



**CALIFORNIA  
ENERGY COMMISSION**



California Energy Commission  
Clean Transportation Program

## **FINAL PROJECT REPORT**

# **Overcoming Barriers to Electric Vehicle Charging in Multi-Unit Dwellings: A Westside Cities Case Study**

**Prepared for: California Energy Commission**

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# California Energy Commission

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# PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to \$20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about \$100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-14-603 and PON-14-607 to provide funding opportunities under the Clean Transportation Program for Zero Emission Vehicle Readiness. This first-come, first-served grant solicitation was an offer to fund projects that support new and existing planning efforts for plug-in electric vehicles and fuel cell electric vehicles. In response to PON-14-603 and PON-14-607, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards on January 16, 2015 and the agreement was executed as ARV-14-063 on March 19, 2015.

# ABSTRACT

The transportation sector is a major source of greenhouse gas emissions in California. To address this issue, Governor Jerry Brown signed an executive order calling for 1.5 million zero emission vehicles on California's roads by 2025. In order to achieve this ambitious goal, significant barriers must be overcome to expand and accelerate plug-in electric vehicle adoption including the need to build out the necessary refueling infrastructure. Currently, residents of multi-unit dwellings such as apartments and condominiums are unlikely to have access to home charging.

The purpose of this report is to explore barriers to plug-in electric vehicle adoption for residents of multi-unit dwellings within the Westside Cities subregion of Los Angeles County, and then identify multi-unit dwellings within the study region that may exhibit high latent plug-in electric vehicle demand and subsequent demand for low-cost electric vehicle supply equipment installation. These multi-unit dwellings should be a priority for targeted outreach for programs that assist with electric vehicle supply equipment installation, since they are most likely to host plug-in electric vehicle drivers in the near future. We find that the multi-unit dwellings with greatest demand for plug-in electric vehicles and charging infrastructure within the study region are located in West Los Angeles, followed in descending order by Beverly Hills, Santa Monica, West Hollywood, Culver City, and unincorporated portions of Los Angeles County.

This report also reviews the various costs associated with electric vehicle supply equipment installation at multi-unit dwelling sites, which are highly variable. To keep charging installation costs as low as possible, property owners should consider Level 1 charging opportunities and group investments for electric vehicle supply equipment installations. The report closes with a discussion of policy tools for scaling up charging infrastructure at multi-unit dwelling sites across the Westside cities subregion, concluding that targeted outreach to promote the plug-in electric vehicle, plug-in electric vehicle rebates, and plug-in electric vehicle ready new construction codes are likely required to ease the multi-unit dwelling related barriers to plug-in electric vehicle adoption.

**Keywords:** Plug-in electric vehicle, multi-unit dwelling, charging, electric vehicle supply equipment, Westside Cities, California Energy Commission, demand, installation costs

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# EXECUTIVE SUMMARY

This report considers the multi-unit dwelling related barriers to greater plug-in hybrid electric vehicle adoption across the Westside Cities subregion. The Westside Cities subregion is a leader in the adoption of plug-in electric vehicles with 10,419 total registrations between December 2010 and September 2016, but its full plug-in electric vehicle adoption potential is constrained by its residential land uses, featuring 30,590 multi-unit dwellings comprised of 253,876 housing units.

The methodology of the study consists of three factors which include understanding the multi-unit dwelling portfolio of the region, estimating plug-in electric vehicle demand for multi-unit dwelling residents, and identifying multi-unit dwelling types with low-cost electric vehicle supply equipment installation.

The cost of installing charging infrastructure presents itself as the greatest barrier to expanded electric vehicle charging in multi-unit dwellings. First, all plug-in electric vehicle drivers need electric vehicle supply equipment for charging their vehicles. These include either Level 1 or Level 2 chargers, which can range from \$300–\$6500. Second, electricians may need to run wiring and conduit in order to power this equipment. Location of the equipment will determine the depth and overall cost of the upgrades, which can run between \$180–\$4600. Third, panel and service upgrades may be required if deemed inadequate. These costs can run between \$60–\$2000 for panel upgrades and between \$274–\$33,500 for service upgrades.

Because of the potential high costs of multi-unit dwelling electrical charging infrastructure installation, state and local public agencies have the ability to deploy policy tools to counteract these barriers. First, financial incentives can offset the cost of plug-in electric vehicles as well as the associated charging infrastructure. Second, public agencies can implement plug-in electric vehicle ready codes that would require newly constructed multi-unit dwelling residences to provide Level 1 or Level 2 charging. Third, additional alternative public charging options is needed for multi-unit dwelling residents. These would include Level 2 or direct current fast chargers readily available near their place of residence.

Finally, plug-in electric vehicle and electric vehicle supply equipment outreach and education is needed in order to help promote the expansion of this technology to a broader base of consumers. This would help to drive demand for home charging among multi-unit dwelling residents and shift the investment from the renter to the property owner in order to attract new residents.



# CHAPTER 1:

## Introduction

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The transportation sector represents the largest source of California’s greenhouse gas emissions, comprising 39 percent of all greenhouse gas emissions in 2015.<sup>1</sup> To reduce emissions from the transportation sector, the state is making a concerted effort to promote the adoption of advanced clean vehicles. The transition to more fuel-efficient and zero-emission vehicles (ZEVs) is critical to achieving the state’s ambitious climate goals and air quality requirements. In 2012, Governor Jerry Brown signed an executive order setting a target of 1.5 million ZEVs on California’s roads by 2025.<sup>2</sup>

To achieve the goals laid out by the Governor’s executive order, a number of adoption barriers must be overcome. One of the key challenges addressed in the Governor’s 2016 ZEV Action Plan is the need to build out the necessary refueling infrastructure in apartment buildings and condominiums, also known as multi-family housing, or as the CEC refers to them, multi-unit dwellings (MUDs).<sup>3</sup> ZEVs, and specifically plug-in electric vehicles (PEVs), require an entirely new set of refueling behavior and equipment. In place of a 15-minute detour to a gas station, most PEV owners refuel overnight when they are at home. While this is generally a straightforward proposition for single-family homeowners, MUD residents face a number of obstacles to installing home charging or electric vehicle supply equipment (EVSE). Foremost is the variable and often high cost of EVSE installation at a MUD site. Additionally, the renter or owner exhibits a low to non-existent investment motivation: renters are unlikely to invest in a piece of immobile equipment that they may move away from in the future, and owners do not yet see home PEV charging as an amenity by which to increase property value and attract tenants. Overcoming these financial and motivational challenges is critical to charting the path towards a low carbon future.

### 1.1 Purpose of the Report

The goal of this report is to explore MUD related barriers to greater PEV adoption within the Westside Cities subregion, as well as to prioritize policy tools and targeted outreach for MUD sites that exhibit relatively high latent PEV demand and a low cost of EVSE installation. This report represents the final report for Task 2 of Agreement Number Agreement M-004-16 with the South California Association of Governments.

The formal boundary of the Westside Cities subregion encompasses the cities of Beverly Hills, Culver City, Santa Monica, West Hollywood, and parts of unincorporated Los Angeles County. For the purposes of this study, the western portions of the City of Los Angeles are also

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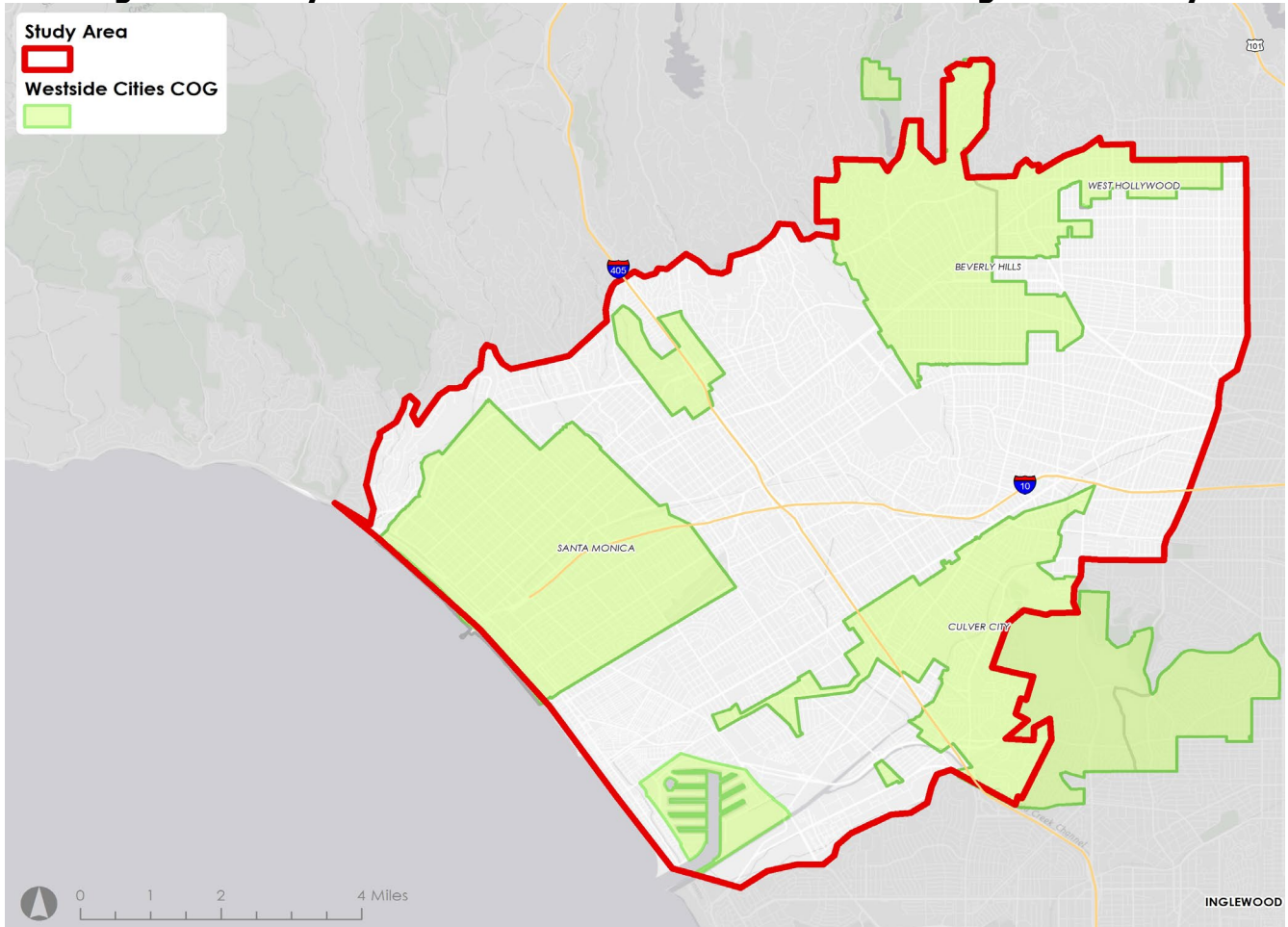
1 California Air Resources Board. 2017. "[California Greenhouse Gas Emission Inventory - 2017 Edition](https://www.arb.ca.gov/cc/inventory/data/data.htm)" Accessed August 2017, available at <https://www.arb.ca.gov/cc/inventory/data/data.htm>

2 California Office of the Governor. 2012. "[Governor Brown Announces \\$120 Million Settlement to Fund Electric Car Charging Stations Across California](https://www.gov.ca.gov/news.php?id=17463)" Accessed August 2017, available at <https://www.gov.ca.gov/news.php?id=17463>

3 Governor’s Interagency Working Group on Zero-Emission Vehicles. [2016. ZEV Action Plan](https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf). Accessed August 2017, available at [https://www.gov.ca.gov/docs/2016\\_ZEV\\_Action\\_Plan.pdf](https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf)

included in the boundary of analysis and are referred to as West Los Angeles. All aggregated numbers that are reported for the Westside Cities subregion throughout out this study reflect results from the jurisdictions within the formal boundary of the Westside Cities subregion, and results from West Los Angeles. Figure 1 shows an overlay of the formal Westside Cities boundary and the boundary of analysis adopted for this study.

**Figure 1: Study Area Versus Formal Westside Cities Subregion Boundary**



Source: UCLA Luskin Center

The Westside Cities subregion is a leader in the adoption of PEVs with 10,419 total registrations between December 2010 and September 2016.<sup>4</sup> Yet it is likely that the full adoption potential of the subregion is constrained by its mix of residential land uses, specifically the significant number of MUDs. In total, there are 30,590 MUDs across the study area, which are home to 253,876 housing units, and comprise 30.1 percent of the residential land use mix.<sup>5</sup> As such, the subregion provides a quality study area to evaluate MUD related barriers to PEV adoption, as well as to implement future policies or programs aimed at overcoming this barrier. The report is organized as follows:

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4 IHS Automotive New Vehicle Registration Data.

5 Los Angeles County Office of the Assessor Secured Basic File Abstract. Accessed October 2015.

Chapter 2 provides an overview of the MUD portfolio in the Westside Cities subregion. Researchers analyzed the Los Angeles County Office of the Assessor's Secured Basic File Abstract to identify MUD characteristics that may influence PEV demand such as size, per unit value, vintage, and ownership type. This chapter concludes with a review of the subregion's 16,495 MUD units located within disadvantaged communities. These may be appropriate targets for investments from Greenhouse Gas Reduction Fund revenues.

Chapter 3 identifies MUDs in the Westside Cities subregion that may exhibit high latent PEV demand. Our PEV demand analysis provides parcel level information: we calculated a propensity to purchase score using the historical adoption rate of PEVs in each census tract, as well as the PEV adoption rate of individuals living in households of a certain value. Those MUD parcels that result in a higher propensity to purchase score should be targets for future outreach efforts or other policy interventions.

Chapter 4 presents the costs associated with Level 1 and Level 2 EVSE installation at MUD sites. Using empirical evidence from visiting MUD sites and obtaining installation cost estimates from a qualified electrician, this chapter investigates how installation costs vary based on the electrical, structural, and parking configuration of the MUD building, and highlights potential low-cost installation solutions.

Chapter 5 offers policy tools that help alleviate the MUD related barriers to PEV adoption. Potential policy solutions include designing rebates to reduce the cost of EVSE installation, implementing PEV ready new construction codes, siting public charge programs to benefit MUD residents, and prioritizing outreach and education to increase PEV adoption.

## **1.2 Intended Audience**

This report is intended for a wide audience of decision makers and advocates seeking to advance PEV adoption in MUDs, with emphasis to those in the Westside Cities subregion. Those that may find the report most useful include regional, subregional, and municipal planners; state agencies; utility representatives; MUD property owners; members of homeowner associations; as well as current and potential PEV drivers.

Regional, subregional, and municipal planners should use this report to facilitate PEV adoption where latent demand is greatest and installation solutions are needed. By outlining the subregion's MUD portfolio, this report empowers planners to strategically conduct targeted outreach and prioritize MUD sites for policy interventions.

State agencies should use this report to understand the MUD related barriers to PEV adoption and consider policy tools, such as rebates, that reduce the cost of installing EVSE at MUD sites.

Utility representatives should use this report to identify and plan for where PEV demand and related electrical load may grow most rapidly in the subregion. Southern California Edison, the predominant electric utility in the Westside Cities subregion, recently received approval for Phase 1 of their Charge Ready program to install charging infrastructure at long dwell-time sites, including MUDs, where PEV drivers will be parked for at least four hours. Southern California Edison should use this report to help identify census tracts and specific parcels to prioritize outreach for this and other PEV programs.

Property managers and members of homeowner associations should use this report to understand the elements of their building's electrical systems and to better predict the cost of installing PEV home charging options.

PEV and prospective PEV drivers should use this report to better understand the challenges and costs of installing PEV charging infrastructure at home.

### **1.3 Methodology**

The guiding objective of UCLA Luskin Center researchers was to prioritize outreach by 1) understanding the MUD portfolio of the Westside Cities subregion, 2) identifying high latent demand for residents of MUDs in the Westside Cities subregion, and 3) identifying MUD types with a low cost of EVSE installation. The MUD parcels that exhibited high latent demand and low-cost installation opportunities represent the low-hanging fruit for outreach or other policy interventions. The following presents the methodology conducted to achieve the goals of the research.

