City of Palo Alto (ID # 11600)

Utilities Advisory Commission Staff Report

Report Type: Agenda Items **Meeting Date: 11/4/2020**

Summary Title: Electric Vehicle Charger Needs Assessment

Title: Discussion of Electric Vehicle Charger Needs Assessment to Reach 80% Electric Vehicle Penetration by 2030

From: City Manager

Lead Department: Utilities

Recommendation

This report is submitted to the Utilities Advisory Commission (UAC) for informational and discussion purposes only, so no recommendation is requested.

Executive Summary

To achieve the Palo Alto community's Sustainability and Climate Action Plan (S/CAP) goal of reducing greenhouse gas (GHG) emission to 80% below 1990 levels by 2030, Palo Alto needs to achieve an electric vehicle (EV) adoption rate of close to 80%, up from the currently estimated adoption rate of 9%.

During the summer an intern undertook the task of developing estimates of EV charging needs to support an 80% EV penetration level and associated costs. The analysis found the need for 24,200 to 38,300 EV charging ports, up from the estimated 4,300 charging ports currently estimated to be in place. The cost of installing these chargers at different types of sites was also evaluated on a preliminary basis.

The analysis findings are outlined in the attached report (Attachment A) and summarized in the form of a presentation (Attachment B). These estimates are preliminary in nature, to inform the community and city staff in its efforts to further accelerate the adoption of EVs in Palo Alto in the coming years. The cost estimates are highly variable depending on the site and flexibility will be important in the City's EV infrastructure planning in coming years.

Timeline

The analysis was undertaken this summer and the broad estimates developed in this study will inform the S/CAP policy discussions in 2021, but as noted, actual costs will depend on a variety of factors.

Resource Impact
A summer intern undertook this analysis over a 10-week period this summer. No additional resources are anticipated to expended on this analysis at this time

Policy Implications
As Council considers S/CAP policy options to accelerate electric vehicle use, the study can inform the discussion. Planning ahead for the potential electrical consumption increases due to the wide-scale adoption of EVs will assist the City's electric utility to continue to provide safe, reliable and cost-effective utility services.

Stakeholder Engagement
The analysis was primarily an internal effort with input from industry stakeholders. The results of this analysis will be part of the S/CAP community outreach efforts.

Environmental Review
The UAC's review of this analysis does not meet the definition of a project under section 21065 of Public Resources Code, thus, environmental analysis is not required at this time.

Attachments:

- Attachment A: Evaluation of Palo Alto Electric Charger Needs
- Attachment B: Presentation

Attachment A

Evaluation of Palo Alto Electric Vehicle Charger Needs to Achieve 80% Electric Vehicle Penetration by 2030

Mo Sodwatana

Stanford University

August 28, 2020

Table of Contents

I. Executive Summary 3

II. Introduction 5

The Sustainability and Climate Action Plan 5
Within the Context of California's Goals 5

Project Objective 5

III. Framework for Analysis 6

IV. Current EV Charging Scene 6

Palo Alto Community Statistics 6

EV Charging Patterns 7

Existing Charging Infrastructure Estimate 8

V. EV Charger Needs in Palo Alto by 2030 8

Residential EV Charging Ports Need 8
Multi-Family EV Charging Needs 9

Non-Residential EV Charging Ports Need 9

VI. Cost Estimate 10

VII. Incorporating Community Feedback 11

VIII. Key Takeaways ..... Error! Bookmark not defined.

Appendix A: EV Charging Stations and Estimating Current Charging Ports in Palo Alto 12

Types of EV Charging Stations 12

Estimating Current Charging Ports in Palo Alto 13

Appendix B: Projection of EVs and Forecasting Charger Needs 14

Projecting EVs in Palo Alto by 2030 14

Forecast of EV Charging Ports Needed 16

Appendix C: Multi-Family Property Survey and Findings 18

Appendix D: Cost Estimation Approach 22

Charging Port to Site Conversion 22

Utility-Side Cost Estimate 23

Customer-Side Cost Estimate 24

I. Executive Summary

In order to reduce greenhouse gas (GHG) emissions to 80% below 1990 level by 2030, the City of Palo Alto needs to undergo aggressive electrification of vehicles. To achieve this goal, the city needs to increase the adoption rate of electric vehicles (EVs) in Palo Alto and ensure adequate EV charging infrastructure.

This study analyzes an 80% penetration scenario of EVs in Palo Alto by 2030, from the current 9%, and determines the quantities of various types of charging infrastructure required to support that level of penetration. The assessment considers various components, such as charging patterns of residential and commuting EV drivers and current EV trends in Palo Alto. The study also gives an estimate of the costs associated with equipment, installation and upgrade. This study also explores the specific needs of charging infrastructure in multi-family properties.

The results of the study are categorized into residential and non-residential categories. Residential includes EVs registered in Palo Alto. The charger types needed to support these EVs are 1) single-family residential (SFR) Level 1 (L1) chargers,[1] 2) single-family residential Level 2 (L2) chargers[2] and 3) multi-family L2 chargers.[3] Non-residential includes EVs commuting to Palo Alto and commercial and governmental EVs registered in Palo Alto. The charger types needed to support these EVs are non-residential L2 and Direct Current Fast Chargers (DCFC).

Due to the highly variable and dependent factors that influence the cost of EV infrastructure, it can be challenging to come up with an exact cost estimate. Examples of such factors include the need to upgrade the electrical service panel, the potential need for trenching across hardscape and the charging ports per site. Due to this high uncertainty, a range of costs are presented.

Table 1. Breakdown of total estimated cost per port.

Charger Type	Number of ports	Number of sites	Cost per port
SFR residential L1	5,000 – 8,000	4,200 – 6,700	$0 – $300
SFR residential L2	10,000 – 12,000	10,000 – 12,000	$3,000 – $10,000
Multi-family L2	3,000 – 6,000	450 – 890	$12,400 – $49,900
Non-residential L2	6,000 – 12,000	240 – 480	$5,400 – $20,500
DCFC	200 – 300	45 – 65	$62,000 – $230,000
Total	**24,200 – 38,300**	**14,935 – 20,135**	

[1] A Level 1 charger is defined as a charger using a 120-Volt alternating current plug.
[2] A Level 2 charger is defined as a charger using 208 or240 Volt electrical service.
[3] Multi-family and single-family L2 chargers are considered separately due to the fact that installation process and costs for L2 chargers in multi-family buildings are significantly different.

The key takeaways from this analysis are:

- If the 80% EV penetration goal is met:
  - The number of EVs will increase tenfold and charging needs are expected to increase 6- to 8-fold – with the assumption that utilization rate per port will be higher than current levels.
  - Energy consumption will increase from the current 1.5% of total load to 15% of total load. On the residential side, it is expected to increase from 6% to 69% of total residential electrical load.
  - The number of EVs per household is projected to increase from 0.18 to 1.7 EVs per household.
- The cost per port is highly variable and is dependent on the need for an electrical service panel upgrade, the potential need for trenching, and the number of ports installed per site.
- Due to economies of scale, greater ports per site is more cost effective. For non-residential L2 ports, the installation cost per port at commercial campuses is projected to be lower than at multi-family properties.

Planning for and financing a project at this scale will be challenging. However, the variability in cost indicates that with strategic planning, it is possible to achieve the low-end cost and avoid the high-end cost. The cost estimates are preliminary in nature and are highly dependent on the site.

II. Introduction

The Sustainability and Climate Action Plan

The City of Palo Alto has ambitious goals to reduce the community's carbon impacts, greenhouse gas (GHG) emissions and resource consumption. One such goal is the Sustainability and Climate Action Plan (S/CAP) launched 2014. In early 2020 the City updated its S/CAP to ensure the sustainability goals are being met, including their "80 x 30" goal which aims to reduce GHG emissions to 80% below 1990 levels by 2030.[4] While there are seven identified key areas, shown in Figure 1, this paper will primarily focus on EVs.

Figure 1. Seven proposed key priorities for S/CAP.

Electrifying transport is essential to Palo Alto's plans to address climate change and air quality as more than half of the city's emissions come from the transportation sector. Within the 2020 S/CAP goal, Palo Alto plans to reduce transportation-related GHG emissions 80% by 2030, from 300,000 MT $CO2_e$ to 60,000 MT $CO2_e$ by increasing EVs registered in and commuting to the city 80% and ensuring adequate charging network to support the high level of penetration.

