SILICON VALLEY CLEAN ENERGY

EV AND EVI BASELINE STUDY

SVCE Territory

December 2021
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EXECUTIVE SUMMARY

Silicon Valley Clean Energy's interest in providing carbon-free energy, accelerating innovative electric technologies, and benefitting local communities necessitates a focus on expanding electric vehicle (EV) adoption, especially through increased deployment of electric vehicle infrastructure (EVI). This first EV/EVI Baseline study aims to assist in that focus by giving SVCE and its member municipalities a clearer picture of what EV and EVI distribution looks like currently. Providing this information will help programs and policies made to increase equitable EV access consider the current context of EVs and EVI and make data-based decisions on where key opportunities or challenges exist. It will also provide a helpful snapshot in time to measure against when assessing the success of these programs and policies in the future.

Overall, this study had difficulty drawing clear connections between EV adoption and the deployment of EVI at a more granular scale within SVCE territory. However, there are several important takeaways of where EV adoption is strongest and where it still needs to grow, as well as where and how charging infrastructure is being used.

- While EV growth is strong in the region, segments of the market still lag, such as SUVs and pickup owners, as well as multi-family residents and residents who are low-income, or otherwise more socio-economically vulnerable.
- Charging infrastructure has less data available for shared private charging, which makes up most of the charging in SVCE territory. The available data suggests that public and shared private charging are primarily located in different areas, reducing the redundancy of charging infrastructure and sunk costs. Despite the amount of public and shared private infrastructure, most charging does still happen at home.
- It was not possible to draw strong connections between EV adoption and EVI deployment (location, type, etc.) when analyzing across communities in SVCE territory. This is important to better understand because while EV adoption rates need targeted support to reach California state goals, EVI is already growing speedily, perhaps outpacing EV growth, and must be done efficiently to limit costs.

The rest of this summary will show the 16 key takeaways from this study.

(S-1) *The types of EVs that residents own shows that the market still does not provide the diversity of plug-in electric SUV and pickup truck models that residents enjoy with Internal Combustion Engine (ICE) vehicles. SUVs show slightly more variety in the EV market, as electric pick-ups are an emerging technology.*

Figure ES 1: Carbon-Powered and Electric Passenger Cars by Body Type in 2021

Carbon Powered
450 Thousand Cars

Electric Cars
30 Thousand Cars
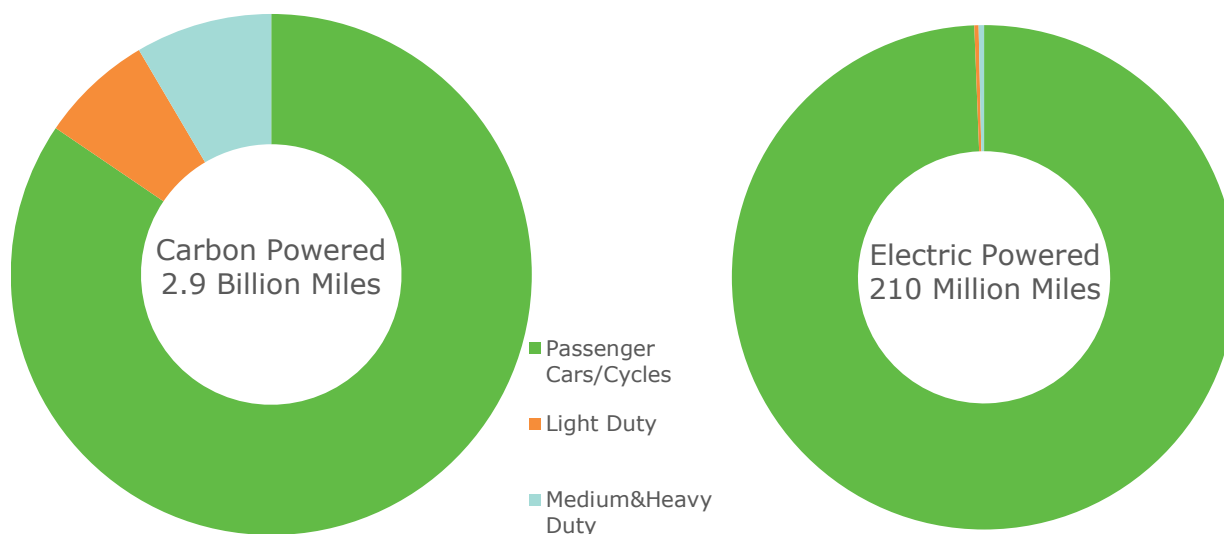
- Sedan
- SUV
- Pickup
- Hybrid
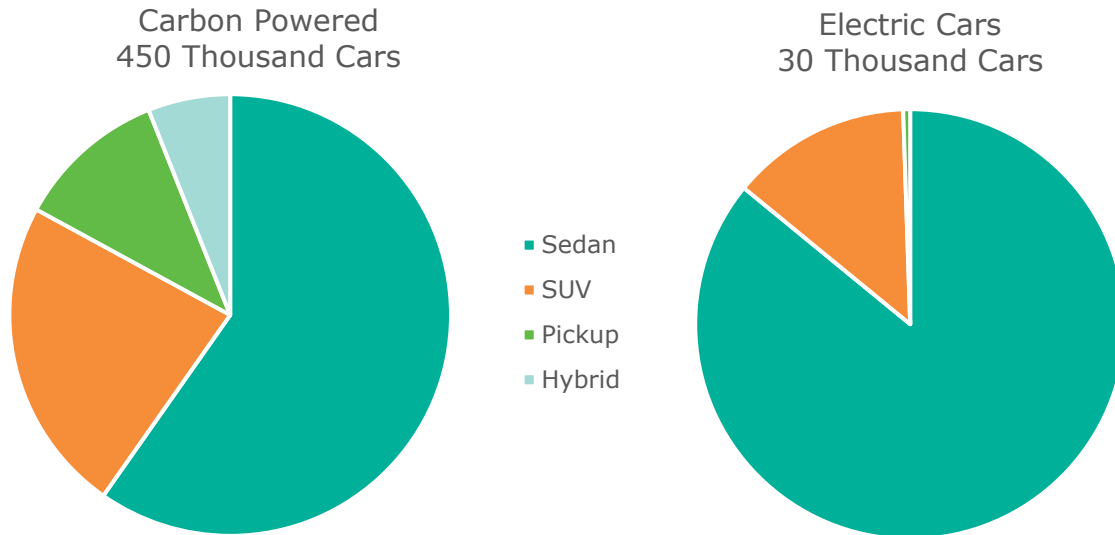
In SVCE territory, despite a lower number of pickups coming to about eleven percent of all cars as opposed to the nationwide 20 percent, there are still challenges with the desire for pickup trucks. About 46 thousand carbon powered cars are pickups. There are more SUV offerings in the EV market, but they are still not quite performing at parity compared to ICE vehicles. Fourteen percent of EVs in SVCE are classified as SUVs, but 23 percent of fossil-fuel powered cars are SUVs. This suggests that there is still not enough choice of electric SUVs to fully meet the desire of costumers to drive these types of cars.

(S-2)   *Transitioning all passenger vehicles, including SUVs, would lead to over a 1,000 percent increase in electric vehicle miles traveled.*

AND

(S-3)   *Medium and heavy-duty vehicles will also be important to electrify, as each mile driven by one such vehicle is responsible for double the amount of greenhouse gas emissions as a typical passenger vehicle.*

Figure ES 2: Annual VMT by Body Type for Carbon-Powered and Electric Vehicles in 2020

Carbon Powered
2.9 Billion Miles

Electric Powered
210 Million Miles

- Passenger Cars/Cycles
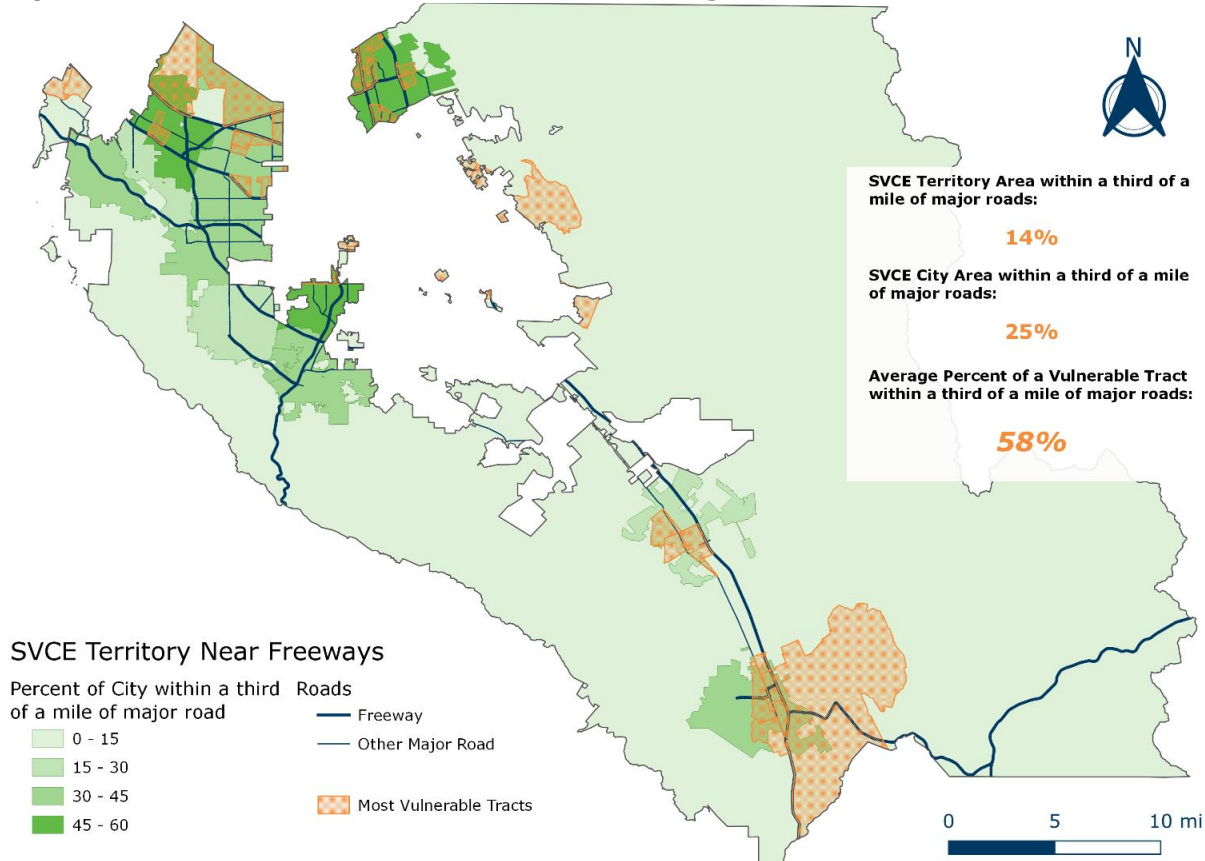- Light Duty
- Medium&Heavy Duty

California Air Resources Board's EMFAC model includes SUVs in the passenger cars section. Carbon-powered passenger vehicles and cycles are responsible for 2.4 billion vehicle miles traveled (VMT) a year, compared to all electric VMT only coming to 210 million miles a year.

Meanwhile, medium- and heavy-duty carbon powered vehicles account for eight percent of daily carbon powered VMT, but fourteen percent of all on-road emissions. these vehicles are often less efficient per mile than passenger vehicles due to their weight, these miles are big contributors to greenhouse gas emissions and other criteria air pollutants. Decarbonizing the medium and heavy-duty vehicles that drive through SVCE territory will be a critical piece of reducing transportation emissions – but likely challenging to accomplish.

(S-4) *Increased electric vehicle adoption throughout the region can reduce NOx pollution and PM2.5 deaths. This is especially true for vulnerable tracts, which, compared to less-vulnerable tracts, have on average a larger proportion of land near major roads where pollutants are most troubling for human health.*

Map ES 1: Area in SVCE within a Third Mile of Big Roads

SVCE Territory Area within a third of a mile of major roads:

14%

SVCE City Area within a third of a mile of major roads:

25%

Average Percent of a Vulnerable Tract within a third of a mile of major roads:

58%

SVCE Territory Near Freeways

Percent of City within a third of a mile of major road

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60

Roads

—— Freeway

—— Other Major Road

Most Vulnerable Tracts

0   5   10 mi

Traffic pollution may cause various negative health effects, such as asthma in children and impaired lung function, which are most pronounced within the area from a quarter to a third of busy roads. Electric vehicles unlike traditional ICE vehicles, produce no nitrogen oxides, eliminating that source of pollution. Fine particulate matter ($PM_{2.5}$) is a particularly dangerous criteria air pollutant. A recent study of the health impacts of the transition to EVs finds that electrification in metropolitan statistical areas always leads to less $PM_{2.5}$ related deaths. San Jose metro area's death rate would be cut by about four fifths. Defining health impacts from these air pollutants and quantifying the benefits to health that the specific circumstances of EV adoption in SVCE territory produce requires economic modeling and understanding of air pollution science but would emphasize public health benefits of EV adoption as well as climate benefits.

(S-5)   *EV adoption rates are highest in West Valley, varying in Mountain View and Sunnyvale, and lowest in eastern and southern Santa Clara County.*

Map ES 2: EV Adoption Rate by Census Tract in SVCE Territory
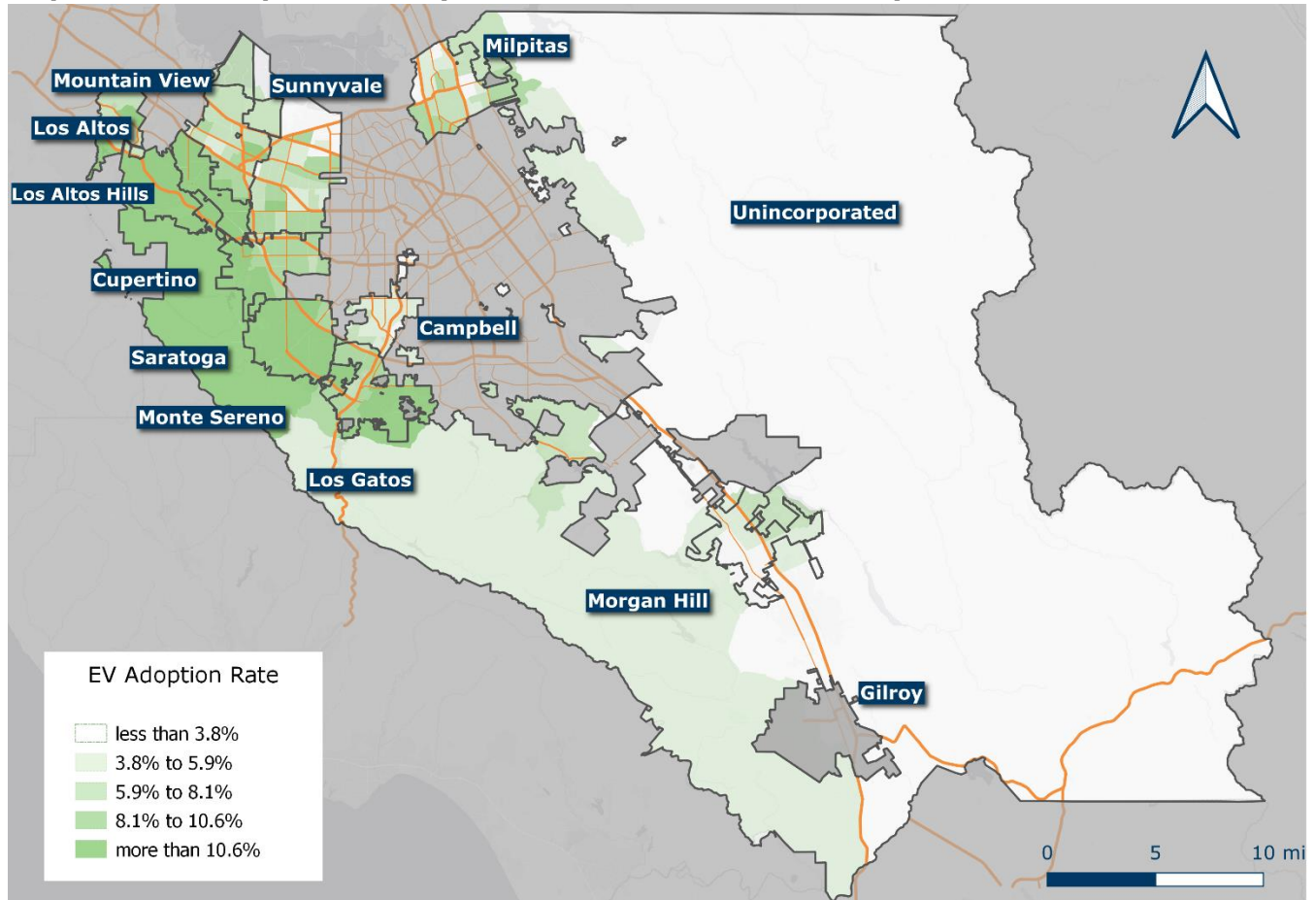
(S-6) *Multi-family EV adoption rates are lower than single-family adoption rates in the region as a whole and in all cities.*

Table ES 1: Residential EV Ownership by Community

	Single Family EV Adoption Rate	Multi-Family EV Adoption Rate	Multi-Family Cars Replaced with EVs to Achieve Parity	% Growth of EVs with Cars Replaced	% of All Cars Replaced
Campbell	5.7%	2.1%	390	166.8%	1.29%
Cupertino	10.1%	6.5%	305	55.4%	0.82%
Gilroy	2.4%	0.3%	199	586.1%	0.37%
Los Altos	12.9%	5.8%	102	122.0%	0.43%
Los Altos Hills	8.0%	2.5%	4	220.5%	0.04%
Los Gatos	9.0%	3.5%	279	155.2%	0.84%
Milpitas	5.7%	2.6%	348	116.5%	0.68%
Monte Sereno	9.7%	0.0%	0	*	*
Morgan Hill	4.8%	0.7%	224	590.2%	0.50%
Mountain View	9.5%	3.9%	1,540	144.8%	3.18%
Saratoga	10.9%	5.0%	41	119.9%	0.16%
Sunnyvale	7.2%	3.6%	1,479	98.4%	1.68%
Unincorporated	2.9%	1.6%	39	117.5%	0.10%
SVCE Territory	6.9%	3.6%	4,524	111.6%	0.93%

Rectifying the disparity between single- and multi-family EV adoption rates would require the replacement of many ICE vehicles. While these numbers add a great deal to each community's EV population, they are generally a relatively small part of their entire car population. This is especially true for Gilroy, while Mountain View, a city further along in its EV adoption curve would have to transition a more sizeable chunk of their car population for a modest growth in EV adoption.

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(S-7) *EV adoption rates are strongly correlated with median household income, with higher incomes generally associated with higher EV adoption rates. The socio-economic vulnerability index (SEVI) is also correlated with EV adoption, with more vulnerable tracts owning fewer EVs.*

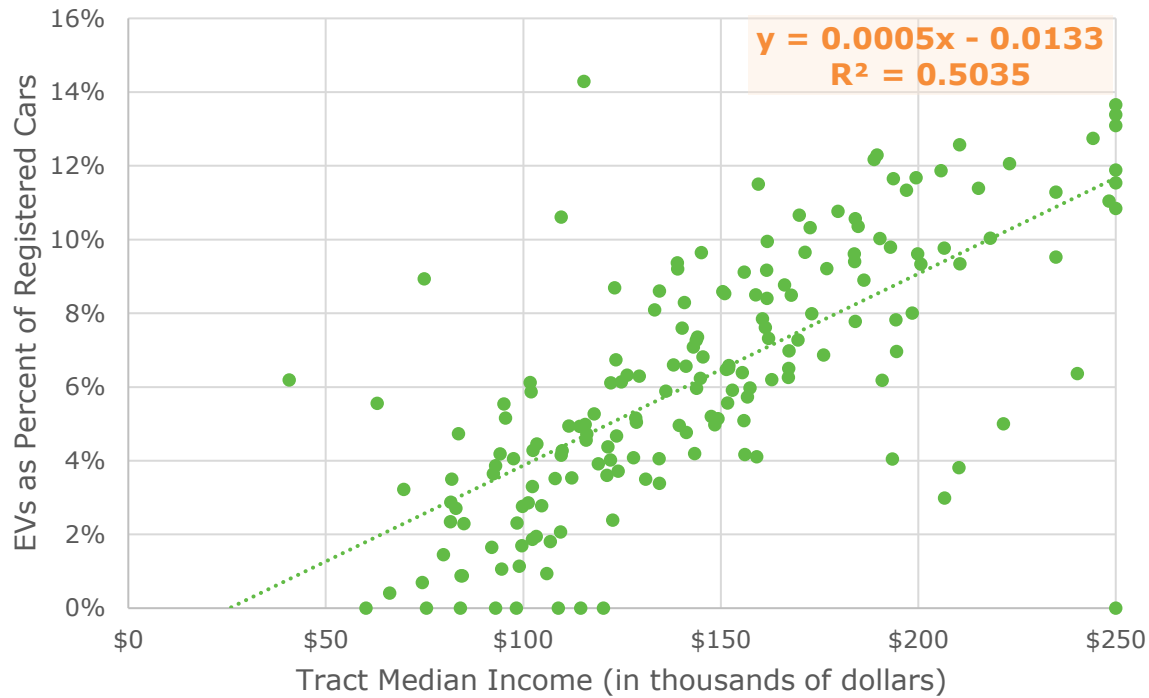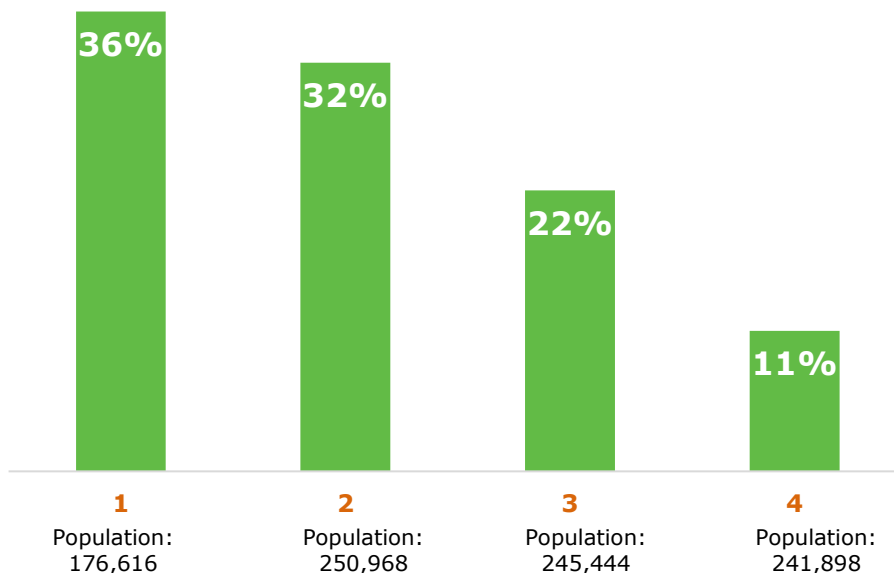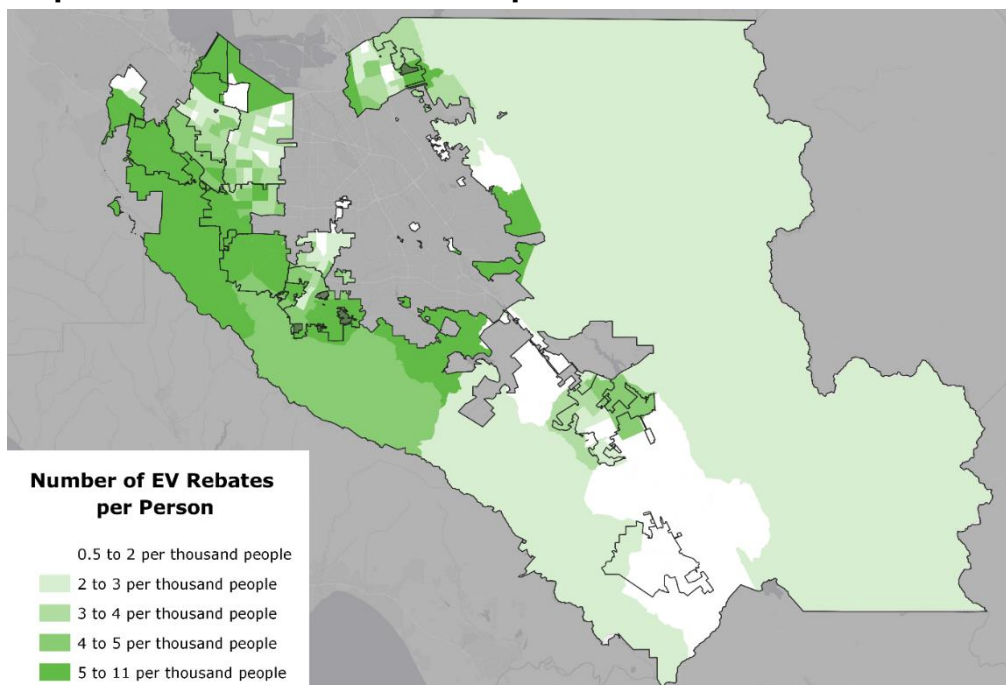**Figure ES 3: Relationship between Tract Median Income and EV Adoption Rate**

$y = 0.0005x - 0.0133$
$R^2 = 0.5035$

EVs as Percent of Registered Cars (y-axis)

Tract Median Income (in thousands of dollars) (x-axis)

Figure ES 4: Percent of All EVs Owned by Each SEVI Quartile (1 = least vulnerable, 4 = most vulnerable)

1	2	3	4
36%	32%	22%	11%
Population: 176,616	Population: 250,968	Population: 245,444	Population: 241,898

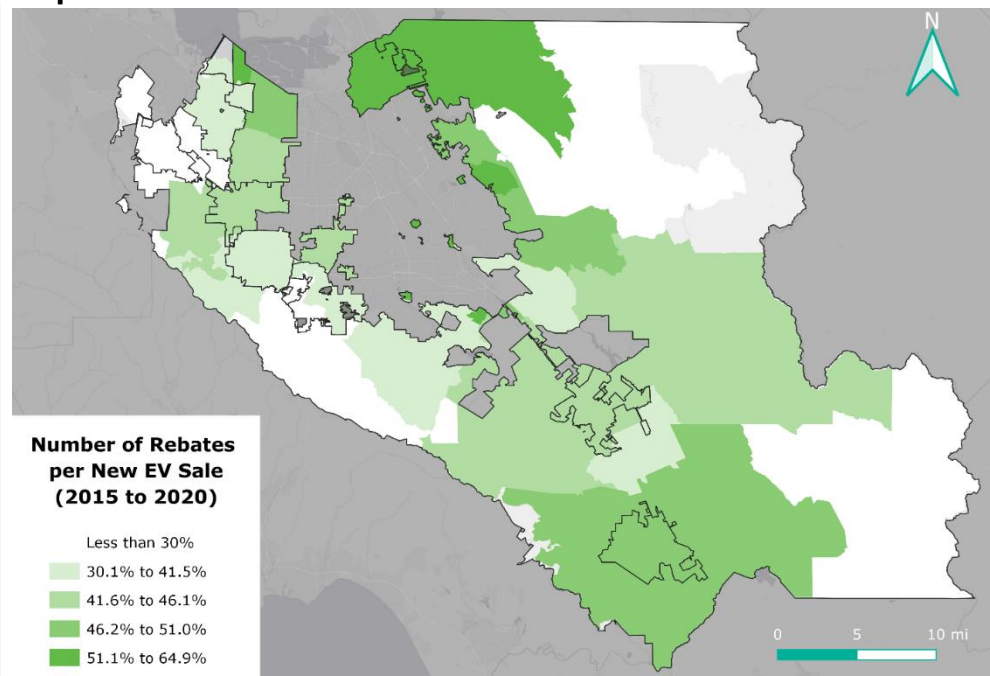**SILICON VALLEY CLEAN ENERGY**

8

(S-8) *There is a difference between where the highest rebates per capita are and where the highest percent of new EVs are purchased with rebates, suggesting a mismatch between where rebates are going and where they are most needed.*

Map ES 3: Number of EV Rebates per Person

Map ES 4: Percent of New EVs Purchased with Rebates

Number of EV Rebates per Person

- 0.5 to 2 per thousand people
- 2 to 3 per thousand people
- 3 to 4 per thousand people
- 4 to 5 per thousand people
- 5 to 11 per thousand people

Number of Rebates per New EV Sale (2015 to 2020)

- Less than 30%
- 30.1% to 41.5%
- 41.6% to 46.1%
- 46.2% to 51.0%
- 51.1% to 64.9%

Map ES 3 shows that the distribution of rebates is far from even, with some census tracts getting ten to twenty times more rebates per capita than others. The West Valley leads in SVCE territory, having used the most rebates per capita. Mountain View and Sunnyvale, two of the larger cities in the western section of SVCE territories, show variation in where people are accessing more rebates.

Map ES 4 shows the percent of EV sales that used a rebate. Here, the West Valley falls into the lower segments, with less than 46% of their new EV sales purchased with assistance from a rebate. Milpitas and the area of Unincorporated Santa Clara County near it now have higher rates of rebates per sale than the West Valley, with more than half of EVs purchased with the assistance of a rebate. The difference between these two maps suggests that the EVs that are being purchased in places like Milpitas and the eastern edge outside San Jose use rebates for more of their EV purchases but lack some access to rebates. Meanwhile, areas in the West Valley have accessed many more EV rebates but use these rebates to buy less than half of the EVs they purchase.

SILICON VALLEY
CLEAN ENERGY

(S-9) *Public L2 chargers are about equally spread between retail and schools/universities while public DC fast chargers are overwhelmingly in retail locations, with a total of 1,348 L2 chargers and 295 DCFCs available to the general public.*

Table ES 2: Land Use of Public Chargers in SVCE Territory

SVCE Territory	Lvl 2	DCFC
Residential	11%	1%
Industrial and Manufacturing	13%	4%
Utilities and Service Stations	0%	1%
Retail Uses	**21%**	**65%**
Office Uses	13%	5%
Parking	1%	0%
Parks and Recreation Centers	2%	0%
Schools and Universities	**22%**	9%
Hospitals and Nursing Facilities	3%	0%
Public and Other Quasi-Public Buildings	3%	0%
Agricultural	1%	7%
Unknown	8%	8%
Vacant Land	2%	0%
Grand Total	1,348	295

(S-10) *The CEC provides the number of shared private chargers at a county level only, but an average of various methods suggests that SVCE territory has about 4,600 of these chargers, which is around three-fourths of all charging in the area.*

AND

(S-11) *Using CALeVIP application data, this study estimates that about two-thirds of these shared private chargers are for workplaces, and the remaining one-third is for residences, primarily multi-family buildings.*

Table ES 3: Estimate of Existing Shared Private L2 Chargers by Land Use

	Employee	Resident	Total
Workplace	2,560	-	2,560
Multi-Family Building	21	1,391	1,412
Parking Lot or Garage	201	17	219
Public facility	142	-	142
Entertainment	-	35	35
Religious Establishment	77	-	77
Hospital	35	-	35
Retail Centers	21	-	21
Colleges and Libraries	-	-	-
Unknown	35	-	35
None of the above	91	-	91
Grand Total	3,182	1,443	4,626

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(S-12) *According to data from SVCE pilot GridShift, about 80 percent of the electricity used to charge EVs comes from home.*

**Figure ES 5: Energy Delivered (kWh) during EV Charging by Location**
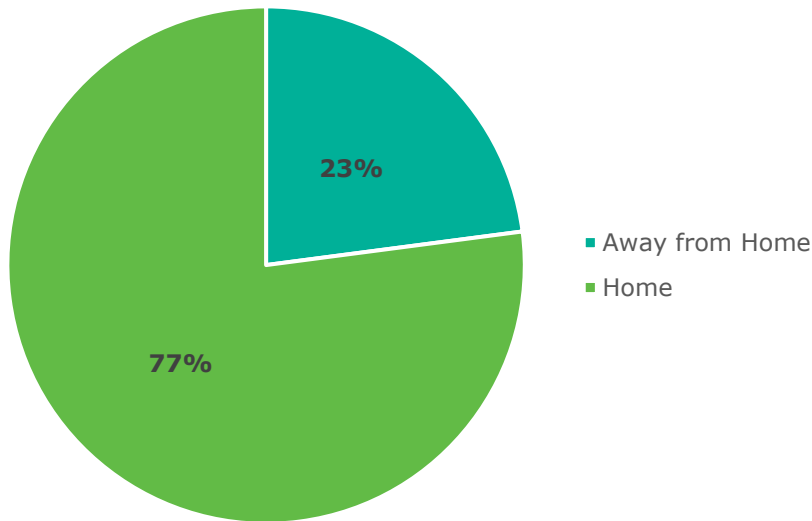
While this may change as EVI evolves and the population of EV owners change, the current charging paradigm matches historical ones and shows the continuing importance of home charging. Most, if not all, GridShift participants live in single-family homes.

(S-13)   *There is no clear connection between EV adoption and charger location on a census tract level – although this should be an area of continued study at different levels, such as the county and household levels.*

Because EVs need chargers the way that ICE vehicles need gas stations, this study attempts to see if there is a relationship between the siting of chargers and EV adoption. While the county overall has both one of the highest EV adoption rates as well as one of the highest numbers of chargers installed, ultimately, there seemed to be no robust relationship between the number of chargers and the number of EVs on a census tract level, even controlling for a few explanatory factors like median income.