#### **1) Understanding the multi-unit dwelling portfolio of the Westside Cities subregion**

Researchers analyzed Los Angeles County Office of Assessor Secured Basic File Abstract data across a number of parcel specific variables. Most importantly, the data provided researchers with the assessor identification number, number of units, land and improvement value ("total value"), year built ("vintage"), and ownership type (i.e. rental or condominium). Researchers assessed the spatial distribution of MUDs in the Westside Cities subregion using geographic information systems.

#### **2) Estimating plug-in electric vehicle demand for multi-unit dwelling residents**

To identify high latent PEV demand at the parcel level in the Westside Cities subregion, we used census tract PEV registration data from IHS Automotive (formerly R.L. Polk & Co), census tract socioeconomic data from the 2011-2015 American Community Survey and parcel level data from the Los Angeles County Office of the Assessor. We then calculated the propensity to purchase scores through these steps:

- i. First, we forecasted the number of PEV purchases per census tract based on that census tract's number of purchases between October 2015 and September 2016. Here we assume that as many PEVs that were sold during the sample period (i.e., October 2015 through September 2016) will also be sold during the next 12-month period (i.e., October 2016 through September 2017). In other words, the more PEVs historically purchased in a census tract, the higher the average propensity to purchase score for that census tract, all else being equal.
- ii. Second, we downloaded survey data from the California Clean Vehicle Rebate Program and computed the proportion of PEV purchases in each income group (<\$24,999; \$25,000-\$49,999; \$50,000-\$74,999; \$75,000-\$99,999; greater than \$100,000).<sup>6</sup> Here we assume that PEV purchaser's income distribution at the census tract level is identical to that of the whole state. We also assume that the historical relationship between income and PEV adoption will continue into the future. In other words, the greater the proportion of high-income residents in a census tract, the higher the average propensity to purchase score for that census tract, all else being equal.
- iii. Finally, we downloaded data on income by home value for each census tract and used this to estimate the probability of someone with a certain income level living in a home

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<sup>6</sup> Center for Sustainable Energy. 2016. California Air Resources Board Clean Vehicle Rebate Project, [EV Consumer Survey Dashboard](https://cleanvehiclerebate.org/eng/survey-dashboard/ev). Accessed August 2017, available at <https://cleanvehiclerebate.org/eng/survey-dashboard/ev>



with a given value. Since MUDs are the focus of this study, home values were assumed to be commensurate with condo values and apartment values. We also assume that the historical relationship between home values and income will continue into the future. In other words, the greater the value of a condo or apartment, the higher the likelihood that someone with a high income is living in that unit, and the higher the propensity to purchase score assigned to that unit.

In summary, we used three variables – the forecasted PEV purchases per census tract, the number of PEV purchases per income group, and the percentage of income group living in homes of certain values – to determine a relationship between the value of a home and its propensity to purchase a PEV. We then spatialized that relationship using parcel level data obtained from the Los Angeles County Office of the Assessor. For each MUD in the study area, we assigned a propensity to purchase score based on the MUD's average unit value (i.e., total property value divided by number of units).

### **3) Identifying multi-unit dwelling types with low-cost EVSE installation**

This chapter reviews findings from the report *Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study*, in which cost estimates were developed for the installation of charging infrastructure at sample sites within the South Bay Cities Subregion.<sup>7</sup> With the South Bay Cities Council of Governments, researchers released a Request for Information for qualified electricians in Los Angeles County with experience installing EVSE in MUDs. Researchers requested 30 MUD site visits to assess Level 1 and Level 2 charge readiness, and to estimate the cost of installing a single Level 2 EVSE unit. From those site visits, 15 complete cost estimates were obtained, the results of which are discussed in this chapter.

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<sup>7</sup> UCLA Luskin Center for Innovation. 2016. [Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf). Accessed August 2017, available at [https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming\\_Barriers\\_to\\_EV\\_Charging\\_in\\_MUDs-A\\_South\\_Bay\\_Case\\_Study.pdf](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf)

# CHAPTER 2:

## MUDs of the Westside Cities Subregion

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The Westside Cities is home to around 250,000 MUD households, making up 30 percent of the subregion’s residential land use.<sup>8</sup> Although the Westside Cities subregion is driving PEV adoption for Southern California, this land use mix may very well be constraining the full potential of the area’s PEV uptake. The MUDs present a series of hurdles to installing charging infrastructure, or EVSE, at home - the preferred refueling choice for early adopters of PEVs - including the variable and often high costs of installation.

The following chapter provides an overview of the Westside Cities’ MUD portfolio, including MUD characteristics that can influence the cost of EVSE installation and the investment motivation such as building size (i.e. number of units), per unit value, vintage, ownership type, and locational attributes such as those MUDs located in disadvantaged communities. Subregional and city planners and other interested parties can review this chapter to understand the MUD composition of the subregion at large and where the MUD might be significantly constraining PEV adoption.

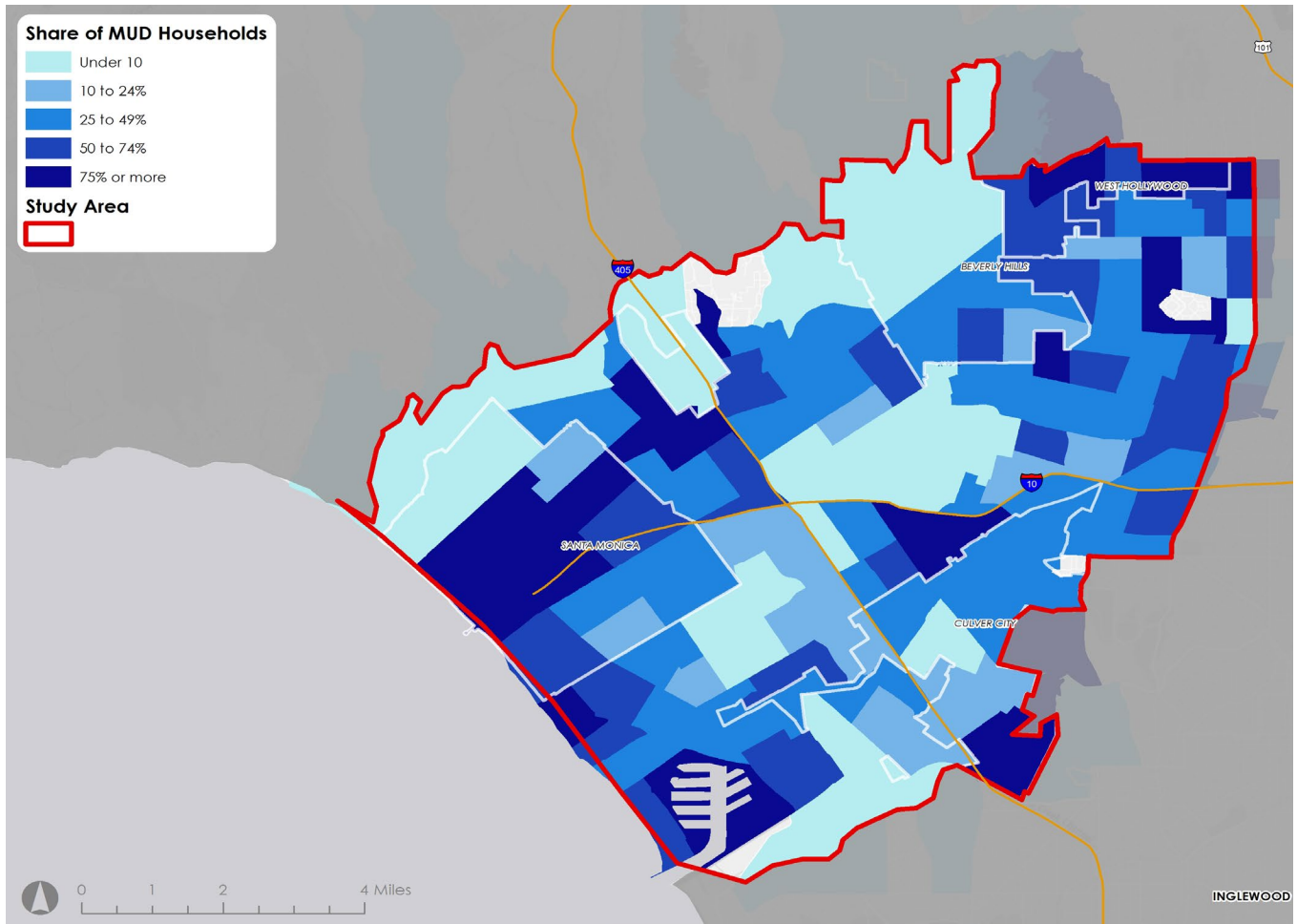
### 2.1 Density

The density of MUDs ranges greatly across the Westside Cities region. Figure 2 shows the MUD share of residential land use per census tract. Santa Monica, West Hollywood, West Los Angeles, and portions of unincorporated Los Angeles County are each home to census tracts in which more than 75 percent of the residential land is occupied by MUDs. In contrast, Culver City does not have a single census tract in which more than 50 percent of the land area is occupied by MUDs. Similarly, most of Beverly Hills is occupied by census tracts with less than 50 percent of the land dedicated to MUDs, with the exception of one census tract in the southern boundary of the city with between 50 and 75 percent of the residential land dedicated to MUDs.

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<sup>8</sup> Reflects modified study area for this report. See Figure 1 for an overlay of the formal Westside Cities boundary and the boundary of analysis adopted for this study.

**Figure 2: MUD Share of Residential Land Use by Census Tract across Westside Cities**



Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

Table 1 summarizes the number of MUDs and the number of MUD units in each city within the study area. The table also summarizes the percentage of residential land that is occupied by MUDs for each city. West Hollywood has the greatest density of MUDs on residential land, followed in descending order by unincorporated portions of Los Angeles County (explained by MUDs in Marina Del Rey), Santa Monica, Culver City, and Beverly Hills. In contrast, West Los Angeles has the greatest number of MUDs and MUD units, followed in descending order by Santa Monica, West Hollywood, Culver City, Beverly Hills, and unincorporated portions of Los Angeles County.

**Table 1: MUD Unit Count and Share of Residential Land Use for Westside Cities**

<b>City</b>	<b>Number of MUDs</b>	<b>Number of MUD Units</b>	<b>MUD % of Residential Land Use</b>
Beverly Hills	1,273	10,451	10.2%
Culver City	1,763	10,774	32.0%
Santa Monica	5,016	41,165	37.9%
West Hollywood	2,264	23,366	73.1%
West Los Angeles	20,267	167,698	30.3%
Unincorporated Los Angeles County	7	422	69.7%
<b>Total</b>	<b>30,590</b>	<b>253,876</b>	<b>30.7%</b>

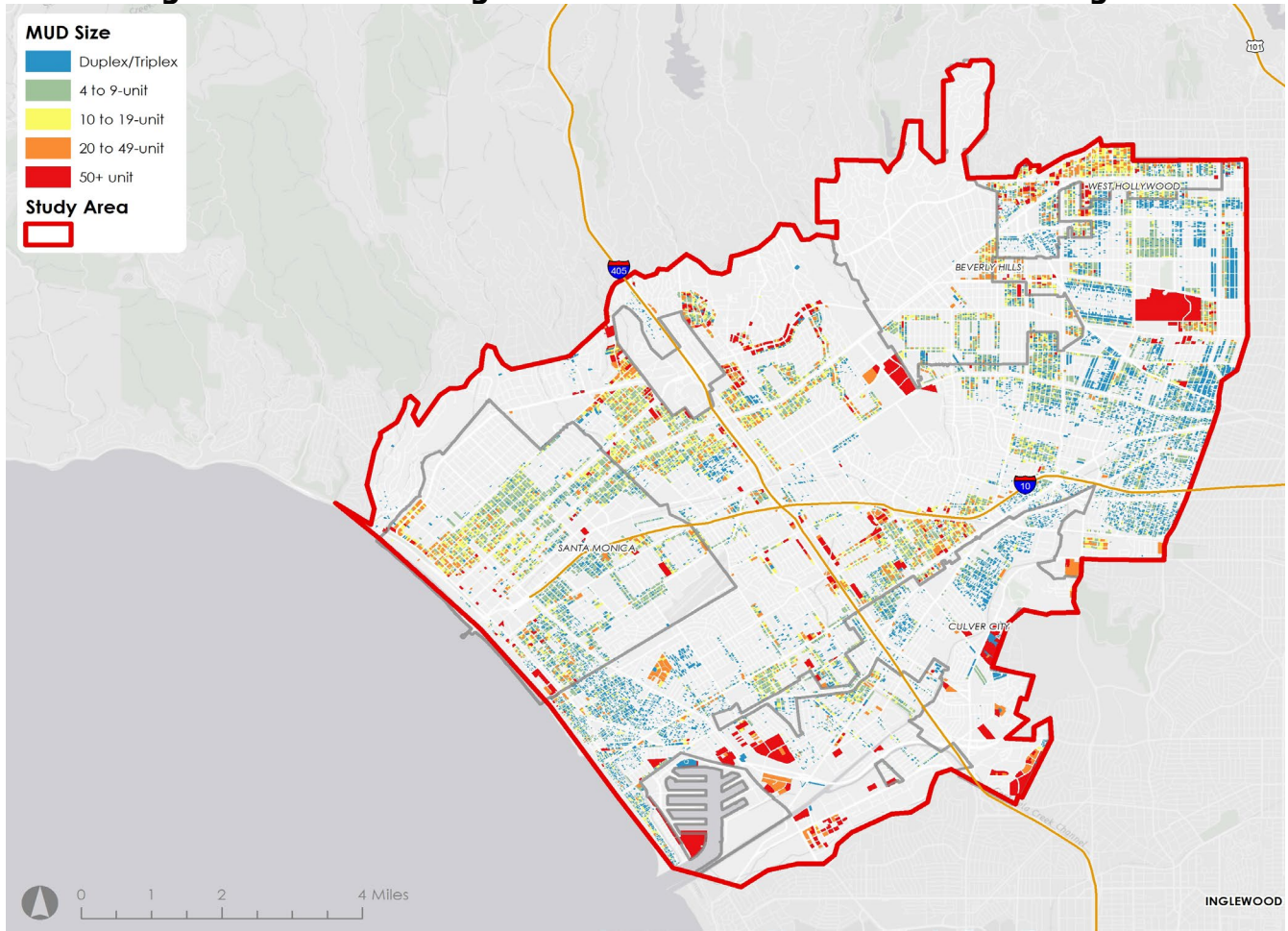
Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

## 2.2 Building Size

Mapping the precise location of MUDs and knowing the density of units on a site is helpful for utility planning. Utilities can use such maps to anticipate where upgrades may be needed for transformers and distribution stations to accommodate PEV charging at MUDs. As PEVs become increasingly adopted by residents, the electricity load capacity at large MUDs (e.g., 50 unit plus buildings) will likely need to be upgraded.

MUDs within the Westside Cities subregion range in size from duplexes to 770-unit buildings. Figure 3 shows MUD sizes and their spatial distribution across the Westside Cities subregion. Each city within the study region is home to a wide range of MUD sizes. Duplexes and triplexes can be found within each jurisdiction, as well as buildings with more than 50 units.

**Figure 3: MUD Building Sizes across the Westside Cities Subregion**



Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

Table 2 provides a count of MUDs by building size for each in the Westside Cities subregion. Most of the region's MUDs are 4 to 9-unit buildings, followed by duplexes and triplexes (i.e., two- and three-unit buildings, respectively), 10 to 19-unit buildings, 20 to 49-unit buildings, and 50+ unit buildings. This distribution is fairly consistent from city to city, except in Culver City (where duplexes and triplexes comprise most of the MUD housing stock), and in unincorporated portions of Los Angeles County (where there is only a sample of 7 MUDs in total).