Within the Context of California's Goals

Within the context of California's goals, Palo Alto's transport electrification goals go beyond those set by the state. As of 2019, there are 25 million cars registered in California, of which around 2% or 568,000 are EVs.[5] With the state aiming for 5 million EVs by 2030[6], the EV penetration could reach 20% by 2030. This goal will help cut the state's GHG emissions to 40% below 1990 levels by 2030.[7]

Project Objective

Expanding access to charging infrastructure is a necessary complement to EV adoption, and with the Palo Alto's goal to electrify 80% of vehicles registered in and commuting to Palo Alto by 2030, it becomes essential to assess EV charging infrastructure needs in Palo Alto.

---

[4] City of Palo Alto. 2020. *Sustainability and Climate Action Plan.* June 6. Accessed August 21, 2020. https://www.cityofpaloalto.org/services/sustainability/sustainability_and_climate_action_plan/default.asp.
[5] Statista. 2019. *US Automobile Registration in 2018, by State.* December. https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics and https://www.statista.com/statistics/196010/total-number-of-registered-automobiles-in-the-us-by-state/.
[6] https://ww2.arb.ca.gov/zev-collaboration
[7] California Public Utilities Commission. n.d. *Zero-Emission Vehicles.* https://www.cpuc.ca.gov/zev/.

This study will answer the question of what charging infrastructure Palo Alto will need to support 80% EV penetration and what type of chargers will be needed. The study will also provide a high-level cost estimate associated with installation, equipment and upgrade.

III. Framework for Analysis

The framework for analyzing EV charger needs in Palo Alto to accommodate 80% EV penetration is shown in Figure 2.

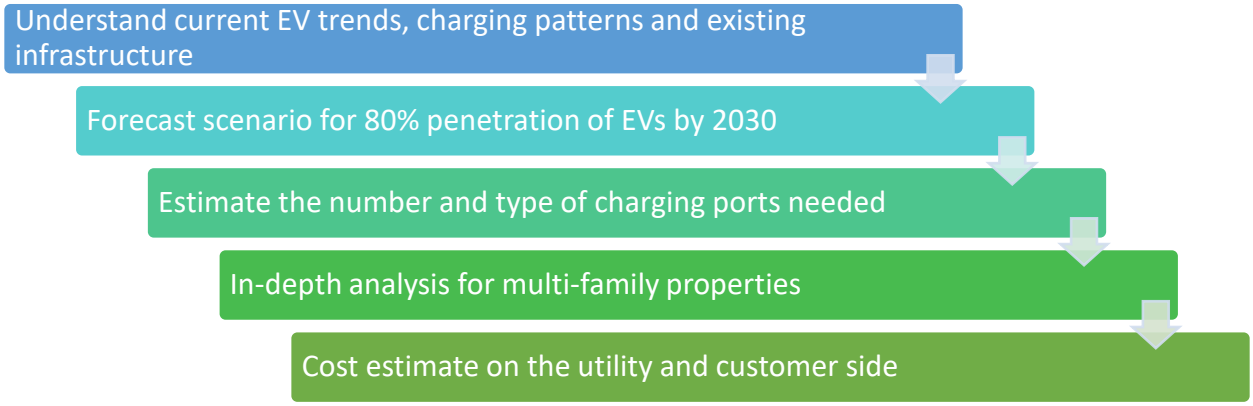


Figure 2. EV charging infrastructure assessment analysis process.

It is important to note that the assessment is based on current understandings of EVs and their charging needs and that improvements such as in battery technology and charging efficiencies can alter these results. In addition, the cost estimates do not include site specific detailed engineering design and are to be considered directional or order of magnitude estimates for planning purposes.

While the focus is on achieving 80% penetration of EVs by 2030, three other scenarios were also explored. These scenarios were of 25%, 30% and 50% penetration. The 25% penetration case represents the base case, which is aligned closely with the state's current goal of reaching 5 million EVs by 2030.

IV. Current State of EV Charging in Palo Alto

Palo Alto Community Statistics

The City of Palo Alto is located in the San Francisco Bay Area in the heart of Silicon Valley. The city has a population of 65,000 residents living in 25,000 households. Of these households, 15,000 are single family residences (SFR) and 10,000 are multi-family units.[8]

[8] Bay Area Census. n.d. *Bay Area Census: City of Palo Alto.*

In 2019, there were 52,000 vehicles registered in Palo Alto with EVs accounting for 9%, or 4,500, of the total registered.[9] Figure 3 is the distribution of these vehicles and the breakdown of EVs.

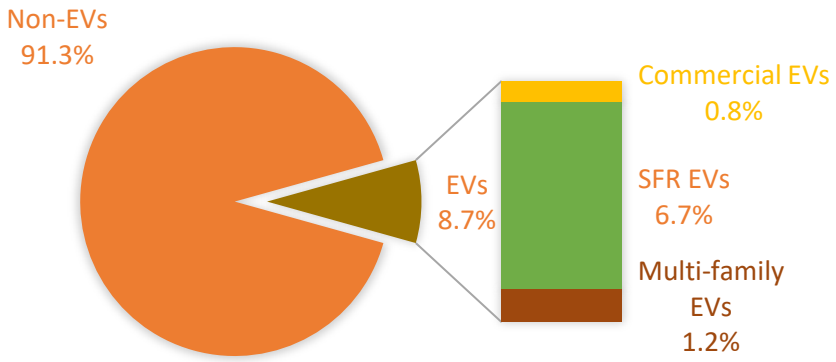


Figure 3. Distribution of vehicles registered in Palo Alto in 2019.

As seen in Figure 3, EVs registered in Palo Alto include both commercial and residential. This is an important distinction because commercial EVs and residential EVs have different charging needs, which will be discussed in the next section.

In addition to the vehicles registered in Palo Alto, it is estimated that 50,000 vehicles drive into the city daily. Looking at the current percent penetration of EVs in the Bay Area, around 6% to10% of these vehicles are assumed to be EVs.

EV Charging Patterns

Observed charging patterns suggest that most EV drivers choose to charge at home, as seen in Figure 4.[10] As such, residential and non-residential EV drivers will require different quantities and types of charging. The charger type assessed for residential EVs are SFR residential L1, SFR residential L2 and multi-family L2[11], while the type of chargers assessed for commuting and commercial EVs are non-residential L2 and DCFC.[12]

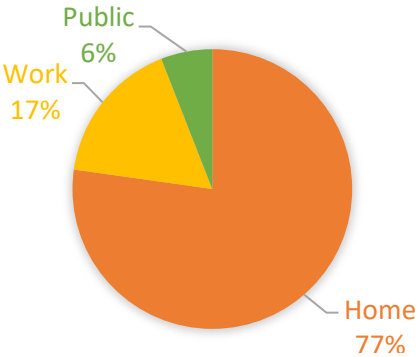


Figure 4. Distribution of total electricity provided to EVs based on location.

[9] Department of Motor Vehicles information provided to Palo Alto in 2018, extrapolated with 2019 estimates.
[10] Melaina, Marc, and Michael Helwig. 2014. *California Statewide Plug-in Electric Vehicle Infrastructure Assessment.* National Renewable Energy Laboratory.
[11] In this study multi-family properties are considered to have only L2 charging ports. L1 charging ports in MF units can replace L2 for a 2:1 or 4:1 ratio.
[12] An explanation of the different charging stations can be found in Appendix A.

Existing Charging Infrastructure Estimate

The current estimate for the number of charger ports in Palo Alto is summarized in Table 2.[13]

Table 2. Estimate of charging ports in Palo Alto in 2019.

Charger Type	Charging Ports
SFR residential L1	3,100
SFR residential L2	300 – 350
Multi-family L2	50 – 100
Non-residential L2	800
DCFC	30
Total	**4,280 – 4,380**

V. EV Charger Needs in Palo Alto by 2030

Residential EV Charging Ports Need

In 2019, there are 52,000 vehicles registered in Palo Alto, of which 9% are residential EVs. By 2030, it is projected that 56,000 vehicles will be registered in the city. An 80% penetration means 42,000 residential vehicles will be EVs. Table 5 summarizes the current EVs and charging ports in Palo Alto, as well as the projected number to reach 80% penetration by 2030.[14]

Table 3. Current and projected residential EVs and charging ports.

