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SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Southern California Plug-in Electric Vehicle Readiness Plan

Prepared for the Southern California Association of Governments

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Southern California Plug-in Electric Vehicle Readiness Plan

About this Document

This document was prepared for the Southern California Association of Governments (SCAG) by the UCLA Luskin Center for Innovation. It constitutes Deliverable 10 of SCAG contract 12-021-C1 to support regional planning for plug-in electric vehicle (PEV) adoption. SCAG is coordinating a multi-stakeholder group of government agencies, utilities, and university researchers to prepare multi-faceted and interdisciplinary regional PEV readiness plans. Among other purposes, these plans will help illuminate and guide strategic infrastructure investment, PEV-related economic development, and supportive policy design in Southern California.

Disclaimer

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Southern California
Plug-in Electric Vehicle Readiness Plan

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Southern California Plug-in Electric Vehicle Readiness Plan

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1 Introduction

Every day, more and more plug-in electric vehicles (PEVs) can be spotted on the roads of Southern California. High gasoline prices, state zero emission vehicle programs, federal fuel economy and vehicle emissions standards, improved battery technology, and concerns over climate change and energy security have created a growing market for PEVs.

PEVs provide many benefits to different stakeholders. For drivers, PEVs are a way to save money on fuel, avoid trips to the gasoline station, contribute to energy independence, and improve air quality. For utilities, PEVs represent a new source of demand for power. For state air-quality regulators, PEVs help reduce criteria air pollutants and greenhouse gas (GHG) emissions.

Planners have a key role to play in facilitating the transition to PEVs as one of many sustainable modes of transportation. By helping create opportunities to charge at drivers' daily destinations, such as home, work, and retail centers, planners will lead the way in making PEV charging convenient and cost-efficient.

To play this new role, planners must understand new dynamics created by PEVs as well as effectively employ traditional planning tools. This Southern California Regional PEV Readiness Plan will enable planners to understand:

- Where PEVs are being driven across the region and how many more will be on local roads in order to prioritize and target planning efforts
- The travel patterns and charging needs of PEV drivers to facilitate the siting of charging opportunities that support drivers' daily travel
- The challenges of creating charging opportunities at residences, workplaces, and retail centers in order to better design technical assistance, and
- How zoning, building codes, permitting and parking regulations can drive down the soft and hard costs of charging equipment installation

In addition, this plan also provides practical planning guidance on:

- Permitting and inspecting PEV charging equipment cost-effectively
- Making building and zoning codes PEV-ready
- Regulating parking and signage for PEV charging
- Incentivizing new development to provide wiring and/or hardware for PEV charging
- Siting and pricing charging stations on public property
- Designing and providing technical assistance to commercial property owners, employers and owners of multi-unit dwellings (MUDs)
- Designing supportive utility polices, and
- Developing outreach to prospective PEV drivers and charge station site hosts

1.1 How to use this Plan

PEV planning carries with it several challenges. These include estimating how many PEVs will be driven in a given area; prioritizing PEV efforts for individual jurisdictions and land uses; and maximizing the number of electric miles driven at the lowest possible cost and at maximum convenience for drivers.

The chapters in this document help planners meet these challenges with the following tools:

- Chapter 2 and Chapter 3 provide **basic knowledge about PEVs**, types of charging, and the ecosystem of stakeholders that support PEV readiness.
- Chapter 4 introduces methods of **assessing the local land use mix** and prioritizing the dominant land uses for targeted PEV readiness efforts.
- Chapter 5, Chapter 6, Chapter 7, and Chapter 8 feature **siting support** methods for PEV charging at single-family homes, multi-unit dwellings, workplaces, retail, and public-sector locations.
- Chapter 9 discusses **financial viability**, including pricing and cost models for charge station hosts and drivers.
- Chapter 10, Chapter 11, Chapter 12, and Chapter 13 describe **measures that drive down the hard and soft costs** of installing PEV charging. These include zoning ordinances, building codes, permit and inspection streamlining, and parking policies.
- Chapter 14 evaluates PEV readiness at **utilities** in the SCAG region.
- Chapter 15 guides **outreach** efforts to stakeholders in single-family homes, multi-unit dwellings, workplaces and retail properties.

1.2 The Southern California Plug-in Electric Vehicle Atlas

For the first time, local planners can see **how many PEVs are registered locally** and in **what neighborhoods** PEV registrations are concentrated. The Southern California Plug-in Electric Vehicle Atlas also provides projections of PEV growth over time by council of government (COG).

Using the Southern California Association of Governments' regional travel model, local planners can also see predictions of PEV daytime travel to employment and retail destinations. For each of the 15 COGs that comprise the SCAG area, the Southern California Plug-in Electric Vehicle Atlas features the following tools:

1. A table and graph forecasting PEV growth to 2022
2. A map of neighborhood PEV registration density as of 2012
3. A map of PEV morning travel to work, providing spatial daytime PEV density
4. A map of employment centers identified by numbers of employees
5. A map overlaying employment centers on daytime PEV density
6. A map of publicly-accessible charging locations, identified by power level and number of stations per location
7. A map of multi-unit residences by number of units and density
8. A map of retail destinations, from older strip development to regional centers
9. A map overlaying retail centers on PEV mid-day travel, providing spatial retail PEV density
10. A map of stand-alone parking facilities

The Atlas provides this suite of spatial tools for PEV readiness planning for the following COGs:

Arroyo Verdugo Subregion
City of Los Angeles
Coachella Valley Association of Governments
Gateway Cities Council of Governments
Imperial County Transportation Commission
Las Virgenes Malibu Council of Governments
North Los Angeles County
Orange County Council of Governments
San Bernardino Associated Governments
San Fernando Valley Council of Governments
San Gabriel Valley Council of Governments
South Bay Cities Council of Governments
Ventura County Council of Governments
Western Riverside Council of Governments
Westside Cities Council of Governments

1.3 Utility PEV growth projections

The Southern California Plug-in Electric Vehicle Atlas also provides projections of annual PEV growth over 10 years by utility service territory for the following utilities[1]:

- Azusa Light and Power
- Burbank Water and Power
- Cerritos Electric Utility
- Glendale Water and Power
- Pasadena Water and Power
- Vernon Light and Power
- Anaheim Public Utilities Department
- City of Banning Electric Utility
- City of Colton Utilities Services
- Imperial Irrigation District
- Los Angeles Department of Water and Power
- Riverside Public Utilities
- Southern California Edison
- Anza Electric Cooperative
- City of Industry Electric Utility Service
- Moreno Valley Electric Utility
- Rancho Cucamonga Municipal Utility
- San Diego Gas & Electric (portion within SCAG)

These projections are designed to help regional planners and utilities locate current and future demand for PEV charging and coordinate efforts to meet that demand.

1 Utilities not represented by the Southern California Public Power Authority and that have less than 2 PEVs attributable to their service territories have been excluded from this analysis. They are Bear Valley Electrical Service, Corona Water and Power, Needles Public Utility Authority, and Victorville Municipal Utility Services.

2 The PEV Ecosystem

2.1 Introduction

Cities, counties, and regions have a stake in the successful deployment of plug-in electric vehicles (PEVs). As highlighted in the previous chapter, PEVs can help lower greenhouse gas emissions, improve air quality, increase electric grid efficiency, and reduce fuel costs. The extent of PEV deployment, however, will depend in part on how effectively PEV infrastructure is planned.

This chapter serves to help planners understand the landscape of PEV planning by exploring the "ecosystem" of PEV stakeholders whose actions shape the technology's viability and success. These stakeholders include consumers, manufacturers, installers, utilities, property owners, network service providers, employers, retailers, and different levels of government. The chapter will discuss the roles and choices of these stakeholders, organized by the stage of PEV experience in which they are involved.

2.2 Shopping for a PEV

For many drivers, their first exposure to PEVs will be at the consumer level, when shopping for a new vehicle and a PEV becomes a viable alternative. **Consumers** will consider a number of factors, including vehicle attributes like price, overall range, charge time, and whether to go for a full battery electric vehicle (BEV) or a plug-in hybrid (PHEV). But the decisions they ultimately make will also reflect available infrastructure, land use, and public policy.

For example, commute distance and the availability of workplace charging will help to determine the electric range needed by a consumer. The availability of residential, workplace and public charging stations may help to negate "range anxiety" when considering a BEV, or "gas anxiety" when considering a PHEV, and tip a decision in favor of one vehicle or the other.[2] The price of electricity relative to that of gasoline and the availability of incentives will

2 Range anxiety is the fear that a BEV has insufficient range to reach its destination. Gas anxiety is the fear that a PHEV will have to run on gasoline once the electric range has been depleted.

help consumers assess the private costs and benefits of a PEV relative to a traditional vehicle. Housing type will often determine access to reliable charging at home. Many of these non-vehicle attributes that consumers consider are shaped by planners and policymakers in cities, counties, and regions. Consequently, their role in facilitating and planning for infrastructure has a significant effect on the amount of electric miles driven and greenhouse gas emissions reduced.

Much like with consumers, **manufacturers of PEVs** also respond to the changing policy and planning landscape. Automakers plan, design, engineer, manufacture, and market PEVs based on anticipated consumer demand given expected levels of infrastructure, incentives, and fuel prices, as well as regulation and the availability of technology. For example, in response to the high cost of batteries and the scarcity of public charging infrastructure, both of which limited the success of first-generation BEVs, manufacturers introduced the plug-in hybrid, which offers a smaller battery for electric driving and a gasoline engine to address range anxiety. PHEVs now represent two-thirds of PEVs sold in the U.S. since December 2010, when the Chevrolet Volt and Nissan LEAF were introduced. Manufacturers realize the importance of coordinating with planners, policymakers, utilities, and charge providers so that policy and infrastructure support the current and future supply of these vehicles.

2.3 Refueling at single-family homes

Because electricity is readily accessible from the grid and because it is more cost-effective to charge over a period of hours rather than minutes, most PEV drivers who live in single-family homes find it ideal to charge slowly overnight and incorporate the process into their daily routine. In contrast to the short and irregular pit stops needed to refuel a conventional vehicle, this home-based framework takes advantage of the fact that most cars spend a lot of idle time parked.

If a convenient outlet is available, most PEVs (and in particular PHEVs) can be charged overnight with no special equipment by using the portable cordset included with the car. However, some PEV owners may need or want to incorporate dedicated electric vehicle supply equipment (EVSE) that allows for quicker charging. There are presently a number of **EVSE manufacturers** that fill this need, including those with automaker contracts to supply and install EVSE for a fee (e.g., AeroVironment, SPX, and Leviton for Nissan, GM, and Toyota/Ford, respectively), as well as those who have received U.S. Department of Energy grants to supply and install home EVSE at no cost to select consumers: ECOtality (EV Project) and Coulomb Technologies (ChargePoint America program). EVSE manufacturers also sell home charging equipment online and at big box retailers, from which consumers can purchase the equipment for installation through their own electrician. Licensed **charge station installers**, who typically interact with planners on behalf of consumers, should be aware of relevant local building codes, permitting processes, and installation best practices relating to EVSE.

Utilities are clearly a key stakeholder in the deployment of PEVs, as they will be directly affected by the changes in electrical load as a result of PEV charging. Although nighttime off-peak charging will help to increase grid efficiency and revenue for utilities, daytime on-peak charging can be highly demanding on the grid, particularly if provided at high power to shorten charging times. With single-family refueling, on-peak charging is less of an issue because most consumers charge overnight. This is because some utilities incentivize efficient charging behavior by offering time-of-use rates that make off-peak charging cheaper and on-peak charging more expensive. These strategies will help utilities anticipate, plan, and manage electricity loads.

The PEV ecosystem described thus far is illustrated in Figure 2.1.

Figure 2.1: The PEV ecosystem for single-family homes

2.4 Refueling at multi-unit dwellings

For residents living in multi-unit dwelling (MUD) environments, charging can present a unique set of challenges. These range from physical limitations that make EVSE installation difficult to disagreements as to who should assume responsibility for EVSE costs. Yet a large portion of Southern Californians live in MUDs. As such, **property owners and managers** of MUDs play an important role in facilitating the deployment of PEVs, and thoughtful planning can help them be responsive to PEV charging requests from residents.

The level of involvement for this stakeholder group will vary depending on context. For example, residents with their own EVSE may need special parking and electricity metering arrangements from their utility and property manager. Property owners may also find it prudent to invest in shared charging stations that can help make their buildings more attractive. Property owners and managers will need to work out how such EVSE installations will be funded and determine the policies on which they operate.

Owners and property managers may choose to contract with **network service providers**, also known as **electric vehicle service providers (EVSPs)**, to provide shared charging stations. Charging networks such as Coulomb's ChargePoint Network and ECOtality's Blink Network provide nationwide access to stations with a consistent method of payment and access.

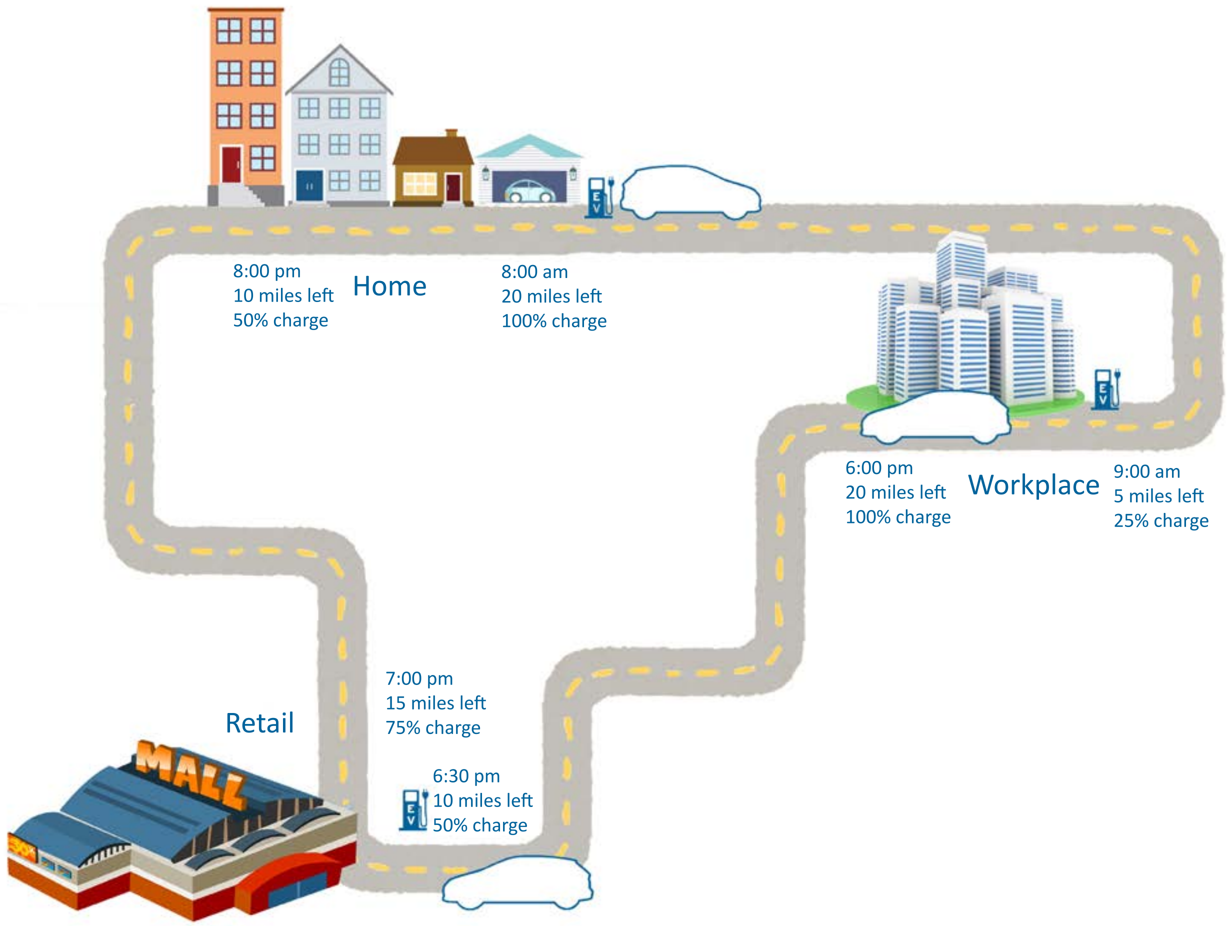
2.5 Refueling at workplaces, retail, and public places

Access to charging at work, while shopping, and in other environments outside the home helps keep PEV batteries topped off, which will minimize range anxiety with BEVs and maximize electric miles driven with PHEVs.

By offering workplace charging, **employers** can help enhance the user experience of PEVs. Workplace charging provides BEV drivers with greater confidence that they will make the return trip home. Likewise, workplace charging would allow a driver of a 20-mile range PHEV and a 40-mile round-trip commute to drive entirely on electricity. Providing a charging station at work may also help with corporate branding, fleet cost savings, and employee retention. **Retailers**, too, may find it prudent to offer PEV charging to shoppers, with the benefits of customer attraction and user fees generated possibly outweighing the costs of hardware, installation, and maintenance.

Figure 2.2 illustrates the role of residential, workplace, and retail charging in the daily commute.

Figure 2.2: The Role of Charging in the Daily Commute



2.6 The role of government

As indicated earlier, plans and policies have a significant effect on the level of PEV deployment, electric miles driven, and greenhouse gas emissions reduced. Changes to different municipal procedures can help to enhance the PEV user experience and increase the likelihood of PEV adoption. Cities, regions, and states themselves can also buy PEVs and build charging infrastructure for use by the public.

Cities and counties can provide guidance for the siting, operations, and maintenance of public chargers. Changes to zoning and building codes, streamlining the permitting and inspection process, and managing access to charging through signage, parking and pricing policies can help facilitate EVSE installation. Local governments can provide incentives such as rebates for PEV and EVSE purchase, parking privileges, and discounted time-of-use rates for charging (for municipally-owned utilities). Existing incentives and policies for single-family homes can be extended for multi-unit dwellings. Local governments can also target not only drivers, but workplace and retail site hosts.

Regional governments can also be involved by helping to plan PEV infrastructure. Councils of government, air-quality management districts (AQMDs) and metropolitan planning organizations all have a stake in supplying technical assistance to cities that advance subregional PEV readiness. They can also assist in the deployment of quick charging stations that allow for inter-regional PEV travel.

State and federal government can provide incentives that encourage PEV adoption and use. Various subsidies from states and the federal government have helped to reduce the costs of PEV ownership.

The following chart summarizes the types of policies available to California drivers that incentivize PEV purchasing and refueling.

Expenditure	Policy	Stakeholder
Vehicle purchase	Tax credit	Federal government
	Rebate	Local, regional, and state government
	Employee cash incentives	Businesses
Charging equipment	Rebates and subsidies	Utilities and regional, state, and federal government
Electricity costs	Time-of-use rates and discounts	Utilities
Installation soft costs (permitting and inspection)	Permit and inspection streamlining	Local government
Installation hard costs (retrofitting)	Building code changes	Local government

3 PEVs and Charging Basics

3.1 Introduction

The plug-in electric vehicle (PEV) landscape of today is evolving at a rapid pace. Rising gas prices and heightened concerns over climate change have led to an increase in demand for more efficient, less polluting vehicles, while recent advances in technology have led to the ability to supply PEVs in volume. This convergence of supply and demand has created a growing marketplace for PEVs. Cities, counties, and regions across California are responding to this development by laying the groundwork for PEV charging infrastructure. This chapter serves to explain for planners the basics of PEVs by looking at emerging vehicle trends as well as charging types.

3.2 Emerging PEV trends

The last major attempt to commercialize PEVs was during the 1990s, after California passed zero-tailpipe-emission vehicle (ZEV) regulations to address the high levels of pollution in its metropolitan areas. Manufacturers responded by offering a small fleet of lease-only battery electric vehicles (BEVs), which run entirely on electricity stored in batteries. This generation of BEVs never quite reached large-scale commercial success. The high cost of technology and low anticipated demand gave manufacturers little incentive to produce these vehicles, while high prices, limited driving range, and the low price of gasoline limited their appeal with consumers. Automakers discontinued major commercialization efforts, arguing for hybrid and hydrogen fuel cell electric vehicles instead.

Beginning in 2010, a new generation of PEVs built by major automakers emerged, owing to higher gas prices, environmental concerns, alternative fuel policies, manufacturer initiative, and the aforementioned advances in technology. These second-generation PEVs use lithium-ion batteries as opposed to lead-acid or nickel-metal hydride cells, which weight less, charge more quickly, use energy more efficiently, and are more practical than before. The concurrent development of the plug-in hybrid electric vehicle (PHEV), which uses gasoline in conjunction with grid electricity to overcome many of the limitations of BEVs, further expanded consumers' choices within the PEV marketplace. A range of PEV body types is shown below.

Image 3.1: 2013 Ford Fusion Energi PHEV (© Ford Motor Company)

Image 3.2: 2013 Chevrolet Volt (© General Motors)

Image 3.3: Mitsubishi Concept PX MiEV-II (© Mitsubishi Motors North America)

3.2.1 Battery electric vehicles

Manufacturers will continue to release new battery electric vehicle (BEV) models. The California Air Resources Board's ZEV regulations require approximately 7,500 BEV or fuel cell vehicles be brought for sale in California between 2012 and 2014. Tens of thousands of ZEVs per year are required starting in 2015, with the number of ZEVs brought for sale each year reaching the hundreds of thousands in the next decade. In response, many manufacturers have, or will soon, release limited-availability BEVs to meet that requirement. These models are sometimes referred to as "compliance cars." Other manufacturers who have invested substantially in BEVs have indicated a commitment to high-volume production of BEVs. Cumulative sales of the Nissan LEAF, for example, exceed 18,000 vehicles in the U.S., a large share of which can be found in California.

