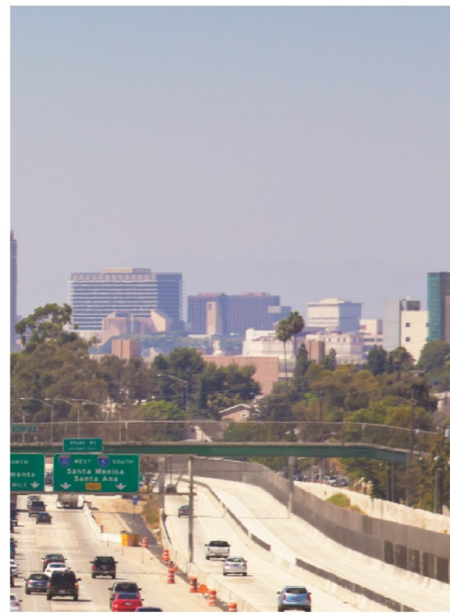
Applied Policy Project

Prioritizing Workplace Electric Vehicle Charging Station Investments in Los Angeles County



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May 2017

Client

This report was prepared for the Southern California Association of Governments (SCAG), an association of local governments consisting of six counties and 191 cities formed with the purpose of facilitating cooperation between governments on regional issues. In Los Angeles County, SCAG is subdivided into nine subregions: City of Los Angeles, Gateway Cities Council of Governments, Las Virgenes/Malibu Council of Governments, North Los Angeles County, San Gabriel Valley Council of Governments, San Fernando Valley Council of Governments, South Bay Cities Council of Governments, and Westside Cities Council of Governments.

SCAG is a state-designated metropolitan planning organization responsible for regional transportation planning. SCAG has taken a leadership role in facilitating the market adoption of plug-in electric vehicles (PEV) in the Southern California region. As part of this initiative, SCAG leads efforts to ensure adequate workplace electric vehicle charging infrastructure support for the region's PEVs. In support of these efforts, SCAG has asked our team to provide analysis and recommendations on a public investment siting strategy for electric vehicle charging infrastructure for Los Angeles County workplaces.

This report was prepared in partial fulfillment of the requirements for the Master of Public Policy degree in the Department of Public Policy at the University of California, Los Angeles. It was prepared at the direction of the Department and of the Southern California Association of Governments as a policy client. The views expressed herein are those of the authors and not necessarily those of the Department, the UCLA Luskin School of Public Affairs, UCLA as a whole, or the client.

Acknowledgements

This report could not have been completed without the generous help and support of our advisor JR DeShazo.

We would also like to thank Manisha Shah, John Villasenor, Norman Wong, and Wesley Yin for their valuable contributions. Additionally, we are grateful to our peer reviewers Tony Castelletto, Chika Fukugama, Yumi Komai, Philip Lee, and Jeffrey Mercado, as well as our other colleagues in the public policy program for their insightful feedback.

We thank the UCLA Luskin Center for Innovation and SCAG for providing data sources without which this analysis would have been impossible.

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Glossary of Terms

Air pollutant	Pollutants such as nitric oxides and hydrocarbons that degrade air quality and harm human health.
All-electric range	The distance that a vehicle can travel using only stored electricity.
Battery electric vehicle (BEV)	A vehicle that is powered entirely by electricity.
Charging point	The individual charging connection (plug). Many non-residential charging stations have multiple charging points.
Charging station	Equipment used to recharge the batteries of plug-in electric vehicles.
Disadvantaged community (DAC)	Communities that face disproportionate environmental impacts from local pollution due to location and demographic features.
Greenhouse gas (GHG)	Gases such as carbon dioxide which trap heat in the atmosphere. Anthropogenic climate change is caused by greenhouse gas pollution.
Plug-in electric vehicle (PEV)	A vehicle that recharges its battery by plugging into an outlet. These include both plug-in hybrid electric vehicles and battery electric vehicles.
Plug-in hybrid electric vehicle	A vehicle capable of running on either gasoline or electric power from an onboard battery.
Vehicle miles traveled (eVMT and cVMT)	A metric used to measure an aggregate number of miles traveled by vehicles. VMT is split into electric (eVMT) and combustion (cVMT) miles traveled to distinguish miles traveled on electric or gasoline power.
Zero emissions vehicle (ZEV)	A vehicle that emits no tailpipe emissions of climate or air pollutants. This includes battery electric vehicles and hydrogen powered vehicles.
Zone (origin and destination)	Transportation Analysis Zones are a geographic unit built from census blocks, encompassing areas of equal population or employment for use in travel demand forecast modeling. We distinguish between zones where trips originate (origin zone) and those where trips terminate (destination zone).

List of Acronyms

BEV	Battery electric vehicle
CalEPA	California Environmental Protection Agency
cVMT	Combustion vehicle miles traveled
DAC	Disadvantaged community
eVMT	Electric vehicle miles traveled
GHG	Greenhouse gas
PEV	Plug-in electric vehicle
SCAG	Southern California Association of Governments
SCE	Southern California Edison
TAZ	Transportation analysis zone
TDM	Travel demand model
VMT	Vehicle miles traveled
ZEV	Zero emissions vehicle

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Executive Summary

Policy support for non-residential charging infrastructure is crucial to increasing the fraction of overall miles traveled that are driven on electric power in Los Angeles County. The Southern California Association of Governments (SCAG) has been awarded grant funding from the California Energy Commission to plan investments in non-residential electric vehicle charging. A portion of that funding will be invested in workplace charging infrastructure for plug-in electric vehicles, specifically targeting an increase in the share of commute miles that are driven on electric power.

This report analyzes how charging infrastructure siting decisions impact commutes in Los Angeles County. It provides geographically-targeted investment recommendations for funding workplace charging infrastructure installations.

In our analysis, we identify alternative locations for investment (zones[1]) with sufficient numbers of plug-in electric vehicle commuters and insufficient numbers of existing chargers to warrant investment, narrowing the number of potential investment zones to 905. We apply two criteria to evaluate the identified zones: (1) potential to increase miles traveled on electric power and (2) environmental justice and investment equity.

We use a model that combines commute trip data from SCAG's Transportation Demand Model with plug-in electric vehicle registration data, information on vehicle all-electric range, and point data on existing charging infrastructure locations to predict the total number of electric commute miles that could be gained in each location given full support for plug-in hybrid vehicles. To align our investment recommendations with California's environmental justice goals, we use a tool from California Environmental Protection Agency to identify which zones fall within disadvantaged communities and therefore may require additional investment support. Zones are ranked by investment potential based on the number of additional electric commute miles predicted by the model.

The results of our analysis show that there is significant spatial variation in the effect that workplace charging infrastructure investment will have on the number of commute miles traveled on electric power and that a significant number of locations that have high investment potential are located in disadvantaged communities. Key findings include:

- There are **5,861** plug-in hybrid commuters that would benefit from workplace charging but currently do not have access. Full support of those commutes would yield as many as **75,858** additional miles driven on electric power per day.
- Much of the expected potential to increase commute miles driven on electric power is concentrated in a few top zones. **The top thirteen percent of all zones are predicted to yield more addition miles than the bottom 60 percent .**

[1] The analysis uses transportation analysis zones (zone) as the principal geographic unit of analysis because underlying trip generation data from SCAG's Travel Demand Model is reported by zone.

- Areas with high or very-high investment potential exist in locations across Los Angeles County.
- Disadvantaged zones are well represented across the ranking distribution, making up **36 percent** of all zones identified as potential for investment.

SCAG's size and the large number of investment zones make a one-by-one approach to investment impractical. To provide a more useful ranking, we group zones with similar investment potential into five tiers listed by priority. Due to the uneven distribution of investment potential, higher ranked tiers contain considerably fewer numbers of individual investment zones than low-ranked tiers.

Priority Tiers	Number of Zones	Number of Disadvantaged Communities
Highest	9	3
High	28	14
Medium	85	36
Low	240	99
Lowest	543	171

Based on our analysis we make the following recommendations:

1. SCAG should follow a structured approach to investment using the five suggested functional groupings of locations which require similar investment. Investments should be made in order of tier priority, beginning high tier zones, moving to less productive investment tiers as time and budget allows.
2. SCAG should direct additional funding per charging station installation to zones in disadvantaged communities to ensure the benefits of the program are distributed equitably among similarly prioritized zones.

1. Introduction

Los Angeles County has a reputation for its car-centric culture. The region has developed around transportation infrastructure built for the personal automobile, and as a consequence, personal transportation in Los Angeles has significant impacts on regional air quality and global climate change. Plug-in electric vehicles (PEV) emit fewer greenhouse gases (GHG) and air pollutants when compared against conventional gasoline powered vehicles. PEVs are a good substitute for gasoline-based transportation because they offer the same individual mobility benefits as conventional vehicles, allowing many drivers of conventional vehicles to switch to PEVs with few behavioral changes. Furthermore, PEVs utilize pre-existing transportation infrastructure such as roads and highways, an especially important attribute in car-dependent regions such as Los Angeles County.

PEVs diverge from gasoline vehicles on the issue of fueling infrastructure. Unlike the mature market of readily available gasoline stations, the electric vehicle charging station market is still in the early stages of development. While most PEV users enjoy the ability to charge their vehicle at home, non-residential charging stations are an important complementary good to PEVs. The number of miles that PEVs drive on electric power is dependent on the availability of non-residential charging infrastructure (Kassakian et al. 2015). The public benefits of PEVs lend urgency to the rapid development of the nascent electric vehicle charging market. However, without continuing policy support, the momentum of market growth will not be maintained (International Energy Agency 2016).

Unlike gasoline stations which fuel vehicles in minutes, charging a PEV may take several hours. Consequently, electric vehicle charging stations are generally located in parking areas where drivers will leave their vehicle for periods longer than one hour (ECOtality 2013). Commuters parking at or near their place of work are likely to leave their vehicles for the entirety of their workday, creating a charging opportunity for PEV drivers. Increasing the availability of workplace charging stations can increase the fraction of commute miles driven on battery power (Kassakian et al. 2015).

1.1 Policy Support for Plug-in Electric Vehicles

Regulators in both California and Washington D.C. have identified PEV adoption as an important component in meeting statutory requirements for GHG and local air pollution reductions. Under California's Global Warming Solutions Act of 2006 (Assembly Bill 32), the state has committed to reductions in GHG to 1990 levels and 40% below 1990 levels by 2020 and 2030, respectively (Air Resources Board 2014). Additionally, under both federal and state clean air laws, California must meet strict ambient air quality standards (Air Resources Board 2016). Both California and the Federal Government have adopted programs that offer policy support to the PEV market.

California's Zero Emission Vehicles (ZEV) Program requires manufacturers offering vehicles for sale in California to bring a specified number of ZEVs to market in California each year. The ZEV classification includes other technologies such as hydrogen fuel cell vehicles. However, the vast majority of ZEV program mandated sales have been PEVs (Air Resources Board 2017).

In addition to California's ZEV program quota, both California and the Federal Government offer individual incentives for PEV purchasers. Federal tax credits up to $7,500 are available for purchasers of qualified PEVs through the Plug-In Electric Drive Vehicle Credit (Internal Revenue Service 2017). California offers incentives up to $7,000 for qualified PEVs through the Clean Vehicle Rebate Project (Air Resources Board 2017). Furthermore, the California state government incentivizes PEV sales by providing early adopters of PEVs with decals granting single occupant access to high occupancy vehicle lanes (Air Resources Board 2017). High occupancy vehicle lanes allow drivers to bypass some freeway congestion, saving drivers' time and increasing the value proposition of PEV ownership.

Electric utilities currently offer programs incentivizing workplace charging infrastructure to customers across their entire service areas (Department of Energy 2017). However, such programs do not take into account spatial variations that make charging infrastructure more beneficial in some areas over others and therefore may not incentivize efficient deployment of charging infrastructure.

1.2 Client and Policy Question

As a state metropolitan planning organization, the Southern California Association of Governments (SCAG) is responsible for both achieving transportation related GHG reductions as mandated by the Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375) and meeting transportation air quality standards set by state and federal clean air regulations (SCAG 2017). The California Energy Commission has awarded SCAG grant funding through its Alternative and Renewable Fuel and Vehicle Technology Program's *Charging Infrastructure Awards* to be used in support of charging station deployment (California Energy Commission 2017). A portion of the grant funding that SCAG receives will be devoted to planning investment in workplace charging.

SCAG wishes to prioritize the allocation of funding to workplaces in locations which present the greatest potential benefits to the public. This report supports SCAG's goal by establishing a framework to identify locations for increased workplace charging stations across Los Angeles County, answering the following policy question: **Where should SCAG prioritize investment funding for workplace plug-in electric vehicle charging infrastructure in Los Angeles County?**

We begin by identifying which locations (zones) in Los Angeles County that are candidates for investment due to their potential to benefit from workplace charging infrastructure investment. For each zone, we calculate the total potential improvement in electric vehicle miles traveled (eVMT) that can be obtained through electric vehicle charging infrastructure investment and assess whether the zone is in a disadvantaged community. These two criteria are used to determine each zone's investment priority. This analysis structures our recommendations by assigning each zone to investment priority tiers (from highest to lowest) commensurate with its investment potential. We find that as many as 78,500 more miles per day could be driven on electric power given increased charging infrastructure investment. Importantly, zones identified as disadvantaged communities are well represented in each investment tier. Much of the daily increase in eVMT is expected from a small number of zones; the top thirteen percent of charging station locations have more potential to increase eVMT than the bottom 60 percent.

1.3 Background Information

This section provides background information and context for the analysis and recommendations included in this report. It discusses the PEVs, their environmental benefits, the current market for PEVs and charging stations, information on where charging occurs, electric vehicle owner behavior, and vehicle charging options.

1.3.1 Plug-in Electric Vehicles

PEVs are a class of vehicles with internal batteries that are charged from external electricity sources. PEVs include both battery electric vehicles (BEV), such as the Tesla Model S®, and plug-in hybrid vehicles, such as the Chevrolet Volt®. BEVs run only on battery power, whereas plug-in hybrids are capable of running on either battery power or gasoline. Most BEVs have ranges that exceed 100 miles on a single full charge. Plug-in hybrids have smaller batteries with a limited all-electric range (the distance they can travel on electric power) and switch to gasoline once electricity reserves are exhausted. Figure 1 shows an example of a BEV (1.A) and a plug-in hybrid (1.B).

1.3.2 Environmental Benefits of Plug-in Electric Vehicles

PEVs cause fewer adverse environmental impacts than gasoline powered vehicles. Gasoline use in passenger vehicles is a significant contributor to GHG emissions, accounting for nearly 35 percent of all GHG emitted in the SCAG region in 2010 (Strait et al. 2012). Gasoline combustion emits carbon dioxide, a GHG that traps heat in the atmosphere and is the main contributor to anthropogenic climate change. The effects of climate change are expected to inflict serious consequences on Los Angeles County including increased high-heat days, increased water scarcity, extreme weather, and sea level rise (Los Angeles County Department of Public Health 2014). The county's vulnerability to adverse impacts of global climate change makes local climate action an imperative.

Figure 1. Plug-in Electric Vehicles (Tesla 2017, Consumer Reports

In addition to carbon dioxide, gasoline combustion also emits hydrocarbons, nitric oxides, and particulate matter, local air pollutants that harm human health by causing illness and early death, contribute to unsightly smog, and degrade the local environment (UCLA Institute of the Environment and Sustainability 2015). Despite significant progress made on curtailing local air pollutants, Los Angeles County still regularly exceeds national ambient air quality standards and remains in the top five polluted counties in the country.

In California, PEVs operating on electric power produce on average 60%-75% less GHG than gasoline vehicles per mile traveled (California Plug-In Electric Vehicle Collaborative 2010). In addition to GHG reductions, electric vehicles emit 97% fewer air pollutants (Argueta 2010). Electric vehicles operating in California are clean in comparison to gasoline vehicles in part because electricity used in state is predominately sourced from low-carbon and renewable energy resources (California Plug-In Electric Vehicle Collaborative 2010).

1.3.3 Plug-in Electric Vehicles Market

California's PEV market accounts for half of all PEV sales in the United States and is projected to expand as the prices of PEVs decrease due to increases in manufacturing efficiencies and reductions in battery costs (Fitzgerald et al. 2016; Harrington et al. 2016; California Plug-In Electric Vehicle Collaborative 2010; McKinsey & Company. 2017; Gaines, Cuenca 2000). As the price for PEVs drops, sales are expected to increase.

However, charger supply has historically failed to keep up with demand, leading to an undersupply of charging stations as the number of PEVs on the road continues to grow (Patterson 2015).

1.3.4 Market for Plug-in Electric Vehicles Charging Stations

Current incentive programs for electric vehicle charging stations are primarily administered through public and investor owned utility rebate programs. Local utilities offer rebates to both residential and commercial customers who install electric vehicle charging infrastructure. These programs are not targeted and can be claimed by any customer within the utility service area (Alternative Fuels Data Center 2016). While private investment should be encouraged, public investment is critical to address the market's failure to supply adequate charging infrastructure supply (Alternative Fuels Data Center 2016).

Potential vehicle buyers do not choose BEVs if they are not assured constant access to compatible charging stations (Bonges 2016). The scarcity of workplace charging can lead to tension between PEV owning employees and range anxiety, or the fear of running out of electricity when driving a BEV (Tully 2015; Ritchel 2015; Quirk 2015). This means that better support infrastructure, including workplace charging, could help potential vehicle buyers to overcome purchase barriers, such as range anxiety (Neubauer 2015; Knutsen, Willén 2013).

Researchers from Cornell University found indirect network effects between the deployment of charging stations and the adoption of PEVs (Li et al. 2016). Indirect network effects suggest that an increase in charging stations will increase the sales of PEVs. The paper suggests that a "10 percent increase in the number of charging stations per million inhabitants will result in 8 percent increase in electric car market share within a given city" (Li et al. 2016, 3). Therefore, charging infrastructure investments can encourage future growth in the PEV market (Melaina, Helwig 2014).

1.3.5 Plug-in Electric Vehicles Charging Facts

The majority of PEV charging occurs at home (Melaina, Helwig 2014). The ability to charge at home is one of the most valued features by customers as it is convenient and offers easy access to cheap off-peak electricity (California Electric Vehicle Collaborative 2010). Multiple studies suggest share of home-based charging ranges from 70 to 90 percent (ECOtality 2012; California Energy Commission 2011; Electric Vehicle Collaborative Center 2013).

After home-based charging, workplaces are the second most important location for charging infrastructure deployment (Melaina, Helwig 2014). It is particularly important for plug-in hybrids which have limited electric range (Tal et al. 2014). Workplace charging access can increase eVMT as PEV owners indicated a strong willingness to use workplace charging, whether free or priced (Melaina, Helwig 2014). The potential of workplace charging is reinforced by both the likelihood of increasing PEV adoption and management support for workplace charging station installations (Melaina, Helwig 2014).

To date, studies examining an optimal relationship between the charging station availability and PEV numbers report a wide range of potential ratios. The International Energy Agency estimates a charging points to PEV ratio range between 0.08 and 0.3 (Clean Energy Ministerial et al. 2013). Research conducted by Roland Berger suggests that a charging points to PEV ratio of 0.01 (one public station per 100 PEVs) would greatly alleviate the range anxiety of PEV owners (Roland Berger Strategy Consultants 2010). The report "California Statewide Plug-in Electric Vehicle Infrastructure Assessment" published by the National Renewable Energy Laboratory reports a varying PEV ratio depending on the percentage of home-based charging. However, because consumer perception and other factors make it difficult to identify an exact ratio, no consensus has emerged from the literature (Todd 2013).

1.3.6 Electric Vehicle Owner Behavior

A consumer's decision to purchase a PEV may be motivated by the consideration of environmental benefits or the benefits of tax credits and rebates (Melaina, Helwig 2014; Center for Sustainable Energy California 2013; ECOality 2012). Furthermore, economic benefits gained by driving PEVs may motivate purchases. Fuel costs for electric vehicles are approximately half that of conventional gasoline vehicles (Leistikow 2017). In Los Angeles, the average price of gasoline in 2016 was $2.80 per gallon (U.S. Energy Information Administration 2017), while the average price of driving an equivalent distance on electricity is approximately $1.65 (Leistikow 2017).

2. Alternatives

We repurpose transportation analysis zones (referred to simply as zones in this report) from SCAG's Travel Demand Model (TDM) as both our unit of analysis in our methodology and as our alternatives for investment. Zones are selected because the TDM commute forecasts are reported at the zone level and cannot be further disaggregated. To be useful and actionable as a planning tool, our recommendations for where to prioritize workplace charging are provided at the highest possible spatial resolution given available data. Detailed spatial information allows for closer identification of specific workplaces where charging station investments will be the most effective. The results of our analysis lose impact when scaled up to larger political geographies such as cities, or SCAG subregions.

To determine which locations in Los Angeles County should be prioritized for workplace charging station investment funding, we assess each location's potential to yield public benefits from additional charging infrastructure installations. This analysis requires spatial data including the locations between which PEVs commuters are driving and where charging stations are currently located. We calculate the number of PEVs commuting to each zone using PEV registration data and commute data predicted by SCAG's TDM. Information about the number and location of existing charging points is obtained from PlugShare, a charging station locator software.

2.1 Examples of Alternatives

The following paragraphs highlight specific examples to show how our analysis works to prioritize different zones on an individual basis. For example, one zone identified as presenting a significant opportunity for investment is located south of Wilshire Boulevard in the Westwood neighborhood of Los Angeles (see Figure 2). The area has several high-rise office buildings and a stretch of commercial properties, creating high draws for daily commutes. Furthermore, the nearby affluent neighborhoods from which the majority of commuters are expected to originate have large numbers of registered PEVs.

Our model predicts that a total of 376 daily PEV commute trips will terminate in the Westwood zone, yet only five electric vehicle chargers currently serve this location. Of those 376 PEV trips, 177 are likely to be plug-in hybrids from which additional electric mileage could be generated. With additional charging station investment, the zone has the potential to increase electric miles driven by commuters up to a cumulative 1,041 miles per day, the largest potential of any location within Los Angeles County.