	EVs	
	As of 2019	2030
Residents in single family homes	3,500	30,000
Residents in multi-family units	600	12,000
Total	**4,100**	**42,000**
Charger Type	Charging Ports	
	As of 2019	2030
SFR L1	3,100	5,000 – 8,000
SFR L2	300 – 350	10,000 – 12,000
Multi-family L2	50 – 100	3,000 – 6,000
Total	**3,450 – 3,550**	**18,000 – 26,000**

[13] The approach to estimating current charging ports in Palo Alto can be found in Appendix A.
[14] Detailed steps to EV projections and charger needs forecasting can be found in Appendix B.

Multi-Family EV Charging Needs

Incentivizing EV charger installations in multi-family properties can be very challenging and complex as there are many obstacles to overcome. Such obstacles include the lack of electrical capacity, lack of parking space and uncertainty about equipment ownership and electricity bill. In order to help overcome these obstacles, staff conducted a survey[15] to get a general sense of the type of parking and the number of parking spaces available per unit at various multi-family properties. Table 6 shows the EV charging port needs by property category using results from the survey.

Table 4. Breakdown of a high need scenario for charging ports needs in multi-family property for 80% penetration.

Property Category		Characteristics of Existing MF Property:			EV Infrastructure Needs:	
		Total # of Units	Total # of Properties	Approx. # Cars in MF	Charging Ports Needed[16]	Estimated Ports/ Property
Apartment	Duplex	483	243	725	290	1.2
	3 - 4	926	260	1,389	556	2.1
	5 - 10	1,253	185	1,754	702	3.8
	11 - 20	693	45	970	388	8.6
	21 - 50	1,082	36	1,407	563	15.6
	51 - 100	1,104	21	1,435	574	27.3
	Over 100	2,217	15	2,882	1,153	76.9
	Other	375	15	488	195	13.0
Townhomes		336		504	202	
Condos		2,522		3,279	1,311	
Other		141		183	73	
Total		**11,132**		**15,015**	**6,006**	

Non-Residential EV Charging Ports Need

On the commuting side, there are around 50,000 vehicles driving into the city daily, with 6% to 10% being EVs[17]. By 2030, the number of vehicles commuting to the city is expected to increase to 65,000. An 80% penetration would be 52,000 EVs. Note that the potential for an increased

[15] Survey methodology can be found in Appendix C.

[16] This is a high end estimate, assuming 2 EVs share a charging port. The low end estimate is that 4 EVs share a port. These assumption gives a range of 3,000 – 6,000 ports for MF units for 80% penetration.

[17] Current vehicle count is based on best estimates by staff based on current available data. Efforts are underway to improve this estimate as part of the S/CAP update using traffic counts and modeling.

level of post-COVID telecommuting was not factored into this estimate. The extent to which expanded telecommuting will occur and its effects on commuting and the use of real estate will require several years of monitoring before it can be fully taken into account in forecasts.

Additionally, 4,500 vehicles registered in Palo Alto are EVs, with 9% being commercial or governmental. A 60% penetration of EVs is expected on the commercial side by 2030.[18]

Table 7 summarizes the EV projection and charger needs on the non-residential side.[19]

Table 5. Current and projected EVs and charging ports on the non-residential side.

	EV	
	As of 2019	2030
Commuters to Palo Alto	4,400	52,000
Commercial and government	400	2,700
Total	**4,800**	**54,700**
Charger Type	Charging Ports	
	As of 2019	2030
Non-residential L2	800	6,000 – 12,000
DCFC	30	200 – 300
Total	**830**	**6,200 – 12,300**

VI. Cost Estimate

The infrastructure segments assessed for cost estimate are broken up into 4 parts circled in orange in Figure 5.

[18] The reason commercial vehicles are expected to experience a slower adoption rate is due to the difficulty of electrifying heavy duty vehicles, which are a part of the commercial fleet.

[19] A detailed explanation of the steps to forecasting charger needs can be found in Appendix B.

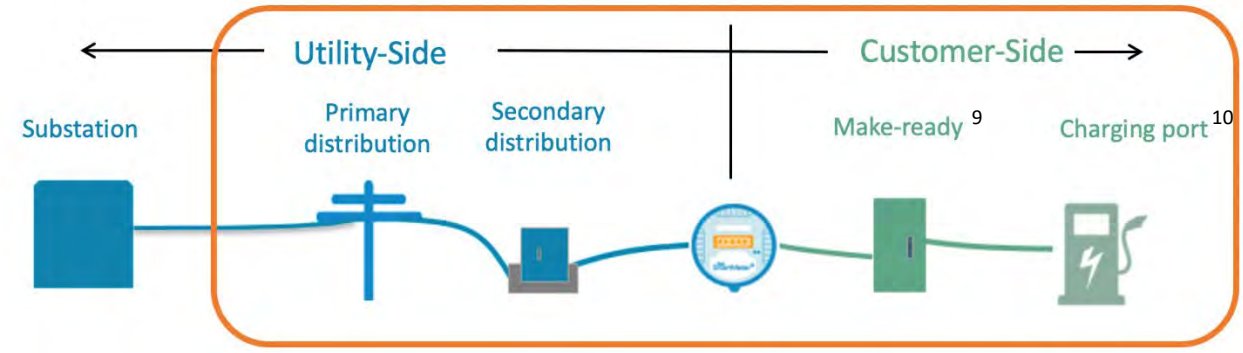


Figure 5. EV charging infrastructure electrical segments, considered in cost estimation circled in orange.

The cost estimates of the infrastructure segments were assessed following these steps:

1. Determining the number of charging ports per site
2. Calculating the power level at each site
3. Assessing the probability of an upgrade
4. Multiplying by the low and high cost estimate if an upgrade is needed

Table 6 is a breakdown of the total incurred cost per port by charger type.[22]

Table 6. Breakdown of cost per port.

Charger Type	Cost per port	
	Low	High
SFR residential L1	-	$300
SFR residential L2	$3,000	$10,000
Non-residential L2	$5,400	$20,500
Multi-family L2	$12,400	$49,900
DCFC	$62,000	$230,000

VII. Incorporating Community Feedback

The findings of this study were presented to a group of EV advocates from the Palo Alto community and the following feedback was incorporated.

[20] Make-ready includes electrical work and permit.
[21] Per port cost is the cost of hardware.
[22] An in-depth explanation of the approach as well as the range of costs of equipment and upgrades used can be found in Appendix D.

- A clarification was made on the definition of "make-ready" and "per port" cost. The low and high cost estimates for the make-ready and per port were also adjusted from the CalETC report[23] per comment that Palo Alto permitting costs are higher than average of California.
- The possibility of adding L1 chargers in multi-family properties was also discussed in the report per comment that L1 chargers should not be neglected at these properties due to their generally lower cost and favorability to the grid.
- In order to reach 80% penetration, it is important to note the importance of education and outreach to inform potential car buyers of EV options and available rebates.
- The slower adoption rate of commercial vehicles registered to Palo Alto does not curtail the importance of electrifying that sector. A 60% penetration is for 2030 but the aim is much higher for 2045.

Appendix A: EV Charging Stations and Estimating Current Charging Ports in Palo Alto

Types of EV Charging Stations

An infographic of the three types of EV charging stations is shown in Figure A-1. [24]