3.2.2 Plug-in hybrid electric vehicles

PHEVs allow drivers to incorporate miles of electric driving without the "range anxiety" of BEVs, the fear that a vehicle will have insufficient charge to reach its destination. PHEVs feature a battery that is recharged by plugging in to a wall outlet or charging unit. As the battery becomes depleted, a gasoline engine runs to extend the driving range of the vehicle. Depending on how often drivers charge their vehicles, PHEVs allow consumers to drive primarily on electricity while having a gasoline engine available whenever needed.

Owing to the lack of range anxiety, PHEVs have since become very popular, accounting for 70% of PEVs registered in the SCAG region from December 2010 to September 2012 according to R.L. Polk data obtained by the Luskin Center. Judging by the list of current and future cars in Table 3.1, PHEVs are expected to make up the majority of PEVs sold in the near future, until battery technology becomes significantly cheaper or the network of charging infrastructure is sufficiently built out.

Table 3.1: PEV models: current and planned for U.S. release through 2013

Model (in order of U.S. market release where available)	Year	Type	EPA electric range (mi.)	EPA MPG equivalent	Current Base MSRP
Nissan LEAF	2010	BEV	73	99	$35,200
Chevrolet Volt	2010	PHEV	38	98	$39,145
smart fortwo electric drive	2011	BEV	68	107	$25,750
Fisker Karma	2011	PHEV	33	54	$102,000
Mitsubishi i (aka IMiEV)	2011	BEV	62	112	$29,125
Ford Focus Electric	2012	BEV	76	105	$39,200
Toyota Prius Plug-In	2012	PHEV	11	95	$32,000
Coda Sedan	2012	BEV	88	73	$37,250
Tesla Model S (85 kWh)	2012	BEV	265	89	$77,400
Honda Fit EV	2012	BEV	82	118	$36,625
Toyota RAV4 EV	2012	BEV	103	78	$49,800
Ford C-MAX Energi	2012	PHEV	21	100	$33,745
Honda Accord Plug-In	2013	PHEV	13	115	$39,780
Ford Fusion Energi	2013	PHEV			$39,495
FIAT 500e	2013	BEV			
Chevrolet Spark EV	2013	BEV			
BMW i3	2013	BEV			
Cadillac ELR	2013	PHEV			
Mitsubishi Outlander PHEV	2013	PHEV			
Porsche 918 Spyder	2013	PHEV			

Source: Manufacturer websites and press releases

3.3 Charge levels

Currently, there are three major levels of PEV charging: Level 1 (120 volts), which utilizes standard 3-prong household outlets; Level 2 (240 volts), which typically requires additional charging equipment; and DC fast charging (up to 500 volts, direct-current), which requires a specialized high-voltage commercial quick charger.[3] Some residential circuits (including special outlets for dryers) supply power at 240 volts and many commercial buildings use 208-volt rather

3 The U.S. standard household nominal voltage is 120V and 240V. However, voltage sags can bring Level 1 voltage down to 110V, which is typically the lowest acceptable limit, at the outlet level.

than 240-volt circuits.

The power being transferred at these various levels depends on how much current (Amperes [A]) flows in the circuit (power equals voltage times amperage). Thus, charging can demand differing levels of power even within a given charging level category, limited by how much current the circuit and charging equipment (on- and off-board the vehicle) supply. PEVs typically come with either 3.3- or 6.6-kilowatt (kW) chargers onboard the vehicle.

3.3.1 Level 1

Level 1 charging provides the slowest rate of charge and lowest power draw, typically about 1.4 kW (120V at 12A). However, Level 1 charging may be sufficient for: most PHEVs; BEVs with relatively smaller batteries; and even PEVs with larger batteries that are not fully depleted every day. All of these can be fully charged at 120V overnight. Furthermore, Level 1 charging does not require special electric vehicle supply equipment (EVSE) apart from the portable cordset that comes with the vehicle and a standard single-phase household outlet. Thus, the costs to entry for Level 1 charging are considerably lower, and it becomes a potentially cost-effective option for when there is a long “dwell time,” such as at home or at work, where vehicles spend a lot of idle time parked.

3.3.2 Level 2

Level 2 charging typically does require additional electric vehicle supply equipment (EVSE) but charges at a faster rate. Level 2 allows most PEVs currently on the road to take advantage of their 3.3 kW charging capability, and newer models can charge at double that rate at 6.6 kW or even 19.2 kW—the upper limit of Level 2 (240V at 80A). Typical amperages for Level 2 current are 15-30A.

Table 3.2 illustrates the number of electric miles of range that can be recharged per hour at different charging levels.

Table 3.2: Variations in charge times and electric miles per hour of charge by charging level and PEV type

Charging Level	Power Supply	Charger Power	Miles of Range for 1 Hour of Charge	Charging Times From Empty to Full*	
				BEV	PHEV
Level 1	**120VAC** Single Phase	**1.4 kW @ 12 amp** (on-board charger)	**~ 3 - 4 miles**	**~ 17 Hours**	**~ 7 Hours**
Level 2	**240VAC** Single Phase up to 19.2 kW (up to 80 amps)	**3.3 kW (on-board)**	**~ 8 - 10 miles**	**~ 7 Hours**	**~ 3 Hours**
		6.6+ kW (on-board)	**~ 17 - 20 miles**	**~ 3.5 Hours**	**~ 1.4 Hours**
DC Fast Charge Level 2	**200 - 500 VDC** up to 100 kW (approximately 200 amp)	**45 kW (off-board)**	**~ 50 - 60 miles** (~ 80% per 0.5 hr charge)	**~ 20 - 30 Minutes** (to ~ 80%)	**~ 10 Minutes** (to ~80%)

Source: Adapted from California PEV Collaborative (CG#-3).

3.3.3 DC fast charging

DC fast charging uses an external high-voltage charger to supply direct current (DC) to PEV batteries. Typically, DC fast charging can charge common BEVs (with less than 100 miles of range) to 80% full in 20 or 30 minutes. Most PEVs on the road that are capable of DC fast charging use the CHAdeMO connector, developed in Japan. However, SAE International has released, and most American and European automakers have chosen to adopt, a new hybrid connector for fast charging that adds high-voltage DC power to the standard J1772 connector used for Level 1 and Level 2 charging. Tesla has introduced its own proprietary connector for their private network of DC fast charging stations.

3.3.4 Multi-armed chargers

In addition to aforementioned single-armed chargers that charge one vehicle at a time, multi-armed chargers are becoming increasingly available. These chargers can have between two and six cords which enable all of the connected vehicles to charge at once. The arms on these chargers can offer either Level 1 or 2 charging. Some versions of these chargers are “smart” in that they can be programmed to operate in response to the different charging needs of vehicles and constraints on the power that is available to the charge station. The potential advantage of multi-armed chargers is that, when fully utilized by several vehicles, they more cheaply deliver power to PEVs than could an equivalent number of single armed chargers. The economies of scale in charging that they offer could provide very cost effective charging opportunities in both MUDs and workplaces once there are multiple PEVs at these locations.

3.4 Charging environments

PEVs can be charged at different times of day at home, work, and other locations. However, each of these charging environments has advantages and disadvantages. Overnight residential charging is the most cost-effective charging scenario, as it takes advantage of the long periods of time that the PEVs are parked. Many utilities offer discounts for charging overnight and in the early morning, as it is less demanding on the grid and helps the utility sell the excess electricity that can be produced during overnight hours. On-peak afternoon and evening charging, on the other hand, can be highly demanding on the grid and relatively expensive, though drivers may still find it worthwhile to charge at these times of day to increase their range or electric miles driven. Early data indicate that PHEVs tend to be charged more frequently than BEVs, despite the option to run on gasoline. This may be both because their batteries tend to be smaller and thus depleted more quickly, but also because of what is sometimes referred to as "gasoline anxiety," the desire to avoid or minimize the use of the gasoline engine (with associated lower vehicle fuel economy, higher fuel costs, and environmental impact).

Table 3.3 summarizes the typical "dwell times" (length of time a vehicle is parked) and charging characteristics for each of type of charging site type. Most PEV charging takes currently takes place at home, while workplace and retail charging provide the opportunity to "top off" the battery throughout the day.

Table 3.3. Typical dwell times for charging environments

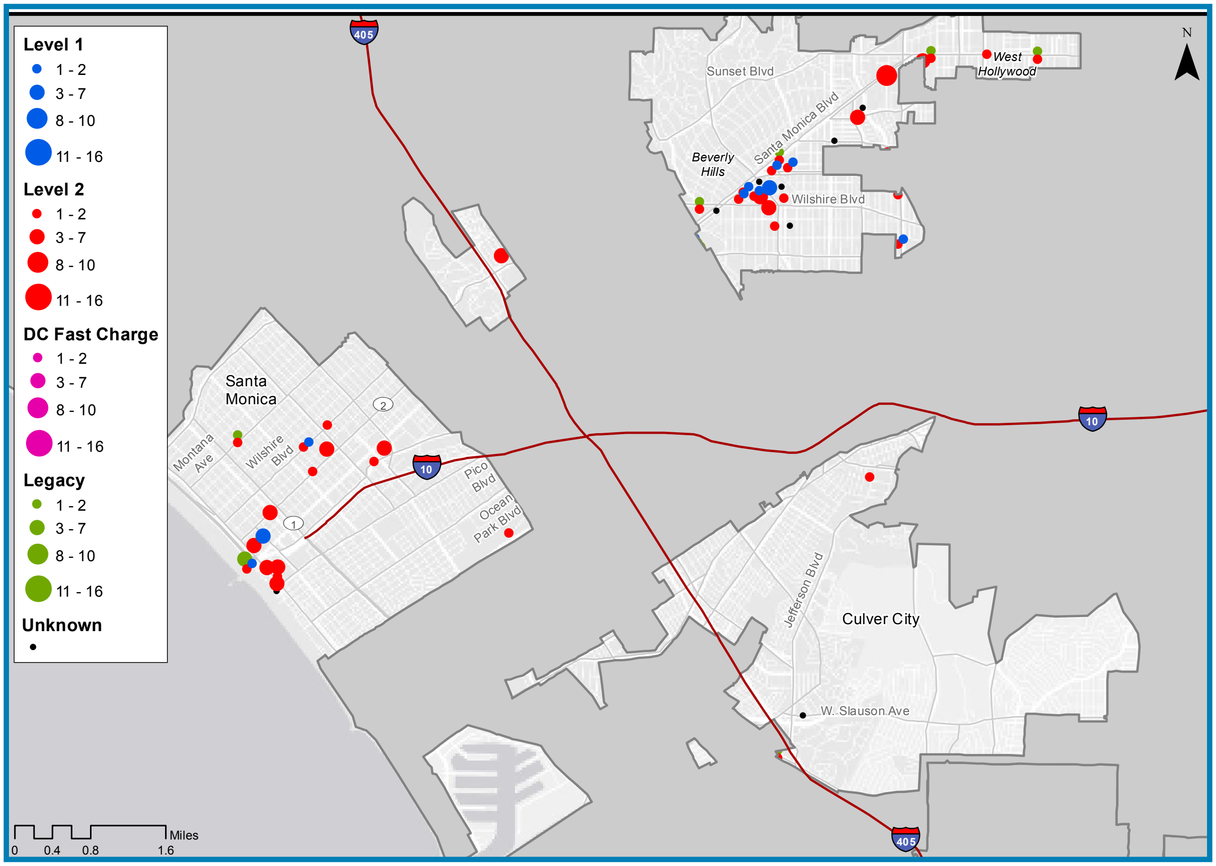
Site Type	Typical Dwell Times (hours)*	Charging Hours	Average Electricity Cost
Residential	14	10 pm - 6 am (optimal)	Low
Workplace	8-9	9 am - 2 pm (optimal)	Medium
Retail	1-3	11 am - 8 pm	High

**UCLA Luskin Center estimates*

3.5 Finding charge stations

Planners can assess the local supply of existing publicly-accessible charging stations using the maps provided in the Southern California PEV Atlas that accompanies this document. They can compare the location of existing publicly-accessible charge stations with the locations of employment centers, retail centers and PEV daytime destinations. An example map is shown on the next page [Map 3.1].

Map 3.1: Publicly-accessible PEV charging stations, Westside Cities Council of Governments



PEV drivers have many sources of information for finding out where to charge their vehicles. Planners can use these sites to stay up-to-date on new charging stations in their local jurisdictions:

- The U.S. Department of Energy's Alternative Fuels Data Center lists PEV charging locations by geography, ownership type, charge levels and payment systems. http://www.afdc.energy.gov/fuels/electricity_locations.html
- Network providers such as ChargePoint https://na.chargepoint.com/index.php/charge_point and Blink http://www.blinknetwork.com/blinkMap.html display their charge stations with information on pricing and real-time availability. Members can reserve a charging station in advance of their arrival at the location.
- Recargo www.recargo.com and PlugShare www.plugshare.com are user-generated sites to which drivers can add new charge location listings, offer their private chargers for public use, and alert other drivers about whether equipment at publicly-accessible locations is non-operational.

3.6 References

California Plug-in Electric Vehicle Collaborative. 2012. PEV Charging: Where and When? Communication Guide 3. http://www.pevcollaborative.org/sites/all/themes/pev/files/Comm_guide3_122308.pdf.

4 Evaluating Land Use Opportunities and Existing Charge Stations

4.1 Introduction

Plug-in electric vehicles charge while parked. Parking spaces are distributed over local land uses such as single-family residential, multi-unit residential, workplaces, and retail establishments. The type and availability of parking spaces at these land uses will vary across municipalities. Variation in these parking resources will shape local PEV readiness efforts, by defining both the opportunities and the limits on where, how much and when PEV charging can occur locally. This chapter explains the role a parking assessment by land use should play in developing a local PEV readiness plan. It also illustrates some planning metrics that can be used to identify local land use opportunities and constraints that should guide the prioritization of local PEV charging strategies.

The second half of this chapter presents the location and level of service provided by existing publicly-accessible charge stations in the region. Such spatial information can be used by planners to better understand their current publicly-accessible charging resources. It can also be used to identify where there are gaps in meeting demand for charging as described in the chapters on charging at workplaces (Chapter 7), government properties and retail establishments (Chapter 8).

4.2 Identifying local land use priorities for PEV readiness

One goal of municipal PEV readiness planning is to expand PEV drivers' access to charging opportunities. In pursuit of this goal, PEV planners would ideally like to know:

- How many parking spaces are there in my jurisdiction?
- Where are the parking spaces on all parcels in my jurisdiction?
- At what times of day and night do drivers use those spaces?
- How long are cars typically parked in those spaces?

These characteristics of parking spaces determine both how long PEVs can charge and what the cost of electricity will be during the time that PEV reside in these spaces. Planners can acquire this information on parking utilization patterns by identifying the types of land uses (e.g., residential, workplace, retail) associated with the parcels that host these parking spaces. Knowing the distribution of land uses within a jurisdiction is also helpful because different land uses are also associated with distinctive parking, electrical, and building configurations which can greatly and systematically affect the cost of installing charging equipment on that parcel.

Understanding the distribution of parking spaces across land uses is the foundation for all subsequent municipal PEV planning. It enables planners to understand the number and type of potential charging sites within their jurisdiction. Planners are able to prioritize PEV planning for dominant local land uses. A parking-oriented land use analysis also enables them to anticipate when during the day or night PEV drivers charge at these different parcels. This will help utilities track changes in the electrical load over space and time as the PEV market grows. Finally, a land use analysis of parking enables planners to roughly anticipate where the high- and low-cost charging opportunities will be and how many of each type their jurisdiction is likely to have.

4.2.1 Steps and assumptions in land use/parking analysis

A central task within municipal PEV plans should be to identify and prioritize planning for those types of charging environments *given the availability of local land use hosting opportunities.* Figure 4.1 describes the steps involved in this planning process.

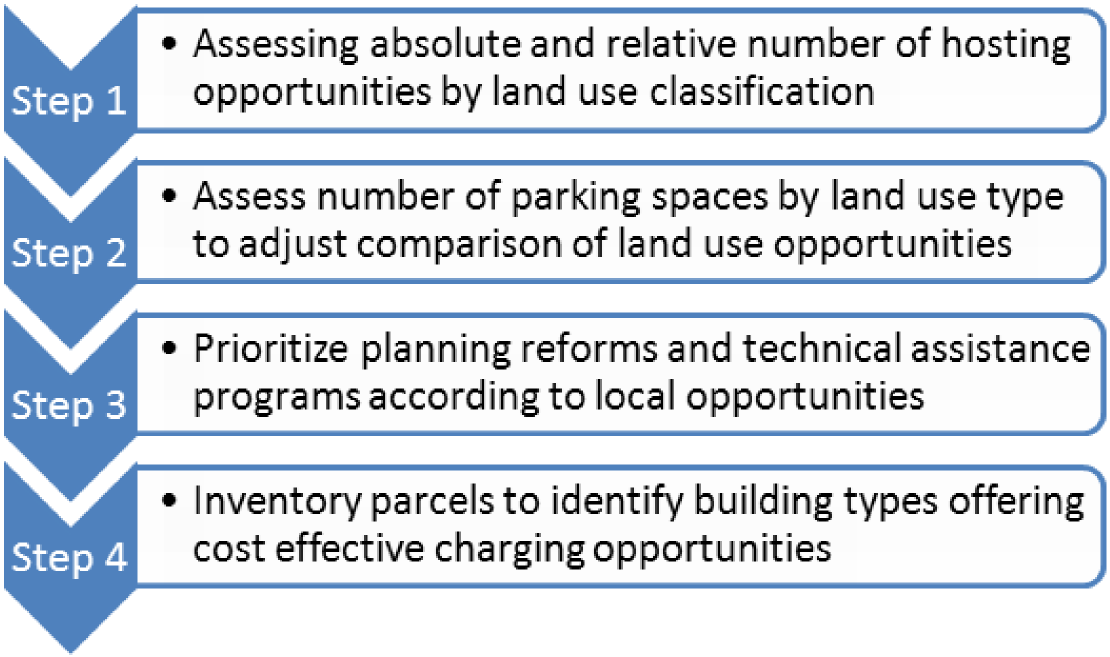
First, planners must identify the availability of types of residential, workplace, government-owned and retail parcels that could host charging infrastructure. This involves identifying the location and numbers parcels of different types.

Second, the number of potential parking spaces at each parcel must be estimated. Ideally this would be based on the knowledge of local zoning and building code history (or, even better, a field survey of parking at these parcels). However, in the absence of more refined information, we make the following simplified **assumptions** for the purposes of illustrating analysis:

- We assume that the number of residential units on a parcel is equal to the number of on-site parking spaces for both single-family and multi-unit dwellings (MUDs).
- We count MUDs in terms of individual units (i.e., apartments or condominiums), not buildings, because each unit represents at least one potential parking space. For MUDs that do not have parking, workplaces and publicly-accessible sites will become important charging options.
- We also assume that there is a parking space for every employee at a workplace.

The third step involves deciding which types of land use and parking resources should be targeted and in which order. The fourth step, which involves evaluating and targeting specific parcels within a land use category, will not be discussed in this chapter but an example of it can be found in the chapter on workplace charging (Chapter 7).

Figure 4.1: Steps in PEV land use assessment



We demonstrate the Steps 1–3 using Los Angeles County cities as an example later in this chapter. We chose Los Angeles County because, like most major metropolitan areas, it is where PEV adoption will occur first before spreading to smaller metropolitan and rural areas.

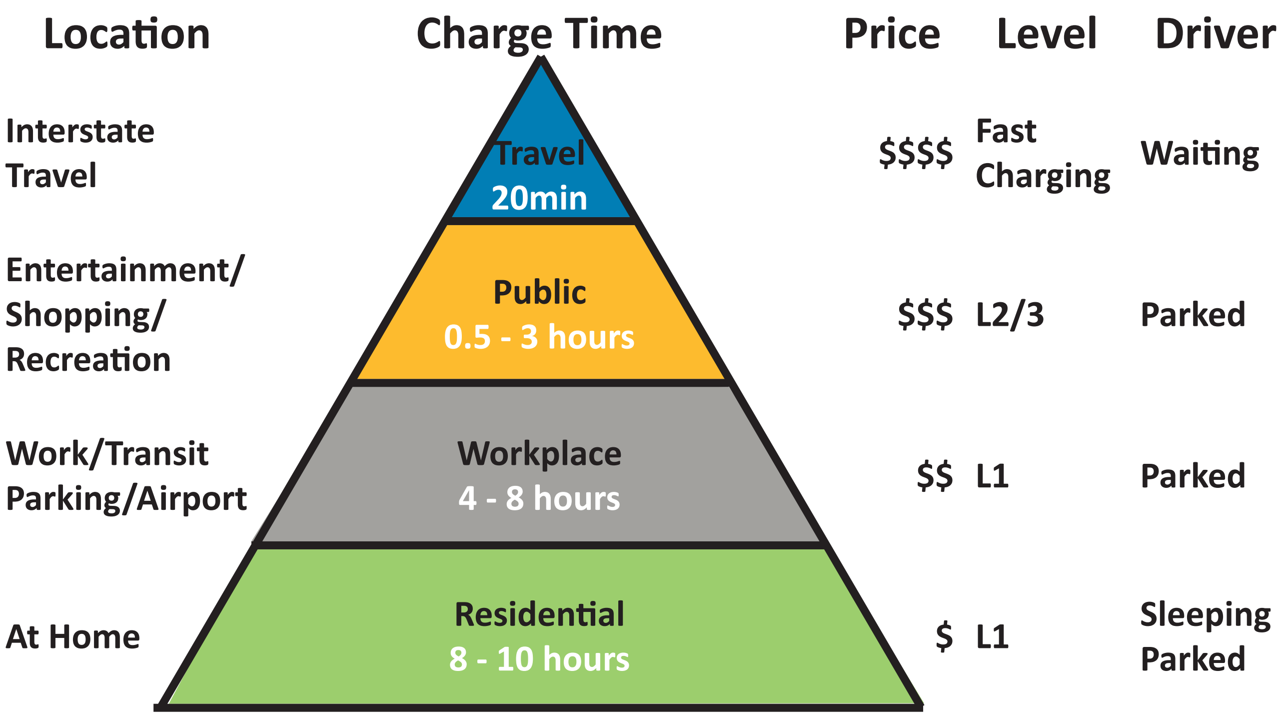
Land use patterns may vary greatly across cities, sometimes being highly skewed toward one land use for some cities and more balanced across land uses for others. With respect to residential land uses, we find several cities have predominantly single-family homes and also several that have extremely high percentages (80% or higher) of MUD units. A number of cities have almost exclusively workplace parcels and virtually no residential units of either kind. Nearly all cities have at least as many workplace parking spaces they have residential spaces combined. A majority of cities have two, and sometimes three, times the number of workplace parking spaces as they do residential spaces.