(S-14)   *It is unclear if EVs are growing linearly or exponentially but they need to grow more than linearly to reach the area's portion of the 5 million EVs by 2030, likely requiring further policy support.*

Figure ES 6: Projected EV Population Growth Compared to State Goal
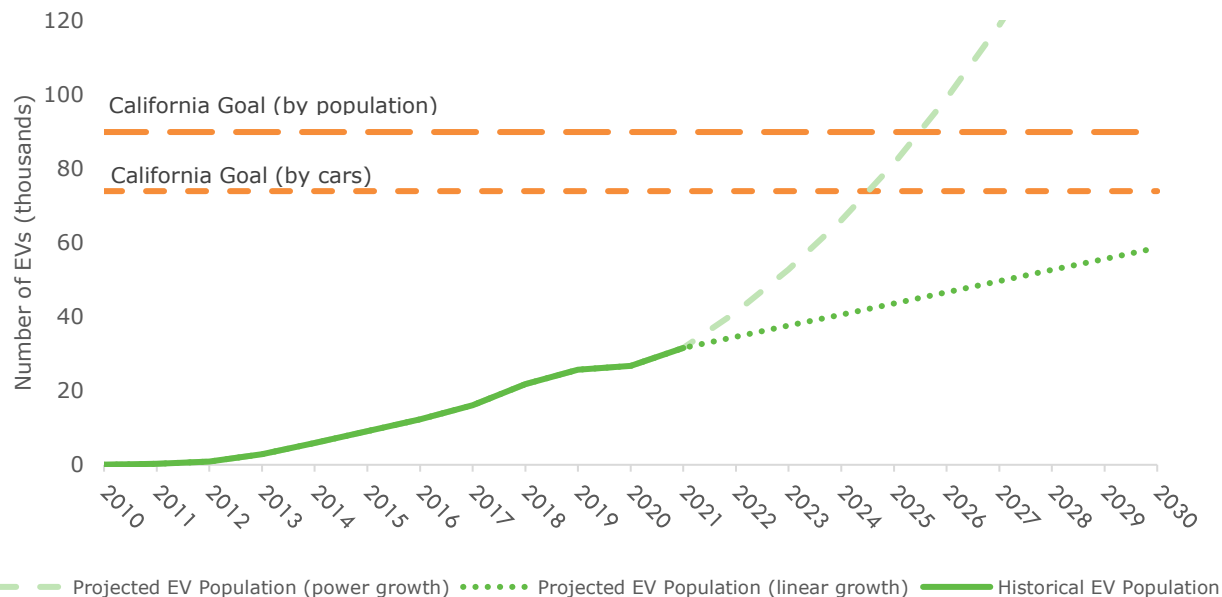
Executive Order B-48-18 requires 5 million zero emission vehicles (ZEVs) on California roads by 2030. If historical growth of EVs continues linearly in SVCE territory, the area is not on track to meet its portion of that goal. However, other projections that suggest polynomial growth in EV population could put the territory past its goal by 2026. To follow these other projections will require continued involvement by the state to ensure that EVs are to be adopted by all kinds of people, not just those who have been able and willing to purchase them historically.

(S-15) *EVI is growing very fast in the simplified model for this study, far outpacing the EV growth rate. More complex assumptions may change that rate of growth.*

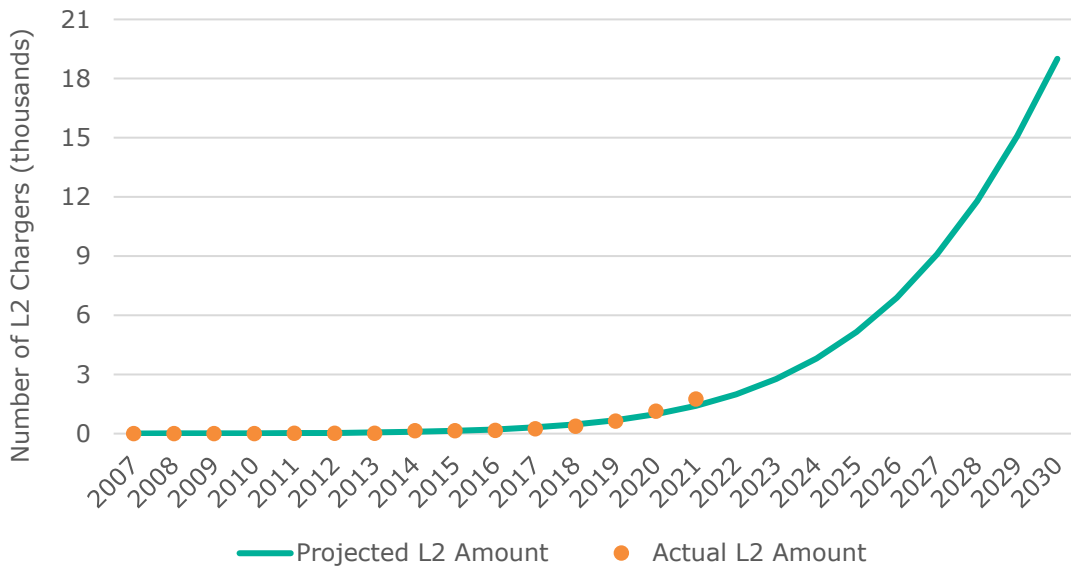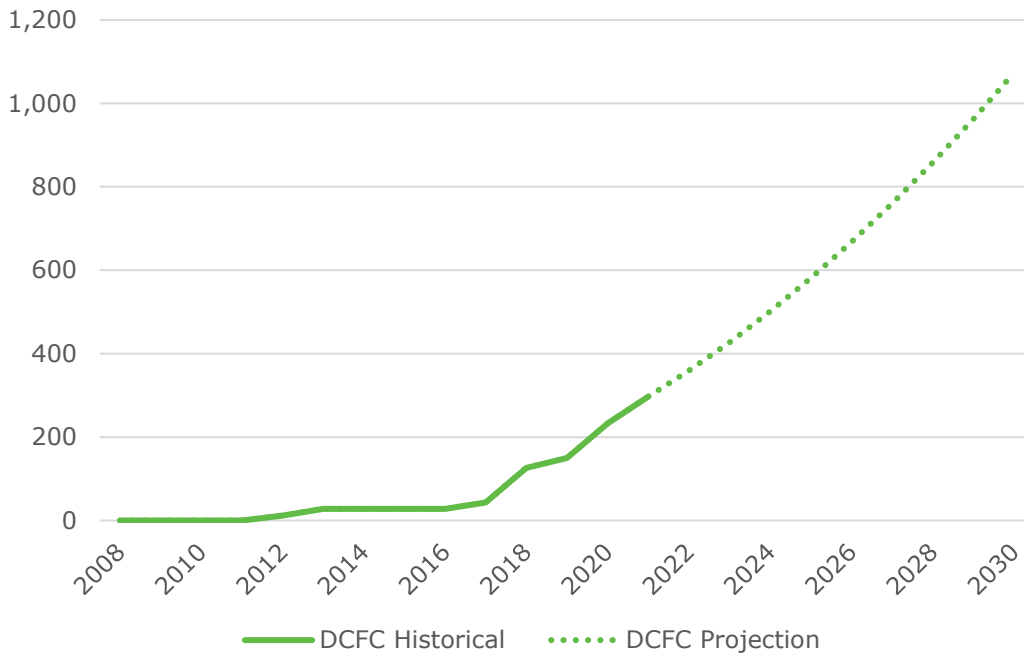**Figure ES 7: S-Curve Projected Growth of L2 Chargers in SVCE Territory**

Figure ES 8: Polynomial Projected Growth of DCFC in SVCE Territory

Compared to EV's historically linear growth, both L2 and DCFC have recently grown, and may continue to grow, much faster. Of course, this kind of rapid growth cannot continue forever.

(S-16) *When the region hits its portion of the 5 million EVs goal, the grid may need to provide almost 100 MW of power during the evening (equal to about one seventh of the power capacity of renewable energy projects SVCE has developed to date).*

Figure ES 9: Modelled EV Charging Load Curve (based on CEC's AB 2127 report)
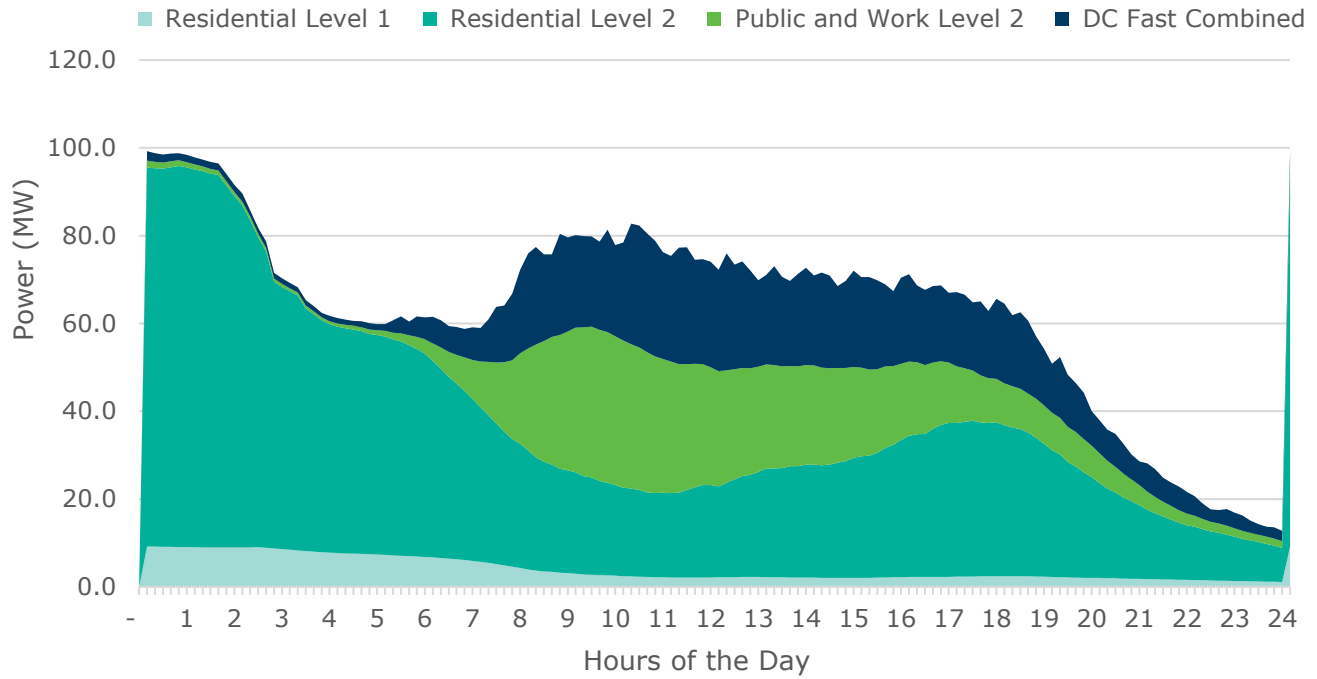
SVCE currently has clean energy projects that will provide more than 700 megawatts (MW) of capacity, which means that about a seventh of that power capacity could be taken up just charging cars. Figure ES 9 also shows an extreme ramp up of charging at midnight, in part because of simplifying model assumptions. However, the underlying importance of overnight charging to this projection is undeniable, as the convenience of refueling for a low cost at home while the vehicle is not in use is one of the perks of EVs. Unfortunately, nighttime is also when the grid is more dependent on fossil fuels, posing a challenge for decarbonization goals.

Contents

SILICON VALLEY
CLEAN ENERGY

INTRODUCTION

Purpose

Silicon Valley Clean Energy's interest in providing carbon-free energy, accelerating innovative electric technologies, and benefitting local communities necessitates a focus on expanding electric vehicle (EV) adoption, with efforts to date largely on increased deployment of electric vehicle infrastructure (EVI). This first EV/EVI Baseline study aims to assist in that focus by giving SVCE and its community a clearer picture of what EV and EVI distribution looks like currently. Providing this information will help programs and policies made to increase equitable EV access consider the current context of EVs and EVI and make data-based decisions on where key opportunities or challenges exist. It will also provide a helpful snapshot in time to measure against when assessing the success of these programs and policies in the future.

Context

Silicon Valley Clean Energy (SVCE) is a community choice aggregator, purchasing clean electricity for its member communities shown below. SVCE is working to reduce greenhouse gas emissions from 2015 baseline levels 30% by 2021, 40% by 2025, and 50% by 2030. As of 2021, SVCE territory has seen a 35% reduction in greenhouse gas emissions. However, to keep meeting these goals a further reduction in both buildings and transportation emissions are necessary.

Map 1: SVCE Service Territory and Member Communities
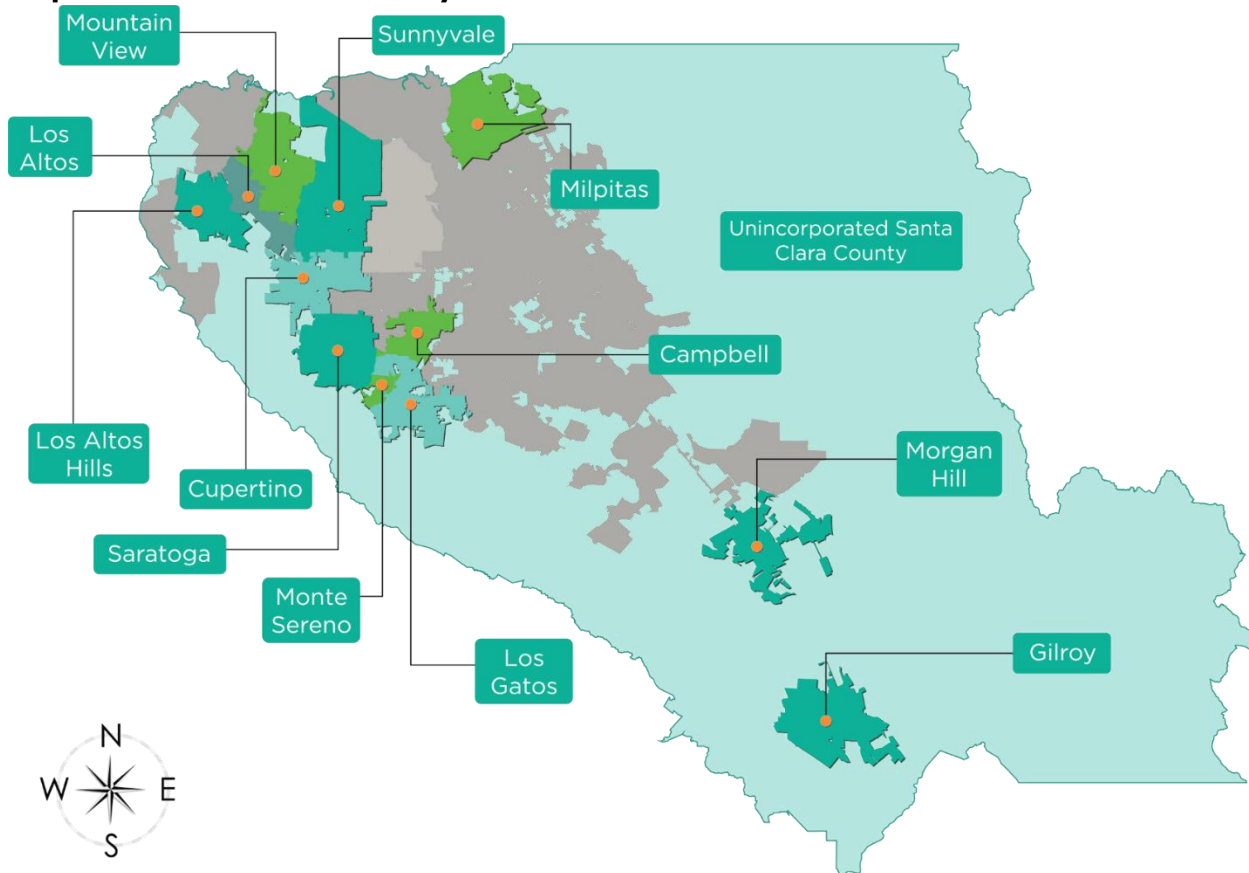
SVCE recognized from its inception that transportation electrification would be a vital element of its program portfolio. SVCE created an EVI Joint Action Plan in 2019 to guide strategic choices around program design. This led to programs like CALeVIP, FutureFit Assist EV Charging, and GridShift, alongside pilots with companies like EVmatch and Ecology Action. This study shares information on how the region is doing today and where additional opportunities lie.

As of SVCE's 2020 Greenhouse Gas Emission Inventory, transportation makes up more than half of all greenhouse gases, and of that, on-road transportation comprises 79 percent. This makes transportation electrification a vital element of SVCE's greenhouse gas emissions reductions goals of 40% reductions by 2025 and 50% reductions by 2030. In addition, dire warnings from the sixth IPCC report recently published underline the importance of complete and rapid decarbonization of energy usage, if the globe wants to come back under 1.5 degrees of warming by the end of the century. The urgency of the report highlights the need for transportation systems to decarbonize and makes clear that the effort will require action from SVCE and a variety of other agencies to meet the scale and timing of the challenge.

Figure 1: Sources of SVCE Territory Greenhouse Gas Emissions in 2020
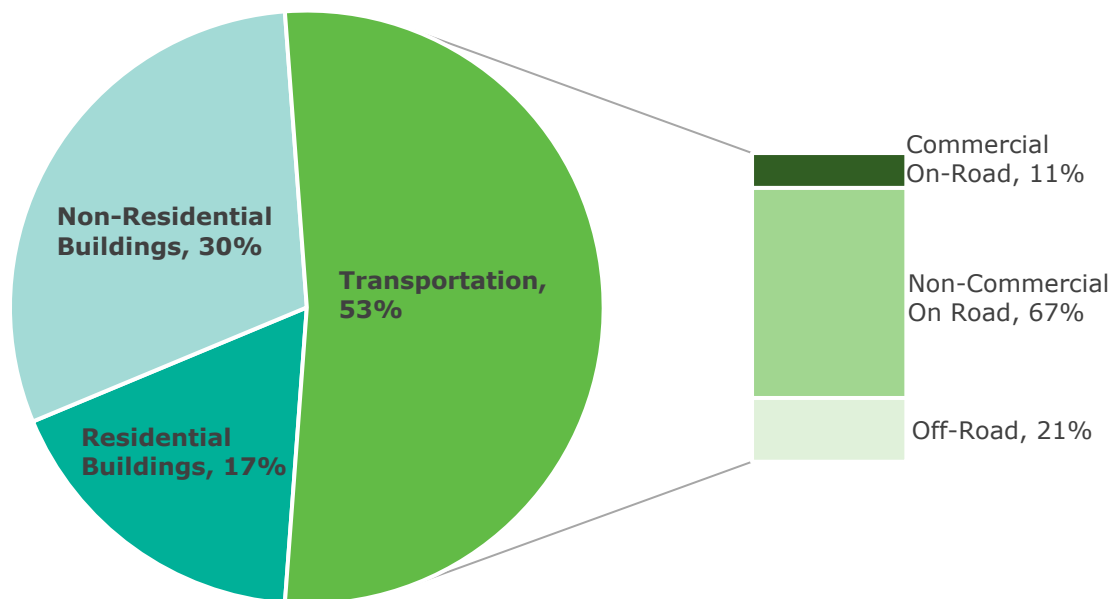
Structure

This study will proceed in three sections before concluding with some key takeaways on the current state of EVs and EV infrastructure deployment and future program and policy research avenues.

The first two sections will focus on the physical and policy landscapes of EVs and EVI respectively. EV infrastructure cannot be understood without a discussion of who it is attempting to serve, which is why this study looks at both EVs and the charging stations that support them. The current landscape of EVs will show how EVs compare to internal combustion engine (ICE) vehicles, as well as whether EVs are equitably spread across the territory. While looking at the physical landscape of EVI, the report will discuss distribution and charging paradigms, but insufficient data is available to discuss SVCE-specific charger utilization. Looking at the policy landscapes around both will show how policy is supporting further adoption.

The last section before the conclusion will take a brief look at forecasting models, to understand how the results currently presented in SVCE territory compare to future goals. Aside from the distribution of EV and EVI, this section will also mention possible changes in load.

The conclusion lists the 16 key takeaways from this study and some next steps in terms of data and policy research. Sections throughout the study will highlight what takeaways and next steps they correspond to. Finally, there are also some appendices with more specific information not vital to the study, but still related. Cities who are interested in finding specific figures for their municipalities should look to these appendices as well.

Gaps

While this baseline aims to give as comprehensive a view as possible about the current state of EV adoption and EVI in SVCE territory, there remain significant gaps in information available to make a truly comprehensive report. This study aims to clearly highlight those gaps, include a forthright discussion about how some were overcome, and discuss future possibilities for closing others.

EVs

Electric vehicles distinguish themselves from internal combustion engine (ICE) vehicles through the construction of their engine. However, both engines can exist in a single vehicle, which can lead to confusion about what counts as an EV from study to study. There are four types of cars that at least partially use an electric motor. These types are:

- Gasoline Hybrid Vehicle
- Plug-in Hybrid Electric Vehicle (PHEV)
- Battery Electric Vehicle (BEV)
- Fuel Cell Electric Vehicle (FCEV)

For a clearer understanding of the differences between these vehicles, look at **Appendix A: Explanation of EVs**. This study primarily discusses PHEVs and BEVs when referring to electric vehicles. These two types of cars are often lumped together into a category called plug-in electric vehicles (PEVs), which this study uses interchangeably with EVs.

EVs in Comparison to ICE Vehicles

Electric vehicles offer an important opportunity to decarbonize the transportation sector. EV passenger cars have penetrated the market, making up 6.5 percent of registered cars in SVCE territory, triple the national value of less than 2 percent[1]. As new passenger EVs are released in the coming years in key pickup truck and SUV markets, the hope is that local and national adoption will ramp up further. Along with passenger cars, EV technology is being further developed for commercial vehicles as well. While some, such as electric semi-trucks, are just being developed, other medium- and heavy-duty vehicles, like transit buses and smaller off-road construction vehicles, are already available.

By looking at how ICE vehicles compare to PEVs in a couple of ways, this study aims to show what transportation needs are left unfilled by PEVs currently, as well as future avenues for further decarbonization.

[1] Center for Sustainable Energy. 2021. The State of Electric Vehicle Adoption in the U.S. and the Role of Incentives in Market Transformation. California, September 27.

By Age

Comparing the age of ICE vehicles to PEV vehicles in the current fleet suggests an expansion opportunity for EVs as cars from model years 2000 to 2010 reach the end of their lifetimes. Model year 2018's impressive ratio of PEVs to non PEV passenger cars suggest that the "year of the EV" has valuable lessons for the future growth of the EV market.

Figure 2: Model Years of Current Passenger Car Fleet (all cars) vs PEV Fleet (subset)
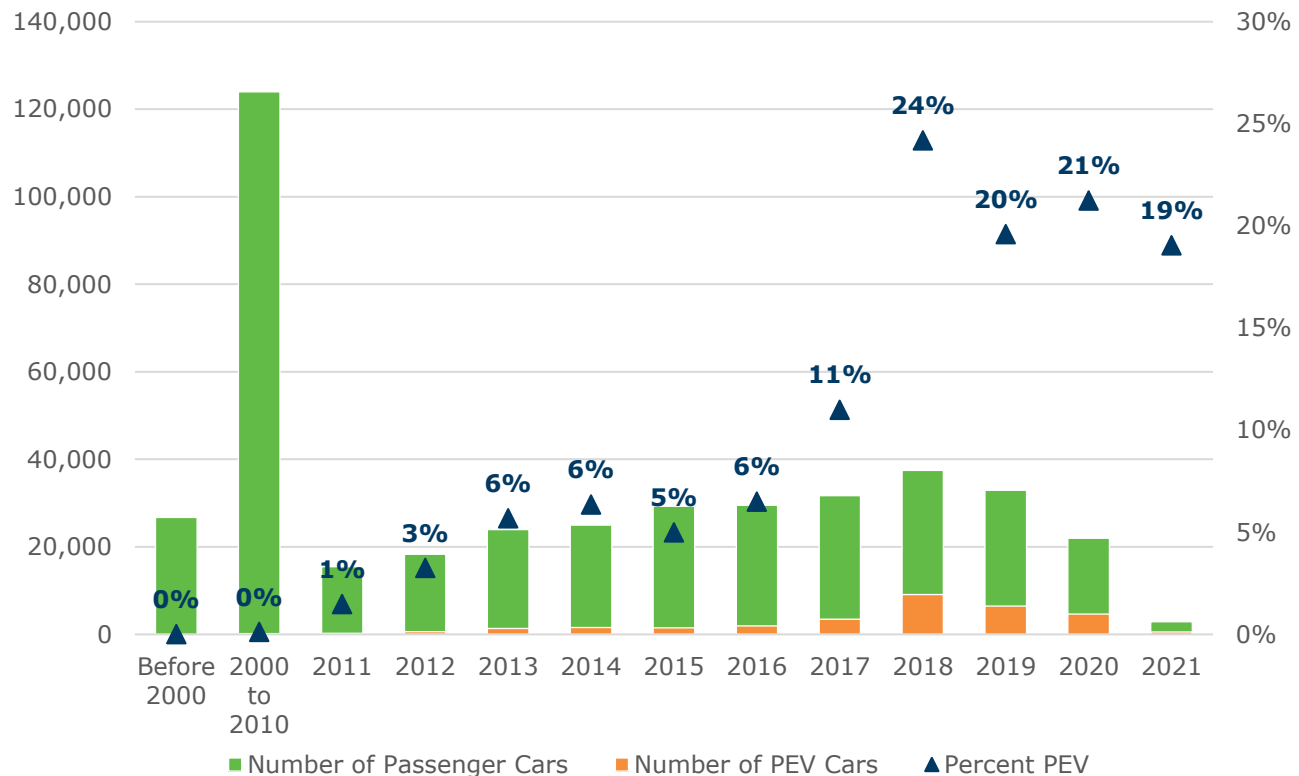

Figure 2 presents the model year for all vehicles currently registered in SVCE territory. As it shows, many current passenger cars were built between 2000 and 2010, with very few EVs from this time. With the first commercially viable EVs like the Tesla Roadster, Chevy Volt, and Nissan LEAF coming out around 2010[2], it makes sense that there would be relatively little EVs from that year, especially in today's fleet. With IHS Markit research showing that owners are keeping a car for an average of 12.1 years[3], this large group of cars is likely to turn over in the next few years. With more affordable EVs on the market, this represents a chance for larger customer groups to choose PEVs for their next vehicle.

The largest single model year group in the current fleet is 2018. This is true both for passenger vehicles generally and PEVs. Nearly a fourth of model year 2018 cars are PEVs. The larger amount of PEVs from model year 2018 compared to model year 2017 is impressive, going from around 3.5 thousand to 9 thousand vehicles. 2018 is the year that Tesla's Model 3 reached production

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[2] Department of Energy. 2014. The History of the Electric Car. September 15. https://www.energy.gov/articles/history-electric-car.

[3] Colias, Mike. 2021. "Americans Are Keeping Their Cars Longer, as Vehicle Age Hits 12 Years." Wall Street Journal, June 14: https://www.wsj.com/articles/average-u-s-vehicle-age-hits-record-12-years-11623680640.

numbers above 5,000 cars a week and became the best-selling car by revenue[4]. Plug-in SUVs also became available from brands like Jaguar and Audi, helping to fill in gaps in the EV market for consumers who want to purchase electric but prefer SUVs. Two thirds of the PEVs in the entire fleet come from model year 2018 on. Continuing to increase the availability of different car types for EVs, as well as bringing familiar names into the EV market by showing how profitable EVs can be could help the EV market continue to grow into the future.

By Car Type

A significant concern that has dogged the growth of PEVs is the relative lack of car types. Historically, PEVs have only been sedans, even though almost half of car sales in the US have been for sports utility vehicles (SUVs) since 2019, and pickup trucks regularly take the highest sales slots[5]. Though PEVs have expanded into SUVs in recent years with Tesla's Model Y, there is still a gap in the EV market for SUVs and pickup truck types of cars in SVCE territory. **(S-1)**

Figure 3 looks at current vehicle registration as of January 1, 2021, and breaks them into four or three categories, depending on the source of power. These categories attempt to represent different segments of the market, which, in the carbon-powered chart, may have different challenges to transitioning into EVs.

Figure 3: Number of Carbon-Powered and Electric Passenger Cars by Body Type in 2021

Carbon Powered
450 Thousand Cars

Electric Cars
30 Thousand Cars

- Sedan
- SUV
- Pickup
- Hybrid
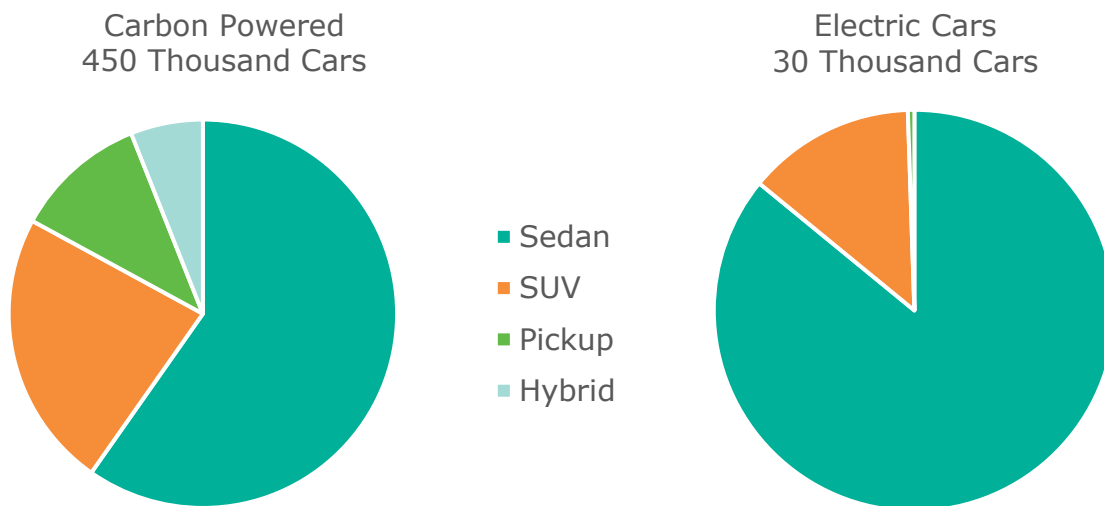
Looking at registered passenger cars in SVCE territory as of January 2021, there are clear gaps in what electric vehicles can offer. Pickup trucks are popular passenger cars in the US, making up 20 percent of cars in the US[6]. In SVCE territory, despite a lower number of pickups coming in to about eleven percent, there are still challenges with the desire for pickup trucks. EV pickups are almost nonexistent, while about 46 thousand carbon powered cars are pickups. The EV market will need to continue to expand its electric pickup offerings to become a truly substitutable good for carbon-powered cars.

[4] EVANNEX. 2018. 2018 EV Recap: The Year Of The Electric Vehicle And Tesla Prevails. December 31. https://insideevs.com/news/341847/2018-ev-recap-the-year-of-the-electric-vehicle-and-tesla-prevails/.

[5] Voelk, Tom. 2020. "Rise of S.U.V.s: Leaving Cars in Their Dust, With No Signs of Slowing." New York Times, May 21: https://www.nytimes.com/2020/05/21/business/suv-sales-best-sellers.html.
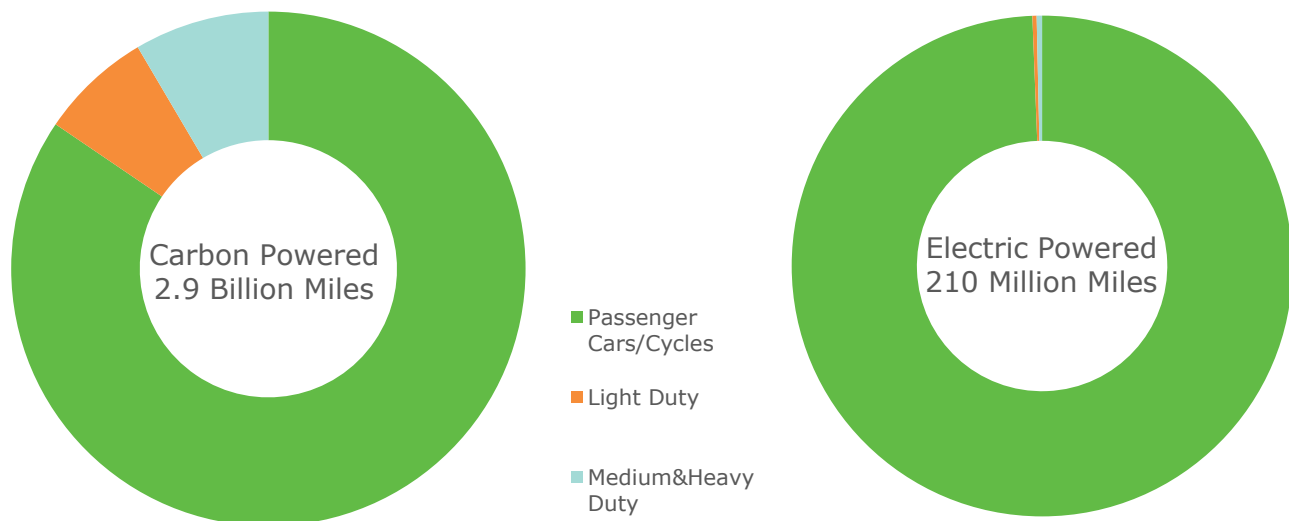
[6] Miller, Marty. 2019. King of the Road: Breaking Down the Popularity of Pickup Trucks. August 30. https://www.experian.com/blogs/insights/2019/08/king-road-breaking-popularity-pickup-trucks/.