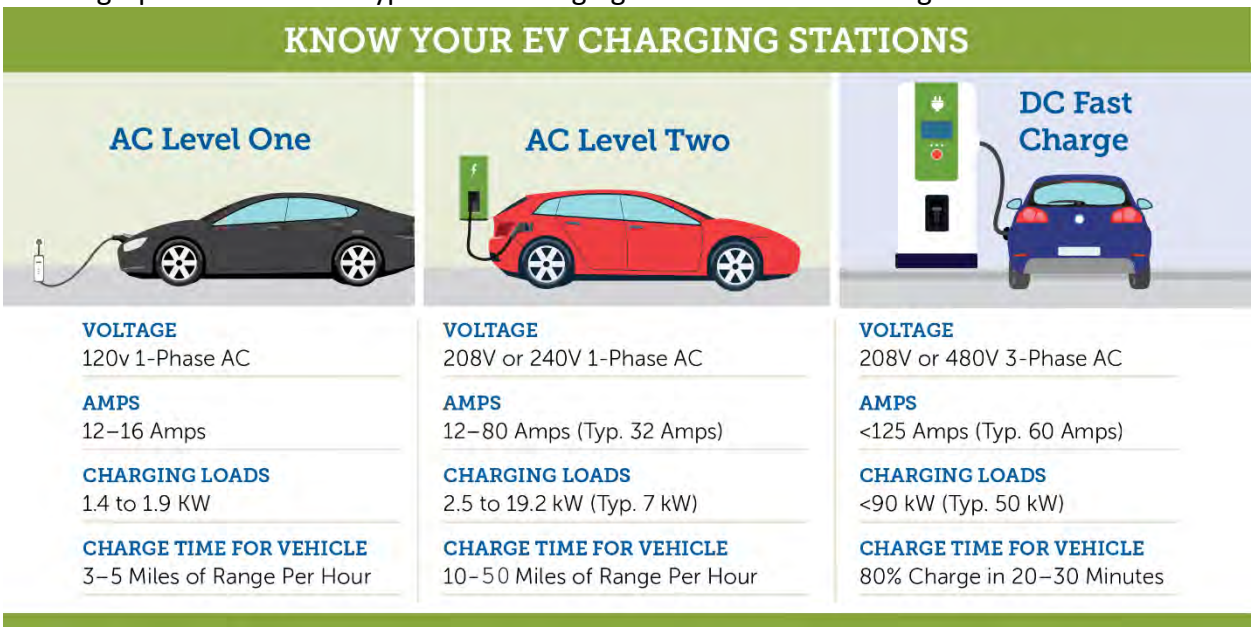


Figure A- 1. Infographic of EV charging stations.

[23] CalETC. 2020. *Infrastructure needs assessment for 5M light-duty vehicles in California by 2030.* (https://caletc.com/just-released-infrastructure-needs-assessment-for-5m-light-duty-vehicles-in-california-by-2030/)

[24] Carolina County. 2017. *Find Charging Option for Your Electric Vehicle.* July. Accessed August 21, 2020. https://www.carolinacountry.com/your-energy/energytech/know-charging-options-to-keep-your-ev-rolling

Estimating Current Charging Ports in Palo Alto

This section will explain how the current charging port estimate in Palo Alto was obtained. Table A-1 summarizes the estimated charging port in 2019.

Table A- 1. Estimate of charging ports in Palo Alto in 2019.

Charger Type	Charging Ports
SFR residential L1	3,100
SFR residential L2	300 – 350
Multi-family L2	50 – 100
Non-residential L2	800
DCFC	30
Total	**4,280 – 4,380**

Since there are 3,500 EVs registered to residents in SFR and most drivers choose to charge their EVs at home, it is assumed that each resident has either an L1 or L2 charger at home. So, the total SFR chargers adds up to around 3,500.

The number of DCFC in Palo Alto is known to be around 30 chargers,[25] while the number of L2 chargers are estimated from the number of permits given by the Engineering Division of CPAU. The number of "Engineering Division defined L2 and L3"[26] permits combined is 833. Since around 30 are DCFC, that leaves 800 to be chargers considered L2 in this study. Of those 800 L2 chargers, 400 were permitted to unique addresses, assumed to be SFR because it is unlikely that more than one charger will be installed in a SFR. Given there are currently more EVs registered to SFR than to multi-family, the estimate for charging ports for SFR L2 is 300-350 and for multi-family L2 is 50-100. The remaining 400 L2 chargers were permitted to repeated addresses, assumed to be non-residential locations because commercial properties typically have more than one charger. Additionally, assuming 2 ports per charger at these site, the estimate for non-residential L2 charging ports is 800.

[25] PlugShare. https://www.plugshare.com/

[26] CPAU Engineering Division charger level definition:
Level 1 – Any charger that can plug into standard 120VAC outlet. Typically limited by a standard 15A breaker
Level 2 – Any 240VAC charger that is <40 amps (breaker size 50A).
Level 3 – Any 240VAC charger that is >40 amps.

Appendix B: Projection of EVs and Forecasting Charger Needs

Projecting EVs in Palo Alto by 2030

The forecast for the number of EVs is done by extrapolating the number of residential and commuting autos in Palo Alto linearly from 2019 to 2030, while the number of EVs are extrapolated exponentially to meet the 80% penetration.[27] The impact of telecommuting in the post-COVID period was not considered in this projection.

Additionally, this forecast also distinguishes between plug-in hybrid vehicles (PHEVs) and battery electric vehicles (BEVs). This is an important distinction because BEVs and PHEVs have different needs for charging infrastructure. However, while changes in trends will affect this ratio, this ratio is kept constant at 2018 Palo Alto ratio of 1 PHEV to 2.5 BEV.[28]

Figures B-1 and B-2 shows the exponential adoption rate of EVs to reach 80% penetration by 2030 for residential and non-residential sectors, respectively.

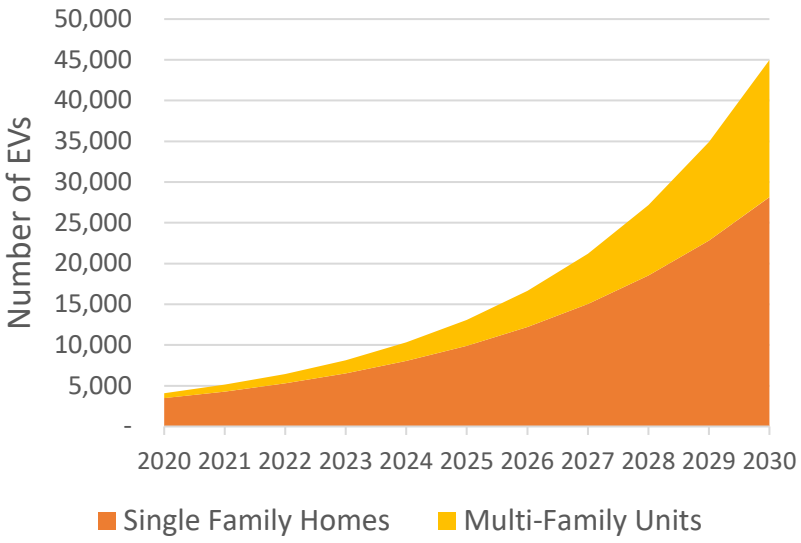


Figure B- 1. Forecast of residential EV adoption rate to reach 80% by 2030.

[27] The underlying assumption is that auto purchases grow at a constant rate, as a reflection of constant population growth. Whereas, EV purchases experience a higher adoption rate due to increasing incentives and industry trends.
[28] Department of Motor Vehicles data provided to Palo Alto in 2018.

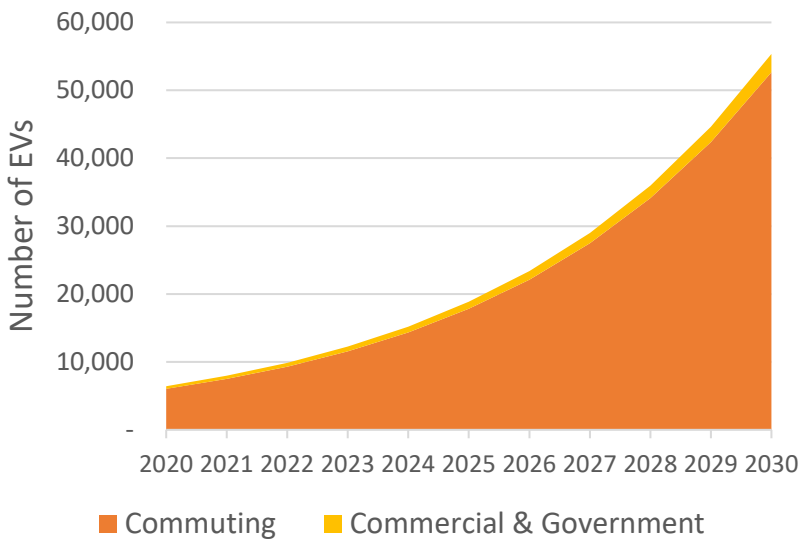


Figure B- 2. Forecast of EV commuting and commercial & government EV adoption rate to reach 80% by 2030.

The forecasted number of residential and non-residential EVs Palo Alto by 2030 for all four cases is summarized in Table B-1. The table also shows the anticipated electrical demand expected to result from the growth of EVs. [29]

Table B- 1. Projected EVs and electrical demand for the four cases of penetration.

