

# Siting Analysis for Plug-in Electric Vehicle Charging Stations in the City of Santa Monica

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Center**  
FOR INNOVATION



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## About this Document

This document was prepared for the Office of Sustainability and the Environment at the City of Santa Monica by the UCLA Luskin Center for Innovation. It constitutes the final deliverable of contract 3226 between the City of Santa Monica and the UCLA Luskin Center for Innovation, with the purpose of supporting plug-in electric vehicle adoption for Santa Monica residents, and outside commuters, so that the City of Santa Monica can reach its ambitious goal of carbon neutrality by 2050 or sooner.

## Acknowledgments

We thank the Southern California Association of Governments (SCAG), particularly Marco Anderson, Kimberly Clark, John Cho, Cheol-Ho Lee, Tom Vo, Ying Zhou, for sharing two of the primary datasets that made much of this analysis possible. We would also like to acknowledge the valuable research support that we received from UCLA graduate students in developing maps and text for this document, namely, Mustafa Ghuneim, Britta McOmber, and Julie Wedig. Lastly, we thank Ariana Vito and Garrett Wong at the City of Santa Monica for the expert guidance in developing a final product that will be of value to planners and policymakers in growing the PEV market, and ultimately working towards the goal of carbon neutrality.

## Disclaimer

The UCLA Luskin Center for Innovation appreciates the contributions of the aforementioned individuals and their agencies and organizations. This document, however, does not necessarily reflect their views or anyone else other than those of the authors. Anyone other than the authors make no claims regarding the accuracy or completeness of the information in this report. Any errors are the responsibility of the primary authors.

## For More Information

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# Executive Summary

## Introduction

The transportation sector represents the largest source of greenhouse gas (GHG) emissions in the City of Santa Monica, comprising 64% of all GHG emissions in 2015.<sup>1</sup> To reduce emissions from the transportation sector, and achieve carbon neutrality by 2050 or sooner, the City of Santa Monica is making a concerted effort to promote the adoption of plug-in electric vehicles (PEVs) that are capable of zero emissions.<sup>2</sup> This effort, however, requires strategic investment in electric vehicle charging infrastructure (also referred to as electric vehicle supply equipment or EVSE). The lack of conveniently accessible charging infrastructure is one of the key barriers preventing PEVs from achieving a larger market share of new vehicle purchases. This barrier is particularly significant for residents in multi-unit dwellings (MUDs) who do not have access to dedicated parking spaces with outlets for charging equipment.

The purpose of this report is to provide planners and policymakers in Santa Monica with critical spatial information to inform PEV charging investment decisions, and therefore induce demand for PEVs. Since local governments face financial constraints in making EVSE investments, each investment should be as cost-effective as possible, so that each charging station is located where latent demand is the greatest, and where there is a lack of nearby charging opportunities.

## Key Findings

After analyzing a variety of data sources, including vehicle registrations, regional commute patterns, land use patterns, employment densities, and the existing inventory of publicly-accessible charging infrastructure, the following conclusions can be drawn:

- Demand for PEVs has grown exponentially over the last five years in Santa Monica. In 2011, a total of 48 PEVs were registered within the city. In 2015, a total of 267 of PEVs were registered, representing a 456% increase in the annual volume of PEVs sold.
- The neighborhoods with the greatest number of PEV purchases are located in the northern part of the city (between San Vicente Blvd. and Montana Ave.), as well as the southwestern part of the city (near the airport), both of which are largely comprised of single family homes. PEV drivers living in single family homes can usually get their charging needs met at home by plugging into a standard 110/120-volt outlet overnight.
- The greatest need for workplace charging exists in the Downtown and Bergamot Metro Expo Line station areas. These areas contain some of the city's largest employers and the greatest concentration of incoming PEVs during peak morning hours (6AM to 9AM).
- The greatest need for commercial (retail) charging exists in the Downtown Expo Line station area. This area contains some of the city's largest retail centers (as measured by employment size) and the greatest concentration of incoming PEVs during mid-day peak hours (9AM to 3PM).

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<sup>1</sup> City of Santa Monica. 2016. 15x15 Climate Action Plan, Final Report. Accessed July 2017 from [https://www.smgov.net/uploadedFiles/Departments/OSE/Climate/CSM\\_1515\\_CAP\\_FinalReport2016.pdf](https://www.smgov.net/uploadedFiles/Departments/OSE/Climate/CSM_1515_CAP_FinalReport2016.pdf)

<sup>2</sup> City of Santa Monica. 2016. Draft EV Action Plan.

- The central and eastern portions of the Wilshire and Pico corridors are the strongest candidates for curbside charging. These segments lack public parking facilities, contain clusters of small businesses, and host a significant number of incoming PEVs during mid-day peak hours (9AM to 3PM).
- The MUDs with the highest latent demand for PEVs are located in the Downtown Expo Line station area, the northwest corner of the city, and the residential blocks surrounding the Wilshire corridor, the central stretch of Ocean Park Boulevard, the airport, and Virginia Avenue Park. These MUDs are home to high income earners and are located in census tracts with historically high rates of PEV adoption.
- The cost of EVSE installation at MUD locations is variable and is particularly high in buildings that do not have electric outlets located in parking areas. Based on a sample of 15 estimates, the cost of installing Level 2 EVSE ranged between \$1,800 and \$17,800 and averaged \$5,400. Thus, the estimated cost of installing Level 2 EVSE for all 41,000 MUD units in Santa Monica is around \$222 million.

## Policy Recommendations

There is a wide variety of investment opportunities for expanding PEV charging infrastructure, including home charging, workplace charging, commercial (retail) charging, and curbside charging. Home charging (i.e., overnight charging) is currently the most affordable way to charge, since this is when electricity rates are the lowest. Reducing the barriers associated with home charging, therefore, should be a top priority for planners and policymakers.

Home charging is relatively straightforward for residents in single family homes, who usually have access to a dedicated parking space with a nearby electrical outlet. MUD residents, however, often lack this amenity, likely suppressing PEV adoption among this group. To incentivize MUD owners to install charging infrastructure for their residents, we recommend piloting a rebate program with the following design considerations:

- Financial incentives should be tied to performance metrics. For example, a partial rebate can be offered to property owners once they have purchased EVSE, and the remainder of the rebate can be offered to the property owner once the city can verify that a PEV is using the charging station.
- Eligible expenses should include EVSE equipment, installation materials, and installation labor. During the early stages of an incentive program, however, we recommend excluding electrical service upgrades as a covered expense. This expense can potentially be avoided through strategic energy efficiency measures that reduce the building's overall electrical load.
- Increased incentives should be offered to the following applicants: (1) low-income property owners, (2) property owners that rent to low-income residents, (3) property owners that have a building located in a Disadvantaged Community, and (4) property owners that install two or more EVSE units. These progressive incentives ensure that investments in charging infrastructure are cost effective and equitable.

## Report Roadmap

**Chapter 1** provides an overview of how the PEV market has grown in Santa Monica between 2011 and 2015, and how the market is expected to grow between 2016 and 2025. This will provide planners with estimates for the number of PEVs that may require charging throughout the day in Santa Monica over the next ten years.

**Chapter 2** models where PEVs can be expected during three time periods: night, morning, and early afternoon. These maps help planners understand where public charging infrastructure may need to be located to accommodate overnight charging for Santa Monica residents, workplace charging for morning commuters, and commercial charging for drivers running afternoon errands.

**Chapter 3** identifies gaps in current workplace charging coverage, contrasting the locations of PEVs during morning peak hours with other key variables, such as the locations of Santa Monica's largest employers and the current supply of publicly-accessible charging stations. The chapter then identifies the top-25 workplace sites that do not currently host on-site charging.

**Chapter 4** identifies gaps in current commercial-retail charging coverage, contrasting the locations of PEVs during early afternoon hours with other key variables, such as the locations of Santa Monica's largest retail centers, curbside parking meters, and the current supply of publicly-accessible charging stations. The chapter then identifies the top-25 commercial-retail sites that do not currently host on-site charging.

**Chapter 5:** identifies the locations of multi-unit dwellings (MUDs) in Santa Monica according to size, and then identifies which MUDs have the highest propensity to purchase a PEV. Since overnight charging is often the most affordable and convenient way to charge, MUDs should be prioritized for investments in charging infrastructure.

**Chapter 6** complements Chapter 5 with a summary of the costs associated with Level 1 and Level 2 EVSE installation at MUD sites. Cost ranges are provided for the various stages of EVSE, including the cost of acquiring EVSE equipment, running wires and conduit to the charge point, panel upgrades, and potential service upgrades.

**Chapter 7** provides recommendations for a financial incentive program to induce PEV demand amongst MUD residents. This discussion includes an overview of sample incentive programs in Southern California, program design considerations for maximizing cost-efficiency, suggested rebates levels, and estimates for overall program costs.

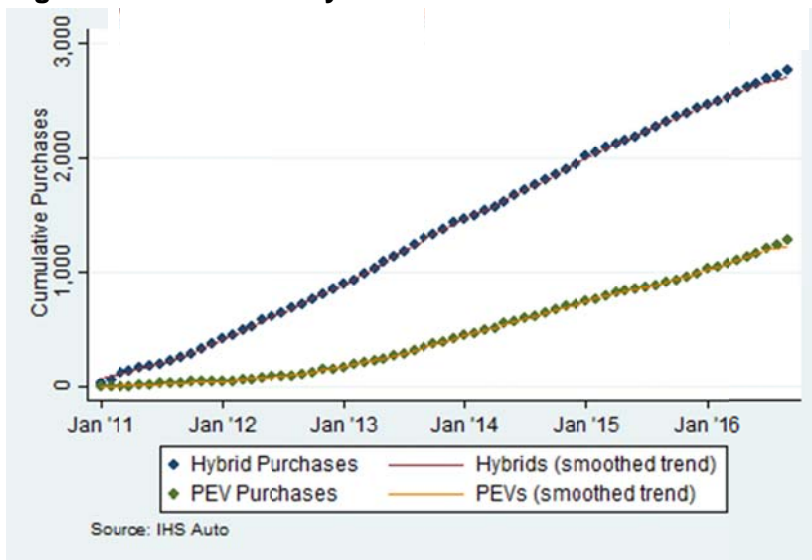
A summary of the methods used for estimating PEV growth and for generating all of the maps in this report can be found in the **Technical Appendix**.

# Chapter 1: PEV Growth in Santa Monica

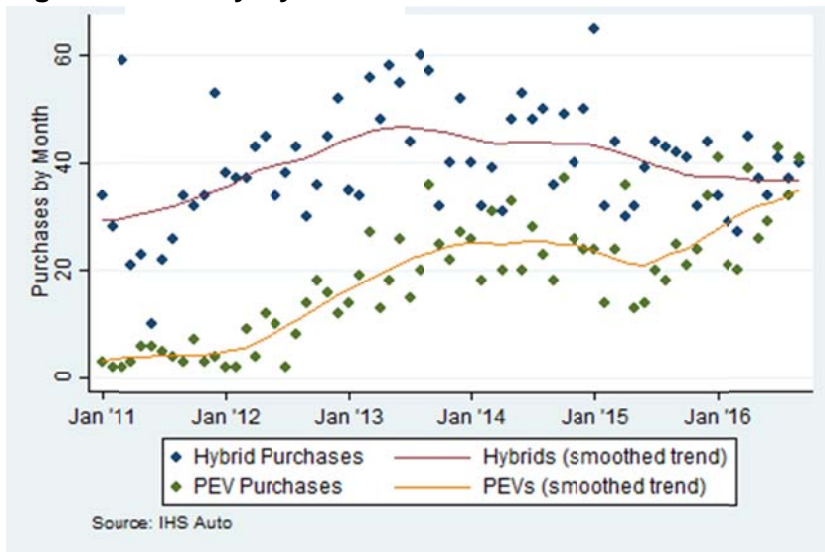
## Cumulative PEV Growth

From January 2011 through the end of December 2015, a total of 990 PEVs were purchased in Santa Monica. In comparison, a total of 2,429 hybrids were purchased during the same period. While cumulative hybrid purchases still greatly outnumber PEV purchases, monthly purchases of the two vehicles types are closely approaching, signaling the growing market share of PEVs in the advanced technology vehicle market. See **Figure 1** and **Figure 2** for a summary of cumulative and monthly purchases for PEVs and hybrids in Santa Monica from January 2011 through September 2016.