In contrast to the Westwood zone, a lower priority investment zone will have less potential to increase commute miles traveled on electric power. For example, consider the zone located in Santa Fe Springs, east of the 605 freeway (Figure 3). This zone is dominated by light industrial and wholesale commercial areas, with a few low-rise office buildings. Commercial activity in this location draws significant numbers of daily commutes. However, unlike the Westwood location, residents in surrounding communities, which comprise most of the zone's commute pool, have purchased far fewer PEVs than the affluent neighborhoods surrounding Westwood. In total, 42 PEVs are

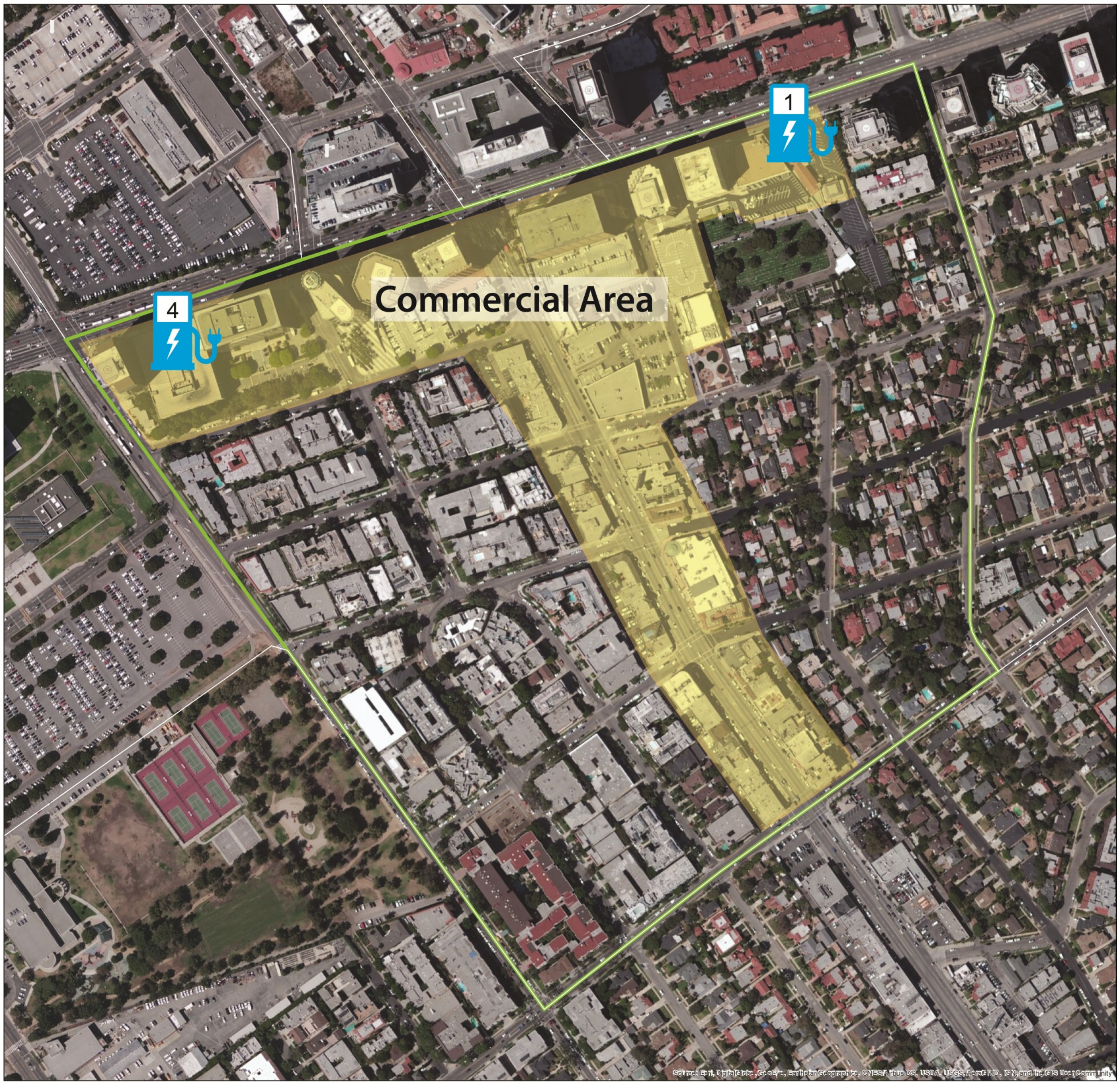


Figure 2. Westwood Zone: Area expected to draw commutes is shaded in yellow; locations and number of existing charging stations shown in blue.

expected to commute to the Santa Fe Springs zone, 23 of which are expected to be plug-in hybrids. Currently there are no charging stations available for PEV drivers.

Given additional charging stations, we expect that the unsupported plug-in hybrids in Santa Fe Springs could yield an additional 249 daily commute miles driven under electric power. This modest number is much less than the Westwood location, but still signals that the zone has potential for charging infrastructure investment. Furthermore, the Santa Fe Springs location is located in a disadvantaged community (DAC), impacted by higher pollution levels and characterized by low incomes in nearby residential areas. Because this area would likely realize greater than average benefits from charging station investment, it warrants more attention and investment funds than similarly scoring zones not situated in a DAC.

Figure 3. Santa Fe Springs Zone: Areas expected to draw commutes is shaded in yellow.

2.2 Data

The previous examples illustrate just two of the 905 alternatives zones analyzed in this report. We analyze each individual zone by utilizing data from the following three sources.

2.2.1 PEV Registration Data

Data on PEV registrations was obtained from IHS Automotive, an automotive information vendor. The data includes the year, make, and model of all individual new PEV sales in California between January 2011 and September 2016. The dataset reports the census tract in which each vehicle was registered at the time of purchase.

To transform tract-level data on PEV registrations to zone level, the number of PEVs within a tract are allocated to the smaller zones proportional to the fraction of the tract area that the zone occupies.

Because zones are comprised of census blocks, zone boundaries generally do not overlap census tract borders.[2] The number of registered PEVs per zone is illustrated in Figure 4.

2.2.2 Daily Commute Trips Data

Data on the number of work and non-work trips that transit between origins and destinations in the SCAG region was retrieved from SCAG's Travel Demand Model (TDM), a peer-reviewed model that is used for regional transportation forecasting and planning. The model estimates trip distributions by predicting the number of commutes leaving points of origin and arriving at destinations for 4,109 geographic zones. Similar to a census tract, zones are constructed from U.S. census blocks to enclose areas of approximately equal resident populations or employment (SCAG 2016). There are 4,109 zones in the entire SCAG region and 2,243 in Los Angeles County.

2.2.3 Electric Vehicle Charging Station Locations

To assess the current support for electric vehicles in Los Angeles County, we use data on existing electric vehicle charging station locations from PlugShare.[3] PlugShare is a free application that provides electric vehicle owners with a database of detailed information on charging stations all over the world (PlugShare 2017).[4] Figure 5 illustrates the locations of charging stations across Los Angeles County.

2.3 Narrowing Alternatives

We apply two filtering thresholds to narrow the number of alternative zones we consider to ensure we only consider zones where we are confident that some need for charging station investment exists. First, we use a plug-in hybrid trips threshold to focus our analysis on zones that have a sufficient number of expected PEV commute trips to warrant additional investment. Second, we apply a service gap threshold to include only those zones which currently have fewer incoming PEV commutes than chargers available to service them.

2.3.1 Plug-in Hybrid Trips Threshold

To limit the inclusion of zones which represent inefficient investments, we include only those locations where we expect five or more plug-in hybrid commutes. Many zones in Los Angeles County are either predominantly residential or rural and therefore do not draw many commutes. Others are located too far away from neighborhoods where plug-in

[2] This method is a standard spatial analysis technique. The operation is based on the assumption that PEV ownership is evenly distributed within each census tract. We use this necessary simplification because precise location data for PEV registrants is unavailable. While the technique can potentially match some PEVs to the wrong zone, misallocated PEVs will only be assigned to neighboring zones which share similar commute patterns. Errors introduced by this method will not significantly affect the analysis.

[3] For the purposes of this analysis, we exclude all residential charging points reported by PlugShare.

[4] Information on charging station location is provided by PlugShare users and therefore may contain inaccuracies.

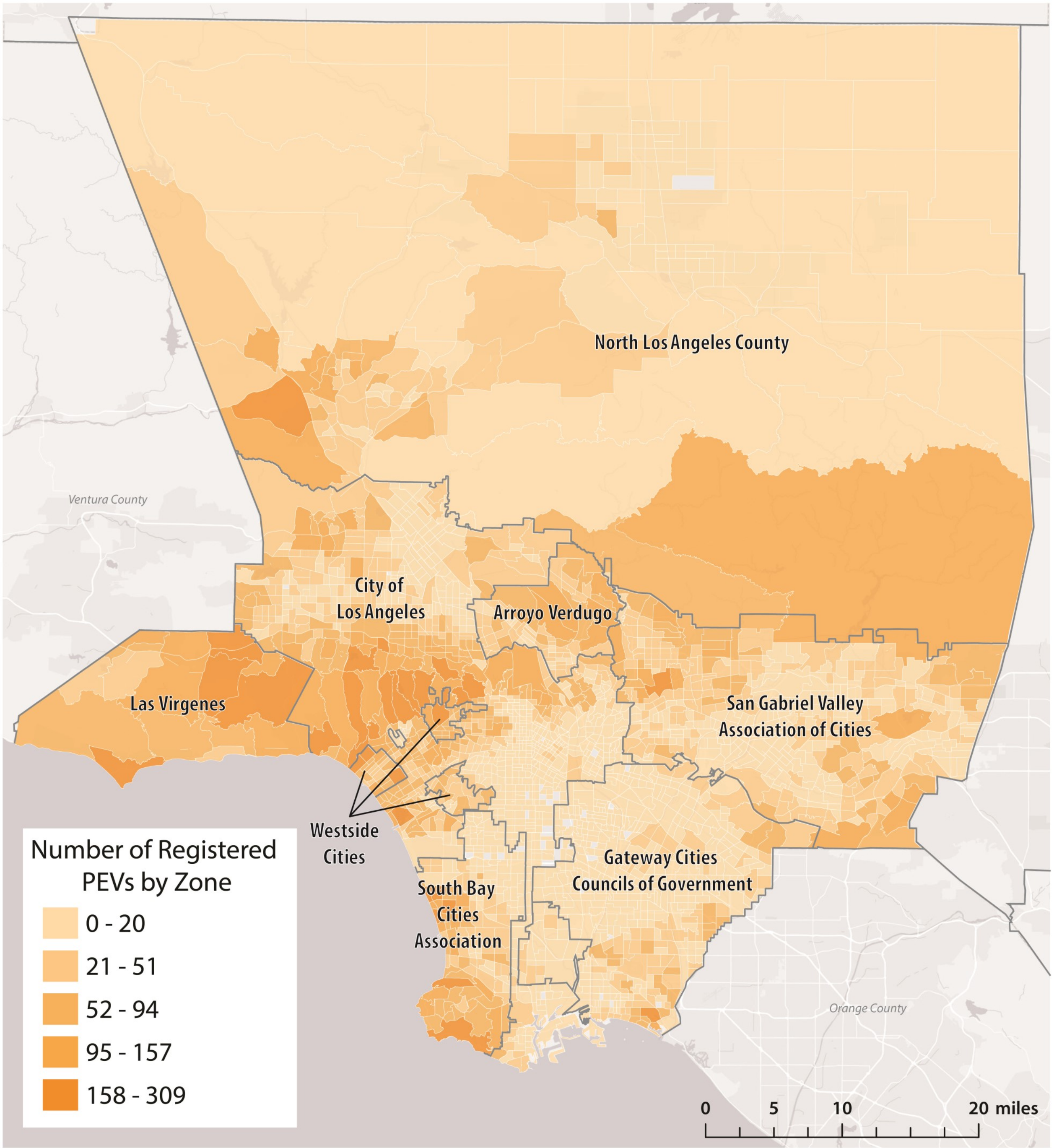


Figure 4. Number of registered PEVs per Zone in Los Angeles County.

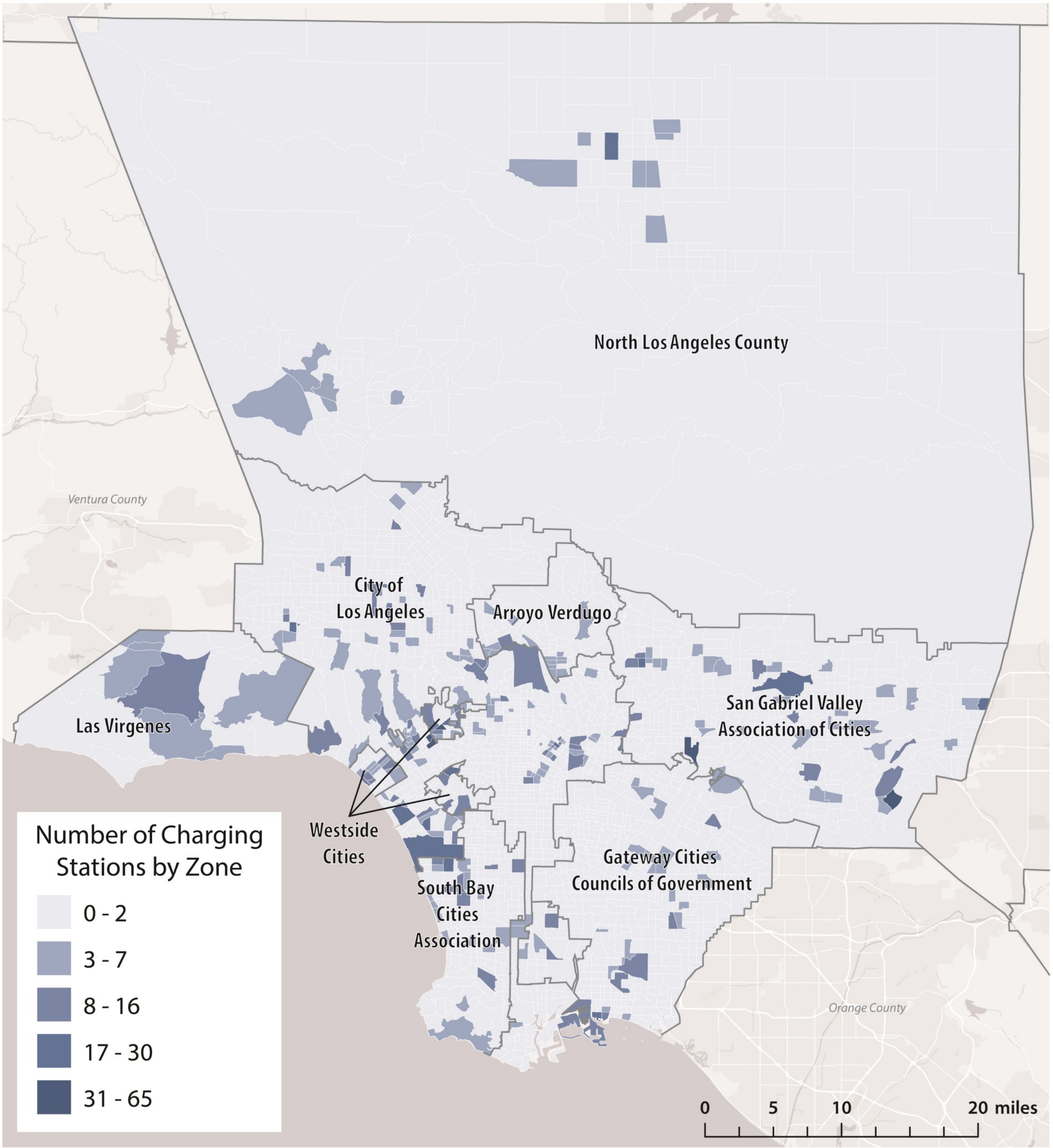


Figure 5. Number of charging stations per Zone in Los Angeles County.

hybrids are registered to draw significant numbers of plug-in hybrid commuters. One example of such a zone is located in Hawthorn along the 110 freeway (Figure 6). This zone is comprised mostly of low-density residential areas with one small section of commercial properties. It is also located in an area far removed from PEV-dense neighborhoods. As a result, only two plug-in hybrids are predicted to commute to the Hawthorn zone, making the location an inefficient investment choice for additional charging infrastructure.

In addition to limiting inefficient investment, applying a five plug-in hybrid trips threshold is useful in improving the accuracy and confidence of our model output. We utilize a probabilistic model in which fractional trips are summed from every origin zone in the SCAG region to arrive at an expected value of PEV trips terminating in a destination zone. Small PEV trip values indicate either that a destination zone is amalgamating many extremely low probability trips from far-away origins, or is picking up a few higher probability PEV trips from nearby locations. In both scenarios, the close-to-zero expected values of vehicles make it more probable that there are, in fact, no vehicles commuting to those zones. By excluding zones with fewer than five plug-in hybrid trips, we balance reducing the chance of erroneous scoring against the risk of excluding a potentially productive location for charging infrastructure investment.

2.3.2 Service Gap Standard Threshold

A small number of zones in Los Angeles County have more chargers available than expected PEV commuters to use them. For example, the destination zone with most electric vehicle chargers is located in Rosemead in the San Gabriel Valley (Figure 7). The zone has a golf course and predominantly low-density housing. However, it also contains the headquarters for Southern California Edison (SCE), the investor owned utility serving Los Angeles County. With 65 vehicle chargers installed on the SCE campus, the Rosemead zone has a number of available chargers far exceeding the twelve PEV commutes our model predicts will terminate in that location. Given the large excess of chargers relative to PEV commuters, investing in additional workplace charging in the Rosemead zone would not yield any additional benefits. Zones where available charging points exceed expected PEV commutes are not considered for investment.

2.4 Alternatives for Investment

As a result of these two filtering thresholds, we include 905 out of 2,243 total zones in Los Angeles County for investment consideration. We analyze each of these zones by two evaluative criteria to determine how to prioritize them for charging station investment. We ultimately recommend zones in groups with similar levels of priority to allow SCAG flexibility in their investment program, schedule, and budget.

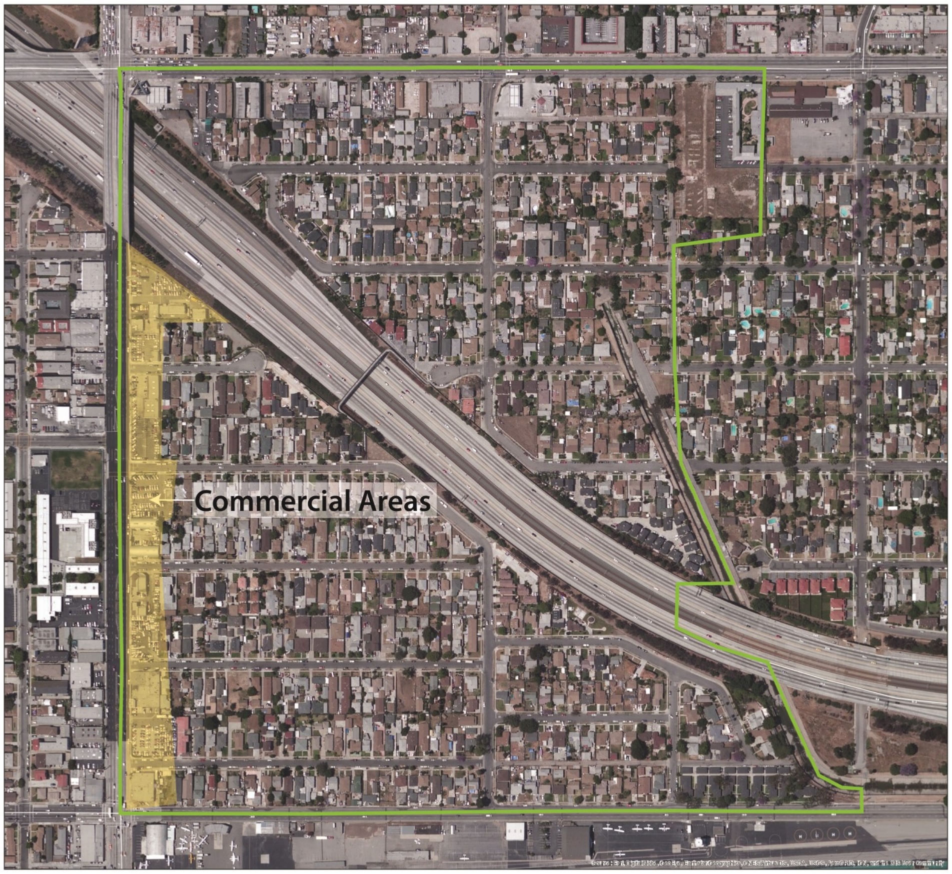
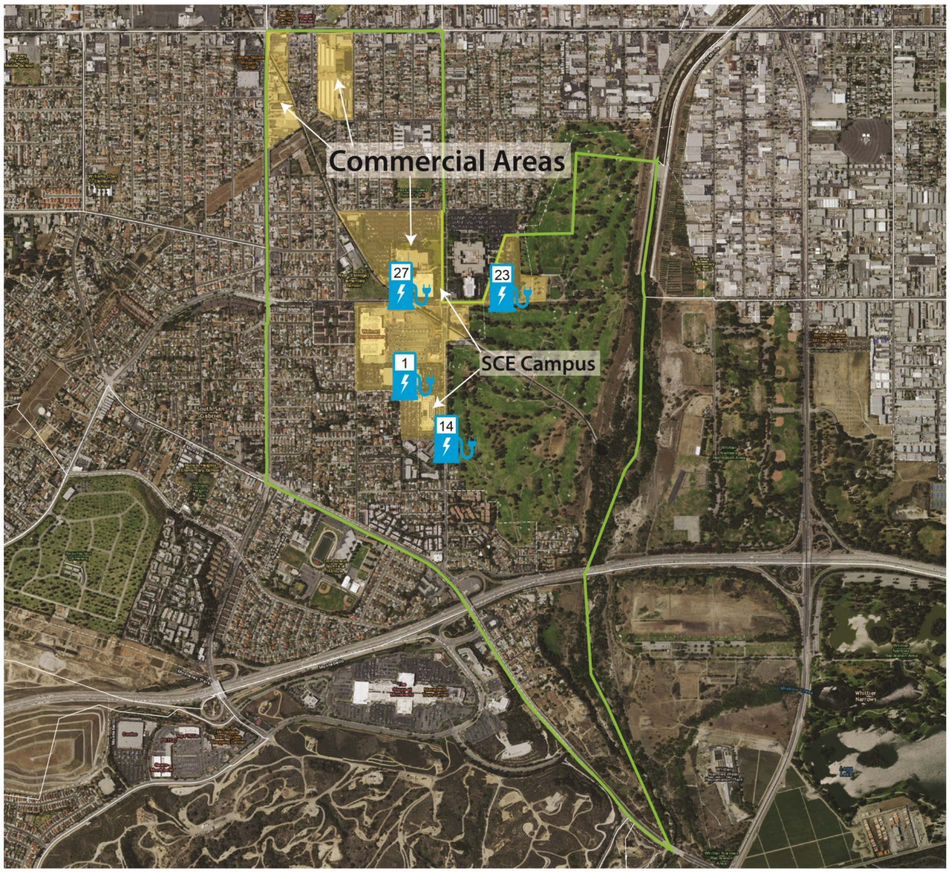


Figure 6. Hawthorn Zone: Areas expected to draw commutes is shaded in yellow.