	Current (2019)	Case 1: 25% Penetration	Case 2: 30% Penetration	Case 3: 50% Penetration	Case 4: 80% Penetration
# of residential EVs	4,100	14,600	16,900	28,100	42,000
# of non-residential EVs	4,800	17,100	19,700	32,900	54,700
Total EVs	8,900	31,700	36,600	61,000	96,700
Res EVs energy	9,324	33,800	39,000	65,100	104,200
% of total res energy	6%	23%	26%	43%	69%
Comm EVs use	2,242	8,700	10,000	16,700	26,700
% total non-res energy	0%	1%	1%	2%	4%
Total EVs energy use	11,566	42,500	49,100	81,800	130,900
% total energy	1%	5%	5%	9%	15%

[29] The total electricity consumption in Palo Alto is 900,000 MWh per year, with residential using 150,000 MWh and the remaining non-residential using 750,000 MWh. The electrical consumption from PEVs is determined from the observed charging pattern of PEV owners, where 77.5% charge at home, 17.0% at work and 5.5% in public places. It also considers that the average electricity use per BEV per year is 3,399 kWh/vehicle-year while for PHEV the average electricity use is 1,924 kWh/vehicle-year.

Forecast of EV Charging Ports Needed

The estimate number of charging ports needed for SFRs was based on DMV's data that there are on average 2.1 cars per household. In the absence of exact data, for this analysis staff assumed 2.5 cars per SFR and 1.5 cars per multi-family unit. An 80% penetration means that 2 cars per SFR would be EV while the remaining "0.5" car would not be EV. With every SFR owning 2 EVs, the assumption is that they all have either an L1 or L2 charger so the total charging ports for SFR L1 and SFR L2 would be 15,000.

The estimate for multi-family is discussed in Appendix C.

The base estimate number of EV charging ports needed for the non-residential side is from the whitepaper published on infrastructure needs and costs in California by the California Electric Transportation Coalition (CalETC).[30] The CalETC estimate is done by dividing the forecasted number of PEVs by 1,000 and multiplying by the values under each charger type. The detailed table from CalETC on infrastructure needs per 1,000 PEVs by scenario, vehicle type, and charging type is shown in Table B-2.[31]

Table B- 2. CalETC infrastructure needs per 1,000 EVs by vehicle and charging type.

	Charging Port Needs per 1,000 Vehicle					
Vehicle Type	Level 1 Res	Level 1 Non-Res	Level 2 Res	Level 2 Non-Res	Level 2 MUD	DCFC
BEV	300	50	500	75	120	4
PHEV	850	100	25	25	25	0

The estimates were then adjusted accordingly to Palo Alto's specific charging scenario after talking to charging infrastructure experts, Palo Alto residents and EV drivers. A summary of the charging ports is shown here in Table B-3.

[30] CalETC. 2020. *Infrastructure needs assessment for 5M light-duty vehicles in California by 2030.* (https://caletc.com/just-released-infrastructure-needs-assessment-for-5m-light-duty-vehicles-in-california-by-2030/)

[31] Each vehicle type have different needs for each type of infrastructure. However, other than distinguishing between PHEVs and BEVs, the specific breakdown of the PEVs types, such as mile range and rideshareship, in Palo Alto are unknown. Therefore, the estimate using CalETC's approach assumes that all PHEVs are 30+ mi type and all BEVs are 100-200 mi type.

Table B- 3. Summary of charging ports needed for 80% penetration.

Charger Type	Charging Ports	
	As of 2019	2030
SFR residential L1	3,100	5,000 – 8,000
SFR residential L2	300 – 350	10,000 – 12,000
Multi-family L2	50 – 100	3,000 – 6,000
Non-residential L2	800	6,000 – 12,000
DCFC	30	200 – 300
Total	**4,280 – 4,380**	**24,200 – 38,300**

Appendix C: Multi-Family Property Survey and Findings

Figure C-1 shows the spread of multi-family properties across Palo Alto.

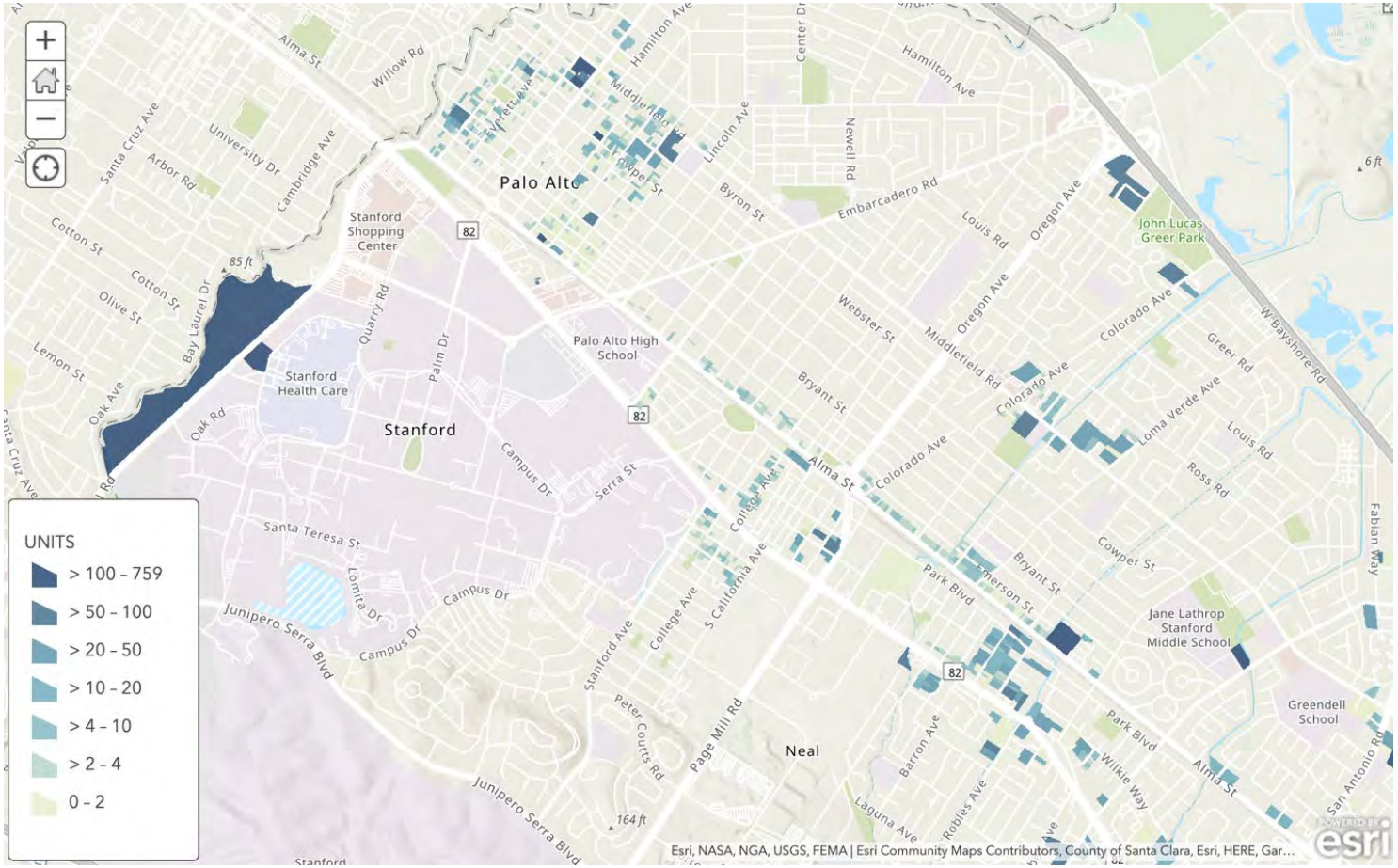


Figure C- 1. Locations of multi-family properties classified as apartments in Palo Alto. [32]

[32] Santa Clara County. Parcel Data. https://services6.arcgis.com/evmyRZRrsopdeog7/arcgis/rest/services/AssessorsParcels/FeatureServer/0

Staff did a survey of several multi-family properties of different unit categories to gain insight on parking space and EV charger installation barriers. Questions asked included:

- Parking space-related questions: How much parking is available to each unit? What type of parking (underground, covered, uncovered)? Do units have street parking?
- EV charger-related questions: How many residents currently own an EV? Does the property have any EV chargers installed? Are the property owners interested in installing chargers? Are they aware of the existing rebates the City has to offer?

From the survey responses, shown in Table C-1, staff concluded that the multi-family properties had at least 1 parking space per unit. If the resident in a unit has more than 1 car, he or she would be parking on the street. The type of parking is typically a mix.

