store gas stations.

Yet, EV charging fundamentally differs from conventional vehicles in that 50-80% of all charging for EVs occurs at home, 15-25% of commuters charge their vehicles at work, and less than 10% of charging occurs at public fast charge and slow charging locations (Funke et al., 2019). In the majority of cases, around 10 fast charging stations are found to be sufficient for every 1000 EVs (Funke et al., 2019). However, these findings were made under the assumption that most EV owners had the ability to charge from home. The study did not take into account the portion of the population that did not have the ability to charge from home would need to rely on public charging stations. Analyzing and understanding the accessibility barriers to EV
adoption is essential to understanding how to equitably develop and implement EV infrastructure so all communities can experience the benefits of EV ownership regardless of housing type or socioeconomic status.

4.1 Accessibility Analysis

Similar to the advent of the internet, EVs are a novel technology that requires the generation of a new infrastructure that was previously nonexistent and the entry point for participation requires a certain amount of capital (i.e., money, credit). The term “digital divide” (first used in the late 1990’s, early 2000’s) is defined as the investigation of physical access to the internet. Primarily, who has access to the hardware and software to connect to the internet (Van Dijk, 2017).

Access to EV technology and infrastructure is following the same trajectory as the early days (late 90’s, early 2000’s) of internet access, where computer ownership with internet capabilities was (and in some cases still is) found to be directly correlated with income, education level, age, and race (Van Dijk, 2017; Canepa et al., 2019). EVs and the buildout of the associated supporting infrastructure primarily goes to those who can afford the novel technology. Inequities at the infancy stages of EV technology and infrastructure creates a positive feedback loop that will continue to perpetuate systemic inequity in EV accessibility. Van Dijk’s (2017) study of the digital divide in technology created a 5 step framework for analyzing access to new technology:

1. Categorical inequalities in society produce an unequal distribution of resources.
2. An unequal distribution of resources causes unequal access to technologies.
3. Unequal access to digital technologies also depends on the characteristics of these technologies.
4. Unequal access to digital technologies brings about unequal participation in society.
5. Unequal participation in society reinforces categorical inequalities and unequal distributions of resources.

Adjusting Van Dijk’s framework to assess the implementation of EVs, it is evident that a similar positive feedback loop is forming as EV infrastructure is quickly expanding to meet the needs of both early adopters and climate change goals set by state and local governments (Figure 6).

Analyzing the development and strategic implementation of EV infrastructure, sheds light on how societal inequalities are likely to perpetuate and widen the chasm of access to EV
ownership if not addressed in the early stages of development and implementation.

Thus far, the rollout of EV technology (to include infrastructure development) has primarily been implemented in communities with a higher percentage of housing stability and higher average income (Min & Lee, 2020). Additionally, case studies of urban and rural areas in Washington and California have reached similar conclusions: EV charging infrastructure is concentrated in neighborhoods with higher income levels, home ownership, and higher single family housing rates (Canepa et al., 2019; Min & Lee, 2020; Ku et al., 2021). Moving forward, this literature review will assess strengths and weaknesses in the development and implementation of EV infrastructure using Van Dijk’s accessibility framework adjusted for EVs. Lastly, an assessment will be made to address policies in place to increase access and break the positive feedback loop.
4.1.1 Categorical inequalities in society produce an unequal distribution of resources.

For the purpose of this literature review, categorical inequalities in society will be referring to the demographics of socioeconomic status (i.e., total income), homeownership, race, and highest level of education completed. Figure 7 shows the distribution of new EV owners to total households ratio.

![Figure 7](image.png)

Figure 7. The distribution of new EV owners to the total number of households in disadvantaged communities (DAC) and non-disadvantaged communities (nDAC) from the census and CVRP dataset. Source: Canepa et al., 2019.

In both disadvantaged communities (DAC) and non-disadvantaged communities (nDAC) the proportion of EV owners is small. The average ratio of EV owner to household in DACs is less than 0.5% and in non-DAC households the average 1.7% (Canepa et al., 2019). The blue distribution curve, representing EV owners in non-DACs, has a long tail which indicates some non-DAC households have a high number of EVs. The red distribution curve, representing EV owners in DACs, has a short tale which indicates that there are no DAC households with a high percentage of EV owners (Canepa et al., 2019).

The analysis shows that PEV adoption occurs at a lower rate in disadvantaged communities; both
new and used PEVs are more commonly purchased in non disadvantaged census tracts, with a majority of PEV owners residing in non disadvantaged communities (Canepa et al., 2019). Lastly the study found that households owning an EV had both a higher income level and higher levels of education in both disadvantaged and non disadvantaged communities. Moving forward, research will show that these categorical inequities that prevent access to EV ownership result in the unequal distribution of EV charging infrastructure needed to support ownership of an EV.

4.1.2 An unequal distribution of resources causes unequal access to charging infrastructure.

Unequal access to the initial purchase of an EV causes the unequal distribution of charging infrastructure. In California, census block tracts with the lowest median household income (<$44,000 per year) have the least access to public charging facilities than communities in higher income brackets (Hsu & Fingerman, 2021). Distribution inequality extends past economic differences census tract data to reveal an inequity in EV infrastructure among ethnicities. When looking at racial and ethnic demographics in California, Hispanic and Black majority census tracts have the lowest access (13%-14%) to EV public charging stations when compared to all other ethnic majority groups, while those who live in a community that has a white majority population are twice as likely (25%-27%) to have access to public chargers (Hsu & Fingerman, 2021). Inequity in the initial affordability of EVs creates less demand for EV infrastructure in marginalized communities, resulting in a higher concentration of EV infrastructure development and implementation in higher income neighborhoods (Hsu & Fingerman, 2021).

Low income households are less likely to take advantage of incentive programs (e.x. tax credit and rebate programs) due to lack of resources (Min & Lee, 2020). Additionally, an equity analysis of California’s Vehicle Rebate Program found income-based equity disparities in allocation of subsidies. Based on median income census tracts, the bottom 75% only receives 38% of the total personal EV subsidies while the top 12.5% of the most advantaged census tracts received 25% of the total rebate amount (Guo & Kontou, 2021). Similar results were found in an analysis of Federal tax credits and the qualified plug-in electric drive motor vehicle credit (Canepa et al., 2019; Guo & Kontou, 2021).
4.1.3 Unequal access to EV infrastructure also depends on the characteristics of EV chargers made available.

Housing type plays a significant role in accessibility to EV charging infrastructure. EV owners who live in multi-unit dwellings are more reliant on public charging stations. Hsu and Fingerman (2021) found that (in California) as the percentage of multi-unit dwellings units increases the probability of access to a public charging station also increases. However, those who live in the lowest median household income census tracts have a significantly lower rate of increase than those who live in high-income census tracts. Residents of high income multi-unit dwellings have more than twice the accessibility to public charging stations than residents of low-income multi-unit dwellings (Hsu and Fingerman, 2021). Residential EV charging installations are strongly correlated to economic status. Figure 8 shows the differences in charging convenience and price to charge an EV depending on the location of the charging station. The most convenient and cheapest option is to charge in the home, while the most inconvenient and costly charge location is found on curbside and public charging stations (Thingvad et al, 2019).

<table>
<thead>
<tr>
<th>Charging Locations</th>
<th>Destination Charging</th>
<th>Charging Destinations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Home Private</td>
<td>Home Shared</td>
</tr>
<tr>
<td></td>
<td>11 kW</td>
<td>11 kW</td>
</tr>
</tbody>
</table>

Figure 8. Destination charging refers to charging availability located conveniently at the driver's predetermined destination while charging destination refers to the driver accessing a charge station as the primary reason for the trip. This chart shows that typically the less convenient the charging location, the more costly to charge the EV.

Source: Thingvad et al., 2019.

Disadvantaged communities in California were found to have an excess of DC fast chargers and an inadequate number of level 2 chargers (Canepa et al., 2019). The reason for this disparity is because most residents in disadvantaged communities who live in multi-unit dwellings do not have the ability to charge their EV overnight. The stress of finding public charge stations is
exacerbated by restricting access to who can use the station’s services. Public charging stations create additional barriers to consumers by requiring consumers to have a membership to be able to charge their EVs. There are currently several charging infrastructure providers and in some cases more than 20 different providers in a single region (Hardman et al., 2019). For a consumer to access all stations they are required to have a separate membership for each company. Usually membership is obtained through an app or online (Figure 9). If an EV owner doesn’t have immediate access to a smartphone or computer, they have no way of charging their vehicle using the public charger.

Figure 9. A prominent public charging company, EVgo requires the use of an app or EVgo swipe-card to use their chargers. Image Source: Mirror Review, 2021.