**Figure 1. Cumulative Hybrid and PEV Purchases in Santa Monica**



**Figure 2. Monthly Hybrid and PEV Purchases in Santa Monica**

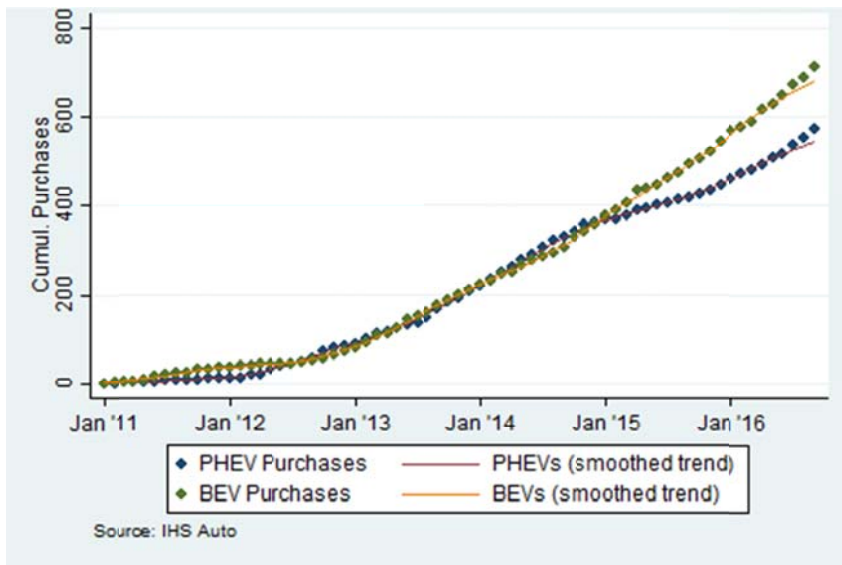




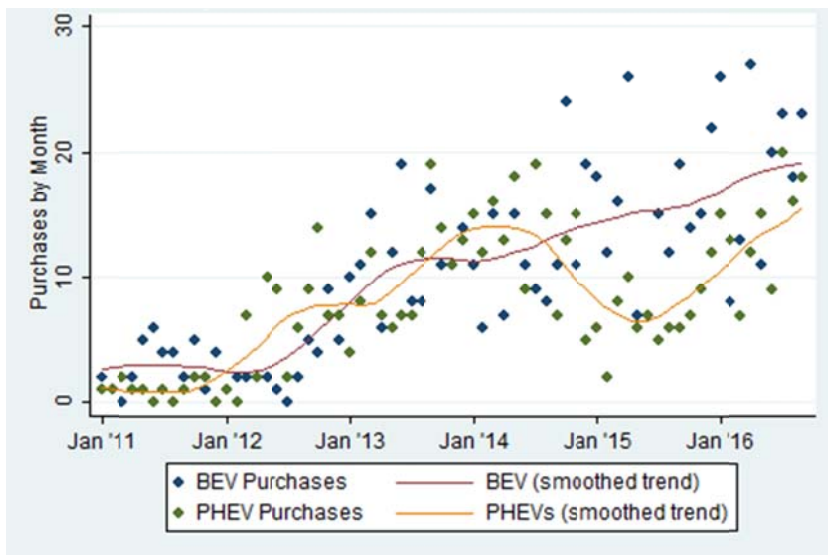
### BEV and PHEV Growth

There are two kinds of PEVs, battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). BEVs run entirely on electricity, while PHEVs can run on electricity (albeit for shorter ranges) and gasoline. BEV and PHEV purchases have closely mirrored one another from 2011 through 2014. However, towards the end of 2014, BEV purchases began to consistently outpace PHEVs, likely explained by advances in battery technologies that allow for greater electric mile ranges, and an alleviation of range anxiety among consumers. See **Figure 3** and **Figure 4** for a summary of cumulative and monthly purchases for BEVs and PHEVs in Santa Monica from January 2011 through September 2016

**Figure 3. Cumulative BEV and PEV Purchases in Santa Monica**



**Figure 4. Monthly BEV and PHEV Purchases in Santa Monica**

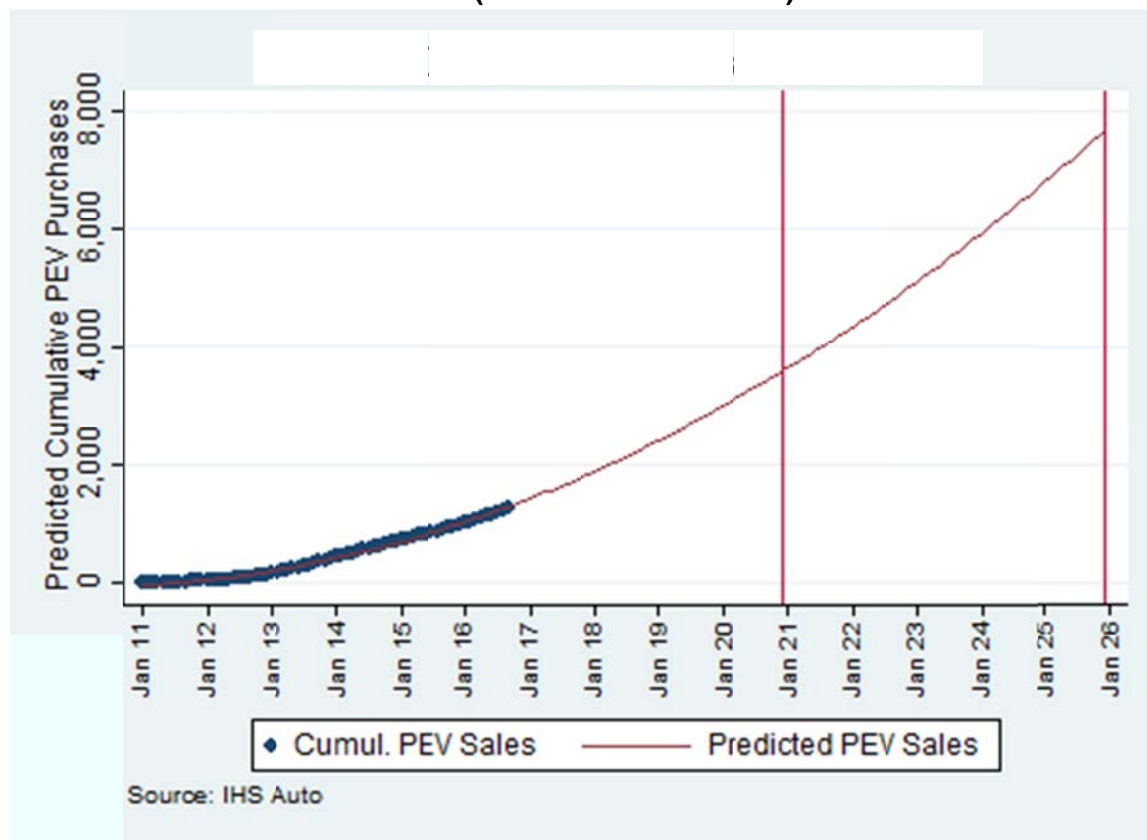


### Predicted PEV Growth

From January 2016 through December 2020, registered PEVs in Santa Monica are expected to grow by an additional 2,568 vehicles. Extending the forecast through the end of 2025, PEV purchases in Santa Monica are expected to grow by 6,660 vehicles (from January 2016). These estimates were obtained from a quadratic growth model based on observed monthly PEV purchases between December 2010 and September 2016 in the City of Santa Monica (see **Technical Appendix** for detail methods).

At some point the PEV market will reach saturation, so the predicted PEV sales presented here assume that PEVs are in the early stages of technology adoption. We believe that 2025 is early enough in the PEV lifecycle that market saturation will be unlikely. However, a potential limiting factor is significant number of Santa Monica residents that live in multi-unit dwellings (MUDs). According to parcel data for the City of Santa Monica, there are around 41,000 MUD units in Santa Monica, including condo units occupied by their owners, and apartments occupied by renters.<sup>3</sup> Unless steps are taken to facilitate charging options for MUD residents, PEV ownership may not grow as projected. See **Figure 5** and **Table 1** for a summary of predicted cumulative PEV purchases in Santa Monica since December 2010.

**Figure 5. Predicted Cumulative PEV Purchases in Santa Monica (Since December 2010)**



<sup>3</sup> Los Angeles County Office of the Assessor data, accessed June 2017.

**Table 1. Predicted Cumulative PEV Purchases in Santa Monica**

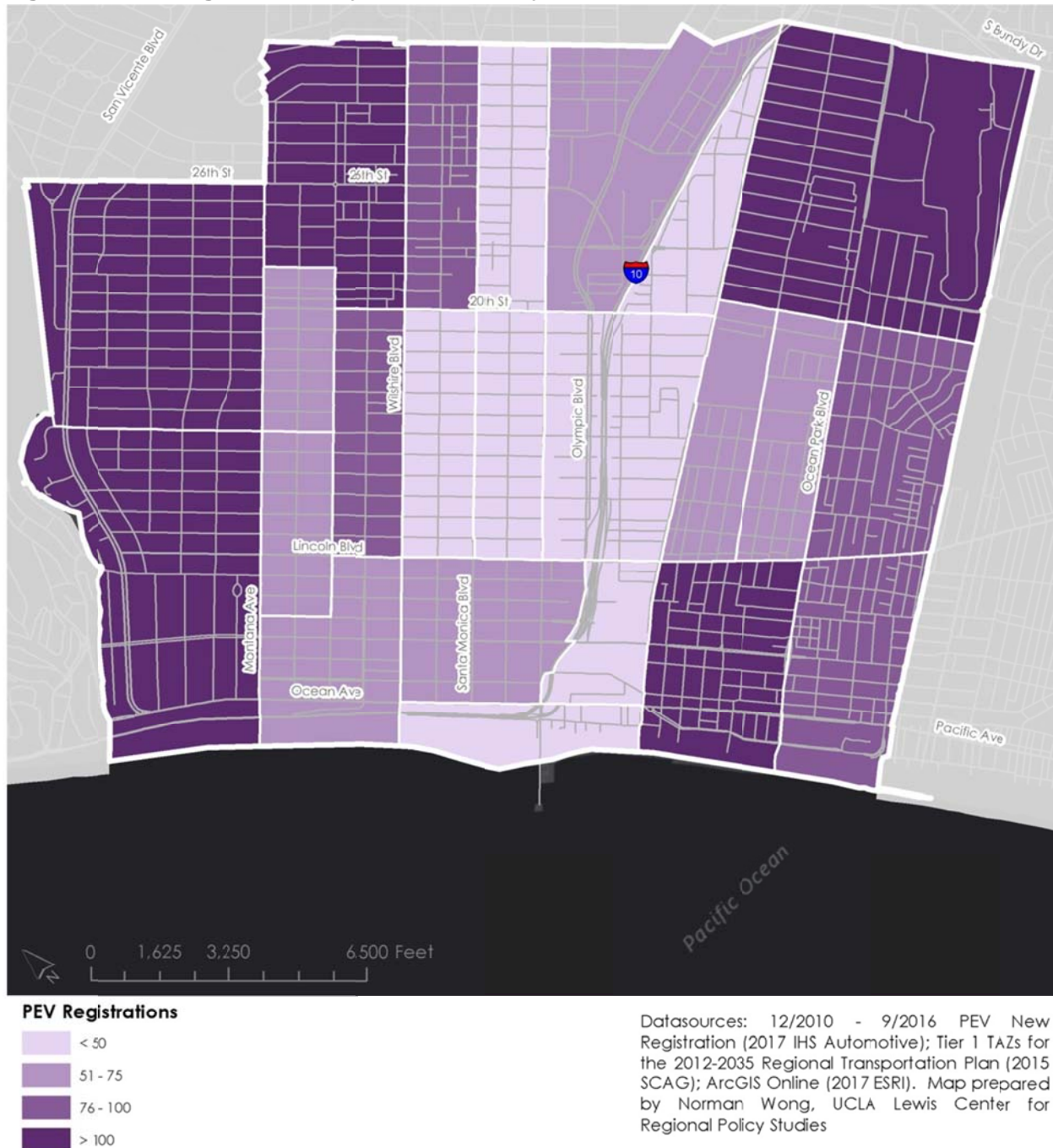
Year	Cumulative PEV Registrations (Since December 2010)
2016	1,399
2017	1,852
2018	2,366
2019	2,940
2020	3,576
2021	4,272
2022	5,029
2023	5,848
2024	6,727
2025	7,667

## Chapter 2: Regional Travel Demand Analysis for Santa Monica

### PEV Registrations

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 6** shows the density of PEV registrations within each Travel Analysis Zone (TAZ) across Santa Monica. TAZs closely follow census tract boundaries and are used by the Southern California Association of Governments (SCAG) to estimate travel within and between neighborhoods.