There are more SUVs offerings in the EV market, but they are still not quite performing at parity compared to ICE vehicles. Fourteen percent of EVs in SVCE are classified as SUVs, but 23 percent of fossil-fuel powered cars are SUVs, meaning a one and a half times greater proportion of fossil-fuel powered cars are SUVs. This suggests that there is still not enough choice of electric SUVs to fully meet the desire of costumers to drive these types of cars. This is further supported by the number of different types of SUV in each market. In the EV market are dominated by Tesla's Model Y and Volkswagen's E-Golf, but with a total of only 91 options across model years and brands, EV SUVs still have a long way to go to catch up to the over 4000 different model varieties across years that fossil powered car

A final category for carbon powered but not electric vehicles is hybrids, which gained a lot of support as an efficient and environmentally friendly car before EVs became commercially viable. There are about 25 thousand gasoline hybrids on the road, almost as many as total PEVs on the road. Sunk costs might stop this group of drivers from transitioning to plug-in electric vehicles in the near term. In addition, hybrids have a large advantage in the current transportation infrastructure, as they can utilize the prevalent gas fuel infrastructure while also providing fuel savings through high mileage. These advantages to hybrids may compel people to continue buying hybrid cars instead of transitioning fully to electric vehicles.

Turning to look at vehicles miles travelled (VMT) per year from different types of cars in Figure 4, the predominance of passenger cars for EV trips is clear again. Another takeaway from this breakdown is that around eight percent of travel on the road in SVCE territory is happening in medium and heavy-duty vehicles, emphasizing the necessity of continuing innovation in medium and heavy-duty electrification. **(S-2; S-3)**

Figure 4: 2020 Annual VMT by Body Type for Carbon-Powered and Electric Vehicles in SVCE Territory

Carbon Powered
2.9 Billion Miles

Electric Powered
210 Million Miles

■ Passenger Cars/Cycles

■ Light Duty

■ Medium&Heavy Duty

This data comes from California Air Resources Board's EMFAC model, which forms the basis for SVCE's greenhouse gas emissions inventory. Instead of using cars registered in SVCE territory, this model uses estimates of cars travelling along roads in the territory. Unlike Figure 3, SUVs are not distinguished from passenger vehicles, and pickup trucks make up the light duty section. In addition, these charts show medium and heavy-duty vehicles, like buses, tractor trailers, and other large vehicles used for commercial purposes, which were excluded from the count for Figure 3.

Figure 4 further demonstrates that continuing to work on passenger vehicle electrification will make massive positive change to assist with decarbonization goals. Transitioning carbon-powered passenger vehicles alone would result in more than a thousand percent increase in electric vehicle miles traveled. **(S-2)**
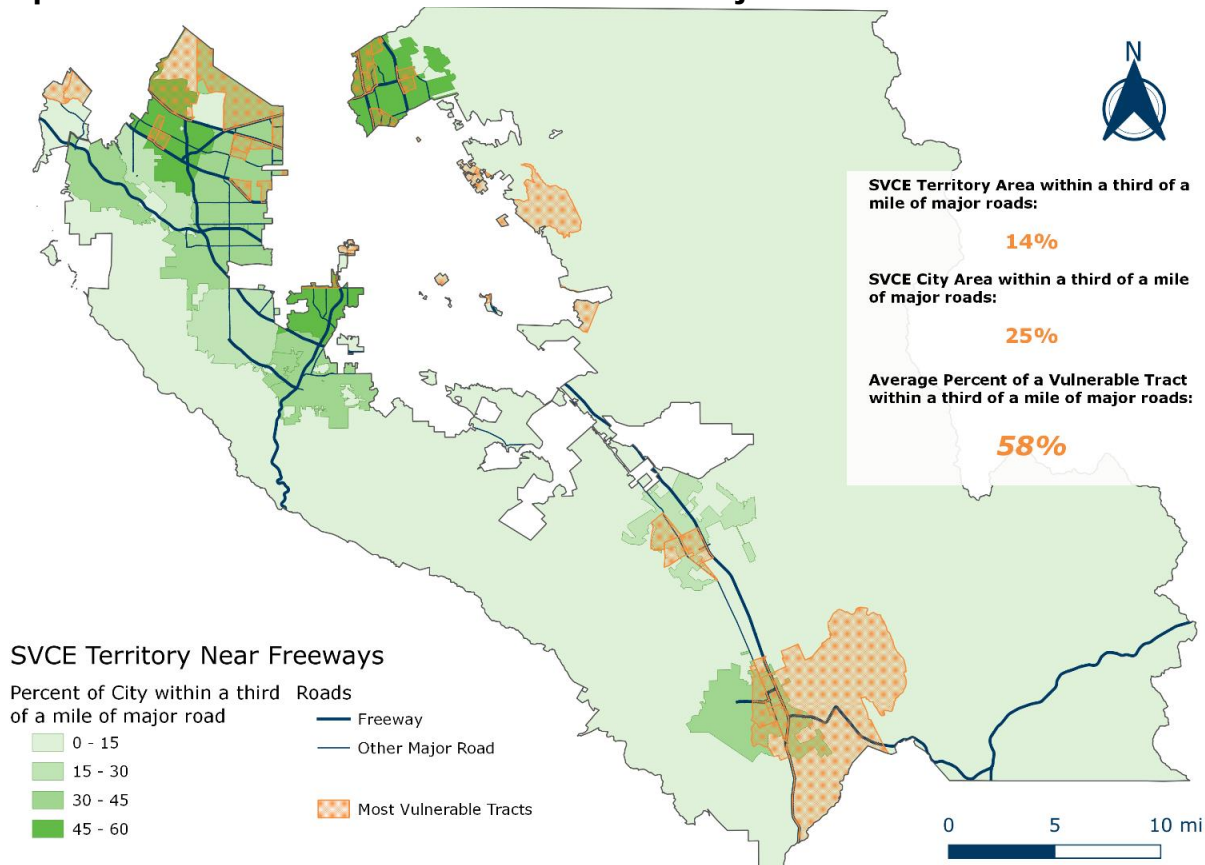
However, this data also shows how much medium and heavy-duty trucks contribute to greenhouse gas emissions. Despite only making up eight percent of VMT in the area, they are responsible for eleven percent of transportation emissions as demonstrated in Figure 1, and fourteen percent of on-road emissions, almost double the proportion of their VMT. Because these vehicles are often less efficient per mile than passenger vehicles due to their weight, these miles are big contributors to greenhouse gas emissions and other criteria air pollutants. **(S-3)** Decarbonizing the medium and heavy-duty vehicles that drive through SVCE territory, not just those registered in it, will be a critical piece of reducing transportation emissions – but likely more challenging to accomplish.

EVs and Other Criteria Air Pollutants

EVs not only reduce the emissions of greenhouse gases, but also reduce the emissions of other criteria air pollutants like fine particulate matter, sulfur dioxide, nitrous oxides and volatile organic compounds. **(S-4)** While the scope of this study does not include a specific analysis of the impacts of current EV deployment on criteria air pollutants in SVCE territory, a sampling of studies showing EV adoptions' impact on these pollutants in other areas can suggest potential benefits for SVCE.

These pollutants cause the most harm to people near large, busy roads. A comprehensive review by the Health Effects Institute[7] concludes that traffic pollution may cause various negative health effects, such as asthma in children and impaired lung function, which are most pronounced within the area from a quarter to a third of busy roads. Map 2 shows these areas, revealing that lots of SVCE territory, especially vulnerable census tracts, are within this critical area for air pollution.

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[7] Tager, Ira, Kenneth Demerjian, Mark Frampton, Michael Jerrett, Frank Kelly, Lester Kobzik, Nino Künzli, et al. 2010. *Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects.* Special Report, Boston: Health Effects Institute.

Map 2: Area in SVCE within a Third of a Mile of Major Roads

SVCE Territory Area within a third of a mile of major roads:

14%

SVCE City Area within a third of a mile of major roads:

25%

Average Percent of a Vulnerable Tract within a third of a mile of major roads:

58%

SVCE Territory Near Freeways

Percent of City within a third of a mile of major road
- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60

Roads
— Freeway
— Other Major Road

Most Vulnerable Tracts

0   5   10 mi

Fourteen percent of SVCE's territory falls within that area and the number rises to nearly a quarter when looking at incorporated areas, with over half the land of certain communities, like Campbell and Milpitas, within a third of a mile of major roads. Vulnerable census tracts, like those that the state defines as low income or disadvantaged communities, are shown and many experience heavy traffic, where large amounts of people could benefit from a reduction in transportation-related air pollution.

Nitrous oxides (NOx), particularly nitrogen dioxide, are the air pollutants most associated with on-road travel, responsible for the creation of smog and ground level ozone. Vehicle tailpipe emissions for ICE vehicles have been dropping because of regulatory standards, despite an increase in the amount of vehicle miles traveled.

Electric vehicles, meanwhile, have no tailpipe emissions, although NOx emissions from upstream electricity generation can be comparable to ICE tailpipe emissions in some instances.[8] Given SVCE's clean power mixture, NOx reductions from electric vehicle adoption would be meaningful.

Fine particulate matter ($PM_{2.5}$) is another, and particularly dangerous, criteria air pollutant, accounting for approximately 90% of deaths due to transportation air pollution in 2005.[9] In a

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[8] Winkler, S.L., J.E. Anderson, L Garza, W.C. Ruona, R Vogt, and T.J. Wallington. 2018. "Vehicle criteria pollutant (PM, NOx, CO, HCs) emissions: how low should we go?" Nature Partner Journals Climate and Atmospheric Science. doi:https://doi.org/10.1038/s41612-018-0037-5.

[9] Choma, Ernani F, John S Evans, James K Hammitt, José A Gómez-Ibáñez, and John D Spengler. 2020. "Assessing the health impacts of electric vehicles through air pollution in the United States." Volume 144 144. doi:https://doi.org/10.1016/j.envint.2020.106015.

recent study of the health impacts of the transition to EVs, Choma et al. find that electrification in San Jose metro area would cause the $PM_{2.5}$-related death rate to be cut by about four fifths. These death rates are small – San Jose's baseline rate is around 3 deaths for every billion miles – but the change in rate is quite drastic, with an estimated 4 cents in health savings for every mile driven by an EV instead of an ICEV.

The study takes care to point out that these reductions are caused in large part because both pollution and people are concentrated into small areas. EVs can remove focused pollution in heavily populated areas and move that pollution to power plants that often operate in less populated areas and can disperse their emissions more effectively. Again, in the case of SVCE customers, the nominal emissions from the agency's carbon-free energy mix means that even these emissions are avoided – indicating the reduction in air pollution death rate would likely be even bigger.

A finer grain analysis of how EVs have and could further benefit residents in regard to the reduction of criteria air pollution would be an important addition to a holistic understanding of the benefits of electrifying transportation. Defining health impacts from these air pollutants and quantifying the benefits to health that the specific circumstances of EV adoption in SVCE territory produce requires economic modelling and understanding of air pollution science but would emphasize public health benefits of EV adoption as well as climate benefits.

EV Adoption by Location

EV adoption rates vary across SVCE's service territory. Map 3 displays adoption rates by census tract. The West Valley has the highest rates of EV adoption overall. Mountain View and Sunnyvale, the two largest and more urban cities in the West Valley, have a much larger range of EV adoption rates. Meanwhile, eastern Unincorporated Santa Clara County, Gilroy, and Morgan Hill have some of the lowest rates of adoption **(S-5)**.

Map 3: EV Adoption Rate by Census Tract in SVCE Territory
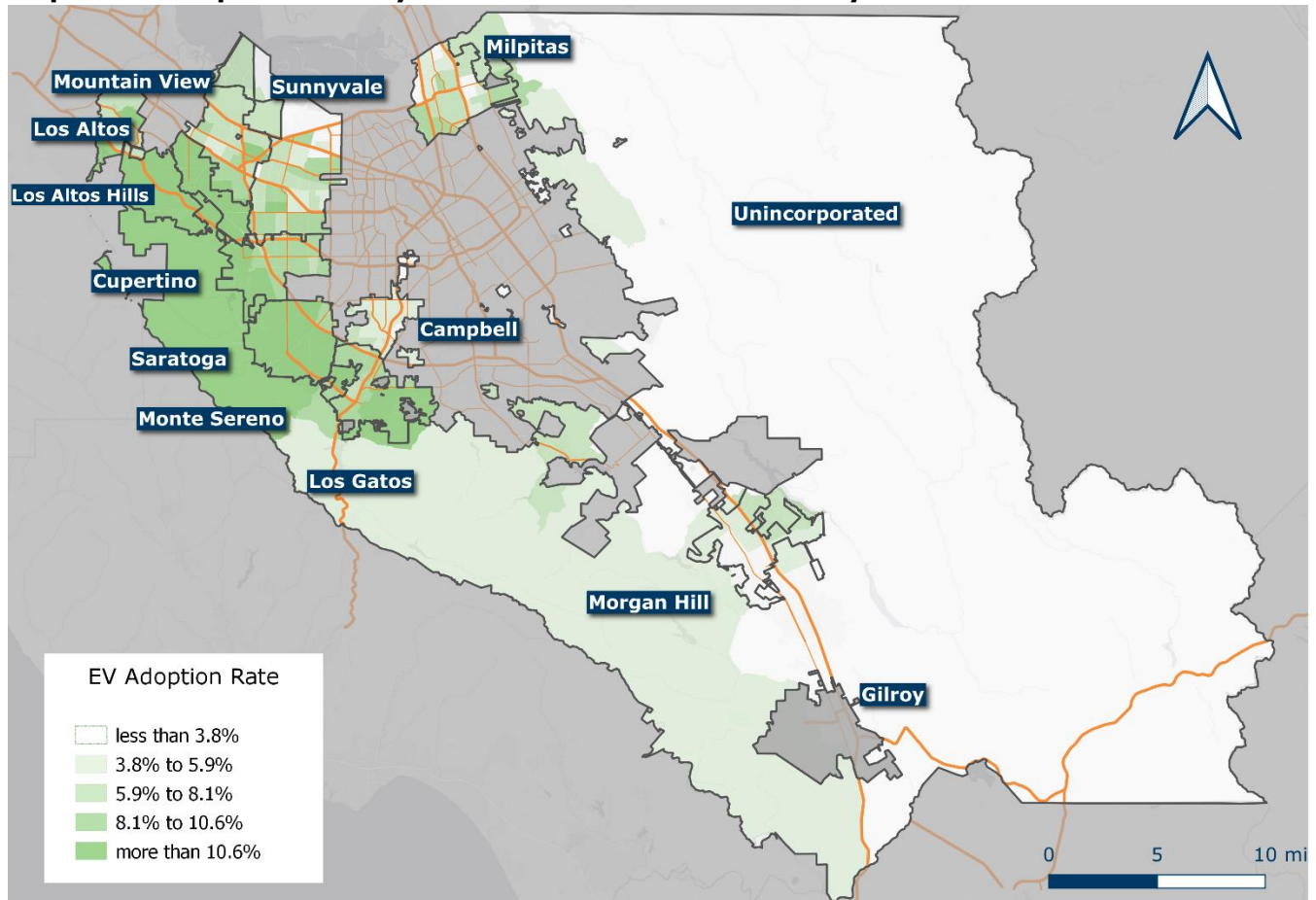
For a clearer visual of how these differing rates play out for each city, refer to **Appendix B: City Maps of EV Adoption**.

Residential Adoption

Most EV adoption is occurring at residences, as opposed to commercial or institutional uses. While residences are far and away the most likely to use EVs, the type of residence also makes a large difference to the ease of EV adoption. Single family residents are much more likely than multi-family residents to purchase EVs as Table 1a shows below. While cities have different ratios of single-family residences to multi-family residences, almost uniformly, multi-family residences are underrepresented in their EV owner population **(S-6)**. Table 1b shows the range of this underrepresentation in connection to how much multi-family housing exists in each community and differences in car ownership patterns for these types of households.

Table 1a: Residential EV Ownership Rates by Community

	Single Family EV Adoption Rate	Multi-Family EV Adoption Rate	Multi-Family Cars Replaced with EVs to Achieve Parity	% Growth Required from Existing Multi-Family EVs to Achieve Parity	% of All Cars Replaced to Achieve Parity
Campbell	5.7%	2.1%	390	166.8%	1.29%
Cupertino	10.1%	6.5%	305	55.4%	0.82%
Gilroy	2.4%	0.3%	199	586.1%	0.37%
Los Altos	12.9%	5.8%	102	122.0%	0.43%
Los Altos Hills	8.0%	2.5%	4	220.5%	0.04%
Los Gatos	9.0%	3.5%	279	155.2%	0.84%
Milpitas	5.7%	2.6%	348	116.5%	0.68%
Monte Sereno	9.7%	0.0%	0	*	*
Morgan Hill	4.8%	0.7%	224	590.2%	0.50%
Mountain View	9.5%	3.9%	1,540	144.8%	3.18%
Saratoga	10.9%	5.0%	41	119.9%	0.16%
Sunnyvale	7.2%	3.6%	1,479	98.4%	1.68%
Unincorporated	2.9%	1.6%	39	117.5%	0.10%
SVCE Territory	6.9%	3.6%	4,524	111.6%	0.93%

Table 1a uses DMV data to compare single family EV adoption rates to multi-family EV adoption rates and show how many multi-family non-EV cars would need to be replaced by EVs to make the adoption rates the same across residence types. It also shows what that number of cars being replaced by EVs would mean for multi-family EV growth, and how it compares to the community's entire car population. Note that some cities have very small multi-family populations, which can make percentage gaps seem much larger than they are in terms of the number of vehicles.

Meanwhile, Table 1b takes data from the 2019 American Community Survey and DMV information to show the breakdown of each community's residential EVs, compared to households and total car population. The household columns show what percent of household live in each type of building, which excludes mobile homes, explaining why single and multi-family households' percentages don't add up to 100%. The car columns show what percent of all cars registered to residences are allocated to each building type, and the EV columns show the percent of EVs registered to residences for each building type.

Both tables may undercount residential cars and EVs, as explored more deeply in the non-residential adoption section. This is because some cars and EVs attributed to agricultural parcels seem to be for residential purposes, since they are mostly sedans.

Table 1b: Distribution of Residential Households, Cars, and EVs

City	Single Family Households	Single Family Cars	Single Family EVs	Multi-Family Households	Multi-Family Cars	Multi-Family EVs
Campbell	56%	72%	87%	43%	28%	13%
Cupertino	69%	82%	88%	31%	18%	12%
Gilroy	74%	86%	98%	23%	14%	2%
Los Altos	87%	95%	98%	13%	5%	2%
Los Altos Hills	99%	99%	100%	0%	1%	0%
Los Gatos	73%	88%	95%	26%	12%	5%
Milpitas	73%	83%	91%	25%	17%	9%
Monte Sereno	100%	100%	100%	0%	0%	0%
Morgan Hill	78%	90%	98%	15%	10%	2%
Mountain View	41%	55%	75%	55%	45%	25%
Saratoga	93%	98%	99%	7%	2%	1%
Sunnyvale	50%	64%	78%	44%	36%	22%
Unincorporated	83%	95%	98%	15%	5%	2%
SVCE Territory	65%	80%	89%	32%	20%	11%

Both tables show that every city has a higher single family EV adoption rate than their multi-family EV adoption rate. Although it is unclear given the data available for this study, one hypothesis for explaining this lack of EV adoption by multi-family residents is a lack of political and economic power to inspire programs that make EV adoption easier, such as increased public charging. The problem does not seem to be an overall lack of EV adoption, however. While Gilroy and the eastern area of unincorporated Santa Clara County have very low EV adoption, Los Altos and other parts of unincorporated Santa Clara in the West Valley have high rates of EV adoption, as shown in Map 2.

Some communities with a large percentage difference in EV adoption rates ultimately do not require many cars to transition for parity. For example, Gilroy has a large disparity between single family and multi-family adoption rates, which would require almost a six-fold increase in their multi-family EV population to fix, even though that is a relatively small part of their overall car populations (just 0.4% of all cars). Sunnyvale is the other way around. Even though achieving parity between their single family and multi-family adoption rates would require nearly 1,500 ICE vehicles to be transitioned into EVs, more cars than any other community (except Mountain View), the growth in multi-family EVs this would create is modest.

Non-Residential Adoption

Overwhelmingly EVs are registered at residences because the vast majority of EVs available are passenger vehicles. However, there are also a few EVs registered to non-residential owners. The following tables show how commercial, institutional, and agricultural sites in each community are contributing to EV adoption.

For all member communities of SVCE, these non-residential parts of the city are not responsible for the proportion of EVs their presence would suggest. Nevertheless, there are some differences between adoption rates across these categories and communities. While Table 2a shows non-residential adoption rates in comparison to overall adoption rates, Tables 2b, 2c, and 2d shows what proportion of the total buildings, cars, and EVs these three nonresidential categories account for in each community.

Table 2a: Non-Residential EV Ownership Rates by Community

City	Overall EV Adoption Rate	Commercial EV Adoption Rate	Institutional EV Adoption Rate	Agricultural EV Adoption Rate
Campbell	4.7%	2.1%	1.7%	*
Cupertino	9.1%	5.3%	0.0%	2.9%
Gilroy	2.4%	0.9%	0.1%	1.3%
Los Altos	13.1%	4.9%	0.0%	16.7%
Los Altos Hills	8.6%	9.5%	2.5%	8.3%
Los Gatos	8.5%	5.1%	0.0%	3.5%
Milpitas	4.9%	2.8%	2.0%	3.8%
Monte Sereno	10.7%	0.0%	0.0%	*
Morgan Hill	4.6%	1.5%	0.4%	1.8%
Mountain View	7.2%	6.7%	5.5%	0.0%
Saratoga	11.0%	5.2%	0.0%	5.6%
Sunnyvale	6.0%	3.4%	1.4%	*
Unincorporated	3.4%	0.8%	6.7%	2.2%
SVCE Territory	6.3%	3.3%	2.8%	1.9%

Table 2b: Distribution of Commercial Buildings, Cars, and EVs

City	Commercial Parcels	Commercial Cars	Commercial EVs
Campbell	6.8%	10.0%	4.5%
Cupertino	3.0%	2.5%	1.4%
Gilroy	6.4%	5.2%	2.0%
Los Altos	4.2%	3.4%	1.2%
Los Altos Hills	2.6%	0.8%	0.9%
Los Gatos	5.1%	4.4%	2.6%
Milpitas	5.9%	5.5%	3.1%
Monte Sereno	0.6%	0.3%	0.0%
Morgan Hill	5.0%	5.2%	1.6%
Mountain View	6.2%	7.1%	6.4%
Saratoga	2.0%	1.1%	0.5%
Sunnyvale	4.2%	3.3%	1.9%
Unincorporated	3.8%	2.3%	0.5%
SVCE Territory	4.2%	3.3%	2.3%

Table 2c: Distribution of Institutional Buildings, Cars, and EVs

City	Institutional Parcels	Institutional Cars	Institutional EVs
Campbell	0.6%	0.2%	0.1%
Cupertino	0.3%	0.3%	0.0%
Gilroy	0.5%	3.1%	0.2%
Los Altos	0.3%	0.5%	0.0%
Los Altos Hills	0.3%	0.8%	0.2%
Los Gatos	0.6%	1.0%	0.0%
Milpitas	0.7%	0.4%	0.2%
Monte Sereno	0.1%	0.1%	0.0%
Morgan Hill	0.7%	1.8%	0.1%
Mountain View	0.3%	0.2%	0.2%
Saratoga	0.3%	0.1%	0.0%
Sunnyvale	0.2%	0.1%	0.0%
Unincorporated	0.5%	5.4%	10.6%
SVCE Territory	0.5%	0.8%	0.5%

Table 2d: Distribution of Agricultural Buildings, Cars, and EVs

City	Agricultural Parcels	Agricultural Cars	Agricultural EVs
Campbell	0.0%	0.0%	0.0%
Cupertino	0.2%	0.5%	0.1%
Gilroy	4.6%	5.7%	3.0%
Los Altos	0.0%	0.0%	0.0%
Los Altos Hills	0.7%	0.3%	0.3%
Los Gatos	1.0%	0.8%	0.3%
Milpitas	0.2%	0.2%	0.1%
Monte Sereno	0.0%	0.0%	0.0%
Morgan Hill	3.8%	4.0%	1.5%
Mountain View	0.0%	0.0%	0.0%
Saratoga	0.5%	0.5%	0.3%
Sunnyvale	0.0%	0.0%	0.0%
Unincorporated	0.2%	4.1%	2.6%
SVCE Territory	0.5%	1.1%	0.4%

SILICON VALLEY CLEAN ENERGY

Commercial owners, including manufacturing and non-manufacturing industrial uses, as well as retail and office owners, have the highest adoption rate in the territory after residential drivers. Nevertheless, commercial organizations fail to achieve parity with the overall EV adoption rate in all communities except Los Altos Hills. As Table 2b shows, commercial vehicles of all types tend to make up a lower percentage of the car population than their proportion of buildings in a community, suggesting that commercial owners are generally less likely to own cars. With a smaller number of overall cars, individual EVs make a larger difference in the commercial EV adoption rate than the residential EV adoption rate. This is true for all non-residential EV adoption rates and may explain why part of why EV adoption rates are so low among non-residential drivers.

Institutional EV adoption rates are an area where cities can be directly involved, as many institutions are local government. Parcels and EV owners described as institutional include local and other governments, as well as schools, universities, hospitals, religious institutions, and museums. This category shows a lot of 0 percent institutional adoption rates, despite some of these communities confirming they have EVs in their municipal government fleet. This may have something to do with what buildings these cars are registered to being differently defined or undefined when it comes to their parcel's land use. It may also be that other institutions that are not city governments are in fact the ones contributing largely to overall car populations, in which case, they need to be incorporated into future transportation electrification planning.

The only community that has an overrepresentation of institutional EVs is Unincorporated Santa Clara County. This is possibly at least in part because of Stanford, as the university engages in pilot programs to increase EV adoption and study the challenges thereof [10].

Agricultural groups are any agricultural use, such as orchards, where food is raised or grown, as well as scenic or unused land. However, many of the agricultural EVs registered seem to be primarily passenger vehicles, which perhaps explains their impressive adoption despite very little EV pickup and medium to heavy duty vehicle development or adoption. Of the total 133 EVs registered in SVCE territory to agricultural plots, more than a third are Tesla sedans, with other popular models including Chevy Volts and Bolts, plug-in Toyota Priuses, and Nissan Leafs, models that are very popular for residential drivers too. It seems possible that agricultural plots with EVs registered to them are a combination of residence and agricultural fields. Though Los Altos has the highest rate of agricultural EV adoption, Gilroy, Morgan Hill, and Unincorporated have the highest numbers of these "agricultural" EVs. These communities also have some of the highest numbers of parcels that are agricultural.

EV Equity

Considering who is not buying an EV and the systemic barriers that impact their decision can inform the policies and programs that will have the most effect in encouraging adoption.

One large systemic barrier that prevents more people from adopting EVs is cost. While the lifetime costs of an EV are now about 40 percent cheaper than those of an ICE vehicle, EVs have yet to achieve upfront cost parity with gasoline cars[11]. This has an impact on lower income households, with studies suggesting that residents of disadvantaged communities buy disproportionately fewer

[10] Stanford Energy, Bits & Watts Initiative. 2020. Flagship Project: EV50. Accessed December 8, 2021.
https://energy.stanford.edu/bitsandwatts/research/ev-flagship-project.
[11] Burnham, Andrew, David Gohlke, Luke Rush, Thomas Stephens, Yan Zhou, Mark A. Delucchi, Alicia Birky, et al. 2021.
Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains.
Technical Report, Argonne, IL: Argonne National Lab. doi:10.2172/1780970.

EVs[12]. In SVCE territory, household income does have a strong relationship with EV adoption rates, as Figure 5 shows **(S-7)**.

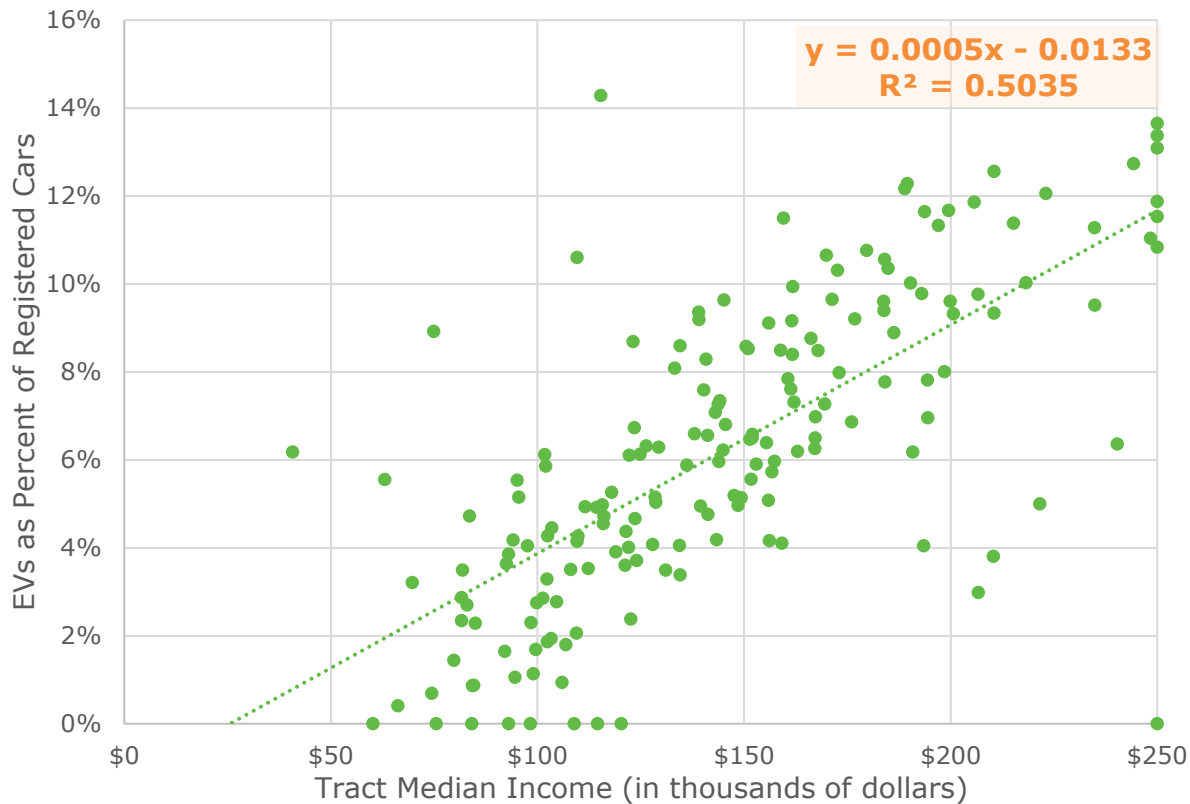**Figure 5: Relationship between Tract Median Income and EV Adoption Rate**

Figure 5 shows just how connected ownership of EVs is to income. The higher the median household income of a census tract is, the larger share EVs make up of all vehicles registered there. The slope of the trendline and equation suggests that for every thousand dollar increase median income, one could expect to see a 0.05 percentage point increase in the number of EVs on average. To see an EV adoption rate increase of one percentage point, one would expect to see a median household income increase of $20,000. Further, the clustering of the points along the trendline demonstrates that the relationship between median income and percent of EVs is robust, and an R^2 value of about 0.5 means that approximately 50 percent of the change in the percent of EVs registered in a census tract is explained by a change in median income.

Importantly, median income also correlates with other variables that might explain EV adoption rates. Renters tend to be lower income and tend to live in multi-family buildings, which, as previously discussed, purchase EVs at lower rates. Other such explanatory variables that have a more direct connection with EV adoption rates and correlate with median income could be contributing to this half of the difference in EV adoption rates.

Figure 5 shows a few outlying tracts with either higher or lower rates of EV adoption than expected given their median household income. Map 4 shows where these census tracts are, providing some

[12] Canepa, Kathryn, Scott Hardman, and Gil Tal. 2019. "An early look at plug-in electric vehicle adoption in disadvantaged communities in California." Transport Policy 78: 19-30. doi:https://doi.org/10.1016/j.tranpol.2019.03.009.

insight into why they might be outliers. Most of them can be chalked up to being border census tracts or other places with relatively small populations.