4.3 Conventional wisdom on charging sites vs. municipal land use priorities

Figure 4.2 illustrates the way charging locations are commonly prioritized: residential charging opportunities should be maximized, followed by workplace charging, and then retail and interstate charging last in order of importance. How do the diverse PEV planning priorities of Los Angeles cities compare to the planning priorities implied in the “charging pyramid”? In our view, there is no conflict. The difference is one of perspective.

The charging pyramid takes the perspective of PEV drivers and what types of charging will best support their charging needs most cost-effectively. Cities must decide what their priorities should be based on the local availability of land uses that can host charging. Cities can only advance those land use portions of the charging pyramid that lie substantially within their jurisdiction. A city may have only workplace land uses or only MUDs. Many have twice as many workplace parking spaces as MUD parking spaces. In these cases, the municipal planners' focus should be on assisting the most prevalent types of site hosts in developing charging opportunities in the most cost-effective manner.

Figure 4.2: Pyramid of PEV charging priorities



Source: Adapted from (Stanek 2011)

4.4 State, regional, and local land use planning metrics

PEV planners at different levels of government may need different types of land use/parking metrics. Below we discuss three different metrics that planners may find useful to support different PEV planning activities.

4.4.1 Estimates of parking space counts by land use

State agencies such as the California Energy Commission, the Governor's Office of Planning and Research, the California Air Resources Board as well as **regional governmental entities** such as the air quality management districts and metropolitan planning organizations can often target and support local municipal PEV planning reforms. Often these state and regional planners must decide which municipalities to prioritize for outreach because they have limited resources. For example, consider a state or regional planner who wants to only target a limited number of municipalities for the PEV planning reforms discussed in Chapter 10 through Chapter 13. These state and regional planners will maximize the effectiveness of their resources by prioritizing reforms in jurisdictions with the largest numbers of the targeted site hosts and/or drivers. In doing so, the policy reforms that are implemented will affect the largest absolute number of prospective charge station site hosts and/or drivers. In order to know which municipalities to target, state and regional planners will need to know how many parking spaces are located at different land uses across municipalities.

4.4.2 Estimating shares of parking spaces by land use

Municipal planners may wish to know what share of parking in their jurisdictions is tied to each land use in order to prioritize PEV planning around those most frequently-encountered land uses. These planning metrics will enable them to assess the relative importance of different land uses within their local PEV readiness plan. For example, a municipality such as Vernon will prioritize workplace charging because this is where nearly 99% of all of its parking spaces are by land use. The municipality of West Hollywood will prioritize MUD charging because nearly all of its residential housing is MUD, representing nearly 43% of all parking spaces by land use. While parking space counts can describe the size of each individual land use opportunity, only data on the *shares* of land uses can assist the planner in identifying the relative importance of specific land uses.

In the next section, we present both **counts** and **shares** of parking by land use within municipalities since these metrics will support both state/regional as well as local PEV planning activities.

4.4.3 Spatial density of parking spaces by land use

A metric that may be useful to **electrical utility** planners is the spatial density of parking spaces at land uses. This is because utilities must plan for future electrical loads for substation areas. Thus, knowing where there will be spatially concentrated growth in loads would be helpful. As we show in the Southern California PEV Atlas, both workplaces and MUDs tend to be spatially concentrated and they could both experience rapid growth in charging equipment installations. This metric is discussed further in the Chapter 7.

4.5 The base of the pyramid: assessing residential potential

In this and the following sections, we provide state, regional and local planners with an example of the type of PEV planning metrics they may wish to develop to more fully understand their local parking and land use resources that could be developed to support PEV charging. As an example, we begin with a Los Angeles County-wide assessment of the base of the charging pyramid by focusing on the spatial distribution of single family and multi-unit residential housing. **For the purposes of this analysis, condominiums are considered MUDs even though they are individually owned because the physical and institutional challenges of charging in condominiums are similar to those of apartment buildings.**

4.5.1 Single-family homes in Los Angeles County

Many observers expect PEV adoption to occur most rapidly for drivers living in single-family homes because of the relative ease and lower costs of charging. As a result, identifying which municipalities have the largest ***number*** of single-family homes helps state and regional planners clarify where early PEV market growth is likely to occur. Identifying which municipalities have the largest ***share*** of single-family homes relative to MUDs and other land uses helps identify which cities are most likely to benefit from prioritizing their PEV plans around this type of land use.

Using Los Angeles County as our example, in terms of the ***absolute*** stock of single-family homes, the list is dominated by the largest cities in the county, such as the cities of Los Angeles and Long Beach. These cities contain more than 460,000 and 60,000 single-family units respectively. However, single-family homes represent only 16% and 20% of prospective charging/parking resources within each city (when the total parking opportunities are comprised of the sum of single-family residential units, individual MUD units, and employees).[4] Seven municipalities on this top 10 list by number of single-family homes also have fewer than 35% of their parking resources in single-family land uses.

Table 4.1: Los Angeles County cities by numbers of single-family homes

	City	Units	% SF	MUD Units	% MUD	Employees	% Employees	Total
1	Los Angeles	460,189	16%	776,423	27%	1,682,582	58%	2,919,194
2	Long Beach	60,276	20%	91,512	30%	154,135	50%	305,923
3	Palmdale	35,945	49%	6,522	9%	30,284	42%	72,751
4	Lancaster	35,452	61%	9,187	16%	13,551	23%	58,190
5	Santa Clarita	31,316	26%	20,420	17%	66,455	56%	118,191
6	Torrance	28,482	17%	24,343	15%	114,489	68%	167,314
7	Glendale	23,719	15%	44,781	28%	91,492	57%	159,992
8	Pomona	23,202	26%	11,216	12%	55,757	62%	90,175
9	Lakewood	22,366	51%	4,398	10%	17,157	39%	43,921
10	West Covina	21,535	32%	12,525	18%	33,669	50%	67,729

4 Information on housing units was obtained from 2007 Los Angeles County Assessor data. Employee counts were aggregated from SCAG's 2008 dataset from Infogroup, a vendor of employment data.

When we look at Los Angeles County cities in which single-family homes represent the largest share of potential parking opportunities, the list changes drastically. As shown Table 4.2, these cities represent a mix of income levels. Local planners in the cities listed should prioritize charging at single-family homes within their PEV readiness efforts.

Table 4.2: Los Angeles County cities by single-family share compared to other in-city land uses

	City	% SF	SF Units	% MUD	MUD Units	% Employees	Employees	Total
1	Bradbury	89%	340	2%	6	10%	37	383
2	Rolling Hills	85%	670	0%	0	15%	121	791
3	La Habra Heights	84%	1,877	1%	24	15%	343	2,244
4	Hidden Hills	73%	702	0%	0	27%	256	958
5	Palos Verdes Estates	68%	5,095	5%	349	27%	2,052	7,496
6	Lancaster	61%	35,452	16%	9,187	23%	13,551	58,190
7	Rancho Palos Verdes	58%	12,573	15%	3,247	27%	5,942	21,762
8	San Marino	57%	4,406	0%	13	43%	3,353	7,772
9	La Mirada	56%	12,185	11%	2,359	33%	7,143	21,687
10	Lakewood	51%	22,366	10%	4,398	39%	17,157	43,921

4.5.2 Multi-unit dwellings

MUDs represent the largest share of residential housing in urban areas within Los Angeles County. They also hold of the promise of providing charging to moderate- and lower-income drivers. Yet they currently host very few charging stations because of institutional and economic barriers. MUDs and workplaces are potential charging environments that would disproportionately benefit from effective PEV readiness. This is largely because these environments may potentially have an advantage of economies of scale in charge station capacity, able to charge multiple PEVs at once and at lower per-kilowatt-hour costs.

State, regional, or county agencies may wish to impact the greatest number of multi-unit residences through technical assistance that targets specific cities. Table 4.3 provides a description of which municipalities within the county have the greatest **number** of MUDs. The list of municipalities by number of MUDs differs significantly from that in Table 4.4, which describes the municipalities for whom MUDs represent the largest **share** of parking by land use type. This difference may mean that **municipalities** in Table 4.3 may view supporting charging on land uses other than MUDs as important, since these other land uses (e.g., workplace charging) represent a larger share of parking resources.

Table 4.3: Los Angeles County cities by counts of MUD units compared to other in-city uses

	City	Units	% MUD	SF Units	% SF	Employees	% Employees	Total
1	Los Angeles	776,423	27%	460,189	16%	1,682,582	58%	2,919,194
2	Long Beach	91,512	30%	60,276	20%	154,135	50%	305,923
3	Glendale	44,781	28%	23,719	15%	91,492	57%	159,992
4	Santa Monica	36,745	29%	7,355	6%	84,066	66%	128,166
5	Pasadena	28,362	18%	21,251	13%	110,082	69%	159,695
6	Torrance	24,343	15%	28,482	17%	114,489	68%	167,314
7	Inglewood	22,626	30%	11,448	15%	42,231	55%	76,305
8	Burbank	22,426	17%	18,481	14%	90,838	69%	131,745
9	Santa Clarita	20,420	17%	31,316	26%	66,455	56%	118,191
10	Hawthorne	20,260	39%	6,653	13%	24,791	48%	51,704

As we see from Table 4.4, when the number of parking spaces for employees is included in the comparison, the share of multi-unit residences in the top 10 list drops to 32% – 43%. This is because municipalities that have significant shares of multi-unit residences also tend to have higher numbers of local employees.

Table 4.4: Los Angeles County cities by MUD share of in-city parking opportunities

	City	% MUD	MUD Units	% SF	SF Units	% Employees	Employees	Total
1	West Hollywood	43%	19,866	2%	1,073	55%	25,137	46,076
2	Cudahy	40%	2,645	7%	479	52%	3,410	6,534
3	Hawthorne	39%	20,260	13%	6,653	48%	24,791	51,704
4	Lomita	37%	4,981	22%	2,966	40%	5,341	13,288
5	Redondo Beach	37%	18,888	17%	8,485	46%	23,084	50,457
6	Bellflower	37%	11,328	28%	8,438	35%	10,608	30,374
7	Maywood	37%	3,287	18%	1,613	45%	3,931	8,831
8	Lawndale	36%	5,467	14%	2,112	50%	7,599	15,178
9	Hermosa Beach	35%	5,700	20%	3,289	45%	7,419	16,408
10	Alhambra	32%	17,432	18%	10,064	50%	27,570	55,066

4.6 Workplace charging in the parking/land use assessment

Perhaps that greatest surprise that arises from this analysis is the size and share of parking resources at workplaces. Nearly all municipalities had at least as much workplace parking as they had parking in both single-family and MUD land uses combined. Well over a third of these municipalities had twice to three times as many parking resources at workplaces as they did in all other land uses combined. This fact is most likely the result of these 88 cities in Los Angeles County being the sites of workplaces that draw workers from the surrounding incorporated areas as well as the adjacent counties. This highlights the importance of understanding the broad intra-regional commuting patterns when assessing parking resources as part of the PEV planning process.

Again we consider state, regional or county agencies who may wish to impact the greatest number of employees through technical assistance that targets specific municipalities. Table 4.5 provides a description of which municipalities within the county have the greatest absolute numbers of employees. Comparing Table 4.5 and Table 4.6, we see that, except for the City of Industry, the list of municipalities with the largest *share* of parking resources for employees differs from the list of those with the greatest *number* of employees. However, in the case of workplaces in Table 4.5, every municipality which ranks in the top 10 by number of employees also has at least 50% of all of their parking resources in workplaces compared to other land uses.

Table 4.5: Los Angeles County cities by employee counts compared to other in-city uses

	City	Employees	% Employees	SF Units	% SF	MUD Units	% MUD	Total
1	Los Angeles	1,682,582	58%	460,189	16%	776,423	27%	2,919,194
2	Long Beach	154,135	50%	60,276	20%	91,512	30%	305,923
3	Torrance	114,489	68%	28,482	17%	24,343	15%	167,314
4	Pasadena	110,082	69%	21,251	13%	28,362	18%	159,695
5	Glendale	91,492	57%	23,719	15%	44,781	28%	159,992
6	Burbank	90,838	69%	18,481	14%	22,426	17%	131,745
7	Santa Monica	84,066	66%	7,355	6%	36,745	29%	128,166
8	Carson	75,483	76%	17,928	18%	5,634	6%	99,045
9	Industry	67,990	100%	111	0%	2	0%	68,103
10	Santa Clarita	66,455	56%	31,316	26%	20,420	17%	118,191

As shown in Table 4.6, five municipalities have over 90% of all their parking resources at their local workplaces. All 10 municipalities have at least 80% (approximately) in workplaces. Clearly, the PEV readiness efforts for these municipalities should focus on workplace charging.

Table 4.6: Los Angeles County cities by employee share compared to other in-city uses

	City	% Employees	Employees	% SF	SF Units	% MUD	MUD Units	Total
1	Vernon	100%	43,739	0%	1	0%	2	43,742
2	Industry	100%	67,990	0%	111	0%	2	68,103
3	Irwindale	96%	16,432	2%	343	2%	257	17,032
4	Commerce	95%	51,427	3%	1,613	2%	1,222	54,262
5	Santa Fe Springs	93%	58,665	5%	3,361	2%	1,287	63,313
6	South El Monte	86%	19,182	10%	2,286	4%	935	22,403
7	La Verne	83%	47,741	13%	7,573	4%	2,112	57,426
8	El Segundo	82%	30,799	7%	2,587	11%	4,071	37,457
9	Westlake Village	81%	12,831	15%	2,426	4%	676	15,933
10	Beverly Hills	79%	58,894	8%	5,830	14%	10,283	75,007

4.7 Publicly-accessible charging opportunities

For MUDs that do not have parking, workplaces and publicly-accessible sites will become important charging options.

In this section, we assess the current supply of publicly-accessible charging stations in the SCAG region. We analyze charging sites by type of ownership and type of activity that takes place at the location. Site ownership and activity type have a direct bearing on how much the stations will be utilized and whether the site will be financially viable. In addition, understanding the location and rate of charge (Level 1, Level 2, etc.) provided by current publicly-accessible charge stations can be used to undertake a “gap analysis” by identifying where public charging resources are and where they need to be.

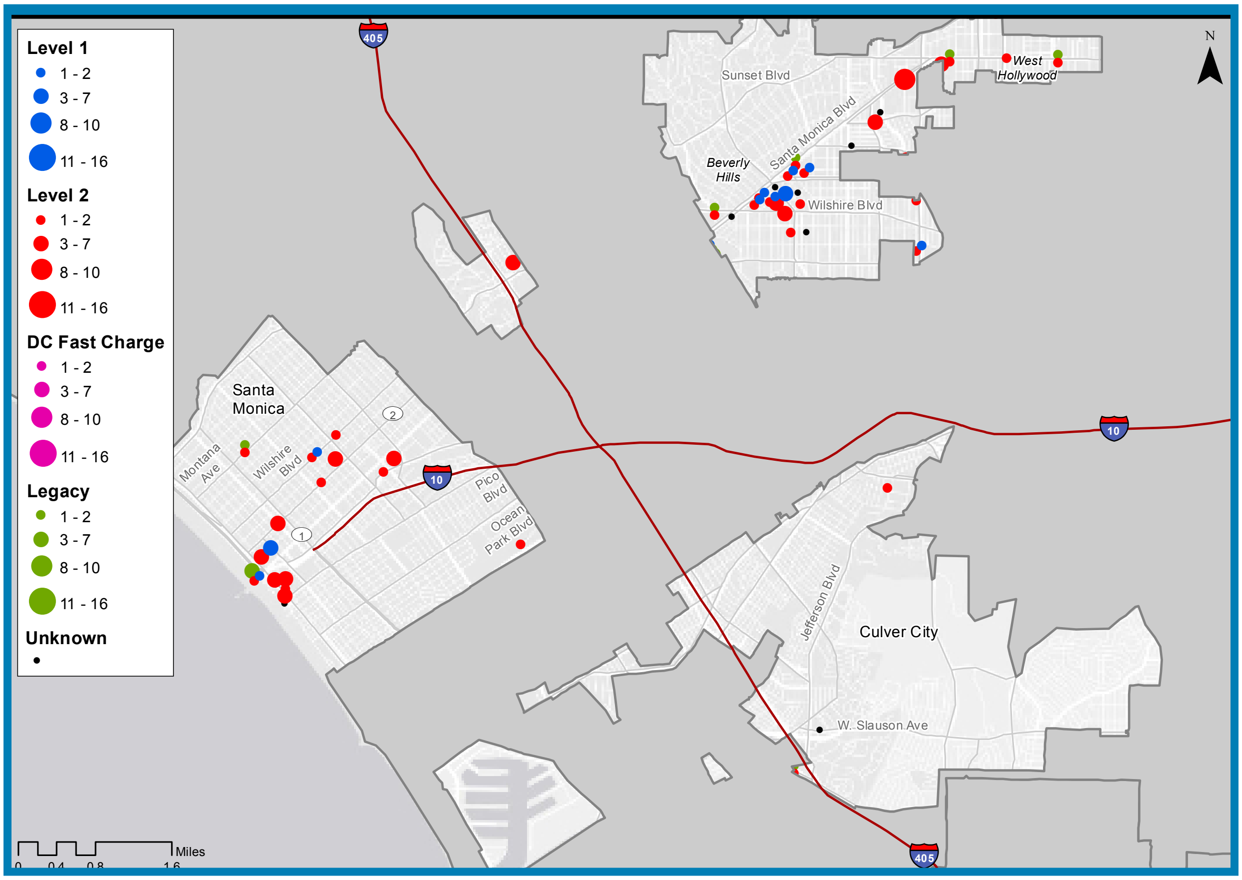
4.7.1 Council of government charge station maps

The Southern California PEV Atlas that accompanies this plan includes maps of publicly accessible charging stations for each council of government (COG) in the SCAG region. The maps identify the number of charging units/cords available at each location along with the level of service (Level 1, Level 2, etc., or “Unknown” where there is charging available but the quantity of connectors and their level of service could not be immediately determined).[5] The maps are based on information collected during the summer and fall of 2012. Map 4.1 presents an

5 The information was compiled in the summer and fall of 2012 using online databases maintained the U.S. Department of Energy (http://www.afdc.energy.gov/fuels/electricity_locations.html) as well as Recargo (www.recargo.com), PlugShare (www.plugshare.com), and Car Stations (www.carstations.com), which contain information posted by users of the charging stations.

example from the Westside Cities Council of Governments.

Map 4.1: Publicly-accessible charging stations, Westside Cities Council of Governments



Planners can compare the location of existing publicly-accessible charge stations with the locations of employment centers, retail centers and PEV daytime destinations, also mapped at the COG level in the Atlas. As of December 2012, there were only two DC Fast charging stations in the region, though more are expected to come online in the coming years.[6] Some stations designated as "legacy" in the Atlas may have since been upgraded to current connector standards under the Reconnect CA program.[7]

4.7.2 A regional overview of publicly-accessible charge stations

Publicly-accessible locations vary by 1) the type of entity that owns the site where charging

6 A settlement between the California Public Utilities Commission and NRG Energy requires the installation of 110 DC Fast stations in the Los Angeles Basin in the next four years. (Joint Offer of Settlement, Public Utilities Commission of the State of California and California Electricity Oversight Board v. Sellers of Long-term Contracts to the California Department of Water Resources, Docket Nos. EL02-60-000 et. al. and EL02-62-000 et. al. (consolidated) 2012)

7 Hosts of publicly-accessible charging stations can have their obsolete hardware upgraded at no cost until July 2013. http://www.clippercreek.com/reconnect-ca-program.html

takes place; and 2) the type of activity that takes place on the site.

4.7.3 Types of charging site owners

Charging site hosts (owners) can generally be classified as public (government-owned), private (e.g., a store or business), non-profit (e.g., a house of worship), or utility. Site **ownership** will help determine the extent of access to the charging unit (for example, all PEV drivers or customers only; 24-hour access, or business hours only). Site ownership also figures into the value proposition for prospective site hosts. Government and non-profit charging sites may only want to cover their costs or some portion, while private businesses may want to profit from charging or attract customers.

In the summer and fall of 2012, the UCLA Luskin Center identified and classified publicly-accessible charging locations in the Southern California Association of Governments region by ownership type. This analysis was based on combining several charge station data sources including those available from the U.S. Department of Energy, PlugShare, Recargo and CarStations. Of the over 519 stations classified, the site hosts were almost one-third government, almost two-thirds private, and a small percentage non-profit or utility. Local jurisdictions may want to do a similar inventory in assessing existing opportunities for public charging.