Table C- 1. Survey response from select multi-family properties in Palo Alto.

Property Number	Units Category	# Units	# Parking Spots	Parking Type (#)	# residents driving EV	EV chargers installed? (#)	Additional notes
1	Over 100	107	N/A	Street parking	N/A	No	Respondent reports they have been told they can't have EV chargers. Limited parking space.
2	Over 100	118	120	Underground, covered	10	Yes (2)	They wanted chargers to be assigned to individual tenants and not at shared parking.
3	51-100	61	67	Covered (61), uncovered (6)	5	No	Use EV charger from property across the street (first come first serve)
4	51-100	63	105	Underground (63), uncovered (42)	5	No	EV charger installation pending
5	21-50	36	40	Covered	About 1/3	No	Looked into program couple years ago, not affordable
6	21-50	45	47	Underground, covered, uncovered	N/A	Yes (2)	
7	21-50	33	33	Covered, uncovered, street parking	A couple	No	A couple residents have asked about EV chargers; company policy is that resident pay for installation, electricity billed to resident; aware of rebate but show no interest
8	21-50	26	29	Underground, street parking	N/A		
9	11-20	17	17	Covered	N/A		
10	11-20	19	20	Covered, uncovered (5)	A couple	No	Company policy is that residents pay for installation, electricity billed to resident

Using the conclusions from the survey, and information on the number of existing multi-family properties and total number of units from Santa Clara County data, a breakdown of the charging ports needed for 80% penetration was determined, shown in Table C-2.

Table C- 2. Breakdown of the high-end estimate of the charging ports needs in multi-family properties for 80% penetration.

Property Category		Total # of Units	Total # of Properties	Estimate # Units/ Property	Estimate # Cars/ Unit	Estimate # Parking Spots[33]	Estimate # Street Parking	Total # Cars in MF	EV Chargers	Chargers per site
Apartment	Duplex	483	243	2.0	1.5	483	242	725	290	1.2
	3 - 4	926	260	3.6	1.5	926	463	1,389	556	2.1
	5 - 10	1,253	185	6.8	1.4	1,253	501	1,754	702	3.8
	11 - 20	693	45	15.4	1.4	693	277	970	388	8.6
	21 - 50	1,082	36	30.1	1.3	1,082	325	1,407	563	15.6
	51 - 100	1,104	21	52.6	1.3	1,104	331	1,435	574	27.3
	Over 100	2,217	15	147.8	1.3	2,217	665	2,882	1,153	76.9
	Other	375	15	25.0	1.3	375	113	488	195	13.0
Townhomes		336	-		1.5	336	168	504	202	
Condos		2,522	-		1.3	2,522	757	3,279	1,311	
Other		141	-		1.3	141	42	183	73	
Total		**11,132**	**820**			**11,132**	**3,883**	**15,015**	**6,006**	

[33] Assuming a 1 to 1 ratio between number of units and available parking space.

Appendix D: Cost Estimation Approach

Charging Port to Site Conversion

Table D-1 is the conversion table from the number of ports to the number of sites. The sites vary in size, small, medium and large, and these site sizes differ in the number of ports and power level. Additionally, the share of site size varies with different site type.

Table D- 1. Number of port to site size conversion from CalETC (highlighted in blue are modified numbers[34]).

Site Type	Site Size	Share of Site Type	Number of Ports and Power Level (kW)						Total Ports	Site Power (kW)
			Low		Mid		High			
Level 1, residential	Small	40%			1	1.4			1	1.4
	Medium	40%			1	1.4			1	1.4
	Large	20%			2	1.4			2	2.8
Level 2, residential	Small	95%	1	7.2					1	7.2
	Medium	0%	2	7.2					2	14.4
	Large	5%					1	19	1	19.0
Level 2, non-residential	Small	20%			5	7.2			5	36.0
	Medium	70%			20	7.2			20	144.0
	Large	10%			100	7.2			100	720.0
Level 2, multi-family	Small	86%			4	7.2			4	28.8
	Medium	13%			18	7.2			18	129.6
	Large	2%			70	7.2			70	504.0
DCFC, micro site	Small	20%	2	50					2	100.0
	Medium	40%	1	50	2	150			3	350.0
	Large	40%			3	150			3	450.0
DCFC, station	Small	30%			4	150			4	600.0
	Medium	40%			5	150	1	350	6	1,100.0
	Large	30%			8	150	2	350	10	1,900.0
DCFC, hub	Small	40%			20	150	5	350	25	4,750.0
	Medium	40%			40	150	10	350	50	9,500.0
	Large	20%			100	150	20	350	120	22,000.0

[34] Level 2, residential share of site type was changed from 75% small and 20% medium to 95% small and 0% medium. This change due to the fact that CalETC classifies a medium site size with two Level 2 chargers in the "Low" column. Because it is unlikely for SFR to own more than one Level 2 charger, the percent share was reduced from 20% to 0%. The "Low" column of the large site size initially contained one 7.2 kW port. This was removed for the same reason that it is unlikely for SFR to own more than one Level 2 charger, in this case, given that the SFR already owns a 19 kW Level 2 charger. Level 2, multi-family percent share of site type and number of ports were altered to reflect Palo Alto specific need, determined from the survey and housing data.

Utility-Side Cost Estimate

The power level at each site is used to determine the probability of upgrades on the utility-side, as seen in Table D-2. The higher the power level, the more likely the site triggers a primary medium voltage and secondary low voltage distribution system upgrade.

Table D- 2. Probability of utility-side upgrades by infrastructure segment and power level.

Power Level	Primary Distribution	Secondary Distribution
<7.2 kW	0%	0%
7.2 kW - 15 kW	0%	2-8%
15 kW - 50 kW	0%	70%
50 kW - 100 kW	0%	96%
100 kW - 5 MW	5-90%	100%
>5 MW	100%	100%

Table D-3 shows the low and high estimate of the cost if a primary or secondary distribution upgrade is triggered.

Table D- 3. Utility-side cost estimate by infrastructure segment.

Infrastructure Segment	Upgrade Cost	
	Palo Alto Estimate Low	Palo Alto Estimate High
Primary distribution	$ 1,000,000	$ 2,000,000
Secondary distribution	$ 30,000	$ 50,000

The primary distribution upgrade costs are recouped from all customers through rates. Certain portions of the secondary distribution upgrade costs could be directly charged to the customer triggering the upgrade.

Customer-Side Cost Estimate

Similarly on the customer-side, each site type has a probability of requiring a "make-ready" and port summarized here in Table D-4.

Table D- 4. Probability of site requiring "make-ready" and port.

Site Type	Make-Ready	Ports
SFR residential L1	12.5%	50%
SFR residential L2	75%	100%
Multi-family L2	100%	100%
Non-residential L2	100%	100%
DCFC	100%	100%