Figure 7. Hawthorn Zone: Areas expected to draw commutes is shaded in yellow; existing chargers labeled in blue.



3. Criteria & Methods

To determine priority locations for PEV charging station investment, we evaluate each zone in Los Angeles County by two criteria: a potential for eVMT improvement criterion and an environmental justice criterion. These criteria are applied to the zones in Los Angeles County sequentially. First, zones are analyzed to assess the benefit of investment based on the potential to increase the commute miles traveled under electric power (eVMT). Second, zones in disadvantaged communities (DACs) that would benefit from additional support are identified. In the following sections of this chapter we explain the importance, methods, and calculation results for both criteria.

3.1 Potential Electric Vehicle Miles Traveled Improvement

As with any other public expenditure, SCAG has a responsibility to make spending decisions in a way that offers the public a positive return on their investment. In this case, that means prioritizing spending in areas where increasing charging infrastructure best supports SCAG's goal to reduce GHG emissions and improve air quality. Workplace charging infrastructure will have the intended effect when it supports a greater fraction of commute miles driven on electric power instead of gasoline.

Unlike BEVs which only drive on electric power, plug-in hybrids have the ability to extend their range by utilizing gasoline engines. However, once under gasoline power, they directly emit carbon dioxide and air pollutants. Furthermore, all-electric ranges of plug-in hybrids are limited due to the tradeoff between battery size and the inclusion of a gasoline engine. Without workplace charging, the capacity for a plug-in hybrid to operate fully on battery power is limited to a round-trip commute within its all-electric range. For commutes greater than this distance, the combustion engine will take over any remainder of miles traveled. However, given access to workplace chargers, plug-in electric vehicles can drive further on electric power, increasing the number of eVMT.

To identify how potential eVMT improvement varies across locations in Los Angeles County, we develop a mathematical model which combines data on commute trips with PEV registration data and existing charging station locations. The model outputs an expected value for the number of additional miles that can be driven under electric power given full support of underutilized plug-in hybrid vehicles in each zone.

We estimate that there are 5,861 plug-in hybrids that are used for commutes that exceed those vehicles' all-electric range. Such vehicles are underutilized resources, which when given the opportunity to charge at work, could yield as many as 75,858 additional electrically driven commute miles per day without requiring any new vehicle purchases. A higher number of potential eVMT improvement signals that a location is a good choice for securing public benefits from workplace charging infrastructure investments.

3.1.1 Methodology for Calculating Potential eVMT Improvement

We use a six-step method to model the daily potential eVMT improvement achievable by providing additional charging infrastructure per zone. The first step estimates the number of plug-in hybrids commuting between all origin and destination zones. Steps two and three calculate the average all-electric range of plug-in hybrids in each zone and the expected commute distances between origins and destinations. In step four, data from step two and three are combined to calculate the potential eVMT improvement of one plug-in hybrid vehicle for each origin-destination pair. Step five both calculates the total eVMT improvement for all plug-in hybrid trips between origin-destination pairs and aggregates those individual origin-destination eVMT improvement numbers for a single destination zone. Step six subtracts the amount of eVMT already supported by the zone's existing chargers from the naive estimate calculated in step five. Steps four through six are repeated for all 905 destination zones. This process results in an estimate of the total potential eVMT improvement for each zone.

3.1.2 Key Assumptions

Given data limitations, the methodology relies on several assumptions about the behavior of PEV drivers, where and how much they drive, and their charging behavior. Key behavioral assumptions are discussed below while those relating to our use of data and techniques are provided in footnotes where they are used in the methodology.

For the purposes of our calculations, we assume that all PEVs located in a zone will be used on a typical workday. While a 100 percent utilization rate for PEVs is unlikely, data on utilization rates of PEVs does not exist. An arbitrary smaller utilization rate could have been applied; however, because we would have applied that rate across all origin zones it would not have impacted the relative ranking of the model output. In any case, we do expect that nearly all PEVs are used on a regular basis.

To differentiate between PEV and non-PEV drivers in the TDM trip predictions, we assume that the probability that a PEV driver will commute between an origin and a specific destination is the same as that of a gasoline vehicle driver driving from the same location. Because plug-in hybrids have supplementary gasoline engines and therefore operate like conventional vehicles, we expect that the assumption is true for those vehicles. BEVs cannot drive beyond their electric range and therefore cannot make two-way commutes outside of their range without access to workplace charging. However, because BEVs have ranges exceeding 100 miles on a single charge and the median two-way commute in Los Angeles is only 17.6 miles, the number of BEV commutes predicted that exceed real-world BEV ranges is minimal (Kneebone, Holmes 2015).

When determining the number of PEVs that are used for commutes versus non-work trips, we assume again that plug-in hybrid drivers originating from a specific location behave like drivers of conventional vehicles from the same location and therefore have the same probability of using their vehicle for a commute as the average gasoline vehicle driver. While this assumption may affect the output values, any other assumption of odds ratio between commute and non-commute vehicle use would have to be applied equally to all origin zones. Therefore, this assumption will not affect relative scoring ranks.

Implicit in our calculation of the number of potential eVMT gains is the assumption that newly available chargers will be used. Because drivers of plug-in hybrids will reduce their overall driving costs by charging at work, we assume that they will use charging stations that are readily available to them. There is evidence that plug-in hybrid drivers charge less in non-residential locations than would be expected given the private benefits they would accrue (Tal et al. 2017). However, it is unclear whether this behavior is simply due to a simple lack of charging availability or if searching to find an available charger is often inconvenient relative to the benefits of charging (Tal et al. 2017). In either case, we expect that increasing the number of charging stations in places where PEV drivers commute should lead to more charging, either by increasing availability or reducing search costs.

Step 1. Calculating the number of plug-in hybrid commute trips to each destination zone

When predicting passenger vehicle trips in the SCAG region, the TDM does not distinguish between plug-in electric and conventional vehicles. To estimate the number of PEVs likely to commute to each destination zone, we adopt methodology previously used by the Luskin Center for Innovation in the 2012 Southern California Plug-in Electric Vehicle Readiness Report (UCLA Luskin Center for Innovation 2012), updated with current PEV registration data and the most recent TDM trip estimates. We further build on the methodology by disaggregating plug-in hybrid and BEV trip numbers from PEV estimates and differentiating commutes from other trips.

The discrete numbers of plug-in hybrid and BEV commutes between an origin-destination pair are calculated by multiplying the number of those vehicles registered in the origin of interest by the probability that any commute trip from the origin of interest will terminate in the destination of interest.[5] We distinguish PEV commutes from those taking non-work trips by multiplying the number of PEVs by the probability that a trip leaving that zone is a commute. A mathematical model of the estimation of the number plug-in hybrid and BEV commutes between origin zone i and destination zone j is shown in equation 1.

$$n(i,j) = \frac{N_w(i,j)}{\sum_{j=1}^{ALL\ Zones} N(i,j)} * (\#\ of\ PHEV\ in\ \text{origin zone}\ i) \quad (1.1)$$

$$n_b(i,j) = \frac{N_w(i,j)}{\sum_{j=1}^{ALL\ Zones} N(i,j)} * (\#\ of\ BEV\ inz\ \text{origin zone}\ i) \quad (1.2)$$

[5] In the time since purchase, many PEV owners may have moved or sold their vehicle on the secondary market. Data limitations preclude us from tracking PEVs after purchase. However, given that the data on the oldest vehicles is only six years old, we expect that the vehicle turnover has not been significant. Furthermore, we do not expect that the rate of vehicle transfers varies systematically across zones. Therefore, while turnover may introduce noise into the model, it will not bias our results.

Where:

- n(i,j) is the plug-in hybrid (PHEV) trips from zone i to zone j;
- nb(i,j) is the BEV trips from zone i to zone j;
- N(i,j) is the all trips from zone i to zone j;
- and Nw(i,j) is the work trips from zone i to zone j.

For illustrative purposes, take for example an origin zone (A) with 20 registered PEVs, which generates a total of 100 commutes and 100 non-work trips (200 trips total) per day. In this scenario, the model predicts that half (ten) of the available PEVs will be used for commutes. Ten out of the 100 commute trips leaving origin zone A will terminate in destination zone B. Of the ten commuting PEVs in origin zone A, 10%, or one PEV, will commute to destination zone B.

A summation of the results of equation 1 for all origin zones serving a single destination zone yields the total expected number of PEV commutes terminating in that zone. Repetition of the summation for all destination zones in Los Angeles County yields a picture of the spatial density of PEVs parked at workplaces during the work day. The results of this operation are illustrated on the map in Figure 8.

Step 2. Calculating the average all-electric range of plug-in hybrids in each origin zone

We calculate the weighted average all-electric range for plug-in hybrid vehicles in each origin zone using the IHS Automotive registration data on the make, model, and year of each vehicle, along with their all-electric range as reported by the U.S. Department of Energy (U.S. Department of Energy 2017). Zone average all-electric ranges are used because the exact year and model of PEV commuting from each zone on any given trip is unknown. The all-electric range determines how far any plug-in hybrid leaving each origin zone may travel using only electric power. For a full list of all-electric ranges by make, model, and year see Appendix A.

Step 3. Calculating the center-to-center distance traveled between zones

We calculate the distance between the center point (centroid) of each origin and destination zone using network analysis in geographic information systems software. This allows us to estimate the commute distance between zones. Centroids were chosen

[6] 20 PEVs multiplied by 100 commutes over 200 total trips equals 10 commuter PEVs.

[7] 10 commute trips to zone B over 100 total trips equals 10%.

[8] Due to data limitations in the TDM we cannot predict the net number of extra-regional PEV commutes. However, given SCAG's size, we expect the net number of PEV commutes that enter or leave its territory is marginal and therefore inconsequential to our analysis.

[9] Where centroids do not intersect the road network, the point on the road network closest to the zone centroid was used.

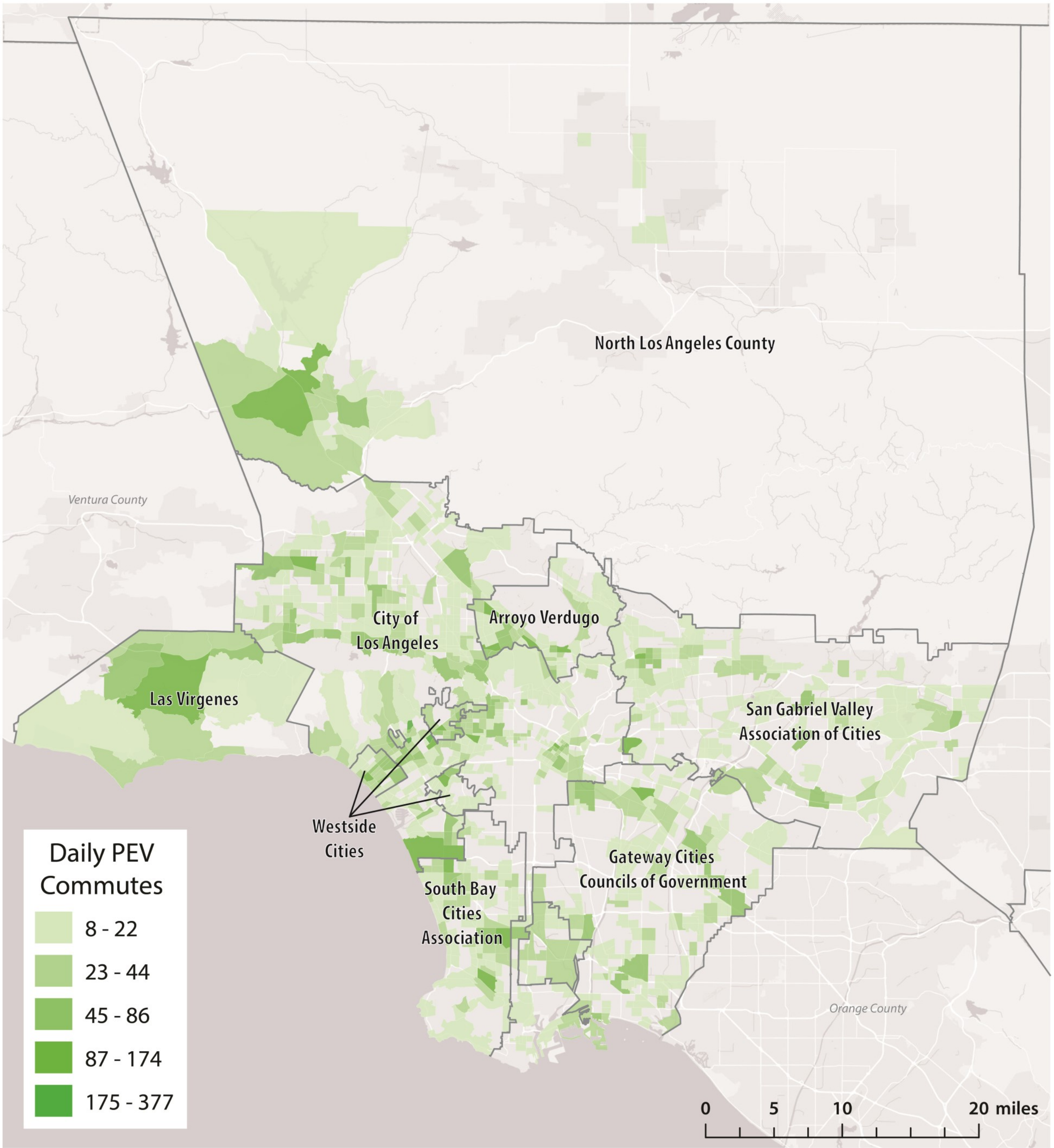


Figure 8. Estimated number of daily PEV commutes to investment alternative zones

to calculate the distance estimation because the exact origin or destination points of trips within a zone are unknown.[9] Network analysis traces the shortest road-based route between each centroid offering a lower bound estimate on the distance a vehicle would travel between origin and destination, taking into account the built environment and natural features such as terrain, coastlines, and rivers. Road network data was retrieved from Open Street Maps, an open source mapping service (Geofabrik 2017).

Step 4. Calculating the potential eVMT of one trip

The potential to increase the eVMT of a plug-in hybrid depends on the all-electric range of that plug-in hybrid and the round-trip distance of its commute. Using the average all-electric range for each origin zone and the commute distance between each origin zone and destination zone, we calculate the potential eVMT improvement attainable when a plug-in hybrid gains the ability to charge at work. For each origin-destination pair there are three potential scenarios that may occur, which determines the eVMT generation potential.

Scenario A: An opportunity to increase eVMT presents itself when a vehicle's all-electric range is less than the round-trip commute distance it travels. We identify such vehicles as unsupported plug-in hybrids. Increases in eVMT caused by charging support depends on the relationship between the electric range and the commute distance.

Scenario A-1: Where a vehicle's all-electric range is greater than its one-way commute distance but less than its round trip commute distance, a workplace charge ensures that the entirety of its return trip can be completed on electric power. The number of eVMT gained is equal to the difference between the round-trip commute distance and the vehicle's all-electric range (Figure 9).

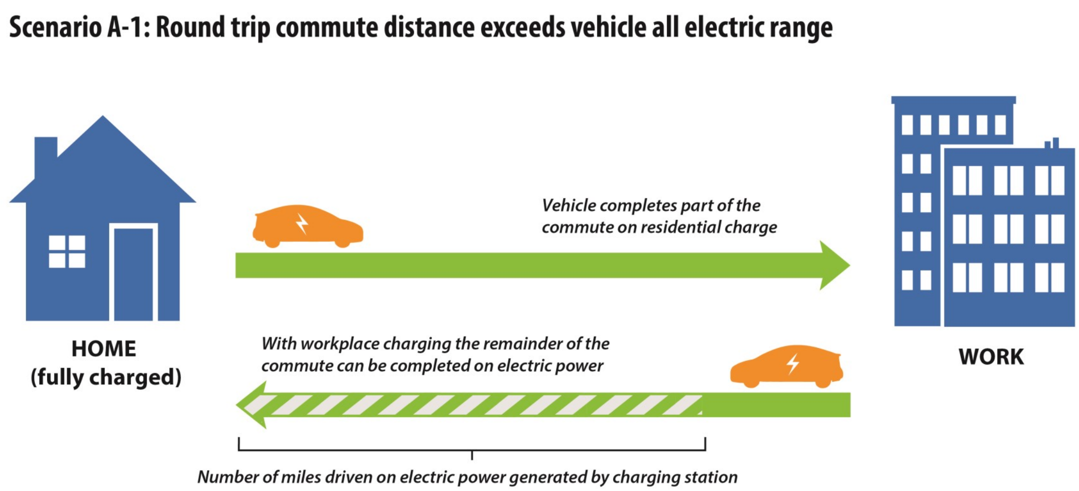


Figure 9. Scenario A-1

[9] Where centroids do not intersect the road network, the point on the road network closest to the zone centroid was used.

Scenario A-2: Where a one-way commute is longer than a commuter vehicle's all electric range, the vehicle will exhaust its battery power prior to arriving at its destination, leaving no reserve for the return trip. Given the opportunity to recharge while at work, such vehicles are able to complete part of the return trip on electric power rather than gasoline combustion. In this scenario the number of eVMT gained is equal to the vehicle's all-electric range (Figure 10).

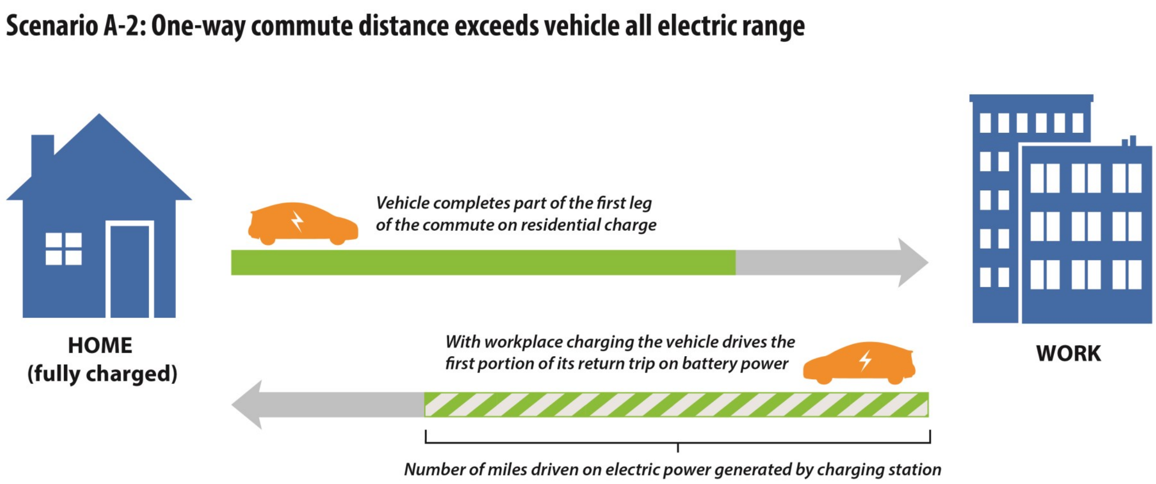


Figure 10. Scenario A-2

Scenario B: Where the round-trip commute distance is less than a commuter vehicle's all-electric range, the vehicle can complete its trip to and from the workplace on the electric reserve from a single residential charge. In this scenario, charging at work will yield zero additional eVMT (Figure 11).

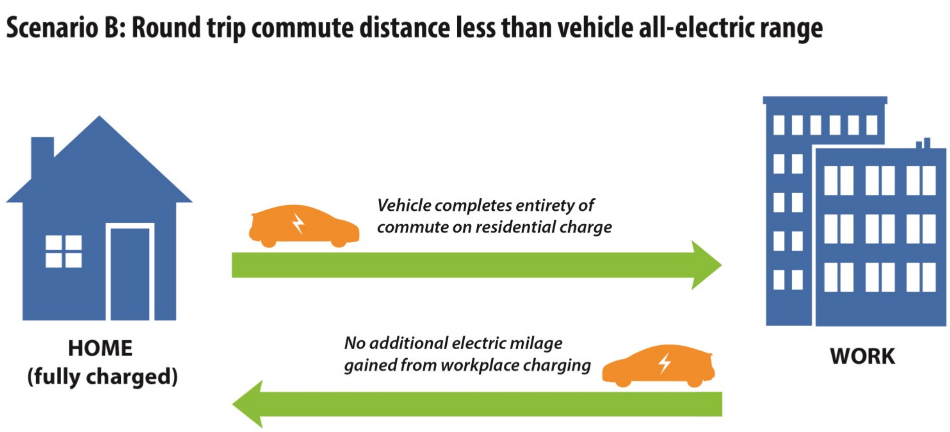


Figure 11. Scenario B

To determine eVMT potential, we combine the results from previous calculations of origin zone average all-electric ranges and commute distances between origin-destination pairs. Each pair is tested against the above three scenarios and assigned an eVMT potential score according to the case in which it fits. Equation 2 illustrates the eVMT potential algorithm in mathematical form.

$$g(i,j) = \begin{cases} 0 & (D(i,j) < \frac{1}{2} AER_i) \\ (2 \times D(i,j) - AER_i) & (\frac{1}{2} AER_i \le D(i,j) \le AER_i) \\ AER_i & (AER_i < D(i,j)) \end{cases} \quad (2)$$

Where:

- *D(i,j)* is the distance from i to j;
- *g(i,j)* is the potential increase in eVMT for a round-trip from i to j;
- and *AER* is the all-electric range.

Step 5. Summing each potential eVMT improvement

We multiply the potential eVMT improvement results for each origin-destination pair by the number of plug-in hybrid trips expected to commute between them to calculate a total potential eVMT improvement score. The scores are summed by destination to arrive at the naive (unadjusted for existing chargers) expected value for eVMT improvement in each destination zone.