Table 4.7: Charging site ownership in the SCAG region, summer/fall 2012[8]

	Frequency	Percentage of Total
Government	168	33%
Non-Profit	10	2%
Private	330	63%
Utility	11	2%

4.7.4 Types of charging sites

Charging opportunities can also be classified according to the type of **activity** associated with the site. Understanding *why* drivers visit a location can help determine the amount of time a PEV is likely to be parked there, and therefore what the value proposition of charging will be for the site host and the driver. Knowing what types of activity are associated with a charging site

8 The UCLA Luskin Center classified publicly-accessible charging locations in the SCAG region listed on online databases maintained the U.S. Department of Energy (http://www.afdc.energy.gov/fuels/electricity_locations.html), Recargo (www.recargo.com), Recargo www.recargo.com, Car Stations (www.carstations.com), and PlugShare (www.plugshare.com).

will also help planners anticipate the demand for charging at the location.

Understanding the value of a charging site is crucial in siting publicly-accessible stations. To date, most publicly-accessible charging stations have been placed where it is convenient to do so, either because the site is public property or because the site owner wants to take advantage of a time-limited subsidy for charging equipment or installation. As a result, existing publicly-accessible charging has not been placed in the lowest-cost, highest-demand locations, such as workplaces.

The UCLA Luskin Center has classified publicly-accessible charging locations in the SCAG region according to site activity in Table 4.8. Locations that serve drivers commuting to work are highlighted in red. Note that there may be overlap between workplace and retail or workplace and government sites, for government or retail employees.

Table 4.8: Charging site types in the SCAG region, summer/fall 2012

	Frequency	Percentage of total
Office building (or hospital)	90	17%
Dealership/vehicle service center/car rental	70	14%
Municipal/government administrative	52	10%
University/college/high school	45	9%
Hotel/resort/inn	40	8%
Shopping center/plaza/mall/outlet	39	8%
Stand-alone parking Lot/structure	35	7%
Drug store	26	5%
Transit/park-and-ride station	26	5%
Beach/park	23	4%
Stadium/convention/performing arts/museum	22	4%
Big box retailer	21	4%
Market/convenience store/restaurant	14	3%
Other (movie theater, gym, street parking, etc.)	16	3%
Total	519	100%

4.8 Charging locations for long-distance travel

At the top of the charging pyramid in Figure 4.2 lies interstate travel. DC fast charging will eventually facilitate interregional and interstate PEV travel along major highway corridors. Such long-distance transportation planning is primarily the purview of state and federal planners. Since the Southern California PEV Readiness Plan is intended to help local and regional planners support PEV charging in the daily commute, a discussion of interregional and interstate planning is beyond the scope of this document. The California Energy Commission is in the process of developing a statewide PEV readiness plan, part of which will develop inter-regional charging.

4.9 Recommendations

Planners should consult other chapters in this document for specific recommendations on facilitating charging in land uses that are locally important. These include single-family charging (Chapter 5), MUDs (Chapter 6), workplaces (Chapter 7), retail and public-sector locations (Chapter 8). The following recommendations summarize the guidance provided in this chapter on assessing local land use opportunities and existing publicly-accessible charging stations.

1. Cities should target their PEV readiness efforts by assessing their land uses and the relative shares of parking supply that are accounted for by single-family homes, MUDs, and workplaces.
2. Regions and COGs should target PEV technical assistance to cities by assessing counts of parking by land use in absolute numbers or by the relative dominance of particular land uses within each city (i.e., target technical assistance on workplace charging to cities that either have the highest employee counts or the highest concentrations of employee parking relative to parking for other purposes).
3. Local, subregional and regional planners should assess their existing supply of charging stations and their dominant land uses to understand where gaps may need to be filled and where obsolete hardware may need to be replaced or removed. The Southern California PEV Atlas that accompanies this document provides COG-level maps of existing charging stations as well as PEV registrations and PEV travel destinations, employment and retail centers, MUDs and stand-alone parking facilities.

4.10 References

Joint Offer of Settlement, Public Utilities Commission of the State of California and California Electricity Oversight Board v. Sellers of Long-term Contracts to the California Department of Water Resources, Docket Nos. EL02-60-000 et. al. and EL02-62-000 et. al. (consolidated). 2012. http://www.cpuc.ca.gov/NR/rdonlyres/CD5E3578-5EAD-47BA-BC5A-B6BD398CCBF6/0/JointOfferofSettlement.pdf.

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5 Demand-driven PEV Planning and Single-Family Residential Charging

5.1 Introduction

Single-family homeowners have represented the largest source of demand for PEVs to date (California Center for Sustainable Energy 2012). This is because charging in single-family homes presents the fewest physical and institutional barriers relative to other charging environments (Williams and Kurani 2006). Attached garages often have household outlets that can be used for overnight charging instead of buying special equipment. The cars may be parked a relatively short distance to an electrical panel, eliminating the need for trenching or lengthy conduit. Unlike condominium owners or apartment tenants, single-family homeowners have sole authority over their property and parking spaces, so they need not obtain permission from a landlord or homeowner association to install charging. They can install second meters so the utility can track their PEV charging or place their whole home on a special discounted rate, which they pay directly. In these ways, the hard and soft costs of charging are lowest in single-family homes.

For these reasons, planners should view residential charging, particularly in single-family homes, as critical to PEV adoption in the near term. Many cities have taken measures to require PEV-ready wiring in new residential construction and to streamline the permitting and inspection process. Reducing the upfront costs of charging in single-family homes is the “low-hanging fruit” of PEV planning. It is also the most effective way to increase the overall value of driving electric miles, regardless of the battery capacity of the PEVs being driven.

This chapter will describe how planners can use the maps and projections provided in the Southern California PEV Atlas as well as their own land use metrics to assess potential for single-family residential charging in their jurisdictions. It will conclude with a discussion of measures that planners can take to reduce the upfront costs of this type of charging as well as a demonstration of the cost savings offered by such measures.

5.2 Assessing the single-family home charging opportunity

To determine the level of readiness efforts a city, council of governments (COG) or county should take to accommodate single-family home charging, planners must first measure the potential demand for such charging in their jurisdictions. The tools in this section will help answer the following questions:

- **Where will PEVs be parked overnight?** Knowing how many PEVs are currently registered in a given area will indicate the location of current and near-future demand for residential charging. By extension, this information can help planners and utilities anticipate locations that will carry additional nighttime electrical load.
- **Where will PEVs be parked during the day?** The answer will reveal the workplaces and retail locations that will experience strongest demand for PEV charging. Planners and utilities can use this information to anticipate locations that will carry additional *daytime* electrical load.
- **How significant a land use are single-family homes in my jurisdiction?** Understanding how much of the land use mix is made up of single-family homes will help planners understand the overall importance of charging in this housing type in a given area.

5.3 Where will PEVs be parked overnight?

Table 5.1 shows the numbers of PEVs currently registered in each council of government (COG) in the Southern California Association of Governments (SCAG) region, calculated from recent disaggregated registration data purchased from R.L. Polk & Co., an automotive data vendor. The tables reflect the current number of PEVs in each COG, followed by growth projections over the next five and ten years.

The current counts reflect vehicles newly registered in each COG from December 2010, when the Chevrolet Volt and Nissan LEAF were introduced, through September 2012. Given that PEV consumer studies to date have shown PEV buyers residing almost exclusively in single-family homes, it can be assumed that the current counts largely reflect PEVs charging overnight in this housing type.

The baseline growth estimate is based on the annual U.S. growth rate of standard Toyota Prius hybrid sales beginning in 2000. This growth rate is the baseline because standard hybrids, a product type dominated early on by the Toyota Prius, can be considered parallel in many ways to plug-in hybrid electric vehicles (PHEVs). PHEVs, which comprise 70% of the PEVs newly registered in the SCAG region since December 2010 according to data from R.L. Polk & Co., are essentially standard Toyota Prius hybrids with a plug-in battery. The ability to recharge from the grid represents the potential for significant fuel cost savings above a standard hybrid. The baseline growth rate is a conservative estimate because PEVs are available in many more models than were standard hybrids in the first years after introduction. Because many more PEV models will become available in the coming years, we also present alternative scenarios in which this growth rate is exceeded by 5% and 10%.

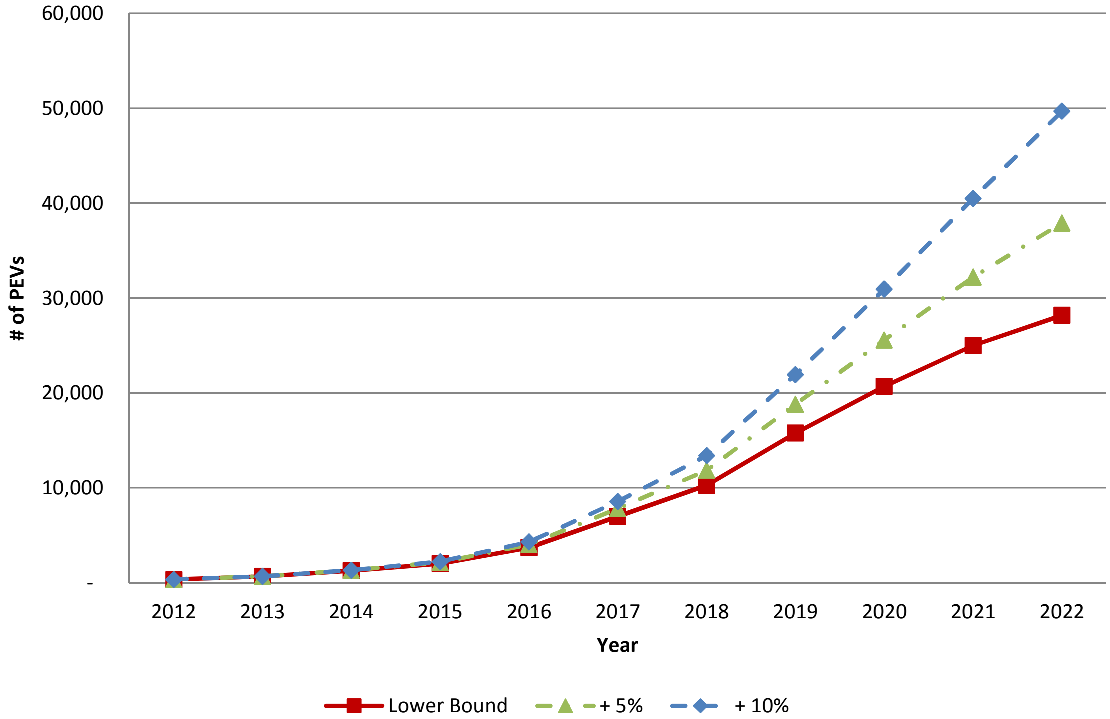
Table 5.1: PEV growth by SCAG subregion[9]

Council of Governments	Number of PEVs						
		2017 (5 year estimate)			2022 (10 year estimate)		
	2012	Lower Bound (Prius)	+ 5%	+ 10%	Lower Bound (Prius)	+ 5%	+ 10%
Arroyo Verdugo Subregion	233	4,976	5,552	6,081	20,074	26,997	35,403
City of Los Angeles	1,831	39,106	43,629	47,787	157,752	212,152	278,207
Coachella Valley Association of Governments	115	2,456	2,740	3,001	9,908	13,325	17,473
Gateway Cities Council of Governments	503	10,743	11,985	13,128	43,336	58,281	76,427
Imperial County Transportation Commission	5	107	119	130	431	579	760
Las Virgenes Malibu Council of Governments	136	2,905	3,241	3,549	11,717	15,758	20,664
North Los Angeles County	215	4,592	5,123	5,611	18,524	24,911	32,668
Orange County Council of Governments	2,263	48,333	53,923	59,062	194,971	262,206	343,846
San Bernardino Associated Governments	390	8,330	9,293	10,179	33,601	45,188	59,258
San Gabriel Valley Council of Governments	753	16,082	17,942	19,652	64,875	87,248	114,413
San Fernando Valley Council of Governments	1,002	21,401	23,876	26,151	86,328	116,098	152,246
South Bay Cities Council of Governments	747	15,954	17,799	19,496	64,359	86,552	113,501
Ventura Council of Governments	405	8,650	9,650	10,570	34,893	46,926	61,537
Western Riverside Council of Governments	398	8,500	9,484	10,387	34,290	46,115	60,473
Westside Cities Council of Governments	327	6,984	7,792	8,534	28,173	37,888	49,685

The Southern California PEV Atlas that accompanies this document also provides COG-specific cumulative PEV count projections for each year between 2012 and 2022. An example is shown in Figure 5.1 below. A potential limiting factor on the actual growth of PEVs is the high percentage of Southern California residents that live in multi-unit dwellings (MUDs). Unless steps are taken to facilitate charging in MUDs (Chapter 6), PEV ownership may not grow as projected.

9 Table 5.1, Figure 5.1 and Map 5.1 are based on 2012 numbers from R.L. Polk & Co., which reflect PEVs registered as new between December 2010 and September 2012.

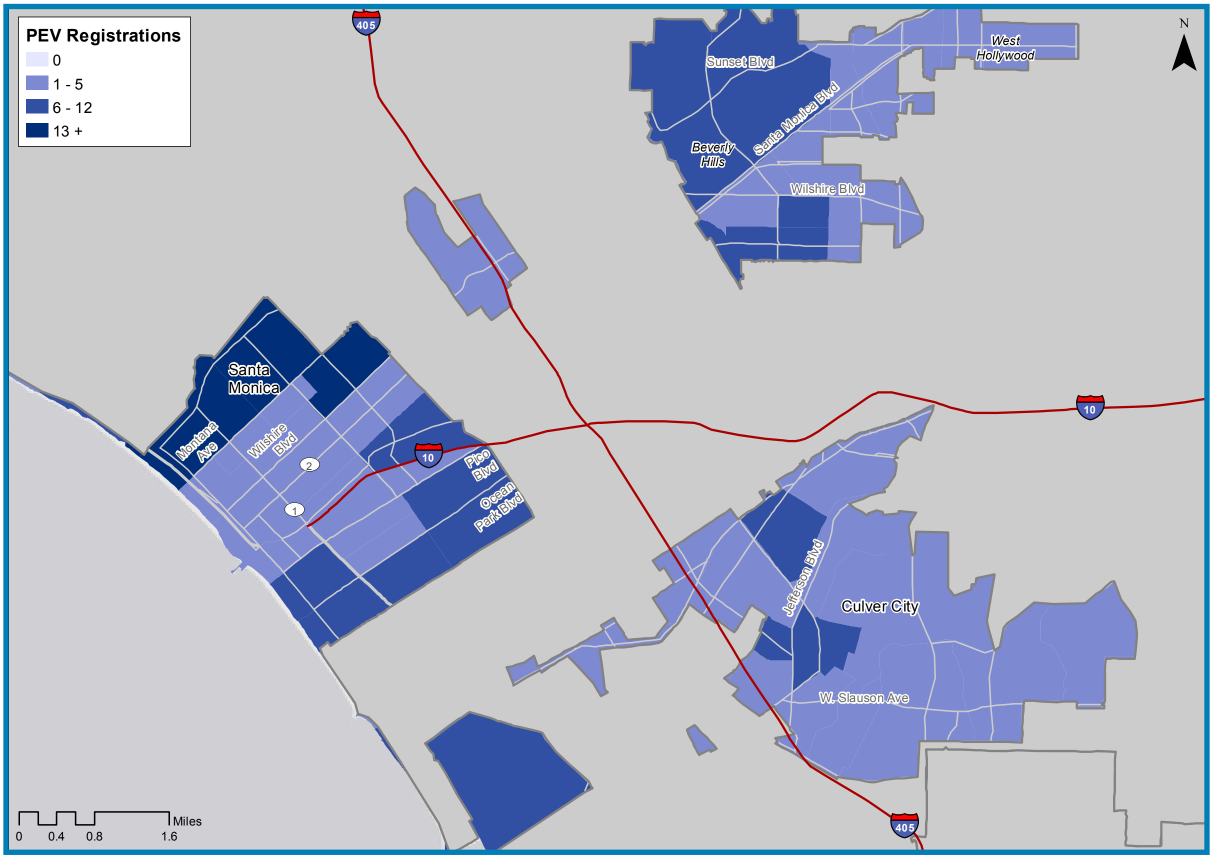
Figure 5.1: Projected growth in PEVs, Westside Cities Council of Governments



Regional and COG-level planners can use this information to assess which subregions may be more or less advanced in their PEV demand and/or readiness planning and target technical assistance appropriately. Jurisdictions can increase their PEV counts by adopting the planning reforms discussed in Chapter 10, Chapter 11, Chapter 12, and Chapter 13 of this document.

The maps provided in the Southern California PEV Atlas that accompanies this document show the numbers of PEVs registered in the COGs by travel analysis zone (TAZ). TAZs closely follow 2000 Census tract boundaries and are used by the Southern California Association of Governments (SCAG) to estimate travel within and between neighborhoods. The colors move from lighter in areas with no or few PEVs registered to darker in areas with more PEVs registered. An example from the Westside Cities COG is shown on the next page. (Map 5.1)

Map 5.1: PEV registrations by travel analysis zone, Westside Cities Council of Governments



These maps are designed to help planners and utilities assess current neighborhood demand for single-family residential charging. They can also be used to pinpoint neighborhoods that show early demand for PEVs in single-family homes but that may also have a large quantity of multi-unit dwellings (MUDs) that could benefit from targeted MUD policies (Chapter 6).

By knowing where PEVs are parked overnight, the SCAG travel model can be used to show where those PEVs are being driven during the day.

5.4 Where will PEVs be parked during the day?

While residential charging (particularly single-family) offers the most cost-effective charging opportunity, the ability to recharge at workplaces and retail locations is critical to advancing PEV adoption. In particular, workplace and retail charging maximizes greenhouse gas reduction potential by facilitating the driving of PHEVs using electric miles instead of the gasoline engine.

Using data on PEV registrations from R.L. Polk & Co. and SCAG's travel demand model of where cars typically drive from home to work and other destinations, the UCLA Luskin Center has produced COG-level maps that show where PEVs are likely to be parked during the day.

These maps are layered with workplaces and retail destinations that are likely to experience the highest demand for daytime PEV charging. Please refer to Chapter 7 for a discussion of measures to facilitate workplace charging and Chapter 8 for a discussion of retail charging opportunities.

5.5 How significant a land use are single-family homes in my jurisdiction?

Planners can use a number of metrics to measure single-family charging potential at the COG or city level.

At the COG level, planners may find it helpful to know:

- **Which cities have the highest numbers of single-family homes in absolute terms?** This will allow the COG to decide where its resources will be most effective in advancing single-family residential PEV readiness for the subregion.
- **Which cities have the highest shares of single-family homes relative to other land uses?** This will indicate areas that may not have the largest impact on the COG in terms of PEV readiness, but would benefit from targeted technical assistance.

The following sections provide examples of how to gauge single-family PEV charging potential among cities at the Los Angeles County level. Planners in COGs and cities can use these methods to prioritize cities, land uses and parcels within their jurisdictions for PEV readiness actions.

5.5.1 Ranking cities by single-family residential counts

Planners at the COG level can assess single-family charging potential by ranking their member cities in order of total number of single-family homes. This simple ranking will show relative single-family charging potential within the COG in terms of sheer numbers. Examples on the county level are shown in Table 5.2.

Table 5.2: Los Angeles County cities by single-family dwelling count

CITY	UNITS
Los Angeles	460,189
Long Beach	60,276
Palmdale	35,945
Lancaster	35,452
Santa Clarita	31,316
Torrance	28,482
Glendale	23,719
Pomona	23,202
Lakewood	22,366
West Covina	21,535

Source: Los Angeles County Assessor 2007

5.5.2 Ranking cities by single-family vs. other uses

Another way to assess single-family charging potential is by ranking cities that have the highest shares of single-family homes relative to multi-dwelling units (MUDs). This type of analysis can help cities align their PEV readiness priorities with their land uses. It can also indicate cities that may wish to prioritize single-family residential planning for PEVs, even if they will not have a significant regional impact in doing so. For the COG, such a ranking may indicate which cities may be receptive to technical assistance on PEV planning for single-family homes.

This measurement assumes that the total number of residential units represent the potential hosting of PEV charging at home. Cities that have a relatively high percentage of single-family units relative to MUDs are potentially strong candidates for single-family charging initiatives.

An example of this analysis using Los Angeles County cities is provided in Table 5.3. The percentages represent shares of the combined total number of single-family dwellings and MUD units in each city (with the MUD unit count representing the total individual apartment and condominium units across all residential buildings). They are ranked in order of the percentage of residential uses within each city that is made up of single-family units.

Table 5.3: Los Angeles County cities by residential share of combined single-family units and individual MUD units

CITY	SF %	MUD %
San Marino	100%	0%
La Habra Heights	99%	1%
Bradbury	98%	2%
Industry	98%	2%
Rolling Hills Estates	96%	4%
La Canada Flintridge	95%	5%
Palos Verdes Estates	94%	6%
Walnut	93%	7%
Cerritos	91%	9%
Palmdale	85%	15%

Source: Los Angeles County Assessor 2007

Another way to measure the importance of single-family charging within a city is to look at the share of *overall* parking opportunities that single-family homes represent versus MUD units and workplaces. For the purposes of this analysis, we assume there is one parking space for every employee in a city.[10] When we look at Los Angeles County cities in which single-family homes represent the largest share of *overall* parking opportunities, the list changes somewhat. As shown Table 5.4, these cities represent a mix of income levels. Local planners in the cities listed should prioritize charging at single-family homes within their PEV readiness efforts.