**Table 2: MUDs by Building Size for the Westside Cities**

<b>City</b>	<b>Duplex/ Triplex</b>	<b>4 to 9 units</b>	<b>10 to 19 units</b>	<b>20 to 49 units</b>	<b>50+ units</b>	<b>Total</b>
Beverly Hills	298	686	181	103	5	1273
Culver City	1,159	489	39	44	32	1,763
Santa Monica	1,128	2,725	831	293	39	5,016
West Hollywood	741	744	513	215	51	2,264
West Los Angeles	8,775	7,784	2,309	1,055	344	20,267
Unincorporated	1	3	0	0	3	7
<b>Total</b>	12,102	12,431	3,873	1,710	474	30,590
<b>% of Total</b>	39.6%	40.6%	12.7%	5.6%	1.5%	100%

Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

## 2.3 Unit Values

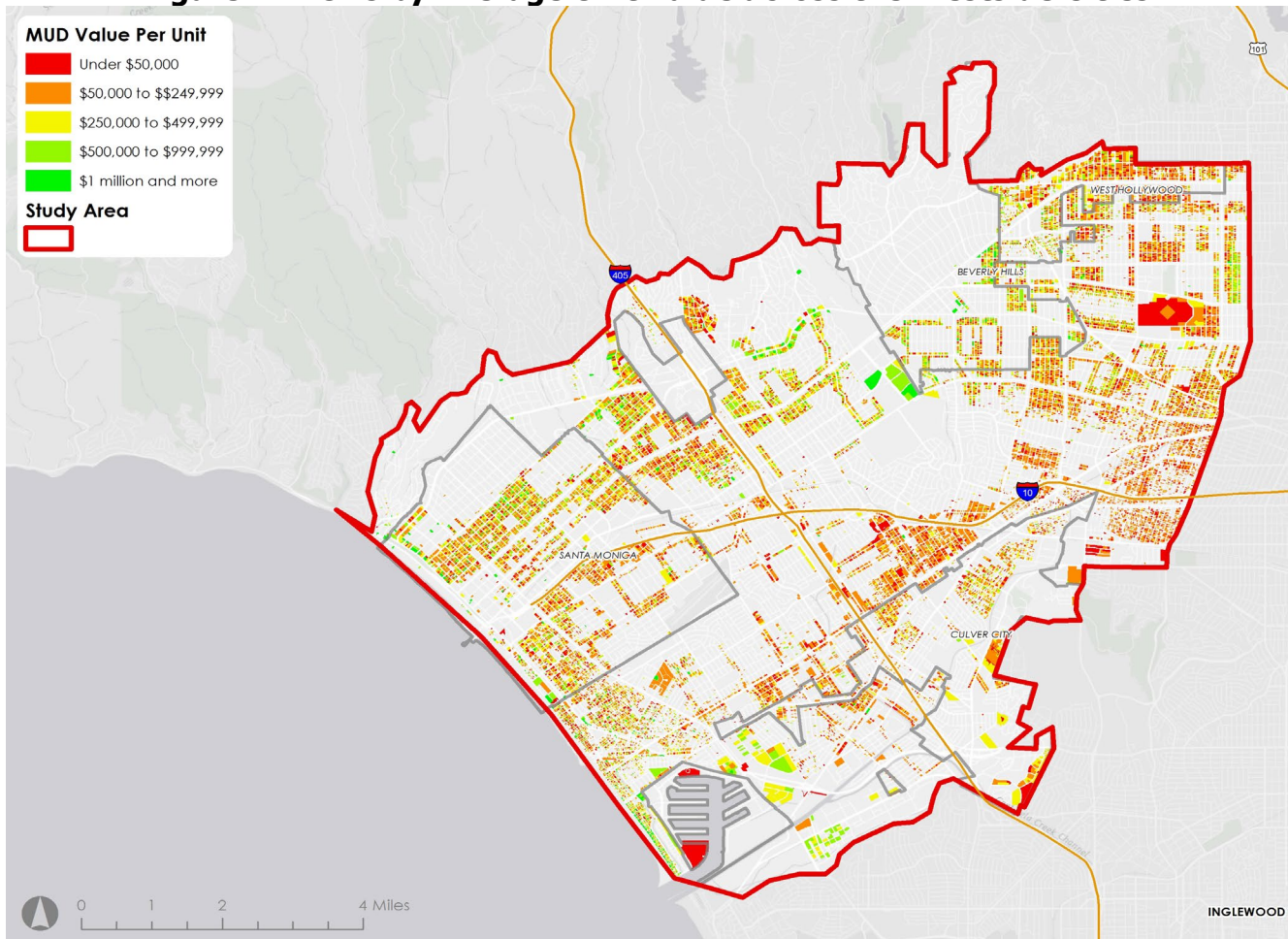
Early PEV sales indicate that higher-income households are purchasing PEVs at higher rates than middle- and low-income households.<sup>9</sup> High-income households tend to purchase new vehicles at faster rates in general and also have more disposable income to spend on new technologies such as PEVs. High-income earners can also afford to live in higher value homes, making the MUD value per unit an indicator of latent PEV demand. This provides the basis for the propensity to purchase measure discussed in Chapter 3.

Figure 4 presents the spatial distribution of MUDs according to the average unit value across the Westside Cities subregion. The average unit value associated with each MUD was calculated by dividing the total property value of an MUD by the number of units at that MUD. Each city within the study region is home to a wide range of MUD unit values. MUDs with an average unit value over a million dollars can be found in each city, as can MUDs with an average unit value under \$50,000.

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<sup>9</sup> Sheldon, Tamara L., J.R. DeShazo, Richard T. Carson, and Samuel Krumholz. 2016. [Factors Affecting Plug-in Electric Vehicle Sales in California](http://innovation.luskin.ucla.edu/content/factors-affecting-plug-electric-vehicle-sales-california). Accessed August 2017, available at <http://innovation.luskin.ucla.edu/content/factors-affecting-plug-electric-vehicle-sales-california>

**Figure 4: MUDs by Average Unit Value across the Westside Cities**



Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

Table 3 provides the total number of MUDs according to the average unit for each city in the Westside Cities subregion. The most common average unit value for an MUD is between \$50,000 and \$249,999, with around 49 percent of the MUDs falling into this category. This is true among all cities within the region, except in unincorporated portions of Los Angeles County, where this is a very small sample of MUDs.

**Table 3: MUDs by Average Unit Value across the Westside Cities Subregion**

<b>City</b>	<b>Under \$50,000</b>	<b>\$50,000-\$249,999</b>	<b>\$250,00 - \$499,999</b>	<b>\$500,00 - \$999,999</b>	<b>\$1 million and more</b>	<b>Total</b>
Beverly Hills	173	488	322	232	58	1,273
Culver City	285	808	525	141	4	1,763
Santa Monica	767	2,354	1,150	602	143	5,016
West Hollywood	471	1,064	467	228	34	2,264
West Los Angeles	3,698	10,161	4,052	1,998	358	20,267
Unincorporated	4	2	1	0	0	7
<b>Total</b>	5,398	14,877	6,517	3,201	597	30,590
<b>% of Total</b>	17.6%	48.6%	21.3%	10.5%	2.0%	100%

Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

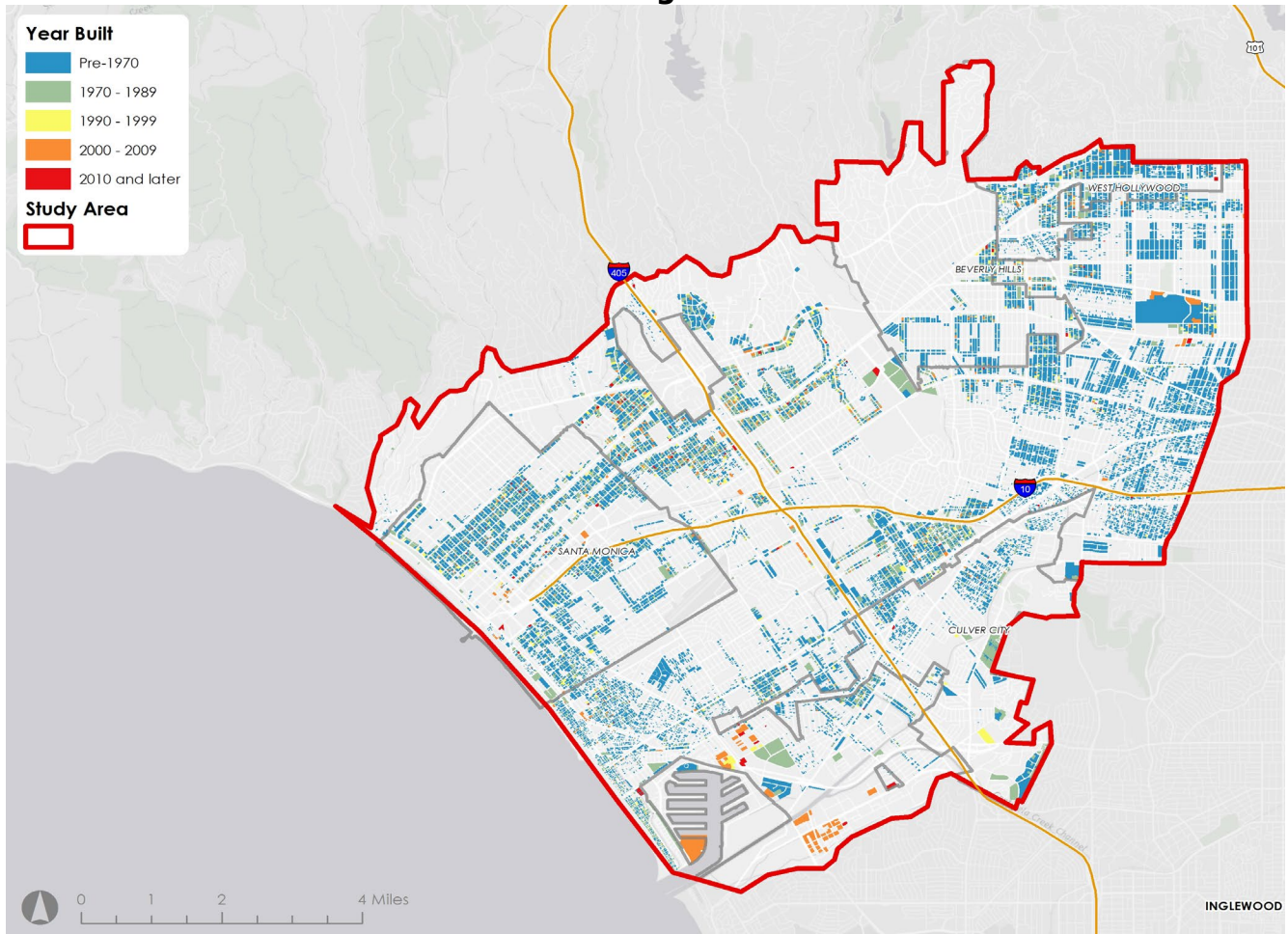
## 2.4 Vintage

More recently constructed MUDs may provide advantages when installing EVSE on site for two reasons. First, the electrical service being provided by the utility to the MUD is more likely to have sufficient capacity for supporting PEV charging, avoiding the need for potentially costly service upgrades like installing a new service wire or transformer. Second, if panel upgrades such as new circuit breakers are required to provide sufficient capacity for PEV charging, replacement materials may be easier to find and less expensive.

Figure 5 presents the spatial distribution of MUDs by year of construction across the Westside Cities subregion. The majority of the housing stock in the Westside Cities subregion is older (built before 1970). Most of the newly built MUDs (2000 and later) are located around the Marina Del Rey area of the region.



**Figure 5: MUD Buildings by Year of Construction Across the Westside Cities Subregion**



Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

Table 4 provides the total number of MUDs by building vintage across the Westside Cities subregion. MUDs built before 1970 comprise the far majority of housing stock in each city within the subregion. Very few MUDs in the region were built after 2000 (around 3 percent of the housing stock in total). These newer properties may be the most cost-effective locations for installing charging infrastructure, since they were likely designed to handle higher electrical loads.

**Table 4: MUD Households by Building Vintage across the Westside Cities Subregion**

<b>City</b>	<b>Pre-1970</b>	<b>1970 to 1989</b>	<b>1990 to 1999</b>	<b>2000 to 2009</b>	<b>2010 and later</b>	<b>Total</b>
Beverly Hills	1,122	107	18	21	5	1,273
Culver City	1,430	297	13	18	5	1,763
Santa Monica	3,905	793	173	121	24	5,016
West Hollywood	1,998	167	31	60	8	2,264
West Los Angeles	16,670	2,390	501	570	136	20,267
Unincorporated	4	1	0	1	1	7
<b>Total</b>	25,129	3,755	736	791	179	30,590
<b>% of Total</b>	82.1%	12.3%	2.4%	2.6%	0.6%	100%

Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

## 2.5 Ownership Types

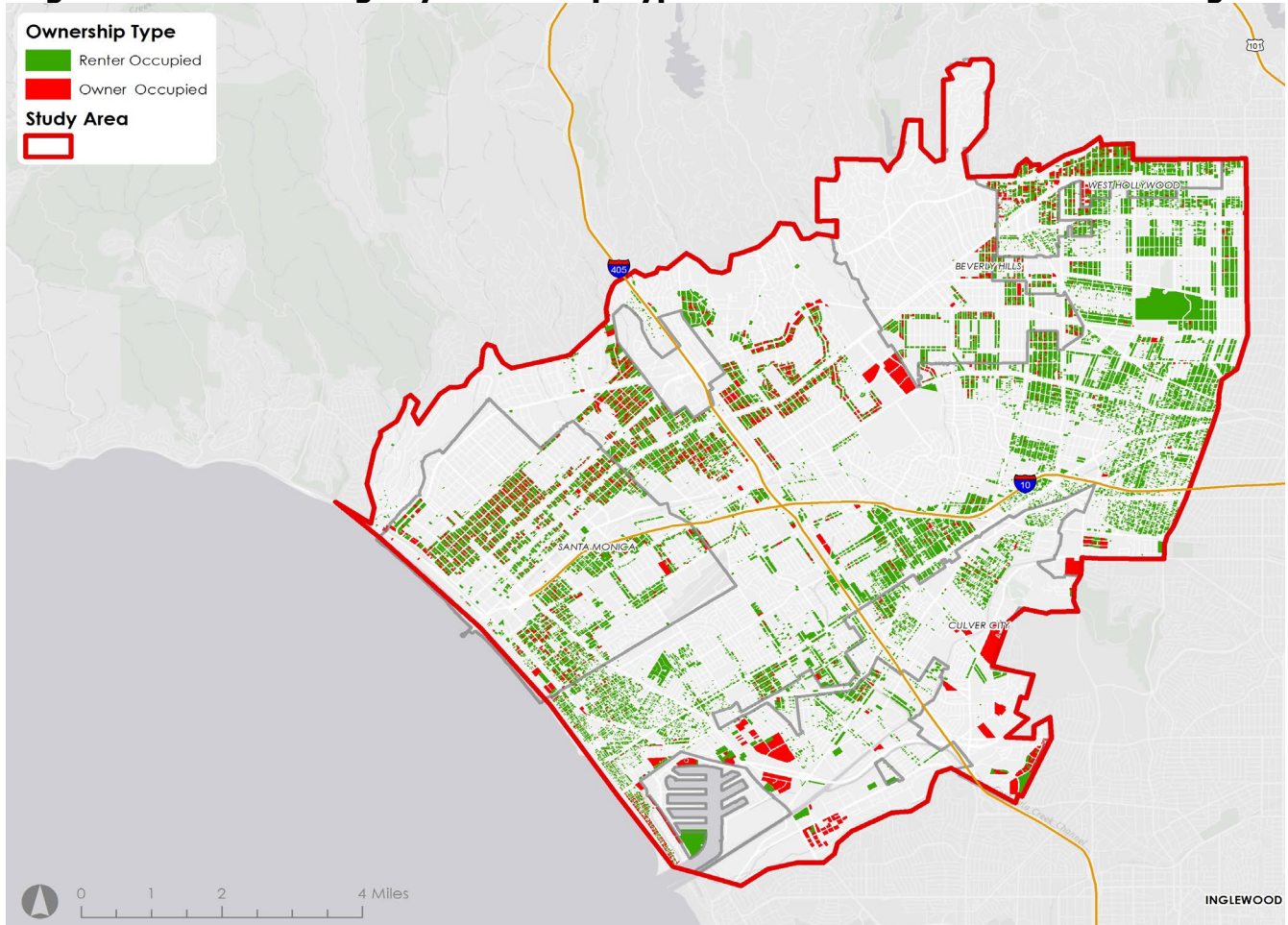
MUD ownership influences a residence’s motivation to invest in home charging. MUDs include both apartment buildings and condominiums. Apartment buildings are generally owned by an individual or company that rents out the units to individual tenants. The building owner is responsible for all common spaces such as lighting for the building’s lobby. Any structural changes to the building will be paid for by the owner who will make investment decisions based on increasing the value of the units and charging higher rents. Condominiums are owned by the resident, and non-unit decisions, such managing common areas, are often made by a homeowner association governing board.