The negative consequence of charge point congestion has been found in cases where free charging is offered to consumers (Hardman, 2017). Free DC fast charging has been shown to incentivize consumers to charge their vehicle when they do not need to, particularly consumers who use the free charging service as a substitute to their overnight home charging (Hardman et al., 2019). This problematic behavior results in charge congestion that restricts access to those who rely on the use of DC fast chargers.
4.1.4 Unequal access to level 2 charging stations brings about unequal participation in society.

The lowest percentage of recharge access are residents of multi-unit dwellings who park their vehicle on the street (17%) or in parking lots (5%) (Axsen and Kurani, 2012). The ability to charge an EV overnight is essential for the smooth transition from a conventional vehicle to an EV. Residents who rely on street parking do not have the advantage of overnight charging. Instead, they have to rely on public DC fast charging stations that require an average of 45 minutes to fully charge a vehicle (Liu et al., 2019). This fact coupled with the stress of “range anxiety,” the worry that your vehicle does not have enough charge to reach its destination, makes the prospect of owning an EV a burden to the owner more than a benefit (Baresch & Moser, 2019). For those who don’t have access to EV charging infrastructure the task of charging their vehicle quickly becomes a daily worry and an inconvenient chore that requires the owner to take a minimum of 45 minutes out of their day to complete.

Finally, lithium batteries are sensitive to high temperatures, relying on DC fast chargers as the primary mode of vehicle charging degrades the life of the battery quicker than the preferred slow charge method due to the increased temperatures associated with fast charging (Liu et al., 2019). Although EV ownership has been found to be cheaper than owning a conventional vehicle (less maintenance costs), a household that relies on DC fast charging infrastructure will find their battery degrades at a higher rate, ultimately resulting in the need to purchase a new battery for their EV. Battery degradation from fast charging creates an additional barrier to low income households by reducing the life of their EV and creating expensive lump sum maintenance costs for replacement (the average cost of an EV battery is $5,500).

4.1.5 Unequal participation in society reinforces categorical inequalities and unequal distributions of resources.

Left unaddressed, the barriers to EV adoption will strengthen with time and will ultimately prevent an equitable transition from conventional vehicles to EVs. Without intervention to ensure equitable access to EVs and their associated infrastructure, the benefits of EVs (e.x. improved air quality from a predominately EV fleet) will not be experienced. Envisioning a future of an EV
fleet must take into account the lasting impacts resulting from inequity in initial EV infrastructure development. EV infrastructure that was built solely by and for those who can afford it creates systemic mobility issues for those in lower income communities who would inevitably rely on older generation EVs and EV infrastructure.

Similar to cable internet vs. dial-up, in the future accessibility to EVs may become affordable, but the experience of EVs ownership is far more convenient and easy to use when equitable accessibility in EV infrastructure is built into the planning and implementation from the beginning. Additionally, it is more cost effective to invest in the development and implementation of a new EV infrastructure from the ground up than it is to have to renovate old infrastructure to be compatible with EV technology and infrastructure. As illustrated above, the transition to EVs contains significant barriers to accessibility. A successful transition to an all electric fleet is one that has successfully removed these barriers to ensure the systemic inequality of access does not continue to perpetuate as the development and implementation of EVs and EV infrastructure continues to expand.

4.2 Just Transition:
Addressing equity issues surrounding EV accessibility can be done using the framework of a “Just Transition.” The term Just Transition is defined as a “fair and equitable process of moving towards a post-carbon society” (McCauley & Heffron, 2018). The process of a Just Transition is one that is composed of four dominant frames of analysis: 1) Distributive Justice, Focuses on the equitable distribution of resources; 2) Procedural Justice, creating a decision-making process that ensures equitable participation; 3) Restorative Justice, taking steps to repair the trust of community when harm has been done; and 4) Interactive Justice, ensure inclusive and respectful social relationships between decision-makers and participants (McCauley & Heffron, 2018). Bringing these four frames of analyses together allows a better assessment of challenges in the transition from conventional vehicles to EVs. Using information from a Just transition analysis of EV infrastructure creates an informed approach to developing and implementing policies that ensure a fair and equitable transition to a post-carbon society for all communities and individuals.
As of December 2021, the state of California accounted for approximately 42% of all registered EVs nationwide (USDOE, 2021). The large rate of EV adoption in California can be partially attributed to the statewide policies that have been implemented to encourage the adoption of EVs and to promote the development and implementation of EV infrastructure throughout the state. Additionally, many cities throughout California have passed local ordinances to encourage EV adoption and infrastructure build development within their communities. Conducting an equity analysis of state and citywide policies will help to reveal gaps in accessibility to EVs and their related infrastructure. The next section will conduct an equity analysis of California and San Francisco’s EV policies regarding infrastructure to determine the strengths of the policy and address any equity concerns that may exist within the policy.

5. California Policy Analysis and Framework
Numerous California policies have been implemented to help facilitate the growth and development of EV infrastructure. The three policies that will be analyzed are: 1) California Capital Access Program’s Electric Vehicle Charging station; 2) Electric Vehicle Supply equipment (EVSE) policies for Multi-Unit Dwellings (California Civil Code 4745 and 4745.1); and 3) EVSE Policies for Residential and Commercial Renters (California Civil Code 1947.6). These three policies outline the different approaches California is taking to increase accessibility to EV infrastructure to include the installation of EV infrastructure in multi-unit dwellings for both homeowners and renters. Each policy will be analyzed using the equity framework from the Just Transition.

5.1.1 California Capital Access Program’s Electric Vehicle Charging Station (CalCAP/EVCS)
California Capital Access Program’s Electric Vehicle Charging Station (CalCAP/EVCS) Financing Program is one of the most influential policies in reducing barriers to EV chargers by providing loans for development, design, purchase, and installation of EV charging stations in California. Funded by the California Energy Commision, the program was developed to encourage lending private capital to Multi-unit dwelling owners and small businesses to encourage charging station installation. The maximum loan amount to be approved for is
$500,000 per borrower. Additionally, borrowers may be eligible for a 10-15% rebate of the loan amount. To qualify for the loan, the charging station must be available to tenants of a multi-unit building, business owner’s employees, or the general public (CSTO, 2021). Loans can be combined with other finance incentives to further reduce the cost of charging station installation.

Substantial funding is available to help with the upfront costs of installing EV charge stations made available through both State and Federal programs. Almost all programs have additional incentives for installing charge stations in multi-unit dwellings and disadvantaged communities. However, the incentive programs have so far been underutilized. One common reason for this is that once the charging station is installed, there seems to be low profitability for businesses in public charging stations. Low profitability in disadvantaged communities is a result of the lower percentage of EV owners, resulting in underutilized public charge stations in these areas. The lack of resource to purchase an EV creates a sort of “chicken and egg” scenario where residents are less likely to purchase an EV because they lack the resources and infrastructure to make a smooth transition which makes businesses less likely to invest in EV charging stations because there is not enough of a demand for the charging stations to be profitable. A potential solution to this problem that will be talked about in more detail at the end of this report would be to create a public EV charging infrastructure that is classified as a utility and maintained by the state.

5.1.2 Electric Vehicle Supply equipment (EVSE) policies for Multi-Unit Dwellings (California Civil Code 4745 and 4745.1)

Originally implemented in 2011 and amended in 2018, Civil Code 4745 (CC 4745) was developed to encourage, promote and remove barriers to the installation of EV charging stations. The law specifically addresses barriers to EV infrastructure development and installation that were due to widespread hesitance of Homeowners Associations (HOA) to allow the installation of EV charging stations. The primary barrier came from HOAs for multi-unit dwellings where parking spaces are shared areas. The law outlines rules and regulations that HOAs must comply with when its members submit a request to install an EV charging station. CC 4745 voids any contract or restriction that prohibits or unreasonably restricts the installation of an EV charging station that is within the owner's designated parking space or unit or a parking space that is
within an owner’s private use common area (SCLC, 2018). The Civil Code also expressly states that any contract that is in conflict with the code itself is void and unenforceable.

Under CC 4745 an EV charging station is defined as: “a station that is designed in compliance with the California Building Standards Code and delivers electricity from a source outside an electric vehicle into one or more electric vehicles” (SCLC, 2018, para. 5). Charging stations are also allowed to have multiple charge points to allow simultaneous charging. Restrictions to EV installations are only allowed if they fall within the parameters of a “reasonable restriction.” A reasonable restriction is a restriction that does not significantly increase the installation cost of the station, or significantly decrease the station's efficiency or performance standard (SCLC, 2018). Additionally the EV charging station must comply with all requirements imposed by state and local authorities (e.x. Health and safety standards, zoning, land use permits, etc.).