Step 6. Subtracting eVMT provided by existing charging points

In locations where charging stations are already installed, a portion of commuting plug-in hybrids are already supported and will not benefit from additional electric vehicle charging infrastructure. Because both BEVs and plug-in hybrids use charging stations, we take into account all PEVs that can use a charger when estimating the probability that any one plug-in hybrid will be able charge on arrival to the zone. This probability is expressed as the number of existing charging points over the total number of PEVs in each zone. Naive eVMT improvement results from step five are multiplied by one minus the charger use probability, adjusting down the potential eVMT improvement score to account for existing charging opportunities. In effect, this calculation subtracts the eVMT already generated by existing charging stations from the eVMT improvement potential that would exist absent the presence of chargers, yielding the true potential eVMT improvement expected from additional charging points. A formal expression of the supported eVMT adjustment calculation is shown in equation 3.

$$\text{eVMT}_j = \sum_{i=1}^{All\ Zone} n(i,j) * g(i,j) * \left\{1 - \frac{k(j)}{\sum_{i=1}^{All\ zone}\{n(i,j)+nb(i,j)\}}\right\} \quad (3)$$

Where:

- *k(j)* is the number of charging points in destination zone j;
- *n(i,j)* is the plug-in hybrid trips from zone i to zone j;
- *nb(i,j)* is the BEV trips from zone i to zone j;
- and *g(i,j)* is the potential increase in eVMT for a round-trip commute from i to j.

3.1.3 Results for Potential eVMT Improvement

Figure 12 maps the daily potential eVMT that can be generated in each zone. Potential eVMT improvements range from 5 to 1,041 eVMT per day.

3.2 Environmental Justice

Disadvantaged communities are disproportionately affected by pollution due to their location and demographic features (U.S. Environmental Protection Agency 2015). The near and long term impacts of climate change are expected to fall more heavily on those same disadvantaged areas (U.S. EPA 2015). DACs often lack the necessary economic capital to directly invest in pollution mitigation (Kameri-Mbote et al. 1996). Moreover, they may face barriers to equitable participation in environmental policymaking and receive fewer benefits from environmental programs (Kameri-Mbote et al. 1996). Environmental justice aims to correct for the disproportionate impact of pollution on disadvantaged communities, involve residents of those communities in the environmental policymaking process, and ensure equitable distribution of the benefits of environmental programs (Kameri-Mbote et al. 1996).

The environmental justice movement developed at the grassroots level in the late 20th century (Department of Energy 2017). More recently, environmental justice has become institutionalized in U.S. and California law. In 2012, California enacted Senate Bill 535 which mainstreamed environmental justice concerns into financing decisions concerning the distribution of proceeds from California's carbon market auctions (California Legislative Information 2012). The bill requires that 25 percent of all invested funds be allocated to projects that benefit residents of DACs and that at least 10 percent of available funds be invested directly into DACs (California Legislative Information 2012). Senate Bill 535 has set legislative precedent for including environmental justice concerns in climate investment decisions. Notably, each of the electric vehicle infrastructure programs of the three California investor owned utilities have set targets for investment in DACs. In its decisions authorizing those programs, the California Public Utilities Commission cited Senate Bill 535 as the impetus for prioritizing investment in DACs

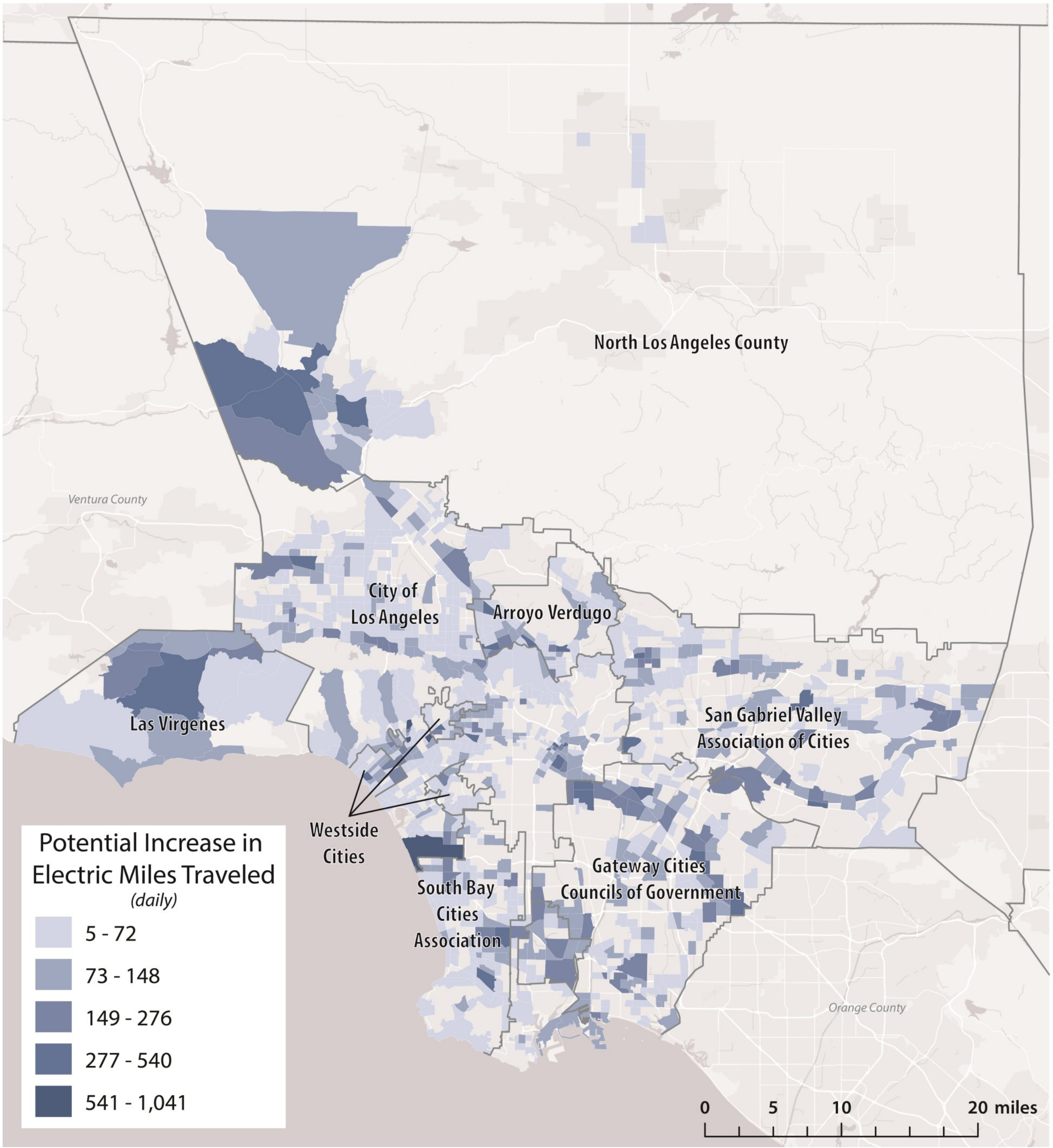


Figure 12. Expected number of additional commute miles traveled under electric power.

(California Public Utilities Commission 2016).

In accordance with SCAG's own environmental justice commitments and the legislative precedent set by Senate Bill 535, we include environmental justice as an evaluative criterion in our analysis. By evaluating the environmental justice implications of electric vehicle charging infrastructure investments in alternative destination zones, we provide recommendations that more equitably allocate investment funding to those communities that most need the environmental benefits of electric vehicle charging infrastructure investments. Such locations are already impacted by heavy air pollution and therefore stand the most to gain from local air quality improvements that would accrue from fewer tailpipe emissions, particularly those which occur on gasoline-powered return trips where cold engine starts cause high rates of pollutant emissions. Furthermore, given historic underinvestment in DACs, prioritizing investment funds to those locations will ensure that they receive infrastructure investment commensurate to their needs.

It is important to note one common critique of PEVs: their use may simply transfer pollution from tailpipe emissions to power plant emissions resulting in a shift in the health impacts of vehicle travel to those living near power plants. While this argument has merit, California's power generation is composed of low carbon and renewable energy sources that emit fewer pollutants than the burning of gasoline (on a per-mile-traveled basis), meaning that net pollution will be reduced by PEV use. Furthermore, charging infrastructure siting decisions will not have an impact on where the power used to charge vehicles is generated so such considerations are outside of the scope of this report.

3.2.1 Methodology to Evaluate Environmental Justice

We utilize the CalEnviroScreen 2.0 tool data to identify which destination zones are located within DACs. The California Environmental Protection Agency (CalEPA) developed the CalEnviroScreen 2.0 tool for the purpose of identifying DACs as directed by Senate Bill 535. The tool uses an index which assigns a composite score to each California census tract by interacting population vulnerability characteristics with pollution exposure factors. Higher composite scores indicate greater disadvantage. CalEPA has designated census tracts in the top 25 percent of those composite scores as DACs. (California Public Utilities Commission 2016; California Public Utilities Commission 2016; San Diego Gas & Electric Company 2015).

We adopt CalEPA's metric for DACs and apply it to our analysis. Because zones are constructed from census blocks, they generally align with or fall inside census tracts. However, in some cases census tract boundaries split zones. Where a zone falls wholly within one census tract, that tract's CalEnviroScreen score is applied. When a zone lies within multiple census tracts, it is given a score equal to the average of each census tract it falls within, weighted by the fraction of the zone in each tract. All zones that receive a score of 36 or above (the CalEPA threshold) are classified as DACs (California

Environmental Protection Agency 2014).

It is important to note that this method only identifies whether or not destination zones (those locations that would receive investment funding) are located within DACs. It does not take into account the environmental characteristics of locations where drivers commute from nor is it intended to. As a result, including this environmental justice criterion in investment decisions will not necessarily provide any additional benefits to PEV commuters from DACs.

3.2.2 Results for Environmental Justice

Figure 13 shows the 323 zones that are located within DACs. DACs are concentrated in the South and the East of the county.

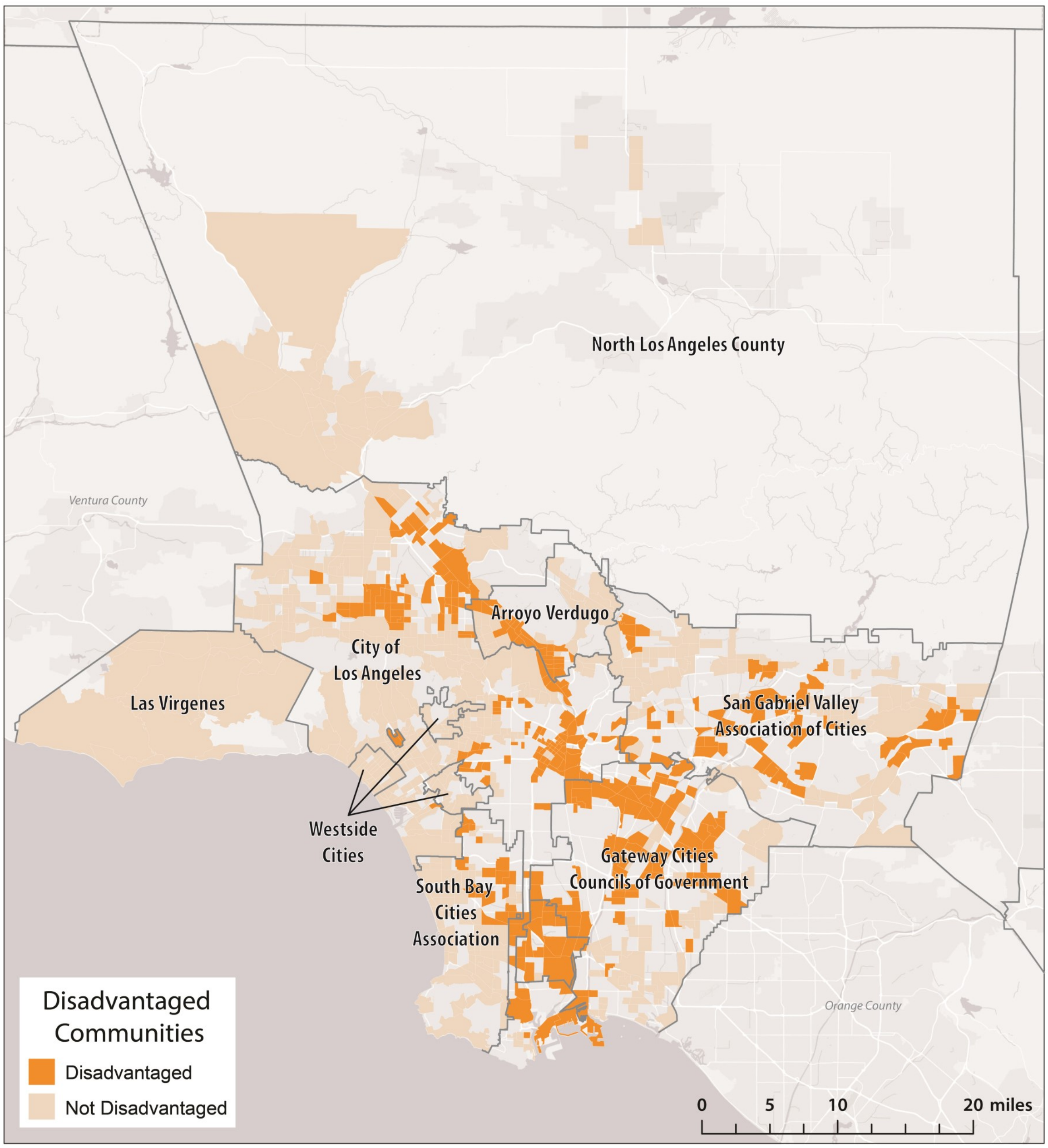


Figure 13. Zones located in disadvantaged communities.

4. Analysis

In this chapter we explain how the priority of each zone is determined by our two criteria: potential eVMT improvement and environmental justice. Potential eVMT improvement provides the basis for ranking zones in order of priority for investment. The environmental justice criterion identifies zones that should be prioritized for a greater proportion of investment. We then group zones into different tiers based on similar levels of priority.

4.1 Prioritizing Zones

4.1.1 Ranking and Categorizing Zones

Potential eVMT improvement directly measures how charging infrastructure investments will advance SCAG's goals and is therefore used to rank zones by order of investment potential. Although the ranked list of zones provides useful detail, SCAG's size and the number of investment zones makes a one-by-one approach to investment impractical. Furthermore, such an approach would require SCAG to make the difficult determination of how much investment is appropriate in each individual zone. We therefore group zones into tiers of similar investment priority to provide SCAG with an investment ranking that is both actionable and useful from a programmatic perspective. By using tiers, SCAG can roll out investments to locations across Los Angeles County simultaneously.

Potential eVMT improvement results are heavily right skewed with a few high scoring outliers. To overcome the skewed distribution and rationally divide the data into groups of similar investment potential, we use a natural breaks algorithm. This groups data into a specified number of bins where the variance within each bin is minimized and the variance between each bin is maximized (Fisher 1958). The algorithm output groups zones into five tiers. Figure 14 shows the potential eVMT improvement score distribution; vertical lines indicate tier breaks.

Table 1 summarizes the results of the use of natural breaks to group zones into tiers. Because of the right skew in the data, the number of zones in each tier increases as tier rank decreases.

Table 1. Number of Zones by Category

Priority Tier	Number of Zones
Highest	9
High	28
Medium	85
Low	240
Lowest	543

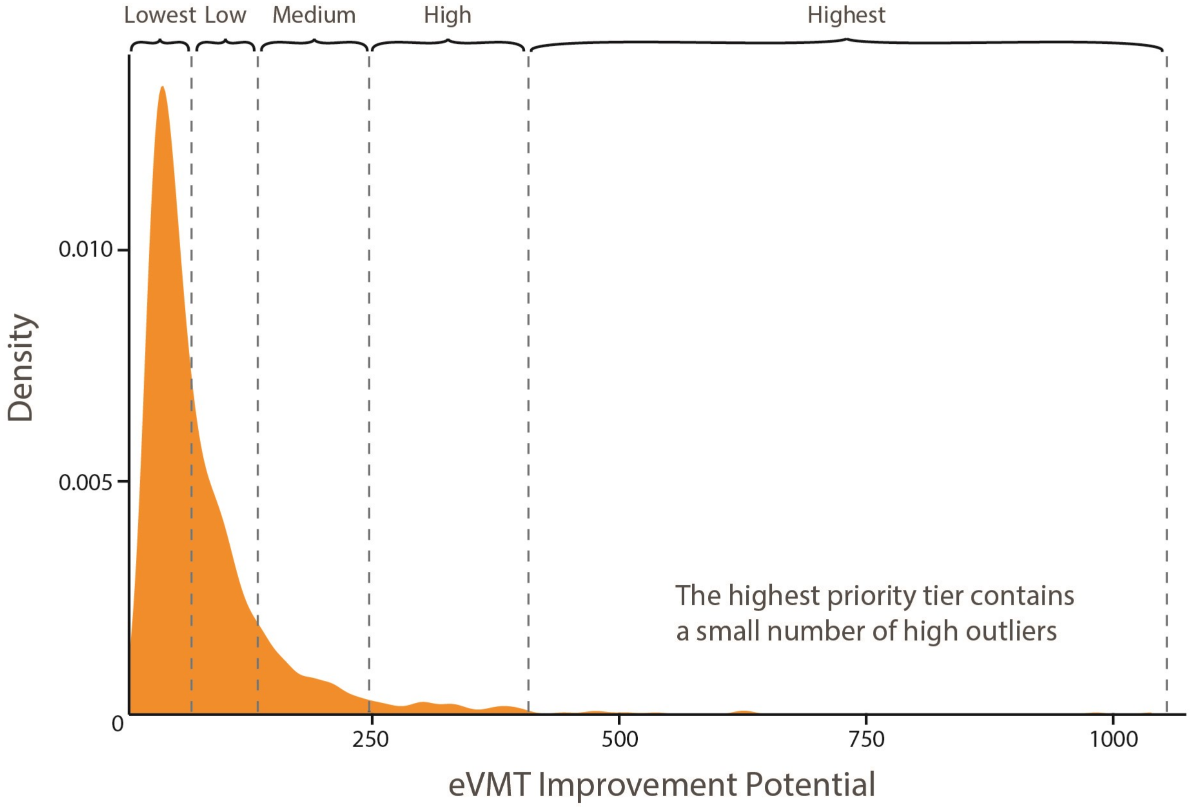


Figure 14. eVMT Improvement Potential Distribution. Brackets denote investment tier.

The zones in the highest priority tier are listed in Table 2. Of the nine zones in this tier, three are designated as DACs. Despite the wide range in existing charging points between zones, each has a high number of PEV commute trips and high potential eVMT improvement. For the full ranking for each tier, see Appendix B.

Table 2. Tier 1 zones

Zone Rank	City	Existing Charging Points	Plug-in Hybrid Commute Trips	PEV Commute Trips	Potential eVMT Improvement	DAC
1	Los Angeles	5	178	377	1,041	No
2	Los Angeles	9	149	317	985	No
3	Los Angeles	45	127	272	631	No
4	Los Angeles	18	87	172	625	No
5	Glendale	2	79	155	540	Yes
6	Commerce	4	47	91	509	Yes
7	Torrance	5	63	119	484	No
8	Santa Clarita	3	70	111	473	No
9	Monterey Park	0	44	88	445	Yes

4.1.2 Aggregating Zones to Subregions

The lack of spatial concentration in eVMT scores makes aggregating potential eVMT improvements to administrative geographies less than ideal. For example, we examine the results if eVMT improvement numbers are aggregated by subregion, SCAG's primary administrative subunit. Each subregion's share of potential eVMT improvement differs by at most six percentage points from its share of the number of zones. In effect, this method would simply prioritize the largest subregions. Averaging the scores within subregions provides a slightly better picture of the variation of investment potential. However, this method prioritizes smaller subregions over larger subregions because high scoring zones carry more weight when there are fewer zones overall. Table 3 lists the results of score aggregation for each SCAG subregion in Los Angeles County.

Table 3. Zone Scores Aggregated to Subregions

SCAG Subregion	Potential eVMT Improvement	eVMT as Percent of Total	Number of Zones	Zones as percent of Total	Average eVMT Improvement
Arroyo Verdugo	4,693	6%	51	6%	92
City of Los Angeles	29,016	38%	400	44%	73
Gateway Cities COG	13,033	17%	127	14%	103
Las Virgenes	2,102	3%	15	2%	140
North Los Angeles County	3,135	4%	32	4%	98
San Gabriel Valley Association of Cities	11,709	15%	127	14%	92
South Bay Cities Association	7,885	10%	102	11%	77
Westside Cities	4,283	6%	51	6%	84

4.1.3 Distribution of eVMT Scores and Impact on Investment Efficiency

Much of the potential eVMT improvement is driven by a small number of zones. The zones in the highest tier represent only one percent of the total number of zones, but drive eight percent of the overall eVMT potential. Moreover, the top three tiers include only thirteen percent of the total zones, but can generate more eVMT improvement than the bottom 60 percent of zones combined. The high potential eVMT improvement scores in those small numbers of top investment zones allows SCAG to focus on very effective early investments which can rapidly increase the number of commute miles driven on electric power. Table 4 shows the number of zones in each tier and their eVMT improvement potentials.

Table 4. Percent of Zones and Percent of eVMT Improvement

Priority Tier	Number of Zones	Zone Percent of Total	Potential eVMT	eVMT Percent of Total
Highest	9	1%	5,732	8%
High	28	3%	9,057	12%
Medium	85	9%	15,226	20%
Low	240	27%	23,173	31%
Lowest	543	60%	22,667	30%

4.1.4 Zones in Disadvantaged Communities

Between one-third and one-half of each priority tier's zones are located in DACs. On average, DACs in priority tiers have 26 percent fewer currently installed charging stations than their non-DAC counterparts. This indicates that among DACs with similar charging needs as non-DACs, DACs have had far less charging infrastructure investment to date. Table 5 shows the number of DACs within each priority tier.