For renters, the investment motivation is weak or non-existent because they are unlikely to invest a significant sum of money in an immobile piece of equipment that they may move away from in the future. Moreover, apartment owners and management groups may not view EVSE as an amenity by which to attract tenants. Alternatively, condominium owners are likely to view the EVSE as a property improvement positively affecting the potential resale value of their unit, although a significant installation may require approval by the homeowner association governing board.

MUD ownership will also determine who is responsible for common area management including overseeing the 110/120-volt outlets that may be accessible in the parking area. In an apartment building setting, these outlets, which can provide Level 1 charging if there is sufficient electrical capacity, are often connected to the house panel. The house panel controls the electrical supply for all shared appliances and common areas such as laundry machines and pool pumps. Renters should seek approval from the property owner to consume electricity

when the parking area electrical outlets are connected to the house panel (see Chapter 4 for more information about the electrical configuration of MUDs). Figure 6 presents the spatial distribution of MUDs by ownership type across the Westside Cities subregion. Most of the MUDs in the region are apartment buildings (i.e., occupied by renters). However, there are still a number of condominium buildings (i.e., owner occupied) across the subregion, particularly in the Westwood Area, the western portion of West Hollywood, and the northern portion of Santa Monica.

**Figure 6: MUD Buildings by Ownership Type across the Westside Cities Subregion**



Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

Table 5 provides the number of MUD units that are renter occupied (i.e., apartment units) versus owner occupied (i.e., condominium units) across the Westside Cities Subregion. Apartment units comprised about 79 percent of the MUD housing stock. Of all the cities within the study region, Culver City has the greatest percentage of condo units (around 41 percent of total units).

**Table 5: MUD Units by Ownership Type across the Westside Cities Subregion**

<b>City</b>	<b>Apartment Units</b>	<b>Condo Units</b>	<b>Total Units</b>
Beverly Hills	8,236	2,215	10,451
Culver City	6,335	4,439	10,774
Santa Monica	32,031	9,134	41,165
West Hollywood	17,990	5,376	23,366
West Los Angeles	135,798	31,900	167,698
Unincorporated	421	1	422
<b>Total</b>	<b>200,811</b>	<b>53,065</b>	<b>253,876</b>
<b>% of Total</b>	<b>79.1%</b>	<b>20.9%</b>	<b>100%</b>

Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

## **2.6 MUD Presence in Disadvantaged Communities**

The Westside Cities subregion includes 15 census tracts that are classified as disadvantaged communities by the California Office of Environmental Health Hazard Assessment's CalEnviroScreen 2.0 screening tool. Disadvantaged communities are defined using a series of environmental, health and socioeconomic criterion with the purpose of identifying areas disproportionately burdened by and vulnerable to multiple sources of pollution.<sup>10</sup>

Understanding the presence of disadvantaged communities within Westside Cities Subregion is important for PEV planning efforts. These communities tend to face significant financial barriers to transitioning from conventional gasoline vehicles to PEVs. To address this challenge, the California Air Resources Board has launched a number of initiatives under its Low Carbon Transportation Program aimed at expanding PEV adoption among low- and moderate-income households. An example is the Enhanced Fleet Modernization Program Plus-Up Pilot Program, which provides significant financial assistance to low income households in the Greater Los Angeles area and the San Joaquin Valley who scrap their old high-polluting car and replace it with a more fuel-efficient vehicle. When purchasing a PEV, low-income participants can receive \$9,500 to buy or lease a new plug-in hybrid electric vehicle (PHEV) plus a \$1,500 Clean Vehicle Rebate Program rebate for a total of \$11,000 of assistance. For a new battery electric vehicle (BEV), the rebate is \$9,500 plus the \$2,500 California Clean

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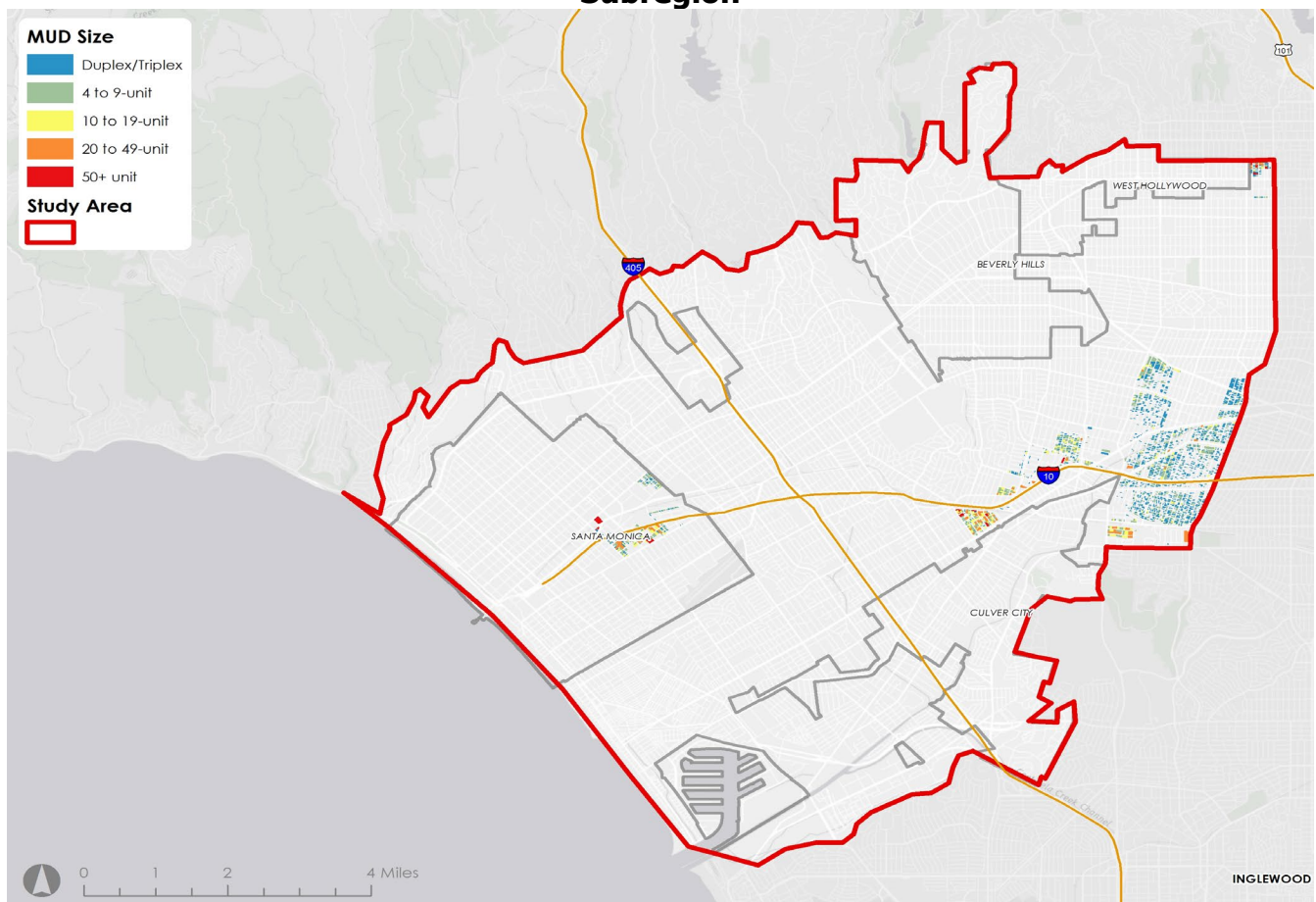
<sup>10</sup> California Office of Environmental Health Hazard Assessment. 2014. [CalEnviroScreen Version 2.0](http://oehha.ca.gov/ej/ces2.html). Accessed August 2017, available at <http://oehha.ca.gov/ej/ces2.html>

Vehicle Rebate Program rebate for a total of \$12,000. In addition, individuals who purchase a BEV are eligible for up to \$2,000 for a charging unit. To qualify, the resident must live in a zip code that includes a disadvantaged community census tract.<sup>11</sup>

Additionally, Southern California Edison's Charge Ready program, which aims to install up to 1,500 charging stations at parking sites where dwell times exceed four hours or longer-term parking sites including MUDs, will target at least 10 percent of its deployment within disadvantaged communities.<sup>12</sup>

Figure 7 provides an overview of the MUD building stock in disadvantaged communities across the Westside Cities subregion. Only Santa Monica and West Los Angeles are home to MUDs located in Disadvantaged Communities, with a much larger share located in West Los Angeles along Interstate 10. The majority of these MUDs are also smaller in scale (i.e., duplexes and triplexes).

**Figure 7: MUD Sizes in Disadvantaged Communities across the Westside Cities Subregion**



Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

11 California Air Resources Board. 2015. "[Making the Cleanest Cars Affordable.](http://www.arb.ca.gov/newsrel/efmp_plus_up.pdf)" Available at [http://www.arb.ca.gov/newsrel/efmp\\_plus\\_up.pdf](http://www.arb.ca.gov/newsrel/efmp_plus_up.pdf)

12 Southern California Edison. "[Charge Ready: A Plan for California.](http://www.edison.com/home/our-perspective/charge-ready-a-plan-for-california.html)" Accessed August 2017, available at <http://www.edison.com/home/our-perspective/charge-ready-a-plan-for-california.html>

Table 6 provides the number of MUD units in Disadvantaged Communities across the Westside Cities subregion. Only Santa Monica and West Los Angeles are home to MUDs located in Disadvantaged Communities. Together, they host about 16,500 MUD units located in Disadvantaged Communities, which comprise about 6.5 percent of the total number of MUD housing units located in the region (i.e., 253,876 total housing units).

**Table 6: Total MUD Units in Disadvantaged Communities for Westside Cities**

<b>City</b>	<b>Number of Units</b>	<b>% of Total Units</b>
Beverly Hills	0	0%
Culver City	0	0%
Santa Monica	2,482	6.0%
West Hollywood	0	0%
West Los Angeles	14,013	8.4%
Unincorporated	0	0%
<b>Total</b>	<b>16,495</b>	<b>6.5%</b>

Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

Table 7 breaks down the number of MUDs in Disadvantaged Communities across the Westside Cities subregion according to their building size. Most of the MUDs are on the smaller end of the spectrum, with around 90 percent of the MUDs containing less than 10 units.

**Table 7: MUDs by Size in Disadvantaged Communities for Westside Cities**

<b>City</b>	<b>Duplex/ Triplex</b>	<b>4 to 9 units</b>	<b>10 to 19 units</b>	<b>20 to 49 units</b>	<b>50+ units</b>	<b>Total</b>
Beverly Hills	0	0	0	0	0	0
Culver City	0	0	0	0	0	0
Santa Monica	74	158	29	16	6	283
West Hollywood	0	0	0	0	0	0
West Los Angeles	1,555	1,043	177	64	10	2,849
Unincorporated	0	0	0	0	0	0
<b>Total</b>	<b>1,629</b>	<b>1,201</b>	<b>206</b>	<b>80</b>	<b>16</b>	<b>3,132</b>
<b>% of Total</b>	<b>52.0%</b>	<b>38.3%</b>	<b>6.6%</b>	<b>2.6%</b>	<b>0.5%</b>	<b>100%</b>

Source: Los Angeles County Office of the Assessor Secured Basic Abstract File

# CHAPTER 3:

## PEV Demand in the Westside Cities

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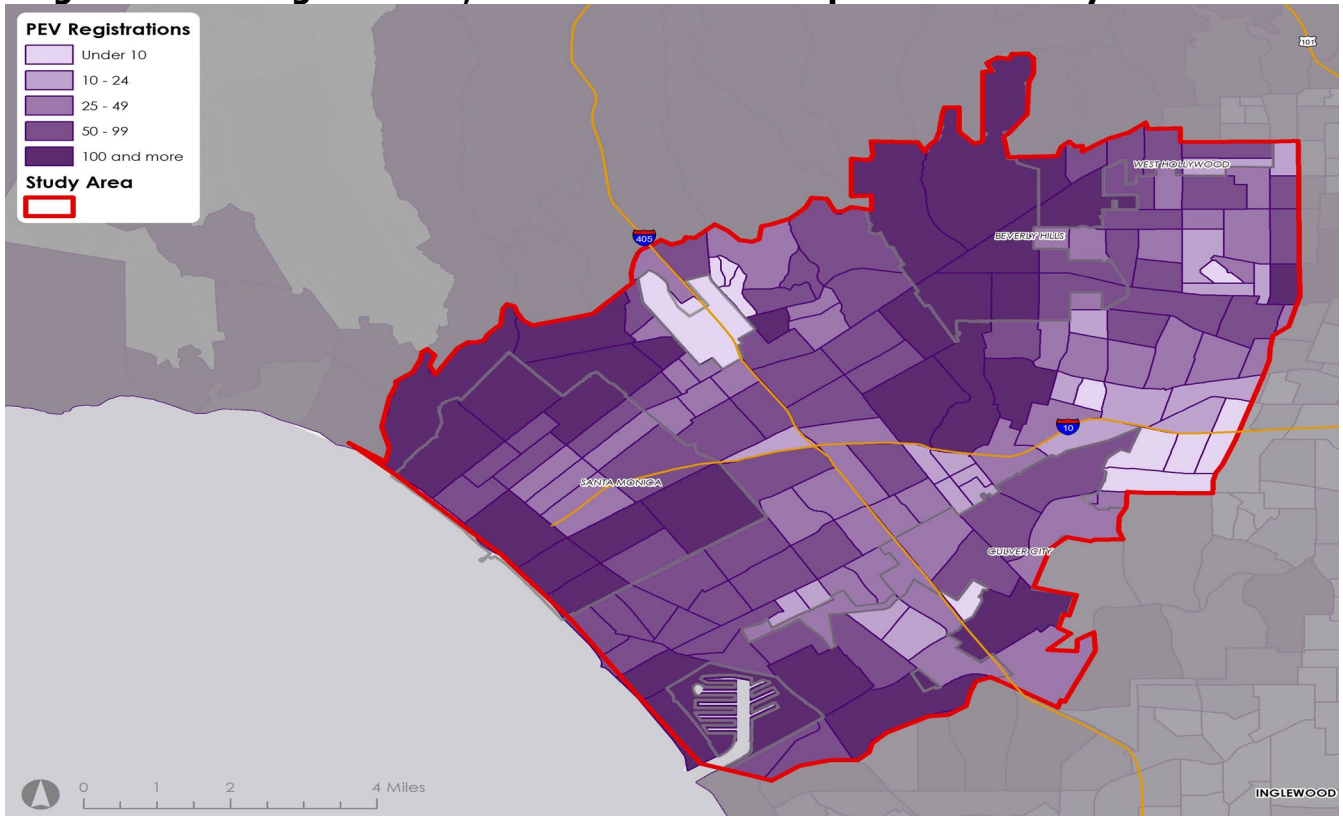
This chapter provides an overview of where PEV demand in the Westside Cities subregion has historically been the greatest and where demand is expected to be the greatest among MUD residents. The latter is calculated using a propensity to purchase score which estimates PEV demand as a function of historical PEV adoption trends as well as income level and MUD per unit value (see Chapter 1.3 for a summary of methods). Subregional and municipal governments and other interested stakeholders should use this chapter to prioritize neighborhood outreach or organize other planning efforts (see Chapter 5 for more detail on outreach strategies).

### 3.1 Historic PEV Demand

Knowing how many PEVs are registered in a given area will indicate the location of current and near-future demand for residential charging. By extension, this information can help planners and utilities anticipate locations that will carry additional nighttime electrical load.

Figure 8 provides an overview of the cumulative number of new PEV registrations between December 2010 and September 2016 by census tract across the Westside Cities subregion. Consistent with statewide trends, early PEV drivers tend to be higher income households. As such, Beverly Hills, the Pacific Palisades, and Brentwood are all home to a number of census tracts containing more than 100 PEV registrations. These neighborhoods are also home to a larger share of single-family residences, as seen in Figure 7. As more moderate-income households begin to view the PEV as a viable transportation option, and as prices of battery technologies continue to come down, adoption will spread beyond wealthier census tracts.

**Figure 8: PEV Registrations, December 2010 to September 2016 by Census Tract**



Source: IHS Automotive, California Department of Transportation

Table 8 sums the number of PEV registrations across the Westside Cities subregion. West Los Angeles is home to greatest number of PEVs, while Beverly Hill has the highest PEV purchase rate per 100 residents over the study period. BEVs are slightly more popular than PHEVs across the region, except for portions of unincorporated Los Angeles County.