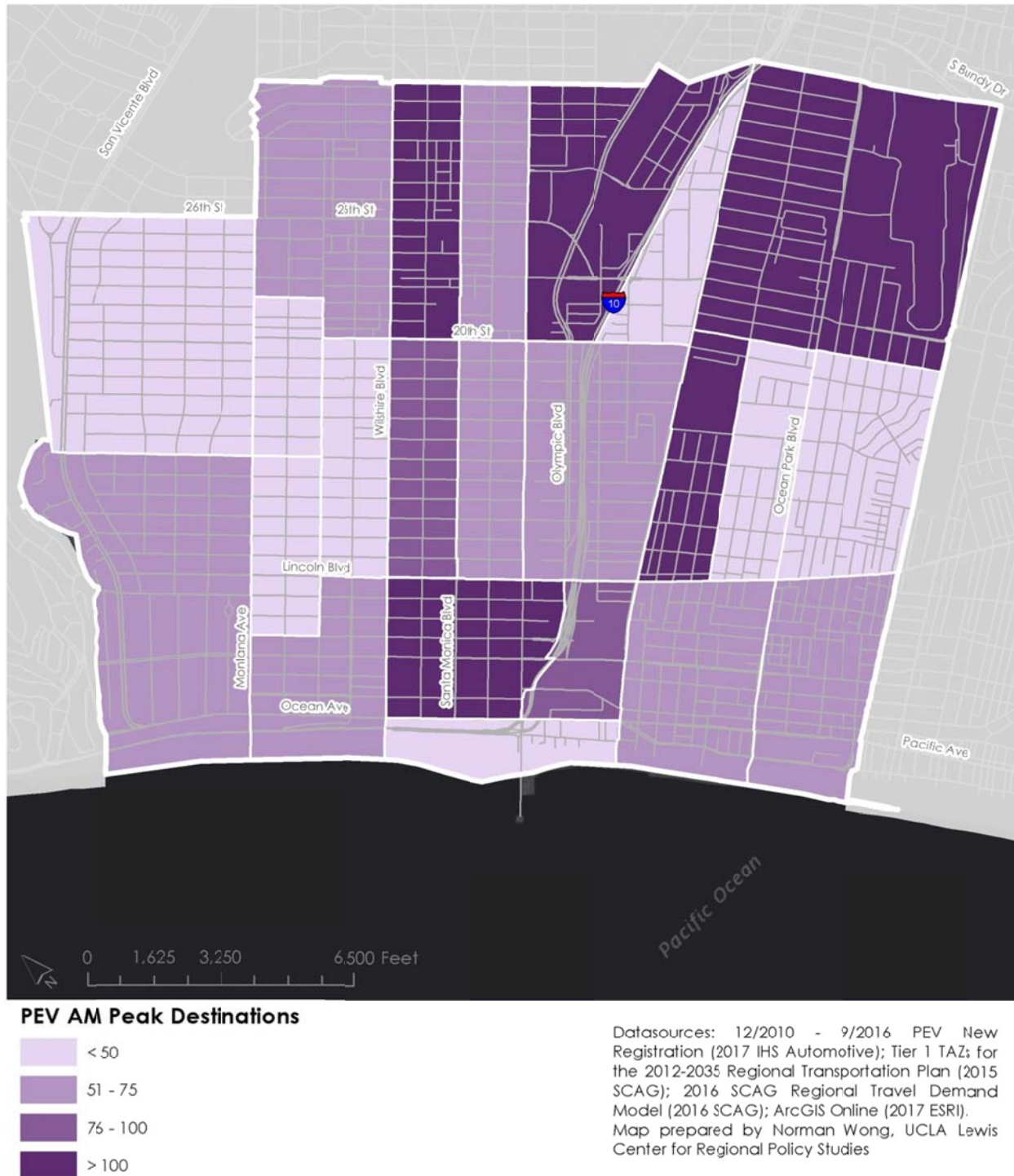
**Figure 6. PEV Registrations by TAZ in the City of Santa Monica**



## PEV Peak Morning Destinations

Understanding where PEVs are concentrated during weekday morning peak hours (6:00 a.m. to 9:00 a.m.) can help planners and utilities identify neighborhoods where there will be demand for workplace charging. **Figure 7** shows the density of PEVs within each TAZ across the City of Santa Monica during morning peak hours.

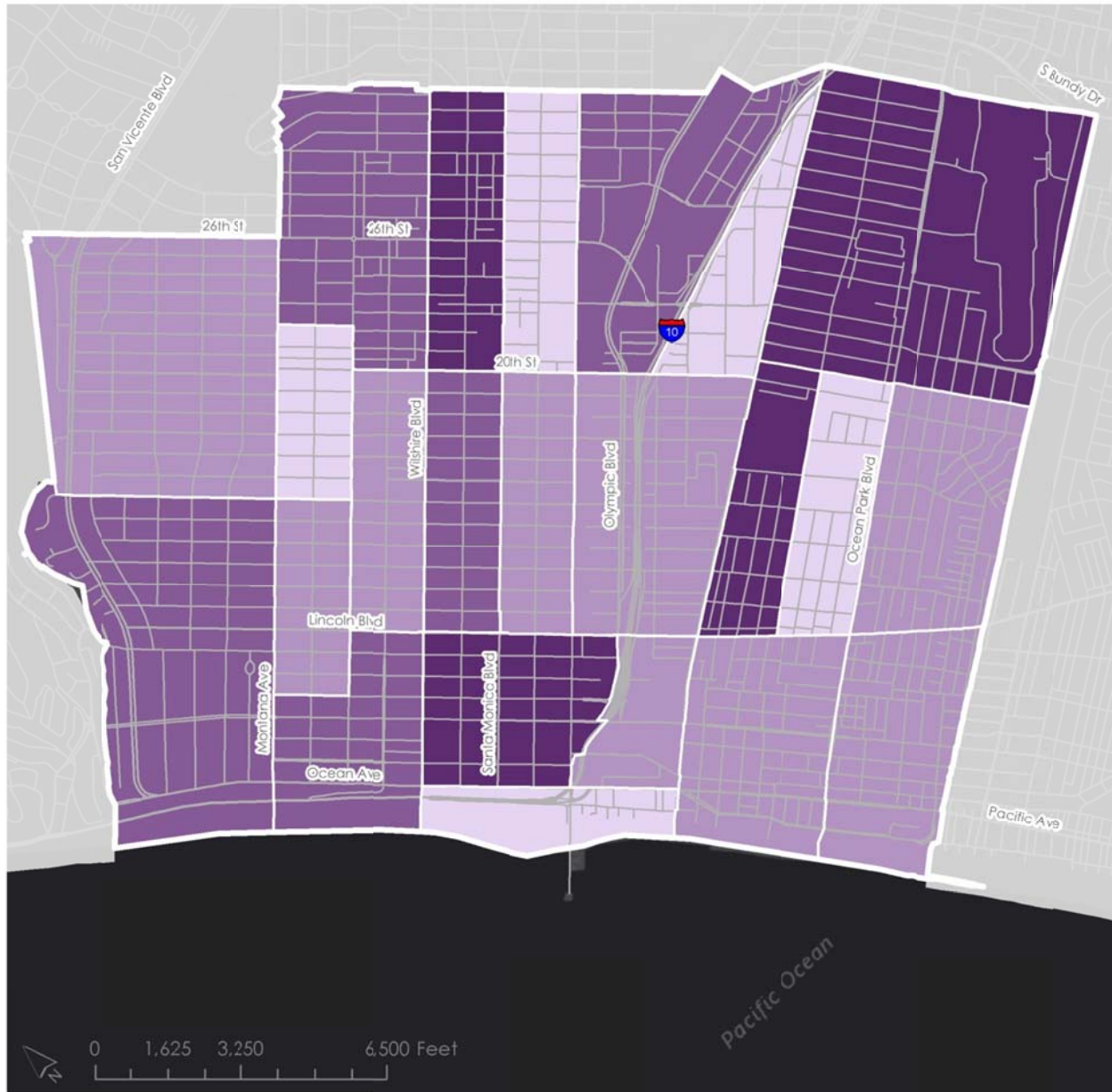
**Figure 7. PEV Destinations between 6AM and 9AM by TAZ in the City of Santa Monica**



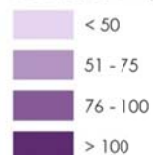
## PEV Mid-Day Destinations

Understanding where PEVs are concentrated during weekday mid-day hours (9:00 a.m. to 3:00 p.m.) can help planners and utilities identify neighborhoods where there will be demand for charging at commercial and retail locations. **Figure 8** shows the density of PEVs within each TAZ across the City of Santa Monica during mid-day hours.

**Figure 8. PEV Destinations between 9AM and 3PM by TAZ in the City of Santa Monica**



### PEV Mid-Day Destinations



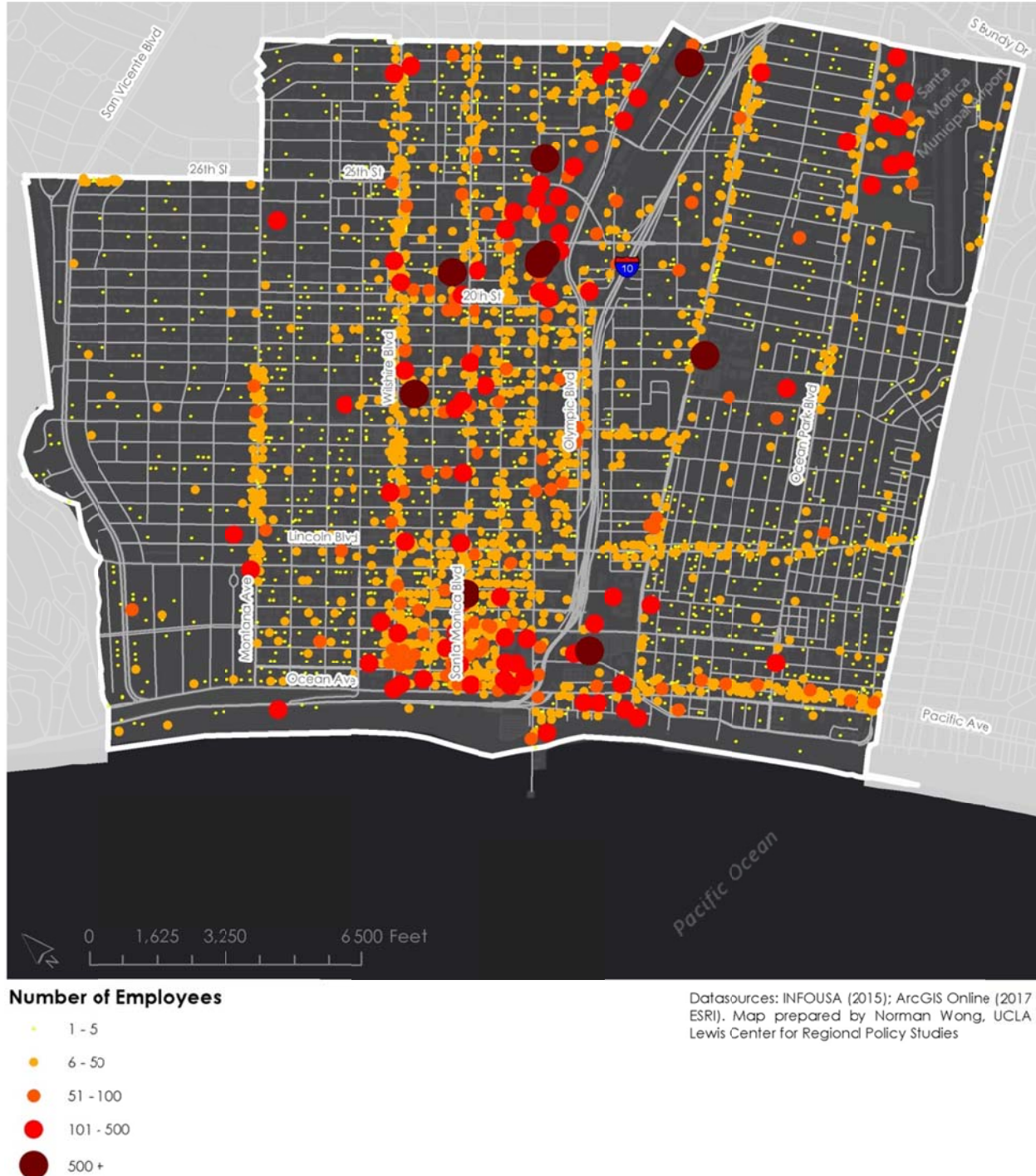
Datasources: 12/2010 - 9/2016 PEV New Registration (2017 IHS Automotive); Tier 1 TAZs for the 2012-2035 Regional Transportation Plan (2015 SCAG); 2016 SCAG Regional Travel Demand Model (2016 SCAG); ArcGIS Online (2017 ESRI). Map prepared by Norman Wong, UCLA Lewis Center for Regional Policy Studies

## Chapter 3: Workplace Charging Gap Analysis

### Workplace by Number of Employees

Planners can target the largest employers for workplace charging initiatives, as they presumably host the largest numbers of parking spaces on-site and can potentially serve the highest numbers of employees. **Figure 9** shows the locations and relative size of employment centers throughout the City of Santa Monica.

**Figure 9. PEV Destinations between 9AM and 3PM by TAZ in the City of Santa Monica**



## Publicly-accessible Charging Stations

Understanding the existing inventory of publicly-accessible charging stations is important for identifying where there may be gaps in meeting demand for charging. **Figure 10** shows locations of publicly-accessible charging stations across the City of Santa Monica, including the level of service and the number of charging outlets at each location. This map is based on information posted by users that charge at these locations as of May 23, 2017. On this date, there were 43 unique charging locations, which together provided a total of 356 charging outlets (6 of which were Level 1, 329 of which were Level 2, and 21 of which were DC Fast Charging).