Map 4: Outlying Census Tracts for EV Adoption Rate Compared to Median Income
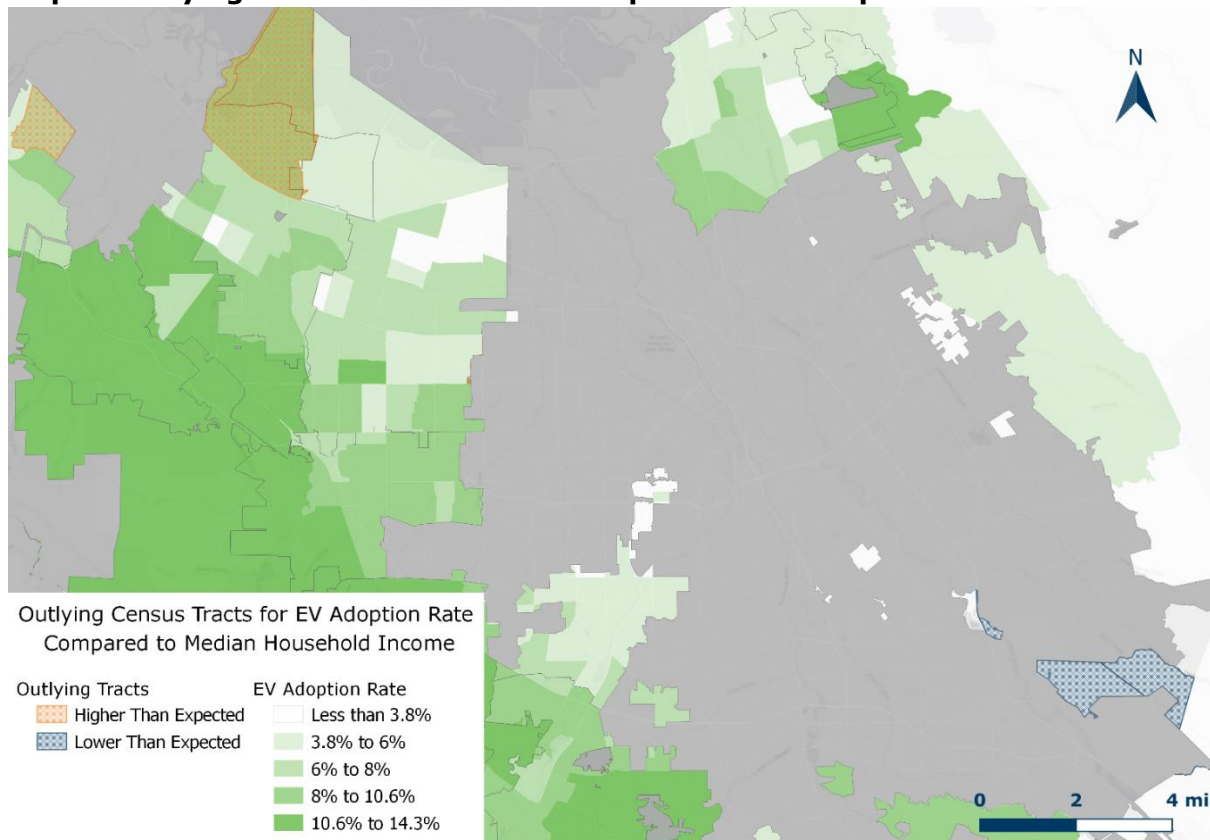

Many of the highlighted outliers are border tracts – that is, they are split between SVCE and non-SVCE territory. Because the DMV data used to calculate EV adoption rates only includes vehicles registered to SVCE territory, these border census tracts have a much smaller car population. A few EVs make a much larger difference in adoption rates here than they otherwise would in census tracts with a higher population of cars. One of the high outliers is so small as to be almost invisible on Map 4, though its 14.3% adoption rate is the highest EV adoption rate seen in Figure 5. This tract lies on the border of Sunnyvale and Santa Clara, and while it shows an impressive EV adoption rate for the four or five blocks in Sunnyvale it covers, the EV adoption rate for the entire census tract could be quite different. Similarly, the low outliers are census tracts split between Unincorporated Santa Clara County and San Jose. These areas are likely to be the less populated parts of the tracts, leading to greater variability in adoption rates.

There is one high outlier, in the Stanford area on the upper left area of the map, that does not fit into this pattern. Though its EV adoption rate is just 6.2%, not particularly high, the tract is notable in that it is the lowest income tract in SVCE territory, seeming to contradict the conclusion of Figure 5 by showing a low-income tract with an adoption rate that is the middle quintile of SVCE territory. However, because this tract is so near Stanford University, it seems likely that student households are driving the median income and car population down, making the EVs that are owned in the area more impactful on adoption rates than they would be elsewhere.

Of course, if half of difference in EV adoption rates across census tracts can be explained by income, other tract characteristics should have some other explanatory power over EV adoption

rates **(S-7)**. SVCE uses a socio-economic vulnerability index (SEVI) to quantify, alongside income, other socio-economic characteristics of census tracts that face systemic barriers to safe, comfortable lives, such as exposure to environmental hazards, language isolation, and housing quality. Census tracts are divided into the four quartiles that show which areas are the most vulnerable (SEVI quartile four) and which are the least vulnerable (SEVI quartile one).

Figure 6: Percent of Total EV Ownership by SEVI Quartile (1 = least vulnerable, 4 = most vulnerable)

1	2	3	4
Population: 176,616	Population: 250,968	Population: 245,444	Population: 241,898
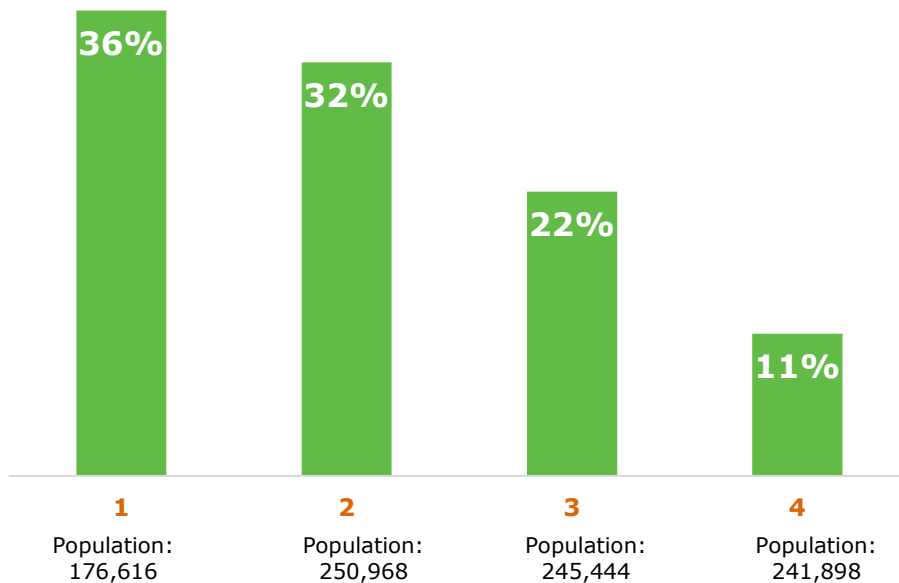
An analysis of EV ownership by SEVI quartile shows that households in the first SEVI group, those who are the least vulnerable, own three times the amount of EVs as those in the fourth group, those who experience the most vulnerability. This is especially notable given that the population of SEVI quartile one, due to smaller average populations in these census tracts, is 25% lower than the population of SEVI quartile four.

Figure 7 shows the variety of EV adoption rates for each tract in the four quartiles. This figure shows that not only are there less EVs in SEVI quartile four overall, but that these census tracts also have lower rates of EV adoption on average compared to SEVI quartile one **(S-7)**. The regression line sloping downwards shows that census tracts that are more vulnerable in the SVCE area also tend to have lower EV adoption rates. In addition, SEVI quartile four also has the smallest range of EV adoption rates, with their highest coming in at 8.9% of cars in the tract being EVs. Interestingly, SEVI quartile two, the second-best off group, is the only quartile that does not have a single census tract with an EV adoption rate of 0%.

Figure 7: Relationship between SEVI Quartile and EV Adoption Rate

Neither income nor the SEVI analysis prove causation, but the clear relationship between vulnerable socio-economic characteristics, including low incomes, and rate of EV adoption suggests that lower income households may still feel that they don't have the money to afford the upfront costs switch to an EV. In the opposite causal direction, a lack of EVs in a community may also make that community more vulnerable to environmental hazards, such as pollution. As explained earlier, EVs can reduce pollution that comes out of gas-powered cars' tailpipes, thus decreasing communities' exposure to environmental hazards. In addition, further work on vehicle to grid integration that allows electricity to run from EVs back to the grid may assist households dealing with energy insecurity, by allowing them to charge their cars when electricity costs are lowest and use that charge during peak cost hours or outages to power their home.

EV Rebates

To increase the number of electric vehicles on the road, the federal and state government provide a variety of incentives to consumers. These incentives range from the federal government's tax credit to free use of high occupancy vehicle lanes in California.
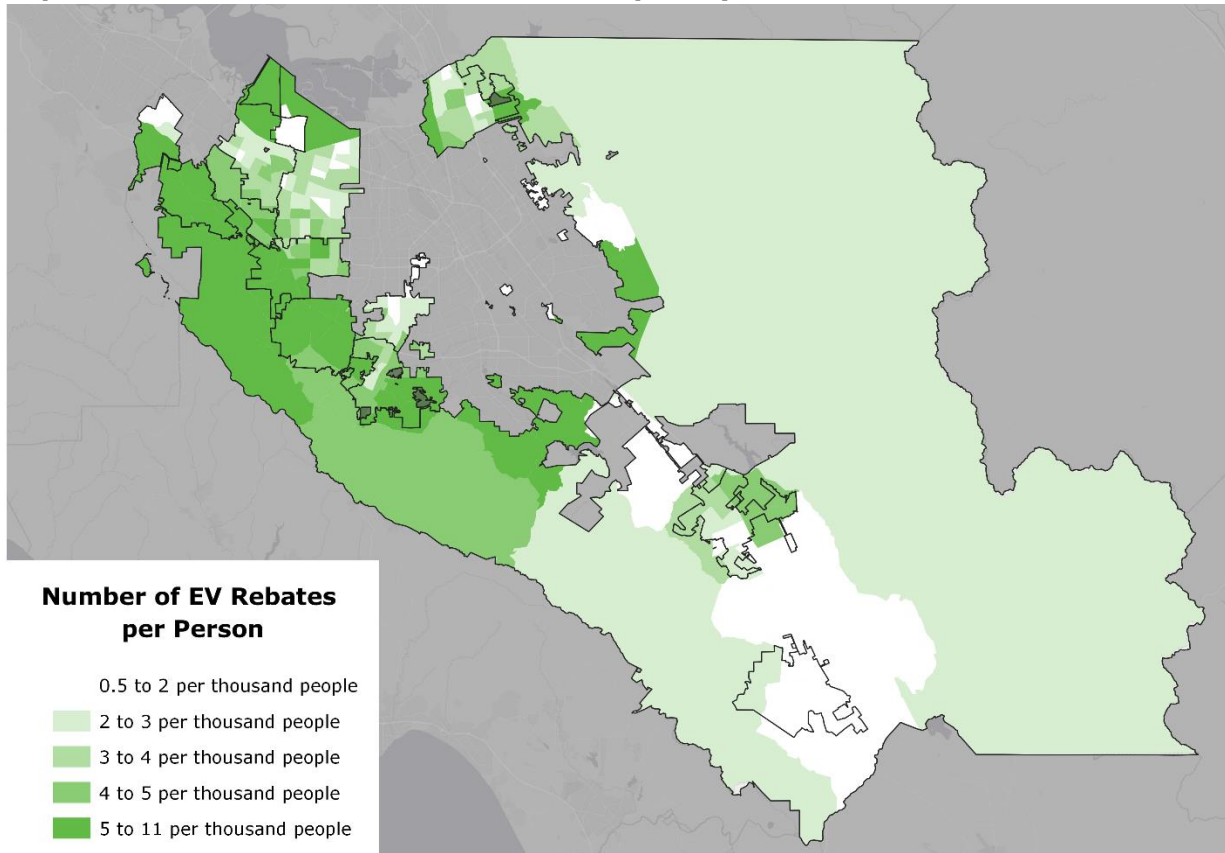
The state of California provides a rebate incentive through the Clean Vehicle Rebate Project (CVRP) for the purchase or lease of new EVs. The express goal of this incentive is making EVs more financially competitive with ICE vehicles. Once a resident of SVCE's territory has bought or leased their new BEV, FCEV, or PHEV, they can apply for the rebate, which will get sent to them while funding is available. Here are the requirements for the rebate:
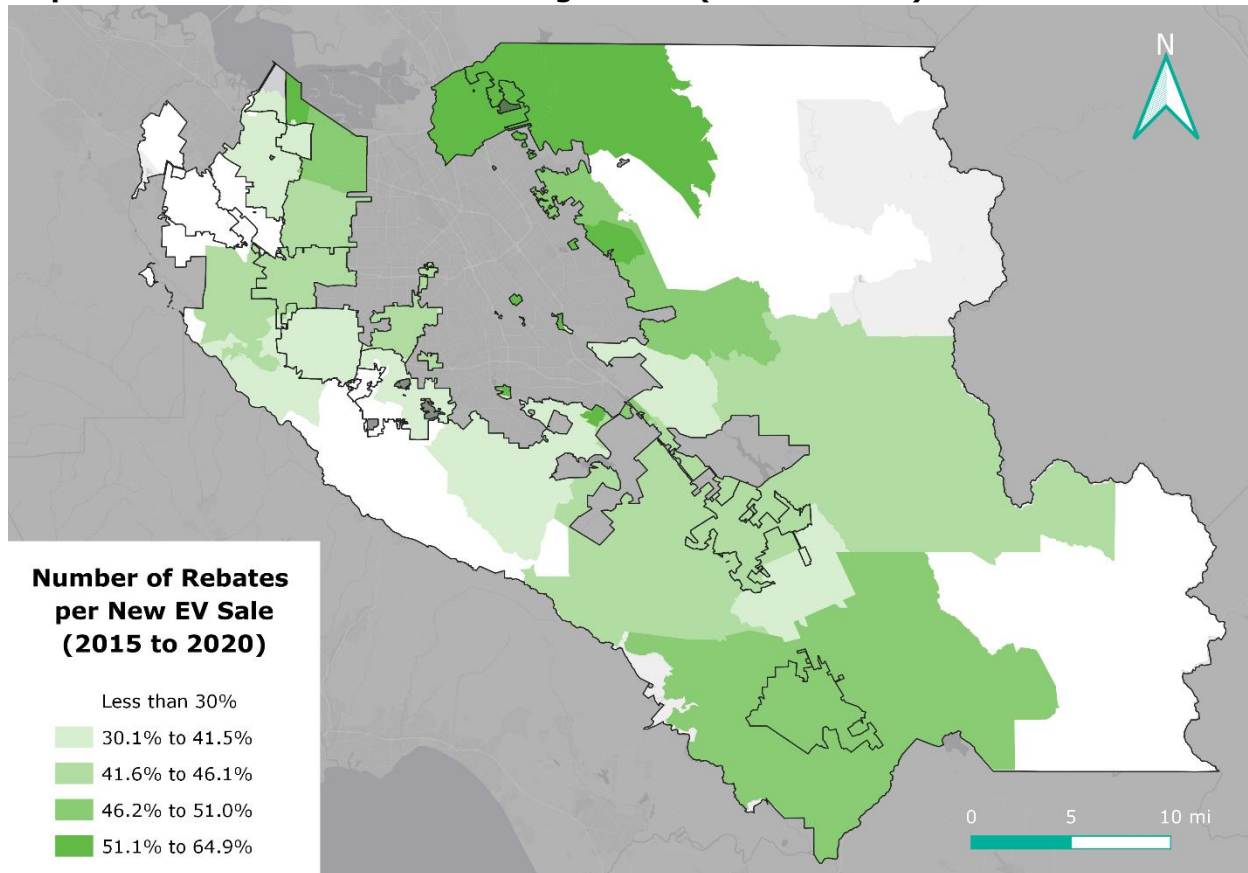
- A consumer must fall below an income cap of $150,000 for single filers and $300,000 for joint filers. Consumers do not have to show proof of income unless they are specifically asked for it.
- Rebates only apply for newly purchased or leased cars

- Rebates are typically about $2,000 for BEVs and $1,000 for PHEVs. However, households making 400% or less of federal poverty level can increase their rebate by $2,500.

Not everyone who purchases an EV is able to access the CVRP rebate, due to waitlists, limited funding, and the requirement that EVs be purchased or leased new. In addition to the restrictions placed by the rebate program itself, people may struggle to apply for the rebate, or they may be unable to afford the upfront costs of an EV while waiting for the rebate. The following two maps help visualize the relative accessibility of rebates and where EVs are most frequently purchased using them **(S-8)**.

Map 5: Total Number of EV Rebates Per Capita by Census Tract

Number of EV Rebates per Person

- 0.5 to 2 per thousand people
- 2 to 3 per thousand people
- 3 to 4 per thousand people
- 4 to 5 per thousand people
- 5 to 11 per thousand people

Map 6: Percent of New EV Sales using Rebate (2015 to 2020)

**Number of Rebates
per New EV Sale
(2015 to 2020)**

Less than 30%
30.1% to 41.5%
41.6% to 46.1%
46.2% to 51.0%
51.1% to 64.9%

Map 5 shows that the distribution of rebates is far from even, with some census tracts getting ten to twenty times more rebates per capita than others. This disparity may reflect difficulty accessing rebates among those in the census tracts with lower rates, or there may be less interest in purchasing EVs in the first place. The West Valley leads in SVCE territory, having used the most rebates per capita. Mountain View and Sunnyvale, two of the larger cities in the western section of SVCE territories, are more patchwork, showing variation in where people are accessing more rebates.

Map 6 shows the percent of EV sales that used a rebate. Because only the purchase or leasing of new EVs is eligible for a rebate, only new car sales are included in this calculation, which cuts out residents who are purchasing used EVs. Additionally, due to data constraints, the percent of new EV purchases using a rebate is shown by zip codes, which eliminates some granularity in areas like Sunnyvale, Mountain View, and Milpitas.

In terms of rebates per EV sale, the West Valley falls into the lower segments, with less than 46% of their new EV sales purchased with assistance from a rebate. This is likely due to income restrictions that only allow those households making $300,000 or less to use a rebate. Milpitas and the area of Unincorporated Santa Clara County near it, previously more of a patchwork, uniformly have much higher rates of rebates per sale than the West Valley, with more than half of EVs purchased with the assistance of a rebate. A significant portion of EV sales in Gilroy also used rebates. The difference between rebates used per capita and rebates used per car is likely because Gilroy has a relatively low EV adoption rate as demonstrated in Map 3 in the Location section.

SILICON VALLEY
CLEAN ENERGY

The difference between these two maps suggests that the large number of rebates going to areas in western Santa Clara County may be supporting EV purchases that could have happened even without the rebates. That so few of the EVs in this area are bought with credits may imply that many of the rebates used in the area were not necessary to the vehicles' purchase (although some residents and census tracts may be in more need of the support even if the zip code as a whole might not need it). The map also suggests that the EVs that are being purchased in places like Milpitas and the eastern edge outside San Jose use rebates for many more of their EV purchases but lack access to similar quantities of rebates even when normalized for population size. Community engagement around the challenges faced in these areas, and Gilroy to a lesser extent, could provide insight about the kind of programming that would most help these residents use rebates to increase their EV adoption rate.

The Greenlining Institute has crafted an Electric Vehicles for All Equity Toolkit[13], which discusses some of the reasons these rebates may not be reaching low-income households. They suggest that rebates that come after the point of purchase, like CVRP's, do not help households overcome the hurdle of a large upfront cost. They also mention that tax credits, like the federal government's, may not be fully useable by all households. Low-income families who do not owe $7,500 in taxes cannot claim the full value of the tax credit. The Greenlining Institute recommends point-of purchase incentives, i.e., rebates that can be applied to the purchase of an EV immediately, to ensure that these residents receive the full value of these incentives and can use them to overcome the hurdle of high upfront costs.

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[13] Greenlining Institute. 2016. Electric Vehicles for All: An Equity Toolkit. August 3. Accessed December 8, 2021.
https://greenlining.org/resources/electric-vehicles-for-all/.

EVI

In the previous section, this study began to discuss the relationship between EV adoption and the accessibility of charging infrastructure. In fact, there are many studies which suggest that a more visible presence of chargers can induce demand for EVs.

Electric vehicle infrastructure, or EVI, comes in 3 levels, defined by their power and thus the time it takes to charge a PEV.[14]

- **Level 1 (L1)** is the equivalent of a normal outlet at a house which charges a car to full in around 24 hours.
- **Level 2 (L2)** is slightly more powerful (but still able to use some outlets in a normal home) and able to charge a car fully within eight to twelve hours.
- **Direct Current Fast Chargers (DCFC)** are the most powerful and thus unable to be installed in normal voltage outlets. But they also charge extremely quickly, taking only a couple of hours and sometimes at little as 40 minutes to charge an EV to full.

For a more detailed description of the three levels of charging, please refer to **Appendix C: Explanation of EVI**. Because of the small amount of L1 currently deployed for shared private and public use in SVCE's territory, this study will primarily focus on L2 and DCFC chargers.

Public Chargers

Santa Clara County has some of the highest numbers of public EV charging in the state, both as an absolute number and per capita,[15] undoubtedly connected to its high EV adoption rates. Where and what kind of chargers these are connect to EV populations, but also other elements of the urban fabric, such as roads and land use. This is especially true for public chargers, or chargers that are open for anyone to use. The Alternative Fuels Data Center, a part of the US Department of Energy, maintains a country-wide data base of the location of each of these public chargers.

Land Use

To understand what land uses public chargers get built on, each charger in the AFDC data set was categorized into one of the groupings listed in Table 3 below. Because some chargers were located on the side of roads, the analysis looks at the nearest parcel of land when calculating these numbers. Chargers were counted by the number of charging ports they had, not just the number of individual chargers, to account for multiple people being able to charge at once for some L2 chargers.

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[14] Meffert, Ryan. 2021. "https://www.getneocharge.com/blog-post/three-levels-of-electric-car-charging." NeoCharge. November 29. Accessed December 8, 2021. https://www.getneocharge.com/blog-post/three-levels-of-electric-car-charging.
[15] California Energy Commission (2021). California Energy Commission Zero Emission Vehicle and Infrastructure Statistics. Data last updated October 29, 2021. Retrieved November 15, 2021 from https://www.energy.ca.gov/zevstats

Table 3: Land Use of Public Chargers in SVCE Territory

SVCE Territory	L2	DCFC
Residential	11%	1%
Industrial and Manufacturing	13%	4%
Utilities and Service Stations	0%	1%
Retail Uses	**21%**	**65%**
Office Uses	13%	5%
Parking	1%	0%
Parks and Recreation Centers	2%	0%
Schools and Universities	**22%**	9%
Hospitals and Nursing Facilities	3%	0%
Public and Other Quasi-Public Buildings	3%	0%
Agricultural	1%	7%
Unknown	8%	8%
Vacant Land	2%	0%
Grand Total	1,348	295

Table 3 shows how these public chargers are divided up amongst land use in the SVCE territory, with L2 chargers being used for different types of land uses, and DCFC chargers overwhelmingly service retail land uses **(S-9)**. For more information about the land use public chargers are located on by city, please refer to **Appendix D: City Tables of Land Use Near Public Chargers**.

Public L2 chargers are spread out primarily between retail locations and schools/universities, with some at office locations. While L2 chargers require more time to fully charge (6-12 hours) when people may only spend a couple of hours at retail locations, the relatively lower cost of L2 installation may make these chargers appealing for retail sites, leading to 21 percent of public L2s locating in retail areas. Many of the L2 chargers located on office uses are shared private chargers meant for just the employees of the companies in the building. Further research into why these offices have chosen to make their charging public could help open more charging to the wider community.

Schools and universities lead the deployment of public L2 chargers. Many of these chargers are located at colleges and universities, like Stanford University, De Anza Community College, and the NASA Ames Research Center/Cornell Satellite. But some, particularly in Los Altos, are located at grade schools. These grade schools tend to be in the middle of residential neighborhoods and are required in every community to provide all children with access to education. There are around 140 school sites[16] in SVCE territory, making them a convenient and plentiful site for public EV charging, though less than 20 grade school sites currently have charging onsite. Schools seem to historically have been a promising location for deployment, so perhaps they are good locations for other jurisdictions to consider when planning to build out charging in their territory.

When it comes to DCFC, chargers are overwhelmingly located in retail areas. These retail areas are fairly condensed as well; 18 parcels house all 191 DCFC chargers that serve retail locations.

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[16] California Department of Education. 2021. "California School Directory." Public Schools and Districts Data Files. Accessed October 2021. https://www.cde.ca.gov/ds/si/ds/pubschls.asp.

Because of the speed of charging, retail locations can be sites that offer locations that provide more customers for the charger throughout the day. More customers mean that the much more expensive installation cost of DCFCs can be recuperated faster. The next largest use category where public DCFC chargers are sited is schools and universities. A little less than two thirds of these are at colleges and universities, which makes sense given that post-secondary students' schedules are more open, and do not require staying in the same place for the full day.

Public chargers play a role in supporting EV ownership for everyone but may be most helpful to those who are not able to charge at home. This group includes multi-family building residents, especially those who are renting, as connecting EVs to home outlets or installing EV charging is often technically or economically infeasible in their situation.

The number of commercial and industrial parcels in a census tract has more of a positive correlation with the number of public chargers than the number of multi-family units. This is likely because commercial parcels are primarily where chargers are placed, so a higher number of siting locations exist. However, both relationships are tenuous, with other unknown factors impacting the number of public chargers in a census tract.

Figure 8: Relationship between Number of Multi-Family Units and Chargers by Tract
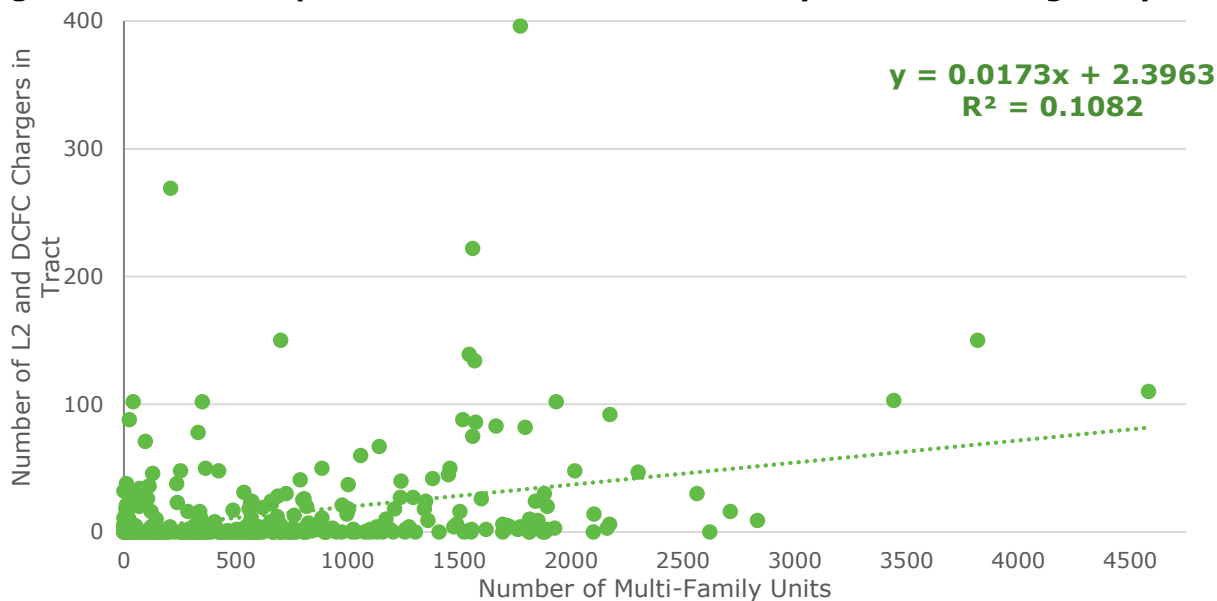

Figure 8 shows the relationship between number of chargers and number of multi-family units in each census tract in SVCE territory. With an r-squared of 0.11, the relationship between these two variables is weak. In addition, the low coefficient on the regression line shows that this result isn't very practically significant either, with this model expecting to see only a one charger difference for every one hundred units of multi-family housing.
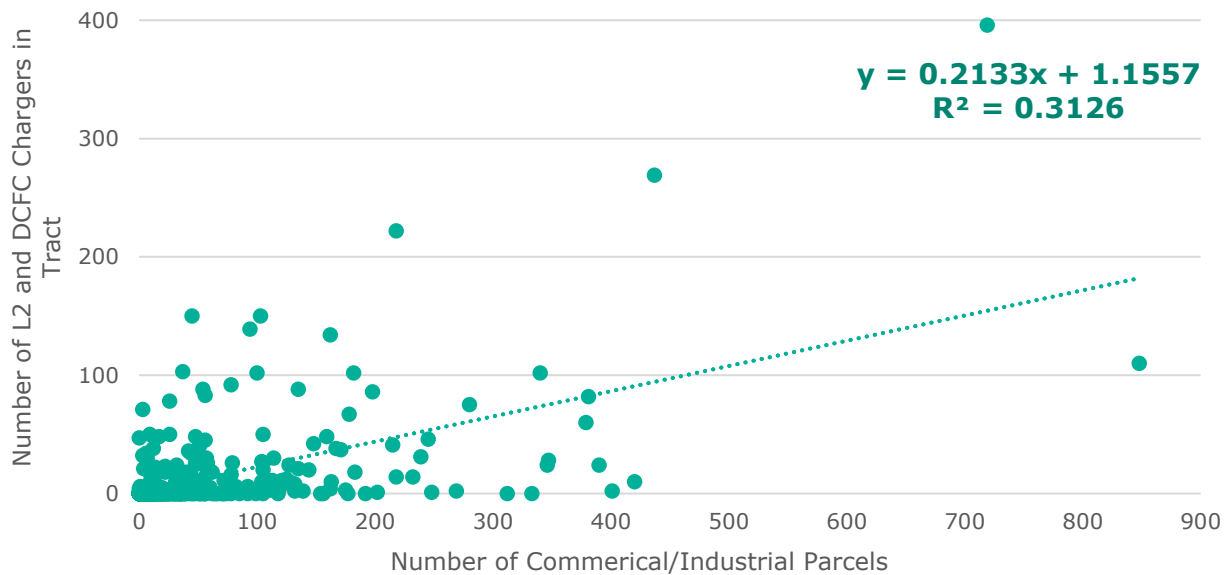
Figure 9: Relationship between Number of Commercial Parcels and Chargers by Tract
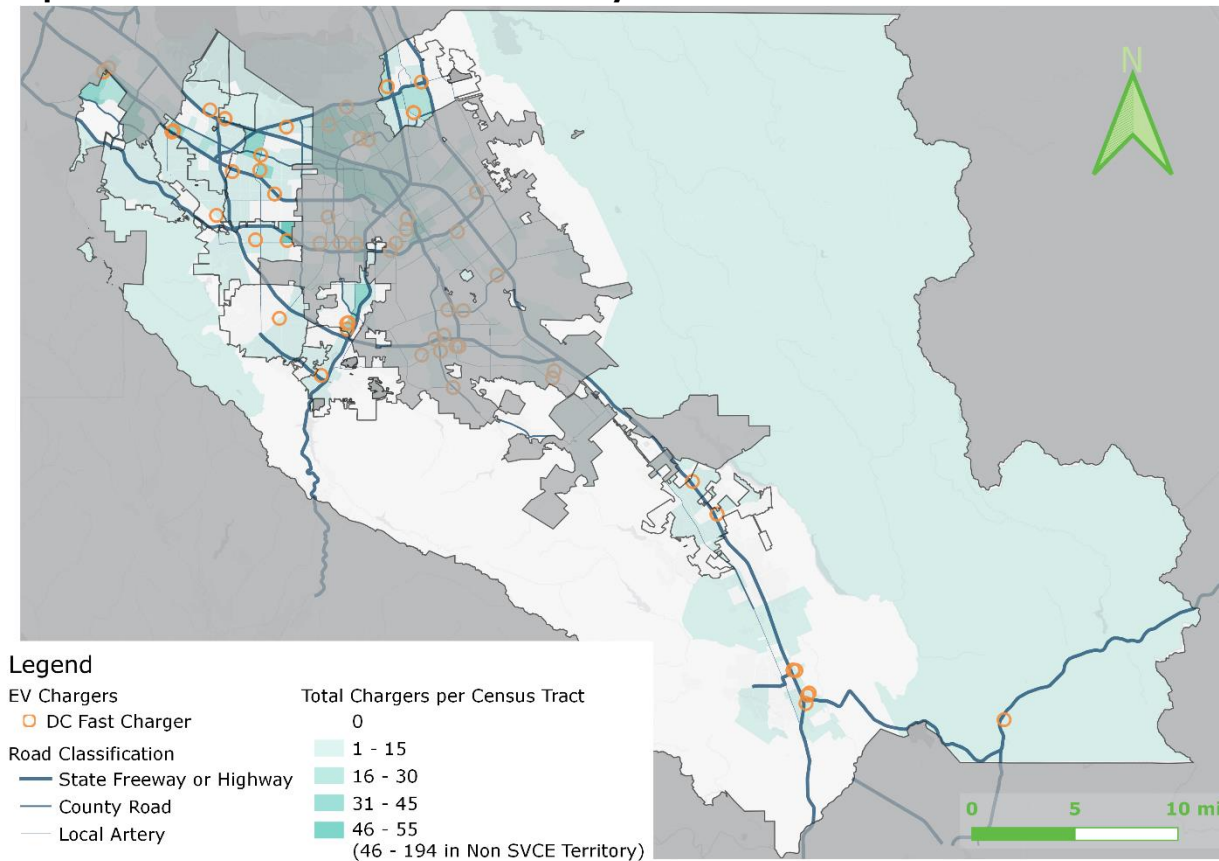

$$y = 0.2133x + 1.1557$$
$$R^2 = 0.3126$$

Figure 9 shows the relationship between the number of commercial and industrial parcels and number of L2s and DCFCs in a census tract. This is a more robust relationship than that between number of public chargers and multi-family units. With an r-squared of 0.31 compared to 0.1, three times more of the variation in the number of chargers in a census tract can be explained by the increase in commercial and industrial parcels than the increase in multi-family units. This positive correlation is the relationship we would expect with commercial areas making public chargers more economical for charging station owners and operators.

Proximity to Transportation

In addition to the land uses chargers are available on, public chargers especially serve nearby land uses as well. To take advantage of as many customers and different land uses as possible, most public chargers seem to be located near large roads. Map 7 shows both L2 and DCFC grouping near major roads.