Table 5. The Number of Zones in Disadvantaged Communities

Priority Tier	Number of Zones	Number of DACs	Proportion DACs
Highest	9	3	33%
High	28	14	50%
Medium	85	36	42%
Low	240	99	41%
Lowest	543	171	31%

4.2 Marginal Productivity of an Additional Charging Station

When ranking alternatives, we do not consider the marginal productivity of a single additional charging point. Marginal productivity provides an approximation of the public return on investment by reporting the expected eVMT increase associated with the installation of a single additional charging point. In a situation where funding is significantly limited, marginal productivity could be used to identify those places where the return on a single investment is highest. However, when the focus is on large gains in eVMT, it is more practical to focus investment in zones with the largest absolute eVMT generation potential.

Although SCAG's primary concern is in the absolute gain of potential eVMT, some attention should be paid to returns on investment when choosing investment locations. This raises the question as to how much weight is given to marginal productivity in the decision-making process. Given SCAG's desire to maximize eVMT, it is reasonable to weight marginal productivity low so that it simply acts as a tiebreaker between zones with similar total eVMT potential scores. Because we group zones into tiers, the tiebreaker concept only operates on the margins of the tier blocks. Sensitivity analysis on the inclusion of marginal productivity on our tier results shows that only seven percent of zones changed tiers when marginal productivity is given a ten percent weight relative to the total potential eVMT improvement. Given the insensitivity of our results to the tiebreaker marginal productivity method, we do not include it in our primary analysis. However, it should be noted that when given an equal weight to eVMT potential, marginal productivity has a greater impact on results. The methods used to calculate marginal productivity of an additional charging point and the results of the sensitivity analysis are presented in Appendix C.

5. Recommendations

905 zones in Los Angeles County have the potential to benefit from public workplace charging station infrastructure investment. Our analysis reveals that potential eVMT improvements vary widely across these zones. A significant portion of zones are located within DACs. These results inform our recommendations for zone investment priority and additional support for DAC zones.

A small number of zones in the top tiers contain a large percentage of Los Angeles County's eVMT generation potential. The concentration of eVMT potential in these top zones makes them clear infrastructure investment priorities. High priority zones are not geographically concentrated in any particular part of Los Angeles County (see Figure 16). The wide geographic distribution of higher priority areas imposes difficulties on prioritizing based on administrative geographies. We therefore recommend a structured approach to investment which uses five priority tiers as functional groupings of locations which require similar investment focus. Investments should be made in order of tier priority, beginning with the highest tiers and moving to less productive investment tiers as time and budget allows. Our recommendations do not include specific programmatic advice on budgets for individual tiers, timelines, or subsidy levels. We expect SCAG will make those determinations once project budgets are established.

A substantial proportion of priority zones are located in disadvantaged communities. While the overall public benefits from investing in a DAC are similar to a non-DAC in the same tier, the DACs themselves may experience greater localized benefits from charging infrastructure investments. Furthermore, generally low private investment in those communities could prove to be a barrier to infrastructure installation. Therefore, we recommend that SCAG should direct additional funding per charging station installation to DAC zones to ensure the benefits of the program are distributed equitably among similarly prioritized zones. Table 6 shows both the total number of zones and the number of DAC zones in each tier. Figure 15 illustrates the locations of zones and their priority level on a map.

Table 6. Recommendations for Each Priority Tier in Los Angeles County

Priority Tiers	Number of Zones	Number of DACs
Highest	9	3
High	28	14
Medium	85	36
Low	240	99
Lowest	543	171

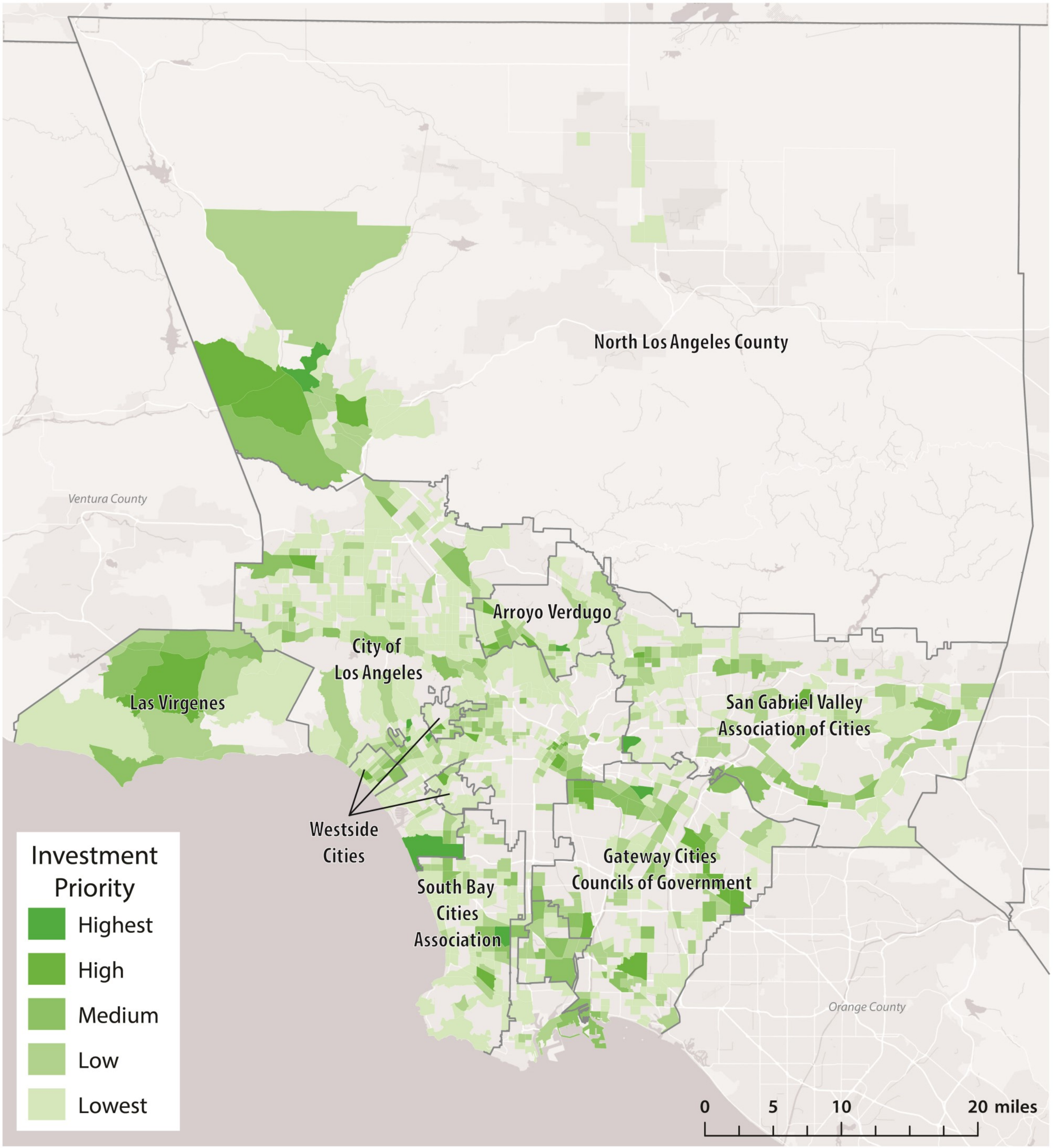


Figure 15. Investment Priority Ranking of Zones in Los Angeles County

5.1 Next Steps

5.1.1 Model Validation

The methodology used to calculate the expected number of PEVs that will travel to each destination zone has not been validated against real-world observations. Prior to the application of the recommendations offered in this report, SCAG should sample a small number of destination zones and directly observe the number of PEVs parked at workplaces or workplace adjacent parking during business hours. The observations should be compared against the PEV predictions for those zones to test the accuracy of the modeled predictions.

5.1.2 Replicability and Revision

The model presented in this report is a widely applicable method for informing charging infrastructure investment decisions. The remaining SCAG counties can easily replicate this methodology with available data. With sufficient PEV registration data, other planning organizations that employ travel demand models can also replicate our work for their planning needs.

Furthermore, the model may be updated as frequently as necessary with the most recent TDM output, vehicle registration data, and CalEnviroScreen scores. Our methodology is limited to eVMT calculations for plug-in hybrids, so declining results can be expected over a longer time horizon as more people switch from plug-in hybrids to BEVs and as all-electric ranges on plug-in hybrids increase (Autoweek 2016).

6. Limitations and Future Work

6.1 Limitations

There are two limitations resulting from a lack of evidence in the existing body of knowledge surrounding PEV charging which constrain the robustness of our policy recommendations. The first limitation is our inability to make precise recommendations about siting workplace charging locations in areas where they may do the most to encourage drivers to switch to electric vehicles. Second, our investment recommendations are limited by a lack of available information by which to determine the ideal number of chargers SCAG should invest in at a given location.

6.1.1 Potential to Increase Plug-in Electric Vehicle Purchases

There are two options for increasing commute eVMT: (1) increasing the share of miles traveled under electric power by existing plug-in electric vehicle commuters; and (2) encouraging conventional vehicle commuters to purchase PEVs. While our analysis addresses the first option, we lack the data necessary to measure how the potential of vehicle charging infrastructure to spur further PEV deployment may vary from location to location within Los Angeles County. This data limitation constrains our ability to provide a complete picture of how charging infrastructure siting choices may influence eVMT in Los Angeles County. However, we expect that our recommendations may indirectly provide SCAG with a course of action that provides a good chance of stimulating further PEV purchases. Regardless of limitation, our recommendation provides a tangible measurement of potential benefits on which to SCAG can base investment decisions for funds that have already been allocated for the purposes of subsidizing electric vehicle charging infrastructure.

To date, only one empirical analysis on the causal effect of non-residential electric vehicle charging infrastructure availability on demand for PEVs has been published. The study finds that deployment of non-residential charging stations independently increases the number of PEV sales in American metropolitan areas (Li et al. 2016). However, it does not examine any potential differentiated effects of micro-level spatial characteristics in infrastructure investment on PEV sales and therefore cannot be directly used to determine an individual location's suitability for charging infrastructure investment relative to other locations (Li et al. 2016).

The available evidence suggests that any investment in workplace charging infrastructure, regardless of location within Los Angeles County, will yield more PEV sales on average. While the exact mechanisms by which charging station availability increases demand for PEVs are unknown, we anticipate that charging station installations will have a higher likelihood to influence buyers who are already somewhat likely to purchase a PEV. Therefore, in the near term, charging infrastructure investment will have the most effect on PEV purchases when sited in workplace locations where likely PEV purchasers are employed.

In California, the factors that best predict propensity to purchase PEVs are previous nearby PEV sales and socioeconomic status indicators (UCLA Luskin Center for Innovation and South Bay Cities Council of Governments 2016). In the early PEV market stage, we assume those factors will hold true for predicting future PEV sales, meaning that the persons most likely to purchase PEVs are residents in neighborhoods with currently high PEV densities. Conveniently, the model we use to predict the commute numbers of PEVs to a location also identifies the areas where high numbers of non-PEV drivers from the same neighborhoods commute, making PEV commute density a ready surrogate for number of likely PEV purchasers. Unfortunately, this measure only increases confidence that installing a charging station in a particular location may yield better results than another and cannot be used to predict the number of additional sales attributable to charging station investment.

While we cannot precisely evaluate each location's specific potential to increase PEV adoption, we do expect that by limiting investment recommendations to zones with at least a minimal number of PEV trips we increase the chance that the charging investments made will incentivize future sales. Furthermore, the scoring metric that we use to estimate potential to increase eVMT from plug-in hybrids increases with the number of PEVs commuting to that location. To the extent to which potential to increase PEV purchases scales with increasing numbers of PEV commutes to a location, we expect that the plug-in hybrid eVMT improvement metric will prioritize investment in zones with more potential to increase PEV sales.

6.1.2 Target Number of Charging Station Installations

Our recommendations provide SCAG with a ranking of investment potential in terms of an upper bound of the benefits of complete support for all unsupported plug-in hybrids. While this metric is useful in predicting which locations represent the best investments, it does not account for potential diminishing returns on investment as more chargers are installed in a specific zone. Therefore, simply installing enough chargers to support each plug-in hybrid deemed unsupported by our model may be inefficient. Furthermore, evidence on how many vehicles may charge per day on a single charger is limited and such charging behavior is likely influenced by individual workplace charging policies and pricing (New Energy Staffing & Recruiting Services 2013). As previously discussed, multiple studies and reports have attempted to determine an ideal ratio between vehicles and chargers; however, results have been mixed and no consensus has emerged from the literature.

Given the lack of evidence, we cannot be confident of asserting a number or ratio of charging stations that indicates that a location has sufficient charging availability.

Additionally, it is unclear that without information specific to individual workplaces such a determination could be made. Therefore, we limit our recommendations to identifying investments for workplace charging that have the most potential to yield public benefits.

6.2 Future Work

The limitations in this report represent opportunities for future study. Growing PEV ownership rates will continue to be an important pathway to increasing the number of miles driven on electric power in Los Angeles County. Better understanding of how workplace specific characteristics may influence the efficacy of charging infrastructure to encourage PEV sales would be invaluable to planning processes. Furthermore, given the lack of consensus in the literature, future study about a reasonable ratio of charging stations to electric vehicles is warranted. Such information would be useful to infrastructure planners for the identification of efficient investment targets.

7. Conclusion

There is significant opportunity to increase commute eVMT with strategically sited charging stations across Los Angeles County. If all 5,861 currently underserved plug-in hybrids in Los Angeles were able to fully charge for their return commute trip, Los Angeles County could replace 75,858 gasoline-powered commute miles with cleaner electric-powered trips. Much of the expected potential to increase commute miles driven on electric power is concentrated in a few top locations. Areas with high or very-high investment potential exist in various locations across Los Angeles County.

We group zones with similar investment potential into five tiers listed by priority. We recommend that SCAG make investments in order of tier priority, beginning with the highest ranked tiers and moving to less productive tiers as time and budget allows. Furthermore, SCAG should direct additional funding to zones in disadvantaged communities to ensure equitable distribution of benefits among similarly prioritized zones. As more PEVs are deployed in California, charging infrastructure investment will remain important to further the environmental benefits associated with increased EV use.

Appendix A: Plug-in Hybrid Models and Ranges

Model Name	Model Year	All Electric Range
Audi A3 e-tron	2016	16
Audi A3 e-tron	2017	16
Audi A3 e-tron ultra	2016	17
Honda Accord Plug In Hybrid	2014	13
Mercedes Benz C350e	2016	11
Mercedes Benz GLE550e	2016	12
Mercedes Benz GLE550e	2017	12
Mercedes Benz S550e	2015	14
Mercedes Benz S550e	2016	14
Mercedes Benz S550e	2017	14
BMW 330e	2016	14
BMW 330e	2017	14
BMW 740e xDrive	2017	14
BMW i8	2014	15
BMW i8	2015	15
BMW i8	2016	15
BMW X5 xDrive 40e	2016	14
BMW X5 xDrive 40e	2017	14
Ford C-Max Energi	2013	20
Ford C-Max Energi	2014	20
Ford C-Max Energi	2015	20
Ford C-Max Energi	2016	20
Ford C-Max Energi	2017	20
Cadillac ELR	2014	37
Cadillac ELR	2015	37
Cadillac ELR	2016	40

Cadillac ELR	2016	36
Porsche Cayenne S E-Hybrid	2015	14
Porsche Cayenne S E-Hybrid	2016	14
Porsche Cayenne S E-Hybrid	2017	14
Fisker Karma	2012	33
Ford Fusion Energi Plug-in Hybrid	2013	20
Ford Fusion Energi Plug-in Hybrid	2014	20
Ford Fusion Energi Plug-in Hybrid	2015	20
Ford Fusion Energi Plug-in Hybrid	2016	20
Ford Fusion Energi Plug-in Hybrid	2017	22
McLaren Automotive P1	2014	19
McLaren Automotive P1	2015	19
Kia Optima	2017	29
Porsche 918 Spyder	2015	12
Chrysler Pacifica Plug-in Hybrid	2017	33
Porsche Panamera S E-Hybrid	2014	16
Porsche Panamera S E-Hybrid	2015	16
Porsche Panamera S E-Hybrid	2016	16
Prius Plug-in Hybrid	2012	11
Prius Plug-in Hybrid	2013	11
Prius Plug-in Hybrid	2014	11
Prius Plug-in Hybrid	2015	11
Prius Prime	2017	25
Hyundai Sonata Plug-in Hybrid	2016	27
Hyundai Sonata Plug-in Hybrid	2017	27
Chevy Volt	2011	35
Chevy Volt	2012	35
Chevy Volt	2013	38
Chevy Volt	2014	38
Chevy Volt	2015	38

Chevy Volt	2016	53
Chevy Volt	2017	53
Volvo XC90 AWD PHEV	2016	14
Volvo XC90 AWD PHEV	2017	14

(U.S Department of Energy 2017)

Appendix B: Complete List and Rank of Zones

Highest Priority Tier

TAZ ID	Subregion	City	Charging Points	PHEV Commutes	PEV Commutes	eVMT*	DAC
20836000	City of Los Angeles	Los Angeles	5	178	377	1041	No
20841000	City of Los Angeles	Los Angeles	9	149	317	985	No
20854000	City of Los Angeles	Los Angeles	45	127	272	631	No
21119000	City of Los Angeles	Los Angeles	18	87	172	625	No
22005000	Arroyo Verdugo	Glendale	2	79	155	540	Yes
21734000	Gateway Cities COG	Commerce	4	47	91	509	Yes
21293000	South Bay Cities Association	Torrance	5	63	119	484	No
20229000	North Los Angeles County	Santa Clarita	3	70	111	473	No
22092000	San Gabriel Valley Association	Monterey Park	0	44	88	445	Yes

**eVMT: Potential eVMT Improvement*

High Priority Tier

TAZ ID	Subregion	City	Charging Points	PHEV Commutes	PEV Commutes	eVMT*	DAC
21608000	Gateway Cities COG	Vernon	0	39	76	408	Yes
20749000	Westside Cities	Santa Monica	9	77	166	398	No
21960000	Arroyo Verdugo	Glendale	4	61	117	395	Yes
20216000	Las Virgenes	unincorporated	8	47	91	385	No
21947000	City of Los Angeles	Los Angeles	28	62	126	383	Yes
20249000	North Los Angeles County	Santa Clarita	2	53	85	375	No
21281000	South Bay Cities Association	Torrance	11	59	111	372	No
20868000	Westside Cities	Beverly Hills	40	80	174	356	No
20633000	Arroyo Verdugo	Burbank	6	59	115	342	No
21560000	City of Los Angeles	Los Angeles	1	40	82	341	Yes
22106000	San Gabriel Valley Association	Pasadena	12	47	95	332	No
20224000	North Los Angeles County	unincorporated	0	25	42	332	No
21843000	Gateway Cities COG	Santa Fe Springs	0	31	58	328	Yes
22307000	San Gabriel Valley Association	Irwindale	0	30	57	324	Yes
21886000	Gateway Cities COG	La Mirada	0	32	59	313	Yes
20632000	Arroyo Verdugo	Burbank	4	49	92	308	Yes
22321000	San Gabriel Valley Association	Industry	1	31	59	307	No
20918000	City of Los Angeles	Los Angeles	2	52	108	302	No
20226000	North Los Angeles County	unincorporated	3	57	90	300	No
21544000	City of Los Angeles	Los Angeles	0	35	69	299	Yes
21607000	Gateway Cities COG	Vernon	0	29	57	292	Yes
20446000	City of Los Angeles	Los Angeles	0	51	90	284	No
20870000	Westside Cities	Culver City	13	55	114	276	No
21363000	Gateway Cities COG	unincorporated	0	26	50	268	Yes
21832000	Gateway Cities COG	Santa Fe Springs	0	24	46	267	Yes
21946000	City of Los Angeles	Los Angeles	7	37	74	260	Yes
21872000	Gateway Cities COG	Santa Fe Springs	0	26	48	256	Yes
21443000	Gateway Cities COG	Long Beach	14	34	63	254	No

**eVMT: Potential eVMT Improvement*

Medium Priority Tier

TAZ ID	Subregion	City	Charging Points	PHEV Commutes	PEV Commutes	eVMT*	DAC
21852000	Gateway Cities COG	Santa Fe Springs	0	23	42	249	Yes
22436000	San Gabriel Valley Association	Pomona	0	25	46	245	Yes
21280000	South Bay Cities Association	Torrance	0	34	64	240	No
20220000	Las Virgenes	Calabasas	1	38	74	238	No
20640000	Arroyo Verdugo	Burbank	12	45	86	235	No
21679000	Gateway Cities COG	Vernon	0	21	42	235	Yes
22309000	San Gabriel Valley Association	West Covina	6	27	51	233	Yes
21138000	South Bay Cities Association	El Segundo	27	45	90	225	No
21953000	City of Los Angeles	Los Angeles	1	29	58	225	Yes
22133000	San Gabriel Valley Association	Pasadena	7	32	65	223	No
22259000	San Gabriel Valley Association	unincorporated	1	19	38	221	No
21134000	City of Los Angeles	Los Angeles	2	33	67	217	No
21731000	Gateway Cities COG	Commerce	0	19	37	215	Yes