**Figure 10. Locations of Publicly-accessible Charging Stations across Santa Monica**



Level 1	Level 2	DC
1 - 2	1 - 2	1 - 2
3 - 7	3 - 7	3 - 7
8 - 10	8 - 10	8 - 10
11 +	11 +	11 +

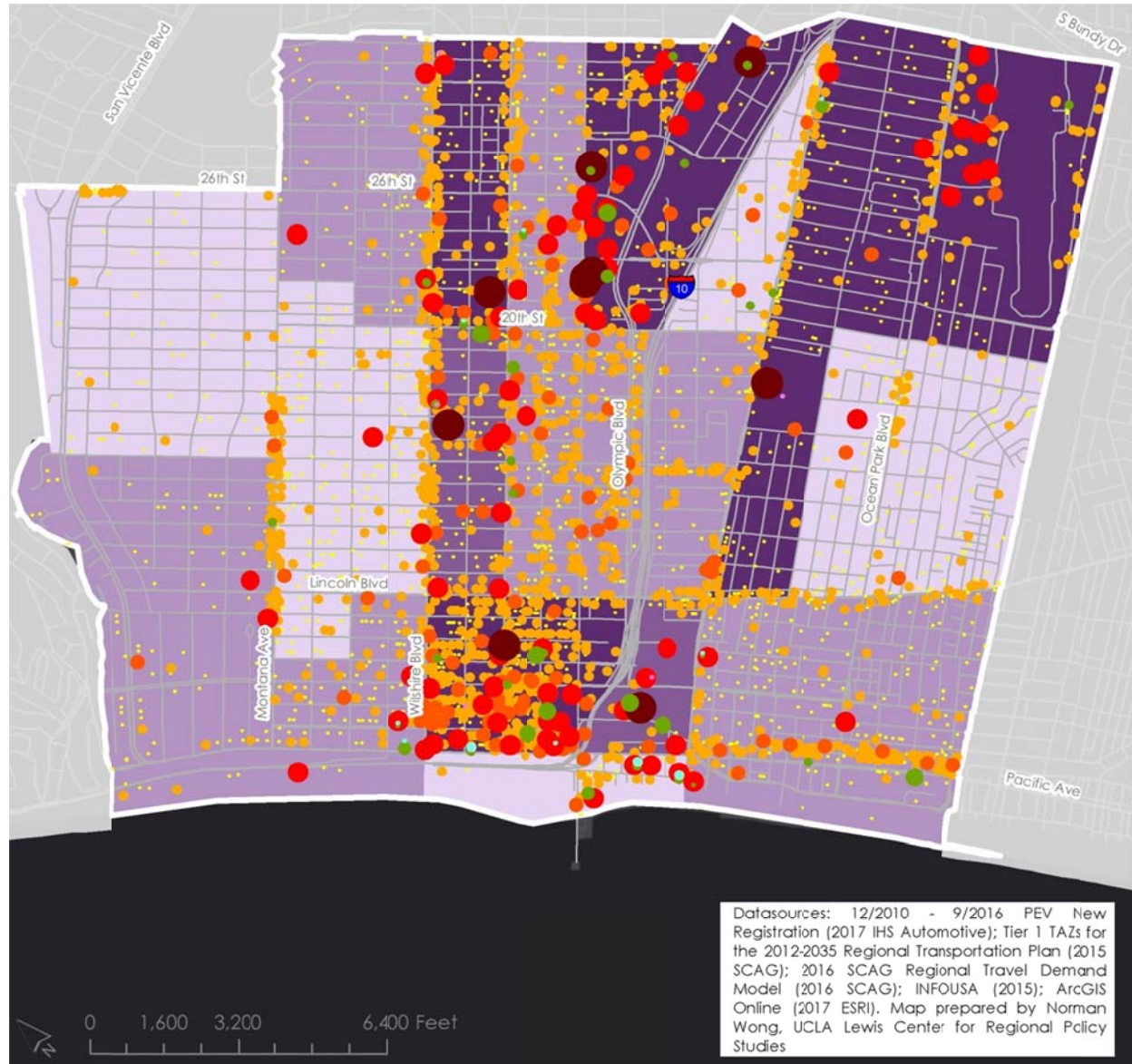
Datasources: Plugshare Database (2017 Plugshare - Downloaded 5/23/2017); ArcGIS Online (2017 ESRI). Map prepared by Norman Wong, UCLA Lewis Center for Regional Policy Studies



## PEV Peak Morning Destinations and Number of Employees

By comparing the spatial distribution of employment centers and weekday morning peak travel destinations for PEVs, planners can identify locations where there may be significant demand for workplace charging. **Figure 11** overlays these two aforementioned variables, along with the location of publicly-accessible charging stations as a reference. Planners should focus their attention on large workplaces located in TAZs that are popular among PEV commuters during peak morning hours, and which do not already host onsite charging infrastructure.

**Figure 11. PEV Peak Morning Destinations (6AM – 9AM) and Number of Employees**



PEV AM Peak Destinations	Number of Employees	Level 1	Level 2	DC
< 50	1 - 5	1 - 2	1 - 2	1 - 2
51 - 75	6 - 50	3 - 7	3 - 7	3 - 7
76 - 100	51 - 100	8 - 10	8 - 10	8 - 10
> 100	101 - 500	11+	11+	11+
	500 +			

## Top 25 Workplace Sites that do not Currently Host On-site Charging

To ensure that investments in workplace charging are cost-effective, potential sites should be prioritized according to their capacity to serve the greatest number of PEV drivers. With this in mind, **Figure 12** highlights the top 25 workplace sites that do not currently host on-site charging, as determined by the two following variables, which were weighted equally: (1) the number of employees hosted by the workplace (2) the morning PEV density for the TAZ in which the workplace is located. Publicly-accessible charging locations are included as a reference.

**Figure 12. Top 25 Workplace Sites that do not Currently Host On-site Charging**



▲ Top 25 Workplace Sites

Level 1

- 1-2
- 3-7
- 8-10
- 11+

Level 2

- 1-2
- 3-7
- 8-10
- 11+

DC

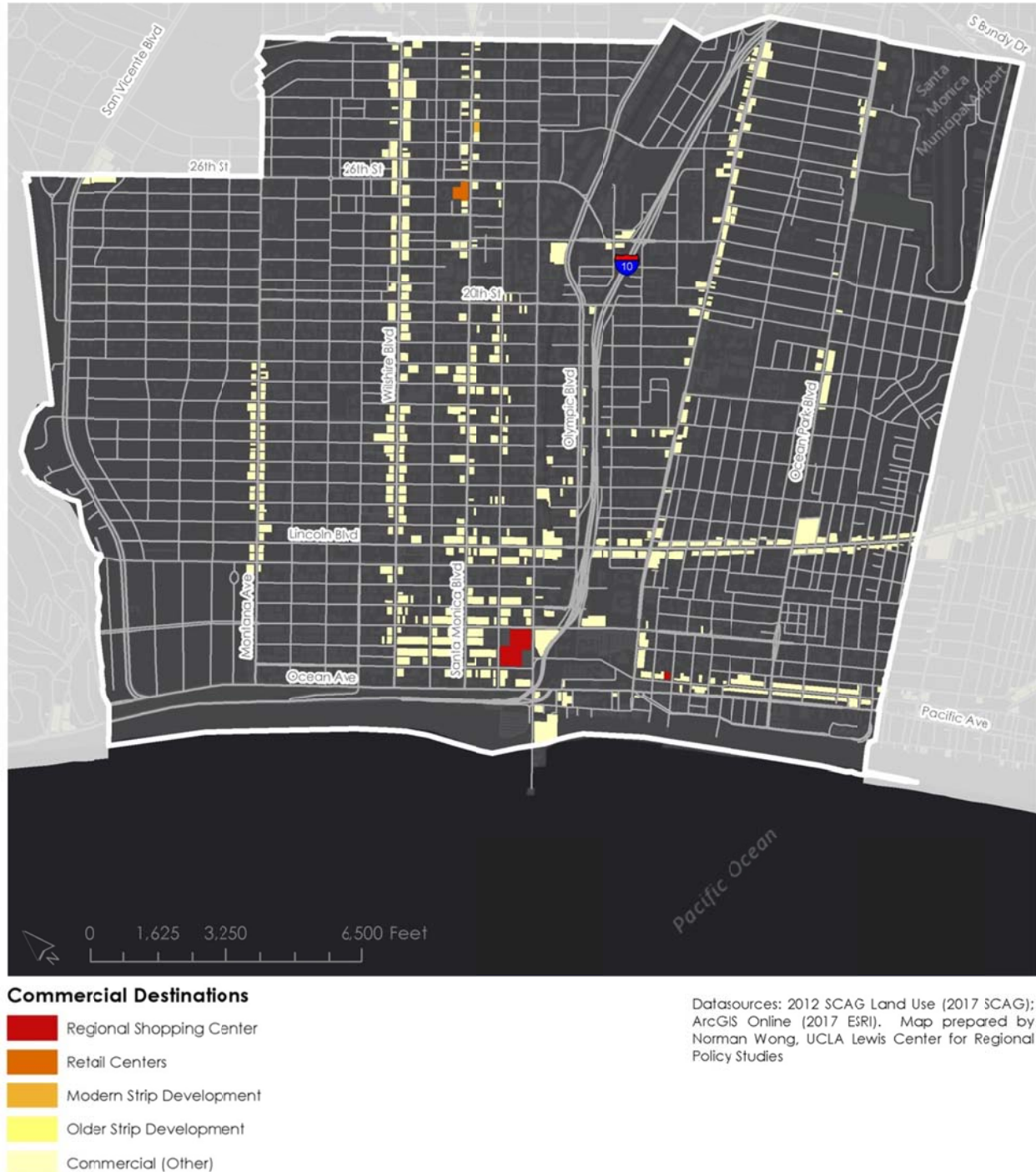
- 1-2
- 3-7
- 8-10
- 11+

## Chapter 4: Commercial (Retail) Charging Siting Analysis

### Commercial Destinations

Many PHEV drivers find it valuable to charge when visiting retail destinations in order to maximize electric miles driven. BEV drivers, on the other hand, are less likely to charge at these locations, since their vehicles have greater electric mile ranges, and most of their charging can be completed at home or at work. **Figure 13** shows the distribution of commercially zoned parcels of land across the City of Santa Monica.

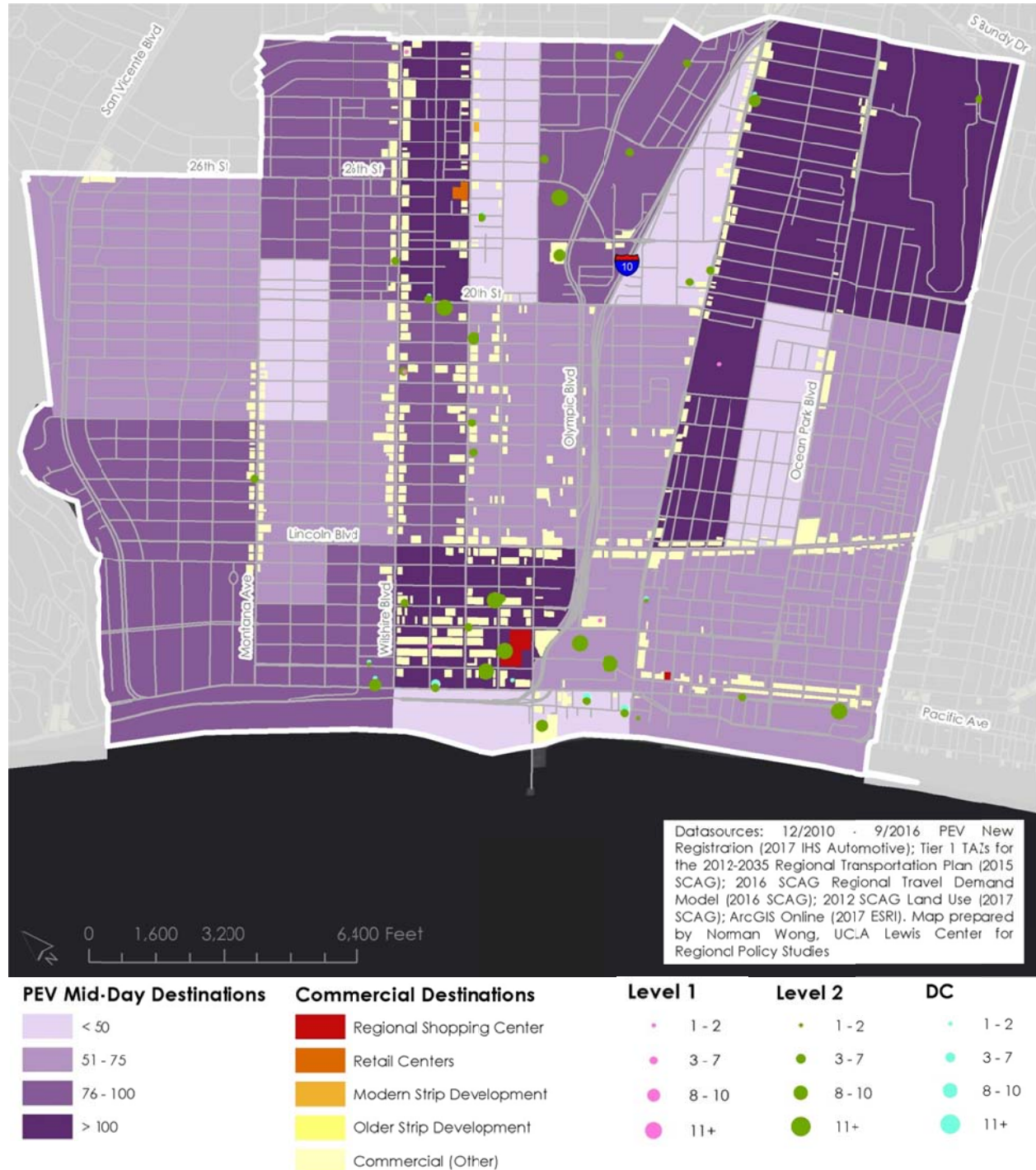
**Figure 13. Commercial Land Uses in the City of Santa Monica**