10 The UCLA Luskin Center obtained its figures from the Southern California Association of Governments' 2008 dataset from Infogroup, a vendor of employment information.

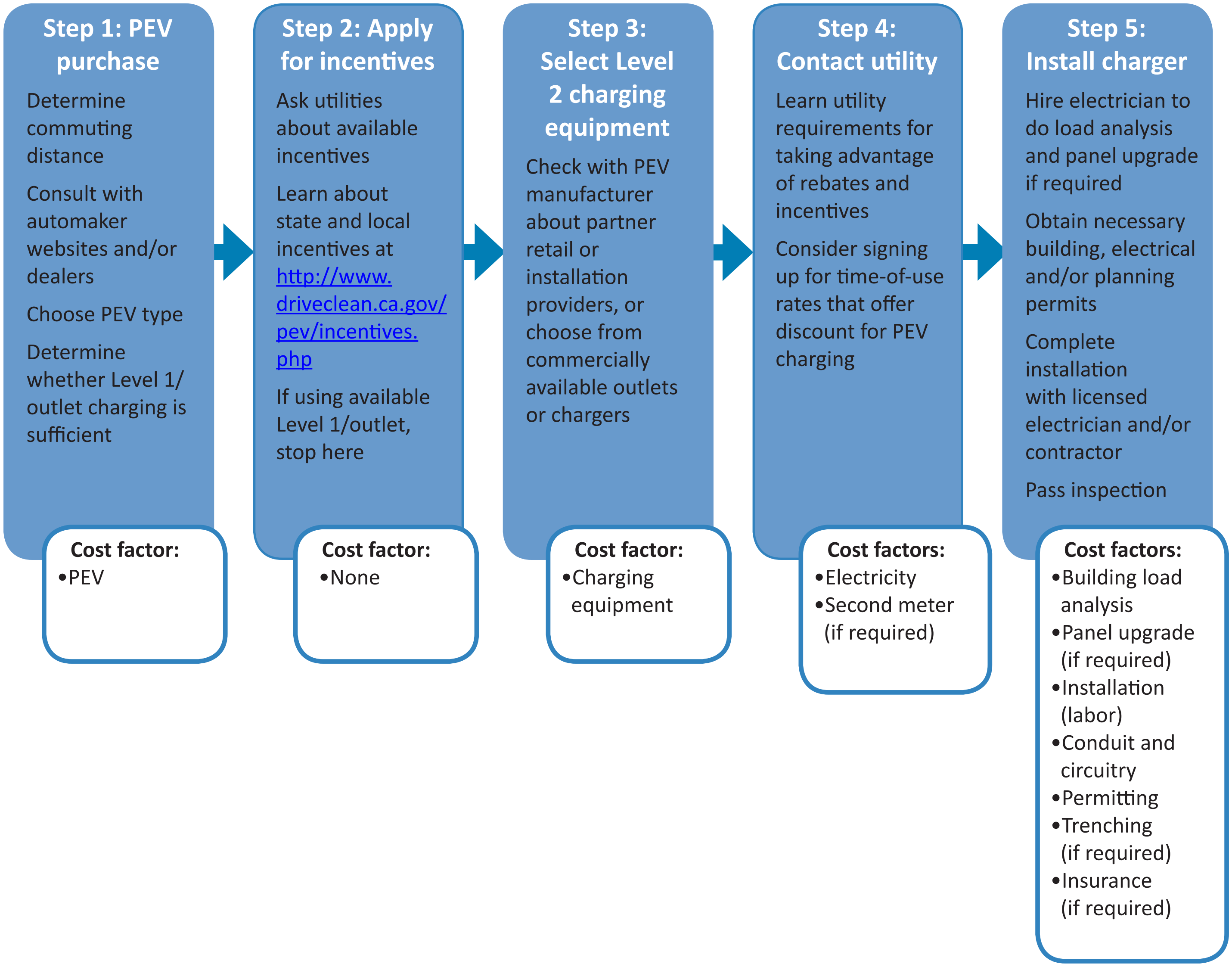
Table 5.4: Los Angeles County cities by single-family share compared to other in-city land uses

	City	% SF	SF Units	% MUD	MUD Units	% Employees	Employees	Total
1	Bradbury	89%	340	2%	6	10%	37	383
2	Rolling Hills	85%	670	0%	0	15%	121	791
3	La Habra Heights	84%	1,877	1%	24	15%	343	2,244
4	Hidden Hills	73%	702	0%	0	27%	256	958
5	Palos Verdes Estates	68%	5,095	5%	349	27%	2,052	7,496
6	Lancaster	61%	35,452	16%	9,187	23%	13,551	58,190
7	Rancho Palos Verdes	58%	12,573	15%	3,247	27%	5,942	21,762
8	San Marino	57%	4,406	0%	13	43%	3,353	7,772
9	La Mirada	56%	12,185	11%	2,359	33%	7,143	21,687
10	Lakewood	51%	22,366	10%	4,398	39%	17,157	43,921

5.6 The single-family charging installation process

The process of installing charging equipment, if needed, in a single-family home is relatively simple and cost-effective compared to charging in MUDs, workplaces and retail locations. Even so, there are several steps in the process that require the driver to make decisions and incur costs along the way. The following flowchart [Figure 5.2] illustrates the key decision points and associated cost factors of installing charging equipment in a single-family home.

Figure 5.2: Steps for installing single-family residential charging



Source: Adapted from (California Plug-in Electric Vehicle Collaborative 2012)

Public agencies and/or utilities are positioned to intervene in these various steps to bring down the hard and soft costs of single-family charging. The following section demonstrates the financial benefit to drivers of various PEV planning reforms and incentives.

5.7 PEV planning reduces the cost of electric driving

As shown in Table 5.5, the upfront costs of equipment and installation make up the majority of the cost elements of charging a PEV. For single-family homes, the upfront costs will likely only include the electrical service and/or charging equipment, installation and permitting, but could increase if additional circuitry is required to handle the additional electrical load.

Table 5.5: Charge station cost elements

Installed Charger Costs	Operational costs
Building Load Analysis	Electricity
Charging equipment	Insurance[c]
Installation (labor)	
Conduit & Circuitry	
Permitting	
Trenching[a]	
Additional electrical meter[b]	
Electrical panel upgrade[a]	
Transformer upgrade[c]	

[a]Possible cost elements depending on building types and installation context.
[b]May only be needed if driver is using utility PEV time-of-use rate.
[c]Associated only with MUD installations and needed only in occasional contexts.

The higher the upfront cost of charging, the more it costs on average to drive each electric mile. PEV drivers who use fewer electric miles, either because they have short commutes or drive PHEVs that switch to gasoline when their batteries are depleted, may still face the same costs of charging equipment, installation and electricity. But given those same upfront and operational costs, they pay a higher average cost for each electric mile driven. As shown in Table 5.6, lowering the upfront cost of charging increases the value of each electric mile driven (known as $ per gallon-equivalent) for *all* PEV drivers.

Table 5.6: Incentives and permit streamlining efficiencies reduce the cost of e-driving*

	10 E-miles driven		30 E-miles driven	
Cost reduction/ incentive level	$ per gallon-e	% reduction	$ per gallon-e	% reduction
0	$4.10	--	$2.59	--
$250	$3.80	7%	$2.49	4%
$500	$3.50	15%	$2.39	8%
$1,000	$2.91	29%	$2.19	15%
$1,500	$2.32	43%	$1.99	23%

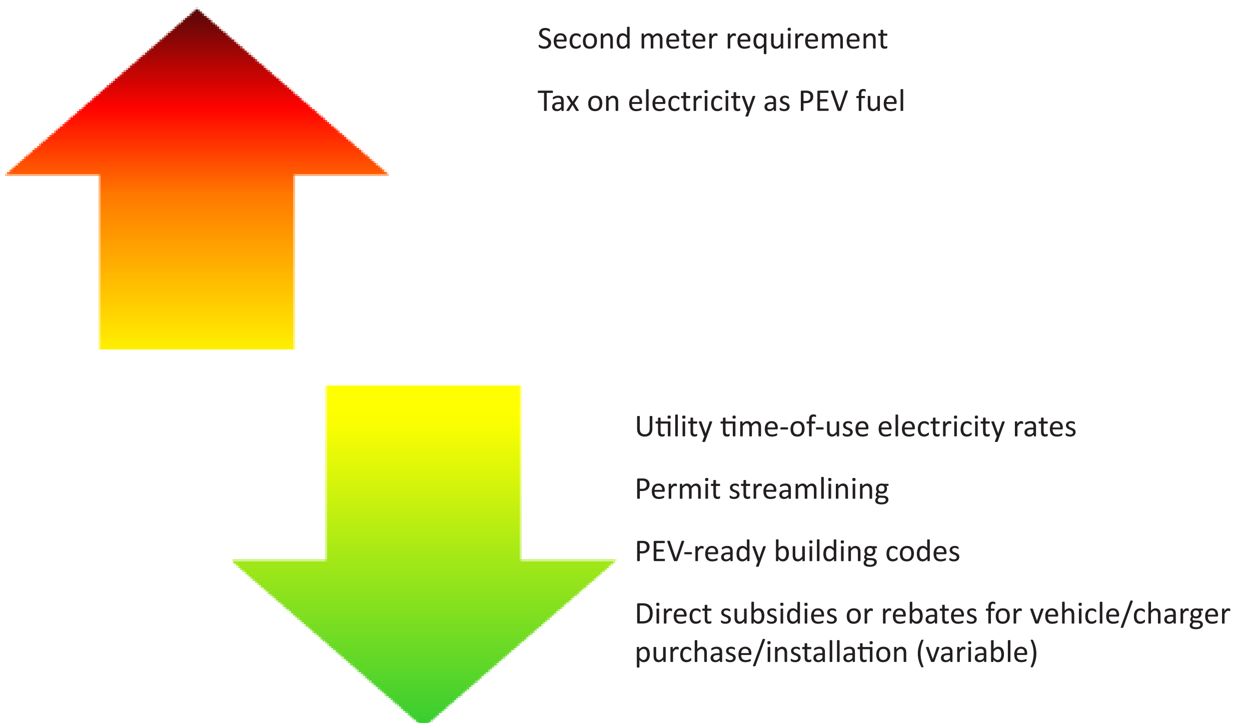
**Table assumes an initial installed charge cost of $2,000 and electricity cost of 20₵ per kWh.*

Planners and utilities should prioritize policies that will reduce upfront costs of PEV charging.

Such policies include direct subsidies and rebates for vehicle, electrical service and/or charging equipment purchase and installation (http://www.afdc.energy.gov/laws/state_summary/CA); building codes that require PEV-ready wiring to minimize the need for retrofits (Chapter 11); a streamlined permitting and inspection process that will reduce permit fees and labor time (Chapter 12); and utility rates that offer a discount for PEV charging (Chapter 14).

Figure 5.3 shows the effect on average cost to the driver per electric mile of different PEV policies and incentives. Utility requirements to install second meters to monitor PEV charging at special discounted electricity rates are usually associated with the installation of Level 2 charging equipment. Second meter requirements add to the cost and complexity of installation, and may later facilitate unapproved conversion of single-family properties to multi-unit rentals or home businesses. Level 1 charging (Chapter 3) may suit the needs of many PEV drivers, particularly those with short commutes or smaller batteries. Taxes on electricity used for PEV charging, similar to gasoline taxes, are now being levied in some states.

Figure 5.3: Effect of policies on average cost of PEV driving



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6 Planning for Charging in Multi-Unit Dwellings

6.1 Introduction

Multi-unit dwellings (MUDs), which include apartment and condominium buildings, make up a significant percentage of the housing stock in many Southern California cities. As such, they represent a large potential source of PEV adoption in the future. A market study by the UCLA Luskin Center found that 65% of prospective early PEV adopters in Los Angeles are MUD residents and renters, and that PEV home charging will be most concentrated in areas of the city that have substantial MUD populations (Dubin et al. 2011). But without policies that enable at-home MUD charging, many residents may not buy PEVs due to the difficulties associated with charger installation.

Identifying clusters of MUDs and understanding their proportion of the land use mix within a local jurisdiction will help planners target PEV readiness priorities to this housing type. This chapter will guide planners in assessing the MUD charging potential in their communities. It will then identify the institutional and physical barriers to MUD charging, explain how those barriers affect the cost of MUD charging, and recommend planning and policy approaches to reducing those barriers and costs. Reforming building codes to require PEV-ready wiring in new MUD construction will be the most cost-effective way of expanding the market for electric vehicles in the long run.

6.2 Planning metrics for MUD charging

Planners can use a number of metrics to measure MUD charging potential at the council of governments (COG) or city level.

At the COG level, planners may find it helpful to know:

- Which cities have **the highest numbers of MUDs in absolute terms**? This will allow the COG to decide where its resources will be most effective in advancing PEV readiness for the subregion.

- Which cities have **the highest concentrations of MUDs**? This will indicate areas that may not have the largest impact on the COG in terms of PEV readiness, but would benefit from targeted technical assistance.

At the city level, planners may find it helpful to know:

- **Which of the land uses** in my city could offer the most PEV charging opportunities?
- Within those land uses, **which parcels/buildings** are most suitable for PEV charging?

Plug-in electric vehicles charge while parked. The type and availability of parking spaces at single-family homes, MUDs and workplaces will vary across municipalities. Understanding the distribution of parking spaces across land uses enables planners to understand the number and type of potential charging sites within their jurisdiction.

Ideally, planners would estimate the number of parking spaces at each parcel based on knowledge of local zoning and building code history (or, even better, a field survey of parking at these parcels). However, in the absence of more refined information, we make simplified assumptions for the purposes of illustrating analysis:

- We assume that the number of residential units on a parcel is equal to the number of on-site parking spaces for both single-family and multi-unit dwellings (MUDs).
- We also assume that there is a parking space for every employee at a workplace.
- We count MUDs in terms of individual units (i.e., apartments or condominiums), not buildings, because each unit represents at least one potential parking space. For the purposes of this analysis, condominiums are considered MUDs (even though they are individually owned) because the physical and institutional challenges of charging in condominiums are similar to those of apartment buildings.

The following sections provide examples of how to gauge PEV charging potential among cities at the Los Angeles County level. Planners in COGs and cities can use these methods to prioritize cities, land uses and parcels within their jurisdictions for PEV readiness actions.

6.2.1 Ranking cities by MUD counts

Planners at the COG level can assess MUD charging potential by ranking their member cities in order of total number of MUD units or MUD buildings. This simple ranking will show relative MUD charging potential within the COG in terms of sheer numbers. Examples on the county level are shown in Table 6.1.

Table 6.1: Los Angeles County cities by MUD unit count

City	Units
Los Angeles	776,423
Long Beach	91,512
Glendale	44,781
Santa Monica	36,745
Pasadena	28,362
Torrance	24,343
Inglewood	22,626
Burbank	22,426
Santa Clarita	20,420
Hawthorne	20,260

The method each COG chooses to prioritize cities for MUD charging will depend on how much variability in MUD density exists within the COG and how the COG would like to focus its PEV readiness efforts for MUDs. COGs can also choose to rank their cities by average number of MUD units per building or by density of MUD units per acre. The number of units per acre will indicate the likely number of parking spaces located on-site and thus the potential number of PEV-ready spaces and/or charging units that these MUDs could house. An example is provided in the following section.

6.2.2 Ranking cities by MUDs vs. other uses

It may be helpful to first simply compare the shares of MUD and single-family residential housing units within a city. Table 6.2 presents the top 10 Los Angeles County cities by the share of their residential units that are comprised of individual MUD units (not MUD buildings). When considering the share of multi-unit residences out of all residential units, we see that MUD units comprise 70% or more of the housing units within almost 10 cities. These cities represent a mix of sizes and income levels.

Table 6.2: Los Angeles County cities by MUD share of residential units in-city

City	MUD %	MUD Units	SF %	SF Units	Total Units
West Hollywood	95%	19,866	5%	1,073	20,939
Cudahy	85%	2,645	15%	479	3,124
Santa Monica	83%	36,745	17%	7,355	44,100
Bell Gardens	79%	4,679	21%	1,221	5,900
Hawthorne	75%	20,260	25%	6,653	26,913
Huntington Park	74%	8,723	26%	3,047	11,770
Signal Hill	74%	2,899	26%	1,027	3,926
Lawndale	72%	5,467	28%	2,112	7,579
Bell	70%	4,820	30%	2,027	6,847
Redondo Beach	69%	18,888	31%	8,485	27,373

Another way to assess MUD charging potential is by ranking cities that have the highest concentrations of MUDs relative to single-family homes and employees. This type of analysis can help cities align their PEV readiness priorities with their land uses. It can also indicate cities that may wish to prioritize MUD planning for PEVs (even if they will not have a significant regional impact in doing so). For the COG, such a ranking may indicate which cities may be receptive to technical assistance on PEV planning for MUDs.

This measurement assumes that the total number of residential units and employees represent the potential hosting capacity of PEV charging at homes and workplaces. This measurement accounts for the number of employees, not employers. This is because larger workplaces have potentially more capacity to host a higher number of PEV charging spaces.

Cities that have a relatively high percentage of MUD units relative to single-family homes and employees are potentially strong candidates for MUD charging initiatives. Cities that have fewer MUDs relative to the number of employees, represented by the lower-ranked cities in the rightmost column in the table below, may be stronger candidates for workplace charging initiatives.

The percentages in Table 6.3 represent shares of the combined total number of MUD units, single-family units, and employees in each city. They are ranked in order of the percentage of uses within each city that is made up of MUD units.

Table 6.3: Los Angeles County cities by share of MUD units, single-family units, and employees

City	% MUD	% SF	% Employee
West Hollywood	43%	2%	55%
Cudahy	40%	7%	52%
Hawthorne	39%	13%	48%
Lomita	37%	22%	40%
Redondo Beach	37%	17%	46%
Bellflower	37%	28%	35%
Maywood	37%	18%	45%
Lawndale	36%	14%	50%
Hermosa Beach	35%	20%	45%
Alhambra	32%	18%	50%

6.2.3 Measuring MUD charging potential within cities

City planners can assess the relative PEV charging potential of their MUDs by looking at a distribution of MUD sizes in their city. Larger MUDs are better candidates for hosting more PEV charging, given that they have more parking spaces (including visitor spaces). Landlords and condominium associations may also be better-positioned to achieve economies of scale and recover their costs with more residents using the charging units.[11]

Cities may vary widely in their MUD size distributions. Planners can use their own data on typical MUD sizes and the number of buildings of each size in their jurisdiction. City planners can apply these methods using their own data on housing and employment density, MUD vintage and income. Substituting the ages of MUDs for the number of units in the distributions shown above can help planners assess the likely percentage of MUDs that do not have any on-site parking as well as the possible need for electrical panel upgrades in older MUDs that do have on-site parking. An MUD building vintage inventory will help planners understand the potential permitting and installation streamlining measures they should consider. Downtown loft buildings in revitalized urban cores often do not have on-site parking, but cater to a higher-income demographic that may wish to park and charge PEVs in stand-alone parking areas or neighboring office parking structures.

11 Smaller MUDs in high-income areas may also experience demand for PEV charging, as studies have shown early adopters of PEVs have been relatively affluent (California Center for Sustainable Energy). However, the PEV owners surveyed to date have mostly been drivers of all-battery electric vehicles (BEVs). Owners of plug-in hybrids may be more varied in their income levels in the mid- to long-term.

6.3 Mapping MUD charging potential at the COG level

While the planning metrics discussed in the previous section provide a precise characterization of MUD charging potential at the COG and city level, they do not show exactly where such opportunities are located spatially. Mapping the precise location of MUDs and knowing the density of units on a site will be of particular use in utility planning. Utilities can use such maps to anticipate where upgrades may be needed for transformers and distribution stations to accommodate PEV charging at MUDs. City planners can also use these maps to identify specific buildings and/or MUD owners that could potentially host charging on-site. Planners can use the maps provided in the Southern California PEV Atlas that accompanies this document to compare spatial distributions of MUD density, PEV registrations and daytime PEV destinations, employment and commercial density, publicly accessible charging stations, and stand-alone parking areas.