If the associated HOA requires that homeowners are to get approval before installing an EV charging station, the HOA may not willfully avoid or delay the application and must process the application in the same manner as an architectural property modification. The HOA has 60 days to provide the approval or denial of the application in writing. If the applicant does not hear from the HOA within that time period then the application is considered approved (SCLC, 2018).

To place an EV charging station in a common area, or exclusive use common area, the homeowner must first obtain approval from the HOA and agree in writing to: 1) Comply with architectural standards of installation 2) Employ a licensed contractor to install the charging station 3) Within 14 days after approval, provide a certificate of insurance naming the HOA as an additional insured 4) Pay for the cost of both installation and the electricity usage associated with the EV charging station (SCLC, 2018). Once the EV charging station has been installed, the owner (to include each successive owner) of the station station is responsible for all costs associated with the charging station, to include 1) damage to the charging station and the surrounding area resulting from installation, repair, maintenance, replacement, or removal 2) electricity associated with the charging station. Additionally the homeowner must disclose to prospective buyers the existence of the charging station and its associated responsibilities (SCLC, 2018).
5.1.3 California Civil Code 4745.1 (CC 4745.1)

Implemented in 2019, CC 4745.1 relates to homeowners (i.e., owners of condos or apartment buildings) requests for installing an EV-dedicated Time of Use Energy Metering Unit (TOU) (Edgett, 2021). Figure 10 shows an example of an EV charging set up with a separate EV-dedicated TOU meter.

![Diagram of an EV charging station with a dedicated TOU meter](image)

Figure 10. Example diagram of an EV charging station with a dedicated TOU meter separate from the house meter. This allows the charging station to be separate from the home, and for the EV owner to utilize special EV charging rates available from some utility service providers. Source: Idaho National Laboratory, 2015.

The meter, designated as an “EV-TOU meter” and is required so the energy use of the EV charging station can be monitored for the purpose of paying electricity bills associated with charging the vehicle (SCLC, 2018). An EV-dedicated charging meter (EV-TOU) is defined in CC 4745.1 as an electric meter installed by an electric utility that is separate from any other electric meter and is dedicated exclusively to charging EVs and tracks the time of use when charging occurs (SCLC, 2018). Additionally, an EV-TOU includes the wiring that was necessary to connect the meter to an EV charging station, regardless of if the wiring was supplied by an electric utility.
The EV-TOU meter allows for homeowners to benefit from favorable electricity rates offered by utility providers by monitoring and modifying their charging behavior to acquire cheaper off-peak energy rates to charge their EVs. Off-peak charging hours are generally between late evening hours and early morning when electricity demand on the power grid is low. Since off-peak energy rates are usually in the late evenings, home charging on a separate meter provides the most cost effective means for charging EVs. CC 4745.1 is designed to allow homeowners to benefit from these savings (Edgett, 2021). The law largely mirrors CC 4745 with the primary difference being that it gives the HOA larger control over ‘reasonable restrictions.’ In the case for EV-TOU installation the HOA is allowed to make restrictions that are based upon the space, structural integrity, aesthetics, and equal access to services for all homeowners on the property (SCLC, 2018). Similar to CC 4745, the HOA must try to find a reasonable accommodation for an installation request unless the HOA would have to pay for the solution.

In the event that an HOA is found to be noncompliant with the civil code, the HOA is required to pay attorney’s fees of the homeowner. Additionally the HOA can face civil penalties of up to $1000 in addition to damages from the case (Edgett, 2021). However, if the HOA wins the case, the homeowner is not required to pay any of the HOA legal fees (SCLC, 2018). This section is important because it puts the onus on the HOA by making it costly to the HOA if they are found to be noncompliant. In contrast if the homeowner loses a civil case, they are not given the extra burden of paying the HOA’s attorneys fees. CC 4745 and CC 4745.1 are two pieces of legislation that ensure that homeowners have the ability to install an EV charging station, provided they have the money for all the associated costs. The civil codes are written in such a way that benefits both the homeowners and the HOA by allowing for the homeowner to take the necessary steps to install a charging station while also ensuring that the HOA is not responsible for any of the costs associated with its installation, maintenance, or removal.

The two laws lessen the barriers to EV infrastructure for homeowners who are subject to an HOA by creating a framework that outlines rules and regulations regarding EV infrastructure that the HOA must comply with. Paired with California’s numerous grant programs that provide funding for the installation of EV infrastructure, the law alleviates the stresses of homeowners negotiating with an HOA to have the ability to charge their vehicles from home. Additionally, both the civil codes have been written in a way that prioritizes the homeowners request for
installation above the power of the HOA. The best example for this being the 60 day period the HOA has to respond to the request before it is automatically approved. This prevents the HOA from preventing the installation of EV charging stations by simply holding onto applications for unreasonable periods of time.

5.1.4 EVSE Policies for Residential and Commercial Renters (California Civil Code 1947.6)

Implemented in 2015 and codified as California Civil code 1949.6 (CC 1947.6), the law establishes a procedure that requires landlords to accept lawful written requests from tenants to install EV charge stations and their associated infrastructure (SCLC, 2019). The tenant must also meet the requirement of the landlord's procedural approval process for the modification to the property. Before the law went into effect most apartment owners refused to provide EV charging stations to tenants (Astanehe, 2021). Civil Code 1947.6 was established to overcome the barriers to EV charging installation, giving California tenants the right to install the necessary equipment to charge their EVs.

CC 1947.6 quickly became known as the “Right to Charge” law in California, however the law does no apply to properties where: 1) At least 10% of designated parking spaces have already installed EV charging stations 2) Parking is not provided in the tenants lease agreement 3) The complex has fewer than 5 parking spaces 4) The apartment is under both a rent control ordinance and an EV charging station ordinance that requires the approval of the tenants written request to install an EV charging station at tenants designated parking space that was adopted on or before January 1, 2019 (SCLC, 2019). Originally apartments under rent control were exempt from the law, but an amendment in 2019 removed the exemption.

Under this law the landlord is not required to provide additional parking to a tenant to accommodate an EV charge station. Further, if the installation of an EV charging station essentially provides a reserved parking space for the tenant, the landlord is allowed to charge a monthly rental amount for the parking space (SCLC, 2019). Additionally the tenant must give consent to a written agreement that includes: 1) Compliance with the landlord's requirements pertaining to the installation, maintenance, use, and removal of the charging station. 2) Compliance with the landlord that the tenant comply with a financial analysis and scope of the work involved in the installation of the charging station and its associated infrastructure. 3)
Tenants must provide a written description of where, how, and when the proposed modifications and property improvements are to be made consistent with the items specified in the Permitting Checklist published by California’s Office of Planning and Research. 4) The Tenant must pay the landlord all costs that are associated with the charging station installation, to include required infrastructure modifications. 5) The Tenant must pay (as part of rent) all costs associated with the electrical usage of the charging station including cost of maintenance, damage, repair, and its removal (SCLC, 2019). Tenants are also required to maintain a one million dollar general liability insurance policy. An exemption to this rule went into effect on January 1, 2020. Tenants no longer have to maintain the general liability insurance policy if the charging station is certified by an OSHA approved Nationally Recognized Testing Laboratory and any alterations to the electrical systems associated with the charging station were made by a licensed electrician (SCLC, 2019).

5.1.5 California Policy Recommendations
When first approved in 2015, CC 1947.6 had two major equity concerns regarding accessibility. The first being the exemption for dwellings that were rent controlled and the second being the requirement to maintain a million dollar general liability insurance policy. Fortunately both of these issues were amended in 2019. These two equity issues were addressed in 2019 through amendments to the Civil Code which removed the exemption to the law for rent control and created the alternative option to the insurance requirement. Unlike The EVSE policies for Multi-Unit Dwellings (CC 4745 and 4745.1), residential and commercial renters can have their applications for an EV charging station denied because the property already meets the minimum requirements for EV charging stations. Landlords have the ability to deny charging station requests if the building already complies with the 10% rule, so if a parking facility with 100 spaces already has two chargers, then the landlord has the right to deny all further written requests (SCLC, 2019).

5.2 San Francisco Policy Analysis
To successfully meet San Francisco’s goal of 100% emissions free ground transportation there has to be a massive reduction in the volume of vehicles on the roads. However, a large portion of San Francisco residents and those who commute into the city for work will still rely on personal vehicles as a mode of transportation. To address these concerns, San Francisco has taken a two
pronged approach by: 1) investing in a robust public transportation system and 2) developing electric vehicle charging infrastructure.