## PEV Mid-Day Destinations and Commercial Locations

By comparing the spatial distribution of commercially zoned parcels of land and mid-day peak travel destinations for PEVs, planners can identify retail sites where there may be significant demand for charging. **Figure 14** overlays these two aforementioned variables, along with the location of publicly-accessible charging stations as a reference. Planners should focus their attention on large retail centers located in TAZs that are popular among PEV commuters during mid-day hours, and that do not already host onsite charging infrastructure

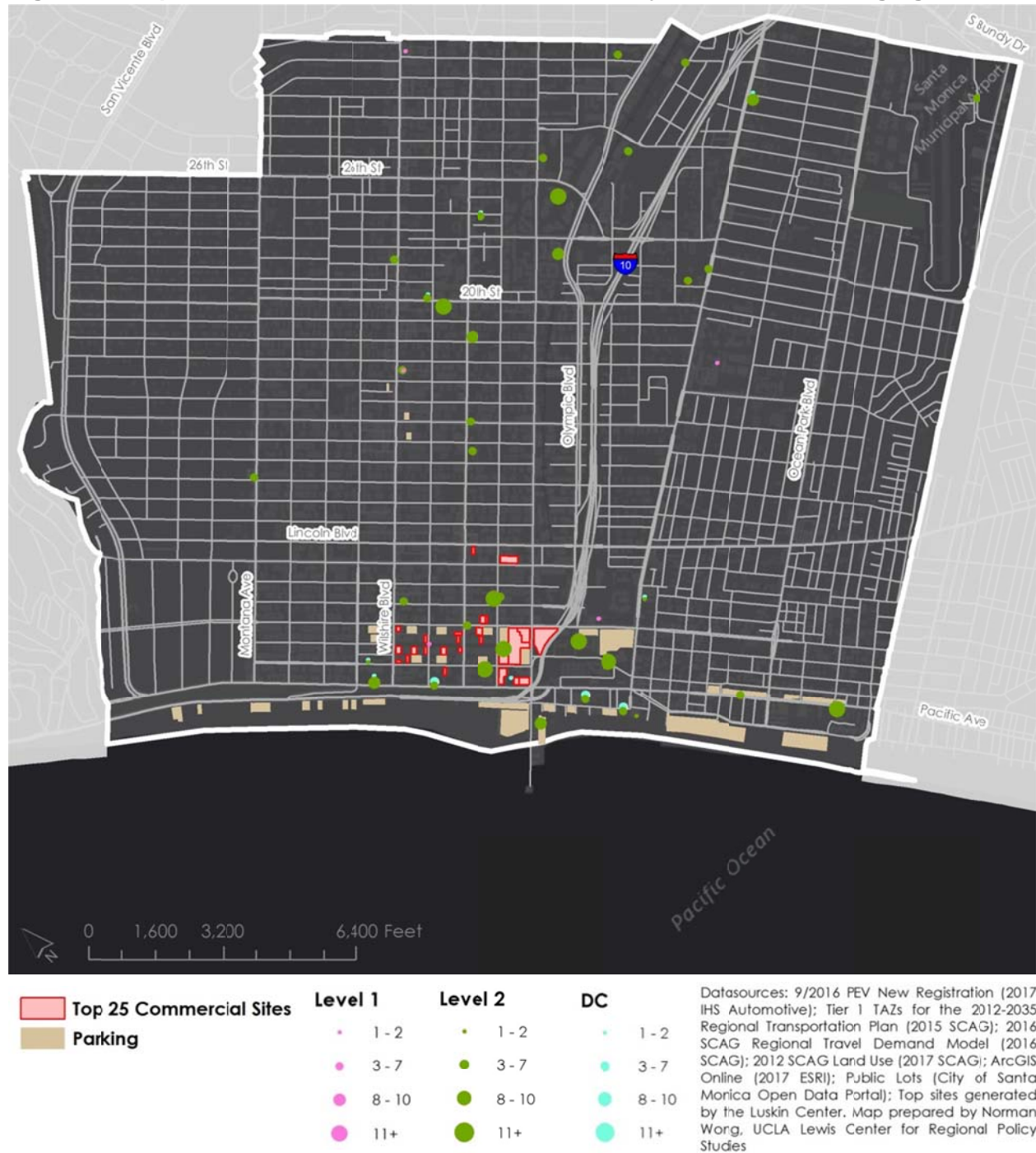
**Figure 14. PEV Mid-Day (9AM – 3PM) Destinations and Commercial Locations**



## Top 25 Commercial Sites that do not Currently Host On-site Charging

To ensure that investments in new public charging stations are cost-effective, potential sites should be prioritized according to their capacity to serve the greatest number of PEV drivers. With this in mind, **Figure 15** highlights the top 25 commercial sites that do not currently host on-site charging, as determined by the two following variables: (1) the number of employees hosted by the commercial site, which is intended to serve as a proxy for customer traffic, and (2) the mid-day PEV density for the TAZ in which the commercial site is located. The existing stock of publicly accessible charging stations is also included as a reference, as are parking facilities.

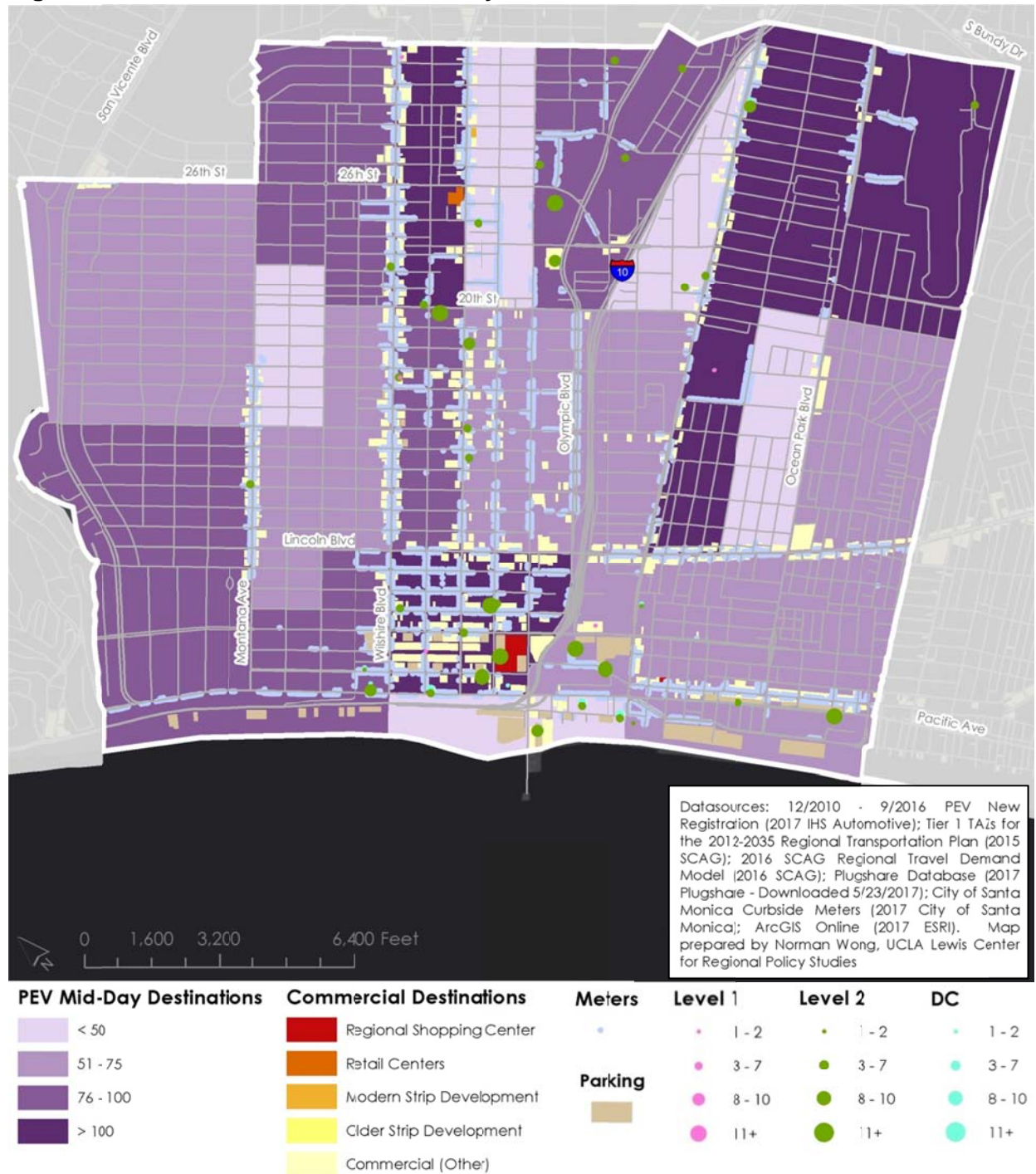
**Figure 15. Top 25 Commercial Sites that do not Currently Host On-site Charging**



## Curbside Charging Siting Potential Assessment

Curbside charging should be prioritized in neighborhoods with clusters of small businesses that host high numbers of mid-day PEV drivers. Small businesses often lack onsite parking facilities, and therefore lack space for charging infrastructure. **Figure 16** overlays the spatial distribution of meter locations (which serves as a proxy for curbside parking), commercial destinations, and mid-day peak travel destinations for PEVs. The existing stock of publicly-accessible charging locations is also included as a reference, as are nearby parking facilities.

**Figure 16. Meter Locations across the City of Santa Monica**



## Chapter 5: Multi-Unit Dwelling (MUD) Analysis

### Multi-Unit (MUD) Analysis

MUD residents face a number of obstacles to installing home charging. Foremost is the variable and often high cost of EVSE installation at a MUD site. Additionally, renters are likely not to invest in a piece of immobile equipment, and owners do not yet see home PEV charging as an amenity by which to increase property value. Overcoming these financial and motivational challenges is critical for scaling up the adoption of PEVs in Santa Monica. **Figure 17** presents the spatial distribution of multi-unit residential land uses across the City of Santa Monica. Planners can use this map to anticipate where utility upgrades may be needed for transformers and distribution stations to accommodate PEV charging at MUDs.

**Figure 17. Multi-Unit Residential Land Uses across the City of Santa Monica**



#### Multi-Unit Residential

- |                      |                               |                         |
|----------------------|-------------------------------|-------------------------|
| Multi-Unit (General) | Low-Rise Apt/Condos/Townhomes | Medium-Rise Apts/Condos |
| Duplexes/Triplexes   | Mixed Multi-Family            | High-Rise Apts/Condos   |

## Propensity to Purchase

To identify and prioritize the MUD households with the highest latent demand for PEVs, we calculated a propensity to purchase score for each MUD parcel in the City of Santa Monica. 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 model allocates a greater score to high-value homes. Refer to the technical appendix for a detailed summary of how the propensity to purchase model was constructed. **Figure 18** presents the distribution of MUDs with the highest propensity to purchase scores across the City of Santa Monica.

**Figure 18. MUDs with the Highest Propensity to Purchase Scores in Santa Monica**





## Chapter 6: EVSE Installation Costs for MUDs

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>4</sup> Level 2 chargers 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 electric vehicle supply equipment (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 for plugging their vehicle into an electrical outlet. 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. 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.

See **Figure 19** for an overview of the various costs that occur at the different stages of EVSE installation for a single charging unit.<sup>5</sup> 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).

**Figure 19. Potential Costs at the Different Stages of EVSE Installation at MUD Locations**

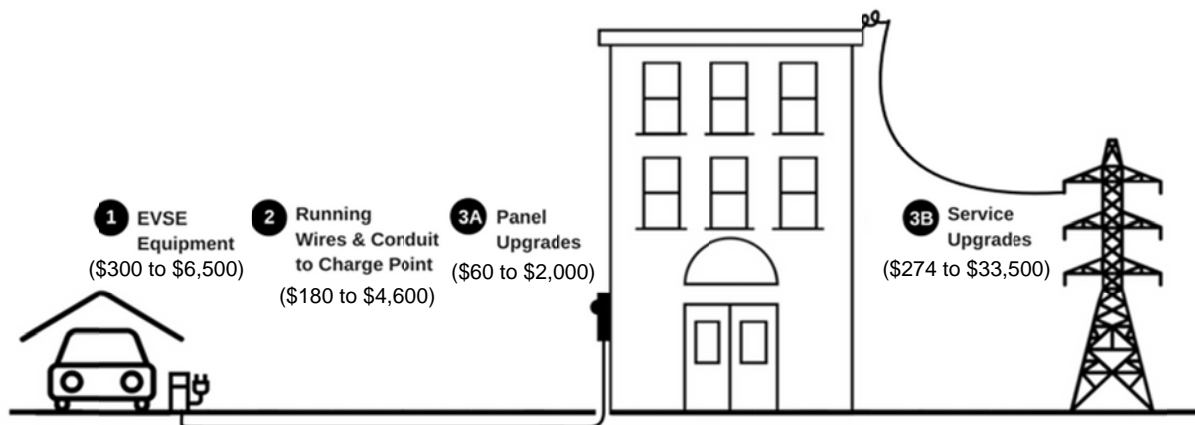


Image Source: Noun Project; Car by Tracy Tam; Electric Equipment by Prosymbols; Building by Nicholas Menghini; Pylon by Arthur Shlain.