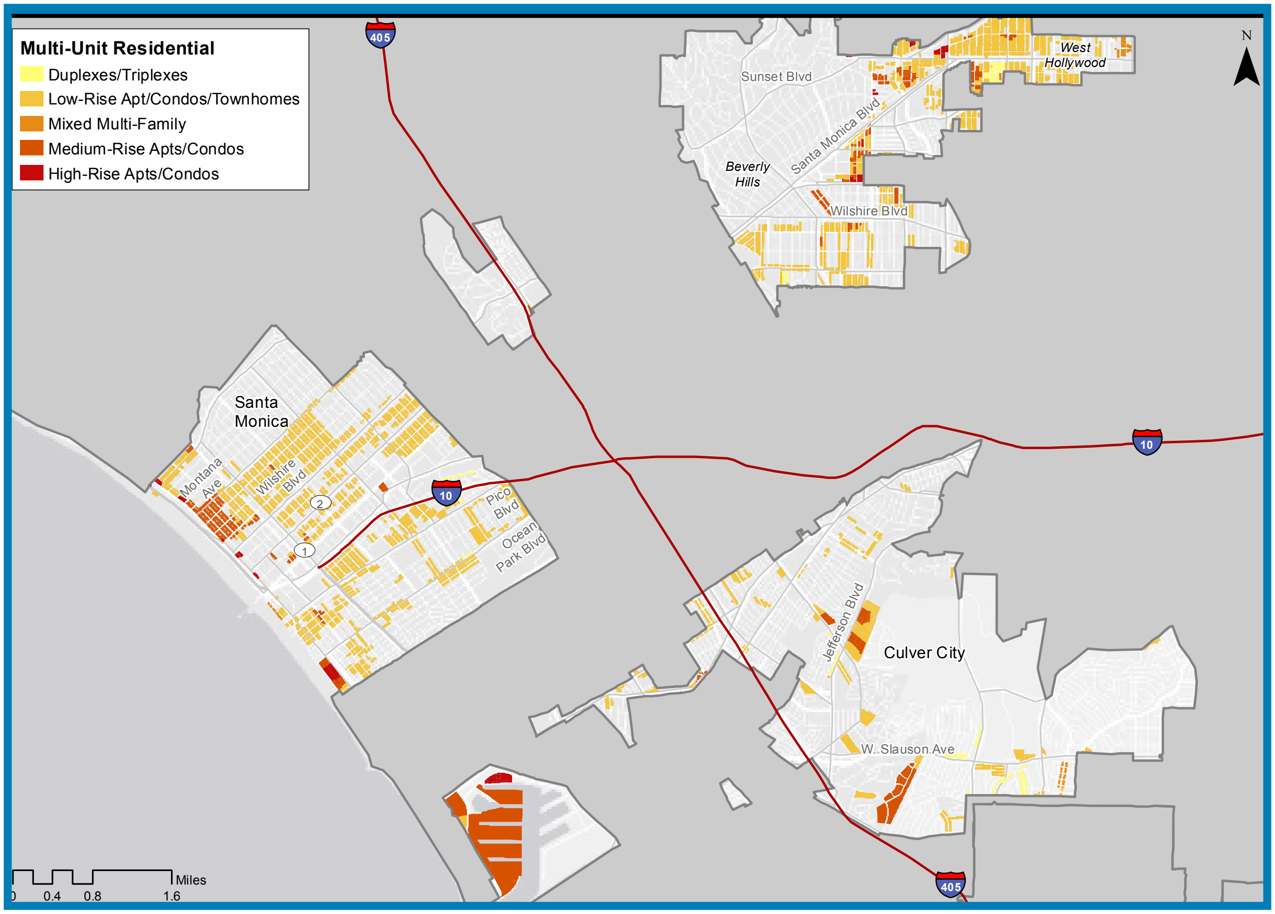
The Southern California PEV Readiness Plan's multi-unit residential density maps were created using data from SCAG's 2005 Existing Land Use Dataset. The data includes information on the concentration of all residential units other than single-family. The designations were determined by using aerial photography to estimate the land uses at the parcel level. Each residential parcel in the dataset is assigned a code that best describes the composition of residential unit types. The factors that contribute to a parcel's residential designation are the height of the buildings, the square footage, and the concentration of multi-unit dwellings per parcel (Southern California Association of Governments 2002).

Table 6.4: SCAG Multi-Unit Residential Density Designations

CODE	DESCRIPTION	DENSITY
1121	Mixed Multi-Family Residential	NA
1122	Duplexes, Triplexes, and 2- or 2-Unit Condominiums and Townhouses	2 units or less
1123	Low-Rise Apartments, Condominiums, and Townhouses	4+ units. 10 to 18 units per acre
1124	Medium-Rise Apartments and Condominiums	Greater than 18 units per acre
1125	High-Rise Apartments and Condominiums	Greater than 18 units per acre

The map shown below is an example of one of the multi-unit residential density maps created by the UCLA Luskin Center for each of the councils of government (COGs) in the SCAG region. All of the COG-level maps can be found in the Southern California PEV Atlas that accompanies this document.

Map 6.1: Multi-Unit Residential Density, Westside Cities COG



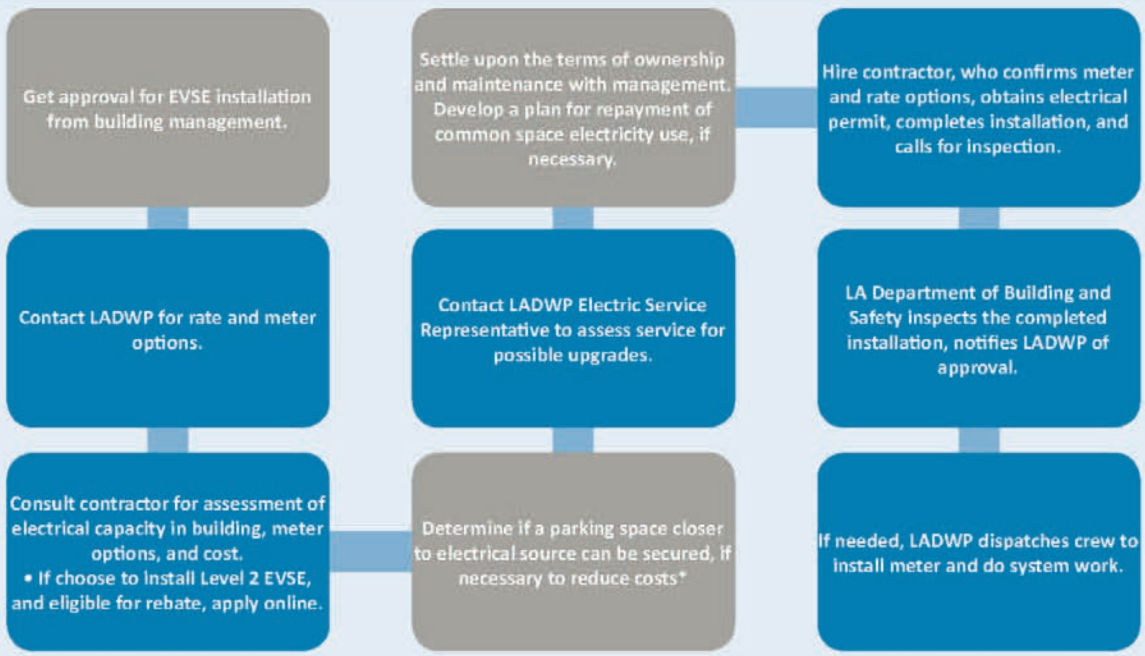
As shown in Map 6.1, the densities of units per acre increase from yellow at the duplex, triplex and townhouse level all the way up to high-rise MUDs in red. The number of units per acre will indicate the likely number of parking spaces located on site and thus the potential number of PEV-ready spaces and/or charging units that these MUDs could house. In older neighborhoods with MUDs that have no parking, publicly-accessible and workplace charging may become a higher priority. See Chapter 7 for guidance on facilitating workplace charging and Chapter 8 for information on retail charging.

Until the challenges to MUD residential charging are met, understanding the location and density of MUDs can help planners assess spatial demand for publicly-accessible charging as well as the level of charge that will be needed. The lack of availability of charging infrastructure in MUDs may steer early adopters who live in multi-unit dwellings towards plug-in hybrid electric vehicles (PHEVs), which unlike all-electric battery-powered vehicles, have a gasoline-fueled component. Level 1 charging may largely suit the near-term needs of PHEV adopters who live in MUDs. MUD-dense areas may also be good candidates for PEV car share programs.

6.4 The PEV Charging Installation Process in MUDs

The process of setting up PEV charging in MUDs generally falls into two categories: **a resident-driven** process in which an individual tenant or condo owner initiates the process and pays for equipment and installation for his or her charger; or an **owner-driven** process in which the landlord or homeowner association (HOA) does so as an amenity for present and future residents. In either scenario, a complicating factor in MUD charging is the number of stakeholders involved. Unlike in a single-family home, PEV drivers must obtain permission for installation from homeowner associations (HOAs), landlords, and/or fellow tenants (Balmin, Bonett, and Kirkeby 2012). Figure 6.1 is based on the Los Angeles Department of Water and Power's process for installing charging in MUDs, but could apply to other utility service territories as well.

Figure 6.1: Charging installation process for MUDs in Los Angeles



*If the resident lives in Common Interest Development and wishes to use a common space for charging, this step may involve getting approval from the architectural committee, obtaining homeowners insurance coverage for the EVSE, and entering into a license agreement with the HOA.

Boxes with gray background are additional steps that must be taken if the installation is initiated by a resident of MUDs rather than the landlord or Homeowners Association. The steps in with blue backgrounds are summarized from LADWP's "Residential EV Level II (240V) Charger Installation Steps" [http://www.ladwp.com/ladwp/cms/ladwp014329.pdf] Other guides recommend gauging interest of other residents in EVSE to incorporate their charging needs in installation plans.

Source: Increasing Electric Vehicle Charging Access in Multi-Unit Dwellings in Los Angeles (2012)

The stakeholders involved in MUD charging interact with institutional, physical and economic challenges that increase the complexity and, by extension, the hard and soft cost of PEV charging installation (such as wiring, trenching, panel upgrades, and permits). We discuss these barriers and make recommendations for addressing them in the following sections.

6.5 Barriers to charging in MUDs

Developing a robust charging environment in MUDs will require overcoming a number of institutional, physical and economic barriers not present in single-family residential charging environments. Some of these barriers can be overcome with properly-targeted state or utility subsidies. Others lend themselves to local policies to drive down the hard and soft costs of installation.

Still other solutions will rely on internal problem-solving between landlords and tenants, or between HOAs and condominium owners. PEV-driving MUD residents interviewed by the UCLA Luskin Center identified HOA/landlord opposition as a significant barrier to at-home charging. Such opposition stems from lack of knowledge about how charging will affect the building's electrical loads, liability issues, and how to recover costs.

Specific challenges to charging in MUDs (listed below) are explained in the following sections and are accompanied by recommendations where possible (Balmin, Bonett, and Kirkeby 2012):

- Lack of on-site parking at some (particularly older) MUDs
- Location, availability and management of on-site parking
- The cost of equipment installation and electrical upgrades
- Ownership models and recovery of equipment, installation and operating costs

6.5.1 Institutional and physical barriers to PEV charging

Location, availability and management of on-site parking. Many apartments and condominiums have assigned or deeded parking spaces, which makes it difficult to convert the spaces closest to the electrical room to PEV spaces. The farther away from the electrical room the charger is located, the more expensive it will be to lay conduit and wiring.

The distance between where the PEV is parked and the electrical panel is a major factor in installation costs, permitting and inspection processes. Garden-style MUDs with surface parking may have the greatest distances between where cars are parked and where service panels are located, and may require trenching. High-rise MUDs with multi-level parking decks may be able to electrify parking spaces with lower-cost surface conduit (California Plug-in Electric Vehicle Collaborative 2012). Either way, these steps can incur more in the way of construction costs and soft costs associated with permitting and inspection.

Opportunities should be explored to trade parking spots or use a common or visitor space for PEV charging. HOAs and landlords can convert visitor spaces to assigned PEV parking or temporary charging. They can also encourage residents to trade parking spots to put the PEVs as close as possible to the electrical room.

In older urban cores, some MUDs may have no on-site parking. Publicly-accessible and workplace charging may fill in the gap for residents of such MUDs. Please see Chapter 4 and

Chapter 7 for respective discussions of publicly-accessible and workplace charging.

The cost of equipment installation and electrical upgrades. Common parking areas often have just enough electrical capacity to support lighting and other basic garage functions. Level 1 charging may only require adding 120-volt outlets, but panel upgrades may be needed to support Level 2 charging. If subsidies for charging equipment and installation require Level 2 charging, property owners may be deterred from taking advantage of the subsidies because of the cost of adding panel capacity. Adding panel capacity can incur hard costs of electrical upgrades as well as soft costs of permitting and inspection.

Building codes offer an opportunity to require PEV-ready wiring and electrical capacity in new construction—a much more cost-effective method than retrofits. Many building codes have begun to require Level 2 charging capacity and a minimum number of PEV-ready parking spaces. These codes, as well as equipment subsidies and rate incentives from local jurisdictions and/or utilities, could be adapted to facilitate more Level 1 charging capabilities. Further guidance on building codes for PEV readiness is provided in Chapter 11.

6.5.2 MUD cost recovery rules

Depending on where the MUD is located, MUD owners face different rules that govern how they are allowed to recoup the costs of electricity from PEV drivers. According to state law, owners of MUDs in an area served by an investor-owned utility company (i.e., Southern California Edison and Bear Valley Electric) can establish their own cost recovery models without being regulated as utilities for the purposes of selling electricity. This means the MUD owner can bill PEV drivers for electricity independently of what the utility charges him or her (California Plug-in Electric Vehicle Collaborative 2012).

Owners of MUDs in municipally-owned public utilities need to check with their utility to determine any restrictions on reselling electricity. For example, MUD owners may not be able to charge PEV drivers based on electricity usage, but may charge an hourly or monthly fee. MUD owners attempting to pass equipment and installation costs on to residents may have to do so separately in addition to passing on the utility's electricity rate (California Plug-in Electric Vehicle Collaborative 2012).

Charging stations owned by the government and nonprofit sectors may be subject to different cost recovery regulations or models. Guidance on pricing access to chargers owned by the public and nonprofit sectors is provided in Chapter 9. A detailed discussion of ownership models and cost recovery at MUDs follows.

6.6 Financial viability of multi-unit dwelling charging

A central concern of most MUD owners is whether multi-unit dwelling charging will be financially viable. They want to know whether they can at least break even on their investment.

Landlords and HOAs must decide if they want to recover the costs of charging equipment and installation and offer charging as an amenity to present and future residents. Alternatively, they can require individual residents to assume these upfront costs.

Creating a PEV charging opportunity in an MUD parking area requires balancing present and future costs and benefits. Renters are unlikely to want to pay the upfront costs associated with charging. Even if they can take the charging unit with them when they leave, they cannot capture the value of their investment in PEV-ready wiring of the parking space. Condominium owners who invest in PEV-ready wiring and charging units can recoup their investment when they sell their homes and parking spaces. In both cases, the landlord or HOA are left with an asset for future residents in the form of an electrified parking space. But property owners also face the prospect of having to maintain or remove old equipment if the space is no longer used for PEV charging (Balmin, Bonett, and Kirkeby 2012).

The California PEV Collaborative offers a case study in which a condominium HOA contracts with an electric vehicle service provider (EVSP) to promote and advertise the building as EV-ready. Once the first homeowner subscribes to the charging service, the HOA pays for the EVSP to wire the parking area to accommodate charging. The EVSP then installs and removes charging units as needed by residents, bills residents for charging, and reimburses the HOA quarterly for electricity used. In this way, upfront costs to the HOA are delayed until use of the charging space is assured (California Plug-in Electric Vehicle Collaborative 2012).

The ability to recover costs of charging equipment, installation and operations differ depending on whether the equipment is owned by an individual MUD resident for personal use or whether the landlord or HOA hosts the charging station for all PEV owners in a building. This section examines cost recovery models assuming a building-wide model of access and the involvement of an electric vehicle service provider (EVSP) to handle installation and billing. The cost recovery model for an individual MUD resident will be similar to that of a single-family homeowner. Please refer to Chapter 5 for a discussion of PEV charging cost recovery at single-family homes.

In this section, we first present a set of questions facing MUD owners (landlords and HOAs) who wish to make well-informed investments in charging equipment. We then explore the financial viability of several types of investment scenarios involving early- and then middle-market demand for multi-unit dwelling charging. We conclude that the two most transparent and effective policies are a variable cost with a markup and, to a lesser extent, an hourly rate policy.

6.6.1 How much resident demand will there be for PEV charging?

In order to assess resident demand for PEV charging, MUD owners will want to know:

- How many residents are currently driving PEVs?
- How will this number grow over time?
- How much will they use the charging equipment if it is available?

6.6.2 How should the MUD owner price PEV charging?

Once the MUD owner estimates the demand for multi-unit dwelling charging, he or she must decide how to price the service. Understanding potential demand will help the owner or property manager determine how much electricity residents will consume for PEV charging and what revenues will be generated by pricing use of the equipment.

MUD owners must be careful not to price charging at levels higher than what residents would have to pay for gasoline. Overpricing will discourage residents who wish to purchase new PEVs, since they will not enjoy the cost savings. It will also discourage current residents with PHEVs from charging at home, since it will be cheaper to refuel with gasoline.

6.6.3 How much charging capacity should the MUD owner provide?

Charge station capacity here refers to the number of cords of each level (1, 2 or fast charging) provided at the location. Currently, single-cord Level 2 chargers are popular. But this may not necessarily be the best capacity for MUD owners to choose. If the MUD owner expects multiple residents to adopt PEVs, then multiple-cord (or multiplex) charging units with different levels of service (1 and 2) could be an MUD owner's most cost-effective solution. Although the upfront costs can be higher, the multiplex chargers, when charging several vehicles at once, may do so at a lower total cost and lower cost per unit of electricity than would a comparable number of single-cord Level 2 chargers. In practice, identifying the most cost-effective choice of charging capacity requires comparing the costs of specific types of charging equipment and how much it will be used in a specific multi-unit dwelling setting.

6.6.4 Financial viability scenarios

The goal of the next sections is to give planners an understanding of how installed charger costs, pricing policy, and driver utilization rates affect the financial viability of multi-unit dwelling charging. Using simple cash-flow models, we describe the net loss or net profit of multi-unit dwelling charging under a wide range of conditions. These examples are intended only as illustrations but are based on several commonly-encountered assumptions.[12] We will consistently evaluate the impacts of wide a range of installed equipment costs, from a low of $500 to a high of $10,000.[13]

12 We assume property owners (or a contracted electric vehicle service provider) will own and operate the charge station with one or more Level 2 chargers every day for 10 years and that he or she pays $0.195 per kilowatt-hour (kWh) for electricity. (This is based on what a typical home would pay on average in the Southern California Edison service territory. Smaller businesses tend to pay more than this rate per kWh and larger businesses tend to pay less. We hold electricity costs constant across our analyses in this Plan in order to simplify comparisons across charging environments). When calculating the net present value we assume the property owner's discount rate is 5%. Variable costs (electricity and markup) grow at a rate of 3% per year. Operation and maintenance costs are assumed to be 5% of total fixed costs.

13 This installed charger costs represent the total upfront costs including charging space design, permitting, electrical upgrades, construction, installation, and the cost of charging equipment.

6.6.5 Recovering costs of charging the first PEV

Given that drivers have only just begun to purchase PEVs, many property owners are considering installing MUD charging for a single "first" PEV. The average driver in United States metropolitan areas travels less than 30 miles per day (Krumm 2012). So a reasonable assumption would be that the PEV arrives at home each day having driven 30 electric miles. This means the driver could restore the electricity used to drive those 30 miles to the battery through multi-unit dwelling charging. For the MUD owner, the revenues that would be generated from that utilization rate require an understanding of what the PEV driver will pay for charging. Our analysis below will identify what multi-unit dwelling prices PEV drivers would be willing to pay based on the price of gasoline.

Although Tables 6.5–6.8 assume the use of one or more Level 2 chargers, MUD owners should first assess their capacity to support Level 1 charging, since it involves the lowest installation and equipment costs. If pre-existing Level 1 outlets are available, and the building's electrical capacity is adequate, the only costs the MUD owner may face are those associated with measuring how much electricity residents consume and billing them accordingly. Table 6.5 illustrates both the cost of Level 1 charging when only electricity costs need to be covered as well as the cost of gasoline at different levels for benchmarking purposes. These costs are the same regardless of the number of daily electric miles driven.[14]

Table 6.5: Benchmarks for electricity and gasoline costs

Comparison cost levels	$/Electric Mile	$/Gallon Equivalent
Level 1/Electricity cost only	$0.06	$1.80
$3.50 gas	$0.12	$3.50
$4.00 gas	$0.14	$4.00
$4.50 gas	$0.15	$4.50

In the following scenario analysis, we explore the impacts of four different types of pricing policies: 1) flat monthly or subscription fees, 2) hourly rate, 3) hourly with connection fee, and 4) cost plus a markup. SeeTable 6.6, Table 6.7, Table 6.8 and Table 6.9 respectively. Within each table we use six different pricing levels and 11 different possible installed charger costs to calculate the present value (or net profits) for the property owner for 66 different pricing scenarios. Each assumes a Level 2 charging rate.

14 For these analyses, we assume that PEVs driving in electric mode are depleting their batteries at a rate of 34.82 kW/100 miles. This represents a weighted average fuel consumption based on the market share of individual PEV models (HybridCars.com 2012). When comparing this fuel consumption to a conventional vehicle (CV), our analyses assume a price of gasoline of $4.00, slightly above the average price of gasoline in California in 2012 (U.S. Department of Energy 2012).

Planners can use the tables in this section to assess financial viability of hosting a charging station from the **MUD owner's** perspective. When used in conjunction with the tables in Chapter 9, planners can evaluate the pricing models presented here against the cost to the **driver** under the same pricing models.

First, the planner can identify investment costs and pricing levels under which owners would at least break even, given this level of utilization. Second, the planner can evaluate the multi-unit dwelling prices that are likely to be above the PEV driver's gasoline cost of refueling. This latter assessment is critical for the property owner because it identifies those prices that are unlikely to generate any revenues for the multi-unit dwelling charge station. Of course, another danger for the property owner is pricing charging at levels too low to cover costs. In our analysis below, we consider both of these possible errors when evaluating the financial viability of multi-unit dwelling charging scenarios.

Monthly Flat Rates. Table 6.6 illustrates the present value calculation for flat rates or monthly subscriptions ranging from $25 to $150 per month. We see again that several price levels would enable the MUD owner to break even: $75 a month would cover up to $500 in investment costs, while $100 a month would cover up to $2,000. However, even at the low levels of investment, only very high e-mileage drivers would find it cost-effective to charge under a flat rate. Higher monthly fees would not be cost-effective for even high-mileage drivers.