Finding the balance between public and private transportation needs is essential to successfully integrating a new transportation infrastructure throughout the city. In the development stages of EV infrastructure city officials have the unique position of determining the “haves” from the “have nots” in terms of EVs. An efficient and effective public transportation option is important to transportation mobility throughout the city, but the question then becomes how do we determine who has the ability to own an EV and who does not. Prior sections of this report have already shown the current trend of EV accessibility is primarily determined upon wealth. Shifting these trends to ensure equitable accessibility to EV ownership is key to ensuring that everyone is afforded a high standard quality of life.

Equitable EV infrastructure relies on designating charging facilities in locations that are not focused on maximizing profits, but instead prioritises the equitable distribution of charge stations throughout the city. An EV infrastructure policy designed for overall maximum efficiency in EV distribution is likely to sacrifice services to some communities. For example, primarily focusing on EV charging infrastructure close to highways may be an efficient strategy to ensure maximum use of the infrastructure, but it does not address the needs of those who need overnight charging infrastructure.

Unequal access to EV infrastructure could lead to growing disparity in the city’s already stratified mobility landscape between those who have economic, social, and personal opportunities and those who do not. As such, an analysis of each policy is essential to understanding the holistic approach San Francisco is taking to address any underlying equity issues within the plan. The key EV-related ordinances approved by the city are: 1) The Transit First Policy; 2) Electric Vehicle Readiness Ordinance; and 3) The Commercial Garage Ordinance; Each of these policies addresses different facets of electric vehicle integration. In this section I will analyze policies developed to increase access to EV infrastructure.
5.2.1 Transit First Policy (SEC. 8A.115.)

While not directly related to EV infrastructure, San Francisco’s Transit First Policy is important to understand the strategy behind current infrastructure development policies. Implemented in 2007, the policy lays out 10 principles to incorporate into all city and county planning. Of the 10 principles, four are directly related to the development and investment into a robust public transportation system that incentivises public transit over the use of private vehicles. Principle eight specifically states that “New transportation investment should be allocated to meet the demand for public transit generated by new public and private commercial and residential developments” (SFMTA, 2020). While the city is taking measures to implement EV charging infrastructure, it is only being done as a supplement to public transit. San Francisco is primarily focused on improving its transit system so that residents do not have the need to own a vehicle, thereby reducing the number of vehicles on the road.

5.2.2 The Electric Vehicle Readiness Ordinance (ON: 92-17)

The Electric Vehicle Readiness Ordinance (2017) is an amendment to the Green Building Code and Environmental Code. The ordinance was developed to support the transition to EVs by preparing new buildings for the increased demand for charging infrastructure by requiring all parking spaces to be at minimum EV flexible (CCSF, 2017). The policy was developed with the goal of eliminating cost barriers to the installation and deployment of EV charging stations in new and existing construction (Soor, 2017). Figure 11 shows the cost difference in new construction versus retrofit projects for EV parking spaces. Over half of installation cost in most buildings comes from the additional wiring needed to distribute electricity to the parking space.

Existing buildings lack the raceway system (enclosed conduit that forms a physical pathway for electrical wiring) required for substantial electrical components, making their installation cost prohibitive (Pike et al., 2016). The ordinance aims to cut these costs by establishing requirements for the installation of raceway for EV charging infrastructure in new buildings or in buildings that are undergoing alterations.
ON: 92-17 requires 10% of parking spaces in new buildings and buildings undergoing major renovations to have EV charge stations and an additional 10% of spaces are to be “EV Flexible” to allow for future upgrades or installation (CCSF, 2017). The remaining 80% of spaces must be EV capable by routing a conduit to the hardest to reach parking areas to avoid cost barriers for future installation of EV charge stations (CCSF, 2017). While developing the policy, the city found that including electrical infrastructure for future EV charging stations reduces the cost of charge station installation by 75% (Pike et al., 2016).

ON: 92-17 also requires that building owners, residents, and lessees are notified of the installation and details the requirements of each EV space to include the space's physical dimensions as well as the minimum voltage requirements to include electrical panel capacity available at the space. Initially, Newly installed EV infrastructure is required to have the electrical capacity to charge 20% of the vehicles simultaneously. The added capacity will allow additional load management systems to be installed at a later date (i.e., as infrastructure demand increases), allowing for a more cost effective expansion of EV charging stations to up to 100% of available parking stations (Soor, 2017).
In regards to Distributive Justice, ON 92-17 is a policy focusing on future buildings and infrastructure upgrades to buildings that had already been planned. The policy is strong in that it develops a standard for all future building projects to be EV ready. However, the policy only focuses on new building infrastructure; it does not provide solutions for old buildings that are unsuitable for the extensive upgrades or the cost of retrofitting existing infrastructure for EV accessible parking spaces. In this way the policy falls short in that it does not ensure the equal distribution of upgrades to all parking garage facilities (to include older multi-unit dwelling complexes).

5.2.3 The Commercial Garage Ordinance (ON: 244 -19)
Approved in 2019, ON: 244 -19 is an amendment to the Environmental Code which requires commercial parking garages and lots with over 100 spaces to install type two EV charging stations. The policy defines commercial parking lots or garages to mean any structure, space or building on privately owned land that is required to hold a commercial parking permit. Article 17, Sect. 1215 of San Francisco’s civil code requires that a commercial parking permit be issued for any building or structure where the public can store or park a vehicle for a charge (CCSF, 2021). The ordinance also amends the Police Code to add compliance with the ordinance a law and condition for existing. The ordinance also requires compliance with the ordinance for approval of permits for future commercial parking lots and garages (CCSFa, 2019). Parking garages with over 100 spaces have until January 2023 to comply with the ordinance.

While ON: 244 -19 is a start towards EV infrastructure development, it only requires a minimum of 10% of the parking spaces to be designated EV charging stations and a maximum of no more than 200 EV spaces per Commercial parking location (CCSFa, 2019). This means that a parking station with 100 spaces is only required to have two level 2 EV charge stations. Unlike The Electric Vehicle Readiness Ordinance, ON:244-19 does not require that commercial garages make all spaces “EV ready.” Under this ordinance, commercial parking lots could design their parking spaces to meet only the minimum EV spaces needed without the additional electrical infrastructure needs (e.g., conduits to each space for future electrical wiring), presenting a barrier to future EV charger expansion within that garage. The city's push to get people out of their
private vehicles and into public transit is apparent with the policy’s low minimum requirement. Currently, the ordinance applies to nearly 300 commercial parking facilities and was designed to work in tandem with San Francisco’s Transit First policy (CCSFb, 2019).

The city has done a good job in engaging with the community regarding the Commercial Garage Ordinance by holding public hearings to allow residents to make comments on the proposed amendments to the regulations laid out by the ordinance. Due to the COVID-19 pandemic, the hearing was conducted online with the availability to call in as well as submit written comments. If approved, ON:244-19 will be amended to allow the city to impose daily fines on non compliant parking lots and garages.

In terms of equitable distribution of EV infrastructure, the city of San Francisco has made clear its intention to have EV infrastructure development be supplemental to better transportation. The Commercial Garage Ordinance helps to expand the availability of charging stations, but the fees associated with parking in these stations could present a barrier to charging availability if the owner has to pay for parking in the spaces in addition to paying for the charging service itself. This ordinance was not created as a potential solution for those who would need the space for overnight parking, but to ease the burden of charging availability for those who commute into the city.

5.2.4 Overall Policy Weaknesses

The continued investment in public transit infrastructure is an easier way to establish mobility equity throughout the city. However, in prioritizing public transit infrastructure over EV infrastructure, the city is creating an inequity between those who will be able to have EVs and those who will have to rely on public transit. The primary barrier to EV adoption in underserved communities is charging infrastructure (Hsu and Fingerman, 2021). San Francisco’s Transit First policy does not help to fill the access gap for underserved communities in the city. The current EV ordinances create restrictions that are felt based on geographic location and economic means. As it stands, some residents could rely on public transit in addition to owning a private vehicle, while others are forced to rely on public transit alone. The distinction between these two populations is based solely on the amenities available to their communities.
San Francisco’s EV infrastructure policies focus solely on parking garages and lots. Both policies are effective in helping the city take steps towards a robust EV infrastructure, but both only require the installation of charging stations in new structures or buildings undergoing major renovations. In not requiring that all buildings renovate their parking garages/lots to be EV ready, the city is creating further disparity between those who can afford to have access and those who do not. San Francisco is relying heavily on its Transit-first policy to fill in the gaps for neighborhoods without access to parking garages instead of developing creative solutions to increase equity through accessibility to charging infrastructure for those who rely on curbside parking.