<sup>4</sup> Center for Sustainable Energy. *California Plug-in Electric Vehicle Driver Survey Results – May 2013*.

<sup>5</sup> Cost estimates for EVSE equipment were obtained from the U.S. Department of Energy's 2015 report, *Costs Associated with Non-Residential Electric Vehicle Supply Equipment*. Cost estimates for all other stages of installation were obtained from the UCLA Luskin Center for Innovation's 2016 report, *Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study*.

## Background on the Electrical Configuration of MUDs

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 (pictured in **Figure 20**). 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 20. Photos of Overhead Service Drops and Meters at MUDs**



Two examples of overhead service drops providing electricity to the MUD's electric box (Photo Credit: UCLA Luskin Center).

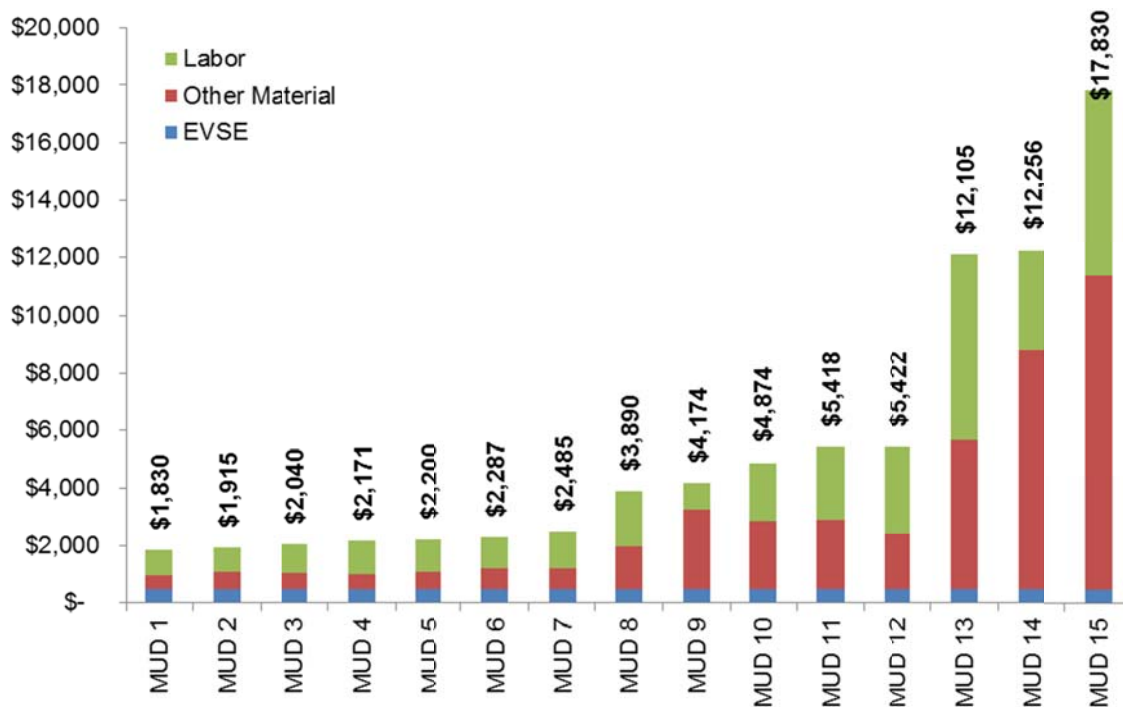
A grouping of house and unit meters (i.e. the meter section) and their main breakers inside an electric box (Photo Credit: UCLA Luskin Center).

## Case Study Findings

This section 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>6</sup> The cost estimates were developed by a qualified electrician. Researchers requested 30 MUD site visits to estimate the cost of installing a single Level 2 EVSE unit. From the 30 selected sites, a total of 27 sites were visited, and a total of 15 complete cost estimates were obtained.<sup>7</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. These cost ranges do not include the potential cost of service upgrades, which could range as widely as \$274 to \$33,499, with service line upgrades averaging \$2,055 and distribution line upgrades averaging \$7,165.<sup>8</sup> To contrast, Level 2 installation costs for single-family residences average \$1,500.<sup>9</sup>

The most significant component of installation costs across the 15 estimates was labor, which on average was 45% of the total project cost. Materials (other than EVSE) were the second greatest cost, comprising 40% of total project costs on average. A constant price of \$480 was assumed for EVSE across all estimates, comprising about 15% of the total project cost on average. See **figure 21** for a breakdown of installation costs across the 15 sample estimates.

**Figure 21. Breakdown of Installation Costs for Level 2 EVSE Unit across 15 MUDs**



<sup>6</sup> UCLA Luskin Center for Innovation. 2016. *Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study*.

<sup>7</sup> 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.

<sup>8</sup> San Diego Gas and Electric. 2014. *Joint IOU Electric Vehicle Load Research Report*.

<sup>9</sup> Electric Power Research Institute. 2013. *Electric Vehicle Supply Equipment Installed Cost Analysis*.

## Chapter 7: Financial Incentives for MUD Owners

### Background on Incentive Design

Policymakers at the local level can design public financial incentive programs to induce property owners to install PEV charging equipment. When implementing a financial incentive program the following factors should be considered: (1) Incentive Type, (2) Qualifying Expenses, (3) Match Requirements, (4) Incentive Tiers, and (5) Project Size. These factors are described in more detail below, including recommendations on how to design a financial incentive program that maximizes cost-effectiveness.

### Incentive Type

There are a variety of incentive types that can be offered at the local level to motivate consumer behavior, including rebates, vouchers, grants, loan assistance, tax credits and abatements, and fee reductions or waivers (see **table 1** for a summary). Almost all of these options require upfront investment from the city, except for tax credits and fee waivers, which may divert revenue that would normally be collected from property owners for city services towards the installation of charging equipment. In the long run, however, these financial incentives may pay for themselves, since they increase the assessed property value of a building or condo.

**Table 1. Summary of Potential Financial Incentive Programs for MUD Owners**

Incentive Type	Description
Rebate	Reimburses a property owner for the costs associated with installing charging equipment at one or more of their buildings. The reimbursement usually occurs after the point of sale, but can be designed so that an intermediate entity, such as an association for property owners, pays for the upfront costs and is reimbursed by the city.
Voucher	Provides property owners with a discount at the point of sale for the cost of installing charging equipment. Voucher programs usually involve contracting with third party vendors, such as a list of qualifying contractors, who receive funding to redeem voucher requests.
Grants	Provides property owners with funding to install PEV charging equipment at one or more of their buildings, often through a competitive application process that rewards the applicants based on the cost effectiveness of their project, or the number of low-income residents served.
Loan Assistance	Provides low interest loans to developers who install PEV charging equipment at one or more of their buildings. Loans are repaid into a revolving fund that is used for additional loans.
Tax Credits and Abatements	Reduces a property owner's tax obligation for a period of time if they install PEV charging equipment at one or more of their buildings.
Fee Reductions or Waivers	Reduces construction related permitting costs for building owners who are performing major alterations on their building, and who commit to providing PEV charging equipment as part of their renovation plan.

Of the financial incentive program discussed here, we recommend a rebate program because it allows the city to tie reimbursement funds to certain performance metrics. For example, a partial rebate can be offered to property owners once they have purchased EVSE (e.g., 50% of rebate funds), and the remainder of the rebate can be offered to the property owner once the city can verify that a PEV is using the charging station (e.g., the other 50% of rebate funds). We recommend making the verification process as simple and as inexpensive as possible. Smart EVSE equipment that logs charging information can be quite costly compared to less advanced technologies. Thus, at a minimum, property owners should be allowed to simply submit a copy of their vehicle registration (or their tenant's vehicle registration) in which the address of the PEV matches the address of the EVSE location. Tax credits can also be tied to performance metrics, but they lack a mechanism for providing partial funding upfront to the property owner, which can be critical for generating initial interest.

### Qualifying Expenses

Financial incentive programs are often designed to cover specific costs associated with installing charging infrastructure. **Table 2** provides a summary of the various financial incentive programs offered in Southern California for PEV charging and the expenses they cover, as well as the maximum incentive amount, which indirectly influences coverage.

**Table 2. Overview of financial incentives programs at the municipal level in Southern California**

Jurisdiction	Name of Program	Coverage	Amount	Eligibility
Anaheim	Plug-In Electric Vehicle Charger Rebate Program	Charger cost Installation cost	Up to \$500	Level 2
Burbank	Electric Vehicle Charger Rebate	Charger cost	Residential: Up to \$500 Commercial: Up to \$1,000	Level 2
Los Angeles	Charge up LA! Program	Charger cost	Residential: Up to \$750 Commercial/MUDs: Up to \$4,000	Level 1; Commercial/MUD must have a minimum of 3 parking spaces
Pasadena	Plug-in Electric Vehicle Incentive Program	Charger cost	Residential: Up to \$400 Commercial: Up to \$600	Level 2
Santa Barbara	Electric Vehicle Charging Station Infrastructure Program	Charger cost Installation cost	Level 2: Up to \$10,000 Level 3: Up to \$20,000	Level 2 or 3; MUDs of 20 units+; EVSE must be available to the public
South Coast Air Quality Management District (SCAQMD)	Residential EV Charging Incentive Pilot Program	Charger cost	Up to \$250 (\$500 if low-income)	Level 2
	EFMP Plus-Up Program	N/A	Up to \$2,000 for BEVs	Income below 400 percent of the federal poverty level; ZIP codes that contain a disadvantaged community; Retiring an older vehicle

Many of the programs in **Table 2** only cover the costs associated with purchasing EVSE, either explicitly through eligibility guidelines, or implicitly through the available incentive amounts (i.e., maximum incentive amounts of \$500). Based on sample cost estimates, however, EVSE comprises a relatively small percentage of the total cost of installing charging equipment, averaging around 15% of total installation costs.<sup>10</sup> Thus, we recommend expanding the coverage of a financial incentive program to include a greater variety of potential costs that may be incurred during the installation process, including installation costs from running additional wiring and conduit from the panel to the charge point, and any necessary panel upgrades. During the early stages of an incentive program, however, we do not recommend using public dollars for financial incentives that compensate property owners for the cost of service upgrades. In some cases, service upgrades can potentially be avoided through strategic energy efficiency measures that 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. Additionally, limited public dollars should first be used for the most cost effective projects that do not require expensive service upgrades.

Incentive funding should be awarded separately for EVSE purchases and installation costs. Each of these costs should also have a separate maximum incentive amount. This will help control for the cost of the incentive program. For example, if a project comes significantly under budget for the cost of running wires and conduit from the panel to the charge point, then the property owner is incentivized to use leftover incentive funds to purchase the most expensive EVSE option available, rather than the most cost effective option. Setting maximum incentive amounts for EVSE and installation activities also encourages retailers and contractors to keep their prices low, since property owners can't combine incentive amounts for any single expense.

The coverage of a rebate program should also take into account the incentives offered by overlapping programs. For example, if a condo owner qualifies for an EVSE unit through SCAQMD's Residential EV Charging Incentive Pilot Program, then the cost of their EVSE should be excluded from their incentive amount offered through the City of Santa Monica. Ensuring that public dollars aren't double counted towards the same purchase requires coordination among public agencies.

### **Match Requirements**

Since the PEV market is still in the early stages of development, matching fund requirements should be as low as possible in order to quickly grow the availability of MUD charging. As the PEV market grows, and property owners begin to see MUD charging as an amenity that increases the value of their building or condo, the required match should increase to ensure that applicants aren't using public funds for upgrades they would have made anyway. Thus, we recommend piloting a financial incentive program that requires 0% in matching funds from property owners for the cost of EVSE and 25% in matching funds from property owners for the cost of installation. We recommend 25% in matching funds for the cost of installation because

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<sup>10</sup> Based on a sample of 15 cost estimates developed from the Southbay subregion.

installation activities may result in private benefits for property owners regardless of whether the EVSE unit is ever used (i.e., additional electrical capacity in parking areas that can support a variety of end uses). As discussed, the cost of any potential service upgrades should be the responsibility of the property owner, at least during the early stages of financial incentive program.