Map 7: Location of Public Chargers in SVCE Territory
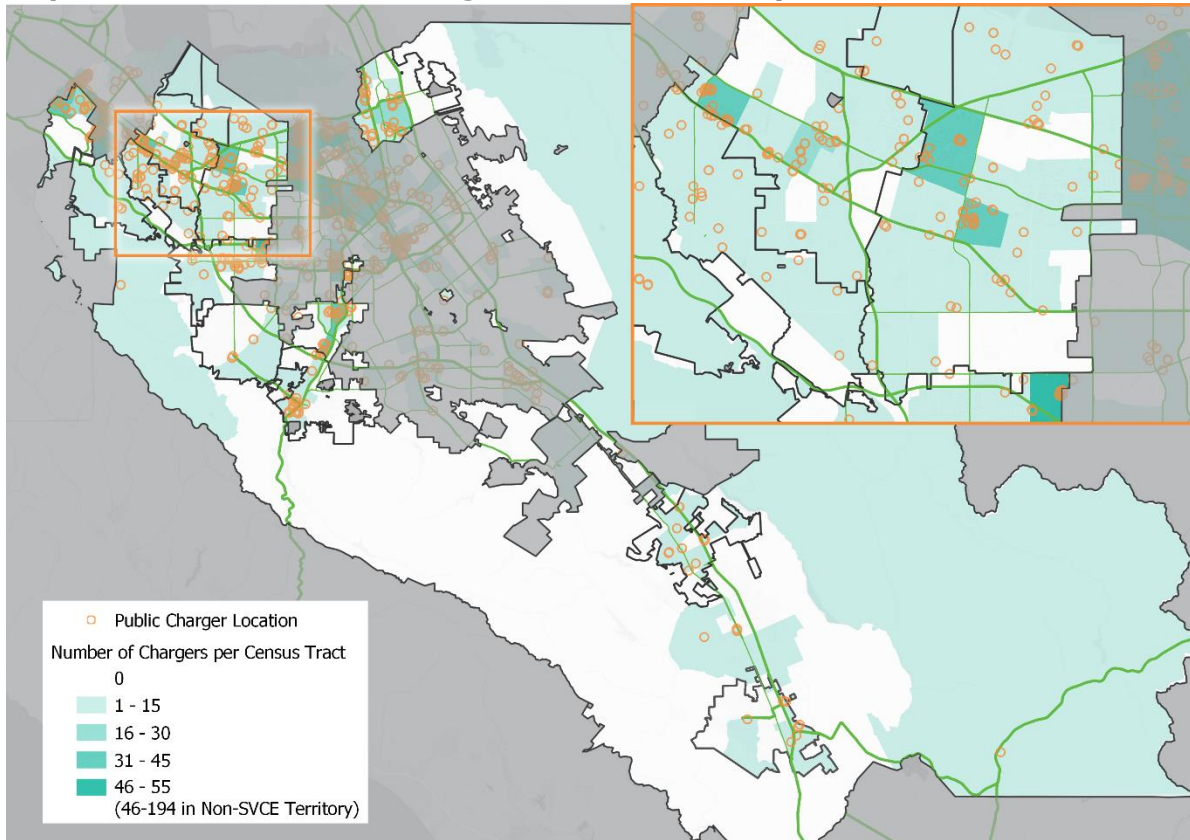
Public chargers gather in Mountain View and Sunnyvale along El Camino Real, as well as in Campbell and Los Gatos along Highway 17. The few chargers in Gilroy and Morgan Hill are along Monterey Road and the 101. These locations provide visibility for chargers, allowing owners and managers to get the as much value as possible from these chargers. In fact, of the 2,085 L2 and DCFC chargers in SVCE territory with precise location information, 1,263, or over 60% percent, are within a third of a mile of a major road.

Map 8: Location of DCFC in SVCE Territory

Legend

EV Chargers
○ DC Fast Charger

Road Classification
— State Freeway or Highway
— County Road
— Local Artery

Total Chargers per Census Tract
0
1 - 15
16 - 30
31 - 45
46 - 55
(46 - 194 in Non SVCE Territory)

Map 8 shows just DC Fast Chargers. The tendency towards gathering by large roads such as freeways is even more noticeable here, with 274 of 297 chargers (90 percent) within a third of a mile of large roads. DC Fast chargers, as the most powerful and most expensive chargers to maintain, require large populations using them to make the chargers economical. They also, as chargers that refill batteries fastest, are a valuable way to keep travelling on to further destinations without having to get bogged down on side-street traffic.

Shared Private Charging

Estimating Territory Shared Private Charging

A large element of charging infrastructure, especially throughout the Silicon Valley, is workplace charging. However, unlike public charging, there is very little information about these workplace chargers, and other "shared private" chargers, as the State of California calls them. The California Energy Commission has done a survey of private EVSE companies to see how many of these shared private chargers exist at the county level. According to this survey, the whole of Santa Clara County has 11,925 shared private chargers, with the breakdown of what different levels of chargers these are in Table 4.

Table 4: Shared Private Chargers by Level in Santa Clara County (not SVCE-only)

Level 1	Level 2	DCFC	Total
74	11,755	96	11,295

Because there is no further location information, or data about which commercial customers have installed these chargers, there is no certain way to understand how many of these chargers are within the SVCE service territory. However, this study has used several methods to estimate the ratio of chargers in Santa Clara County **(S-10)**. The results of these methods are shown in Table 5.

A few methods were based on population, both actual and service. The population method uses a ratio of the population of people living in SVCE territory vs non-SVCE territory to estimate the split of Santa Clara County's shared private charging between SVCE service territory and non-service territory. Slightly more complex population estimates found the ratio of service population, which is defined as the people who both live and work in each community of Santa Clara County, grouped into SVCE territory and non-SVCE territory. The two ratios were calculated in two ways: people who worked in the two areas, and people who lived or worked in them. The service population data was pulled from the MTC Traffic Model[17].

In addition to population ratios, ratios of known chargers were applied to the Santa Clara County number. One method involved using robust Alternative Fuels Data Center (AFDC) data about the number of public chargers in SVCE cities compared to San Jose, Santa Clara, and Palo Alto. Another method looked at applications from the local California Electric Vehicle Infrastructure Project (CALeVIP), an SVCE- and state-funded grant program to help build charging infrastructure. This study used the number of applications for SVCE service territory compared to San Jose, Santa Clara and Palo Alto's volume of applications to estimate how chargers might be split. The results of these various estimation methods, as well as an average of all of them, is shown in Table 5.

Table 5: Methods of Estimating Shared Private Charging in SVCE Territory

	SVCE		Non SVCE	
	Percent	**# of Chargers**	**Percent**	**# of Chargers**
Population	36.8%	4,394	63.2%	7,531
Service Population: Work-In	35.2%	4,193	64.8%	7,732
Service Population: Live-in, Work-in	37.5%	4,476	62.5%	7,449
AFDC: Total Ratio	43.9%	5,237	56.1%	6,688
CALeVIP: All Applications	40.5%	4,828	59.5%	7,097
Average	**38.8%**	**4,626**	61.6%	7,350

All forms of estimates suggest that SVCE territory has somewhere between 35 to 45 percent of the shared private chargers in Santa Clara County **(S-10)**. This is lower than previous estimates done in 2018 by consulting firm DNV suggest. They had estimated around 8,000 private chargers, which is still less than all shared private chargers for the county that the state identifies, but would leave San Jose, Santa Clara, and Palo Alto, which make up almost two thirds of the county's population, with less than 30 percent of its chargers.

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[17] Bay Area Air Quality Management District. 2015. Vehicle Miles Traveled Dataportal. Accessed December 8, 2021. https://vmtdataportal.mtcanalytics.org/.

Land Use

Because locations of shared private charging are largely unknown, there is no perfect way to understand what the split might be between shared private residential and shared private workplace in SVCE's territory might be. To approximate what the split might be, this study looked at applications to the Peninsula-Silicon Valley CALeVIP program for data on chargers throughout Santa Clara and San Mateo Counties **(S-11)**. Applications list what kind of charger and how many the applicant intends to build, as well as listing the location, site use, and existing audience for the chargers, which provides ways to distinguish between public and shared private chargers and provide an idea of what kind of site uses shared private applications are often associated with.

There are numerous caveats surrounding the use of this data. Chief among them is that the data does not represent already built chargers, and so does not show what site uses the current stock of shared private chargers congregates in, just where installers and operators are hoping to locate them in the future. One way this difference is shown clearly in the data is that the split between public and shared private charger applications in the CALeVIP dataset is two to one in favor of public charging, which is significantly different from the State of California's Counting Chargers survey which shows closer to a 75-25 split in favor of shared private chargers. This difference further underlines a disconnect between where and for whom applicants are hoping to install chargers (CALeVIP) and who currently installed chargers serve (Counting Chargers Survey).

A second caveat is that the CALeVIP program has a specific additional incentive for the development of chargers in multi-family dwellings, often cited as a gap in charging infrastructure to date. Thus, application ratios may show a higher percentage of multi-family dwelling shared chargers than currently exists. Additionally, not all the applications cite an existing need for chargers, so leave it blank or unknown.

This estimate will focus on L2 chargers, as opposed to DCFC. The CALeVIP program requires that all DC fast chargers are publicly accessible, making it so that few, if any, DC chargers would be intended for these shared private audiences, thereby skewing the results of this estimate. Additionally, shared private chargers are overwhelmingly L2 in the Counting Chargers survey. This is because L2 chargers take longer to charge a car and thus are better suited to employees and residents, who stay in one place for longer times. Meanwhile the high installations costs of DCFCs have conventionally pushed owners to make them publicly available to maximize utilization.

Despite these caveats, the CALeVIP data is one of the best ways currently available to estimate where shared private charging is in SVCE territory. Table 6 takes a closer look at specific site uses for the shared private charger L2 applications. It shows a general split of two thirds workplace charging and one third residential charging **(S-11)**.

Table 6: Estimate of Existing Shared Private L2 Chargers in SVCE by Specific Site Use Using CALeVIP Application Data

	Shared Private		
	Employee	Resident	Total
Workplace	2,560	-	2,560
Multi-Family Building	21	1,391	1,412
Parking Lot or Garage	201	17	219
Public facility	142	-	142
Entertainment	-	35	35
Religious Establishment	77	-	77
Hospital	35	-	35
Retail Centers	21	-	21
Colleges and Libraries	-	-	-
Gas Station	-	-	-
Unknown	35	-	35
None of the above	91	-	91
Grand Total	3,182	1,443	4,626

The grand total of these chargers suggests that the split between shared private chargers is roughly two thirds going towards workplace charging and one third for residential charging. Residential charging in this case is for multi-unit dwellings, as single-family households do not share their private charging. Given that Silicon Valley has many more people living in single family homes than multi-family ones, and the difficulties of installing chargers in these larger, and often older, buildings, this split makes sense. It's also interesting to note the difference in diversity of site locations. While chargers meant for residents are almost uniformly in multi-family buildings, there are a wide variety of places that may have charging for employees, including some multi-family buildings. Retail centers and hospitals are also locations that can serve employees, though they also may have public charging. From the information provided by CALeVIP, however, it is unclear if these chargers in public places that are intended for employees would be private or would also be available to the public.

Without more detailed data on workplace and other shared private charging, more detailed analysis of how existing workplace charging plays a role in the adoption of EVs is challenging. This lack of knowledge may result in stranded assets, such as installing too much public charging when shared private charging is preferable for consumers. One avenue for cities and other communities to consider is whether they might be able to require reporting on EVI deployed at sites or from active EVSE companies. Or the state could require EVSE companies to report some aggregated information. Making this data usable by public agencies would not only allow communities to keep track of where all their EVI is, it could also open the door to more organized information about utilization, allowing governments and private entities alike to make more informed decisions about how much EVI is enough.

Charging Paradigms

To be able to estimate how much EVI is enough, it is crucial to understand charging paradigms: how, when and where people charge their EVs.

Because of a lack of access to data, disparities in EV adoption across populations, and relatively small sample sizes, charging paradigms can be unclear and subject to dramatic change. Different policies surrounding EVI also has the possibility of shifting charging paradigms in the future. A look what information there is about the current state of charging is helpful, and although high-quality data about where, when, and how EV owners in SVCE territory specifically charge their cars is scarce, this study will look at a non-representative source that SVCE has access to.

SVCE began the pilot phase of its GridShift program in 2020, which uses an app and telematics in the vehicle to manage EV charging at home. The program, which recently expanded its service population from 90 users to about 250, can collect information about which home charging sessions are managed or unmanaged and is also able to identify charging sessions that are away from home but does not provide further information about where they happen. Nevertheless, it provides some information about how much energy the pilot group of customers gets from charging at home, with Figure 10 showing that roughly 80% of energy is received at home **(S-12)**. It should be noted that the express point of this pilot was managing at-home charging, so the population of this pilot all had home charging access, which may be different from the broader vehicle-owning population. In addition, these participants all currently have EVs, and so are still early adopters of the technology. As the CEC points out in their discussion around EVI-Pro, these early adopters have charging habits that may be quite different from what the rest of the population would do if they had EVs. So, while 80% of electricity for EVs is currently received at home, different charging paradigms may need to be created to enable more people, especially multi-family tenants, to adopt EVs.

Figure 10: Energy Delivered (kWh) during EV Charging by Location
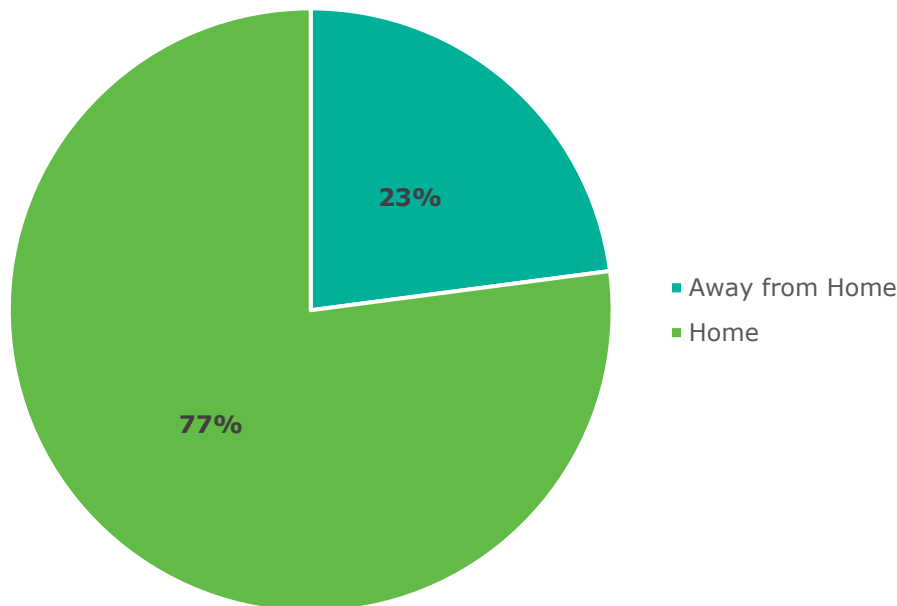
Charging Permit Streamlining

One policy that hopes to increase EVI development is permit streamlining. AB 1236, passed in 2015, requires local governments to create a streamlined process for permitting the construction of EV charging stations. The law requires eight elements to consider the process streamlined, including an ordinance approval for all permit applications that meet requirements and an easily

accessible checklist for interested applicants of what those requirements are.[18] For more information on these requirements, see **Appendix E: Permit Streamlining Requirements and Member Agency Status**.

Many cities in the SVCE territory are at least partially streamlined, according to the Governor's Office of Business and Economic Development.[19] While these streamlined communities have seen an increase in their average charger growth per year, so have the non-streamlined and partially streamlined communities, because the market for EVI deployment grew across the state and the country. Ultimately there is not a statistically significant difference between the charger growth rate of streamlined communities and that of non-streamlined communities yet.

Table 7: Effect of Permit Streamlining on EVI Deployment by Community

	Streamlining Status*	Pre-Streamlining Average Growth (chargers per year)	Post Streamlining Average Growth (chargers per year)	Rate Growth
Campbell	1	1.0	22.2	2146%
Cupertino	1	4.0	53.9	1247%
Gilroy	7	3.8	6.7	77%
Los Altos	Not Streamlined	29.4	not applicable	-
Los Altos Hills	Not Streamlined	9.2	not applicable	-
Los Gatos	7	0.0	17.0	1700%
Milpitas	7	4.6	38.9	755%
Monte Sereno	1	0.0	not applicable	-
Morgan Hill	7	1.3	9.5	613%
Mountain View	5	10.9	109.6	909%
Saratoga	6	0.0	8.1	813%
Sunnyvale	5	26.0	82.3	217%
Unincorporated	7	2.2	55.3	2394%

*refers to the amount out of 7 required and 1 optional elements of permit streamlining that have been completed

Table 7 shows each community's pre and post streamlining average annual growth rate of public chargers. Pre-streamlining growth rates were calculated from the time when their first public charger opened. Only chargers from the AFDC database were included in this calculation, so these growth rates do not account for most shared private chargers. As the table demonstrated, communities run the range of growth, though all communities grew at least a little. However, after a difference in difference regression run on Santa Clara, Alameda, and San Mateo counties and the communities in them (to account for technology growth throughout the years) the difference between growth rates of streamlined and non-streamlined communities was not found to be statistically significant. However, it is important to note that even streamlined communities have substantial variability in how many streamlined elements they have adopted.

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[18] Governor's Office of Business and Economic Development. 2019. "Permitting Electric Vehicle Charging Stations Scorecard:." Plug-in Electric Vehicle Charging Station Readiness. July. Accessed December 9, 2021. https://static.business.ca.gov/wp-content/uploads/2020/01/Permitting-Electric-Vehicle-Charging-Stations-Scorecard.pdf.

[19] —. 2021. Plug-in Electric Vehicle Charging Station Readiness. Accessed December 9, 2021. https://business.ca.gov/industries/zero-emission-vehicles/plug-in-readiness/.

With many of the these streamlined processes newly on the scene, it may be that more noticeable effects will occur over time. A lack of ability to count shared private charging chargers by city may also be obscuring some of the impacts of streamlining.

Charging Reach Codes

On the other end of the spectrum, communities can also use regulations, such as building codes, to require increased EVI development. The state of California updates its building codes every three years, which apply to every newly constructed building, as well as for renovations that increase building size.20 However, communities may also adopt higher standards, called reach codes.

Recently, SVCE engaged in an effort to help member cities to pass reach codes that include provisions requiring a certain amount of EV charging and charging capability for residential and commercial uses. Many member cities have adopted reach codes that require EVI for residential and non-residential buildings. See **Appendix F: SVCE Territory EV Reach Codes** for tables created by SVCE that describe these reach codes.

SVCE is working on evaluating the effects of the reach codes and will share results as they become available. For the moment, eight of thirteen communities have passed reach codes which include EVI requirements. Some communities require wiring that will allow EV charging to be installed at a later date in both residential and commercial areas. Two communities, Sunnyvale and Mountain View, require actual chargers installed at office spaces. As SVCE begins its new round of reach code initiatives, member communities will hopefully continue to increase the ambitions of their building codes in service of further EVI deployment.

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[20] California Department of Housing and Community Development. 2019. California Green Building Standards Code — CALGreen. Accessed December 9, 2021. https://www.hcd.ca.gov/building-standards/calgreen/index.shtml.

COMPARISONS

With a stronger understanding of where both EVs and EVI are being deployed, and who is deploying them, this study now aims to compare the status of EV and EVI deployment with each other, as well as with future estimates and goals for each. These comparisons elucidate the lack of relationship between where EVs exist and public EVI is getting deployed, as well as the further strides the region needs to take in increasing adoption to reach state goals around EVs and grid capacity/reliability.

Comparing EV to EVI

Because EVs need chargers the way that ICE vehicles need gas stations, this study also attempts to see if there is a relationship between the siting of chargers and EV adoption. While the county overall has both one of the highest EV adoption rates as well as one of the highest numbers of chargers installed, the study attempts to see if there is a more granular relationship that can be discovered to identify the most promising EVI deployment strategies in stimulating EV growth.

One would expect a positive correlation between the number of chargers and the number of EVs because access to chargers means EVs can be driven more like ICE vehicles (for longer times and without range anxiety). In addition, access to chargers should make more of a difference for non-single family EV owners. This is because single family EV owners tend to be able to easily plug into an outlet from their garage, while multi-family residents are more dependent on chargers because outlets their car has access to can be few and far between.

There are some data limitations that prevent a closer analysis of how EVI deployment might be related to EV adoption in this study. This study can only look at public chargers because they are the only one with location specific data that allows delving into relationships between EVs and EVI at a census tract level. However, as the CEC Counting Chargers survey shows, the number of public chargers makes up only a quarter of all chargers within the county, with about three quarters of charging being shared private. In addition, location is not the only thing that impacts charger use – the literature also suggests cost, duration, and waiting time all make a difference[21], aspects that even the public chargers do not have consistent data for. It is possible that a survey sampling different EV owners might be the necessary future step to understand more clearly consumer preferences for EVI siting.

Ultimately, however, there seemed to be no robust relationship between the number of chargers and the number of EVs on a more granular level, even controlling for a few explanatory factors like median income **(S-13)**. Analyses done include:

- Number of EVs compared to total number of chargers in SVCE territory by census tract
- Number of EVs Registered to Multi-Family Households Compared to Total Number of Chargers in SVCE Territory by Census Tract
- Number of EVs registered in multi-family building compared to distance from nearest charger in SVCE territory
- Multi-family EV to charger ratio compared to median income by census tract
- Number of EVs registered to single family households compared to total number of public chargers in SVCE territory by census tract

To see these regression analyses, refer to **Appendix G: Comparing EV to EVI Calculations**. The strongest relationship that could be found was between the single family EVs and chargers by

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[21] Wolff, Stephanie, and Reinhard Madlener. 2019. Charged up? Preferences for Electric Vehicle Charging and Implications for Charging Infrastructure Planning. Working Paper, Aachen: Institute for Future Energy Consumer Needs and Behavior (FCN).

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median tract income, showing that the higher income a tract is, the more EVs there are for every charger. This lines up with expectations that single family EV owners are less dependent on public chargers, especially as income goes up. Figure 11 shows this relationship below.

Figure 11: Relationship between Single Family EVs to Public Charger Ratio and Tract Median Income
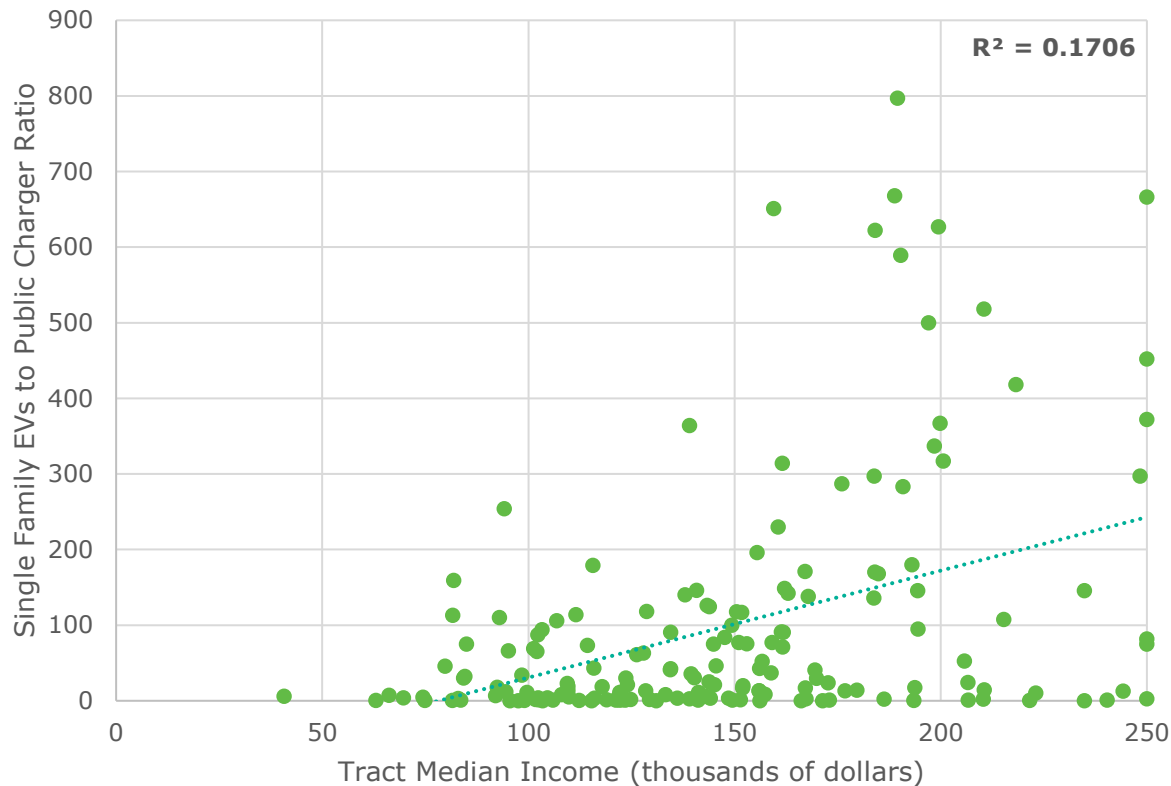
Comparing Current Situation to Forecasts

One important point of comparison is to see how SVCE territory's deployment of EVs and EVI matches forecasts and state mandates. This section will look at what historical trends and other forms of modelling suggest about meeting these goals.

EVs

Executive Order B-48-18 requires 5 million ZEVs on California roads by 2030. If historical growth of EVs continues linearly in SVCE territory, the area is not on track to meet its portion of that goal. However, other projections that suggest polynomial growth in EV population could put the territory past its goal by 2026 **(S-14)**.
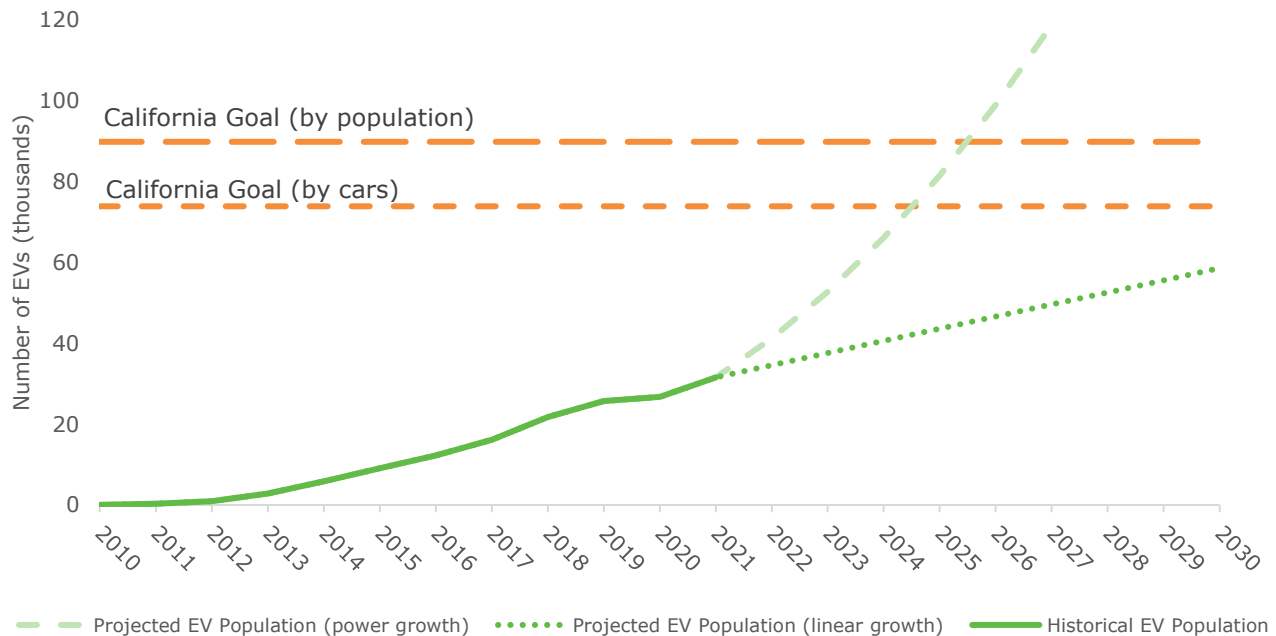
Figure 12: Projected EV Population Growth Compared to State Goal

Figure 12 used historical counts of ZEVs on the road from the CEC[22] for Santa Clara County, as well as data from DMV records for SVCE territory in 2021. To reduce historical counts of ZEVs in Santa Clara County down to the number of ZEVs in in SVCE territory, the 2010-2014 and 2015-2019 ACS population ratios were used. By creating a line of best fit for existing data, EV population in the next 9 years was estimated. SVCE's portion of the five million ZEVs on the road by 2030 was found in in two ways; finding the proportion of people living in SVCE territory compared to the state suggests a goal of nearly 90,000 cars, while finding the proportion of cars registered to SVCE territory compared to cars registered in the state put the number of EVs that SVCE territory is responsible for having on the road at about 74,000.

The linear projection in Figure 12 above is likely a conservative estimate, but it puts the region more than 30,000 ZEVS behind the population-calculated proportion of the five million ZEVs by 2030 mandate. This means that SVCE would only have two thirds of its portion of EVs on the road. Polynomial growth is also a possibility. With an R^2 of 0.93, compared to 0.96 for the linear growth model, historical trends still fit the model quite well. In this case SVCE meets its portion of the five million ZEV goal by 2026 and more than doubling even the higher estimated proportion in 2030.

However, following the polynomial curve instead of the linear one will require continued involvement by the state to ensure that EV adoption growth has increasing momentum. This means that EVs need to be adopted by all kinds of people, not just those who have been able and willing to purchase them historically **(S-14)**.

In addition to the state's goals, SVCE also has its own decarbonization goals of a 50% reduction in greenhouse gas emissions by 2030. To meet this goal with just transportation decarbonization require almost 100 percent of vehicles on the road in SVCE to be transitioned. This means there are about 440,000 ICE vehicles that would need to be EVS, which is still more than double even

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[22] California Energy Commission (2021). California Energy Commission Zero Emission Vehicle and Infrastructure Statistics. Data last updated October 29,2021. Retrieved October 4, 2021 from https://www.energy.ca.gov/zevstats

the exponential estimate. Even if building electrification can take on half of SVCE's reduction goals, this more optimistic projection puts the region just shy of the amount of EVs needed on the road to replace ICE vehicles.

EVI

While there is no state mandate for a specific number of charging stations to reach by 2030, Assembly Bill 2127 does require the CEC to provide an estimate of charging needed to support the state's EV population. The assessment for this bill suggests 1.2 million chargers needed by 2030 for the 7.5 million EVs estimated to be on the roads by then[23]. Due to a lack of historical data on shared private charging, these chargers have not been included in the count. Nonetheless, public charging has shown remarkable growth, especially for L2s. This growth seems more rapid than current EV growth, suggesting that current charger to vehicle ratios may not be optimal **(S-15)**.

Figure 13 shows the historical growth of L2 chargers. L2 and DCFC chargers have been separated out because differing costs and technological growth have made installations of these technologies different.

Figure 13: Historical Growth of Public L2 Chargers in SVCE Territory
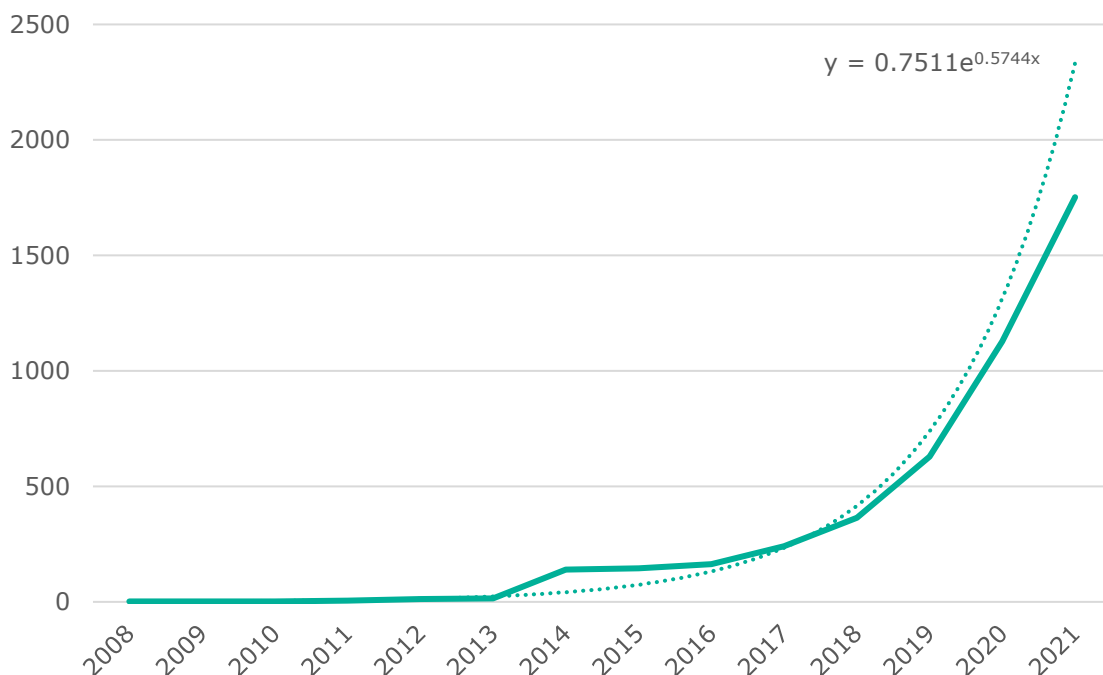

$$y = 0.7511e^{0.5744x}$$

Figure 13 shows that L2s have grown tremendously in the past decade and half, going from almost nonexistent in 2008 to over 1,700 in operation today. The historical growth pattern aligns with exponential growth, suggesting that investments in technology and public incentives have helped L2 deployment growth speedily.