Currently there is no policy in place to install curbside EV chargers in residential communities that do not have designated parking lots or garages that rely on curbside parking. One potential solution to curbside parking would be to install curbside charging stations and make them available to those who have residential parking permits. This would have two major benefits in that would ensure the space is being used by a resident of the community while also creating a way for the city to determine the needs of the neighborhood. The biggest hurdle in curbside charge stations is whether to allow for both public and private curbside charge stations. Additionally, the regulation and distribution of curbside chargers is still a matter of debate in terms of maintenance, installation, and enforcement (if a private charge station). To implement curbside parking, the city would have to make a change from its traditionally limited role in permitting private fossil fuel infrastructure to a far more active role in public-private partnerships with EV charging companies.

5.2.5 San Francisco Policy Recommendations

To address concerns of Distributive Justice, additional policy could be developed that would provide funding for older parking garages to upgrade to be “EV ready.” The development process of creating this new policy can assess equity concerns by including residents who would benefit from this policy in the decision making process through community meetings to assess the extent of the need for EV upgrades. Lastly, a policy review should be conducted to assess how the upgrades have impacted the cost of living for residents (e.g., Has there been a significant
rent increase in housing that has upgraded to EV ready parking?) as a way to determine whether
the policy has been able to equitably distribute EV ready spaces throughout the city.

The Commercial Garage Ordinance should be amended to require that new commercial parking
garages be built with the capacity to easily install EV charge stations to 100% of the spaces. In
doing so, the commercial parking facility will be able to increase their EV charging capacity as
demand for charge stations increases. As noted in The Electric Vehicle Readiness Ordinance,
built parking spaces to be EV ready will keep the cost of installing more EV charge stations
low. Additionally the city could provide subsidies to encourage commercial garages to expand
their charge station infrastructure and provide parking discounts to individuals who choose to
charge their car in these spaces. A discount in commercial parking for EV owners would also
help to facilitate the transition to EVs as an additional benefit.

6. Equity Considerations
San Francisco is ahead of the curve in terms of planning and implementation of EV charging
infrastructure. However, there is still much to be done to ensure that charging stations are
distributed equitably throughout the city. Reviewing the city’s policies regarding EV
infrastructure has revealed a few gaps in the strategies to make the city EV friendly. First,
requiring only new buildings to install EV charging stations has the potential to further divide the
city based on socioeconomic status in the future. The more EVs are on the road, the more
desirable newer buildings with EV charging stations will become, leading to increased rent for
EV friendly apartments. By not prioritizing EV infrastructure in both old and new buildings, the
City is essentially forcing lower-income residents to rely on public transportation. Although the
Transit-First policy has made it a goal to make the City’s public transportation system an
efficient, comfortable, easy, and affordable experience, the combined policies do not make for
equitable access to EV ownership.

According to San Francisco’s Electric Vehicle Roadmap (2018), of the 413,000 registered
vehicles in San Francisco, 30% rely on curbside parking. Current policies do not ease the barrier
of charging to a large portion of San Francisco residents. As San Francisco continues to take
steps forward in creating an equitable EV infrastructure, it becomes clear that the successful
transition to an all electric fleet hinges on how “fuel” (i.e., electricity) is distributed throughout the city. The transition to EVs will require that the city plays a more active role in how and where EV charge stations are distributed, most notably in providing curbside charging infrastructure to the 30% of San Francisco residents who depend upon the service.

7. Current EV Infrastructure
Since the inception of San Francisco’s long-term zero emission vehicles goals, the city has developed an EV roadmap that highlights six strategies designed to address key barriers to EV adoption (SFDE, 2019). Strategy three focuses on charging infrastructure with an objective to ensure that infrastructure to support EVs is convenient and accessible to all businesses, residents, and visitors. The targeted outcome of this strategy is to achieve an “effective and scalable range of charging options for all residents, fleets, and visitors across the City supporting full electrification” by 2020-2025 (SFDE, 2019). In regards to parking availability within the city, San Francisco has a total of 113,000 parking spaces in private garages and parking lots, 56,000 parking spaces managed by state, federal, and local agencies, and an additional 20,000 parking spaces at SFO (SFDE, 2019). Home chargers are the preferred charging EVs. Currently, 80% of EV owners in San Francisco charge their vehicles in the home (Hsu et al., 2020). The City should focus on increasing the availability of EV charging infrastructure to all private garages and lots to help speed the integration of EVs within the City.

As of 2021, there are approximately 579 public charging stations located throughout the City with the majority of stations located within paid parking garages in San Francisco’s city center (PlugShare, 2021). Of the 579 charging stations, 40 are free EV charging stations and 102 are DC fast chargers (68 of which are Tesla Superchargers only available to Tesla owners). To meet San Francisco’s goal of 100% emissions free transportation by 2040, charging infrastructure will need to continue to increase at approximately 18% per year through 2030 (Hsu et al., 2020).

Figure 12 shows a map of San Francisco with median income delineated by 2015 census tracts and the location of public charging stations. From this map we can see that the majority of charging stations are in the downtown Financial district of San Francisco with another small cluster in the Lakeshore district on the campus of San Francisco State University. The map
shows that clusters of public charging stations outside of the downtown area are most commonly in proximity to college campuses. This proximity signifies that the public charging infrastructure is located within university parking and may not be available to the general public. With the exception of downtown and university campuses, EV charging infrastructure is more prevalent in areas with a higher median income than in areas with a lower median income. Notable areas with little to no Public EV charging infrastructure are the Outer Richmond and Bayview/Hunters Point areas.

Figure 12. Map of San Francisco separated by census tracts. Dark green signifies a high median income, the lighter the green the lower the media income of that area. The dots signify public charging stations, different colors delineate chargers availability. The blue sections are college university campuses. If not in the Financial district, clusters of public chargers are more common around university campuses. Mapmaker Lisa Farmos. Data source: DataSF.org (2015) and U.S. Dept of Energy (2021).
When we compare the EV charging infrastructure map (green) with the map of multi-unit dwellings with five or more units we can see that there are a significant number of multi-unit dwellings in the outer Richmond area, but no available public EV charging stations. Similar observations can be made when looking at both the Mission and Castro districts (Figure 13).

Figure 13. Map A shows the multi-unit dwellings (MUD) with five or more units. When compared with map B showing EV charging station location, it is apparent that there are areas with a high concentration of MUDs but little to no EV charging infrastructure support. Source of map A: San Francisco Department of the Environment and Electric Mobility Subcommittee, 2019. Map B: Mapmaker Lisa Farmos. Data source: DataSF.org (2015) and U.S. Dept of Energy (2021).

To better assess EV charging infrastructure needs, SF Environment partnered with Google to create a Blueprint Mapping tool to identify priority areas for future investment in EV charging infrastructure (SFDEb, 2019). Upon completion, the tool will be able to more accurately identify gaps in the City’s existing public charging infrastructure and predict future charging needs. DMV registration data shows that approximately one third of cars registered in San Francisco use parking provided by multi-unit dwellings, one third is parked in the home, and the last third rely on street parking (Figure 14). Home chargers are typically the cheapest to install and charge from, while public chargers are associated with more overall cost (Hsu et al., 2020). To better understand the role socioeconomic status has in how EV infrastructure has developed within the city of San Francisco, the next section will conduct an analysis of different districts of San Francisco.
7.1 Equitable Distribution of Infrastructure

The following assessment of the equitable distribution of EV infrastructure of three groupings of San Francisco districts, 1) Inner Mission and Castro; 2) South of Market and Potrero; and 3) Bayview and Hunters Point, gives insight into the current development and distribution of EV infrastructure within the city. Moving forward, the results from the analysis will present: 1) average vehicle ownership per household; 2) housing type; 3) on- or off-street parking and 4) existing EV charging infrastructure of each of the three district groupings.
7.1.1 Inner Mission/Castro

Cumulatively the two districts have approximately 117,000 residents and 52.9k households. In 2019 the median household income of the Inner Mission and Castro district was $150,715 with 35% of residents reporting an average annual income of $200,000 or more (Figure 15).

Homeownership is 37.8%, almost half of the national average of 64.1%. In terms of work commute, 40.8% of residents use public transit, 26.5% drive to work, and 9.6% work from home (DataUSA, 2019). Regarding vehicle ownership, 44.3% of households own one vehicle and 24.6% of households own two vehicles. Of the 14,083 EVs registered in San Francisco, 1,972 (14%) are registered in Inner Mission/Castro. Regarding public EV charging infrastructure, there are 10 level 2 EV charging stations and 5 Level 3 DC fast charging stations within the two districts.