21353000	South Bay Cities Association	Carson	0	22	41	214	Yes
20515000	City of Los Angeles	Los Angeles	1	43	85	211	No
22322000	San Gabriel Valley Association	Industry	6	24	46	211	No
21571000	Gateway Cities COG	Vernon	0	21	42	210	Yes
22285000	San Gabriel Valley Association	Industry	0	20	39	209	Yes
20626000	City of Los Angeles	unincorporated	12	42	82	208	No
20717000	City of Los Angeles	Los Angeles	2	32	58	207	Yes
20407000	City of Los Angeles	Los Angeles	0	33	60	206	No
21146000	South Bay Cities Association	El Segundo	1	34	67	205	No
21351000	South Bay Cities Association	Carson	2	21	40	203	Yes
21060000	City of Los Angeles	Los Angeles	2	31	64	200	Yes
21553000	City of Los Angeles	Los Angeles	1	22	44	197	Yes
21495000	Gateway Cities COG	unincorporated	0	21	39	192	Yes
22120000	San Gabriel Valley Association	Pasadena	6	27	55	192	No
21427000	Gateway Cities COG	Signal Hill	8	25	47	191	No
21397000	Gateway Cities COG	Long Beach	2	21	40	191	No
21227000	South Bay Cities Association	Gardena	0	22	43	190	Yes
20213000	Las Virgenes	unincorporated	3	23	45	189	No
20787000	Westside Cities	Santa Monica	5	37	77	189	No
22381000	San Gabriel Valley Association	Industry	0	20	39	188	No
20779000	City of Los Angeles	Los Angeles	3	36	77	188	No
20215000	Las Virgenes	Agoura Hills	6	32	60	187	No
20227000	North Los Angeles County	unincorporated	2	22	35	187	No
21144000	South Bay Cities Association	El Segundo	2	29	58	185	No
20791000	City of Los Angeles	Los Angeles	2	34	72	178	No
20926000	City of Los Angeles	Los Angeles	6	34	71	177	No
20522000	City of Los Angeles	Los Angeles	3	40	79	175	No
20777000	Westside Cities	Santa Monica	14	39	83	174	No
20473000	City of Los Angeles	Los Angeles	7	39	73	173	No
21496000	South Bay Cities Association	Carson	0	19	36	173	Yes
20636000	Arroyo Verdugo	Burbank	3	30	58	171	No
20839000	City of Los Angeles	Los Angeles	0	29	63	171	No
22218000	San Gabriel Valley Association	Arcadia	4	22	44	169	No
22421000	San Gabriel Valley Association	La Verne	0	18	32	168	No
21312000	City of Los Angeles	unincorporated	7	24	45	167	Yes
21379000	Gateway Cities COG	Long Beach	26	31	57	167	No
21856000	Gateway Cities COG	Cerritos	1	19	35	164	No
22229000	San Gabriel Valley Association	Arcadia	0	19	37	163	No
21986000	Arroyo Verdugo	Glendale	2	26	50	162	Yes
21783000	Gateway Cities COG	Downey	4	17	33	162	Yes
21724000	Gateway Cities COG	Commerce	0	15	29	161	Yes
21936000	City of Los Angeles	Los Angeles	7	24	48	161	Yes
20671000	City of Los Angeles	Los Angeles	0	23	40	160	Yes
22121000	San Gabriel Valley Association	Pasadena	7	23	48	158	No
21708000	Gateway Cities COG	Bell	0	14	27	158	Yes
20433000	City of Los Angeles	Los Angeles	1	30	56	158	No
21983000	Arroyo Verdugo	Glendale	3	24	48	157	Yes
20506000	City of Los Angeles	Los Angeles	4	35	67	156	No
20796000	City of Los Angeles	Los Angeles	9	33	71	156	No
20863000	Westside Cities	Beverly Hills	10	31	67	155	No
21871000	Gateway Cities COG	unincorporated	4	16	30	153	No
22107000	San Gabriel Valley Association	Pasadena	20	30	61	153	No
21795000	Gateway Cities COG	Pico Rivera	0	14	27	153	Yes
22426000	San Gabriel Valley Association	Pomona	2	17	30	149	Yes
21336000	South Bay Cities Association	Carson	0	17	32	148	Yes
21359000	Gateway Cities COG	unincorporated	0	14	27	146	Yes
20639000	Arroyo Verdugo	Burbank	2	25	48	146	Yes
20767000	Westside Cities	Santa Monica	1	29	62	145	No
21853000	Gateway Cities COG	Norwalk	3	15	29	145	Yes
21365000	Gateway Cities COG	Long Beach	9	18	33	145	Yes
20887000	City of Los Angeles	Los Angeles	4	28	60	144	No
21582000	City of Los Angeles	Los Angeles	2	16	32	144	Yes
20587000	City of Los Angeles	Los Angeles	0	30	60	143	No
21292000	South Bay Cities Association	Torrance	0	20	37	143	No
22249000	San Gabriel Valley Association	Monrovia	15	23	44	143	Yes
20217000	Las Virgenes	unincorporated	0	21	40	142	No
21942000	City of Los Angeles	Los Angeles	14	25	51	141	Yes
20733000	Las Virgenes	Malibu	0	18	38	141	No
21645000	City of Los Angeles	Los Angeles	4	17	34	140	Yes

22304000	San Gabriel Valley Association	Industry	0	14	26	139	Yes
21459000	Gateway Cities COG	Lakewood	2	17	32	139	No
20431000	City of Los Angeles	Los Angeles	5	29	55	138	No

**eVMT: Potential eVMT Improvement*

Low Priority Tier

TAZ ID	Subregion	City	Charging Points	PHEV Commutes	PEV Commutes	eVMT*	DAC
21954000	City of Los Angeles	Los Angeles	7	20	41	137	Yes
20423000	City of Los Angeles	Los Angeles	0	25	47	137	No
21807000	Gateway Cities COG	Cerritos	6	18	33	136	Yes
20801000	City of Los Angeles	Los Angeles	15	32	68	136	No
20766000	Westside Cities	Santa Monica	8	30	65	135	No
22357000	San Gabriel Valley Association	Glendora	0	13	25	135	No
20735000	Las Virgenes	Malibu	5	16	34	135	No
22434000	San Gabriel Valley Association	Pomona	3	16	30	135	Yes
22339000	San Gabriel Valley Association	Industry	3	15	30	135	No
21197000	South Bay Cities Association	Torrance	0	18	34	134	Yes
20448000	City of Los Angeles	Los Angeles	0	26	49	133	No
22266000	San Gabriel Valley Association	Industry	0	13	24	133	Yes
21559000	City of Los Angeles	Los Angeles	1	17	34	133	Yes
20620000	Arroyo Verdugo	Burbank	1	22	41	132	Yes
21055000	City of Los Angeles	Los Angeles	0	18	37	129	No
21142000	City of Los Angeles	Los Angeles	6	24	48	129	No
20629000	Arroyo Verdugo	Burbank	5	25	49	129	No
20496000	City of Los Angeles	Los Angeles	0	28	54	129	No
21125000	South Bay Cities Association	El Segundo	3	20	40	127	No
21282000	South Bay Cities Association	Torrance	0	18	34	126	No
22174000	San Gabriel Valley Association	Pasadena	1	16	33	126	No
21757000	Gateway Cities COG	Paramount	0	12	23	125	Yes
20230000	North Los Angeles County	unincorporated	2	6	10	125	No
20219000	Las Virgenes	Hidden Hills	0	19	39	124	No
20501000	City of Los Angeles	Los Angeles	0	26	51	124	No
20214000	Las Virgenes	Agoura Hills	3	22	41	124	No
21332000	South Bay Cities Association	Carson	0	14	26	124	Yes
20882000	Westside Cities	Culver City	18	30	62	123	No
22101000	San Gabriel Valley Association	Alhambra	11	20	40	123	No
20953000	City of Los Angeles	Los Angeles	4	24	50	122	No
20945000	City of Los Angeles	Los Angeles	5	24	49	122	No
21950000	City of Los Angeles	Los Angeles	0	15	31	122	Yes
21261000	South Bay Cities Association	Rancho Palos Verdes	3	19	36	121	No
21937000	City of Los Angeles	Los Angeles	5	17	35	121	No
20845000	City of Los Angeles	Los Angeles	2	24	51	120	No
21745000	Gateway Cities COG	Montebello	4	13	25	120	Yes
20212000	Las Virgenes	Westlake Village	1	18	35	119	No
21958000	Arroyo Verdugo	Glendale	1	20	38	119	Yes
20734000	Las Virgenes	unincorporated	7	14	29	119	No
21791000	Gateway Cities COG	Downey	3	13	24	119	Yes
20956000	City of Los Angeles	Los Angeles	2	22	45	118	No
21357000	South Bay Cities Association	Carson	0	12	23	118	Yes
20509000	City of Los Angeles	Los Angeles	9	26	48	118	Yes
20898000	Westside Cities	Beverly Hills	0	21	46	116	No
20769000	Westside Cities	Santa Monica	3	24	51	116	No
20818000	City of Los Angeles	Los Angeles	10	24	48	115	No
22091000	San Gabriel Valley Association	Pasadena	9	19	40	115	No
22252000	San Gabriel Valley Association	Duarte	1	12	23	114	Yes
20462000	City of Los Angeles	Los Angeles	3	24	42	114	No
20775000	City of Los Angeles	Los Angeles	0	22	46	113	No
21475000	Gateway Cities COG	Long Beach	2	16	28	113	No
21591000	City of Los Angeles	Los Angeles	13	18	37	112	Yes
20658000	City of Los Angeles	Los Angeles	0	25	43	112	No
22247000	San Gabriel Valley Association	Monrovia	0	13	24	111	No
22275000	San Gabriel Valley Association	Industry	1	11	22	111	Yes
21625000	City of Los Angeles	Los Angeles	0	11	22	111	Yes
21497000	Gateway Cities COG	unincorporated	0	12	23	110	Yes
22418000	San Gabriel Valley Association	Pomona	0	12	22	110	Yes
21782000	Gateway Cities COG	Downey	1	11	21	110	No
20950000	City of Los Angeles	Los Angeles	7	23	47	110	No
21778000	Gateway Cities COG	Downey	5	13	25	110	Yes

20970000	City of Los Angeles	Los Angeles	2	20	41	110	Yes
20622000	City of Los Angeles	Los Angeles	11	25	49	110	No
21037000	City of Los Angeles	Los Angeles	0	15	31	109	No
20412000	City of Los Angeles	Los Angeles	0	21	40	109	No
21864000	Gateway Cities COG	Santa Fe Springs	0	11	21	108	No
20439000	City of Los Angeles	Los Angeles	1	20	36	108	No
21595000	Gateway Cities COG	Compton	0	11	20	108	Yes
21326000	South Bay Cities Association	Carson	0	13	24	107	Yes
21159000	South Bay Cities Association	Inglewood	1	16	32	107	Yes
21147000	City of Los Angeles	Los Angeles	12	21	42	107	No
22353000	San Gabriel Valley Association	Covina	1	12	23	107	No
22240000	San Gabriel Valley Association	Monrovia	2	13	26	107	No
22373000	San Gabriel Valley Association	Glendora	1	11	21	106	No
22117000	San Gabriel Valley Association	Pasadena	0	14	30	106	No
21870000	Gateway Cities COG	Cerritos	0	11	21	106	No
22262000	San Gabriel Valley Association	Industry	0	10	19	105	Yes
21470000	Gateway Cities COG	Long Beach	0	13	23	105	No
21861000	Gateway Cities COG	Santa Fe Springs	3	12	22	105	Yes
20435000	City of Los Angeles	Los Angeles	30	35	65	105	No
22134000	San Gabriel Valley Association	Pasadena	2	15	30	105	No
21369000	Gateway Cities COG	Long Beach	0	11	20	104	Yes
20235000	North Los Angeles County	Santa Clarita	7	22	34	104	No
21830000	Gateway Cities COG	Lakewood	0	13	23	104	Yes
20514000	City of Los Angeles	Los Angeles	0	20	36	103	Yes
21860000	Gateway Cities COG	unincorporated	0	10	18	103	Yes
20896000	City of Los Angeles	Los Angeles	11	25	53	103	No
22356000	San Gabriel Valley Association	Covina	3	12	23	102	No
21702000	Gateway Cities COG	Commerce	0	10	19	102	Yes
20902000	City of Los Angeles	Los Angeles	0	19	41	102	No
22360000	San Gabriel Valley Association	unincorporated	0	11	21	101	No
20237000	North Los Angeles County	Santa Clarita	6	20	32	101	No
21740000	Gateway Cities COG	Commerce	0	9	17	100	Yes
22253000	San Gabriel Valley Association	Duarte	3	12	22	100	Yes
21948000	City of Los Angeles	Los Angeles	0	13	26	100	Yes
20755000	Westside Cities	Santa Monica	5	22	48	100	No
21284000	South Bay Cities Association	Torrance	3	16	30	99	No
21435000	Gateway Cities COG	Signal Hill	0	12	22	99	No
20645000	Arroyo Verdugo	Burbank	1	17	32	99	Yes
21141000	South Bay Cities Association	Manhattan Beach	16	26	51	99	No
21399000	Gateway Cities COG	Long Beach	16	20	36	99	No
22105000	San Gabriel Valley Association	Pasadena	0	12	25	99	Yes
21587000	City of Los Angeles	Los Angeles	14	18	36	99	Yes
20245000	North Los Angeles County	Santa Clarita	0	17	27	98	No
21971000	City of Los Angeles	Los Angeles	0	14	28	98	Yes
22410000	San Gabriel Valley Association	San Dimas	2	12	21	98	No
22221000	San Gabriel Valley Association	South El Monte	0	9	18	97	Yes
20491000	City of Los Angeles	Los Angeles	9	26	45	97	No
20889000	Westside Cities	West Hollywood	2	19	42	97	No
20973000	City of Los Angeles	Los Angeles	0	16	32	97	No
21759000	Gateway Cities COG	Paramount	0	10	18	97	Yes
21744000	Gateway Cities COG	Montebello	0	9	17	96	Yes
21480000	Gateway Cities COG	Long Beach	2	14	26	96	No
21581000	Gateway Cities COG	Compton	0	9	17	96	Yes
21205000	South Bay Cities Association	Hawthorne	0	13	25	96	Yes
21980000	Arroyo Verdugo	Glendale	6	18	35	95	Yes
21362000	South Bay Cities Association	Carson	0	10	19	95	Yes
21611000	City of Los Angeles	Los Angeles	0	11	22	95	Yes
22188000	San Gabriel Valley Association	Pasadena	5	14	28	94	No
22400000	San Gabriel Valley Association	Pomona	2	11	20	94	Yes
20899000	Westside Cities	West Hollywood	12	23	50	94	No
21924000	City of Los Angeles	Los Angeles	3	13	26	94	Yes
22210000	San Gabriel Valley Association	South El Monte	0	10	19	94	Yes
21345000	South Bay Cities Association	Carson	8	15	28	93	Yes
22377000	San Gabriel Valley Association	Covina	4	11	21	93	No
20429000	City of Los Angeles	Los Angeles	0	18	33	93	No
22380000	San Gabriel Valley Association	Walnut	0	10	20	93	No
20741000	City of Los Angeles	Los Angeles	0	9	21	92	No
21555000	City of Los Angeles	Los Angeles	0	11	22	92	Yes
20232000	North Los Angeles County	Santa Clarita	0	15	24	92	No

22452000	San Gabriel Valley Association	Claremont	1	11	20	91	No
21021000	City of Los Angeles	Los Angeles	0	14	28	91	No
22201000	San Gabriel Valley Association	South El Monte	0	9	18	91	Yes
20785000	Westside Cities	unincorporated	4	18	40	91	Yes
20425000	City of Los Angeles	Los Angeles	4	21	38	90	No
21132000	South Bay Cities Association	Redondo Beach	6	22	42	90	No
20941000	City of Los Angeles	Los Angeles	2	14	29	90	Yes
21898000	Gateway Cities COG	Whittier	0	9	17	90	No
21276000	South Bay Cities Association	Torrance	0	16	29	90	No
20764000	City of Los Angeles	Los Angeles	0	18	39	89	No
22445000	San Gabriel Valley Association	Claremont	4	12	22	89	No
20690000	City of Los Angeles	San Fernando	1	15	26	89	Yes
20561000	City of Los Angeles	Los Angeles	0	20	39	89	No
22010000	City of Los Angeles	Los Angeles	0	11	22	89	Yes
21934000	City of Los Angeles	Los Angeles	0	11	22	89	Yes
21266000	South Bay Cities Association	Torrance	5	18	33	88	No
22019000	Arroyo Verdugo	Glendale	1	14	27	88	No
20552000	City of Los Angeles	Los Angeles	4	22	41	88	No
21161000	South Bay Cities Association	unincorporated	3	15	29	88	No
21451000	Gateway Cities COG	Long Beach	1	11	21	88	No
21115000	South Bay Cities Association	El Segundo	0	13	25	88	No
20742000	City of Los Angeles	Los Angeles	0	15	35	88	No
20648000	Arroyo Verdugo	Burbank	1	15	29	88	Yes
21291000	South Bay Cities Association	Torrance	0	13	23	87	No
20571000	City of Los Angeles	Los Angeles	1	17	31	87	Yes
22033000	Arroyo Verdugo	Glendale	5	15	29	87	No
20786000	City of Los Angeles	Los Angeles	2	18	39	87	No
22395000	San Gabriel Valley Association	San Dimas	5	12	21	86	No
21358000	Gateway Cities COG	unincorporated	1	9	18	86	Yes
20666000	City of Los Angeles	Los Angeles	0	14	24	86	No
21540000	City of Los Angeles	Los Angeles	0	10	19	85	Yes
21452000	Gateway Cities COG	Long Beach	1	12	22	85	No
20843000	City of Los Angeles	Los Angeles	6	19	41	85	No
21508000	City of Los Angeles	Los Angeles	1	10	20	85	Yes
22081000	Arroyo Verdugo	La Canada Flintridge	2	11	22	85	No
20527000	City of Los Angeles	Los Angeles	12	24	44	84	Yes
20603000	City of Los Angeles	Los Angeles	0	17	34	84	No
21944000	City of Los Angeles	Los Angeles	9	14	29	83	No
21319000	South Bay Cities Association	unincorporated	7	14	27	83	Yes
20551000	City of Los Angeles	Los Angeles	2	20	39	82	No
21758000	Gateway Cities COG	Paramount	1	9	16	82	Yes
21804000	Gateway Cities COG	Pico Rivera	0	8	15	82	Yes
21714000	Gateway Cities COG	South Gate	1	8	15	82	Yes
22195000	San Gabriel Valley Association	South El Monte	0	9	17	82	Yes
20231000	North Los Angeles County	Santa Clarita	2	15	23	82	No
20883000	Westside Cities	West Hollywood	3	16	36	81	No
20774000	City of Los Angeles	Los Angeles	0	14	29	81	No
20621000	City of Los Angeles	Los Angeles	0	13	24	80	Yes
21784000	Gateway Cities COG	Downey	2	9	16	80	Yes
20754000	Westside Cities	Santa Monica	9	19	42	80	No
21530000	Gateway Cities COG	Compton	0	9	16	80	Yes
20608000	City of Los Angeles	Los Angeles	0	17	32	80	No
20930000	Westside Cities	West Hollywood	2	17	35	80	No
22093000	San Gabriel Valley Association	South Pasadena	0	10	22	80	No
20712000	City of Los Angeles	Los Angeles	0	12	22	80	Yes
20776000	City of Los Angeles	Los Angeles	2	17	36	79	No
21955000	City of Los Angeles	Los Angeles	4	12	23	79	Yes
21762000	Gateway Cities COG	Downey	0	8	14	79	No
21998000	Arroyo Verdugo	Glendale	6	15	30	79	No
22255000	San Gabriel Valley Association	Duarte	0	8	15	78	No
21347000	City of Los Angeles	Los Angeles	0	7	13	78	Yes
20984000	City of Los Angeles	Los Angeles	13	20	41	78	Yes
21224000	South Bay Cities Association	Hawthorne	0	10	19	78	Yes
22009000	City of Los Angeles	Los Angeles	0	10	20	77	Yes
22263000	San Gabriel Valley Association	Irwindale	0	8	15	77	Yes
22223000	San Gabriel Valley Association	El Monte	1	9	17	77	Yes
20857000	City of Los Angeles	Los Angeles	60	41	89	77	No
22196000	San Gabriel Valley Association	El Monte	4	10	19	77	Yes
20613000	City of Los Angeles	Los Angeles	1	16	30	77	Yes

21873000	Gateway Cities COG	Whittier	0	8	14	77	Yes
20762000	Westside Cities	Santa Monica	0	16	34	76	No
21597000	Gateway Cities COG	Compton	0	7	14	76	Yes
20837000	City of Los Angeles	Los Angeles	3	15	32	76	No
20251000	North Los Angeles County	Santa Clarita	0	12	19	76	No
21416000	Gateway Cities COG	Long Beach	1	9	17	76	No
20910000	City of Los Angeles	Los Angeles	0	15	32	75	No
22173000	San Gabriel Valley Association	San Gabriel	0	9	18	75	No
20914000	City of Los Angeles	Los Angeles	0	14	30	75	No
21017000	City of Los Angeles	Los Angeles	1	12	24	75	No
20905000	City of Los Angeles	Los Angeles	1	15	30	74	Yes
20929000	City of Los Angeles	Los Angeles	0	15	31	74	No
21317000	City of Los Angeles	Los Angeles	0	9	17	74	No
21213000	South Bay Cities Association	Inglewood	0	10	19	74	No
22243000	San Gabriel Valley Association	El Monte	1	8	16	73	Yes
20459000	City of Los Angeles	Los Angeles	0	15	26	73	Yes
20436000	City of Los Angeles	Los Angeles	0	14	25	73	No
21355000	South Bay Cities Association	Carson	0	8	15	73	Yes
21709000	City of Los Angeles	unincorporated	13	14	28	73	Yes
22411000	San Gabriel Valley Association	Pomona	0	8	14	72	Yes
20408000	City of Los Angeles	Los Angeles	1	15	27	72	No
20936000	City of Los Angeles	Los Angeles	0	14	29	72	No
22160000	San Gabriel Valley Association	Pasadena	1	10	21	72	No
21278000	South Bay Cities Association	Torrance	2	14	25	72	No
20218000	Las Virgenes	unincorporated	1	10	21	71	No
21392000	Gateway Cities COG	Long Beach	0	8	16	71	No
21867000	Gateway Cities COG	Whittier	0	7	13	71	Yes
20244000	North Los Angeles County	Santa Clarita	0	12	19	71	No
21075000	City of Los Angeles	Los Angeles	4	12	25	71	Yes
21752000	Gateway Cities COG	Montebello	1	7	14	71	Yes
20528000	City of Los Angeles	Los Angeles	0	13	24	71	Yes
21790000	Gateway Cities COG	Downey	0	7	13	70	No
20865000	City of Los Angeles	Los Angeles	0	14	30	70	No
20894000	Westside Cities	West Hollywood	10	18	39	70	No
21387000	Gateway Cities COG	Long Beach	0	8	15	70	No
20746000	Westside Cities	Santa Monica	5	16	35	70	No
22099000	San Gabriel Valley Association	South Pasadena	0	9	20	70	No
22222000	San Gabriel Valley Association	El Monte	0	7	15	70	Yes
21601000	Gateway Cities COG	Huntington Park	0	7	14	70	Yes
21838000	Gateway Cities COG	Norwalk	0	7	14	69	Yes
21325000	City of Los Angeles	Los Angeles	2	9	16	69	Yes