**Table 8: PEV Adoption for the Westside Cities Subregion**

<b>City</b>	<b>PEV Registrations (December 2010- September 2016)</b>	<b>% BEV</b>	<b>% PHEV</b>	<b>Population</b>	<b>PEVs per 100 Residents</b>
Beverly Hills	932	64.9%	35.1%	30,89	3.0
Culver City	481	47.8%	52.2%	33,902	1.4
Santa Monica	1,929	57.8%	42.2%	92,169	2.1
West Hollywood	504	55.2%	44.8%	35,332	1.4
West Los Angeles	6,368	55.3%	44.7%	465,409	1.4
Unincorporated	205	45.9%	54.1%	10,277	2.0
<b>Total</b>	<b>10,419</b>	<b>56.1%</b>	<b>43.9%</b>	<b>667,891</b>	<b>1.6</b>

Source: IHS Automotive; Los Angeles County Office of the Assessor Secured Basic Abstract File; U.S. Census Bureau, 2011-2015 American Community Survey 5-Year Estimates

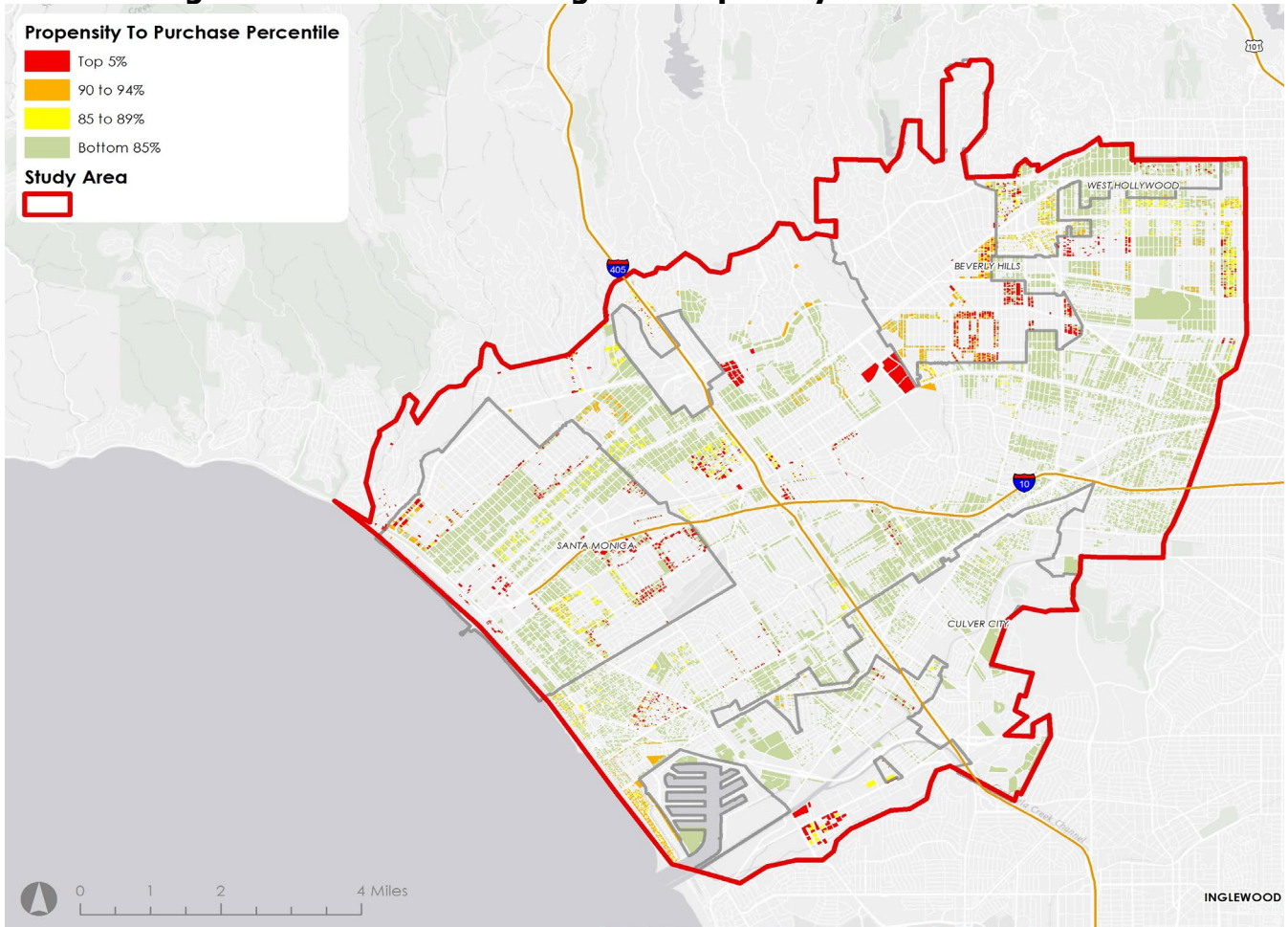
### **3.2 Latent PEV Demand within MUD Parcels**

Census tracts with high PEV adoption and a high share of MUDs may be areas with high latent PEV demand. If MUD residents here do not have access to home charging, it is likely that the MUD is serving as a constraint to these census tracts' full PEV adoption potential.

To identify and prioritize the MUD households with high latent PEV demand, we calculated a propensity to purchase score for each MUD parcel in the Westside Cities subregion. The score accounts for the historical adoption rate of PEVs in each census tract, as well as the PEV adoption rate of individuals living in households of a certain value. Considering that a large share of PEVs are purchased by high-income individuals who are likely to live in high-value homes, the propensity to purchase score model allocates a greater score to high-value homes. Refer to Chapter 1.3 for an overview of how the propensity to purchase model was constructed.

Figure 9 presents the distribution of MUDs with the highest propensity to purchase scores across the Westside Cities subregion. Since Beverly Hills has a high adoption rate of PEVs and is home to a number of high-income households, it has a disproportionate share of MUDs with high propensity to purchase scores.

**Figure 9: MUDs with the Highest Propensity to Purchase Scores**



Source: IHS Automotive, Los Angeles County Office of the Assessor Secured Basic Abstract File

Table 9 summarizes the number of MUDs with the highest propensity to purchase scores across the Westside Cities subregion. Around 61 percent of the MUDs in Beverly Hills fall within the top 15th percentile of propensity to purchase scores for the region. In contrast, only 1 percent of the MUDs in Culver City fall within the top 15th percentile of propensity to purchase scores. West Los Angeles is home to the greatest number of MUDs in the top 15th percentile of propensity to purchase scores (2,388 of 4,506), which is a consequence of the region's size, since most of the MUDs in the region do not have high propensity to purchase scores. Only 7 percent of the MUDs in West Los Angeles fall within the top 15th percentile of propensity to purchase scores.

**Table 9: MUDs with the Top Propensity to Purchase Scores across the Westside Cities**

City	Total MUDs	Bottom 85%	Top 15%	Top 10%	Top 5%
Beverly Hills	1,273	421	852	777	421
Culver City	1,763	1,702	61	17	0
Santa Monica	5,016	4,217	799	508	415
West Hollywood	2,264	1,861	403	249	104
West Los Angeles	20,267	17,879	2,388	1,442	581
Unincorporated	7	4	3	2	2
<b>Total</b>	30,590	26,084	4,506	2,995	1,523

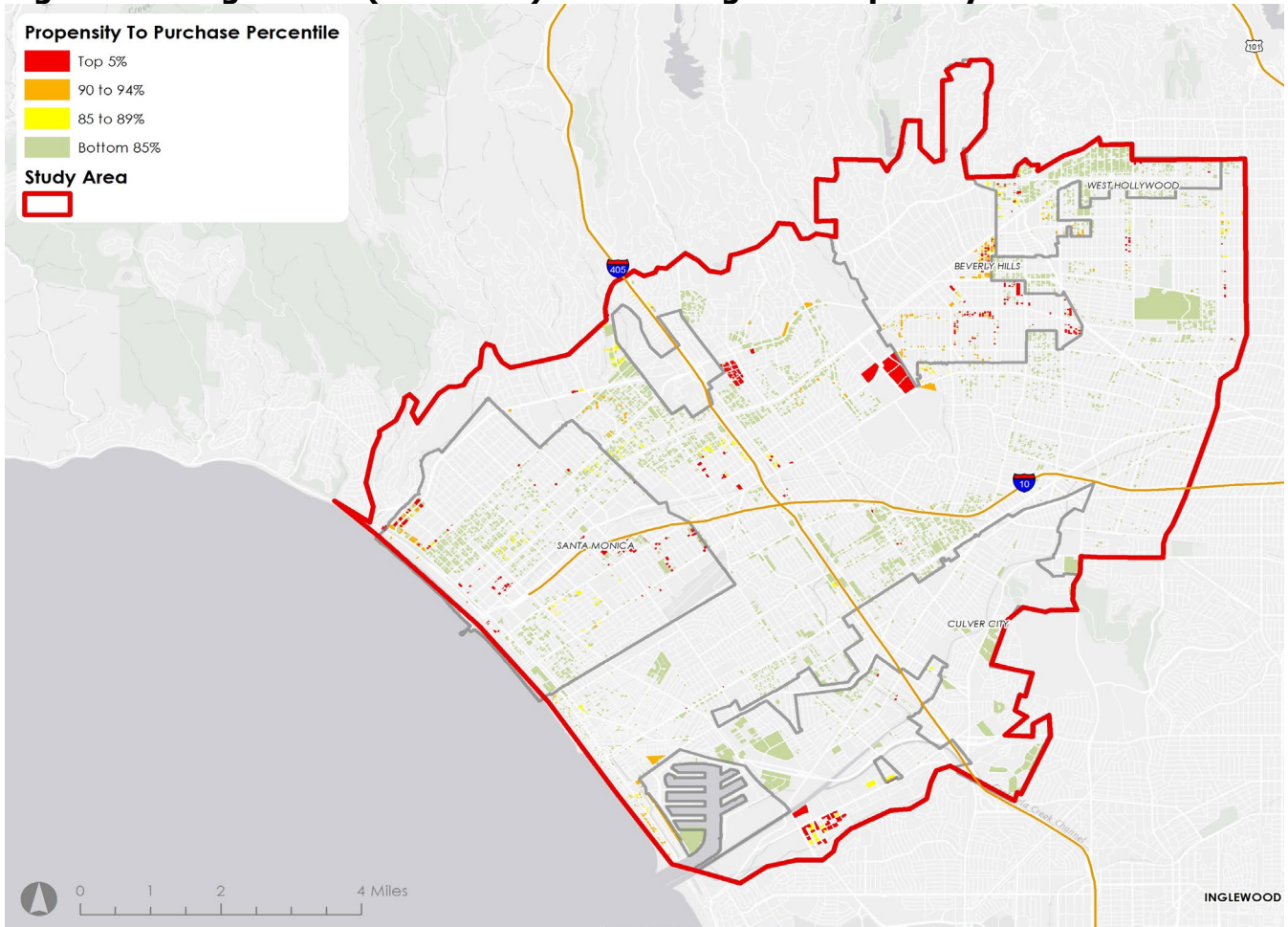
Source: IHS Automotive, Los Angeles County Office of the Assessor Secured Basic Abstract File

### 3.2.1 Latent PEV Demand for Large MUDs

There may be significant advantages to installing multiple EVSE and sharing installation costs among PEV drivers. Additionally, Southern California Edison’s Charge Ready program requires a minimum of 10 EVSEs per site (or 5 EVSEs for sites in disadvantaged communities). Thus, large MUDs serve as prime candidates for outreach programs aimed at increasing PEV adoption and promoting the potential cost savings to group investment in EVSE installation.

Figure 10 presents the distribution of large MUDs (i.e., more than 10 units) with the highest propensity to purchase scores across the Westside Cities subregion. Again, Beverly Hills has a disproportionate share of large MUDs (10+ units) with high propensity to purchase scores, due to its high adoption rate of PEVs, and its population of high-income households.

**Figure 10: Large MUDs (10+ units) with the Highest Propensity to Purchase Scores**



Source: IHS Automotive, Los Angeles County Office of the Assessor Secured Basic Abstract File

Table 10 summarizes the number of large MUDs (i.e., more than 10 units) with the highest propensity to purchase scores across the Westside Cities subregion. Around 70 percent of the large MUDs in Beverly Hills fall within the top 15th percentile of propensity to purchase scores for the region. In contrast, 0 percent of the large MUDs in Culver City fall within the top 15th percentile of propensity to purchase scores. West Los Angeles is home to the greatest number of large MUDs in the top 15th percentile of propensity to purchase scores (357 of 788), which again, is a consequence of the region's size, since most of the large MUDs in the region do not have high propensity to purchase scores. Only 10 percent of the MUDs in West Los Angeles fall within the top 15th percentile of propensity to purchase scores.

**Table 10: Large MUDs (10+ units) with the Highest Propensity to Purchase Scores**

<b>City</b>	<b>Total MUDs (10+ Units)</b>	<b>Bottom 85%</b>	<b>Top 15%</b>	<b>Top 10%</b>	<b>Top 5%</b>
Beverly Hills	289	87	202	177	98
Culver City	115	115	0	0	0
Santa Monica	1,163	994	169	111	90
West Hollywood	779	720	59	39	20
West Los Angeles	3,708	3,351	357	221	125
Unincorporated	3	2	1	0	0
<b>Total</b>	<b>6,057</b>	<b>5,269</b>	<b>788</b>	<b>548</b>	<b>333</b>

Source: IHS Automotive, Los Angeles County Office of the Assessor Secured Basic Abstract File

# CHAPTER 4:

## The Cost of Installing Charging Infrastructure in MUDs

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In place of a 15-minute detour to a gas station, most PEV owners refuel when they are at home and plugged-in throughout the night. To charge PEVs at home, drivers generally choose a Level 1 or 2 charger, depending on charging preference, recharging needs, and cost of installation. Level 1 charging requires a 110/120-volt outlet, the standard 3-prong plug that is already available in many parking layouts. It requires 15 amps of continuous load to charge 4–6 miles per hour. Seventy-eight percent of PEV drivers average 15 to 45 miles of driving per day, which can be satisfied with 3 to 8 hours of Level 1 charging.<sup>13</sup> Level 2 charging units charge PEVs at a much faster rate of 8–24 miles per hour, but they require a 208/240-volt outlet.

For single-family homeowners, home charging is generally an easily available amenity. Single-family homes tend to have sufficient electrical capacity to support overnight charging, and the installation of the necessary EVSE is straightforward and has a predictable cost. The same cannot be said for PEV home charging at MUDs. The cost of installing EVSE in a MUD parking environment varies greatly from site to site and can quickly become a barrier. To begin, all PEV drivers need EVSE equipment for plugging their vehicle into an electrical outlet (covered in section 4.1). Once the desired EVSE unit is obtained, proper wiring and conduit is needed to connect the charging outlet to the electric panel at the MUD (covered in section 4.2). If the panel cannot produce adequate electricity and/or the utility service is not providing enough electricity to the property, then panel and/or service upgrades will be necessary (covered in section 4.3).

Figure 11 shows an overview of the various costs that occur at the different stages of EVSE installation for a single charging unit. Depending on the electrical configuration of a given MUD, not all stages may be relevant. It's worth emphasizing that the ranges provided below are ballpark estimates, and do not reflect the absolute lower or upper limit of installation costs at each stage, especially considering the variation in electrical configurations among MUDs, and the variation in charging preferences among PEV drivers (i.e., Level 1 or Level 2 charging).

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13 Center for Sustainable Energy. California Plug-in Electric Vehicle Driver Survey Results – May 2013.

**Figure 11: Potential Costs at the Different Stages of EVSE Installation at MUD Locations**



**Car by Tracy Tam; Electric Equipment by Prosymbols; Building by Nicholas Menghini; Pylon by Arthur Shlain**

Source: Noun Project

### **Background on the Electrical Configuration of Multi-Unit Dwellings**

The electrical configuration of an MUD is complex. Utilities distribute power to each property's electric meter through either an overhead service drop or an underground service connection. An overhead drop often comes from a utility pole to the roof of the property and down to the meter section or to the electric box. Underground service connections come from a pull section or pull box – an underground compartment that serves as the main termination point for the utility feed. The connection is then run up to the MUD's electric box. Alternatively, an underground service connection can run down a utility pole, be tunneled underground, and then resurfaced at the property's electric box.