Table 6.6: Present value of multi-unit dwelling charging to site owner over 10 years (monthly flat rate)

Installed Level 2 Charger Cost	Monthly Rate: $ 25.00	$ 50.00	$ 75.00	$ 100.00	$ 125.00	$ 150.00
$ 500.00	$ (4,604)	$ (1,980)	$ 645	$ 3,269	$ 5,893	$ 8,518
$ 1,000.00	$ (5,322)	$ (2,698)	$ (74)	$ 2,550	$ 5,175	$ 7,799
$ 2,000.00	$ (6,760)	$ (4,136)	$ (1,511)	$ 1,113	$ 3,737	$ 6,362
$ 3,000.00	$ (8,197)	$ (5,573)	$ (2,949)	$ (324)	$ 2,300	$ 4,924
$ 4,000.00	$ (9,635)	$ (7,010)	$ (4,386)	$ (1,762)	$ 862	$ 3,487
$ 5,000.00	$ (11,072)	$ (8,448)	$ (5,823)	$ (3,199)	$ (575)	$ 2,049
$ 6,000.00	$ (12,509)	$ (9,885)	$ (7,261)	$ (4,637)	$ (2,012)	$ 612
$ 7,000.00	$ (13,947)	$ (11,322)	$ (8,698)	$ (6,074)	$ (3,450)	$ (825)
$ 8,000.00	$ (15,384)	$ (12,760)	$ (10,136)	$ (7,511)	$ (4,887)	$ (2,263)
$ 9,000.00	$ (16,822)	$ (14,197)	$ (11,573)	$ (8,949)	$ (6,324)	$ (3,700)
$ 10,000.00	$ (18,259)	$ (15,635)	$ (13,010)	$ (10,386)	$ (7,762)	$ (5,138)

Hourly Rates. Table 6.7 illustrates the present value calculation for hourly rates ranging from $0.50 to $3.00. It assumes a Level 2 charging rate. In order for the MUD owner to break even on serving the first PEV, the investment costs of $2,000 or less would need to be priced at least at $1.00 per hour. The price of $1.00 per hour is approximately equal to $2.40 per gallon, assuming the fee for charging ends when the vehicle stops demanding electricity. This multi-unit dwelling price would be cost-effective relative to current gasoline prices in the region. An investment cost of $5,000 would need to be priced at least at $1.50 per hour. This multi-unit dwelling price would be cost-effective for many PHEV drivers since this is approximately equal to $3.60 per gallon—less than it would cost California PEV drivers to fill up at the pump. Thus, those PEV drivers with battery ranges less than their roundtrip commute will find it cost-effective to charge at home.

However, an investment cost of $8,000 would need to be priced at $2.00 an hour, which is equivalent to $4.81 a gallon. Thus, any price per hour equal to or greater than $2.00 an hour is unlikely to generate utilization, and thus revenues, for MUD owners.

Table 6.7: Present value of multi-unit dwelling charging to site owner over 10 years (hourly rate)

Installed Level 2 Charger Cost	Hourly Rate: $ 0.50	$ 1.00	$ 1.50	$ 2.00	$ 2.50	$ 3.00
$ 500.00	$ (202)	$ 3,632	$ 7,465	$ 11,299	$ 15,132	$ 18,966
$ 1,000.00	$ (920)	$ 2,913	$ 6,747	$ 10,580	$ 14,414	$ 18,247
$ 2,000.00	$ (2,358)	$ 1,476	$ 5,309	$ 9,143	$ 12,976	$ 16,810
$ 3,000.00	$ (3,795)	$ 38	$ 3,872	$ 7,705	$ 11,539	$ 15,372
$ 4,000.00	$ (5,233)	$ (1,399)	$ 2,435	$ 6,268	$ 10,102	$ 13,935
$ 5,000.00	$ (6,670)	$ (2,836)	$ 997	$ 4,831	$ 8,664	$ 12,498
$ 6,000.00	$ (8,107)	$ (4,274)	$ (440)	$ 3,393	$ 7,227	$ 11,060
$ 7,000.00	$ (9,545)	$ (5,711)	$ (1,878)	$ 1,956	$ 5,789	$ 9,623
$ 8,000.00	$ (10,982)	$ (7,149)	$ (3,315)	$ 518	$ 4,352	$ 8,186
$ 9,000.00	$ (12,419)	$ (8,586)	$ (4,752)	$ (919)	$ 2,915	$ 6,748
$ 10,000.00	$ (13,857)	$ (10,023)	$ (6,190)	$ (2,356)	$ 1,477	$ 5,311

Hourly Rate Plus Connection Fees. Table 6.8 illustrates the present value calculation for hourly rates ranging from $0.50 to $3.00 plus a connection fee of $1.00. In order for the MUD owner to break even on serving the first PEV, the investment costs of $2,000 or less would need to be priced at least at $1.00 per hour. The price of $1.00 per hour of active charging plus a $1.00 connection fee is approximately equal to $5.05, $3.71 and $3.28 per gallon for drivers traveling 10, 20 and 30 e-miles daily.[15] (Recall from Chapter 5 that the effective cost per electric mile varies with the number of e-miles driven when drivers charge at home). Thus the multi-unit dwelling price would be cost-effective relative to current gasoline prices in the region only for drivers traveling more than 20 e-miles daily on average. An investment cost of $5,000 would need to be priced at least at $1.50 per hour. However, prices higher than $1.00 per hour with a $1.00 connection fee may not be cost-effective for PHEV drivers (traveling 20 miles per day or less) if they can purchase gasoline more cheaply than $3.71 per gallon.

15 See the chapters on pricing infrastructure (Chapter 9) and single-family residential charging (Chapter 5) for an explanation of why unit fuel costs vary with certain pricing policies.

Table 6.8: Present value of multi-unit dwelling charging to site owner over 10 years (hourly rate plus connection fee)

Installed Level 2 Charger Cost	Hourly Rate $ 0.50	$ 1.00	$ 1.50	$ 2.00	$ 2.50	$ 3.00
$ 500.00	$ (576)	$ 3,257	$ 7,091	$ 10,924	$ 14,758	$ 18,591
$ 1,000.00	$ (1,295)	$ 2,539	$ 6,372	$ 10,206	$ 14,039	$ 17,873
$ 2,000.00	$ (2,732)	$ 1,101	$ 4,935	$ 8,768	$ 12,602	$ 16,435
$ 3,000.00	$ (4,170)	$ (336)	$ 3,497	$ 7,331	$ 11,164	$ 14,998
$ 4,000.00	$ (5,607)	$ (1,773)	$ 2,060	$ 5,894	$ 9,727	$ 13,561
$ 5,000.00	$ (7,044)	$ (3,211)	$ 623	$ 4,456	$ 8,290	$ 12,123
$ 6,000.00	$ (8,482)	$ (4,648)	$ (815)	$ 3,019	$ 6,852	$ 10,686
$ 7,000.00	$ (9,919)	$ (6,086)	$ (2,252)	$ 1,581	$ 5,415	$ 9,248
$ 8,000.00	$ (11,356)	$ (7,523)	$ (3,689)	$ 144	$ 3,978	$ 7,811
$ 9,000.00	$ (12,794)	$ (8,960)	$ (5,127)	$ (1,293)	$ 2,540	$ 6,374
$ 10,000.00	$ (14,231)	$ (10,398)	$ (6,564)	$ (2,731)	$ 1,103	$ 4,936

Variable Costs Plus a Markup. Table 6.9 illustrates the present value calculation for variable costs plus a markup ranging from zero to $0.30 per kilowatt-hour (kWh) of electricity. Identifying the set of prices that are both cost-effective for PEV drivers and yield a positive present value, we see that a markup of $0.25 or less would generate enough revenue to support up to a $5,000 investment plus ongoing variable costs.

Table 6.9: Present value of multi-unit dwelling charging to site owner over 10 years (markup on electricity)

Installed Level 2 Charger Cost	Markup $ -	$ 0.10	$ 0.15	$ 0.20	$ 0.25	$ 0.30
$ 500.00	$ (719)	$ 2,617	$ 4,284	$ 5,952	$ 7,619	$ 9,287
$ 1,000.00	$ (1,437)	$ 1,898	$ 3,566	$ 5,233	$ 6,901	$ 8,568
$ 2,000.00	$ (2,875)	$ 461	$ 2,128	$ 3,796	$ 5,463	$ 7,131
$ 3,000.00	$ (4,312)	$ (977)	$ 691	$ 2,358	$ 4,026	$ 5,694
$ 4,000.00	$ (5,750)	$ (2,414)	$ (747)	$ 921	$ 2,589	$ 4,256
$ 5,000.00	$ (7,187)	$ (3,852)	$ (2,184)	$ (516)	$ 1,151	$ 2,819
$ 6,000.00	$ (8,624)	$ (5,289)	$ (3,621)	$ (1,954)	$ (286)	$ 1,382
$ 7,000.00	$ (10,062)	$ (6,726)	$ (5,059)	$ (3,391)	$ (1,723)	$ (56)
$ 8,000.00	$ (11,499)	$ (8,164)	$ (6,496)	$ (4,828)	$ (3,161)	$ (1,493)
$ 9,000.00	$ (12,936)	$ (9,601)	$ (7,934)	$ (6,266)	$ (4,598)	$ (2,931)
$ 10,000.00	$ (14,374)	$ (11,039)	$ (9,371)	$ (7,703)	$ (6,036)	$ (4,368)

6.6.6 Recovering the costs of charging several PEVs

The financial viability of multi-unit dwelling charging improves considerably once several PEVs find it cost-effective to charge. Table 6.10 assumes the charging is priced at variable costs plus a $0.20 markup—the equivalent of about $3.64 per gallon—in the first year. The net present value (over 10 years) is evaluated for installed charger costs ranging from $500 to $10,000 and for vehicles needing to charge enough to replace 10 to 90 e-miles driven. As such, the table represents 99 different investment-utilization scenarios.

Table 6.10: Present value of multi-unit dwelling charging to site owner with markup, by utilization level

Installed Level 2 Charger Cost	Scenario	One PEV10	Two PEV10 or One PEV20	One PEV40	Two PEV20	One PEV20 & One PEV40	Two PEV40	Two PEV20 & One PEV40	One PEV20 & Two PEV40	Three PEV40
	Daily Electric Miles	10	20	30	40	50	60	70	80	90
	Hours - Utilization	0.91	1.81	2.72	3.63	4.53	5.44	6.35	7.25	8.16
	$ 500.00	$ 1,505	$ 3,728	$ 5,952	$ 8,175	$ 10,399	$ 12,622	$ 14,846	$ 17,069	$ 19,293
	$ 1,000.00	$ 786	$ 3,010	$ 5,233	$ 7,457	$ 9,680	$ 11,904	$ 14,127	$ 16,351	$ 18,574
	$ 2,000.00	$ (651)	$ 1,572	$ 3,796	$ 6,019	$ 8,243	$ 10,466	$ 12,690	$ 14,913	$ 17,137
	$ 3,000.00	$ (2,089)	$ 135	$ 2,358	$ 4,582	$ 6,805	$ 9,029	$ 11,252	$ 13,476	$ 15,700
	$ 4,000.00	$ (3,526)	$ (1,302)	$ 921	$ 3,145	$ 5,368	$ 7,592	$ 9,815	$ 12,039	$ 14,262
	$ 5,000.00	$ (4,963)	$ (2,740)	$ (516)	$ 1,707	$ 3,931	$ 6,154	$ 8,378	$ 10,601	$ 12,825
	$ 6,000.00	$ (6,401)	$ (4,177)	$ (1,954)	$ 270	$ 2,493	$ 4,717	$ 6,940	$ 9,164	$ 11,387
	$ 7,000.00	$ (7,838)	$ (5,615)	$ (3,391)	$ (1,168)	$ 1,056	$ 3,279	$ 5,503	$ 7,726	$ 9,950
	$ 8,000.00	$ (9,276)	$ (7,052)	$ (4,828)	$ (2,605)	$ (381)	$ 1,842	$ 4,066	$ 6,289	$ 8,513
	$ 9,000.00	$ (10,713)	$ (8,489)	$ (6,266)	$ (4,042)	$ (1,819)	$ 405	$ 2,628	$ 4,852	$ 7,075
	$ 10,000.00	$ (12,150)	$ (9,927)	$ (7,703)	$ (5,480)	$ (3,256)	$ (1,033)	$ 1,191	$ 3,414	$ 5,638

A useful way of interpreting Table 6.10 is to recognize that each additional PEV at the multi-unit dwelling means an additional 30 e-miles that would be recharged at night, assuming no workplace or public charging. Adding a second, and third PEV represent an increase in e-miles of 60 and 90 miles respectively. From Table 6.10 we can see that the addition of a second vehicle needing 30 e-miles using multi-unit dwelling charging yields enough revenue to support $9,000 of investment. Scaling up further, the addition of a third, fourth and fifth PEV (needing 30 e-miles each) supports $6,000, $9,000 and well over $12,000 of financially-viable investment respectively. In other words, if MUD owners can size their charge stations to charge at least three vehicles at once for under $10,000, then they can break even while charging drivers competitive rates. An associated challenge is that property owners must accurately guess the growth of PEV demand for their multi-unit dwelling charge stations. The risk for property owners is that utilization rates in the form of additional relatively empty PEVs may not grow fast enough to cover costs.

6.6.7 Selecting Pricing Policies for MUD Charging

The two most transparent and effective policies are the variable cost with a markup and, to a lesser extent, the hourly rate policy. The hourly rate policy does have the disadvantage of potentially discriminating against drivers of older PEV models that charge more slowly and who will thus have to pay more than will new PEVs. The hourly rate policy may also discriminate against PEV drivers that do not require a lot of charge because they have a short commute or a small battery. Unless drivers move their cars or are not billed after charging is completed, their costs per kilowatt-hour continue to rise, quickly reaching uncompetitive levels.

Both the electricity markup and the hourly rate policy come with the added costs of measuring and billing for the quantity of electricity or time that PEVs consume. Flat-rate policies, in contrast, avoid these measurement and billing costs to property owners but have the disadvantage of imposing different unit costs (e.g., cost per electric mile driven) on PEV drivers who travel differing numbers of e-miles daily. (See Chapter 9 for a more detailed discussion of how to design pricing policies.)

6.7 State-level policies for MUDs

Planners, landlords, HOAs and PEV drivers living in MUDs should be made aware of state-level policies governing at-home charging in this housing type. One set of policies prohibits HOAs from unreasonably restricting PEV charging equipment installation. Local jurisdictions can reduce the need over the long term for this law to be invoked by requiring PEV readiness in new buildings, streamlining permitting and inspection, and providing incentives for HOAs to install charging infrastructure.

The other policies govern the way in which MUD owners are allowed to recover the costs of PEV infrastructure and electricity from residents. These two sets of policies are discussed below.

6.7.1 "EV rights" in MUDs

Rights and responsibilities of HOAs and PEV owners for charging in common-interest developments (condominiums, co-ops and other ownership MUDs) are outlined under California law by Senate Bill 880, which was signed February 29, 2012. The law provides a basic framework for resolving challenges to PEV charging posed by HOAs. However, it does not specify a mechanism for enforcing violation penalties, nor does it cover renters in MUDs (Balmin, Bonett, and Kirkeby 2012).

The basic purpose of the law is to ensure that PEV drivers are not unreasonably prohibited from installing a charging station, either in their deeded or designated parking spaces or in common areas. HOAs must allow charging in common areas only if installation in the PEV owner's deeded or designated space is impossible or unreasonably expensive. If a driver has exclusive use of a charging station in a common area, HOAs must then enter a license agreement with the PEV driver, who must meet the following conditions (SB-880 Common Interest Developments: Electric Vehicle Charging Stations 2012):

- The charging station meets all applicable health and safety standards as well as all other applicable zoning, land use or other ordinances, or land use permits
- Complies with the association's architectural standards for the installation of the charging station
- Engages a licensed contractor to install the charging station
- Within 14 days of approval, provides a certificate of insurance that names the association as an additional insured party under the owner's homeowner liability coverage policy in the amount of $1,000,000 (except when existing wall outlets are used)
- Pays for the electricity usage associated with the charging station

The HOA can also compel current and future owners of the charging station to pay for maintenance, repair or removal of the charging station and for any resulting damage to the station, common area, or exclusive use common area. Importantly, the law allows, without a full HOA member vote, a portion of the common area to be used for utility lines or meters to support charging in a deeded or designated parking space.

As stated earlier, the law is intended to prevent HOAs from unreasonably restricting the installation of PEV charging. But it does not define what a "reasonable" restriction is, other than that the restriction cannot "significantly increase the cost of the station or significantly decrease its efficiency or specified performance" (SB-880 Common Interest Developments: Electric Vehicle Charging Stations 2012). Enforcement of this and other vague provisions in the law may be decided in court. However, there is no need for enforcement if the parties can make their own arrangements. Utilities could make a professional mediator available to assist with negotiations between residents and HOAs, or even between landlords and tenants looking for a way to charge in an MUD. The mediator would be trained to explain applicable laws, building codes and possible billing arrangements (Balmin, Bonett, and Kirkeby 2012).

6.8 Recommendations for facilitating MUD charging

Installing PEV chargers in existing MUDs presents a number of institutional, physical and cost recovery challenges. Local planners and policymakers can make the greatest impact in reducing the hard and soft costs of installation, shifting those costs to developers with PEV-ready requirements or incentives, and supporting Level 1 charging. Utilities, regional, and local planners should consider the following measures to expand access to MUD charging, in addition to the recommendations provided earlier in this chapter and in related chapters.

6.8.1 Utility policies

- Offer time-of-use rates for MUDs that provide a discount on electricity used for PEV charging during late-night and overnight hours.

- Plan capital projects to upgrade electrical distribution systems to accommodate PEV charging in MUD-dense areas.
- Subsidize upgrades of transformers that enable PEV charging at MUDs.
- Partially subsidize costs associated with slower, lower-voltage Level 1 charging, which may only require some additional standard outlets in the parking area. Extending partial subsidies to Level 1 charging would allow existing power supplies to go farther by reducing the need for electrical upgrades. This could also potentially lower the time and cost associated with permitting and inspection.[16]
- Subsidies for equipment purchase and installation should be made available to HOAs and landlords (in addition to drivers), as they are best-positioned to achieve economies of scale with multiple installations, and can reap the benefit over the long run by providing an attractive amenity (Balmin, Bonett, and Kirkeby 2012).[17]

6.8.2 Regional planners

- Conduct demonstration projects to research ways of reaching economies of scale with PEV charging at MUDs.
- Target and support MUD charging within the region based on the metrics described here and elsewhere in this document.

6.8.3 Local planners

- Reform building codes to require a certain number of Level 1 and Level 2 PEV-ready spaces in new MUD construction. This is the most cost-effective, least institutionally complicated method of ensuring more residential charging opportunities for MUDs in the future.
- Require PEV upgrades when an MUD building or unit is sold. In the City of Los Angeles alone, there were about 3,000 annual MUD sales between 2002-2010. PEV charging could be quickly advanced on a wide scale with such a requirement. Exemptions or subsidies could be allowed for buildings for which installation is truly cost-prohibitive (Peterson 2011).
- Allow PEV charging spaces to count towards minimum parking requirements or offer them as a development incentive. Further guidance on these measures is provided in Chapter 10 of this document.

16 Some utilities may wish to directly subsidize purchase and installation of charging units, as the Los Angeles Department of Water and Power does currently with its Charge Up L.A.! program. But if these incentives are designed around faster, higher-voltage Level 2 charging, they will require the purchase of special equipment and most likely require an electrical upgrade. Level 2 charging can thus incur potentially higher upfront costs and a more complex permitting process, slowing PEV adoption.

17 Renters in MUDs may not want to pay for electrical upgrades because they will lose the benefit when they move. Without a subsidy, landlords are unlikely to take on the upfront cost of upgrading electrical panels and purchasing and installing charging equipment.

- Streamline permitting and inspection procedures for PEV charging installations. Further guidance is provided in Chapter 12 of this document.
- Automatically expedite the approval process for PEV charging permits in MUDs (Ready, Set, Charge, California! A Guide to EV-Ready Communities 2011).
- Conduct MUD-specific outreach activities and provide educational materials to prospective PEV drivers in MUDs, landlords and HOAs. These materials should specify the process of installing charging in MUDs and present cost recovery models. Further guidance on outreach and education is provided in Chapter 15.

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7 Planning for Workplace Charging

7.1 Introduction

Workplaces present a significant, and largely untapped, opportunity for PEV charging. After residences, they are the single most important environment for electric refueling. Vehicles are generally parked at workplaces for several hours every weekday, making it possible for them to completely recharge before the commute home. This is especially important for maximizing the electric miles driven by PHEVs, which use gasoline when their batteries are depleted. The ability to charge at work may also encourage PEV adoption by those for whom residential charging is cost-prohibitive or logistically difficult, particularly residents of multi-unit dwellings. Workplace charging thus represents the “missing link” between residential and publicly accessible charging.

Employers may see workplace charging as a way to recruit and retain employees, reduce the company’s carbon footprint, or attain LEED green building certification, among other goals. Workplace charging can also be a relatively cost-effective amenity for employers to provide. The vehicles’ lengthy stays in parking lots allow them to recharge using slower, lower-voltage, less expensive Level 1 charging from common, often available outlets. But the ability to charge several cars at once using multiple cords on Level 2 equipment would also make faster charging a potentially feasible option.

For these reasons, adopting policies and incentives to encourage workplace charging should be a high priority for regional and local planners. This chapter will help planners assess workplace charging opportunities across and within local jurisdictions. It will describe how planners can use their own employment metrics and the maps provided in the Southern California PEV Atlas that accompanies this document to prioritize cities and parcels for targeted workplace charging assistance. This chapter also presents a discussion of measures planners can take to reduce the cost to employers of providing charging. It concludes with a demonstration of how employers can recover PEV electricity costs from employees in a way that is cost-effective for both.