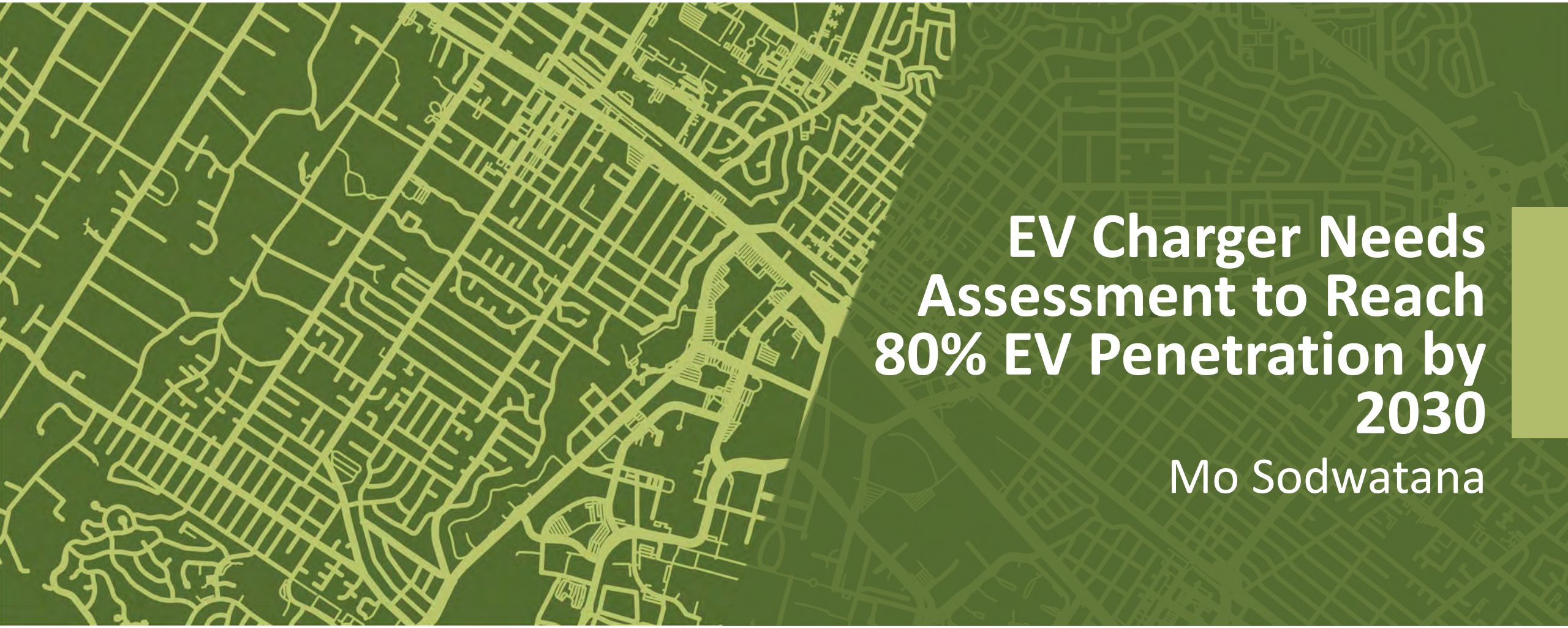
The cost of "make-ready," per site and port is shown below in Table D-5. The cost of make-ready includes the cost of electrical work and permitting. The per port cost is the cost of hardware.

Table D- 5. Customer-side infrastructure cost ranges by site type and infrastructure segment.

Site Type	Make-ready, per site		Per port	
	Low	High	Low	High
SFR residential L1	$ 0	$ 500	$ 0	$ 500
SFR residential L2	$ 0	$ 5,000	$ 500	$ 2,500
Multi-family L2	$ 50,000	$ 250,000	$ 500	$ 5,000
Non-residential L2	$ 50,000	$ 250,000	$ 500	$ 5,000
DCFC	$ 50,000	$ 320,000	$ 20,000	$ 100,000

Attachment B

CITY OF PALO ALTO



EV Charger Needs Assessment to Reach 80% EV Penetration by 2030

Mo Sodwatana

November 4, 2020

www.cityofpaloalto.org

Overview

- Project Objective
- Framework for Analysis
- Results
  - Charger Needs
  - Cost Estimate
- Key Takeaways

Project Objective

The Sustainability and Climate Action Plan (S/CAP)

- Goal to reach 80% penetration of EVs registered in and commuting to Palo Alto by 2030
- Expanding access to charging infrastructure is a necessary complement to EV adoption

Project objective

1. How many chargers will Palo Alto need to support 80% penetration? And what type of chargers are needed?
2. What is the cost estimate of installations, equipment, upgrades?

Figure 1. Seven proposed priorities for S/CAP.

Types of EV Chargers

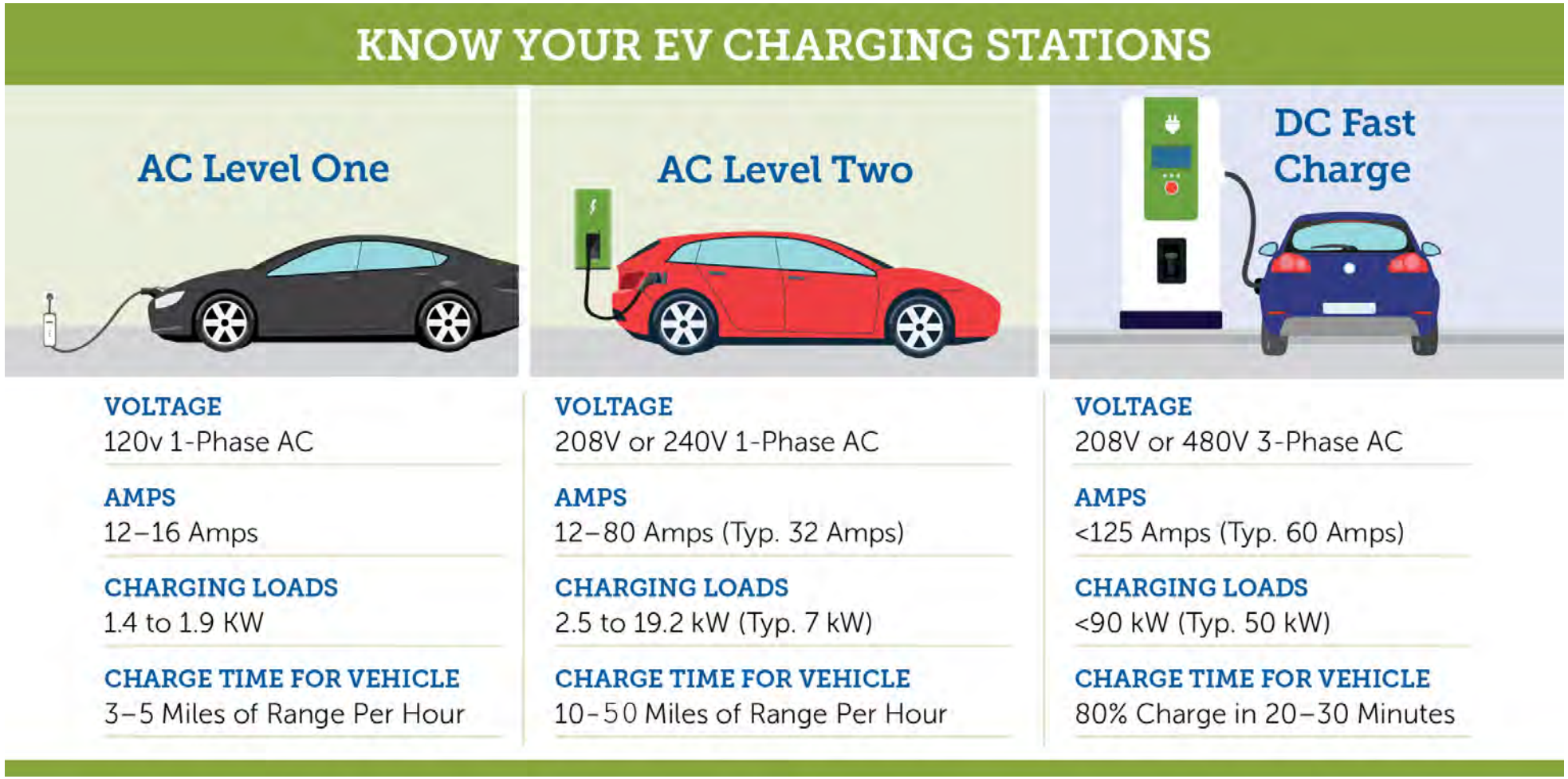


Figure 2. EV charging stations. [1]

CITY OF PALO ALTO

Framework for Analysis

- Understand current EV trends, charging pattern and existing infrastructure
- Forecast EVs in Palo Alto by 2030
- Estimate the number and type of charging ports needed
- In-depth analysis for multi-family properties
- Cost estimate on the utility and customer side

CITY OF PALO ALTO

Palo Alto Community Statistics

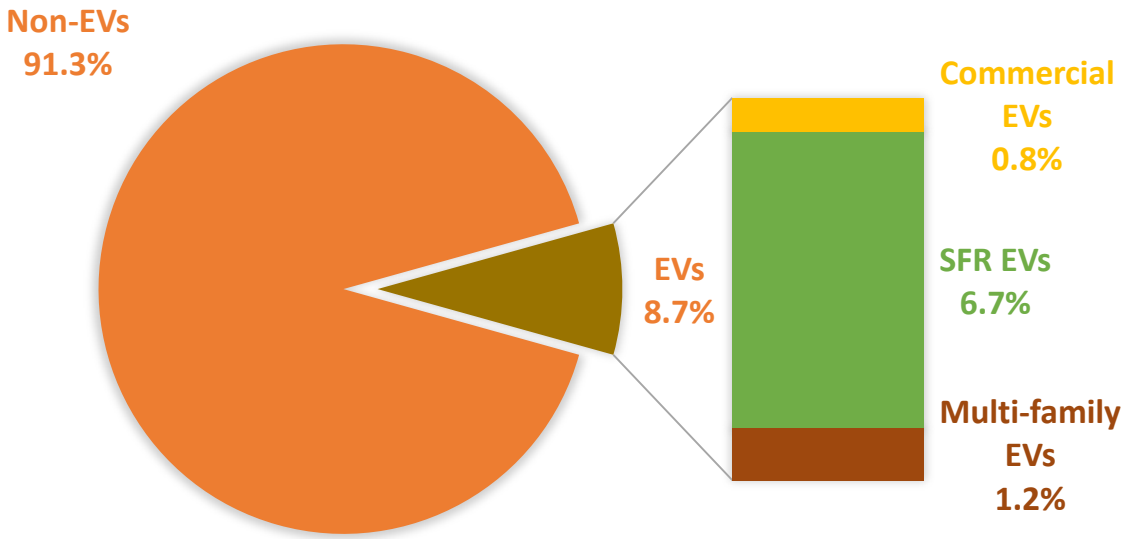


Figure 3. Distribution of vehicles registered in Palo Alto in 2019.