Inner Mission/Castro district housing is a mix of single-family homes, new condominiums, and live-work lofts. A substantial portion of Multi-unit dwellings here were built pre-1940s, have a 2-4 unit occupancy, and often do not provide parking. City issued residential parking permits help to ensure availability of on-street parking for residents. As more residents transition to EVs, so will the need for curbside charging infrastructure and public charging facilities. The city of
San Francisco is currently exploring the feasibility of curbside charging infrastructure and the development of curbside charging policies that address accessibility requirements, ownership and maintenance, and enforcement of the policies (SF Environment, 2020). Public transit is a reliable option for residents with multiple Bus, Bart, and Muni stations. Table 2 shows the current EV charging stations and projected 2030 EV charging infrastructure needs for the Inner Mission/Castro districts.

Table 2. Charging station types and location within the Mission/Castro districts. Projected 2030 public, home, workplace and curbside charging estimates were taken from Hsu et al. (2020). Public charging infrastructure needs were determined by dividing daily energy demand projections by the maximum amount of energy that is supplied by the chargers. Needed home chargers were estimated by dividing the total number of EVs by the average number of vehicles in a household with the assumption that the same household would share a single charger. Workplace charging needs were projected based on the total workplace charging needs per day for inner-city and out of city commuters. Data source: CleanCitiesSF (2021) and Hsu et al. (2020).

<table>
<thead>
<tr>
<th>Location</th>
<th>Location / Charging Type</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>Level 1</td>
<td>N/A</td>
<td>4225</td>
</tr>
<tr>
<td></td>
<td>Level 2</td>
<td>N/A</td>
<td>5,776</td>
</tr>
<tr>
<td>Public</td>
<td>Level 2</td>
<td>10</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>DC Fast charge</td>
<td>5</td>
<td>36</td>
</tr>
<tr>
<td>Workplace</td>
<td>Level 2</td>
<td>N/A</td>
<td>190</td>
</tr>
<tr>
<td>Curbside</td>
<td>Level 2</td>
<td>0</td>
<td>84</td>
</tr>
</tbody>
</table>

Equitable distribution of charging infrastructure relies on a combination of both public and curbside charging infrastructure. Moving forward, the primary concern in this neighborhood will be the development of curbside charging stations for the many residents who do not have access to at-home charging. California and San Francisco policies discussed earlier in this paper are most helpful in this district where tenants may need to upgrade their parking spaces to be able to charge their EVs overnight. However, some barriers to charging will exist with the increased costs associated with installing EV chargers in parking garages that are not EV ready.
7.1.2 South of Market/Potrero

These two districts have a cumulative population of approximately 146,000 residents and 70.4k households. In 2019 the median household income was $93,767 with 25.2% of households reporting an annual income of $200,000 or more (see Figure 16).

Figure 16. Percentage of South of Market and Potrero households separated by average income. Source: DataUSA, 2021.

Multi-unit dwellings are the primary housing type in this district. Homeownership is lower than the Inner Mission/Castro districts at 20.9%. A significant portion (26.9%) of South Market/Potrero residents walk to work and 33.7% of residents use public transit for their work. Only 18.6% of residents drive alone to work. Average vehicle per household is split with 40% of households owning one vehicle and 40.8% of households not owning a vehicle (DataUSA, 2019). In the households that do own a vehicle, there are 1,123 (8%) EVs registered in South Market/Potrero. Examining public EV charging infrastructure, there are significantly more public charging stations available compared to both the Inner Mission/Castro districts and the BayView-Hunters Point districts with 162 level 2 EV charging stations and 7 Level 3 DC fast charging stations within the two districts. This increase in EV infrastructure can be attributed to its downtown location close to the bay bridge with various commercial parking facilities and a high volume of regular commuters. The high volume of commuter traffic makes the location ideal for EV charging infrastructure investment. Additionally, the high density of large scale
multi-unit dwellings (100+ units) and their associated parking infrastructure are required to have at least 10% of their spaces be equipped with EV charging stations.

Table 3 shows the current charging stations in South of Market - Potrero and the projected 2030 EV charging infrastructure needs. Public charging level 2 stations in this district have met the needs for what is projected for 2030. However, it is important to consider that the charging station projections take into account the availability and reliability of public transportation.

Table 3. Charging station types and location within the South of Market/Potrero districts. Data source: CleanCitiesSF (2021) and Hsu et al. (2020).

<table>
<thead>
<tr>
<th>Location</th>
<th>Location / Charging Type</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>Level 1</td>
<td>N/A</td>
<td>3,254</td>
</tr>
<tr>
<td></td>
<td>Level 2</td>
<td>N/A</td>
<td>3,130</td>
</tr>
<tr>
<td>Public</td>
<td>Level 2</td>
<td>162</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>DC Fast charge</td>
<td>7</td>
<td>37</td>
</tr>
<tr>
<td>Workplace</td>
<td>Level 2</td>
<td>N/A</td>
<td>631</td>
</tr>
<tr>
<td>Curbside</td>
<td>Level 2</td>
<td>0</td>
<td>92</td>
</tr>
</tbody>
</table>

Equitable distribution of EV charging stations in this district is primarily needed in multi-unit dwelling parking garages. As more residents transition to EVs, they will need to install EV charging stations in their designated parking spaces. Similar to the Inner Mission/Castro districts, California and San Francisco policies increase accessibility to EV charging infrastructure in multi-unit housing parking garages. Ensuring that the installation of EV charging infrastructure is affordable in residential parking garages should be the primary concern to ensure equitable distribution of EV charging stations for multi-unit dwellings.
7.1.3 Bayview-Hunters Point

Bayview-Hunters Point has a population of 113,964 residents that make up 33.2k households. In 2019 the average median household income was $76,838 with the majority of households within the annual income range of $75-100k (Figure 17).

![Figure 17. Percentage of Bayview and Hunter Point households separated by average income. Source: DataUSA, 2019.](image)

Homeownership in Bayview-Hunters Point is higher than the previous two groups with 59.1% of the housing units being occupied by their owner. 47.3% of residents commute to work by car, 12% carpool and 32.6% use public transit. Bayview-Hunters Point has one of the highest number of vehicles per household with 32% of households owning two vehicles and 22% of households owning three vehicles. Only 963 (6.8%) EVs are registered in Bayview-Hunters Point (DataUSA, 2019).

Regarding EV charging infrastructure, there are 7 Level 2 public charging stations and no Level 3 DC fast charging stations within these two combined districts. Bayview-Hunters Point is the most overparked district in San Francisco (SFMTA, 2020). Due to insufficient public transit options, there are more cars than available on-street parking. Additionally, it is unsafe for
residents to park far from where they live. As a result many cars are illegally double parked on the street or parked on sidewalks.

Overparking in Bayview-Hunters Point is primarily due to limited public transit options within the city, resulting in the district having the highest percentage of residents commuting to work by car than any other district in San Francisco. In response the city of San Francisco implemented a Community Based Transportation Action Plan that focuses on increasing service to Bayview through more frequent bus services (to include a bayview express bus to downtown) and an increase in the muni. The city's continued investment in transportation infrastructure in Bayview-Hunters Point will reduce the community’s reliance on private transportation and alleviate stresses of the extensive charging infrastructure that would need to be in place to support the high volume of vehicles in Bayview-Hunters Point.

Residents of affordable housing developments in Bayview-Hunters Point have cited parking availability as needed improvement (Hunters View, 2021). The development of parking solutions of affordable housing developments provides the opportunity to prepare new parking infrastructure to be EV ready. While the majority of residents live in single family homes with a garage, a lot of families have converted their garages into separate bedrooms (SFMTA, 2020). As the city transitions to EVs, ensuring homes in Bayview will have the financial ability to install charging equipment within their homes is a priority. Table 4 shows current and projected EV infrastructure needed in Bayview-Hunters Point by 2030 for San Francisco to meet its EV goals.

Table 4. Charging station types and location within the Bayview/Hunters Point districts. Data source: CleanCitiesSF (2021) and Hsu et al. (2020).
Projected charger needs assume the successful implementation of Community Based Transportation Action Plan which will significantly increase the transit mobility from Bayview-Hunters Point to the rest of the city and reduce the need for vehicle ownership. As public transportation availability improves, the need for multiple household vehicles will decrease. At the present, public charging infrastructure is almost nonexistent and EV ownership is the lowest in Bayview-Hunters Point. It is important that as San Francisco continues to improve the public transit options in the district that it considers the transition to EVs in the development process. Ensuring that all new parking solutions and early developments are EV ready is a cost effective way of reducing barriers to EV adoption for residents of Bayview-Hunters Point.

When examining the three communities side by side there is a correlation between income and public transportation use to work (Table 5). However, it is important to note that in the South of Market/Potrero districts, 26.9% of residents walk to work. With that in mind, it is difficult to determine how income affects access to public transportation based on numbers alone.