Inside the electric box is the property's meter section, which includes the house and unit meters as well as the main breakers, shown in Figure 12. Each residential unit has its own meter and main breaker. Power is distributed from the meter section to a panel located in each unit, or the unit panel, where circuit breakers safely manage each unit's electric load. The house meter(s) and main breaker(s) distribute power to a house panel(s), which then provides electricity to common areas and general electrical loads such as parking outlets, laundry machines, pool pumps, electric water heaters, and more. The house panel can be located in the electric box or in another common space.

**Figure 12: Photos of Overhead Service Drops and Meters at MUDs**



**Left: Two examples of overhead service drops providing electricity to the MUD’s electric box. Right: A grouping of house and unit meters (i.e. the meter section) and their main breakers inside an electric box.**

Source: UCLA Luskin Center

### **Case Study Findings**

This chapter reviews findings from the 2016 report *Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study*, in which cost estimates were developed for the installation of charging infrastructure at sample MUD sites in the South Bay.<sup>14</sup> The cost estimates were developed by a qualified electrician who considered the following: electrical configuration of MUDs, necessary panel and service upgrades, and opportunities for savings. Researchers requested 30 MUD site visits to assess Level 1 and Level 2 charge readiness, and to estimate the cost of installing a single Level 2 EVSE unit. From the 30 selected sites, a total of 27 sites were actually visited, and a total of 15 complete cost estimates were obtained.<sup>15</sup> Based on these 15 cost estimates, the electrician estimated Level 2 EVSE installation costs ranging from \$1,800 to \$17,800 per site, with an average of \$5,400 per site (including the cost of any panel upgrades, but not including the cost of service

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14 UCLA Luskin Center for Innovation. 2016. [Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf). Available at [https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming\\_Barriers\\_to\\_EV\\_Charging\\_in\\_MUDs-A\\_South\\_Bay\\_Case\\_Study.pdf](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf)

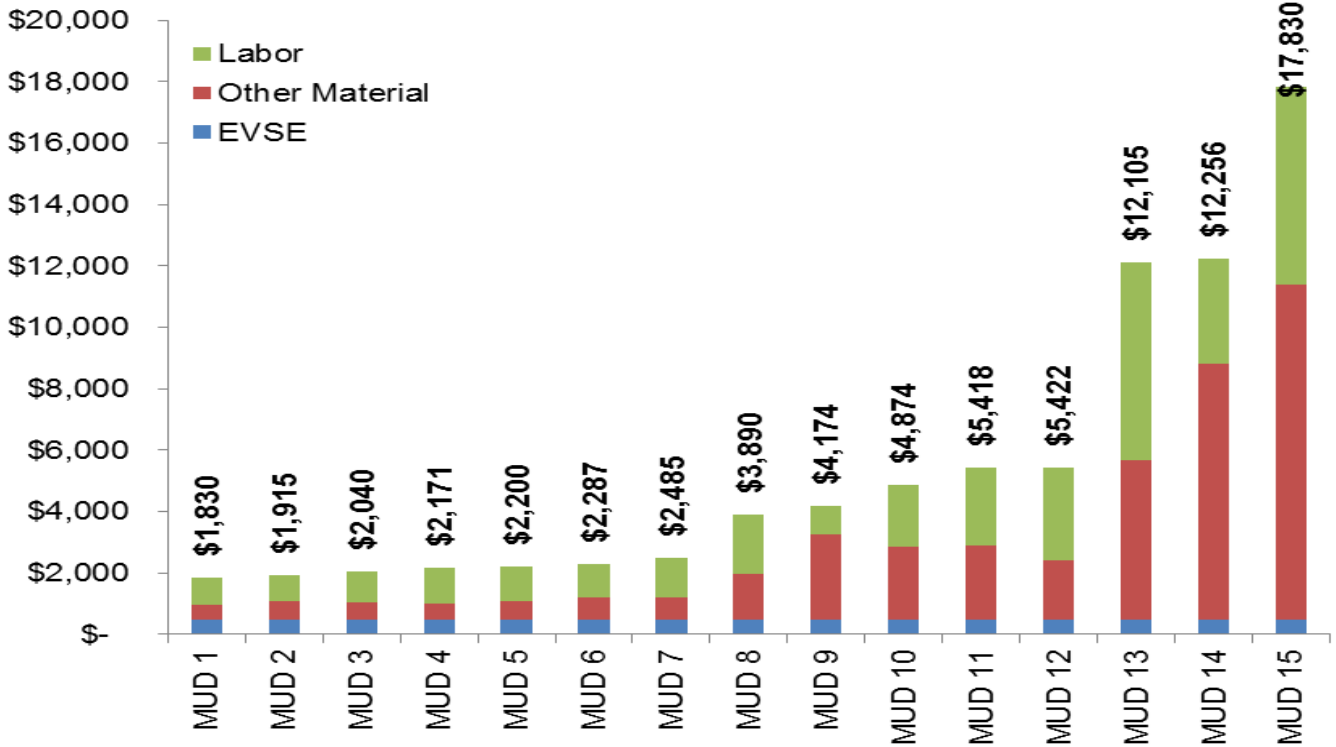
15 Complete cost estimates were not obtained for all 30 properties because some property owners were unable to be found, were not interested in participating in the study, or were unable to provide permission to determine the electrical service being provided to the MUD, which is necessary for determining whether the MUD receives enough power to provide Level 2 charging for one or more vehicles.



capacity upgrades). To contrast, Level 2 installation costs for single-family residences average \$1,500.<sup>16</sup>

The most significant component of installation costs across the 15 estimates was labor, which on average was 45 percent of the total project cost. Materials (other than EVSE) were the second greatest cost, comprising 40 percent of total project costs on average. A constant price of \$480 was assumed for EVSE across all estimates, comprising about 15 percent of the total project cost on average. Figure 13 shows a breakdown of installation costs across the 15 sample estimates.

**Figure 13: Breakdown of Installation Costs for Level 2 EVSE Unit across 15 MUDs**



Source: UCLA Luskin Center

### Savings Opportunities

Although the estimated installation costs were high in this exercise, some potential cost-reduction strategies emerged. These costs savings are detailed in Section 4.4, and summarized below:

- Using Level 1 charging, particularly in dingbat parking lots, shown in Figure 14.
- Sharing EVSE installation costs across multiple PEV drivers.
- Identifying parking layouts and electrical configurations that lend themselves to lower-cost Level 2 charging infrastructure installation (e.g., parking spots close to existing electrical outlets).

<sup>16</sup> Electric Power Research Institute. 2013. [Electric Vehicle Supply Equipment Installed Cost Analysis](https://www.epri.com/#/pages/product/00000003002000577/). Accessed August 2017, available at <https://www.epri.com/#/pages/product/00000003002000577/>

**Figure 14: Dingbat Parking Layouts with Medium to High Probability of Electrical Outlet Access**



Source: UCLA Luskin Center

## **4.1 Electric Vehicle Supply Equipment**

Level 1 and Level 2 EVSE provide alternating current power – the typical power supplied to residences and business – to the PEV’s onboard charging equipment, which then converts it into direct current power for battery charging. Level 1 EVSE can supply up to 120 volts of power, or six miles per hour, while Level 2 EVSE can supply up 240 volts, or 60 miles per hour. Level 1 EVSE can typically be directly plugged into any common outlet as long as there is enough available power supply at the panel level. Level 1 EVSE typically comes at the point of PEV purchase and is the cheapest option. Level 1 EVSE can range anywhere from \$300 to \$1,500, while Level 2 EVSE can range between \$400 and \$6,500, depending on the included features, and whether the unit is mounted on a wall or a free-standing pedestal.<sup>17</sup> Figure 15 shows sample photos of EVSE at each charging level.

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<sup>17</sup> U.S. Department of Energy. 2015. [Costs Associated with Non-Residential Electric Vehicle Supply Equipment](https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf). Accessed August 2017, available at [https://www.afdc.energy.gov/uploads/publication/evse\\_cost\\_report\\_2015.pdf](https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf)

**Figure 15: Examples of Level 1 and Level 2 Charging EVSE**



Left: Level 1 Charging Example. Right: Level 2 Charging Example. Source: Voltrek and Clipper Creek

## **4.2 Running Wires & Conduit to Charge Point**

To provide electricity to the EVSE equipment, an electrician may need to run wires from the electrical panel to the PEV charge point. If the panel is close to the EVSE location, the installation process can be straightforward. As the length between the panel and the EVSE site extends however, additional costs will arise from materials, labor, and construction activities like trenching through concrete or asphalt. In MUDs where parking areas represent a significant structural feature (e.g. subterranean garages), EVSE installation may require engineering tests like x-raying concrete to ensure structural integrity.

Soft costs include permitting and inspection fees, tool rentals for construction or engineering activities, taxes on the materials purchased, and contractor fees. Labor is often the most significant cost component of project installation and can vary depending on the contractor's experience, trade union membership, and the complexity of the job. The cost of tool rentals will be related to the materials and type of labor required and will vary greatly from project to project. Taxes on materials vary by state and profits vary by the company contracted for labor.

Permitting, inspection requirements, and associated fees vary by city and by county. The installation of EVSE and any corresponding electrical upgrade will likely require engineering drawings which must be reviewed by the responsible agency such as a Department of Building and Safety. Requirements for engineering drawings can vary and may require electrical load studies of the property.

Once there is sufficient electrical capacity to perform PEV charging, a contractor needs to run conduit and wire from the relevant panel to the PEV parking spot, overcoming any physical barriers that might arise. The cost of connecting charging infrastructure to the building's

electrical system varies from site to site. The strongest predictor of costs is the distance between the panel with the EVSE-dedicated circuit and the PEV parking spot.

EVSE installations that traverse long distances not only require greater lengths of conduit and wiring, but also increase the likelihood of requiring significant construction and engineering activities. For MUD sites where the PEV parking spot was 100 feet or greater from the relevant electrical panel, these additional construction and engineering activities accounted for \$180 to \$4,600 in material and labor, comprising between 5 percent to 48 percent of total material and labor costs.<sup>18</sup>

### **4.3 Upgrading Electrical Panel and Utility Service**

Sometimes the installation of a Level 1 and Level 2 EVSE will require additional electrical capacity. Electrical upgrades can occur in two ways within an MUD's electrical configuration:

- A. Adding capacity to the unit or house panel, and/or
- B. Upgrading electric service capacity to the MUD from the utility.

These upgrades should be made in consultation with an electrician, or ideally, an electrical engineer. An electrical engineer can provide an installation quote that looks holistically at the overall energy supply and demand of a building and make recommendations for reducing the building's electrical load. Load reduction efforts may allow residents to use the building's existing electricity supply to access Level 1 charging (see Section 4.4 for more information).

The following section reviews costs associated with upgrading MUD panel capacity and utility service. It provides utility-specific information from Southern California Edison Electric Service Requirements and other Southern California Edison Guidelines, plus observations made during site visits at 27 different MUDs across the South Bay with a qualified electrician.

#### **A. Adding Electrical Capacity to the Unit or House Panel**

Level 1 charging requires a dedicated 20-amp breaker rated for continuous use. In many instances, 110/120-volt outlets are available in the parking area and receive electricity from a 15- or 20-amp breaker on the house panel. The amount of available capacity often depends on the other loads tied to that panel, such as electricity needed for common areas. A confluence of loads on the same house panel may trip the main breaker – a safety response that shuts down service to all loads sharing the panel.

To assess the feasibility of Level 1 charging, the resident, property manager, or owner, and an electrician, or electrical engineer, should review the annual peak load of the house panel to determine if there is available capacity. This information is often available from an individual's electric utility at the request of the person named on the bill.

Level 2 charging requires a dedicated 40-amp circuit. If there is sufficient capacity and breaker space on the panel, then an electrician can simply add breakers to the panel to create the necessary dedicated circuits.

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18 UCLA Luskin Center for Innovation. 2016. [Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf). Accessed August 2017, available at [https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming\\_Barriers\\_to\\_EV\\_Charging\\_in\\_MUDs-A\\_South\\_Bay\\_Case\\_Study.pdf](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf)

When there is insufficient capacity or space on the panel for a dedicated circuit, an electrician must create additional capacity in one of the following ways:

- a. Upgrade to a new panel  
A panel upgrade replaces the existing panel (e.g. 50-amp) with one that has additional breaker space or greater capacity (e.g. 100-amp).  
*Cost Estimate: \$1,000 or more for a panel upgrade with new breakers*
- b. Reconfigure the current panel to provide more breaker space  
Electricians can reconfigure the breakers on the existing panel to free up space for additional breakers. For example, a tandem circuit breaker allows for two circuits to be installed in one circuit breaker space.  
*Cost Estimate: \$60 to \$500, depending on its panel breaker's type, size and age*
- c. Add a sub-panel for the EVSE unit  
Electricians may also install a sub-panel. Electricians can, for example, replace multiple breakers with a tandem circuit breaker and run a wire from it to the new sub-panel. The result is a sub-panel with space for multiple breakers, including a dedicated one for Level 2 charging.  
*Cost Estimate: \$500 to \$2,000, depending on distance between panel and sub-panel and the number and type of breakers*
- d. Add a separate panel from the existing service  
An electrician can add a separate panel with a dedicated service for PEV charging. This requires a newly installed panel to connect to the current service drop or connection (sometimes called "tapping into" or "tapping off"). The resident and property manager or owner and an electrician should work with their local utility to ensure they follow all electrical service guidelines.  
*Cost Estimate: \$1,000 or more to install a new dedicated panel and to connect to existing service, depending on the space available for the panel and the distance between the new panel and the service connection.*

For Level 1 charging, 78 percent of the sites we visited had access to 110/120-volt outlets in the parking environment. Depending on the parking layout, outlets were either scattered randomly throughout the parking environment or were available at each individual parking spot. Of these sites, 96 percent of the 110/120-volt outlets were connected to a 15- or 20-amp circuit on the house panel. Without permission to review the annual peak load, it was uncertain whether there was sufficient capacity on the house panels to facilitate Level 1 charging.

For Level 2 charging, 93 percent of the sites visited did not have sufficient panel capacity or breaker space and would require upgrades. At these sites, additional capacity would need to be added through the one of the four options described above (i.e., a panel upgrade, a reconfiguration of panel breakers, the installation of a sub-panel, or the installation of a new dedicated panel that is connected to the existing service).

Before an electrician can make any panel adjustments, a utility representative must visit the site to review the installation plan and provide electrical code instructions. Any electrical upgrade that requires utility approval will also require bringing the property up to Electrical Service Requirement code. For example, Southern California Edison requires flat ground below meters have three feet of clear working space in front of them so that staff can easily and safely access and read meters. If the current panel is not up to the utility's standards or there

is no space for an additional panel, the electrician may be required to move the entire meter section, which would increase costs.

## **B. Upgrading Electric Service Capacity to the MUD from the Utility**

To add capacity at the panel level for EVSE, the property must receive enough power from the utility to support the added load. If there is insufficient power, tenants or owners must apply for a utility service upgrade to replace service wires fed to the MUD and/or upgrade distribution lines (e.g. replacing or upgrading the transformer).

Adding capacity at the panel level may require upgrading the MUD's utility service. Service upgrades may be more likely when the MUD is located at the end of the utility's electrical lines served by a substation or in urban areas where building density has already maximized the electric service capacity.<sup>19</sup> To accommodate additional capacity, the utility may need to perform service line and/or distribution line upgrades.

For these types of upgrades, Southern California Edison is "responsible for the cost of the service connector, connectors, support poles, and metering."<sup>20</sup> These costs are covered by a residential allowance and any amount in excess of the allowance is billed to the customer. The customer is "responsible for any trenching, conduit, substructures, or protective structures required for the upgrade. These costs are not covered by the allowance."<sup>21</sup>

Within Southern California Edison territory, if the service capacity from an overhead drop increases to over 200 amps, the customer is responsible for burying the overhead feed underground.<sup>22</sup> This will likely require costly construction activities, including trenching and the demolition of concrete. Medium-sized MUDs (10–19 units) receiving electricity from an overhead drop may be at or above the 200-amp threshold and thus be subject to this rule and associated costs.