**eVMT: Potential eVMT Improvement*

Lowest Priority Tier

TAZ ID	Subregion	City	Charging Points	PHEV Commutes	PEV Commutes	eVMT*	DAC
20876000	Westside Cities	Beverly Hills	2	14	30	69	No
20908000	City of Los Angeles	Los Angeles	1	14	30	69	No
22156000	San Gabriel Valley Association	San Gabriel	0	8	18	69	No
22006000	City of Los Angeles	Los Angeles	1	11	22	69	Yes
20758000	Westside Cities	Santa Monica	4	16	35	68	No
21865000	Gateway Cities COG	Whittier	0	7	13	68	Yes
21232000	South Bay Cities Association	Gardena	0	9	17	68	Yes
20483000	City of Los Angeles	Los Angeles	0	14	25	68	No
20233000	North Los Angeles County	unincorporated	0	13	20	68	No
21739000	Gateway Cities COG	Commerce	0	6	12	68	Yes
21122000	City of Los Angeles	Los Angeles	3	12	25	68	No
21304000	City of Los Angeles	Los Angeles	0	9	16	67	No
20504000	City of Los Angeles	Los Angeles	0	13	24	67	No
21715000	Gateway Cities COG	Bell Gardens	0	6	12	67	Yes
21748000	Gateway Cities COG	Montebello	0	7	13	67	Yes
20682000	City of Los Angeles	San Fernando	0	11	20	67	Yes
21131000	South Bay Cities Association	Hermosa Beach	2	16	30	66	No
20880000	Westside Cities	Beverly Hills	0	13	27	66	No
20517000	City of Los Angeles	Los Angeles	0	13	23	66	Yes
21982000	Arroyo Verdugo	Glendale	3	12	23	66	Yes
20761000	Westside Cities	Santa Monica	2	15	33	66	No
20903000	Westside Cities	West Hollywood	7	17	35	66	No

22306000	San Gabriel Valley Association	West Covina	0	7	13	66	Yes
22440000	San Gabriel Valley Association	Pomona	0	7	14	66	Yes
21164000	South Bay Cities Association	Redondo Beach	2	14	27	65	No
20891000	City of Los Angeles	Los Angeles	0	13	28	65	No
22045000	City of Los Angeles	Los Angeles	0	9	19	65	No
20765000	City of Los Angeles	Los Angeles	13	17	35	65	No
21985000	Arroyo Verdugo	Glendale	0	10	21	65	Yes
20623000	City of Los Angeles	Los Angeles	1	13	25	65	No
20479000	City of Los Angeles	Los Angeles	0	13	24	65	No
20988000	City of Los Angeles	Los Angeles	0	11	22	65	No
21785000	Gateway Cities COG	Bellflower	0	7	12	64	No
20664000	City of Los Angeles	Los Angeles	0	14	24	64	No
22032000	City of Los Angeles	Los Angeles	1	9	18	64	Yes
21314000	City of Los Angeles	Los Angeles	1	9	16	64	Yes
22147000	San Gabriel Valley Association	Pasadena	0	9	18	64	No
21695000	Gateway Cities COG	South Gate	0	6	12	63	Yes
22150000	San Gabriel Valley Association	Monterey Park	0	7	13	62	Yes
22231000	San Gabriel Valley Association	unincorporated	1	7	15	62	No
20460000	City of Los Angeles	Los Angeles	0	14	26	62	No
22090000	San Gabriel Valley Association	Pasadena	0	9	18	62	No
21813000	Gateway Cities COG	Norwalk	0	6	12	62	No
21933000	City of Los Angeles	Los Angeles	0	8	17	62	Yes
20403000	City of Los Angeles	Los Angeles	2	13	24	62	No
20415000	City of Los Angeles	Los Angeles	3	13	25	62	No
20534000	City of Los Angeles	Los Angeles	0	13	24	62	Yes
21729000	San Gabriel Valley Association	Monterey Park	0	6	13	62	Yes
20840000	City of Los Angeles	Los Angeles	4	14	30	61	No
20457000	City of Los Angeles	Los Angeles	1	13	22	61	No
21157000	South Bay Cities Association	Redondo Beach	8	15	29	61	No
22041000	City of Los Angeles	Los Angeles	6	12	24	61	No
22350000	San Gabriel Valley Association	Covina	4	9	17	61	Yes
20842000	City of Los Angeles	Los Angeles	3	13	27	61	No
20654000	City of Los Angeles	Los Angeles	0	14	24	61	No
20538000	City of Los Angeles	Los Angeles	0	15	29	61	No
20478000	City of Los Angeles	Los Angeles	3	15	26	61	No
20757000	Westside Cities	Santa Monica	1	12	27	60	No
21825000	Gateway Cities COG	Artesia	0	7	13	60	No
21378000	Gateway Cities COG	Long Beach	0	7	12	60	Yes
21819000	Gateway Cities COG	Santa Fe Springs	0	6	12	60	Yes
21471000	Gateway Cities COG	Long Beach	1	9	16	60	No
22130000	San Gabriel Valley Association	Alhambra	2	9	18	60	Yes
21821000	Gateway Cities COG	Pico Rivera	0	6	11	60	No
22449000	San Gabriel Valley Association	Claremont	0	7	12	59	Yes
20678000	City of Los Angeles	Los Angeles	0	9	15	59	No
20708000	City of Los Angeles	Los Angeles	0	8	14	59	No
22103000	San Gabriel Valley Association	Monterey Park	0	6	13	59	No
22109000	San Gabriel Valley Association	South Pasadena	0	8	18	58	No
21428000	Gateway Cities COG	Long Beach	0	6	11	58	Yes
20497000	City of Los Angeles	Los Angeles	0	13	24	58	Yes
21139000	South Bay Cities Association	Manhattan Beach	0	13	26	58	No
21338000	South Bay Cities Association	Carson	0	7	13	58	No
21176000	South Bay Cities Association	Inglewood	0	8	17	58	Yes
22018000	Arroyo Verdugo	unincorporated	0	8	16	58	No
21486000	Gateway Cities COG	Long Beach	0	7	13	58	No
22403000	San Gabriel Valley Association	unincorporated	0	5	10	58	No
21066000	City of Los Angeles	Los Angeles	0	8	17	58	No
20532000	City of Los Angeles	Los Angeles	3	15	28	58	No
20530000	City of Los Angeles	Los Angeles	0	14	26	58	No
22113000	San Gabriel Valley Association	Pasadena	0	8	16	58	Yes
20739000	City of Los Angeles	Los Angeles	10	15	32	58	No
22317000	San Gabriel Valley Association	Azusa	1	6	11	57	Yes
20913000	City of Los Angeles	Los Angeles	0	11	23	57	No
21938000	City of Los Angeles	Los Angeles	6	10	21	57	Yes
21170000	South Bay Cities Association	Lawndale	1	10	20	57	Yes
21592000	Gateway Cities COG	Huntington Park	0	6	11	57	Yes
21136000	South Bay Cities Association	Redondo Beach	0	11	21	57	No
20696000	City of Los Angeles	San Fernando	0	9	15	57	No
21713000	Gateway Cities COG	South Gate	0	6	10	57	Yes
20897000	Westside Cities	Culver City	0	11	22	57	No

21765000	Gateway Cities COG	Paramount	0	6	11	57	Yes
21239000	South Bay Cities Association	Gardena	0	7	14	57	No
21321000	City of Los Angeles	Los Angeles	1	8	15	57	Yes
21766000	Gateway Cities COG	Paramount	0	6	11	57	Yes
20646000	Arroyo Verdugo	Burbank	1	10	20	56	Yes
21401000	Gateway Cities COG	Long Beach	0	7	12	56	No
21772000	Gateway Cities COG	Downey	1	6	12	56	Yes
21800000	Gateway Cities COG	Cerritos	10	12	21	56	Yes
22138000	San Gabriel Valley Association	Monterey Park	0	6	13	56	Yes
20958000	City of Los Angeles	Los Angeles	2	11	23	56	No
21155000	South Bay Cities Association	Hawthorne	8	14	26	56	No
20476000	City of Los Angeles	Los Angeles	0	12	22	56	No
20900000	City of Los Angeles	Los Angeles	7	15	32	55	No
20586000	City of Los Angeles	Los Angeles	0	12	22	55	Yes
21445000	Gateway Cities COG	Long Beach	0	6	11	55	No
20875000	Westside Cities	Beverly Hills	0	11	23	55	No
20807000	City of Los Angeles	Los Angeles	1	12	24	55	No
20225000	North Los Angeles County	unincorporated	1	9	15	55	No
21050000	City of Los Angeles	Los Angeles	0	8	16	55	No
20994000	City of Los Angeles	Los Angeles	0	8	16	55	Yes
20644000	Arroyo Verdugo	Burbank	14	16	31	55	Yes
20872000	City of Los Angeles	Los Angeles	0	11	22	55	No
20635000	Arroyo Verdugo	Burbank	2	11	20	54	Yes
22327000	San Gabriel Valley Association	unincorporated	0	6	11	54	No
20590000	City of Los Angeles	Los Angeles	1	11	21	54	No
20614000	City of Los Angeles	Los Angeles	1	12	22	54	Yes
22288000	San Gabriel Valley Association	Baldwin Park	0	6	11	54	Yes
20885000	Westside Cities	Culver City	1	10	20	54	No
20630000	Arroyo Verdugo	Burbank	2	11	20	54	No
20771000	City of Los Angeles	Los Angeles	0	11	23	54	No
21275000	South Bay Cities Association	Torrance	2	10	19	54	No
20849000	City of Los Angeles	Los Angeles	0	11	23	54	No
22402000	San Gabriel Valley Association	Glendora	0	6	10	54	No
20874000	City of Los Angeles	Los Angeles	1	11	24	54	No
21749000	Gateway Cities COG	Montebello	0	6	11	53	Yes
22363000	San Gabriel Valley Association	Covina	0	6	11	53	No
20858000	Westside Cities	Culver City	0	11	22	53	No
20713000	City of Los Angeles	Los Angeles	0	8	15	53	Yes
22214000	San Gabriel Valley Association	El Monte	0	6	12	53	Yes
22439000	San Gabriel Valley Association	Pomona	0	6	11	52	Yes
21112000	City of Los Angeles	Los Angeles	0	9	18	52	No
21331000	City of Los Angeles	Los Angeles	0	6	11	52	No
21894000	Gateway Cities COG	La Mirada	0	6	11	52	No
21230000	South Bay Cities Association	Gardena	1	8	15	52	No
22139000	San Gabriel Valley Association	San Marino	0	8	16	52	No
20943000	City of Los Angeles	Los Angeles	0	10	20	52	Yes
21818000	Gateway Cities COG	Norwalk	0	5	10	52	Yes
21446000	Gateway Cities COG	Lakewood	0	6	11	51	No
20674000	City of Los Angeles	Los Angeles	7	12	20	51	No
20308000	North Los Angeles County	Lancaster	0	9	15	51	No
21386000	Gateway Cities COG	Long Beach	1	6	12	51	No
22330000	San Gabriel Valley Association	Covina	0	5	10	51	No
21835000	Gateway Cities COG	Pico Rivera	0	5	10	51	Yes
21156000	City of Los Angeles	Los Angeles	4	11	21	51	No
22158000	San Gabriel Valley Association	San Gabriel	0	6	12	50	Yes
22397000	San Gabriel Valley Association	Industry	10	11	21	50	No
20659000	City of Los Angeles	Los Angeles	2	13	23	50	No
21283000	South Bay Cities Association	Torrance	0	9	16	50	No
21929000	City of Los Angeles	Los Angeles	4	8	16	50	Yes
21109000	City of Los Angeles	Los Angeles	3	8	15	50	Yes
22336000	San Gabriel Valley Association	unincorporated	0	6	10	50	No
20544000	City of Los Angeles	Los Angeles	0	9	17	50	Yes
20759000	City of Los Angeles	Los Angeles	1	12	27	50	No
21158000	South Bay Cities Association	unincorporated	7	11	21	50	Yes
20637000	Arroyo Verdugo	Burbank	0	9	18	50	No
20873000	Westside Cities	Beverly Hills	18	18	39	50	No
21801000	Gateway Cities COG	Pico Rivera	0	5	9	49	Yes
21441000	Gateway Cities COG	Long Beach	1	6	12	49	No
21244000	City of Los Angeles	Los Angeles	3	8	15	49	Yes

22179000	San Gabriel Valley Association	unincorporated	0	7	14	49	No
22371000	San Gabriel Valley Association	unincorporated	0	5	10	49	No
22379000	San Gabriel Valley Association	Diamond Bar	0	6	11	49	No
20253000	North Los Angeles County	Santa Clarita	0	10	15	49	No
21699000	City of Los Angeles	unincorporated	0	6	11	49	Yes
22088000	San Gabriel Valley Association	unincorporated	0	6	13	49	Yes
20642000	Arroyo Verdugo	Burbank	6	12	23	49	Yes
21192000	South Bay Cities Association	Inglewood	0	7	14	49	Yes
22251000	San Gabriel Valley Association	Monrovia	0	5	10	49	No
21360000	City of Los Angeles	Los Angeles	0	5	10	48	Yes
22208000	San Gabriel Valley Association	Sierra Madre	0	7	14	48	No
21247000	City of Los Angeles	Los Angeles	0	6	11	48	Yes
20413000	City of Los Angeles	Los Angeles	0	10	18	48	No
21126000	South Bay Cities Association	Manhattan Beach	0	11	22	48	No
20813000	City of Los Angeles	Los Angeles	3	12	24	48	No
21943000	City of Los Angeles	Los Angeles	0	6	13	48	Yes
22007000	City of Los Angeles	Los Angeles	1	8	17	48	Yes
21405000	Gateway Cities COG	Long Beach	0	6	10	48	No
20263000	North Los Angeles County	Santa Clarita	4	11	17	48	No
21117000	South Bay Cities Association	Manhattan Beach	4	13	25	48	No
21458000	Gateway Cities COG	Long Beach	0	6	11	48	No
21753000	Gateway Cities COG	Montebello	2	6	12	48	Yes
22137000	San Gabriel Valley Association	Pasadena	0	7	14	48	No
22087000	San Gabriel Valley Association	Pasadena	0	7	13	48	Yes
21267000	South Bay Cities Association	Torrance	0	8	16	47	No
21270000	South Bay Cities Association	Torrance	0	8	16	47	No
21728000	Gateway Cities COG	Commerce	4	7	13	47	Yes
20430000	City of Los Angeles	Los Angeles	0	10	18	47	No
21257000	South Bay Cities Association	Palos Verdes Estates	0	9	18	47	No
21738000	Gateway Cities COG	Montebello	2	6	12	47	Yes
20895000	City of Los Angeles	Los Angeles	0	10	20	47	No
20487000	City of Los Angeles	Los Angeles	1	11	20	47	Yes
21454000	Gateway Cities COG	Long Beach	0	7	13	47	No
21918000	City of Los Angeles	Los Angeles	0	7	14	47	Yes
21400000	Gateway Cities COG	Long Beach	6	9	16	47	No
21228000	South Bay Cities Association	Gardena	0	6	12	47	No
20539000	City of Los Angeles	Los Angeles	1	11	20	47	Yes
20573000	City of Los Angeles	Los Angeles	0	11	20	46	No
20547000	City of Los Angeles	Los Angeles	0	10	19	46	Yes
20760000	Westside Cities	Santa Monica	0	10	21	46	No
22220000	San Gabriel Valley Association	Arcadia	0	6	12	46	No
22367000	San Gabriel Valley Association	Covina	0	5	10	46	No
20732000	Las Virgenes	unincorporated	2	5	11	46	No
21313000	City of Los Angeles	Los Angeles	1	6	11	46	No
22042000	City of Los Angeles	Los Angeles	1	8	16	46	No
20420000	City of Los Angeles	Los Angeles	1	9	16	46	No
20928000	City of Los Angeles	Los Angeles	4	10	22	45	No
21406000	Gateway Cities COG	Signal Hill	4	8	14	45	Yes
21092000	City of Los Angeles	Los Angeles	0	7	15	45	Yes
20812000	City of Los Angeles	Los Angeles	0	10	20	45	No
22409000	San Gabriel Valley Association	San Dimas	0	5	9	45	No
21439000	Gateway Cities COG	Lakewood	3	7	13	45	No
22080000	Arroyo Verdugo	La Canada Flintridge	0	7	14	45	No
21939000	City of Los Angeles	Los Angeles	0	6	11	45	Yes
21903000	Gateway Cities COG	La Habra Heights	0	5	10	45	No
20856000	City of Los Angeles	Los Angeles	0	9	20	45	No
21895000	Gateway Cities COG	Whittier	0	5	10	45	No
22175000	San Gabriel Valley Association	Pasadena	0	6	13	45	No
21318000	South Bay Cities Association	unincorporated	0	6	11	45	Yes
20406000	City of Los Angeles	Los Angeles	0	9	17	45	No
22100000	San Gabriel Valley Association	Alhambra	0	6	12	44	No
20424000	City of Los Angeles	Los Angeles	8	13	24	44	No
21124000	South Bay Cities Association	El Segundo	11	12	24	44	No
22073000	City of Los Angeles	Los Angeles	0	5	11	44	Yes
20809000	Westside Cities	Culver City	1	11	22	44	No
20773000	Westside Cities	Santa Monica	0	10	21	44	No
20971000	City of Los Angeles	Los Angeles	1	8	16	44	No
21204000	South Bay Cities Association	unincorporated	0	7	13	44	Yes
21993000	City of Los Angeles	Los Angeles	0	7	15	44	No

21090000	City of Los Angeles	Los Angeles	0	8	16	44	No
21455000	Gateway Cities COG	Long Beach	0	6	11	44	No
21972000	Arroyo Verdugo	Glendale	0	8	15	44	Yes
21975000	City of Los Angeles	Los Angeles	0	8	16	44	No
20864000	City of Los Angeles	Los Angeles	0	9	19	44	No
21824000	Gateway Cities COG	Artesia	0	5	10	44	No
21902000	Gateway Cities COG	Whittier	0	5	9	44	No
21841000	Gateway Cities COG	Cerritos	0	6	10	44	No
21921000	City of Los Angeles	Los Angeles	2	7	14	43	Yes
21229000	South Bay Cities Association	Gardena	0	6	12	43	Yes
21327000	South Bay Cities Association	Carson	0	6	11	43	Yes
21259000	South Bay Cities Association	Rancho Palos Verdes	4	9	17	43	No
20972000	City of Los Angeles	Los Angeles	0	6	13	43	No
22114000	San Gabriel Valley Association	Alhambra	1	6	12	43	No
22167000	San Gabriel Valley Association	San Marino	0	6	13	43	No
21172000	South Bay Cities Association	Hawthorne	0	7	13	43	No
21169000	South Bay Cities Association	Inglewood	2	8	16	43	Yes
21272000	South Bay Cities Association	Torrance	0	8	15	43	No
21930000	City of Los Angeles	Los Angeles	16	13	27	43	Yes
22422000	San Gabriel Valley Association	La Verne	0	5	9	43	No
21859000	Gateway Cities COG	Whittier	8	8	15	42	Yes
20234000	North Los Angeles County	Santa Clarita	0	7	11	42	No
22135000	San Gabriel Valley Association	Alhambra	0	5	11	42	Yes
22413000	San Gabriel Valley Association	San Dimas	1	6	11	42	No
21456000	Gateway Cities COG	Long Beach	0	6	12	42	No
20449000	City of Los Angeles	Los Angeles	0	9	16	42	No
20721000	City of Los Angeles	Los Angeles	0	5	10	42	No
21008000	City of Los Angeles	Los Angeles	0	7	14	42	No
22182000	San Gabriel Valley Association	unincorporated	1	6	11	41	No
21449000	Gateway Cities COG	Long Beach	0	7	12	41	No
21102000	City of Los Angeles	Los Angeles	4	9	19	41	Yes
21277000	South Bay Cities Association	Torrance	0	7	13	41	No
21294000	South Bay Cities Association	Rancho Palos Verdes	0	6	11	41	No
22095000	San Gabriel Valley Association	Pasadena	1	6	13	41	Yes
22001000	Arroyo Verdugo	Glendale	3	8	17	41	Yes
20428000	City of Los Angeles	Los Angeles	0	8	14	41	No
20595000	City of Los Angeles	Los Angeles	4	12	23	41	No
22159000	San Gabriel Valley Association	Pasadena	0	6	12	41	No
21002000	City of Los Angeles	Los Angeles	0	7	15	41	Yes
21024000	City of Los Angeles	Los Angeles	1	7	14	41	Yes
20221000	Las Virgenes	unincorporated	4	9	19	41	No
20474000	City of Los Angeles	Los Angeles	0	9	15	41	No
21794000	Gateway Cities COG	Downey	7	8	15	41	Yes
20502000	City of Los Angeles	Los Angeles	1	9	16	41	Yes
20409000	City of Los Angeles	Los Angeles	2	9	18	41	No
20763000	City of Los Angeles	Los Angeles	2	9	20	41	No
22399000	San Gabriel Valley Association	Diamond Bar	0	6	11	41	No
21179000	South Bay Cities Association	Torrance	1	8	15	41	No
20365000	North Los Angeles County	Palmdale	3	8	13	41	No
21061000	City of Los Angeles	Los Angeles	0	7	15	40	No
21135000	South Bay Cities Association	Redondo Beach	1	9	18	40	No
20881000	Westside Cities	Culver City	1	8	16	40	No
20400000	City of Los Angeles	Los Angeles	0	8	14	40	No
21926000	City of Los Angeles	Los Angeles	0	6	11	40	Yes
20503000	City of Los Angeles	Los Angeles	0	9	16	40	Yes
20600000	City of Los Angeles	Los Angeles	0	8	14	40	Yes
20778000	City of Los Angeles	Los Angeles	0	9	19	40	No
22230000	San Gabriel Valley Association	Arcadia	1	5	11	40	No
21118000	South Bay Cities Association	El Segundo	0	7	13	40	No
20649000	City of Los Angeles	Los Angeles	0	9	16	40	No
20222000	Las Virgenes	Calabasas	2	10	20	40	No
20859000	City of Los Angeles	Los Angeles	0	8	18	40	No
21225000	South Bay Cities Association	Gardena	0	6	11	40	Yes
20553000	City of Los Angeles	Los Angeles	1	9	17	40	No
20878000	Westside Cities	Culver City	0	8	16	39	No
21148000	South Bay Cities Association	Redondo Beach	0	9	16	39	No
21143000	South Bay Cities Association	Redondo Beach	0	9	18	39	No
22172000	San Gabriel Valley Association	San Gabriel	0	5	11	39	No
21236000	South Bay Cities Association	Gardena	1	5	10	39	No