Table 5. Comparison of each district's median household income, average number of households in the neighborhoods, percentage that take public transit to work, average vehicle per household, total EV ownership, number of available public EV charging stations (by type), and the combined projected 2030 public charger needs (level 2 and 3). Data source: CleanCities SF (2021), Data USA (2019), and Hsu et al. (2020).

<table>
<thead>
<tr>
<th>Location</th>
<th>Median household income</th>
<th>Avg. Number of Household s</th>
<th>Public transit for work</th>
<th>Avg. vehicle per household</th>
<th>Total EV ownership</th>
<th>Public Level 2</th>
<th>Public Level 3 DC fast</th>
<th>Projected 2030 Charger needs (lvl 2&amp;3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Mission/Castro</td>
<td>$150,715</td>
<td>52.9k</td>
<td>40.8%</td>
<td>1 (44.3%)</td>
<td>1,972</td>
<td>10</td>
<td>5</td>
<td>188</td>
</tr>
<tr>
<td>South of Market/Potrero</td>
<td>$93,767</td>
<td>70.4k</td>
<td>33.7%</td>
<td>0-1 (40%, 40.8%)</td>
<td>1,123</td>
<td>162</td>
<td>7</td>
<td>183</td>
</tr>
<tr>
<td>Bayview-Hunters Point</td>
<td>$76,838</td>
<td>33.2k</td>
<td>32.6%</td>
<td>1-2-3 (25%, 32%, 21.9%)</td>
<td>963</td>
<td>7</td>
<td>0</td>
<td>122</td>
</tr>
</tbody>
</table>
Looking at EV ownership and EV charging infrastructure, it is apparent that San Francisco neighborhoods follow the trend where affluent neighborhoods have a higher percentage of EV ownership and a higher accessibility to EV charging infrastructure. It is also important to note the public charging infrastructure in South of Market/Potrero is concentrated downtown where there are more commercial parking facilities for those who regularly commute into the city.

Housing type plays an important role in the type of EV charging infrastructure available. While Inner Mission/Castro may not have as much public EV infrastructure available, there are more single family style homes in this district compared to South of Market/Potrero. The higher EVs in the Inner Mission/Castro region than South of Market/Potrero could indicate a higher accessibility to at-home charging. Bayview-Hunters Point is primarily single family homes, but has the lowest concentration of EVs indicating that other factors (i.e., income, overparking) may be negatively influencing a resident’s choice to transition to an EV. Overparking in Bayview-Hunters Point makes it difficult to project how much EV infrastructure will be needed in the future. As the city continues to develop more reliable and frequent public transportation in Bayview, proper assessment of EV infrastructure needs and development will become easier. Out of the three groups assessed, The Mission/Castro district has the highest percentage of residents taking public transit to work (40.8%) and the lowest percentage of residents driving to work.

Bayview-Hunters Point has the lowest average of commuters taking public transportation to work largely due to infrequent Muni and bus schedules. Bayview primarily has single family homes with garages which is promising for the transition to EVs because it makes it possible to charge from home. However, the severe overparking hinders access if residents need to own multiple vehicles (due to inadequate public transit) and are forced to park one of their cars far from their home.

To address the problem of overparking and increase intra-city mobility for the community of Bayview-Hunters Point, SFMTA has begun adding bus routes into the neighborhood and increasing frequency. Increasing public transit accessibility will lessen the need for two or more vehicles per household and increase the available parking for the community. Investment in
parking infrastructure for Public housing in Hunters Point creates the opportunity to increase the accessibility to EV ownership for the tenants due to San Francisco’s policy requiring 10% of all new parking infrastructure to have EV charging stations and all additional parking spaces to be EV ready.

As it stands, San Francisco neighborhoods with a higher average income tend to have a higher concentration of EV ownership. The location of the neighborhood within the city also plays an important role in the EV charging infrastructure available. The further the neighborhood is from downtown, the less public EV charging infrastructure is available, regardless of income or housing type. Limited parking availability presents a deterrent to EV adoption by creating a barrier to the development of public charging infrastructure. Implementing residential parking permits in Bayview-Hunters Point (similar to the program in Inner Mission/Castro) may help alleviate the problem with over parking and provide a structure to develop future community use EV public charging points.

It is important to note that these groupings do not take into account how gentrification has shaped demographics within the communities themselves. For example, while one side of Potrero Hill is full of multimillion dollar homes and premium condominiums, the other side of the hill is public housing for low income households. Looking to the future, additional research within each of San Francisco’s 36 unique neighborhoods is needed to better understand intra-neighborhood disparities and how gentrification affects the relationship between income, public transportation accessibility, and EV infrastructure and ownership. Community outreach is needed to specifically address the barriers to EV adoption.

7.2 Interactive Justice
A successful development and implementation of EV infrastructure requires Participatory Action Research (PAR) in each of San Francisco’s neighborhoods to determine the needs of the community. PAR involves collaborative research efforts through community-led investigations to help determine community specific needs. Identifying community specific needs for EV accessibility can pre-empt any barriers that may become present from outside interventions. Focused on community outreach and input, PAR is essential to the early stages of EV
infrastructure development and integration because it helps to ensure a cost effective
infrastructure that the community will get the most use from. For example, PAR conducted with
residents of Hunters View (a public housing development in Hunters Point) focusing on
community concerns found that the majority of residents experienced parking major difficulty in
finding parking near their homes. Residents were concerned about the safety of their unattended
vehicles being parked far from their homes overnight. Conducting PAR research in
Bayview-Hunters Point may find that this concern extends to proposed public charging
infrastructure as well.

Effective PAR helps shape lawmakers' understanding of community-specific needs and develops
a pathway that promotes community-led decision making. Lastly, PAR illustrates the necessity of
community input in the policy and decision making processes. Moving forward, an analysis of
Bayview-Hunters Point will be conducted to identify the community outreach programs that the
City could partner with in planning the future development of EV infrastructure there.

7.2.1 Interactive Justice in Bayview-Hunters Point
Interactive justice is essential in San Francisco’s historically marginalized communities like
Bayview-Hunters Point. Known as the city’s last African-American neighborhood, Bayview is
home to over a fifth of San Francisco’s African-American community (SFMTA, 2019). In the
1950’s - 1960’s African-American residents of the Western Addition/Fillmore districts were
displaced to the Bayview by San Francisco’s Redevelopment Agency’s Urban Renewal effort.
Discriminatory housing policies and restrictive covenants (i.e., San Francisco Housing
Authority’s “neighborhood pattern” policy) prohibited African-American families from living in
certain areas of the city until 1968 (i.e., redlining). The systemic racism experienced created a
community that has been historically neglected by the City with inadequate access to city
services like public transportation. In 1995 an Area Plan was approved to revitalize Bayview and
develop housing, commerce, industry, land use, community facilities and services, transportation,
and public safety (SF Planning, 2021). Efforts to improve overall quality of life in Bayview are
ongoing. In regards to transportation, San Francisco Municipal Transportation Agency (SFMTA)
has made interactive justice a priority in assessing the neighborhoods transportation needs.
Presently there is very little community outreach happening in Bayview that expressly addresses the development of an EV action plan that is specific to the needs of Bayview residents. However, SFMTA’s Community Based Transportation Plan for Bayview developed an excellent framework for interactive justice within the community that can be used to engage Bayview residents. The project team prioritised the community by initially reaching out and conducting interviews with community leaders to become familiar with the project, build trust within the community, and establish a frame of reference for the needs of Bayview residents (Figure 18) (SFMTA, 2020).

The two years spent working with the community of Bayview informed strategies and developments utilized to create an effective community-based transportation action plan. Since its implementation, Bayview residents have seen an increase in job accessibility using public transit by 154% since pre-covid numbers (SFMTA, 2021). Increased access to public transportation reduces the number of vehicles needed per household, thereby reducing parking congestion and increasing the future availability for EV infrastructure development within Bayview-Hunters Point.

Figure 18. An excerpt from Bayview Community Based Action Plan showing the extensive outreach and interviews conducted with various community leaders prioritizing the importance of community engagement in the project’s developmental stages. Source: SFMTA, 2020.
The relationships built in developing the Bayview Community Based Transportation Plan are essential to the development of a community based EV infrastructure plan for Bayview residents. Moving forward an analysis of procedural and restorative justice of marginalized communities within San Francisco will be conducted to assess how the City is ensuring equity in the development of EV infrastructure.