Extending out exponential growth to 2030 puts SVCE territory at over 300,000 public L2 chargers. It seems deeply unlikely that this number of chargers will be built by then, given that exponential growth rarely lasts for a long time, and that there are currently less than 500,000 total vehicles on

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[23] California Energy Commission. 2021. Report Shows California Needs 1.2 Million Electric Vehicle Chargers by 2030. June 9. Accessed December 12, 2021. https://www.energy.ca.gov/news/2021-06/report-shows-california-needs-12-million-electric-vehicle-chargers-2030.

SVCE territory roads. EVI-Pro modeling[24] for Santa Clara County until 2025 (Figure 14) suggests more of a logarithmic growth for L2s in the whole county, getting to 12,000 L2 chargers in the whole county.

Figure 14: EVI-Pro Model of L2 Chargers in all Santa Clara County
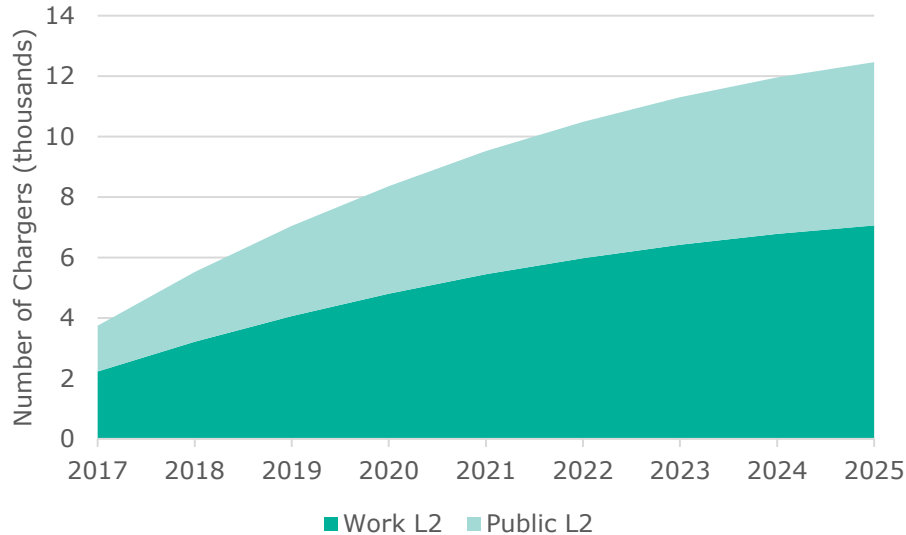
Along with EVI-Pro modeling at the county level showing a tempered growth pattern, typical development patterns of these type of technology suggest that the growth of L2 chargers will follow more of an s-curve shape. S-curves show a technology deployment progression that starts slowly, often because early models are expensive and not yet manufactured at scale. The middle portion of growth shows technology being rapidly deployed as economies of scale come into play, making mass production and adoption an affordable option. The final slowing of growth in a s-curve suggests that as the technology reaches saturation in the market, where almost everyone who wants or needs the technology has access to it, there are simply less people who need the technology, necessarily slowing and sometimes stopping the growth of the technology. These three phases seem likely to occur in the deployment of EVI, as prices for installation can still be prohibitively expensive in this early stage of adoption. Nonetheless, Figure 13 already shows rapid growth, which as mentioned in the previous paragraph must be tempered by the fact the population of SVCE territory, and in particular the car population of the territory, is not growing at nearly that speed.

To that end, Figure 15 shows an s-curve model of L2 growth until 2030. Many simplifying assumptions were made to create this model, which connect EVI growth directly to assumptions about the future EV population of SVCE territory. With this set of assumptions in place, Figure 15 shows the rate of growth of L2 deployment in SVCE territory still growing in 2030. This is why the figure does not show the third phase of a traditional s-curve shape.

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[24] NREL. 2018. *CEC EVI-Pro.* March. Accessed December 10, 2021. https://maps.nrel.gov/cec/.

Figure 15: S-Curve Projection of L2 Chargers
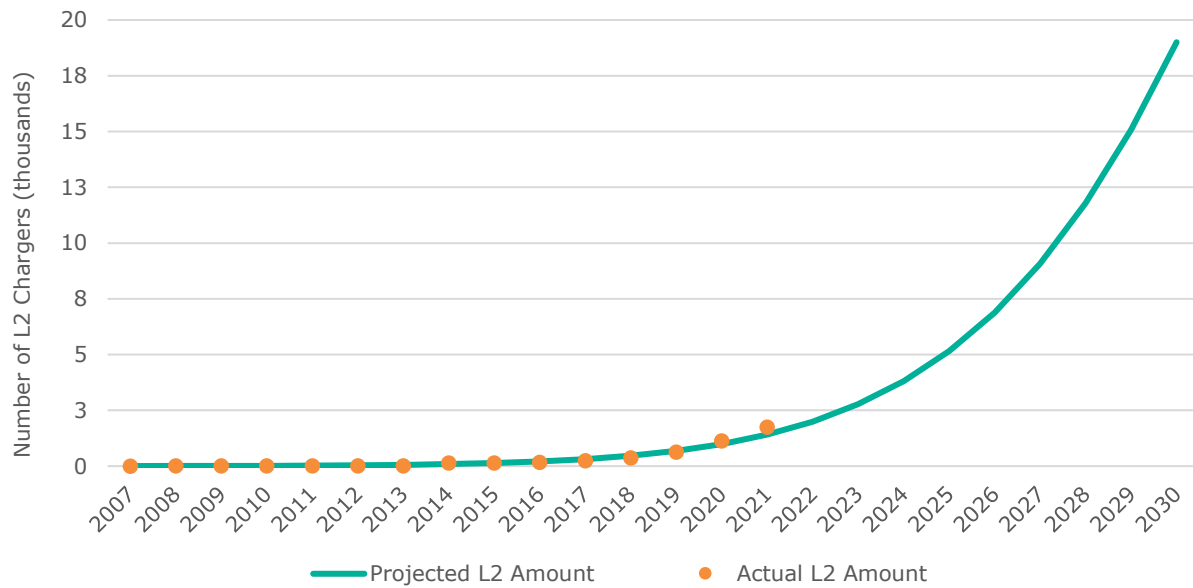
As previously mentioned, this model relies on several simplifying assumptions that likely do not hold true, making the number of L2 chargers that this model projects in 2030 likely too high. These assumptions are discussed in depth in **Appendix H: L2 S-Curve Projection Assumptions**. What follows is a summary of some of the most important assumptions and their impact on the model.

These assumptions rely heavily on EVs continuing to be adopted and becoming the entire car population in SVCE territory, and L2 chargers reacting exactly in tandem with that growth. Realistically, the growth of EVI is likely to be either a few years ahead or behind the growth of EVs, meaning the dates on this model are likely to be off by a few years. Another large assumption this model makes is just how many L2 chargers are needed to support the EV population. The maximum number of L2s in this curve is about 236 thousand, because it assumes that one L2 will serve two cars. DCFC charging, as well as the many private chargers that the data in this model does not account for means that this is an extremely conservative number, with less L2 chargers likely needed to support the EV population. L1 charging will also contribute to meeting the need.

DCFC chargers are also growing fast, though not as quickly as L2s, as Figure 16 shows. This is likely because DCFCs are much more expensive and trickier to install, requiring communication about interconnection with PG&E, due to the amount of power they need. Another reason for this slower growth is that fewer DCFCs are needed to serve the same number of cars as L2s, because charging time is much faster. Still, fast chargers are growing faster than a linear projection can account for.
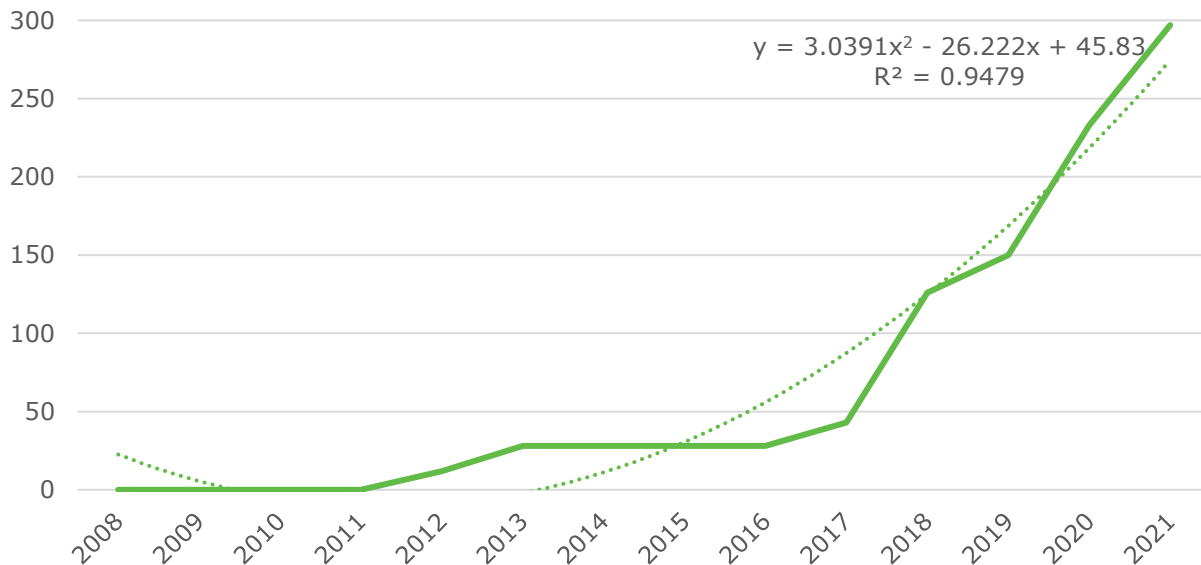
Figure 16: Historical Growth of DCFC Chargers in SVCE Territory

$$y = 3.0391x^2 - 26.222x + 45.83$$
$$R^2 = 0.9479$$

Figure 17 extrapolates that polynomial growth out to 2030, suggesting that SVCE territory could see over a little less than 600 by 2025, and one thousand fast chargers by 2030, which would be a doubling and more than a tripling of today's number respectively. Comparing these numbers against EVI-Pro's estimate for all of Santa Clara County in 2025, almost 600 chargers is about 30% of their estimate of 1,913 fast chargers in the whole county. Different methods of estimating the ratio of chargers in SVCE compared to the whole county in Table 5 put that ratio between 35% and 45%. As a result, this projected number of DC fast chargers may be a little low.

Figure 17: Projected Growth of DCFC in SVCE Territory
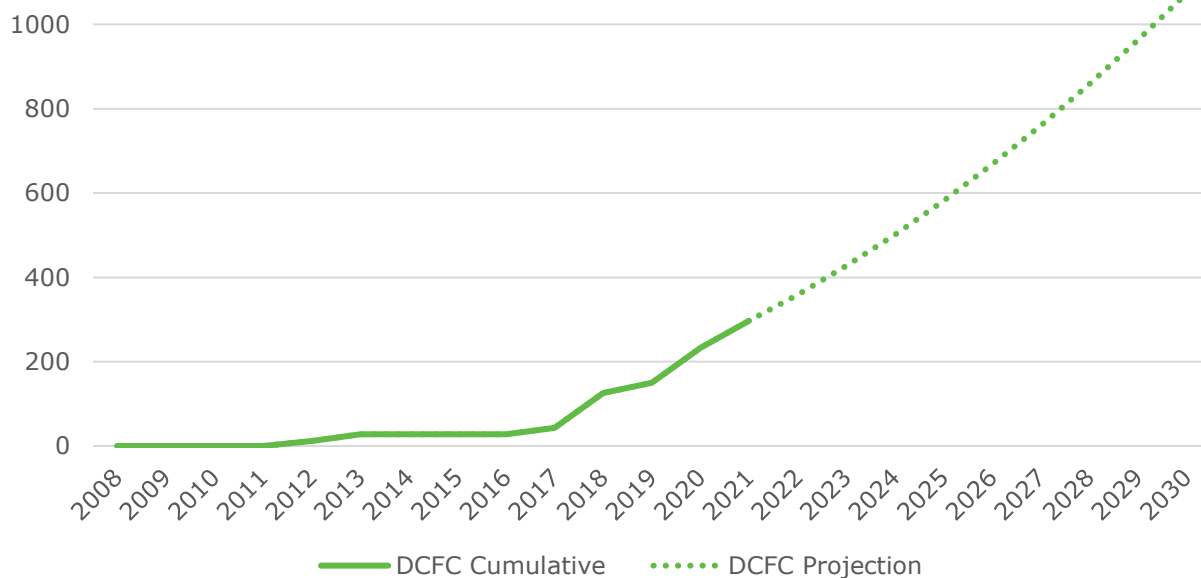
Comparing Future Loads

EV and EVI growth cannot happen in a vacuum. SVCE, as a load serving entity, must also provide electricity to power chargers and cars, while helping maintain reliability. To that end, understanding the load use and curve of future charging is vital to SVCE procurement and is a part of ongoing and periodic modeling (see SVCE's Integrated Resource Plan for more details).

AB 2127 requires the CEC to report on the amount of charging required to meet California's five million EVs on the road by 2030 goal. As part of this report, the CEC created a load curve estimate of how much electricity the 1.2 million chargers they estimate are needed to serve five million EVs use. Figure 18 below shows that load charge prorated to show SVCE's charging load and presents several challenges for the agency and the area's decarbonization goals in general. These challenges include the amount of power capacity needed to charge EVs, the difficulties associated with decarbonizing late night electricity usage, and the large deployment of residential level chargers **(S-16)**.

Figure 18: Modelled EV Charging Load Curve (based on CEC's AB 2127 report)
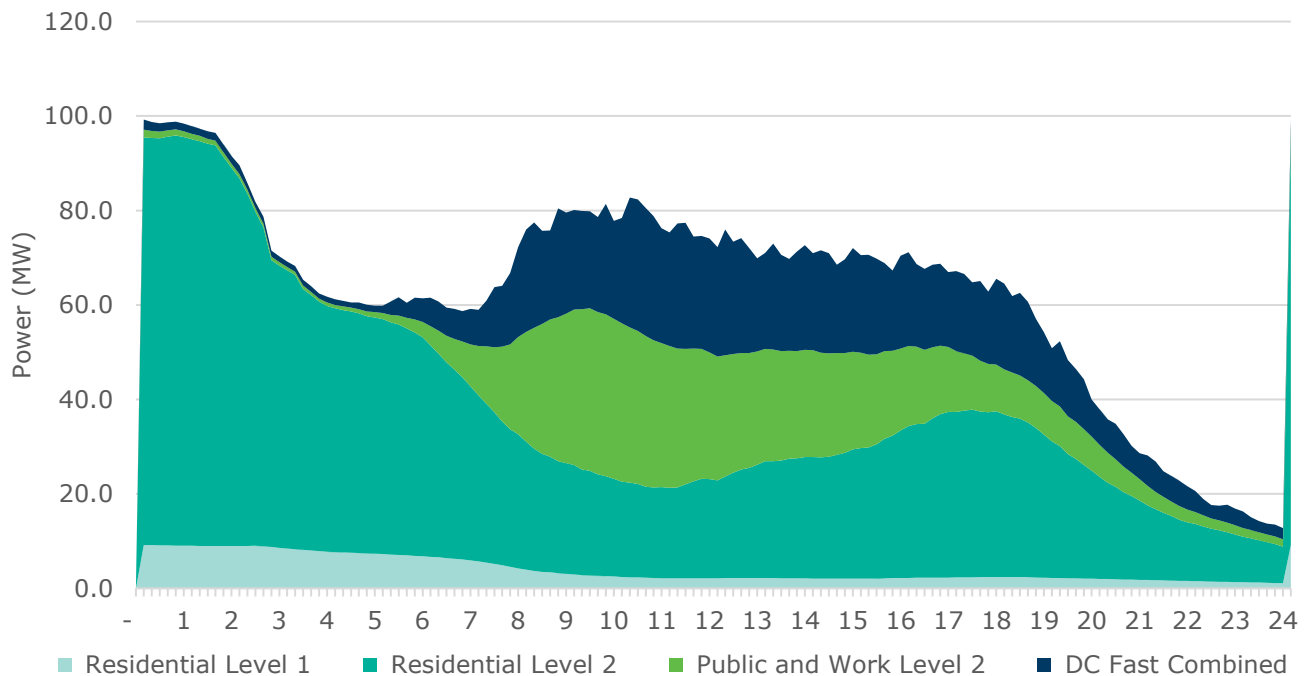
The staff report from the CEC that Figure 18 is based on uses four different modelling systems to estimate the number of chargers needed to serve Executive Order B-48-18's five million EVs on the road.[25] These models account for different types of vehicles as well as different vehicle trip patterns. They are:

- EVI-Pro 2 – local trip charging
- EVI-RoadTrip – interregional and interstate trip charging
- WIRED – Ride hailing/TNC charging needs
- HEVI-LOAD – medium and heavy-duty local charging

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[25] Alexander, Matt, Noel Crisostomo, Wendell Krell, Jeffrey Lu, and Raja Ramesh. 2021. Implementation of AB 2127 Electric Vehicle Charging. Commission Report, Sacramento: California Energy Commission.

As shown in Figure 18, the maximum expected power needed to charge EVs is about 100 MW. SVCE currently has clean energy projects that can provide "more than 700 megawatts (MW) of capacity," which means that about a seventh of that power capacity would be taken up just charging cars. Putting enough power on the grid to charge these cars reliably will require even more back up capacity. Another concern for the grid is the "spikiness" of DC fast chargers. Because they use large amounts of power intermittently, the fast load ramps will need a source of energy that can easily be turned off and on to provide the correct amount of electricity. These peak loads have been historically served by natural gas power plants, which are much more responsive and easier to turn on and off than wind turbines or solar PV **(S-16)**.

Focusing in on charger deployment, this graph also shows just how important residential L2 chargers will be. However, L2 chargers currently cost around $7,500-$8,000[26], including installation, in places like multi-family buildings and other tricky places, which is a hefty price tag. Ensuring that that these chargers are also available to low-income households may be a challenge.

Figure 18 also shows an extreme ramp up of charging at midnight. While this is in part because of simplifying model assumptions, the underlying importance of overnight charging to this projection is undeniable, as the convenience of refueling for a low cost at home while the vehicle is not in use is one of the perks of EVs. Unfortunately, nighttime is also when the grid is more dependent on fossil fuels because of renewable intermittency – solar power cannot be generated at night. This is problematic for SVCE's decarbonization goals. To overcome this mismatch between charging times and when electricity on the grid is cheapest and cleanest, large scale battery storage seems like a necessary investment. SVCE currently has "nearly 175 MW of battery capacity" which would be more than half taken up by overnight car charging, leaving little for other nighttime electricity usage.

SVCE continues to prepare for these challenges by tracking and forecasting EV growth in its territory. The agency is required to periodically file integrated resource plans[27] with the state to demonstrate how it will meet its forecasted load and address these challenges. Pilot programs like GridShift also aim to spread this load into non-peak daytime hours, using managed charging to target daytime hours where the grid is most powered by renewables, in addition to agency research on virtual power plants[28], which focuses on managing electricity demand throughout the day to increase renewable penetration without sacrificing grid reliability.

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[26] Courtney, Chris. 2021. "How Much Does it Cost to Install an EV Charger?" Behind the Wheel: Carvana Blog. July 19. Accessed December 10, 2021. https://blog.carvana.com/2021/07/how-much-does-it-cost-to-install-an-ev-charger/.

[27] Silicon Valley Clean Energy. 2020. "Standard LSE Plan: 2020 Integrated Resource Plan." Integrated Resource Plan, Sunnyvale.

[28] Silicon Valley Clean Energy and Gridworks. 2019. Silicon Valley Clean Energy Virtual Power Plant Options Analysis. Options Analysis, Sunnyvale: Silicon Valley Clean Energy.

CONCLUSION

Summary

Overall, this study was not able to identify clear connections between EV adoption and EVI deployment on a more granular scale within SVCE territory. However, there are several important takeaways of where EV adoption is strongest and where it still needs to grow, as well as where and how charging infrastructure is being used.

While EV growth is strong in the region, segments of the market still lag, such as SUVs and pickup owners, as well as multi-family residents and residents who are low-income, or otherwise more socio-economically vulnerable. Here are the key takeaways from the EV section:

(S-1)   The types of EVs that residents own shows that the market still does not provide the diversity of electric SUV and pickup truck models that residents enjoy with ICE vehicles. SUVs show slightly more variety in the EV market, as electric pick-ups are an emerging technology.

(S-2)   Transitioning all passenger vehicles, including SUVs, would lead to a 1,000 percent increase in electric vehicle miles travelled compared to today.

(S-3)   Medium and heavy-duty vehicles will also be important to electrify, as each mile driven by one such vehicle is responsible for double the amount of greenhouse gas emissions as a typical passenger vehicle.

(S-4)   Increased electric vehicle adoption throughout the region can reduce NOx pollution and PM2.5 deaths. This is especially true for vulnerable tracts, which, compared to less-vulnerable tracts, have on average a larger proportion of land near major roads where pollutants are most troubling for human health.

(S-5)   EV adoption rates are highest in West Valley, varying in Mountain View and Sunnyvale, and lowest in eastern and southern Santa Clara County.

(S-6)   Multi-family EV adoption rates are lower than single-family adoption rates in the region as a whole and in all cities.

(S-7)   EV adoption rates are strongly correlated with median household income, with higher incomes generally associated with higher EV adoption rates. The socio-economic vulnerability index (SEVI) is also correlated with EV adoption. The 19% of people who are in SEVI quartile 1 (the least vulnerable group) own 36% of all EVs in SVCE territory.

(S-8)   There is a difference between where the highest rebates per capita are and where the highest percent of new EVs are purchased with rebates, suggesting a mismatch between where rebates are going and where they are most needed.

Charging infrastructure has less data available for shared private charging, which makes up most of the charging in SVCE territory. The available data suggests that public and shared private charging are primarily located in different areas, reducing the redundancy of charging infrastructure and sunk costs. Despite the amount of public and shared private infrastructure, most charging today does still happen at home. Here are the key takeaways from the EVI section:

(S-9) Public L2 chargers are about equally spread between retail and schools/universities while public DC fast chargers are overwhelmingly in retail locations, with a total of 1,348 L2 chargers and 295 DCFCs available to the general public.

(S-10) The CEC provides the number of shared private chargers at a county level only, but an average of various methods suggests that SVCE territory has about 4,600 shared private chargers, which is around three fourths of all charging in the area.

(S-11) Using CALeVIP application data, this study estimates that about two thirds of these shared private chargers are for workplaces, and the remaining one third is for residences, primarily multi-family buildings

(S-12) According to data from SVCE pilot GridShift, about 80 percent of the electricity used to charge EVs comes from home.

No connections were able to be clearly drawn between sub-regional EV adoption and EVI deployment in SVCE territory. This may explain the difference in growth, as EV adoptions rates need targeted support to reach California state goals, while EVI is growing speedily, perhaps outpacing EV growth. Here are the key takeaways for the comparisons section:

(S-13) There is no clear connection between EV adoption and public charger location on a census tract level – although this should be an area of continued study at different levels, such as the county and household levels.

(S-14) It is unclear if EVs are growing linearly or exponentially but they need to grow more than linearly to reach the area's portion of the 5 million EVs by 2030, likely requiring further policy support.

(S-15) EVI is growing very fast in the simplified model for this study, far outpacing EV growth. More complex assumptions may change that rate of growth.

(S-16) When the region hits its portion of the 5 million EVs goal, the grid may need to provide almost 100 MW of power during the evening (equal to about one seventh of the power capacity renewable energy projects SVCE has developed to date).

Next Steps

There have been long standing data gaps complicating the study of EV and especially EVI deployment. These potential fixes could improve SVCE's ability to gather and analyze data:

EVs

- **Understanding Car Type**: Because of the overlap in different vehicle body types, DMV data lists many models under lots of different categories, making accurate accounting of broader vehicle types challenging. Being able to accurately distinguish between different types of cars will demonstrate the markets that EV cars are not serving in SVCE territory
- **Used EV Sales**: Most sources on EV sales only look at new car sales. As the market continues to grow, used EV sales will be especially important to track to understand affordable options for transitioning. Finding a reliable source of data for used EV sales will be vital to tracking

- **Multi-Family Car Ownership:** DMV data can be poorly set up to track different units inside of a multi-family dwelling. Since multi-unit dwelling residents are an important customer segment for equitable transportation decarbonization approaches, clarifying individual household car ownership through additional data would be valuable for developing strategies to engage these residents.

EVI

- **Shared Private/Workplace Charging Data**: The lack of specific information about where shared private chargers, specifically workplace chargers, are located, hampers analysis about the impact of workplace charging versus home or public charging. Whether this data is gathered from collaboration with EVSE network owners or customer surveying, this information will be vital for understanding what EVI deployment is the most valuable
- **Understanding Charger Utilization**: In the future, it would be good to know how much chargers are getting used, to help avoid sunk costs in EVI deployment.

There are some potential policy and program paths that have come from various elements of the analysis done with this baseline study. Since the purpose of this study was to gain an understanding of the current state of EV and EVI deployment, not to make policy recommendations, these paths all require further research before being implemented. Nevertheless, these may be valuable future research topics in continuing transportation decarbonization.

- **Rebate Access:** Disparities between where most CVRP rebates are going and where they purchase the most proportion of EVs suggests that people who need access to rebates to buy EVs do not have that access. Programs that help customers get access to these rebates or policy that funnels them towards the customers who need it most may help increase EV adoption rates.
- **Continue Permit Streamlining Processes:** Four out of thirteen communities in SVCE territory are completely streamlined. Ensuring that all thirteen communities are streamlined according to the Governor's Office of Business and Economic Development (and continuing to explore additional best practices) should make the development of EVI simpler and faster.

APPENDICES

Appendix A: Explanation of EVs

Electric vehicles distinguish themselves from internal combustion engine (ICE) vehicles through the construction of their engine. However, both engines can exist in a single vehicle, which can lead to confusion about what counts as an EV from study to study. There are four types of cars that at least partially use an electric engine[29].

The first type is the gasoline hybrid car, typified by the Toyota Prius. The gasoline hybrid relies primarily on an ICE to start the car and drive. These kinds of cars also recoup energy normally lost when breaking and reroute that energy to a small battery that powers the electric motor in the car, thus extending the miles per gallon efficiency of the ICE. Because these cars require gasoline to move, most studies of EVs do not include them in accounting for EV distribution and adoption. This study also will not include them as part of Silicon Valley Clean Energy's service territory EV population.

The next type of car to use an electric engine is the plug-in hybrid electric vehicle (PHEV). These cars are like gasoline hybrid cars in that they also contain an ICE as well as an electric engine and battery. However, the battery in a PHEV, usually much larger than the batter in a gasoline hybrid, can be charged by plugging it into an electric outlet. This means that the electric motor can start and drive the car, requiring no gasoline. PHEVs can often drive on just their battery charge for a range of up to ~50 miles, depending on the brand and other external conditions. Once the battery charge runs out, the car shifts to using its small ICE and functions in the same way that a gasoline hybrid car does. Because this car can function through just electricity as a fuel source, PHEVs will be included in counts of electric vehicles, unless otherwise noted.

The car that is what most people think of as an EV is often called a battery electric vehicle (BEV). These cars do not have any ICE and rely purely on electricity charged in a battery to be able to drive. Because they do not include another engine, the batteries for BEVs can be larger, thus allowing larger travel ranges using electricity than PHEVs, with some brands getting as high as 200 miles per single full charge. Oftentimes the combination of BEVs and PHEVs are called plug-in electric vehicles because they both charge by being plugged into an electric supply.

A final, and rare, type of electric vehicle is the fuel cell EV (FCEV). Like BEVs, these cars run entirely on an electric engine, but instead of using the charge of a battery as a fuel, they use a fuel cell filled with hydrogen. Using hydrogen as a fuel allows these cars to "gas up" as quickly as traditional gasoline and diesel cars, without having to wait for a battery to charge, but because of the expense of making hydrogen into a useable form, as well as lack of infrastructure, few people have purchased them. SVCE territory only has about 50 FCEVs, so these vehicles have been excluded from most analyses.

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[29] Arbulu, Lucas, John Cornwell, Julie Crookston, Kimberly Dabrowski, Dashiell Daniels, Margaret Devlin, Henry Freeman, et al. 2019. Electric Vehicle Charging Infrastructure: Publicly Funded Necessity or Commercially Funded Convenience? White Paper, Austin: LBJ School of Public Affairs at the University of Texas.

Appendix B: City Maps of EV Adoption

For those interested in an up-close view of city-specific EV adoption rates, the following images show a close of view and additional information about the total numbers of EV as well as the total number of parcels that have registered EVs.
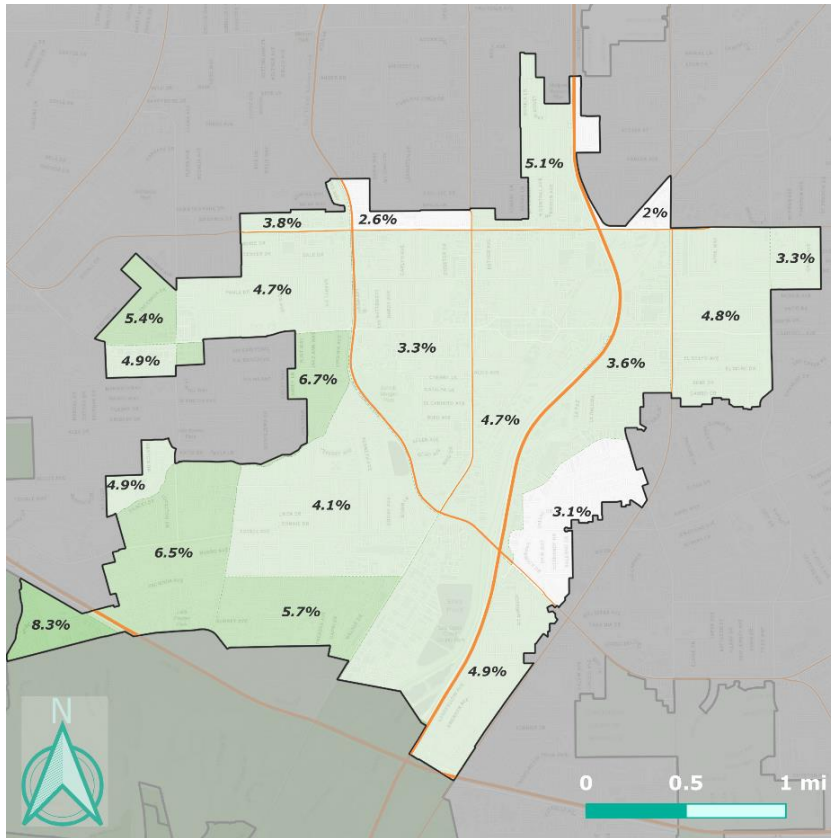
Campbell

Total Number of EVs:

1,436

City-Wide EV Adoption Rate

4.7%

EVs' Proportion of Registered Vehicle Population

- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

Roads
— Freeway
— Highway
— Other Major Roads

Cupertino

Total Number of EVs:
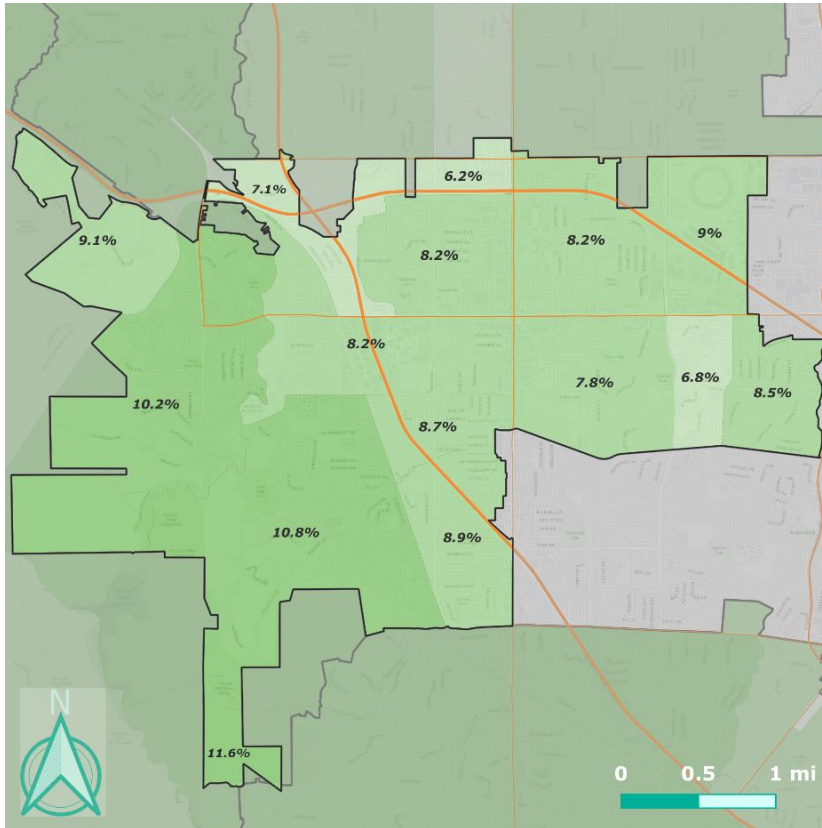
3,387

City-Wide EV Adoption Rate

9.1%

EVs' Proportion of Registered Vehicle Population

- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

Roads
- Freeways
- Highways
- Other Major Arterial Roads

0   0.5   1 mi

Gilroy

Total Number of EVs:
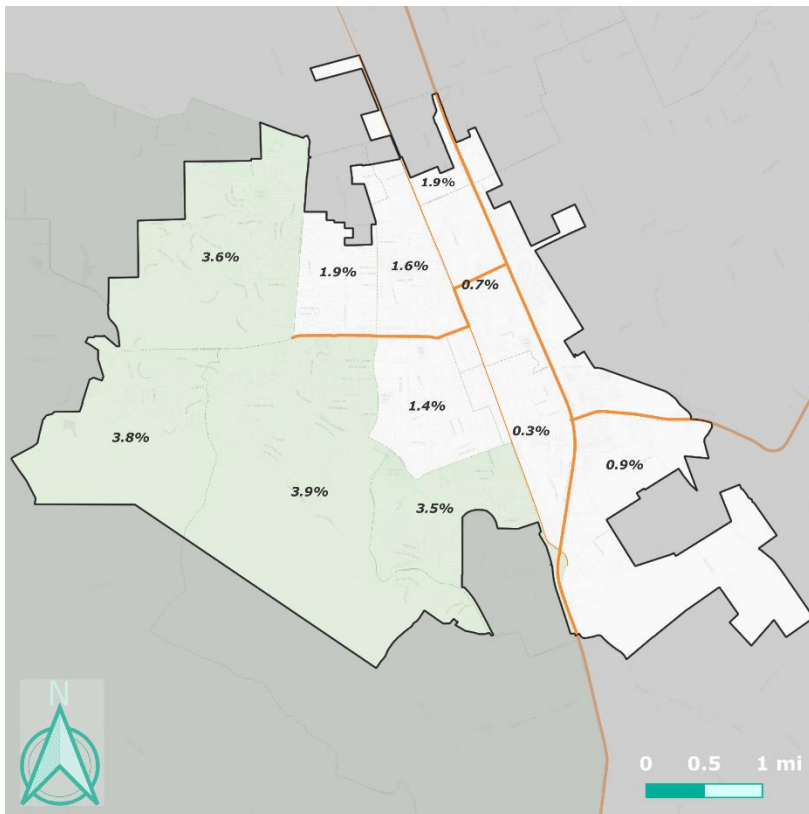
1,299

City-Wide EV Adoption Rate

2.4%

EVs' Proportion of Registered Vehicle Population

- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

Roads
- Freeways
- Highways
- Other Major Arterial Roads

0   0.5   1 mi

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Los Altos Hills

Total Number of EVs:
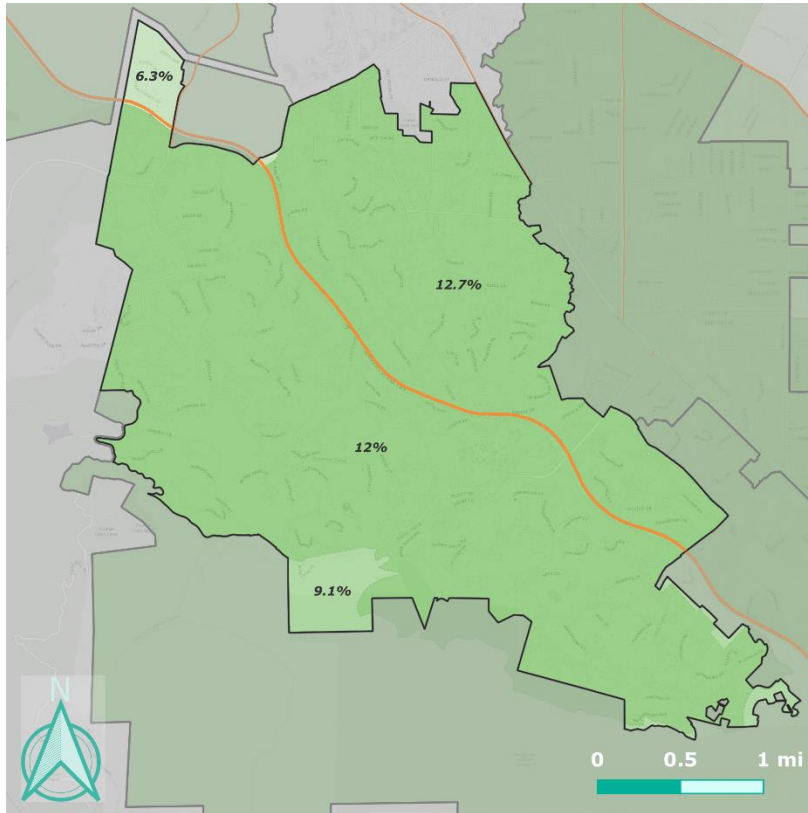
915

City-Wide EV Adoption Rate

8.6%

EVs' Proportion of Registered Vehicle Population
- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

Roads
- Freeways
- Highways
- Other Major Arterial Roads

Los Altos

Total Number of EVs:

3,128

City-Wide EV Adoption Rate

13.1%

EVs' Proportion of Registered Vehicle Population
- less than 3.8%
- 3.8% to 5.9%
- 5.9% to 8.1%
- 8.1% to 10.6%
- more than 10.6%

Roads
- Freeways
- Highways
- Other Major Arterial Roads

Los Gatos

Total Number of EVs:
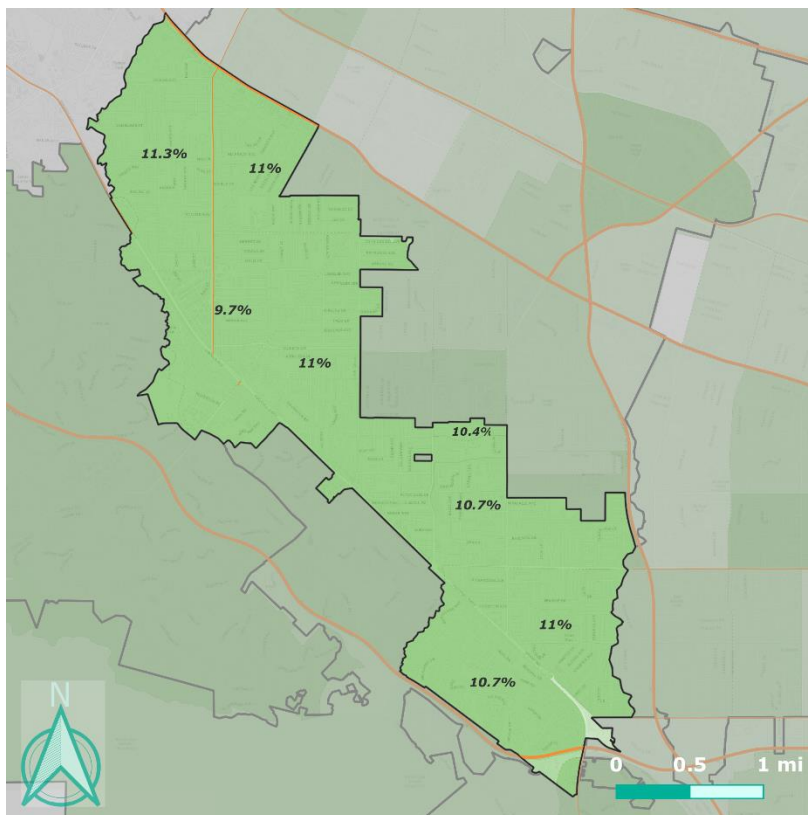
2,816

City-Wide EV Adoption Rate

8.5%

EVs' Proportion of Registered Vehicle Population
- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

Roads
- Freeways
- Highways
- Other Major Arterial Roads

Milpitas

Total Number of EVs:

2,550

City-Wide EV Adoption Rate

4.9%

EVs' Proportion of Registered Vehicle Population
- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

Roads
- Freeways
- Highways
- Other Major Arterial Roads

Monte Sereno

Total Number of EVs:

310

City-Wide EV Adoption Rate

10.7%

EVs' Proportion of Registered Vehicle Population

- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

Roads
- — Freeways
- — Highways
- — Other Major Arterial Roads

(map labels: 9.4%, 7.3%, 9%, 9%)

Scale: 0 — 0.5 — 1 mi

Morgan Hill

Total Number of EVs:

2,069

City-Wide EV Adoption Rate

4.6%

EVs' Proportion of Registered Vehicle Population

- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

Roads
- — Freeways
- — Highways
- — Other Major Arterial Roads

(map labels: 6.3%, 4.8%, 6.3%, 5.1%, 5%, 4.3%, 3%, 2.1%, 2.6%, 1.7%, 3.3%)

Scale: 0 — 0.5 — 1 mi

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Mountain View

Total Number of EVs:

3,503

City-Wide EV Adoption Rate

7.2%

EVs' Proportion of Registered Vehicle Population
- less than 3.8%
- 3.8% to 5.9%
- 5.9% to 8.1%
- 8.1% to 10.6%
- more than 10.6%

Roads
— Freeways
— Highways
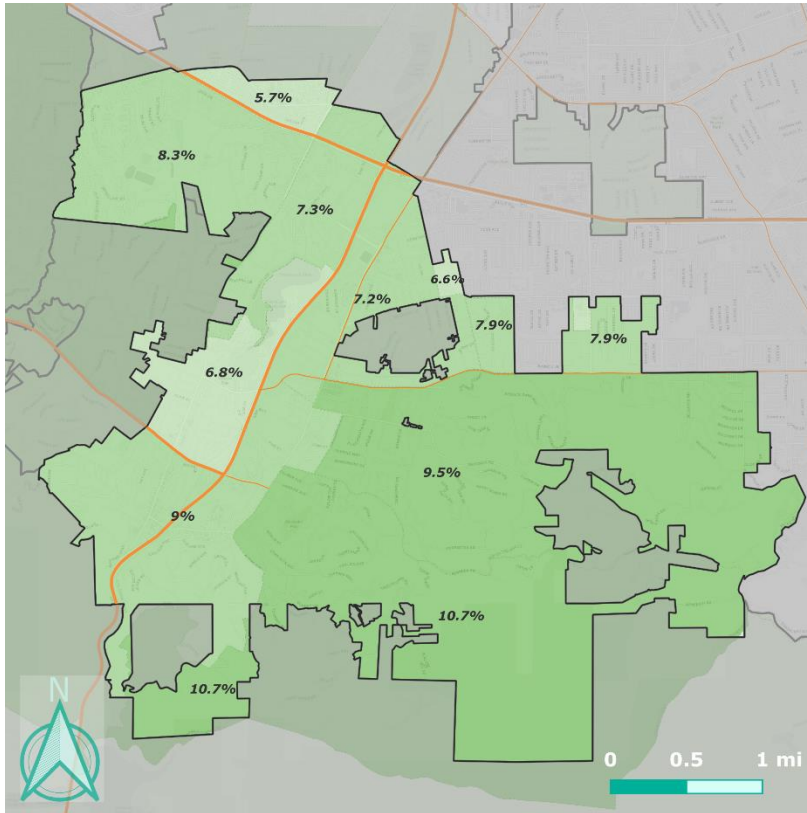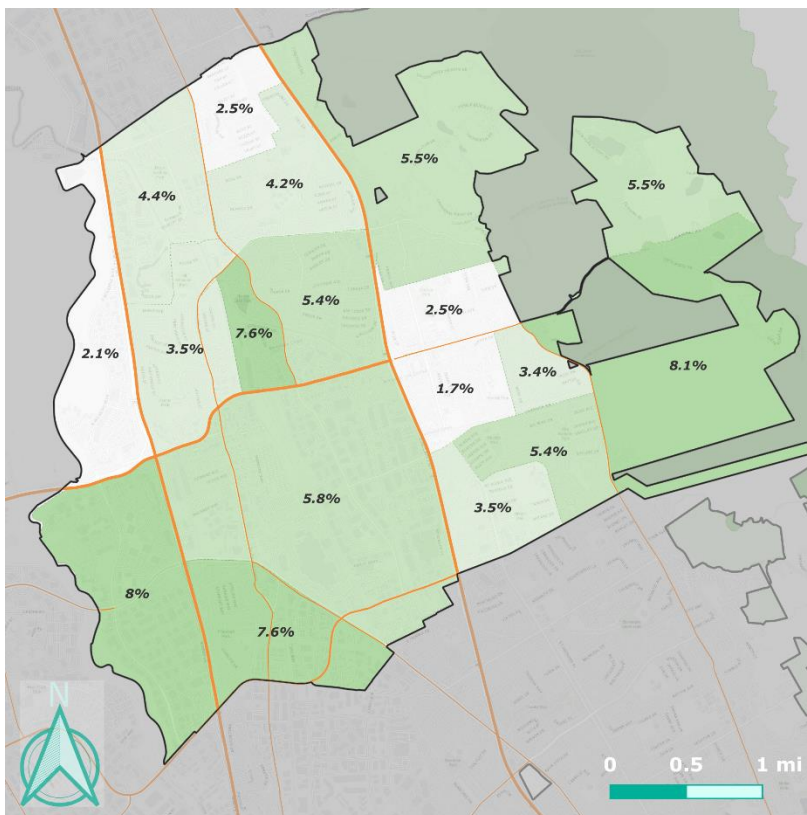— Other Major Arterial Roads

Saratoga

Total Number of EVs:

2,777

City-Wide EV Adoption Rate

11.0%

EVs' Proportion of Registered Vehicle Population
- Less than 3.3%
- 3.3% to 5.1%
- 5.1% to 6.9%
- 6.9% to 9.1%
- 9.1% to 12.7%

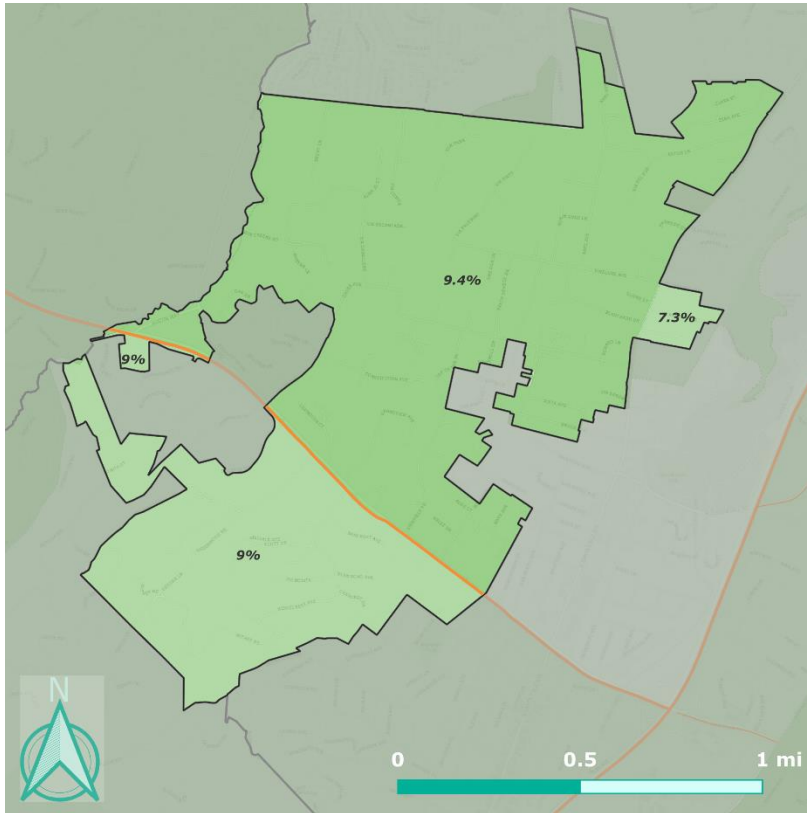Roads
— Freeways
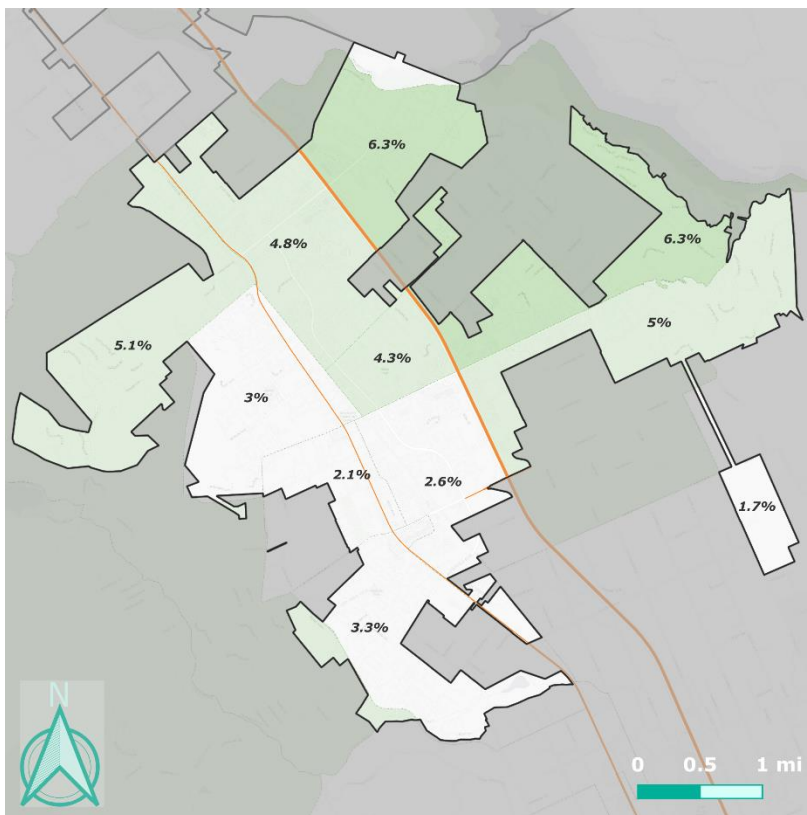— Highways
— Other Major Arterial Roads
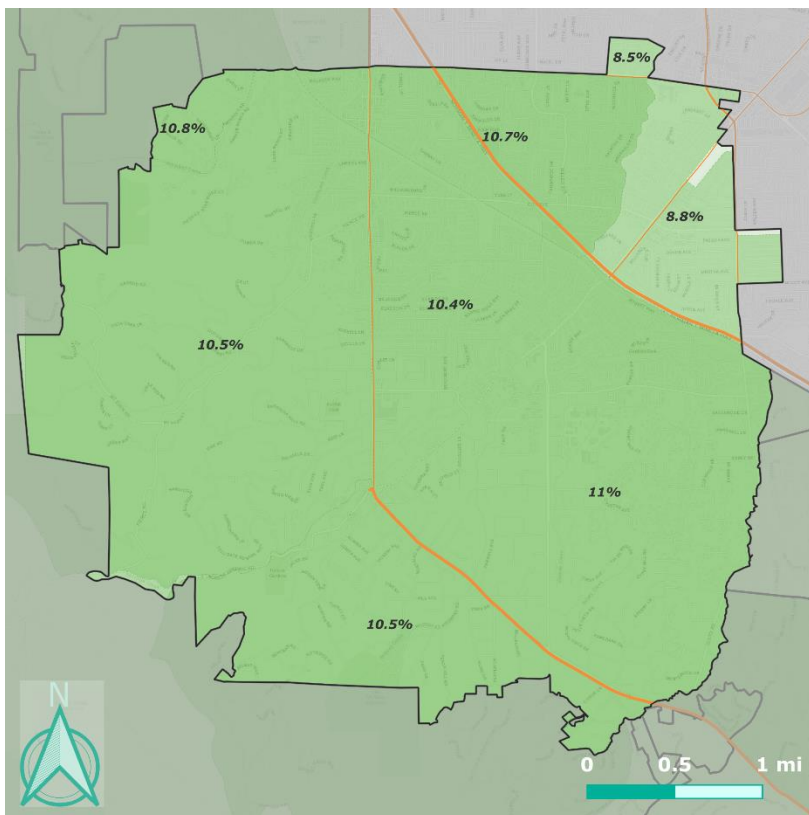
Sunnyvale

Total Number of EVs:

5,242

City-Wide EV Adoption Rate

6.0%
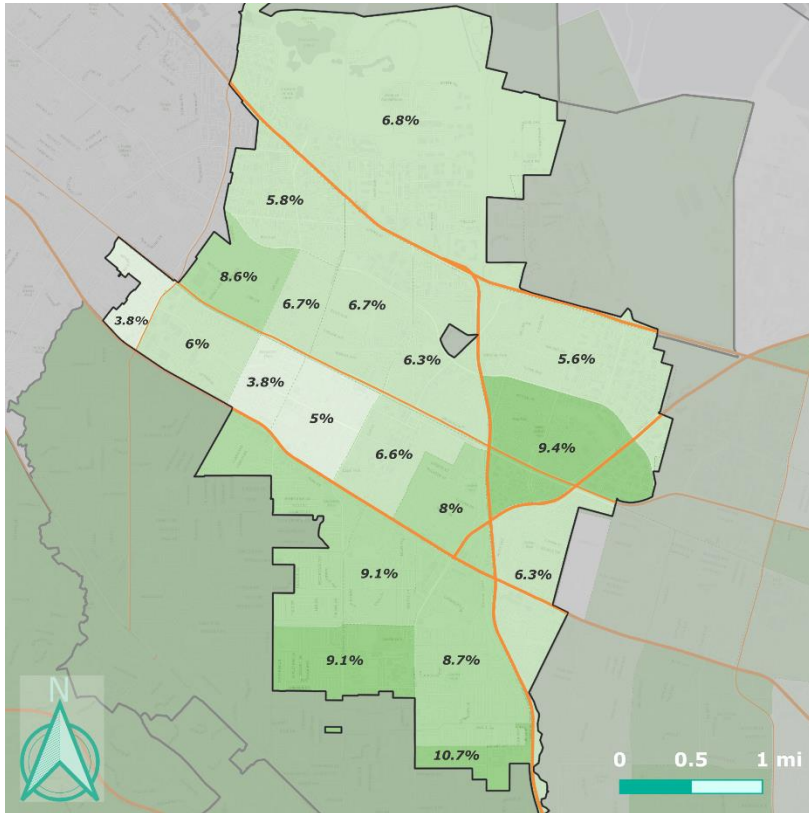
EVs' Proportion of Registered Vehicle Population
- less than 3.8%
- 3.8% to 5.9%
- 5.9% to 8.1%
- 8.1% to 10.6%
- more than 10.6%

Roads
- Freeways
- Highways
- Other Major Arterial Roads

Unincorporated Santa Clara County
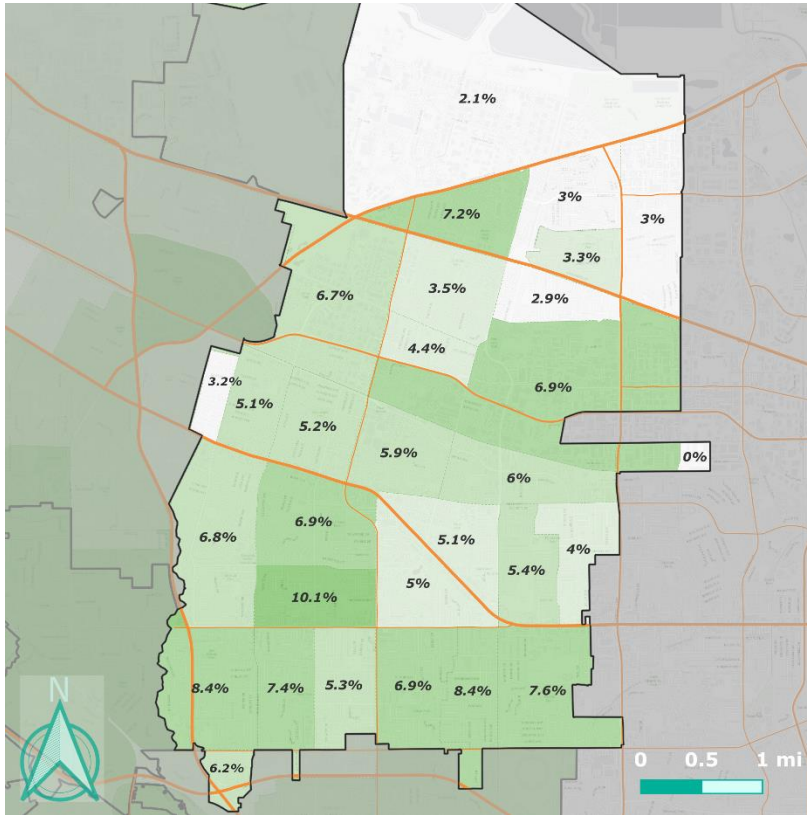
Total Number of EVs:

1,287

City-Wide EV Adoption Rate

3.4%

EVs' Proportion of Registered Vehicle Population

- less than 3.8%
- 3.8% to 5.9%
- 5.9% to 8.1%
- 8.1% to 10.6%
- more than 10.6%
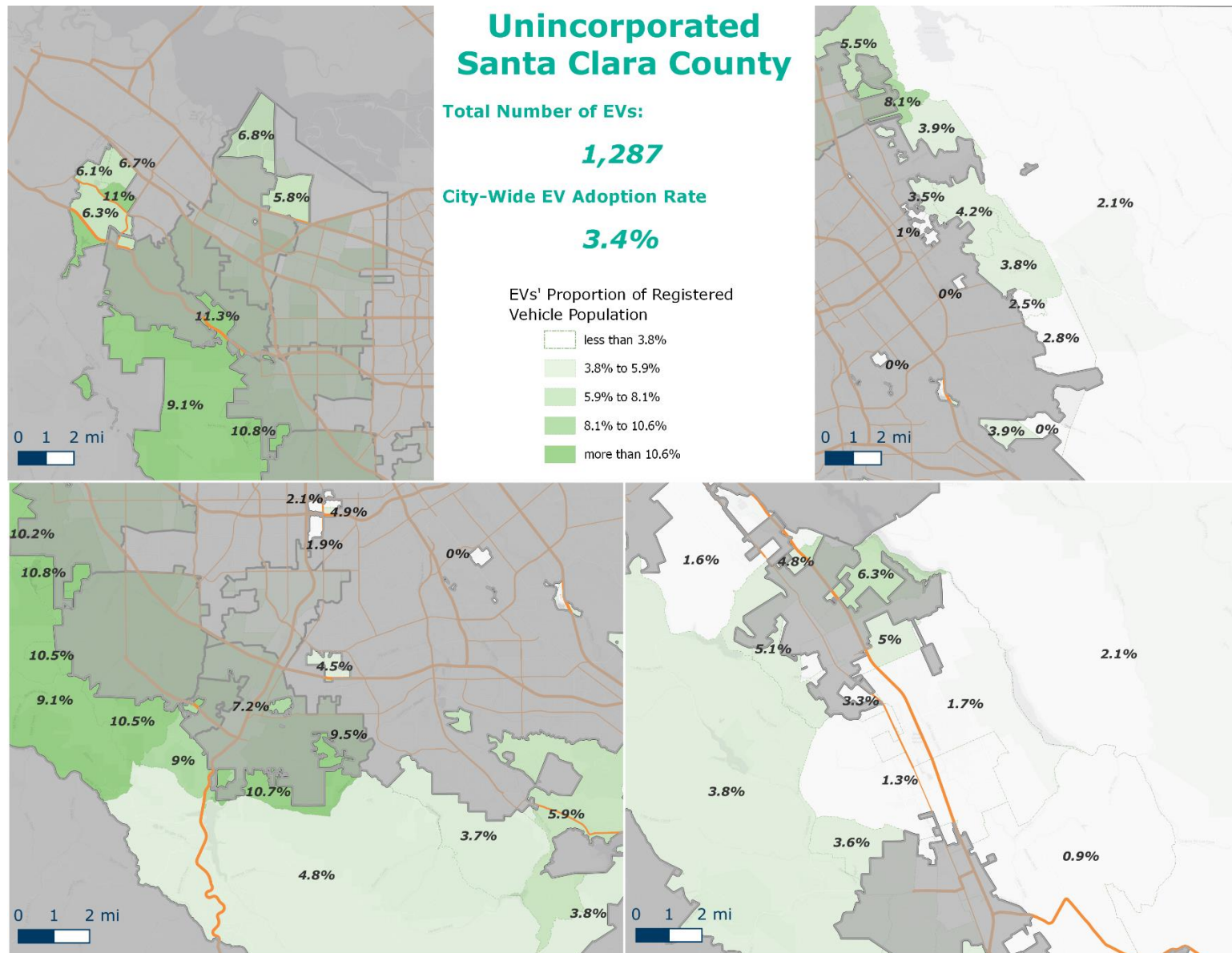
Appendix C: Explanation of EVIs

Electric vehicle infrastructure, or EVI, comes in 3 levels, defined by their power and thus the time it takes to charge a PEV. What follows is a description of these 3 levels.

Level 1 (L1): (110 volts AC) Typically used for residential overnight charging or long-dwell charging at workplaces, L1 charging provides ~4.5 miles of additional range per hour of charging.

Level 2 (L2): (208-240 volts AC) Commonly found in workplace, public, and some home charging applications, L2 charging provides ~26 miles of additional range per hour at a 6.6kW charge rate. Level 2 charging is becoming quicker over time, with 20 kW charge rates possible on some vehicles and chargers (potentially providing over 50 miles of range per hour).

Level 3 or Direct Current Fast Charging (DCFC): High-powered DC Fast Charging (ranging from 24kW – 350 kW) is typically found in public commercial charging plazas and fleet charging applications. DCFC provides ~40 miles of range in ten minutes at a 50kW charge rate. DCFC is also becoming much quicker over time, with 150kW – 350kW chargers now being deployed. Fast Chargers typically require high-cost electric infrastructure upgrades.

Technical Note on EVSE Deployment Measures: Charging Stations vs. Charging Ports

Commercial EV Charging Stations – also known as Electric Vehicle Service Equipment (EVSE) – can be counted in two ways: 1) based on the number of charging stations – typically defined as a single charging pedestal with one or two charging ports, or 2) based on the number of charging ports (also known as "plugs," "points," or "connectors"). For Level 2 stations, a dual port station can typically be used concurrently by two vehicles.

For DC Fast Chargers, in cases where two ports are provided in the two primary connector formats (CCS and CHAdeMO), most often only one vehicle can charge at a time. Most public data sources do not distinguish between charging stations (typically referred to as EVSE) and charging ports. Where such data is available, it is reported here in terms of ports. Where port level data is not available, and data sources report only the number of Level 2 EV charging stations (or EVSE), it can be assumed that an unknown but significant percentage of these Level 2 stations (likely more than 20%) include at least two ports each.

Appendix D: City Tables of Land Use Near Public Chargers

Campbell	L2	DCFC
Residential	6%	0%
Industrial and Manufacturing	**45%**	**100%**
Retail Uses	12%	0%
Office Uses	16%	0%
Parking	10%	0%
Public and Other Quasi-Public Buildings	10%	0%
Grand Total	67	12

Cupertino	L2	DCFC
Residential	11%	0%
Retail Uses	**49%**	**70%**
Office Uses	2%	0%
Parks and Recreation Centers	2%	0%
Schools and Universities	18%	4%
Hospitals and Nursing Facilities	1%	0%
Public and Other Quasi-Public Buildings	3%	0%
Agricultural	1%	0%
Unknown	14%	26%
Grand Total	219	46

Gilroy	L2	DCFC
Utilities and Service Stations	29%	3%
Retail Uses	**71%**	**65%**
Agricultural	0%	32%
Grand Total	7	62

Los Altos	L2	DCFC
Retail Uses	5%	31%
Office Uses	7%	0%
Parking	0%	0%
Schools and Universities	**81%**	**69%**
Public and Other Quasi-Public Buildings	1%	0%
Unknown	6%	0%
Grand Total	154	13

Los Altos Hills	L2	DCFC
Schools and Universities	**55%**	-
Public and Other Quasi-Public Buildings	6%	-
Unknown	39%	-
Grand Total	15	0

Los Gatos	L2	DCFC
Industrial and Manufacturing	7%	0%
Retail Uses	**42%**	0%
Office Uses	22%	20%
Parks and Recreation Centers	4%	0%
Public and Other Quasi-Public Buildings	7%	0%
Unknown	15%	**80%**
Vacant Land	4%	0%
Grand Total	55	15

Milpitas	L2	DCFC
Residential	3%	0%
Industrial and Manufacturing	**80%**	2%
Retail Uses	3%	**98%**
Office Uses	3%	0%
Vacant Land	10%	0%
Grand Total	127	45

Monte Sereno	L2	DCFC
Public and Other Quasi-Public Buildings	100%	-
Grand Total	1	

Morgan Hill	L2	DCFC
Industrial and Manufacturing	4%	0%
Retail Uses	**50%**	**100%**
Parks and Recreation Centers	4%	0%
Public and Other Quasi-Public Buildings	14%	0%
Unknown	7%	0%
Vacant Land	21%	0%
Grand Total	23	16

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Mountain View	L2	DCFC
Residential	21%	0%
Industrial and Manufacturing	11%	0%
Retail Uses	12%	**46%**
Office Uses	**31%**	23%
Schools and Universities	7%	31%
Hospitals and Nursing Facilities	6%	0%
Public and Other Quasi-Public Buildings	4%	0%
Unknown	9%	0%
Grand Total	242	52

Saratoga	L2	DCFC
Retail Uses	**60%**	0%
Unknown	40%	**100%**
Grand Total	5	1

Sunnyvale	L2	DCFC
Residential	25%	6%
Industrial and Manufacturing	6%	0%
Utilities and Service Stations	0%	0%
Retail Uses	**30%**	**94%**
Office Uses	23%	0%
Parking	1%	0%
Schools and Universities	10%	0%
Agricultural	3%	0%
Unknown	2%	0%
Vacant Land	1%	0%
Grand Total	261	33

Unincorporated Santa Clara	L2	DCFC
Parks and Recreation Centers	12%	-
Schools and Universities	**69%**	-
Hospitals and Nursing Facilities	10%	-
Public and Other Quasi-Public Buildings	5%	-
Unknown	5%	-
Grand Total	172	0

Appendix E: Permit Streamlining Requirements and Member Agency Status

One policy that hopes to increase EVI development is permit streamlining, offering incentives to potential charging station owners and managers that make the process of getting permission to build a charging station as simple and low cost as possible. AB 1236, passed in 2015, requires local governments to create a streamlined process for permitting the construction of EV charging stations. The law requires eight elements to consider the process streamlined:[30]

- **Ordinance:** there must be a law on the books explicitly describing the permitting process for EV charging stations
- **Checklist:** the municipality or local government must post an easily accessible checklist on their website of all the required elements to get a charging station permit.
- **Administrative Approval:** For all charging station projects that meet required elements as listed on the checklist, non-discretionary approval should be granted
- **Health and Safety:** Municipal and local governments only review whether a project meets health and safety requirements
- **eSignature:** permit applications can be signed using an electronic signature on the city or county website
- **No Association:** charging station projects do not need to meet the approval of any association, like non-profits, homeowners' associations, or other groups created to manage a common interest development
- **One Deficiency Notice:** if a permit application is incomplete, the receiving government will send one complete list of all the things needed for a complete application, as well as any additional information needed by the applicant to qualify for a streamlined permit process.
- **Bonus Expedited Timeline:** The only optional element, the local government may also create a faster timeline for permit approvals, meaning that applicants will receive their permit faster.