22022000	City of Los Angeles	Los Angeles	1	6	11	39	Yes
21837000	Gateway Cities COG	Cerritos	2	6	11	39	No
22029000	City of Los Angeles	Los Angeles	0	6	13	39	No
21927000	City of Los Angeles	Los Angeles	0	5	11	38	Yes
20866000	Westside Cities	Culver City	0	8	17	38	No
20794000	City of Los Angeles	Los Angeles	4	10	21	38	No
21274000	South Bay Cities Association	Torrance	2	8	14	38	No
21464000	Gateway Cities COG	Long Beach	0	6	10	38	No
22016000	City of Los Angeles	Los Angeles	0	5	11	38	Yes
20663000	City of Los Angeles	Los Angeles	0	9	15	38	No
20937000	City of Los Angeles	Los Angeles	0	8	16	38	No
20921000	City of Los Angeles	Los Angeles	0	8	18	38	No
20802000	City of Los Angeles	Los Angeles	0	9	18	38	No
20411000	City of Los Angeles	Los Angeles	0	8	15	38	No
21951000	City of Los Angeles	Los Angeles	9	9	19	38	Yes
21223000	South Bay Cities Association	Gardena	0	5	10	38	Yes
22079000	Arroyo Verdugo	La Canada Flintridge	2	7	15	38	No
20261000	North Los Angeles County	Santa Clarita	0	7	10	38	No
20417000	City of Los Angeles	Los Angeles	0	8	15	37	No
20535000	City of Los Angeles	Los Angeles	1	9	16	37	Yes
21440000	Gateway Cities COG	Long Beach	0	5	10	37	No
20592000	City of Los Angeles	Los Angeles	0	7	13	37	Yes
20911000	City of Los Angeles	Los Angeles	0	7	15	37	Yes
20748000	Westside Cities	Santa Monica	8	11	24	37	No
21121000	South Bay Cities Association	Manhattan Beach	3	10	21	37	No
20254000	North Los Angeles County	Santa Clarita	0	6	10	37	No
20915000	Westside Cities	West Hollywood	0	8	17	37	No
22082000	San Gabriel Valley Association	Pasadena	2	7	14	37	No
21222000	South Bay Cities Association	Torrance	0	6	11	37	Yes
22124000	San Gabriel Valley Association	Alhambra	2	6	12	37	No
20236000	North Los Angeles County	Santa Clarita	0	6	10	37	No
21186000	South Bay Cities Association	Lawndale	5	8	16	37	Yes
20919000	City of Los Angeles	Los Angeles	0	7	15	36	Yes
20855000	Westside Cities	Beverly Hills	12	12	27	36	No
20602000	City of Los Angeles	Los Angeles	0	6	12	36	Yes
20584000	City of Los Angeles	Los Angeles	0	8	15	36	No
21308000	City of Los Angeles	Los Angeles	0	5	9	36	Yes
22424000	San Gabriel Valley Association	La Verne	2	6	10	36	No
21457000	Gateway Cities COG	Long Beach	1	6	11	36	No
21932000	City of Los Angeles	Los Angeles	0	5	11	36	Yes
21956000	Arroyo Verdugo	Glendale	0	6	12	36	Yes
21925000	City of Los Angeles	Los Angeles	0	5	11	36	Yes
20814000	City of Los Angeles	Los Angeles	0	8	16	35	No
20835000	City of Los Angeles	Los Angeles	11	12	26	35	No
20260000	North Los Angeles County	Santa Clarita	0	7	11	35	No
20512000	City of Los Angeles	Los Angeles	0	8	14	35	Yes
20255000	North Los Angeles County	Santa Clarita	0	7	10	35	No
20257000	North Los Angeles County	Santa Clarita	0	6	10	35	No
21289000	South Bay Cities Association	Lomita	0	6	12	35	No
20697000	City of Los Angeles	Los Angeles	0	6	10	35	Yes
21941000	City of Los Angeles	Los Angeles	3	6	12	35	Yes
20554000	City of Los Angeles	Los Angeles	0	7	13	35	No
20714000	City of Los Angeles	Los Angeles	0	5	9	35	Yes
20465000	City of Los Angeles	Los Angeles	0	8	15	35	No
21133000	South Bay Cities Association	Hermosa Beach	2	10	20	35	No
21482000	Gateway Cities COG	Long Beach	0	5	9	35	No
20788000	City of Los Angeles	Los Angeles	0	8	17	35	No
20916000	City of Los Angeles	Los Angeles	0	7	15	35	No
20625000	Arroyo Verdugo	Burbank	2	8	14	35	No
20912000	City of Los Angeles	Los Angeles	1	7	14	35	Yes
20572000	City of Los Angeles	Los Angeles	0	8	16	35	No
21767000	Gateway Cities COG	Downey	3	5	9	35	Yes
20548000	City of Los Angeles	Los Angeles	0	7	13	34	Yes
20888000	City of Los Angeles	Los Angeles	0	7	15	34	No
22014000	City of Los Angeles	Los Angeles	0	6	12	34	Yes
20516000	City of Los Angeles	Los Angeles	0	7	13	34	No
21152000	City of Los Angeles	Los Angeles	0	6	12	34	No
21065000	City of Los Angeles	Los Angeles	0	5	11	34	Yes
20563000	City of Los Angeles	Los Angeles	0	9	17	34	No

20488000	City of Los Angeles	Los Angeles	0	8	14	34	No
20585000	City of Los Angeles	Los Angeles	0	7	13	34	Yes
20594000	City of Los Angeles	Los Angeles	0	6	11	34	Yes
21296000	South Bay Cities Association	Lomita	0	5	10	34	No
22236000	San Gabriel Valley Association	El Monte	3	5	10	34	Yes
20698000	City of Los Angeles	Los Angeles	0	6	10	34	Yes
22021000	Arroyo Verdugo	Glendale	2	7	14	34	No
20518000	City of Los Angeles	Los Angeles	9	12	22	34	Yes
20437000	City of Los Angeles	Los Angeles	0	7	13	33	No
20470000	City of Los Angeles	Los Angeles	0	7	13	33	No
22331000	San Gabriel Valley Association	Azusa	3	5	9	33	Yes
20692000	City of Los Angeles	Los Angeles	0	5	10	33	Yes
22415000	San Gabriel Valley Association	San Dimas	3	5	10	33	No
20844000	City of Los Angeles	Los Angeles	8	10	22	33	No
22192000	San Gabriel Valley Association	Temple City	2	5	11	33	Yes
21191000	South Bay Cities Association	Inglewood	0	5	10	33	No
21970000	Arroyo Verdugo	Glendale	0	6	12	33	No
20438000	City of Los Angeles	Los Angeles	0	7	13	33	No
20628000	Arroyo Verdugo	Burbank	0	7	14	33	No
22083000	San Gabriel Valley Association	Pasadena	0	5	11	33	No
21188000	South Bay Cities Association	Hawthorne	0	5	10	32	No
20966000	City of Los Angeles	Los Angeles	5	8	17	32	No
20495000	City of Los Angeles	Los Angeles	0	8	14	32	No
20938000	City of Los Angeles	Los Angeles	0	6	14	32	No
20597000	City of Los Angeles	Los Angeles	0	7	14	32	No
20886000	City of Los Angeles	Los Angeles	5	9	20	32	No
22028000	Arroyo Verdugo	unincorporated	0	5	10	32	No
20960000	City of Los Angeles	Los Angeles	0	5	10	32	No
21979000	City of Los Angeles	Los Angeles	0	6	11	32	Yes
20752000	Westside Cities	Santa Monica	3	9	19	31	No
20593000	City of Los Angeles	Los Angeles	0	6	11	31	Yes
20443000	City of Los Angeles	Los Angeles	0	7	13	31	No
21258000	South Bay Cities Association	Rancho Palos Verdes	0	6	11	31	No
20404000	City of Los Angeles	Los Angeles	0	7	13	31	No
20962000	City of Los Angeles	Los Angeles	0	5	10	31	No
20557000	City of Los Angeles	Los Angeles	0	8	15	31	No
20744000	Westside Cities	Santa Monica	1	8	18	31	No
21969000	Arroyo Verdugo	Glendale	0	6	11	31	Yes
22393000	San Gabriel Valley Association	Diamond Bar	5	6	13	31	No
20610000	City of Los Angeles	Los Angeles	0	6	11	31	Yes
20803000	City of Los Angeles	Los Angeles	0	7	15	31	No
20890000	City of Los Angeles	Los Angeles	2	7	15	31	No
21149000	South Bay Cities Association	Redondo Beach	0	7	14	31	No
20472000	City of Los Angeles	Los Angeles	1	8	14	31	Yes
20808000	City of Los Angeles	Los Angeles	0	6	13	31	No
20611000	City of Los Angeles	Los Angeles	4	9	17	31	No
21178000	South Bay Cities Association	Inglewood	0	5	10	31	No
20806000	City of Los Angeles	Los Angeles	1	7	15	31	No
20740000	City of Los Angeles	Los Angeles	0	8	18	31	No
20992000	City of Los Angeles	Los Angeles	0	5	11	31	No
22002000	Arroyo Verdugo	Glendale	4	7	14	31	Yes
20531000	City of Los Angeles	Los Angeles	0	7	13	30	Yes
20925000	City of Los Angeles	Los Angeles	0	6	13	30	Yes
21997000	Arroyo Verdugo	Glendale	1	5	9	30	No
20768000	City of Los Angeles	Los Angeles	4	8	18	30	No
20948000	City of Los Angeles	Los Angeles	0	5	11	30	Yes
20569000	City of Los Angeles	Los Angeles	5	9	17	30	No
20665000	City of Los Angeles	Los Angeles	0	6	11	30	No
21287000	South Bay Cities Association	Torrance	0	5	9	30	No
21305000	City of Los Angeles	Los Angeles	1	5	10	30	Yes
20829000	City of Los Angeles	Los Angeles	0	6	13	30	No
20720000	City of Los Angeles	Los Angeles	1	5	10	30	No
20361000	North Los Angeles County	Palmdale	0	5	8	30	No
21271000	South Bay Cities Association	Torrance	0	6	11	29	No
21140000	South Bay Cities Association	Manhattan Beach	1	8	15	29	No
21761000	Gateway Cities COG	Downey	5	5	10	29	Yes
20719000	City of Los Angeles	Los Angeles	0	5	10	29	No
20252000	North Los Angeles County	Santa Clarita	1	6	9	29	No
20949000	City of Los Angeles	Los Angeles	0	6	13	29	No

21999000	Arroyo Verdugo	Glendale	2	6	12	29	Yes
21174000	South Bay Cities Association	Hawthorne	0	5	10	29	No
20546000	City of Los Angeles	Los Angeles	0	7	14	29	No
21590000	City of Los Angeles	Los Angeles	4	5	11	29	Yes
20669000	City of Los Angeles	Los Angeles	2	7	12	29	No
20676000	City of Los Angeles	Los Angeles	0	5	9	29	Yes
22023000	Arroyo Verdugo	Glendale	0	5	10	29	Yes
20638000	Arroyo Verdugo	Burbank	2	7	12	29	No
20309000	North Los Angeles County	Lancaster	1	6	9	29	No
20904000	City of Los Angeles	Los Angeles	1	7	14	29	No
20924000	Westside Cities	unincorporated	0	5	10	29	No
21966000	City of Los Angeles	Los Angeles	0	5	11	29	No
20295000	North Los Angeles County	Lancaster	4	7	11	28	No
21987000	Arroyo Verdugo	Glendale	0	5	10	28	No
20827000	City of Los Angeles	Los Angeles	1	7	13	28	Yes
21957000	City of Los Angeles	Los Angeles	8	9	18	28	No
20969000	City of Los Angeles	Los Angeles	2	6	13	28	Yes
21981000	Arroyo Verdugo	Glendale	4	7	14	28	Yes
20536000	City of Los Angeles	Los Angeles	0	6	10	28	Yes
20452000	City of Los Angeles	Los Angeles	0	6	12	28	No
22015000	Arroyo Verdugo	unincorporated	1	5	10	28	No
21128000	South Bay Cities Association	Manhattan Beach	0	8	16	28	No
20783000	City of Los Angeles	Los Angeles	0	7	15	28	No
20485000	City of Los Angeles	Los Angeles	2	8	15	28	No
20549000	City of Los Angeles	Los Angeles	2	7	12	28	Yes
20821000	City of Los Angeles	Los Angeles	0	6	13	27	No
20619000	City of Los Angeles	Los Angeles	0	6	11	27	No
20933000	City of Los Angeles	Los Angeles	1	5	11	27	Yes
20575000	City of Los Angeles	Los Angeles	0	7	14	27	No
20519000	City of Los Angeles	Los Angeles	1	6	11	27	Yes
20670000	City of Los Angeles	Los Angeles	0	6	10	27	No
21285000	South Bay Cities Association	Torrance	1	5	10	27	No
21163000	South Bay Cities Association	Redondo Beach	0	6	12	27	No
20609000	City of Los Angeles	Los Angeles	3	8	16	27	No
20596000	City of Los Angeles	Los Angeles	1	8	15	27	No
20781000	City of Los Angeles	Los Angeles	0	6	14	27	No
21127000	South Bay Cities Association	Hermosa Beach	6	10	19	27	No
20826000	City of Los Angeles	Los Angeles	0	6	12	27	No
20607000	City of Los Angeles	Los Angeles	0	5	9	27	Yes
20484000	City of Los Angeles	Los Angeles	1	7	12	27	No
21010000	City of Los Angeles	Los Angeles	0	5	11	27	Yes
20792000	Westside Cities	unincorporated	0	6	13	27	Yes
21145000	South Bay Cities Association	Redondo Beach	0	7	14	26	No
20772000	City of Los Angeles	Los Angeles	0	6	14	26	No
20490000	City of Los Angeles	Los Angeles	0	7	13	26	No
20860000	Westside Cities	Culver City	0	6	12	26	No
20414000	City of Los Angeles	Los Angeles	0	5	9	26	No
20627000	Arroyo Verdugo	Burbank	0	6	11	26	No
20823000	City of Los Angeles	Los Angeles	0	6	12	26	No
20521000	City of Los Angeles	Los Angeles	0	5	9	26	Yes
20631000	Arroyo Verdugo	Burbank	2	7	13	26	No
20486000	City of Los Angeles	Los Angeles	0	6	11	26	Yes
20673000	City of Los Angeles	Los Angeles	0	5	9	26	No
21279000	South Bay Cities Association	Rolling Hills Estates	0	5	10	26	No
21952000	City of Los Angeles	Los Angeles	8	7	15	26	Yes
20892000	City of Los Angeles	Los Angeles	0	6	12	25	No
20467000	City of Los Angeles	Los Angeles	0	6	10	25	No
20793000	City of Los Angeles	Los Angeles	0	6	13	25	No
20489000	City of Los Angeles	Los Angeles	0	7	12	25	No
20589000	City of Los Angeles	Los Angeles	2	7	13	25	No
20745000	City of Los Angeles	Los Angeles	4	7	17	25	No
20505000	City of Los Angeles	Los Angeles	2	7	13	25	No
20909000	City of Los Angeles	Los Angeles	0	5	11	25	No
20426000	City of Los Angeles	Los Angeles	0	5	10	24	No
20601000	City of Los Angeles	Los Angeles	1	5	9	24	Yes
20751000	City of Los Angeles	Los Angeles	3	6	14	24	No
20747000	Westside Cities	Santa Monica	0	6	14	24	No
21260000	South Bay Cities Association	Torrance	1	5	10	24	No
20789000	City of Los Angeles	Los Angeles	5	7	16	24	No

22282000	San Gabriel Valley Association	Baldwin Park	6	5	10	24	Yes
20265000	North Los Angeles County	Santa Clarita	2	5	9	23	No
20421000	City of Los Angeles	Los Angeles	0	5	9	23	No
20468000	City of Los Angeles	Los Angeles	0	5	9	23	No
20968000	City of Los Angeles	Los Angeles	2	5	11	23	Yes
20668000	City of Los Angeles	Los Angeles	0	5	9	23	No
20811000	City of Los Angeles	Los Angeles	0	6	12	23	No
20833000	City of Los Angeles	Los Angeles	4	6	14	23	No
20907000	City of Los Angeles	Los Angeles	0	5	11	23	No
20599000	City of Los Angeles	Los Angeles	0	5	9	23	Yes
20507000	City of Los Angeles	Los Angeles	0	5	9	23	No
2.20E+07	Arroyo Verdugo	Glendale	3	6	12	22	Yes
20822000	City of Los Angeles	Los Angeles	6	7	15	22	No
20598000	City of Los Angeles	Los Angeles	0	5	10	22	No
21249000	South Bay Cities Association	Palos Verdes Estates	0	5	9	22	No
20578000	City of Los Angeles	Los Angeles	0	6	10	22	No
20634000	Arroyo Verdugo	Burbank	0	5	10	22	No
20851000	City of Los Angeles	Los Angeles	1	5	11	22	No
20820000	City of Los Angeles	Los Angeles	0	5	11	22	No
20498000	City of Los Angeles	Los Angeles	0	5	9	21	No
20750000	Westside Cities	Santa Monica	0	6	13	21	No
20838000	City of Los Angeles	Los Angeles	0	6	14	20	No
21350000	South Bay Cities Association	Carson	8	6	12	20	Yes
20657000	City of Los Angeles	Los Angeles	0	5	9	20	No
20920000	City of Los Angeles	Los Angeles	0	6	15	19	No
20615000	City of Los Angeles	Los Angeles	3	6	12	19	No
20581000	City of Los Angeles	Los Angeles	0	5	10	19	No
20800000	City of Los Angeles	Los Angeles	0	5	11	19	No
20798000	City of Los Angeles	Los Angeles	0	5	11	19	No
20901000	Westside Cities	unincorporated	11	8	17	17	No
22312000	San Gabriel Valley Association	unincorporated	8	6	11	16	Yes
20780000	Westside Cities	Santa Monica	4	6	12	16	No
20591000	City of Los Angeles	Los Angeles	4	5	9	13	Yes
20834000	City of Los Angeles	Los Angeles	6	5	11	12	No
20879000	Westside Cities	Culver City	16	10	20	12	No
20307000	North Los Angeles County	Lancaster	5	5	8	11	No
20784000	City of Los Angeles	Los Angeles	10	6	14	7	No
20672000	City of Los Angeles	Los Angeles	16	10	18	5	Yes

**eVMT: Potential eVMT Improvement*

Appendix C: Marginal Productivity and Sensitivity Analysis

The marginal productivity criterion measures the expected eVMT increase the installation of a single additional charging point. This provides an estimate for the public return on investment for each individual location.

Methodology for Calculating Marginal Productivity of an Additional Charger

We divide the total potential eVMT improvement by the number of plug-in hybrids that do not have access to a charger in that zone. This provides us with the potential eVMT improvement per plug-in hybrid that does not have access to a charger in that zone.

We then multiply this by the probability that a plug-in hybrid will use this additional charger. We assume that a plug-in hybrid and a BEV in the same zone have an equal chance of using that charger and the same willingness to charge. We use the ratio of plug-in hybrids to PEVs as the probability of a plug-in hybrid using that charger. For example, if there is one plug-in hybrid and one BEV in a zone, the probability of plug-in hybrid to use this charger is 0.5. If the plug-in hybrid has a potential of generating 10 eVMT, the expected marginal effect is 10 eVMT multiplied by 0.5, or 5 eVMT.

$$\text{Ratio}_j = \frac{k(j)}{\sum_{i=1}^{All\ Zone}\{n(i,j) + nb(i,j)\}}$$

$$\text{Probability} = \left(\frac{\sum_{i=1}^{All\ Zone} n(i,j)}{\sum_{i=1}^{All\ Zone}\{n(i,j) + nb(i,j)\}}\right)$$

$$\text{Marginal Productivity}_\text{j} = \frac{\text{eVMT}_j}{\{\sum_{i=1}^{All\ Zone} n(i,j)\} * (1 - Ratio_j)} * \text{Probability}$$

Where:

- *n(i,j)* is the plug-in hybrid (PHEV) trips from zone i to zone j;
- $n_b(i,j)$ is the BEV trips from zone i to zone j;
- and *k(j)* is the number of charging points in destination zone j.

Sensitivity Analysis

We conduct a sensitivity analysis to determine the impact of including marginal productivity on our results with two different weights.

We create an index to rank all destination zones in Los Angeles County with both potential eVMT improvement and marginal productivity. This index is the weighted sum of each destination zone's standardized score for each criterion. Each destination zone is assigned a z-score, which indicates the number of standard deviations that the value of the criteria is away from the mean. We re-rank all zones based on the index score and see how weight affect the results.

Marginal Productivity Index Weighted at 0.1

We first weight total potential eVMT improvement at 0.9 and marginal productivity at 0.1. Using these weights, the ranking and distribution of zones among tiers only slightly changes. 93% of zones did not change tiers. Zones in Tier 1 do not change and only two zones in Tier 3 move to Tier 2.

The Number of Zones That Changed Tier with a Weight of 0.1

Change in Tier	Number in Tier	Percentage
Unchanged	846	93 %
Moved to Lower Tier	15	2 %
Moved to Higher Tier	44	5 %

Marginal Productivity Index Weighted at 0.5

We then see the impact of weighting total potential eVMT improvement and marginal productivity equally (0.5 for both). In this scenario, more than half of the zones change tiers. Importantly, the number of the zones within each tier also changes notably. For example, the lowest priority tier sees a decrease in zones from 543 to 285.

The Number of Zones That Changed Tier with a Weight of 0.5

Change in Tier	Number in Tier	Percentage
Unchanged	399	44 %
Moved to Lower Tier	18	2 %
Moved to Higher Tier	488	54 %

Result of Sensitivity Analysis

As a result of this analysis, we can say that including the marginal productivity for the purpose of being a tiebreaker, or when weighting this criterion low, between zones with similar total eVMT potential has a small effect on our results. However, if marginal productivity is weighted more, there would be a larger impact on the ranking of zones and their groupings into tiers.

Summary of Sensitivity Analysis

Priority Tier	Only Including Potential eVMT Improvement	Marginal Productivity Weighted at 0.1	Marginal Productivity Weighted at 0.5
Highest	9	9	34
High	28	30	124
Medium	85	88	205
Low	240	257	257
Lowest	543	521	285

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