7.3 Procedural Justice and Restorative Justice

Procedural justice involves having integrity in the decision making process that gives respect and a voice to all involved and neutrality guided by transparent reasoning (McCauley & Heffron, 2018). In regards to EV policies, procedural justice looks like equity-driven decision making processes that include review periods for quality assurance and space for course correction if needed. Restorative justice involves fixing and repairing inequities as they emerge (McCauley & Heffron, 2018). San Francisco’s Planning Department has focused on equity issues within the city and is developing action plans to address and work to repair inequities as they arise.

The Environmental Justice Framework Project (EJFP) run by the SF Planning Department has identified communities with the highest environmental justice burden to inform future projects to reduce the burden (Figure 19). The EJFP’s governing policies are the SFPUC Environmental Justice Policy (2009) and the SFPUC Community Benefits Policy (2011). The EJFP is in the process of developing an environmental justice working group made up of community members who live in neighborhoods that experience a high environmental justice burden. The SF planning department has also created community engagement grants to partner with the city to support outreach.
Thus far, the City of San Francisco has worked hard in its outreach efforts to marginalized communities and has made significant progress in good-faith efforts to develop and implement community informed restorative justice actions (SFMTA, 2021). The San Francisco EV roadmap has also created an implementation plan for its six proposed strategies for EV integration, the plan specifies deliverables and timelines for reassessment to adjust and address any unforeseen problems. Procedural and restorative justice are continuous actions that must be integrated into every policy decision regardless of sector. In researching the numerous EV integration policies and plans there has been an associated section that addresses equity in the development process.
8. Management Recommendations

8.1 Develop curbside parking policy and infrastructure in neighborhoods that use residential street parking permits.

Curbside parking infrastructure is essential to ensure all residents have access to charge their EVs from home. Regarding placement of curbside chargers, the city should begin by focusing on residential parking permit areas (Figure 20). The curbside chargers should be made available to residents with a parking permit associated with the location of the EV charger. Creating residential EV charging infrastructure can be achieved by creating a pass associated with the parking permit that is scanned to charge the EV. When residents apply for a residential parking permit they can request a residential EV permit card to scan to provide access to the curbside EV infrastructure associated with their residential parking permit. For communities like Bayview-Hunters Point where overparking is a major issue, residential parking permits may help decrease the volume of street parked vehicles. However, the implementation of residential parking permits should only be done once residents have frequent and reliable access to public transportation to meet commuter needs and with support from the community.
A residential charging program creates a pathway for residents to request additional EV chargers in their community if needed. If there are an insufficient number of curbside EV stations, residents can request to have one installed in that permitting zone. This way the City will be able to continually track how many EV passes are issued based upon the number of residential permits issued and calculate the number of EV chargers that are needed to support that area. To ensure equity and the strategic placement of the residential curbside EV chargers, an initial assessment of community needs regarding charging infrastructure can be conducted through organizing community meetings with residents of each parking permit zone. Reserving curbside chargers to only be available to residents ensures the EV chargers are not taken by those who do not live within the community and prioritizes the availability of chargers for residents who rely on curbside charging.

Instituting this kind of EV curbside parking strategy requires that the city expand their residential parking permit areas throughout the city. Bayview-Hunters Point is a neighborhood that has seen substantial improvements regarding accessibility to public transit accessibility; implementing residential parking permits in this area can also help to reduce the problems the neighborhood has with overparking and will help the city to assess where curbside charging infrastructure is most needed within the community.

### 8.2 Equip existing street lights with public EV chargers.

One of the single biggest hurdles to EV adoption in San Francisco is accessibility to EV charging infrastructure for those who live in apartments. The City of Los Angeles has installed public EV chargers on over 130 street light poles to increase accessibility to charging stations in areas that have predominantly multi-unit housing (Berman, 2019). San Francisco should adopt a similar program for its curbside chargers. EV chargers mounted on light poles eliminates the need for additional equipment to be installed on the sidewalk and utilizes the already built electrical circuitry required for installation. Street light EV chargers would be operated and maintained by the owner of the street light (most street lighting in the City is owned and managed by either San
Francisco Public Utilities Commission or PG&E) while the charging station itself is operated by familiar EV charging network companies (ex EVgo, ChargePoint, and GreenLots).

Figure 21. Curbside charging infrastructure installed on a street light in Los Angeles, California. Image source: Berman 2019.

8.3 Create City EV charger support or incentives for low-income residents.

While there are federal and state incentives that provide tax rebates and subsidies for residential EV chargers, the City of San Francisco does not provide any support for low-income residents to install charging stations at their homes. With the knowledge that current state and federal programs alone have not been enough to make charging infrastructure affordable for low-income households, San Francisco should develop a policy that allocates funding to make EV charging infrastructure accessible to low-income households.

The amount of funding available should be based on household income and be provided in conjunction with state and federal subsidies. One of the primary barriers to EV adoption is having the initial capital available to purchase an EV and its associated infrastructure. As noted in section 7.1.3, a high percentage (59.1%) of Bayview-Hunters Point residents are homeowners. City EV charger support and incentives would be particularly beneficial in increasing access to EV ownership for low-income residents within the Bayview community. Ensuring that all residents have access to EV charging infrastructure prevents accessibility barriers from strengthening over time (as illustrated in section 3.1.2 of the accessibility analysis).
8.4 Develop infrastructure grants for outdated apartment buildings with parking facilities. 
As noted in the analysis of San Francisco EV infrastructure policies (section 5.2), both the Electric Vehicle Readiness Ordinance and the Commercial Garage Ordinance only apply to newly constructed buildings and existing buildings undergoing major alterations. Some older apartment complexes are unable to upgrade their parking garages due to the expensive costs associated with retrofitting. Developing infrastructure grants to cover some or all of the costs associated with an EV retrofit for older buildings will ensure that all apartments (regardless of building age) will be equipped with the infrastructure needed to support EVs. Additionally, an increase in the percentage of EV charging infrastructure required during major renovations is essential to ensuring that as more people transition to EVs, the infrastructure needed to support EVs is readily available. Charging infrastructure should not be treated as an amenity, but as a necessary utility. Ensuring that all housing types are EV accessible removes barriers to EV ownership and ensures equitable access for all levels of household income.

8.5 Invest in Participatory Action Research in San Francisco neighborhoods to engage with residents and determine the communities specific needs and concerns regarding EV infrastructure.
A proper assessment of EV infrastructure needs should be conducted utilizing PAR methods to understand community concerns regarding San Francisco’s plans to transition to 100% emissions free transportation by 2040. SFMTA has established the framework for community engagement with the Bayview Community Based Transportation Plan to assess transportation needs for the residents of Bayview-Hunters Point. Using the same framework, community outreach programs can establish and address residents' concerns regarding the transition to EVs.

As noted before, the San Francisco Planning Department has identified the communities in the City that are experiencing a high environmental justice burden. Extending PAR research to these communities within San Francisco will provide information that is essential to an equitable transition to EVs. The relationships built and information gained from PAR will be essential for the development of community-oriented EV infrastructure actions to ensure that all residents experience a smooth transition to EVs. PAR establishes a starting point for EV implementation
and provides a point of reference to continually assess the efficiency and equity of actions implemented to achieve the long term goal of an equitable EV integration in the city of San Francisco.

9. Conclusions

The transition to EVs requires a fundamental shift away from the infrastructure created for combustion engine vehicles. The biggest barrier to EV adoption is the lack of supporting infrastructure. After examining the current body of research on EV integration and conducting a case study of San Francisco (a city that is leading the charge in EV integration), the primary barrier lies in the accessibility to EV infrastructure. Both the city of San Francisco and the state of California have enacted policies that begin to dismantle these barriers, particularly for residents of multi-unit dwellings. However, there is still a lot of work to be done regarding affordability. As outlined in section 3.1.2, California EV rebates and subsidies do not close the gap enough to make EV ownership and EV charging installation affordable to most low-income households.

The accessibility analysis revealed how systemic inequities are created if there are no measures taken to ensure that everyone has access to EV infrastructure at its beginning stages. When comparing San Francisco neighborhoods by median household income and EV integration, we saw that areas with the highest median income overlapped with areas that had a higher percentage of EV ownership. Additionally the areas that had the highest volume of commuter traffic and high concentrations of parking garages (downtown SF) had the highest concentration of EV charging infrastructure. These findings suggest that current public charging infrastructure is being built in areas that are most profitable, but not necessarily the most equitable. Public EV charging infrastructure must expand to San Francisco neighborhoods with high volumes of multi-unit housing and on-street parking.

Regarding whether to invest first in encouraging and subsidizing EV ownership or in supporting EV infrastructure, early investment in EV infrastructure allows residents to smoothly transition to EVs without the worry of where the vehicle will be charged. When consumers know they have
reliable charging infrastructure within their community, they are more comfortable swapping their conventional fuel vehicle for an EV.

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