Out of 9,300 on-site residential service assessments for PEV charger installations completed before November 2014, Southern California Edison required service upgrades only 26 times (0.3 percent).<sup>23</sup> The service upgrade costs ranged from \$274 to \$33,499, with service line upgrades averaging \$2,055 and distribution line upgrades averaging \$7,165.<sup>24</sup> It is important to note that these include a significant share of single-family households that are more likely to have sufficient capacity available. Southern California Edison also needed 9 service upgrades for commercial installations, which may be more reflective of medium- and large-

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19 California Department of Housing and Community Development. 2013. [Electric Vehicle Ready Homes](http://www.hcd.ca.gov/building-standards/state-housing-law/docs/ev_readiness.pdf). Accessed August 2017, available at [http://www.hcd.ca.gov/building-standards/state-housing-law/docs/ev\\_readiness.pdf](http://www.hcd.ca.gov/building-standards/state-housing-law/docs/ev_readiness.pdf)

20 San Diego Gas and Electric. 2014. [Joint IOU Electric Vehicle Load Research Report](http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M143/K954/143954294.PDF). Accessed August 2017, available at <http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M143/K954/143954294.PDF>

21 Ibid.

22 Phone Interview with Southern California Edison, November 28, 2015.

23 San Diego Gas and Electric. 2014. [Joint IOU Electric Vehicle Load Research Report](http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M143/K954/143954294.PDF). Accessed August 2017, available at <http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M143/K954/143954294.PDF>

24 Ibid.

sized MUDs. In the event that a service upgrade is required, the applicant shall be granted an allowance of \$3,402 per residential dwelling unit.<sup>25</sup>

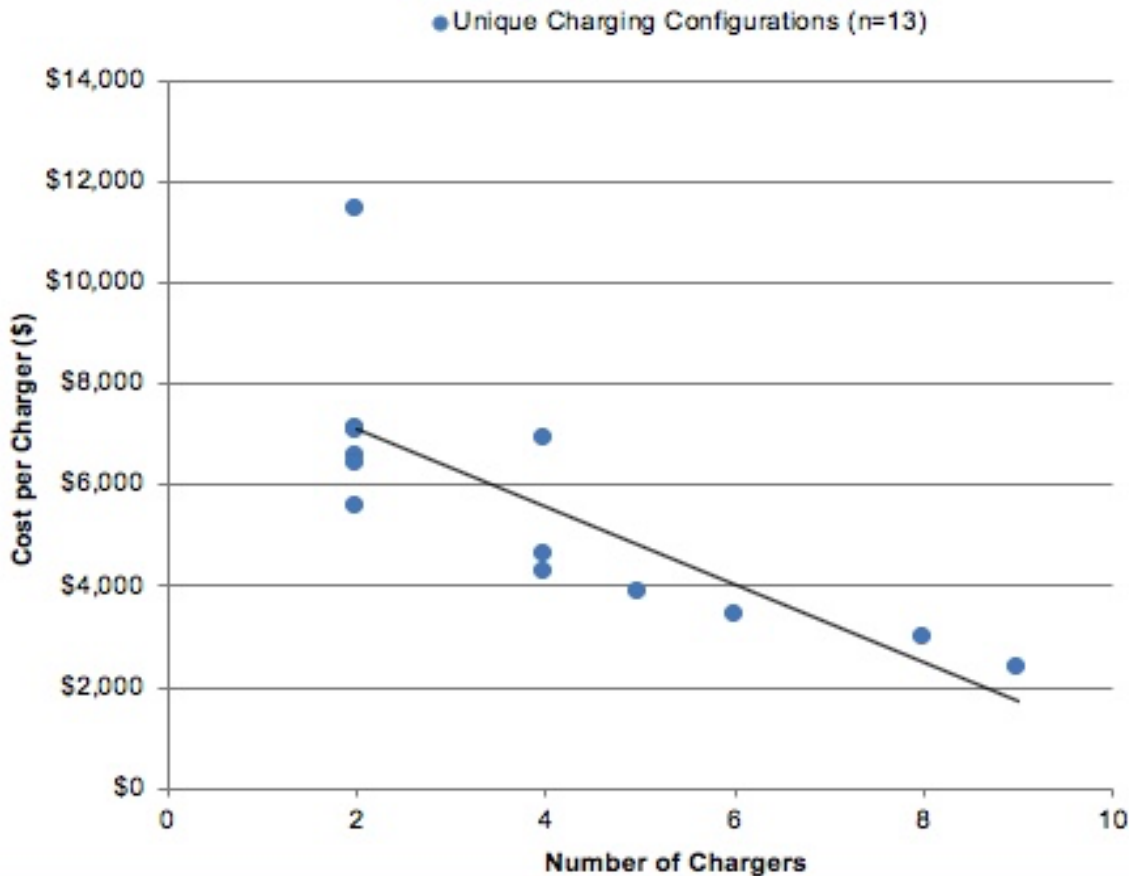
#### 4.4 Cost-Saving Opportunities to Reduce Charging Fees

To help reduce the cost of EVSE installations at MUD sites, multiple PEV drivers at one location can split the up-front installation costs. If this isn't an option, PEV drivers can opt to rely on Level 1 charging and possibly avoid installation costs altogether. This section reviews these two cost saving strategies.

##### Cost Advantages to Group Investing in Level 2 Charging Infrastructure

PEV owners can share EVSE installation costs at MUD residences. Figure 16 shows the decreasing cost per added EVSE on a site, as based on 13 different potential charging configurations at 8 different sample sites.<sup>26</sup> When considering EVSE installation, an owner or renter should survey neighbor units to gauge interest in PEV ownership and sharing the costs associated with EVSE installation.

**Figure 16: Cost Reductions Achieved due to Multiple EVSE Installations**



Source: On Target Electric, for study purposes only

25 Southern California Edison Tariff Books. [Rule 15](https://www.sce.com/NR/sc3/tm2/pdf/Rule15.pdf). Accessed August 2017, available at <https://www.sce.com/NR/sc3/tm2/pdf/Rule15.pdf>

26 UCLA Luskin Center for Innovation. 2016. [Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf). Accessed August 2017, available at [https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming\\_Barriers\\_to\\_EV\\_Charging\\_in\\_MUDs-A\\_South\\_Bay\\_Case\\_Study.pdf](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf)

Technological solutions can support group investments in EVSE installation. For example, energy saving technologies such as energy management systems can be installed to optimize multiple PEV charges. The management of energy in response to the charging needs of PEVs and the available electrical capacity of a building can delay the need for costly electrical upgrades. For example, if a building's electrical capacity can only handle one PEV charging at full capacity, but there are three PEVs in the building, energy management systems technology can distribute power to each PEV at different times so that all three PEVs can charge overnight. This prevents the need to upgrade the electrical capacity of the building to accommodate all three PEVs.

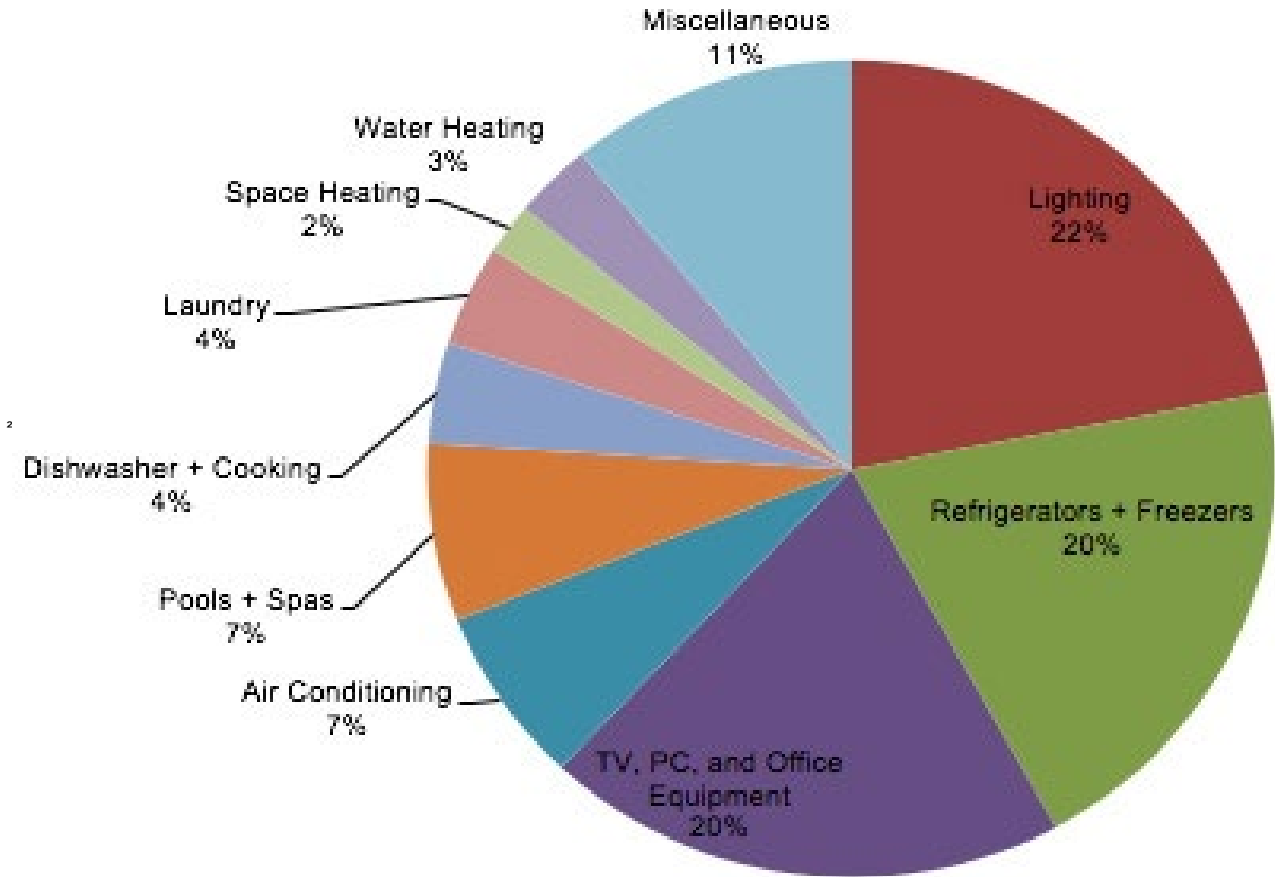
### **Accessing Level 1 Charging to Avoid Electrical Upgrades**

Depending on a PEV driver's available charge time and daily commute, MUD parking environments with access to 110/120-volt outlets may be good candidates for Level 1 EVSE charging. The resident, property manager, or owner, along with an electrician or electrical engineer, should review the annual peak load of the house panel to determine if there is available capacity considering other loads tied to the panel, such as laundry machines, pool pumps, etc. This information is often available from the utility provider at the request of the person named on the electric bill.

If the house panel does not have sufficient capacity to accommodate Level 1 charging, strategic energy efficiency measures may be deployed to reduce the overall load of the house panel. This can include efficient lighting, or energy efficient replacements for a property's electric water heater, washer/dryer, or pool pump. Electric utilities offer a number of rebates and incentives to improve efficiency. Figure 17 shows an overview of how the average household in California consumes electricity. The greatest savings can be achieved in improving the efficiency of lighting fixtures, refrigerators/freezers, and household devices with screens (e.g., televisions, personal computers, etc.).



**Figure 17: Average California Electricity Consumption per Household (6,296 kilowatt-hours per Household)<sup>27</sup>**



Source: CEC

#### **4.5 Charging Potential in the Westside Cities by Parking Layout**

In Southern California and the Westside Cities subregion, the private vehicle has played a significant role in shaping land use patterns and the built environment, as well as MUD architectural designs. The latter tends to change over time and location depending on construction trends and sociodemographic changes. These changes can influence unit size, the availability of on-site amenities such as laundry services, and the parking layout of the property.





The parking layout is of particular importance to PEV ownership and EVSE installation. Indeed, one of the most significant drivers of EVSE installation costs is the distance from the electrical panel to the PEV charging spot and a MUD’s parking layout will greatly influence this length of distance. The parking layout may also determine whether a PEV driver will have access to an electrical outlet for Level 1 charging. And finally, some parking layouts such as shared garages may provide opportunities for sharing the installation costs for multiple EVSE or the deployment of new technologies such as energy management systems which allow for the

<sup>27</sup> California Energy Commission, 2010. [2009 California Residential Appliance Saturation Study](http://www.energy.ca.gov/appliances/rass/). Accessed August 2017, available at <http://www.energy.ca.gov/appliances/rass/>

strategic charging of multiple PEVs by optimally balancing each vehicle’s state of charge with available electrical capacity.





Eight common MUD parking layouts across the Westside Cities Subregion include: 1) dingbat with door, 2) dingbat without door, 3) detached parking with door, 4) detached parking without door, 5) podium garage, 6) subterranean garage 7) parking lot, and 8) driveway only. Figures 18 and 19 show a description of each parking layout.

**Figure 18: Common MUD Parking Layouts Across the Westside Cities Subregion**

Parking Layout Type	Sample Photo
<p><b>Dingbat with Door</b></p> <ul style="list-style-type: none"> <li>• Enclosed individual garage partitioned by walls</li> <li>• Equipped with private garage door</li> <li>• Often located below driver’s housing unit</li> <li>• At or below grade</li> <li>• High probability of electrical outlet access</li> </ul>	
<p><b>Dingbat without Door</b></p> <ul style="list-style-type: none"> <li>• Open or partitioned parking spots</li> <li>• Not equipped with private garage door</li> <li>• Located below housing units</li> <li>• At or below grade</li> <li>• Medium probability of electrical outlet access</li> </ul>	
<p><b>Detached Parking with Door</b></p> <ul style="list-style-type: none"> <li>• Enclosed individual garage partitioned by walls</li> <li>• Equipped with private garage door</li> <li>• Detached from main MUD structure</li> <li>• At grade</li> <li>• Medium to high probability of electrical outlet access</li> </ul>	
<p><b>Detached Parking without Door</b></p> <ul style="list-style-type: none"> <li>• Open parking structure often partitioned by walls</li> <li>• Not equipped with private garage door</li> <li>• Detached from main MUD structure</li> <li>• At grade</li> <li>• Low to medium probability of electrical outlet access</li> </ul>	

Source: UCLA Luskin Center

**Figure 19: Common MUD Parking Layouts Across the Westside Cities Subregion**

Parking Layout Type	Sample Photo
<p><b>Podium Garage</b></p> <ul style="list-style-type: none"> <li>• Enclosed shared garage</li> <li>• Not equipped with private garage door</li> <li>• Located below housing units</li> <li>• At grade</li> <li>• Medium to high probability of electrical outlet access</li> </ul>	
<p><b>Subterranean Garage</b></p> <ul style="list-style-type: none"> <li>• Enclosed shared garage</li> <li>• Not equipped with private garage door</li> <li>• Located below housing units</li> <li>• Below grade</li> <li>• Medium to high probability of electrical outlet access</li> </ul>	
<p><b>Driveway Only</b></p> <ul style="list-style-type: none"> <li>• Open parking spot or spots not partitioned by walls</li> <li>• Not equipped with private garage door</li> <li>• Located adjacent to main MUD structure</li> <li>• At grade</li> <li>• Zero to low probability of electrical outlet access</li> </ul>	
<p><b>Parking Lot</b></p> <ul style="list-style-type: none"> <li>• Open parking lot not partitioned by walls</li> <li>• Not equipped with private garage door</li> <li>• Located adjacent to main MUD structure</li> <li>• At grade</li> <li>• Zero to low probability of electrical outlet access</li> </ul>	

Source: UCLA Luskin Center

Figure 20 describes opportunities for installing Level 1 and 2 charging EVSE in different MUD parking layouts based on our observations from visiting sample MUD sites in the South Bay.<sup>28</sup> The eight layouts in the Figures 18 and 19 were consolidated into six in Figure 19, based on overlapping information.