The table below shows how many of these requirements each of the member agencies in SVCE territory have met, as well as the most recent date of when they adopted their ordinance, or the most recent element if no ordinance exists.

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[30] Governor's Office of Business and Economic Development. 2019. "Permitting Electric Vehicle Charging Stations Scorecard." Plug-in Electric Vehicle Charging Station Readiness. July. Accessed December 9, 2021. https://static.business.ca.gov/wp-content/uploads/2020/01/Permitting-Electric-Vehicle-Charging-Stations-Scorecard.pdf.

	Score Card	Adoption Date	Ordinance	Checklist	Admin Approval	Health & Safety	eSignature	No Association	One Notice	Bonus - Timeline
Campbell	1	July-05		X						
Cupertino	1	December-16		X						
Gilroy	7	September-18	X	X	X	X	X	X	X	
Los Altos	0	not yet adopted								
Los Altos Hills	0	not yet adopted								
Los Gatos	7	September-17	X	X	X	X	X	X	X	
Milpitas	7	August-17	X	X	X	X	X	X	X	
Monte Sereno	1	unclear		X						
Morgan Hill	7	September-17	X	X	X	X	X	X	X	
Mountain View	5	November-19	X		X	X	X		X	
Saratoga	6	July-16	X		X	X	X	X	X	
Sunnyvale	5	November-16	X	X	X		X	X	X	
Unincorporated	7	February-18	X	X	X	X	X	X	X	

Source: Office of Business and Economic Development
Plug-in Electric Vehicle Charging Station Readiness

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Appendix F: SVCE Territory EV Reach Codes

The following tables describe the code requirements for EV charging in new and remodeled buildings for those communities that have adopted reach codes in this area. Communities not on these tables have not adopted EV charging reach codes. These tables are current as of February 17th, 2021.

- EV Capable: Linked to electrical panel with sufficient capacity to provide 120V, 20A to space
- EV Ready Circuit: Complete electric circuit with outlet installed
- EV Charging Station: Electric vehicle supply equipment installed

Table F-1: Single Family EV Charging Reach Codes

Community	Single Family
CalGreen	One Level 2 EV Capable per unit
Cupertino	1 parking space per unit: one Level 2 EV Ready Circuit > 1 parking space per unit: one Level 1 EV Ready Circuit and one Level 2 EV Ready Circuit
Los Altos	1 parking space per unit: one Level 2 EV Ready Circuit > 1 parking space per unit: two Level 2 EV Ready Circuits
Los Gatos	Two Level 2 EV Ready Circuits per unit
Milpitas	One Level 1 EV Ready Circuit and one Level 2 EV Ready Circuit per unit
Monte Sereno	Two Level 2 EV Ready Circuits per unit
Mountain View	One Level 1 EV Ready and one Level 2 EV Ready Circuit per unit
Saratoga	One Level 2 EV Ready Circuit per unit
Sunnyvale	One Level 1 EV Ready Circuit and one Level 2 EV Ready Circuit per unit

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Table F-2: Multi-Family EV Charging Reach Codes

Agency	Multi-Family (≤20 units)	Multi-Family (>20 units)
CalGreen	10% of parking spaces: Level 2 EV Capable	10% of parking spaces: Level 2 EV Capable
Cupertino	100% of units: one Level 2 EV Ready Circuit Affordable Housing: 10% of units: one Level 2 EV Ready Circuit 90% of units: one Level 1 EV Ready Circuit	25% of units: one Level 2 EV Ready Circuit 75% of units: one Level 1 EV Ready Circuit Affordable Housing: 10% of units: one Level 2 EV Ready Circuit 90% of units: one Level 1 EV Ready Circuit
Los Altos	100% of units: one Level 2 EV Ready Circuit Affordable Housing: 10% of units: one Level 2 EV Ready Circuit 90% of units: one Level 1 EV Ready Circuit	25% of units: one Level 2 EV Ready Circuit 75% of units: one Level 1 EV Ready Circuit Affordable Housing: 10% of units: one Level 2 EV Ready Circuit 90% of units: one Level 1 EV Ready Circuit
Milpitas	15% of units: one Level 2 EV Ready Circuit 35% of units: one Level 1 EV Capable Affordable Housing: 5% of units: one Level 2 EV Ready Circuit 35% of units: one Level 1 EV Capable	20% of units: one Level 2 EV Ready Circuit 35% of units: one Level 1 EV Capable Affordable Housing: 10% of units: one Level 2 EV Ready Circuit 15% of units: one Level 1 EV Capable
Mountain View	15% of spaces: Level 2 Charging Stations 85% of spaces: EV Ready DC Fast Charger for every 100 spaces	15% of spaces: Level 2 Charging Stations 85% of spaces: EV Ready DC Fast Charger for every 100 spaces
Sunnyvale	70% of units: one Level 1 EV Ready Circuit	30% of units: one Level 1 EV Ready Circuit 70% of units: one Level 2 EV Ready Circuit

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Table F-3: Non-Residential EV Charging Reach Codes

Agency	Office	Non-Office
CalGreen	6% of parking spaces: Level 2 EV Capable	6% of parking spaces: Level 2 EV Capable
Cupertino	≥ 10 parking spaces: 20% of spaces: Level 2 EV Charging Station 10% of spaces: Level 1 EV Ready Circuit 30% of spaces: EV Capable	≥ 10 parking spaces: 6% of spaces: Level 2 EV Charging Station 5% of spaces: Level 1 EV Ready Circuit Substitution of DC Fast Charger may be applicable
Los Altos	10% of spaces: Level 2 EV Charging Station 10% of spaces: Level 1 EV Ready Circuit 30% of spaces Level 2 EV Capable	6% of spaces: Level 2 EV Charging Station 5% of spaces: Level 1 EV Ready Circuit > 100 parking spaces: Substitution of DC Fast Charger may be applicable
Milpitas	5% of spaces: Level 2 EV Charging Station 10% of spaces: Level 1 EV Ready Circuit 20% of spaces: Level 2 EV Capable	≥ 10 parking spaces: 4% of spaces: Level 2 EV Charging Station 3% of spaces: Level 1 EV Capable > 100 parking spaces: Substitution of DC Fast Charger may be applicable
Mountain View	< 10 parking spaces: One Level 2 EV Charging Station ≥ 10 parking spaces: 15% of parking spaces: Level 2 EV Charging Station ≥ 100 parking spaces: DC Fast Charger for every 100 spaces	< 10 parking spaces: One Level 2 EV Charging Station ≥ 10 parking spaces: 15% of parking spaces: Level 2 EV Charging Station ≥ 100 parking spaces: DC Fast Charger for every 100 spaces
Sunnyvale	35% of spaces: EV Charging Station 35% of spaces: EV Capable	35% of spaces: EV Charging Station 35% of spaces: EV Capable Hotel and Motels: 50% of spaces: EV Capable 20% of spaces: Level 2 EV Ready Circuit

Appendix G: Comparing EV to EVI Calculations

As previously mentioned, this study attempts to see if there is a relationship between the siting of chargers and EV adoption on a more granular level than the county as a whole. While the study finds no clear relationship between the two, the following section demonstrates some of the potential relationships explored, the hypotheses leading to their exploration, and the results of that exploration.

This first graph shows the number of EVs in each census tract compared to the total number of identifiable chargers, both L2 and DCFC. This was done to test the overall hypothesis that EVs and EVI are positively correlated, that is, where there are more EVs, there will likely also be more charging.

Figure G-1: Number of EVs Compared to Total Number of Chargers in SVCE Territory by Census Tract
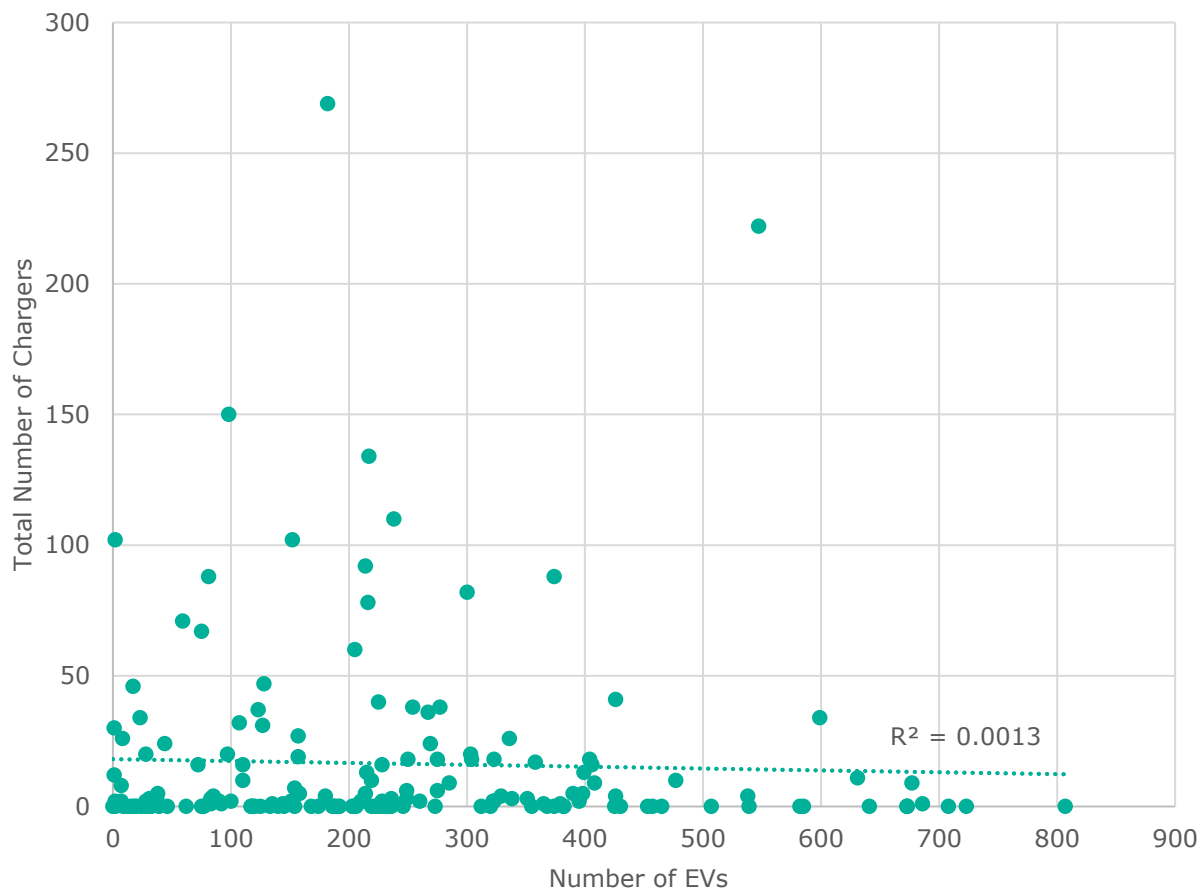
The figure does not show much correlation, with a very low R squared score, suggesting that the relationship between the two is more or less random. In fact, the regression line slopes slightly downwards, which is especially clear when zooming in the graph to ignore some of the outlier census tracts with extremely high numbers of chargers, suggesting that census tracts with more EVs tend to have slightly less chargers, quite the opposite of the initial hypothesis. However, this result does not mean much, because the line the statement is based on does not fit the data points very well, as shown by the R squared. More likely is that this regression is heavily impacted by the number of census tracts with few or no chargers at all, bringing the line further down as outliers become less frequent.

The next graph compares a census tract's total number of public chargers to the amount of EVs registered to multi-family EVs within it. Multi-family buildings tend to have less charging accessibility at home, because of lack of connection to home outlets and the expense of charger installations, so the hypothesis was that places with more multi-family EVs would also be places where there were more publicly accessible chargers.

Figure G-2: Number of EVs Registered to Multi-Family Households Compared to Total Number of Chargers in SVCE Territory by Census Tract
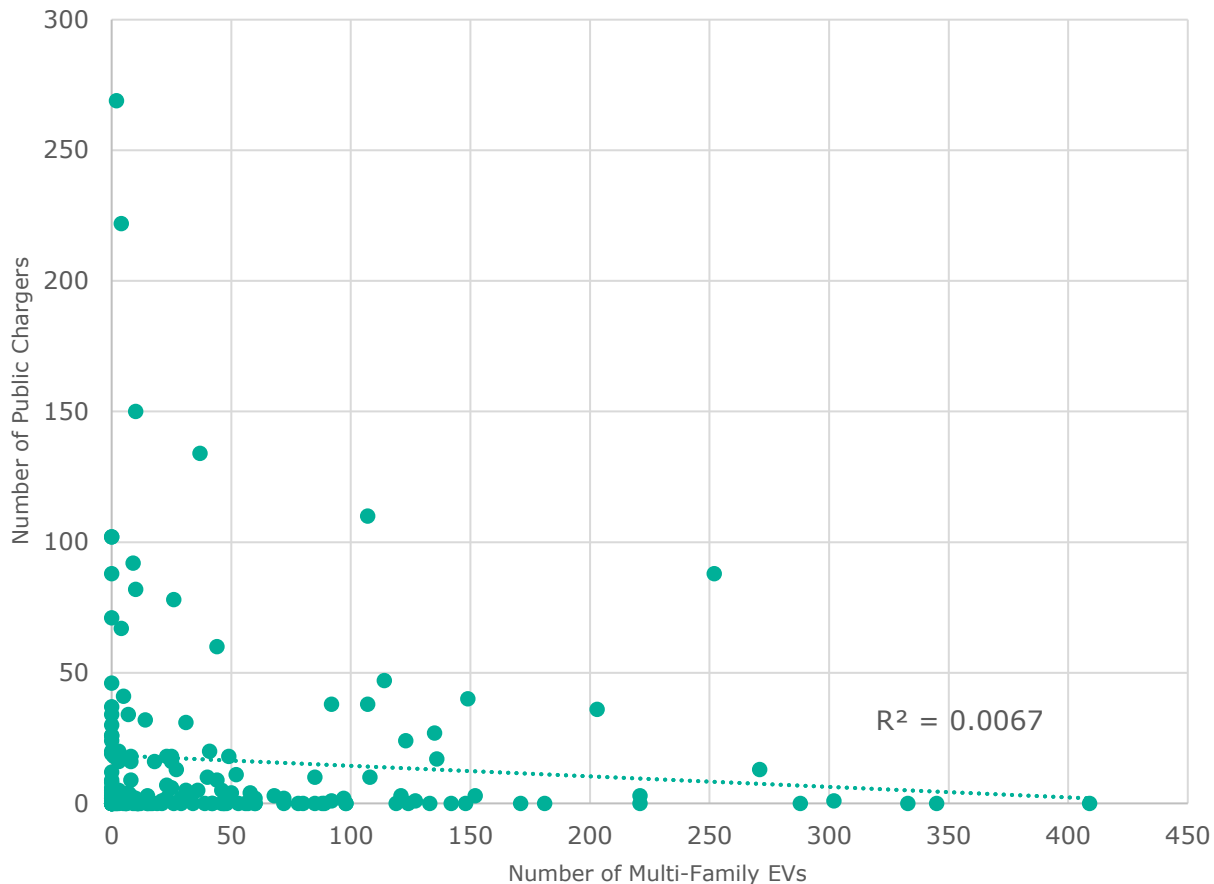
Figure G-2 also shows a random relationship between the two. The R squared score, only slightly higher than the previous graph, shows that less than 1 percent of the variation in the number of public chargers is related to the variation in the number of multi-family EVs. In fact, this regression line slopes downward even more noticeably that the line in Figure G-1, which would imply that the more multi-family EVs in a census tract, the less chargers there are. However, similar to the previous graph, the large amount of census tracts with few or no chargers make this claim more likely a result of a lack of outlier tracts with large numbers of charger to pull the regression line up.

There is a cluster of census tracts with low numbers of multi-family EV and low numbers of public chargers. This just shows that both multi-family EV adoption and general EVI deployment rates are still relatively low in tracts. While this graph may highlight the continued need to invest in increasing EV adoption for multi-family residents, it does not show a census-tract level connection between the locations of chargers and that adoption.

Continuing an exploration of how chargers and multi-family EV adoption are related, Figure G-3 shows the number of EVs in a multi-family building compared to distance to nearest charger. Each dot represents a multi-family building with at least one EV registered there. If public chargers are an important way for multi-family residents to charge their EV, this graph should show a downward sloping regression line, demonstrating that multi-family buildings with more EVs are also those closer to their nearest public charger.

Figure G-3: Number of EVs Registered in Multi-Family Building Compared to Distance from Nearest Charger in SVCE Territory
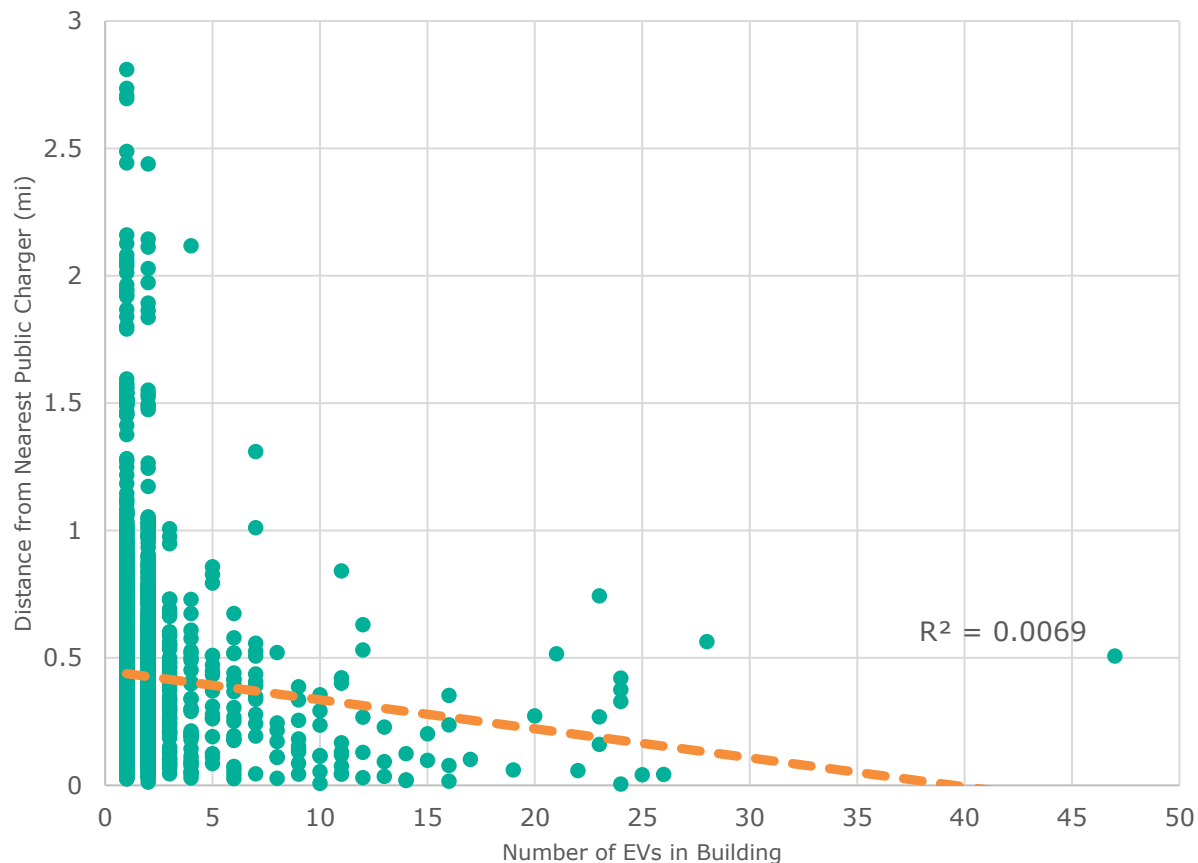

Figure G-3 does show that relationship, but, again, the low R-squared score means that this relationship is not very robust. Again, less than one percent of the variation in the number of EVs in a building can explain or be explained by its distance from the nearest public charger.

Furthermore, there is a huge cluster of multi-family buildings that are less than half a mile from the nearest charger, but still only have one or two EVs registered to the building. In fact, there are many more of this type of building than there are buildings which are also close to a public charger but have more EVs.

The final exploration of the relationship between multi-family EV adoption and EVI deployment for this study created an EV to charger ratio for each census tract and compared it to the tract's median income. The ratio can be understood as how many EVs in the tract "shared" one public charger. While there is not yet a clear understanding of the ideal EV to charger ratio, for the purposes of this study, lower ratios were preferred, as they suggest more charger options for each EV in its registered census tract. However, a lower number could also come from smaller amounts of EVs registered to multi-family residents.

Figure G-4: Multi-Family EV to Charger Ratio Compared to Median Income by Census Tract
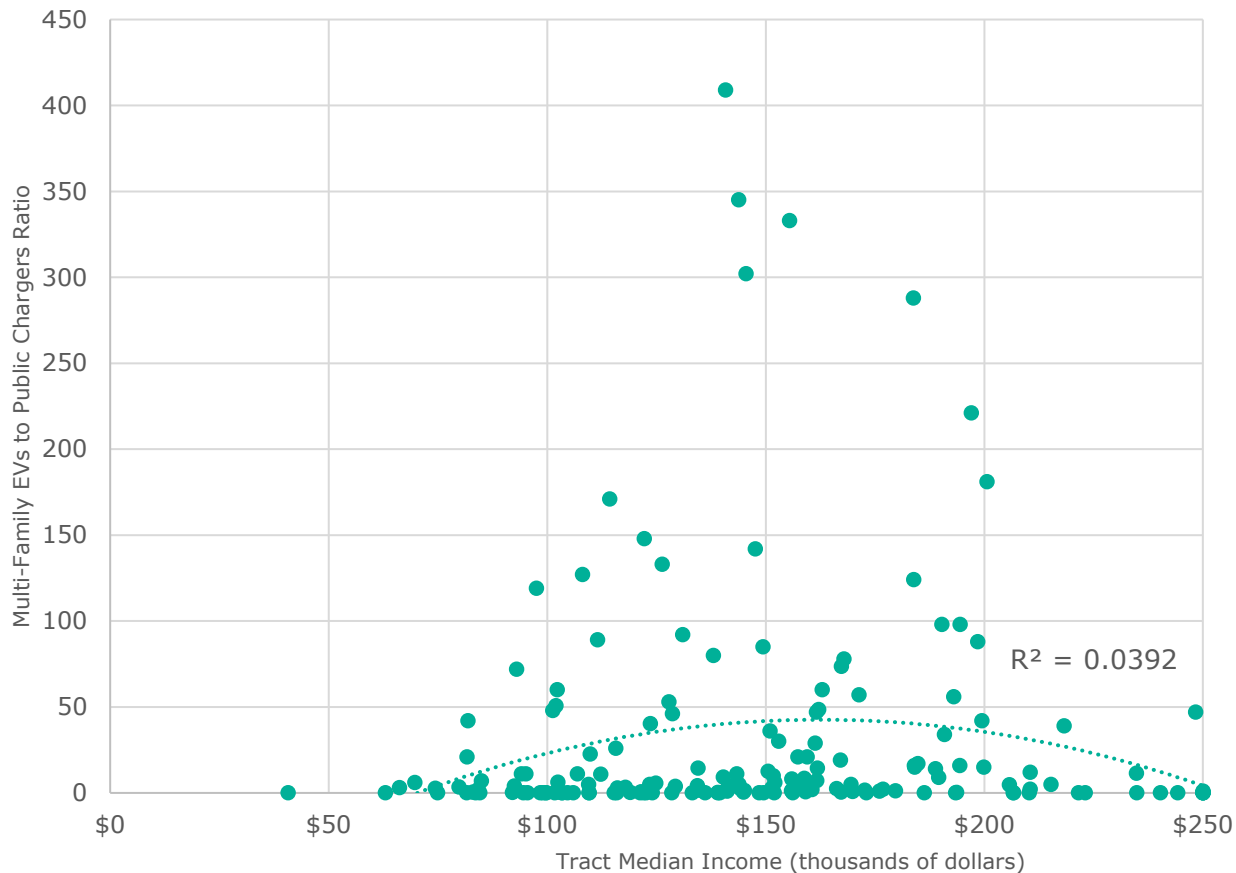
One observation is that most census tracts have a multi-family EV to charger ratio of 50 or less regardless of income. The R-squared score is still low, so the curve of the regression line is likely due to chance as opposed to any robust relationship between the multi-family EV to charger ratio of a census tract and its median income. However, the negative parabola shape of the regression suggests that in the middle range of median income, tracts are more likely to have higher ratios, leaving EV owners to compete over fewer charging locations. This could imply that attempts to focus EVI deployment in particular areas have overlooked this middle-income group in favor of the lowest or highest income tracts.

Figure G-5 turns to single-family EV ownership and its relationship to charger placement. Single-family residents tend to be able to charge at home, and so may be less dependent on public charging than multi-family residents. If this were the case, one would expect to see a less robust relationship between the number of single-family EVs and public chargers in census tracts, although possibly still a positive one.

Figure G-5: Number of EVs Registered to Single Family Households Compared to Total Number of Public Chargers in SVCE Territory by Census Tract
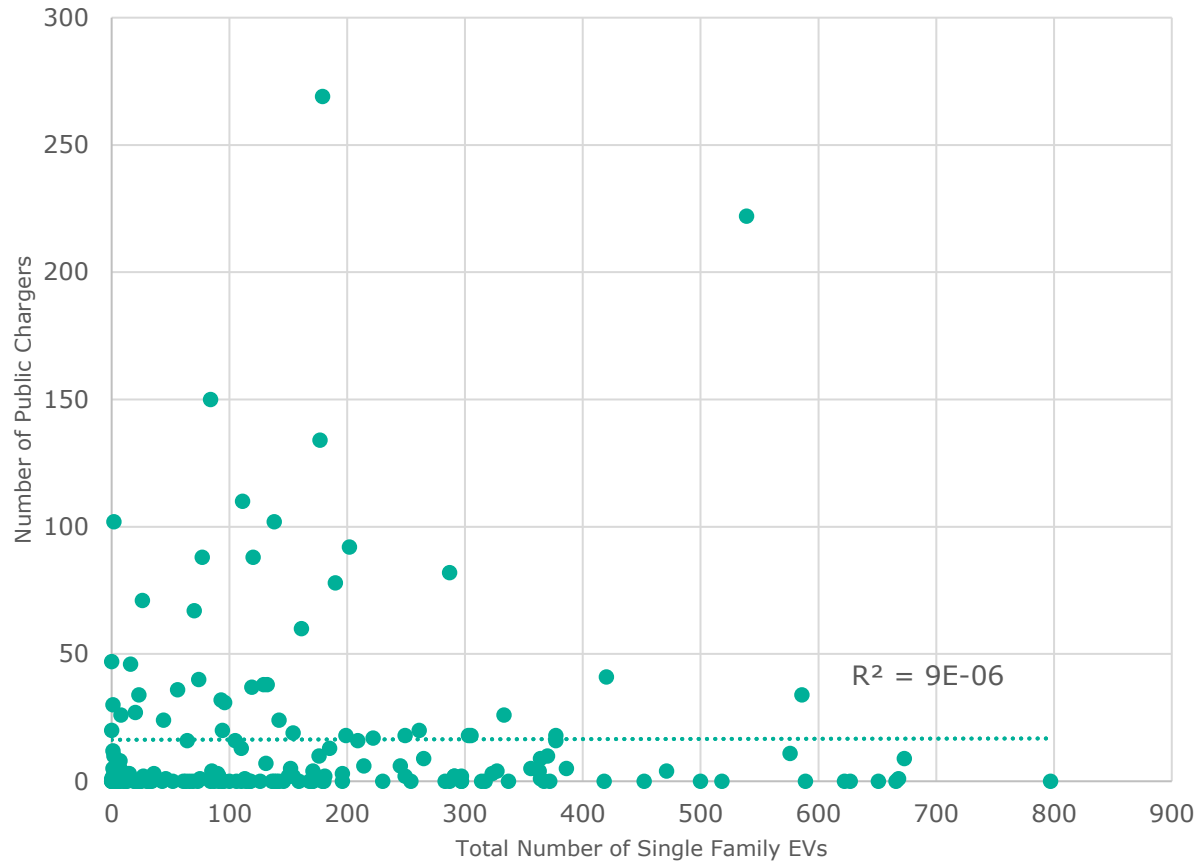

Figure G-5 does indeed show a less robust relationship between single family EVs and public chargers in census tracts than that between multi-family EVs and chargers shown in Figure G-2. In fact, this relationship is nearly non-existent.

Also worth pointing out is that there are many more census tracts that reach high numbers of EVs even with zero public chargers than is the case when looking at multi-family EVs. This supports the theory that single family households are less reliant on nearby public charging than their multi-family counterparts.

Appendix H: L2 S-Curve Projection Assumptions

This is the generic formula of an s-curve:

$$\frac{L}{1 + e^{-k(x - x_0)}}$$

Where:

- L = the maximum number of L2 chargers the region can support
- x_0 = the year at which the region would reach half of the maximum number of L2 chargers it can support
- k = the steepness of the curve

Defining each of these variables required several assumptions. As much as possible, this study erred on the side of conservative assumptions, which made the rate of L2 growth slower than it may prove to be.

To find the max number of L2 chargers needed in SVCE territory (L), this model assumed:
- The very maximum number of L2s that SVCE territory needs would be half of all the EVs on the road, so that each charger served at least 2 cars
- Vehicle population would not grow, but each ICE vehicle in the territory would be replaced with an EV

These assumptions led to an L of 236,000.

To find the year at which the region would reach half of the maximum number of L2 chargers it can support, this model assumed:

- The year when half of all cars are EVs would also be the year that half of the maximum L2 chargers would be built
- EVs would grow linearly, but at a speed that would get the territory to its (larger) portion of the 5 million ZEV by 2030

These assumptions led to a midpoint of when half of the maximum number of L2s the region could support of 2052 (suggesting that complete vehicle electrification would not happen until 2097)

The model then used these assumptions as well as historical data about the growth of L2 chargers in the region to solve for k. Because the real-world data does not fit perfectly along an s-curve, the researcher solved for k using data from every year from 2007 to 2021. This led to distinct two distinct phases in the growth of L2 chargers, pre- and post- 2014, shown in Figure _.

Figure H-1: k-values Plotted against Time

y = -0.006x + 0.2458
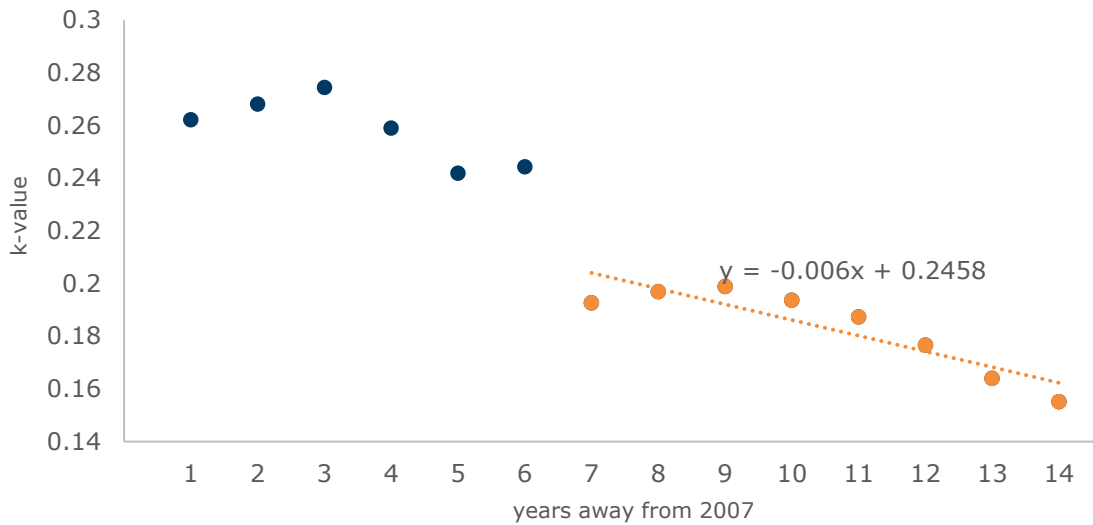
Because of its closer proximity to current trends, the model chose to follow the post-2014 pattern, drawing a line of best fit that was then used to project k values through 2030. The fact that K is getting closer to zero suggests that the steepness of the s-curve is increasing – technology is growing its rate of adoption.

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