Residential

- Population 65,000 residents
- 25,000 households
  - 15,000 single family residence (SFR)
  - 10,000 multi-family residence
- 52,000 vehicles registered in Palo Alto
  - Of which 9% or 4,500 are EVs

Non-residential (commuting to Palo Alto)

- Palo Alto supports ~70,000 jobs
- Estimate 50,000 vehicles drive in daily
  - Of which, ~6-10% are EVs

CITY OF PALO ALTO

Existing Charging Infrastructure Estimate

- Single family residence L1 internal estimate
  - SFR have 3,500 EVs
- Multi-family L2 internal estimate
  - Multi-family have 600 EVs
- Permits for L2 Chargers = 800 chargers*

Table 1: Estimate of charging ports in Palo Alto in 2019.

Charger Type	Charging Ports
SFR residential L1	3,100
SFR residential L2	300 – 350
Multi-family L2	50 – 100
Non-residential L2	800
DCFC	30
Total	**4,280 – 4,380**

*Unique address = SFR residential L2/Multi-family L2 (1 ports per charger)
Repeated address = Non-residential L2 (2 ports per charger)

CITY OF PALO ALTO

Residential EV Charging Ports Estimate

Table 2: Current and projected residential EVs and charging ports.

	EV	
	As of 2019	2030
EVs in single family residence	3,500	30,000
EVs in multi-family residence	600	12,000
Total	**4,100**	**42,000**
Charger Type	Charging Ports	
	As of 2019	2030
SFR residential L1	3,100	5,000 – 8,000
SFR residential L2	300 – 350	10,000 – 12,000
Multi-family L2	50 – 100	3,000 – 6,000
Total	**3,450 – 3,550**	**18,000 – 26,000**

Residential

- Average in Palo Alto 2.1 cars per household
  - 2.5 cars per single family residence
  - 1.5 cars per multi-family residence
- Estimated the need for more L2 chargers than L1 chargers in SFR by 2030
  - L1 chargers not applicable to longer range EVs
  - On average 1.7 EVs per household

CITY OF PALO ALTO

Non-Residential EV Charging Ports Estimate

Non-residential (commuting to Palo Alto)

- Base estimate following CalETC whitepaper, *Infrastructure needs assessment for 5M light-duty vehicles in California by 2030* [2] and NREL, CEC EV Infrastructure Projection Tool [3]
- Currently, 4,500 vehicles registered in Palo Alto are commercial and governmental
  - ~ 9% are EVs are commercial
  - Estimate 60% penetration by 2030 = 2,700 are EVs

Table 3. Current and projected commuting EVs and charging ports.

	EV	
	As of 2019	2030
Commuters to Palo Alto	4,400	52,000
Commercial & Government	400	2,700
Total	**4,800**	**54,700**
Charger Type	Charging Ports	
	As of 2019	2030
Non-residential L2	800	6,000 – 12,000
DCFC	30	200 – 300
Total	**830**	**6,200 – 12,300**

Overview of Cost Estimate Approach

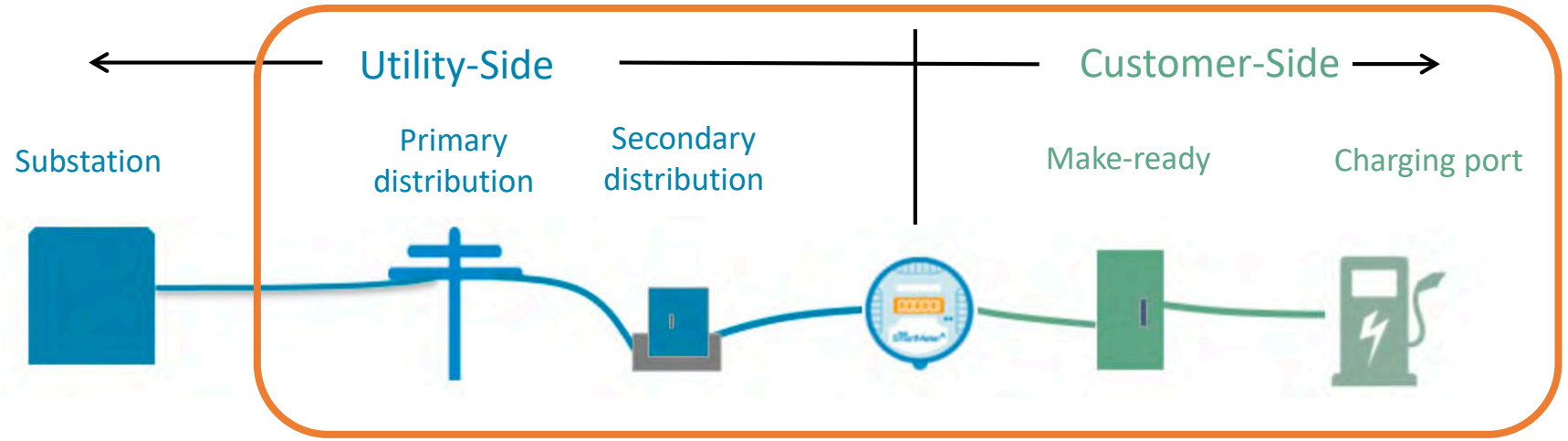


Figure 4. Electrical infrastructure segments for EV chargers. [2]

*Make-ready includes electrical work and permits
** Charging port is the cost of hardware

Expected cost of each infrastructure segment assessed by:

1. Number of charging ports per site
2. Power level at each site
3. Probability of an upgrade
4. Low and high cost of upgrade scenario to represent variability in site condition

Summary of Per Port Costs by Charger Type

Table 4. Summary of per port cost by charger types.

Charger Type	Number of port	Number of site	Port per site	Cost per port
SFR residential L1	5,000 – 8,000	4,200 – 6,700	1.2	$0 – $300
SFR residential L2	10,000 – 12,000	10,000 – 12,000	1.0	$3,000 – $10,000
Multi-family L2	3,000 – 6,000	450 – 890	6.7	$12,400 – $49,900
Non-residential L2	6,000 – 12,000	240 – 480	25.0	$5,400 – $20,500
DCFC	200 – 300	45 – 65	4.5	$62,000 – $230,000
Total	**24,200 – 38,300**	**14,935 – 20,135**		

CITY OF PALO ALTO

Key Takeaways

- If the 80% EV penetration goal is met:
  - The number of EVs is likely to increase tenfold and charging needs are estimated to increase 6- to 8-fold – with the assumption that utilization rate per port will be higher than current levels.
  - At these penetration levels, energy consumption is estimated increase from 1.5% of total load to 15% of total load. On the residential side, it is estimated to increase from 6% to 69% of total residential electrical load.
  - In this scenario, the number of EVs per household would increase from 0.18 to 1.7 EVs per household.

Key Takeaways

- The cost per port is highly variable and is dependent on the need for electrical service panel upgrade, the potential need for trenching, and number of ports installed per site.

- Due to economies of scale, greater ports per site is more cost effective. For non-residential L2 ports, the installation cost per port at commercial campuses is projected to be lower than at multi-family properties.

CITY OF
PALO
ALTO

Mo Sodwatana
Stanford Fellow
Jarupa.Sodwatana@CityOfPaloAlto.org
(678) 860-5746