### **Incentive Tiers**

The role that cost plays in investment decisions around PEV charging infrastructure ultimately depends on the property owner's household income. For wealthy condo owners, the cost of installing charging infrastructure may be relatively marginal, and their reluctance to switch to a PEV may be due to other some motivating factor (e.g., loyalty to a particular car brand that does not yet offer an electric option). For lower income condo owners, on the other hand, the cost of installing charging infrastructure is likely more critical in their decision to invest. To accommodate a range of incomes, incentive programs should offer tiered incentives based on income levels of property owners, such that lower income individuals receive the greatest financial incentives. These types of progressive incentives have proven to be more cost effective, have lower total policy costs, and result in greater allocative equity.<sup>11</sup>

Tiered incentives should also be offered for apartment building owners that rent to low income individuals, regardless of the property owner's income. To receive the increased incentive for low income renters, the property should be required to document that the EVSE unit has been installed at a dedicated space for the low-income resident. Again, we recommend requiring a certain amount of charging sessions be logged at the EVSE unit by the low-income resident before the full financial incentive is distributed. This will help prevent property owners from using the increased incentive funding to install EVSE units at a parking sites that they plan to quickly reallocate to higher income renters.

In addition to income, locational attributes can also be incorporated into an incentive scheme to ensure that the co-benefits of charging investments are maximized. If a MUD is located in a disadvantaged community, as identified by the California Environmental Protection Agency, then the financial incentive should be increased to incentivize greater investment in these neighborhoods. Disadvantaged communities are disproportionately affected by environmental pollution, or contain concentrations of people that are of low-income, high unemployment, low levels of home ownership, high rent burden, sensitive populations, or low levels of educational attainment.<sup>12</sup> Investments in charging infrastructure in these neighborhoods can help reduce tailpipe emissions and improve local air quality.

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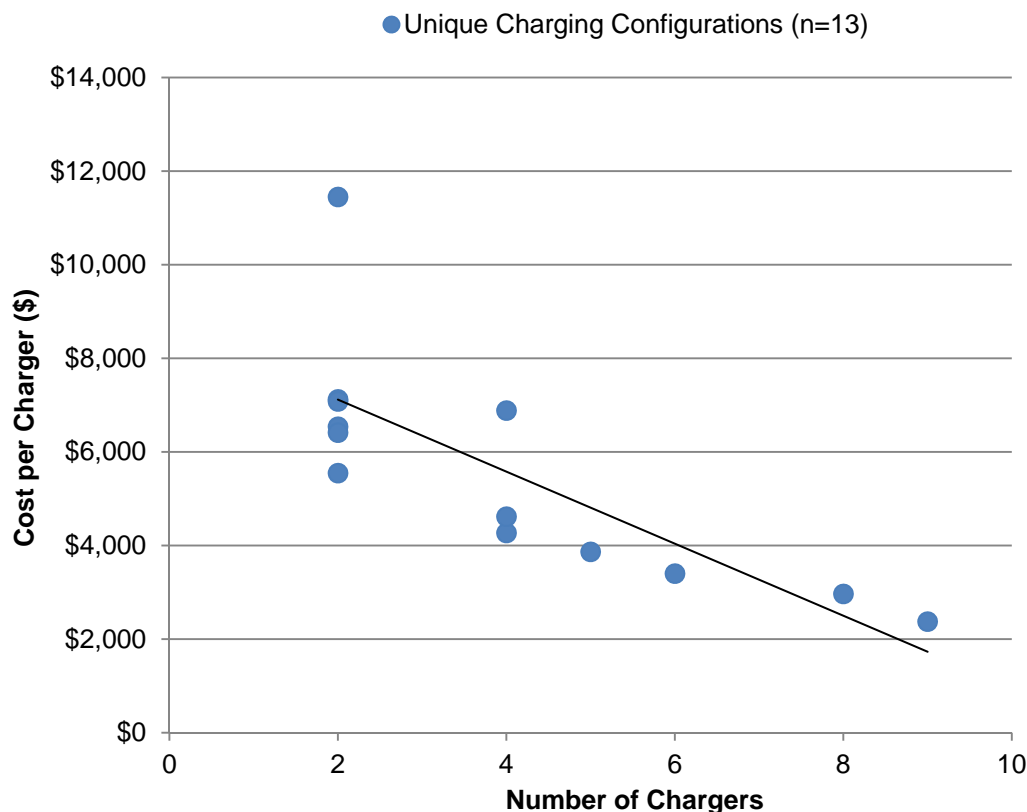
<sup>11</sup> Sheldon, Tamara L., J.R. DeShazo, Richard T. Carson, and Samuel Krumholz. 2016. *Factors Affecting Plug-in Electric Vehicle Sales in California*. Accessed August 2017 from <http://innovation.luskin.ucla.edu/content/factors-affecting-plug-electric-vehicle-sales-california>

<sup>12</sup> CALEPA. 2017. Designation of Disadvantaged Communities Pursuant to Senate Bill 535 (De León). Accessed on August 2017 from <https://calepa.ca.gov/wp-content/uploads/sites/34/2017/04/SB-535-Designation-Final.pdf>

## Project Size

The per-unit cost of installing charging infrastructure is significantly reduced when costs are shared across multiple residences. **Figure 21** shows the negative relationship between the average charger installation cost and the number of installed chargers, as based on 13 different potential charging configurations at 8 different sample sites.<sup>13</sup> Since EVSE installations become more cost-effective as the number of chargers increase, we recommended increasing financial incentives for property owners that install more than one EVSE unit. For example, a property owner that installs two or more EVSE units could be eligible for free installation services (i.e., 0% matching funds), as long as cost of the installation services are below a given threshold. This increased incentive will motivate property owners to provide more EVSE units than they would have provided in the absence of the increased incentive. Again, to obtain the full incentive for each charging unit, the property owner should be required to document that the EVSE unit is actually serving a PEV.

**Figure 21. Cost Reductions Achieved due to Multiple EVSE Installations**



Source: On Target Electric, for study purposes only

<sup>13</sup> UCLA Luskin Center for Innovation. 2016. *Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study*.



## Proposed Financial Incentive Program for the City of Santa Monica

Based on the design considerations discussed in this report, we recommend piloting a rebate program that covers 100% of EVSE equipment costs (up to \$750 in funding) and 75% of the installation costs (up to \$3,000 in funding).

The rebate amounts are grounded in observed installation costs, as based on 15 sample cost estimates collected in the South Bay Region.<sup>14</sup> Across the 15 sample cost estimates, \$3,900 was the median cost of installation for a Level 2 EVSE unit, including the cost of EVSE and installation, but not the cost of service upgrades to the building. When all of the proposed rebate amounts are combined with the required match for installation costs, they sum to a total project cost of \$4,750, which is about 22% above the median the total project cost observed in the South Bay region. Designing the rebate amounts for a total project cost that is slightly above the median cost observed in the South Bay allows for some contingency costs (i.e., unforeseeable costs that occur once installation activities actually begin), as well as more advanced EVSE technologies (the cost estimates from the South Bay region assume EVSE units that cost \$480).

We also recommend an increased incentive for the following applicants: (1) low-income property owners, (2) property owners that rent to low-income residents who will charge a PEV in their designated parking spot, (3) property owners that have a building located in a Disadvantaged Community, and (4) property owners that install two or more EVSE units. For the increased incentive, we recommend waiving the match requirement for installation costs, as long as an EVSE unit is also installed. This would raise the full available incentive amount for installation costs from \$3,000 to \$4,000.

To qualify for installation related rebates, we recommend that applicants submit a cost estimates from a minimum of two qualified contractors before beginning their installation. If the total cost of installation falls below the upper limit of the allowable rebate amount (\$3,000 for standard incentive or \$4,000 for increased incentives), the property owner should be required to go with the least expensive contractor. Half of the rebate amount should be provided upfront, and the remaining half of the rebate should be provided once the property owner can document that the EVSE unit is serving a PEV.

The design of the financial incentive program, including match requirements and maximum rebate amounts, should be updated on an annual basis for the first three years of the program, and a biennial basis thereafter. A review of the program should evaluate whether the program is inducing demand, whether the incentive amounts accurately reflect the cost of EVSE installation for buildings in Santa Monica, and whether property owners are realizing private benefits from EVSE installation (e.g., an increase in property value). As the private benefits of EVSE installation becomes more recognized by property owners, an increasing match should be required from property owners at each stage of installation.

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<sup>14</sup> UCLA Luskin Center for Innovation. 2016. *Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A South Bay Case Study*.

## Estimated Cost for the City of Santa Monica

With the discussed financial incentive program in mind, **Table 4** estimates the potential cost of the program, according to the number of MUD households that are served. The estimated funding levels assume that applicants will exhaust the incentive funding that is available to them. Based on the cost estimates from the South Bay region, around 60% of the installation projects would come in under the maximum cumulative incentive amount of \$3,750 (which corresponds to a total project cost of \$4,750), so these funding levels are likely overestimates. However, since the cost of installing charging infrastructure is highly variable, it's difficult to predict the exact number of projects that will come in under budget. Thus, the funding levels provided below are provided as conservative estimates for planning purposes.

**Table 4. Program Cost for Varying Levels of MUD Households Served**

Propensity to Purchase Score	Number of MUDs	Number of MUD Units	Maximum Cumulative Incentive Amount (EVSE + Installation)	Program Cost (1 unit per MUD)	Program Cost (All MUD units)
Top 5%	282	2,554	\$3,750 (Regular Incentive)	\$1,057,500	\$9,577,500
			\$4,750 (Increased Incentive)	\$1,339,500	\$12,131,500
Top 10%	509	5,151	\$3,750 (Regular Incentive)	\$1,908,750	\$19,316,250
			\$4,750 (Increased Incentive)	\$2,417,750	\$24,467,250
Top 15%	754	6,669	\$3,750 (Regular Incentive)	\$2,827,500	\$25,008,750
			\$4,750 (Increased Incentive)	\$3,581,500	\$31,677,750
DACs	283	2,482	\$3,750 (Regular Incentive)	\$1,061,250	\$9,307,500
			\$4,750 (Increased Incentive)	\$1,344,250	\$11,789,500
All MUDs	5,014	41,096	\$3,750 (Regular Incentive)	\$18,802,500	\$154,110,000
			\$4,750 (Increased Incentive)	\$23,816,500	\$195,206,000

We recommend focusing outreach efforts on MUDs with the top 5%, 10% and 15% of propensity to purchase scores. This will ensure that outreach efforts are targeted towards MUDs with the greatest latent PEV demand, and that installed EVSE units are regularly used by residents. Refer to **Figure 17** for the distribution of these properties throughout Santa Monica.

To ensure that funds are distributed equitably, we also recommend targeting MUDs located in Disadvantaged Communities. Since low-income residents also face significant financial barriers to purchasing a PEV altogether, programs devoted to reducing charging costs should also be

coupled with programs that focus on reducing vehicle costs. To support this effort, the California Air Resources Board (CARB) has launched several initiatives under its Low Carbon Transportation Program aimed at expanding PEV adoption among low- and moderate-income households (e.g., EFMP Plus-Up, Light-Duty Financing Assistance, CVRP increased incentives, etc.).<sup>15</sup> Outreach to MUD residents in Disadvantaged Communities should focus on making these programs more visible to low- and moderate-income households.

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<sup>15</sup> CARB. 2015. "Low Carbon Transportation Light-Duty Project Projects that Benefit Disadvantaged Communities." Accessed on August 2017 from [https://www.arb.ca.gov/msprog/aqip/ldv\\_pilots.htm](https://www.arb.ca.gov/msprog/aqip/ldv_pilots.htm)

## Technical Appendix

This appendix describes the methods, assumptions and data sources used to create the maps and charts presented in this study. They are presented in the same order in which they appear.

### PEV growth

In this study, we define a PEV as any fully electric vehicle (including low-speed neighborhood electric vehicles and electrified trucks) or a plug-in hybrid electric vehicle (PHEV). See **Table A.1** for a summary of the PEV models counted in this analysis. The scope only includes PEVs registered as new in the City of Santa Monica between December 2010 and September 2016 inclusive. PEV registrations were supplied at the 2010 Census tract level by IHS Automotive (formerly R.L. Polk & Co).

Once the 2010-2016 PEV counts were obtained, a reasonable growth rate was needed to predict how PEVs would grow through the end of 2025 in the City of Santa Monica. We experimented with a number of different models of monthly and cumulative growth. Ultimately a quadratic model of monthly cumulative growth appeared to fit the data best. We estimated the following model for months between December 2010 and September 2016:

$$Cumul_m = \alpha + \beta month_m + \gamma month_m^2 + \epsilon_m$$

where  $Cumul_m$  is the cumulative PEV sales in a given month,  $month_m$  is the number of months elapsed since December 2010,  $month_m^2$  is the number of months elapsed since 2010 squared and  $\epsilon_m$  is a mean-zero error term. Using the coefficient estimated from this regression, we predicted cumulative PEV sales for all months until the end of 2025. At some point the PEV market will reach saturation, so this quadratic growth model represents PEV registrations in the early stages of technology adoption. We believe that 2025 is early enough in the PEV lifecycle that market saturation will be unlikely.

However, a potential limiting factor on the actual growth of PEVs is the high percentage of Santa Monica residents that live in multi-unit dwellings (MUDs). Unless steps are taken to facilitate charging in MUDs, PEV ownership may not grow as projected.