**Figure 20: Evaluation of Charging Potential across Different MUD Parking Layouts**

	Level 1 Charging	Level 2 Charging
<b>Dingbat with Door</b>	⚡ Likely access to a 110/120-volt outlet in parking garage, particularly with an automatic door that relies on electricity. Outlets in this configuration are typically connected to the house panel. If the outlet does not already serve energy intensive loads from things such as a laundry machine or pool pump, it may provide a convenient opportunity for charging.	⚡⚡ Many have convenient access to the unit panel if the garage is below or in front of the unit, which reduces the distance between the panel and parking spot. Even though the distance between the two may be minimal, electricians may still need to core the wiring and conduit through unit walls and/or the floor.
<b>Dingbat without Door</b>	⚡ Likely access to 110/120-volt outlets, although outlets may be scattered across the parking environment. These outlets are almost always connected to the house panel. PEV drivers should consider the capacity and shared loads. In scenarios where tenants have assigned parking, a PEV driver may swap spots for easier access to the outlet.	⚡⚡ Many have convenient access to the unit panel if the garage is below or in front of the unit, which reduces the distance between the panel and parking spot. The conduit and wiring can often be surface-mounted along the length of the parking site.
<b>Detached Parking</b>	⚡⚡ Possible access to an outlet in each detached garage. Higher value and newer MUDs with detached parking are more likely to have outlets. With an automatic door, there is also a higher likelihood of access to an outlet. When parking is assigned, residents may need to swap parking spots to gain access to Level 1 charging.	⚡⚡⚡ Most are separated from the MUD structure and the house and unit panels by concrete or asphalt. Costly construction activity such as trenching to run wire Case Study 3 in Section 4.5.3 illustrates this point.
<b>Subterranean Garage and Podium Garage</b>	⚡ Likely access to 110/120-volt outlets. Every subterranean garage and podium garage we visited did have at least one outlet available. The outlets may be scattered throughout the shared parking environments. In scenarios where tenants have assigned parking, a PEV driver may swap spots for easier access to the outlet.	⚡⚡⚡ Wiring and conduit may need to traverse through building material and/or earth. Large subterranean garages may have multiple levels of parking and require coring through concrete decks. MUDs with podium parking garages are likely to have an electrical box on the same level as the parking area, which may reduce the risk of coring through structure or ground.
<b>Driveway Only</b>	⚡⚡ Unlikely access to a 110/120-volt outlet. There may be access in the case that there is an outlet on the outside wall of the MUD that faces the driveway.	⚡⚡⚡ Unlikely access to 110/120-volt outlet.
<b>Parking Lot</b>	⚡⚡⚡ Unlikely access to an electrical outlet.	⚡⚡⚡ Unlikely access to an electrical outlet.

**Key: 1 Bolt = Straightforward, 2 Bolts = Moderately Complex, 3 Bolts = Ver Complex.**

Source: UCLA Luskin Center

28 UCLA Luskin Center for Innovation. 2016. [Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf). Accessed August 2017, available at [https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming\\_Barriers\\_to\\_EV\\_Charging\\_in\\_MUDs-A\\_South\\_Bay\\_Case\\_Study.pdf](https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_South_Bay_Case_Study.pdf)

# CHAPTER 5:

## Policy Tools to Overcome Barriers to PEV Adoption in MUDs

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To achieve the State of California’s ambitious ZEV adoption goals, and to ensure equitable distribution of the ZEV benefits, residents of MUDs must have the option to charge their PEVs at home. This is particularly true for a Westside Cities subregion, which has 253,876 MUD units. As reviewed in Chapter 4, EVSE installation costs at MUD sites are variable and often high. Moreover, renters and property owners show a low- to non-existent motivation to invest in charging infrastructure at their residence or property. To this end, regional, subregional, and municipal governments, as well as state agencies, air quality management districts, and utilities (hereafter “other administrative entities”) can deploy the following policy tools to overcome MUD related EVSE installation barriers to PEV adoption:

1. Design incentives to reduce the cost of EVSE installation.
2. Implement PEV ready new construction codes.
3. Expand availability of public PEV charging opportunities for MUD residents.
4. Conduct outreach to drive PEV ownership and EVSE installation in MUDs

These policy tools are the focus of this chapter.

### 5.1 Design Incentives to Reduce the Cost of EVSE Installation

Policymakers can design public financial incentives such as price subsidies, rebates, tax credits, sales tax exemptions, and subsidized financing to induce consumers to adopt PEV technology. The Clean Vehicle Rebate Program offers PEV buyers \$1,500 for a PHEV, or a \$2,500 rebate for a BEV after purchase. Sixty-five percent of PEV drivers found the California Clean Vehicle Rebate Program to be extremely or very important to their purchase decision.<sup>29</sup> The state, local municipalities, and other administrative entities can also provide free or subsidized Level 2 chargers. Sixty percent of early PEV adopters found a rebate to be extremely or very important to their decision to install a Level 2 charger.<sup>30</sup> Due to the variable and often high cost for installing EVSE at MUD sites, a specific installation rebate may be an effective policy tool to ease the cost barrier and expand PEV access.

To increase the cost-effectiveness of rebates for EVSE installation, and to maximize the adoption of PEVs at MUDs, we recommend requiring multiple PEV drivers per single MUD to qualify. As reviewed in Chapter 4, the high variable costs for EVSE installations provide an opportunity to share costs across multiple residences.

To accommodate a range of incomes, administrative entities could offer tiered rebates based on consumer income levels. These types of progressive rebates have proven to be more cost

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29 Center for Sustainable Energy. California Plug-in Electric Vehicle Driver Survey Results – May 2013.

30 Ibid.

effective, have lower total policy costs, and result in greater allocative equity.<sup>31</sup> We recommend designing rebate tiers so that they vary by household income or locational attributes such as MUDs within disadvantaged communities.

Rebates for Level 1 charging can also be an effective option. If drivers at MUDs have access to an outlet, the driver would only need to ensure that the outlet is connected to a panel with sufficient electrical capacity for Level 1 charging. For this level of charging, we recommend a program that partners with utilities and covers the cost for local electricians or electrical engineers to review the electrical capacity of the panel and to conduct an overall assessment of charging readiness.<sup>32</sup>

## **5.2 Implement PEV Ready New Construction Codes**

Local jurisdictions can also set guidelines for remodels and new MUD construction that require developers to provide Level 1 or 2 charging readiness. Many new building code examples exist throughout California that can serve as models for the cities on the west side. Local jurisdictions should implement the 2013 California Green Building Standards, which in relation to PEVs in MUDs states, “at least 3 percent of the total parking spaces, but not less than one, shall be capable of supporting future EVSE.”<sup>33</sup>

The city of Los Angeles already has a Green Building Code (Chapter IX, Article 9, of the Los Angeles Municipal Code), which mandates newly constructed “high-rise” residential (i.e. multi-level MUDs) to be Level 2 charging-station ready. It also requires, “208/240 Volt 40 Amp outlets equal to 5 percent of the total number of parking spaces, with the outlets located in the parking area.”

Unfortunately, much of the residential land use in the Westside Cities subregion is already built out. If new construction codes were adopted by the cities in the subregion, it would take many years at current construction rates for a significant percentage of MUDs to be capable of providing PEV charging access. Thus, this policy tool should not be adopted in isolation of the other policy tools discussed in this chapter.

## **5.3 Expand Public Charging Opportunities for MUD Residents**

Local governments can also provide alternative public charging sites in locations such as city-owned parking lots. Strategic siting of Level 2 or Direct Current Fast Chargers near clusters of MUDs may provide an option for multi-unit dwellers, who cannot charge at home. A charging program may need to be administered by a local government to organize and coordinate charge times.

The City of Torrance, for example, launched the "One Mile, One Charger Project" with the goal of expanding PEV infrastructure throughout Torrance so that a PEV driver is never more than

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31 Sheldon, Tamara L., J.R. DeShazo, Richard T. Carson, and Samuel Krumholz. 2016. [Factors Affecting Plug-in Electric Vehicle Sales in California](#). Accessed August 2017, available at <http://innovation.luskin.ucla.edu/content/factors-affecting-plug-electric-vehicle-sales-california>

32 A utility's primary role can be to be responsive to annual peak load requests per site.

33 California Department of Housing and Community Development. 2013. [Electric Vehicle Ready Homes](#). Accessed August 2017, available at [http://www.hcd.ca.gov/building-standards/state-housing-law/docs/ev\\_readiness.pdf](http://www.hcd.ca.gov/building-standards/state-housing-law/docs/ev_readiness.pdf)

one mile from a charging station within the city.<sup>34</sup> The City of Torrance worked with ChargePoint to install, operate, and maintain publicly accessible PEV charging infrastructure at six public locations (e.g., parks, libraries, civic buildings, etc.). All sites included a minimum of two Level 2 charging units and one Direct Current Fast Charging unit.

## **5.4 Conduct Outreach to Encourage PEV / EVSE Investments at MUDs**

The PEV remains a relatively new technology. Substantial sales of BEVs started only in 2010, and most believe we are still in the very early stages of PEV adoption.<sup>35</sup> As with many new technologies, consumers have been hesitant to switch out their internal combustion engine for a PEV. Some of this hesitation can be rooted in the comfort level drivers have with the internal combustion engine and/or the uncertainty, real or perceived, of new technologies, like range anxiety – the fear of running out of battery mid-trip. Internal combustion engine have been the dominant form of private transportation for over a century. Its refueling infrastructure is robust and easily accessible.

Outreach and education can help address this hesitation and introduce potential PEV drivers to the new technology by promoting its environmental and financial benefits as well as answering common questions and concerns. From an EVSE in MUD perspective, the goal with outreach and education is to drive demand for home charging among MUD residents and shift the investment motivation from the renter to the property owner, who may be motivated to attract tenants by providing new amenities. With strong PEV adoption rates in the Westside Cities subregion, as well as large number of high-value MUDs (3,798 MUDs with an average unit value of \$500,000 or greater), the subregion may help lead this shift in investment motivation.

Outreach and education can include direct mailing initiatives, advertising, hosting workshops, and e-newsletters. Local governments and/or Southern California Edison should focus neighborhood-level outreach on MUDs, identified in Chapter 3, that are high-quality candidates due their estimated latent PEV demand. The outreach and education materials should focus on a series of topics including:

- **New technology education** including available makes and models and associated lifespan, range, and maintenance requirements; purchase or lease costs and associated rebates; charging technologies such as Level 1 and Level 2 charging including a time of recharge tool (with Level 1 highlighted as a feasible charging choice); and location of public chargers.
- **Environmental and financial benefits** including emissions avoided and fuel savings.
- **Charging in MUDs** including instruction on how to evaluate panel electrical capacity for Level 1 (20-amp circuit with available panel capacity), Level 2 charging (40-amp circuit with available panel capacity), and how to identify cost drivers for EVSE installation (as reviewed in Chapter 4).

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34 The City of Torrance. "[EV Project](https://www.torranceca.gov/our-city/community-development/planning/ev-project)." Accessed August 2017, available at <https://www.torranceca.gov/our-city/community-development/planning/ev-project>

35 Sheldon, Tamara L., J.R. DeShazo, Richard T. Carson, and Samuel Krumholz. 2016. [Factors Affecting Plug-in Electric Vehicle Sales in California](http://innovation.luskin.ucla.edu/content/factors-affecting-plug-electric-vehicle-sales-california). Accessed August 2017, available at <http://innovation.luskin.ucla.edu/content/factors-affecting-plug-electric-vehicle-sales-california>

- **For Level 1 charging**, instruction on how to verify available electrical capacity on the house or unit panel by reviewing shared loads such as laundry machines, pool pump, etc., as well as the annual peak load from the utility bill.
- **For Level 2 charging**, instruction on how to evaluate installation cost drivers including the distance from the electrical box or relevant electrical panel to the PEV parking spot, and insight into the cost advantages of group purchases for Level 2 charging installation including recommendations to survey other tenants' interest in PEV ownership.
- **Renters' rights** including information about California law SB 880 (Corbett), which makes it illegal to impose any condition that "effectively prohibits or unreasonably restricts" installation of charging in an owner's designated parking space, and California law AB 2565 (Muratsuchi), which requires a lessor of a dwelling to approve a request to install EVSE at a designated parking spot if the installation "complies with the lessor's procedural approval process for modification of the property."
- **Westside specific benefits** including the cost and time savings that come from access to high-occupancy vehicle lanes, a benefit that has had a significant impact on PEV sales.<sup>36</sup>
- **Specialized and culturally sensitive outreach and education** including Spanish language materials and income-adjusted rebate information, such as with the Enhanced Fleet Modernization Program Plus-up Program, for the disadvantaged communities of the South Bay.

Increasing adoption among low- and moderate-income households within disadvantaged communities is a particular challenge but important to achieve the environmental equity goals of California. Low- and moderate-income households are less likely to purchase new vehicles, and many reside in MUDs without access to home charging.

To address this challenge, the California Air Resources Board has launched a number of initiatives under its Low Carbon Transportation Program aimed at expanding PEV adoption among low- and moderate-income households. The Enhanced Fleet Modernization Program Plus-Up program, for example provides low-income households up to \$12,000 for the purchase or lease of a BEV.<sup>37</sup> In addition, individuals who purchase a BEV are eligible for up to \$2,000 for a charging unit.<sup>38</sup> To qualify, the household must reside in a zip code that includes a disadvantaged community census tract.

Additionally, Southern California Edison's Charge Ready program - which aims to install up to 1,500 charging stations at parking sites where dwell times exceed four hours or longer-term

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36 Sheldon, Tamara L., J.R. DeShazo, Richard T. Carson, and Samuel Krumholz. 2016. [Factors Affecting Plug-in Electric Vehicle Sales in California](http://innovation.luskin.ucla.edu/content/factors-affecting-plug-electric-vehicle-sales-california). Accessed August 2017, available at <http://innovation.luskin.ucla.edu/content/factors-affecting-plug-electric-vehicle-sales-california>

37 Includes the \$2,500 Clean Vehicle Rebate Program rebate.

38 California Air Resources Board. "[Making the Cleanest Cars Affordable](https://www.arb.ca.gov/newsrel/efmp_plus_up.pdf)." Accessed August 2017, available at [https://www.arb.ca.gov/newsrel/efmp\\_plus\\_up.pdf](https://www.arb.ca.gov/newsrel/efmp_plus_up.pdf)



parking sites including MUDs - will target at least 10 percent of its deployment within disadvantaged communities.<sup>39</sup>

We recommend that the City governments in the Westside Cities subregion, California Air Resources Board, Southern California Edison, and the South Coast Air Quality Management District collaborate to optimize outreach effectiveness by conducting joint efforts within disadvantaged communities. Events such as “ride and drives” can be held with representatives from both programs to showcase the PEV, as well as the significant amount of savings that can be realized when participating in both programs. Additional mailing campaigns and workshops where both programs and the potential savings are promoted are also encouraged (See Chapter 2.6 for locations of disadvantaged communities within the Westside Cities Council of Governments). Event staff and outreach materials should be conscious of language and cultural barriers and adjust accordingly.

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39 Edison International. “[Charge Ready: A Plan for California](http://www.edison.com/home/our-perspective/charge-ready-a-plan-for-california.html).” Accessed August 2017, available at <http://www.edison.com/home/our-perspective/charge-ready-a-plan-for-california.html>

## GLOSSARY

**BATTERY ELECTRIC VEHICLE (BEV)**—Also known as an “All-electric” vehicle (AEV), BEVs utilize energy that is stored in rechargeable battery packs. BEVs sustain their power through the batteries and therefore must be plugged into an external electricity source in order to recharge.

**ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)**—Infrastructure designed to supply power to EVs. EVSE can charge a wide variety of EVs, including BEVs and PHEVs.

**MULTI-UNIT DWELLING (MUD)**— (also known as multi-dwelling unit or MDU) is a classification of housing where multiple separate housing units for residential inhabitants are contained within one building or several buildings within one complex. Units can be next to each other (side-by-side units) or stacked on top of each other (top and bottom units). A common form is an apartment building. Many intentional communities incorporate multifamily residences, such as in cohousing projects.

**PLUG-IN ELECTRIC VEHICLE (PEV)**—A general term for any car that runs at least partially on battery power and is recharged from the electricity grid. There are two different types of PEVs to choose from—pure battery electric and plug-in hybrid vehicles.

**PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV)**—PHEVs are powered by an internal combustion engine and an electric motor that uses energy stored in a battery. The vehicle can be plugged in to an electric power source to charge the battery. Some can travel nearly 100 miles on electricity alone, and all can operate solely on gasoline (similar to a conventional hybrid).

**ZERO EMISSION VEHICLE (ZEV)**—Vehicles that produce no emissions from the on-board source of power (e.g., an electric vehicle).