**Table A.1. PEVs included in the Analysis**

Vehicle Make	Vehicle Model	Vehicle Type
Audi	A3	PHEV
Azure	Transit Connect	BEV
BMW	330e	PHEV
BMW	I3	BEV
BMW	X5	PHEV
Cadillac	ELR	PHEV
Chevrolet	Spark	BEV
Chevrolet	Volt	PHEV
Fiat	500	BEV
Fisker	karma	BEV
Ford	Focus	BEV
Ford	Fusion	PHEV
Ford	C-max	PHEV
GEM	N/A	NEV
Honda	Accord	PHEV
Honda	FCX	FCEV
Honda	Fit	BEV
Hyundai	Sonata	PHEV
Kia	Soul	BEV
Mclaren	P1	PHEV
Mercedes-Benz	B-Class	BEV
Mercedes-Benz	S550	PHEV
Mitsubishi	Miev	BEV
Nissan	Leaf	BEV
Porsche	918	PHEV
Porsche	Cayenne	PHEV
Porsche	Panamera	PHEV
Smart Car	Fortwo	BEV
Tesla	Model S	BEV
Tesla	Model X	BEV
Tesla	Roadster	BEV
Toyota	Mirai	FCEV
Toyota	Prius	PHEV
Toyota	Rav4 EV	BEV
Volkswagen	Golf	BEV
Volvo	XC89	PHEV

## PEV registration

The PEV registration maps show the number of PEVs registered between December 2010 and September 2016 in the City of Santa Monica by Tier 1 travel analysis zone (TAZ). TAZs closely follow 2000 Census tract boundaries and are used by the Southern California Association of Governments (SCAG) to estimate travel within and between neighborhoods. Within the City of Santa Monica, there are 23 TAZs and 19 Census tracts. The map colors move from lighter in areas with no or few PEVs registered to darker in areas with more PEVs registered. PEV registration data was supplied at the 2010 Census tract level by IHS Automotive (formerly R.L. Polk & Co), and was harmonized with TAZ boundaries.

## PEV morning peak destinations

We used the outputs from SCAG's 2016 Regional Model to determine the arrival locations and densities of PEVs during peak morning hours.<sup>16</sup> Using surveys of household travel behavior, SCAG's travel demand model estimates the number of trips from home to work, school, and other destinations by time of day. The morning peak period represents weekday trips that occur between 6:00 a.m. to 9:00 a.m. (i.e., commutes to work). The model does not distinguish commuting patterns by vehicle type, so we assumed that the commuting patterns of PEVs are the same as those of conventional vehicles, and applied the proportion of PEVs registered in the origin TAZ to the commute patterns that characterize that TAZ. The data on PEV registrations comes from automotive data vendor IHS Automotive (formerly R.L. Polk & Co), which provided the number of PEVs registered as new within each 2010 Census tract from December 2010 through September 2016. It is important to note that these morning peak destination TAZs receive vehicles from outside the City of Santa Monica.

## PEV mid-day destinations

We used the outputs from SCAG's 2016 Regional Model to determine the arrival locations and densities of PEVs during mid-day hours.<sup>17</sup> Using surveys of household travel behavior, SCAG's travel demand model estimates the number of trips from home to work, school, and other destinations by time of day. The mid-day period represents weekday trips that occur between 9:00 a.m. to 3:00 p.m. (i.e., trips to run errands). The model does not distinguish commuting patterns by vehicle type, so we assumed that the commuting patterns of PEVs are the same as those of conventional vehicles, and applied the proportion of PEVs registered in the origin TAZ to the commute patterns that characterize that TAZ. The data on PEV registrations comes from automotive data vendor IHS Automotive (formerly R.L. Polk & Co), which provided the number of PEVs registered as new within each 2010 Census tract from December 2010 through September 2016. It is important to note that these mid-day destination TAZs receive vehicles from outside the City of Santa Monica.

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<sup>16</sup> SCAG. 2016. SCAG Regional Travel Demand Model and 2012 Model Validation. Accessed August 2017 from [http://www.scag.ca.gov/Documents/SCAG\\_RTDM\\_2012ModelValidation.pdf](http://www.scag.ca.gov/Documents/SCAG_RTDM_2012ModelValidation.pdf)

<sup>17</sup> Ibid.

## Employment density

The maps of employment density were prepared using commercially available Infogroup data from 2015 on employer size (i.e., number of employees) and location. This data is compiled from public documents that disclose employment size, as well as through a website and phone verification process. Each circle on the map represents one workplace. The circles move from small to large and from yellow to red as the number of employees per workplace increases.

## Publicly-accessible charging stations

Data on publicly-accessible charging stations was obtained from the online database maintained by PlugShare ([www.plugshare.com](http://www.plugshare.com)), which contains information posted by users that charge at these locations. “Publicly-accessible” refers to stations that are owned by either the government or private businesses but that are available for use by the general public. The precise number of connectors or charging units that are operational at any given time and location are subject to maintenance and upgrade schedules. The distribution of publicly-accessible charging stations presented in this report reflect a snapshot of the PlugShare database as of May 23, 2017.

## Top 25 workplace sites that do not currently host on-site charging

This map highlights the top 25 workplace sites that do not currently host on-site charging, as determined by the two following variables: (1) the number of employees hosted by the workplace (2) the morning PEV density for the TAZ in which the workplace is located. To construct this map, all workplaces that currently host on-site charging were excluded from the analysis. This step was completed by spatially joining all workplace sites and publicly-accessible charging stations to parcels of land, and then excluding any workplaces that shared a parcel of land with a publicly accessible charging station. Then, a percentile ranking was assigned to each workplace site according to the two aforementioned variables (i.e., employment density and morning PEV density). These two percentile rankings were then summed to create a combined ranking. Each percentile ranking was weighted equally during the summation process.

## Commercial (retail) destination maps

This map data is obtained from SCAG’s 2012 Existing Land Use Dataset, which includes information on the concentration of retail centers in the SCAG region. The land use data was originally developed by Aerial Information Systems, Inc. as a Modified Anderson Land Use Classification for the 2008 SCAG land use dataset. The 2012 dataset is based on the 2008 dataset and is updated using 2008-2012 new construction data and inputs from local jurisdictions in the SCAG region.<sup>18</sup> The designations were determined by using aerial photography to estimate the land use at the parcel level.

The commercial (retail) destination maps contain retail and small business locations (such as beauty salons and small offices) within the City of Santa Monica. They highlight five types of

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<sup>18</sup> SCAG. 2012. Land Use Los Angeles. Accessed August 2017 from [http://gisdata-scag.opendata.arcgis.com/datasets/0c432b1bca21426e83e40a358414fe7c\\_0](http://gisdata-scag.opendata.arcgis.com/datasets/0c432b1bca21426e83e40a358414fe7c_0)

retail centers that are likely to attract many of the non-work related vehicular trips. These five categories are summarized in **Table A.2**.

**Table A.2. Commercial (Retail) Designations in the 2012 SCAG Existing Land Use Dataset**

Code	Description	Key Attribute
1220	Commercial (Other)	Retail stores and other/unknown commercial development
1221	Regional Shopping Center	Department store with surrounding parking
1222	Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking)	Magnet store with in-front parking
1223	Modern Strip Development	Small businesses with parking on-street and on one side
1224	Older Strip Development	Small businesses with on-street parking

Land use Code 1220, Commercial (Other), is the general code used for retail stores and commercial development when the specific sub-land use is not discernable.

Land use Code 1221, Regional Shopping Center, contains large retail centers with at least one major department store and a range of other smaller retail establishments. These shopping centers are generally enclosed malls with parking surrounding the one to three story building. This also includes factory outlet malls.

Land use Code 1222, Retail Centers, is comprised of at least one large magnet store, a large off-street parking lot, and additional detached commercial stores, including small retail stores, gas stations, and restaurants. All structures are generally one story tall. Retail Centers are often located conveniently off major highways or highly trafficked surface streets.

Land use Code 1223, Modern Strip Malls, designates parcels which contain retail stores, restaurants, service shops, and offices, and are often located along major traffic corridors. Parking is available on-street as well as off-street either in front, on the side, or behind the structures. Included in this category are gas stations, auto repair shops, convenience stores, liquor stores, small bank branch offices, clothing stores, restaurants, furniture stores, discount stores, novelty stores, car dealerships or auto centers, drug stores, small corner markets, auctions, and smaller malls which do not contain a large magnet store.

Finally, land use Code 1224, Older Strip Development, contains parcels of land with little or no off-street parking. This category is commonly found in older city and town business corridors. Units are small retail establishments, restaurants, and offices with storefronts without setback,



adjacent to the sidewalk. Units are often attached to the neighboring unit creating and uninterrupted streetscape. Units with commercial space on the first floor and residential units on upper floors can be considered Older Strip Development.<sup>19</sup>

### **Top 25 Commercial sites that do not currently host on-site charging**

This map highlights the top 25 commercial sites that do not currently host on-site charging, as determined by the two following variables: (1) the number of employees hosted by the commercial site, which is intended to serve as a proxy for customer traffic, and (2) the mid-day PEV density for the TAZ in which the commercial site is located. To construct this map, all commercial sites that currently host on-site charging were excluded from the analysis. This step was completed by spatially joining all the publicly-accessible charging stations to commercial parcels of land, and then excluding any parcels with a publicly-accessible charging station. Then, a percentile ranking was assigned to each commercial site according to the two aforementioned variables (i.e., employment density and afternoon PEV density). These two percentile rankings were then summed to create a combined ranking. Each percentile ranking was weighted equally during the summation process

### **Parking Facilities**

The locations of parking facilities were obtained from the Public Facilities shapefile published on Santa Monica's Open Data portal.<sup>20</sup> The shapefile includes public land parcel boundaries, including: public schools, public parks, hospitals, libraries, fire and police stations, public parking facilities and city occupied parcels. For the purposes of this study, public parking facilities were isolated from the all other public facility types.

### **Parking Meters**

The locations of parking meters were obtained from a dataset maintained by the City of Santa Monica, and made available on November 28, 2016.

### **Multi-unit residences maps**

This data is obtained from SCAG's 2012 Existing Land Use Dataset, which includes information on the concentration of all residential units other than single-family in the SCAG region. The land use data was originally developed by Aerial Information Systems, Inc. as a Modified Anderson Land Use Classification for the 2008 SCAG land use dataset. The 2012 dataset is based on this 2008 dataset and is updated using 2008-2012 new construction data and inputs from local jurisdictions in the SCAG region.<sup>21</sup> The designations were determined by using aerial photography to estimate the land use at the parcel level. Each residential parcel in the dataset is assigned a code that best describes the composition of residential unit types. The factors that

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<sup>19</sup> SCAG. 2002. Southern California 1990 Aerial Land Use Study: Land Use Code Descriptions and Key Signatures, Level III/IV.

<sup>20</sup> City of Santa Monica. 2017. Santa Monica Open Data: Public Facilities. Accessed August 2017 from <https://data.smgov.net/Public-Services/Public-Facilities/efsc-edft>

<sup>21</sup> SCAG. 2012. Land Use Los Angeles. Accessed August 2017 from [http://gisdata-scag.opendata.arcgis.com/datasets/0c432b1bca21426e83e40a358414fe7c\\_0](http://gisdata-scag.opendata.arcgis.com/datasets/0c432b1bca21426e83e40a358414fe7c_0)

contribute to a parcel’s residential designation are the height of the buildings, the square footage, and the concentration of multi-unit dwellings per parcel.<sup>22</sup> See **Table A.3** for a summary of the Multi-unit dwellings designations in the 2012 SCAG Existing Land Use Dataset.

**Table A.3. Multi-unit Dwellings Designations in the 2012 SCAG Existing Land Use Dataset**

Code	Description	Density
1120	Multi-Family (General)	Uncategorized
1121	Mixed Multi-Family Residential	Mix of different density types
1122	Duplexes, Triplexes, and 2- or 3-Unit Condominiums and Townhouses	3 units or less
1123	Low-Rise Apartments, Condominiums, and Townhouses	4+ units; 10 to 18 units per acre; and 1-2 stories
1124	Medium-Rise Apartments and Condominiums	4+ units ; more than 18 units per acre; and 3-4 stories
1125	High-Rise Apartments and Condominiums	4+ units; more than 18 units per acre; and 5 stories or greater

### Propensity to Purchase Scores

To identify high latent PEV demand at the parcel level in the City of Santa Monica, 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 three steps:

1) 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.

2) Second, we downloaded survey data from the California Clean Vehicle Rebate Program (CVRP) and computed the proportion of PEV purchases in each income group (<\$24,999;

<sup>22</sup> SCAG. 2002. Southern California 1990 Aerial Land Use Study: Land Use Code Descriptions and Key Signatures, Level III/IV.

\$25,000-\$49,999; \$50,000-\$74,999; \$75,000-\$99,999; greater than \$100,000).<sup>23</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 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.

3) 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 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).

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<sup>23</sup> Center for Sustainable Energy. 2017. "EV Consumer Survey Dashboard." Accessed August 2017 from <https://cleanvehiclerebate.org/eng/survey-dashboard/ev>