7.2 Assessing the workplace charging opportunity

To determine whether and how to prioritize workplace charging efforts, planners must first measure the potential demand for such charging. The questions planners should ask lead from the most general assessment of the overall size and location of workplaces to a more specific look at how they compare to other land uses within the jurisdiction. Cities can further target specific employers based on size and industry type. Additonally, white-collar employees, high-tech workplaces, and other characteristics may indicate PEV charging demand by employees.

The tools in this chapter will help councils of government (COGs) answer the following questions:

- How many employees are there in absolute numbers within each city?
- How many workplaces are there in absolute numbers within each city?
- How significant are workplaces compared to other types of parcels?

The tools in this chapter will help city planners and utilities answer the following questions:

- What are the largest employers and where are they located?
- Which employers have the highest numbers of white-collar and high-tech workers?
- Which employers are located in neighborhoods where current PEV owners drive on weekday mornings?

7.2.1 How many employees and workplaces are there in absolute numbers within each city?

Comparing the employee populations of cities will help a COG determine where its resources will be most effective in advancing workplace charging for the highest number of employees in the subregion. The UCLA Luskin Center obtained its figures from the Southern California Association of Governments' 2008 dataset from Infogroup, a vendor of employment information. The U.S. Census, Bureau of Labor Statistics and California Employment Development Department are other sources of employment information.

While absolute counts are a helpful indicator of the importance of a city's employees to advancing regional PEV readiness, these counts may not reflect the relative importance of workplace charging opportunities compared to residential charging within a city. They may also overlook areas that are rich in workplaces—places that may benefit from employer incentives and outreach.

While most PEV policies and incentives are geared towards drivers, workplaces represent an opportunity for targeted incentives. They can benefit from permit streamlining and PEV-ready building codes geared to non-residential uses. Jurisdictions rich in workplaces can also benefit from education and outreach programs targeted to employers. An example of a ranking of jurisdictions by number of employees and workplaces at the Los Angeles County level is provided in Table 7.1.

Highlighted in red are cities that did not rank in the top counts of *employees* but that have a large number of *employers*. This may indicate the presence of more, smaller businesses that may not be able to achieve sufficient economies of scale to make workplace charging feasible. However, in the case of Beverly Hills, the city ranks highly on the attribute of a high number of white-collar workers that may be early adopters of PEVs. This attribute is explored further in Section 7.2.4.

Table 7.1: Los Angeles County cities by number of employees and workplaces, 2012

Cities by employees	Number of workplaces
Los Angeles (1,683,000)	169,000
Long Beach (154,000)	13,000
Torrance (114,000)	10,000
Pasadena (110,000)	9,000
Burbank (91,000)	8,000
Glendale (91,000)	8,000
Santa Monica (84,000)	Beverly Hills (7,000)
Carson (75,000)	7,000
Industry (68,000)	6,000
Santa Clarita (66,000)	Inglewood (4,000)

7.2.2 How significant are workplaces compared to other types of parcels?

The previous two metrics simply assess workplace charging potential in terms of raw numbers. The actual priorities of a local jurisdiction may differ based on the relative percentage of employees compared to potential residential users of PEV charging. For example, a bedroom community may choose not to prioritize workplace charging if residents significantly outnumber employees.

A third way to assess workplace charging potential is by ranking cities that have the highest shares of employees relative to single-family homes and multi-unit dwellings (MUDs). This type of analysis can help cities align their PEV readiness priorities with their land uses. It can also indicate cities that may wish to prioritize workplace planning for PEVs, even if they will not have a significant regional impact in doing so. For the COG, such a ranking may indicate which cities may be receptive to technical assistance on PEV planning for workplaces.

This measurement assumes that the total number of residential units and employees represent the potential demand for PEV charging spots at homes and workplaces. This measurement accounts for the number of employees, not employers. This is because larger workplaces will be more likely to install PEV charging, as it will be more cost-effective for them to do so than for small businesses.

Cities that have a relatively high percentage of employees relative to single-family homes and MUDs are potentially strong candidates for workplace charging initiatives. The percentages in Table 7.2 represent shares of the combined total number of MUD units, single-family units, and employees in each city. They are ranked in order of the percentage of uses within each city that is made up of employees.[18]

Table 7.2: Los Angeles County cities by share of employees, single-family residential units, and MUD units

City	Employee %	SF %	MUD %
Industry	100%	0%	0%
Vernon	100%	0%	0%
Irwindale	96%	2%	2%
Commerce	95%	3%	2%
Santa Fe Springs	93%	5%	2%
South El Monte	86%	10%	4%
La Verne	83%	13%	4%
El Segundo	82%	7%	11%
Westlake Village	81%	15%	4%
Beverly Hills	79%	8%	14%

7.2.3 What are the largest employers and where are they located?

Workplaces with large numbers of employees may be better-positioned than small businesses to recover costs from offering PEV charging due to higher potential usage. Determining which employers are the largest will help city planners target outreach efforts and help utilities prioritize locations for transformer and power distribution upgrades.

18 Information on housing units was obtained from 2007 Los Angeles County Assessor data.

Table 7.3 presents an example of aggregated rankings from Infogroup of the top employers in Los Angeles County by the number of employees. Excluding fossil-fuel firms that may not be motivated to adopt workplace charging, the list reveals employers with a focus on research, technology, health and entertainment. Such firms may be interested in promoting their mission by hosting PEV charging or attracting workers who are prospective PEV drivers.

Table 7.3: Top Los Angeles County employers by number of employees and firm type

Employers (overall)	Number of employees	Non-fossil-fuel firms	Number of employees
UCLA	36,000	UCLA	36,000
USC	12,000	USC	12,000
L.A. Police Dept.	9,000	L.A. Police Dept.	9,000
L.A. County Medical Ctr.	8,000	L.A. County Medical Ctr.	8,000
Pacific Enterprises	7,000	Pacific Enterprises	7,000
Jet Propulsion Lab.	6,000	Jet Propulsion Lab.	6,000
Westcoast	6,000	Westcoast	6,000
BP West Coast Products	6,000	Walt Disney Co.	6,000
BP Carson Refinery	6,000	Kaiser Foundation Hospital	5,000
Walt Disney Co.	6,000	Kaiser Permanente	5,000

7.2.4 Which employers have the highest numbers of white-collar and high-tech workers?

Studies of PEV buyers to date have shown that they tend to be high-income, college-educated homeowners (CCSE 2012; Landy 2011; Southern California Edison 2012). Another metric by which to prioritize cities and employers for workplace charging is the number of white-collar workers. An example from Los Angeles County is shown in Table 7.4 below.

Table 7.4: Top Los Angeles County cities and employers, by number of white-collar workers

Number of white-collar employees	Number of white-collar employees (overall)	Number of white-collar employees (non-fossil fuel firms)
Los Angeles (1,005,000)	UCLA (31,000)	UCLA (31,000)
Long Beach (83,000)	USC (11,000)	USC (11,000)
Pasadena (72,000)	L.A. County Medical Ctr. (7,000)	L.A. County Medical Ctr. (7,000)
Torrance (66,000)	Jet Propulsion Lab. (6,000)	Jet Propulsion Lab. (6,000)
Burbank (59,000)	Westcoast (5,000)	Westcoast (5,000)
Glendale (57,000)	Kaiser Permanente (5,000)	Kaiser Permanente (5,000)
Santa Monica (53,000)	Walt Disney Co. (5,000)	Walt Disney Co. (5,000)
Carson (43,000)	Kaiser Foundation Hospital (5,000)	Kaiser Foundation Hospital (5,000)
Beverly Hills (38,000)	BP West Coast Products (4,000)	Pacific Enterprises (4,000)
Santa Clarita (37,000)	BP Carson Refinery (4,000)	VA Greater Los Angeles Health (4,000)

Similarly, cities with the highest numbers of high-tech workplaces may be strong candidates for technical assistance for workplace charging, or outreach to employers. An example from Los Angeles County is shown in Table 7.5 below.

Table 7.5: Los Angeles County cities by number of high-tech workplaces

City	Number of high-tech workplaces
Los Angeles	3,089
Torrance	286
Glendale	247
Industry	194
Santa Monica	175
Pasadena	172
Burbank	158
Long Beach	155
Santa Clarita	143
El Segundo	111

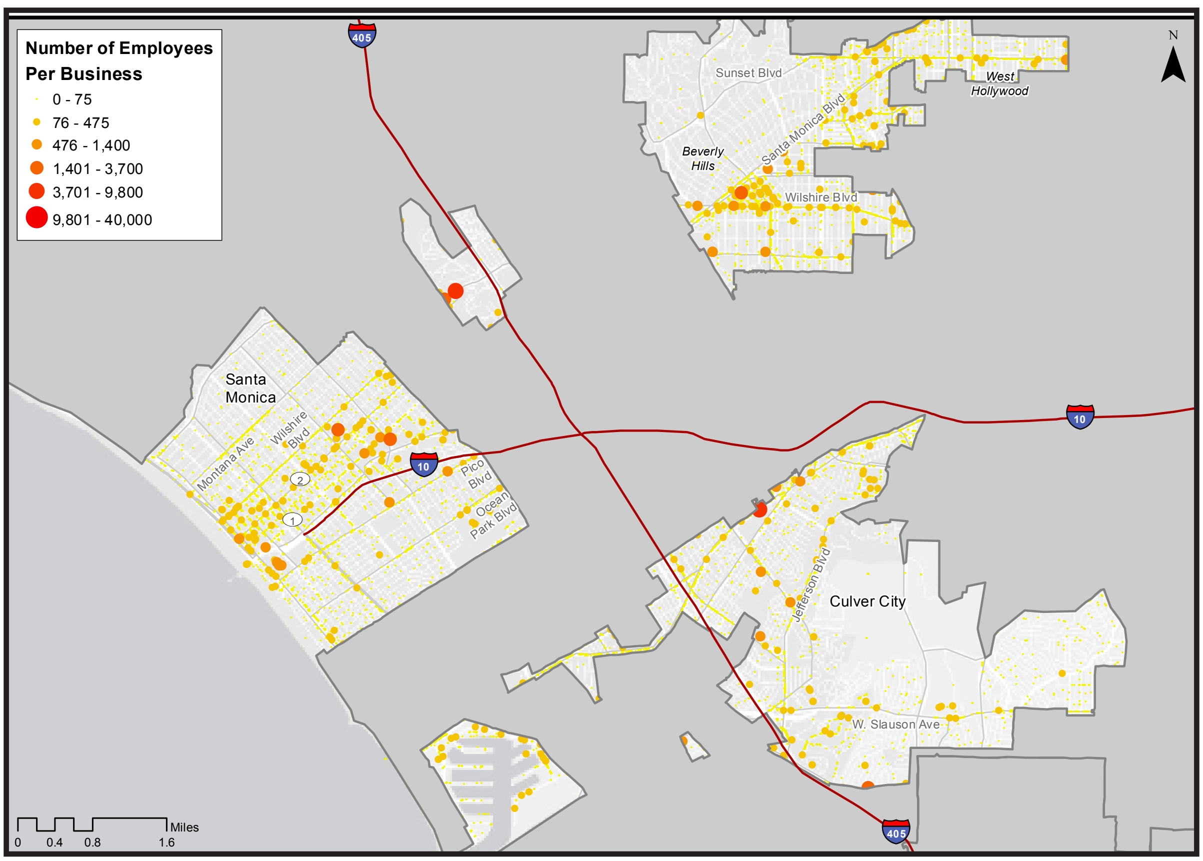
Cities and COGs may want to conduct more than one of the analyses presented above to cross-check the rankings of cities and employers. Cities and workplaces that rank higher using multiple metrics are likely to be good targets for workplace charging initiatives.

7.2.5 Which employers are located in neighborhoods where current PEV owners drive on weekday mornings?

The COG-level maps in the Southern California PEV Atlas that accompanies this document overlay employment centers of different sizes with densities of PEVs traveling to daytime destinations. Planners and utilities can use these maps to compare the spatial distribution of employers and daytime travel destinations for PEVs. Examples from the Westside Cities Council of Governments are provided below.

The maps overlaying employment density were prepared using 2008 Infogroup data on employer size (i.e., number of employees) and location. Each circle on the map represents one workplace. The circles move from small to large and from yellow to red as the number of employees per workplace increases. While the largest, reddest circles represent the largest workplaces (and thus locations that may be amenable to providing charging on-site), areas rich in small workplaces may represent demand for charging streetside or in stand-alone parking structures. Parking structures that are not attached to other land uses are also mapped at the COG level in the Southern California PEV Atlas that accompanies this document.

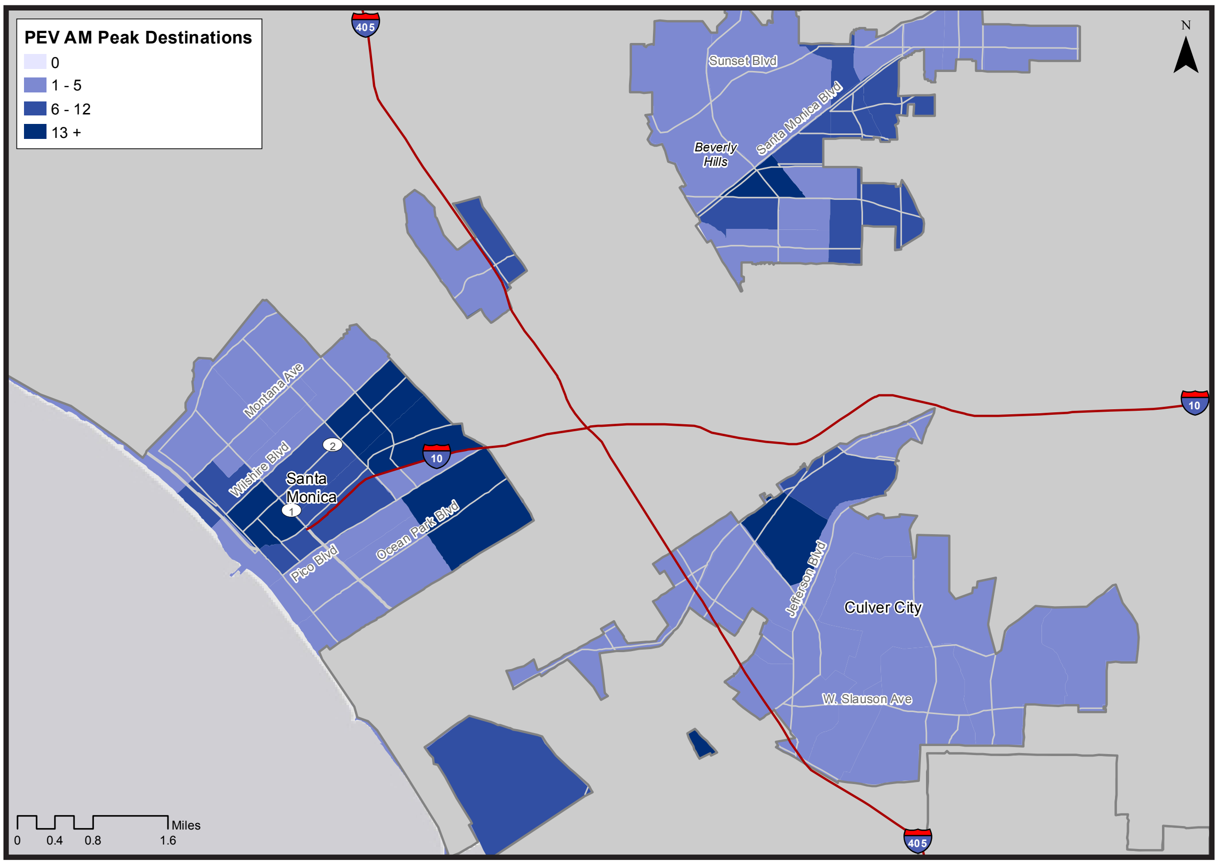
Map 7.1: Employment density, Westside Cities Council of Governments



After mapping employment densities, the UCLA Luskin Center mapped the locations where currently-registered PEVs are traveling during morning weekday rush hour. The data on PEV registrations comes from automotive data vendor R.L. Polk & Co., which provided the number of PEVs registered as new within each Census tract through September 2012. These Census tracts represent the neighborhoods where PEVs originate their trips from home.

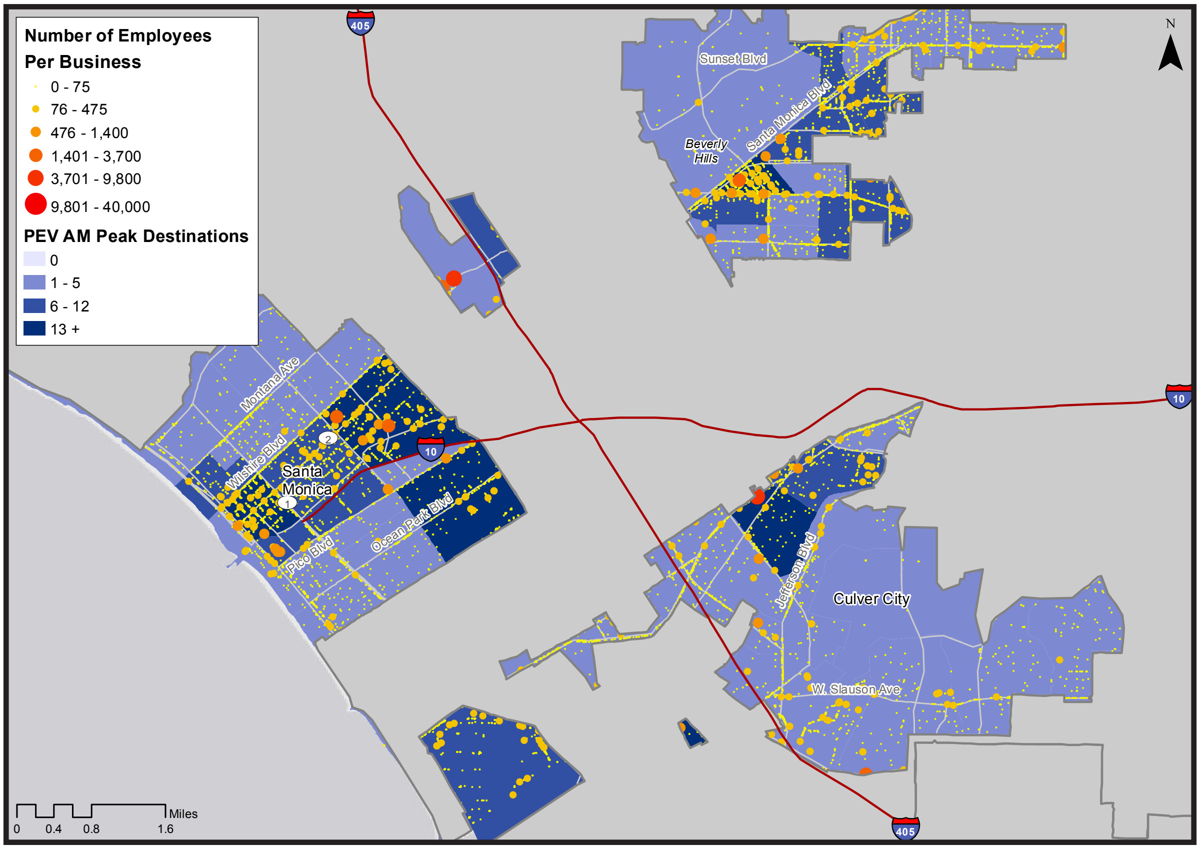
Census tracts closely follow the boundaries of travel analysis zones (TAZs), which are the geographic areas used by the Southern California Association of Governments to model vehicle travel. Using a network of sensors located on streets, SCAG's travel demand model estimates the number of trips from home to work, school, and other destinations by time of day. By counting the number of PEVs from each *origin* TAZ that feed into each of the daytime *destination* TAZs, we are able to map the locations and densities of PEVs traveling to work. The neighborhoods where PEVs travel during the day are the daytime destinations mapped in example Map 7.2.

Map 7.2: PEV daytime destinations, Westside Cities Council of Governments



Example Map 7.3 on the next page combines the previous two maps [Map 7.1 and Map 7.2] into an overlay of employment density and daytime PEV destinations. Planners should consult the COG-level maps in the Southern California PEV Atlas that accompanies this document to assess existing potential demand for workplace charging. Combined with the metrics described earlier in this chapter, the data will provide a strategic approach to prioritizing workplace charging resources, policies and incentives. Recommendations for such policies and incentives are provided later in this chapter.

Map 7.3: PEV daytime destinations and workplaces, Westside Cities Council of Governments



7.3 The workplace PEV charging installation process

The process of setting up charging at workplaces requires the cooperation of the parties that own and operate the company's parking area. Some employers own their own buildings and dedicated parking areas. Other employers lease parking from commercial landlords, who in turn may contract with a parking management company to operate the lot or structure.

The diagram [Figure 7.1] on the next page presents the basic process for installing workplace charging. While many of the steps require internal decision-making at the company level, other decision points involve interactions with utilities and city departments. These stakeholders can help clear the way for workplace charging with proper incentives and installation approval procedures. They can also be a valuable source of information for employers considering workplace charging.

Figure 7.1: The workplace PEV charging installation process

Source: (California Plug-in Electric Vehicle Collaborative 2012)

7.4 Planning for workplace charging

Local planners and utilities can facilitate workplace charging in two ways: 1) by providing information to employers considering workplace charging and 2) reducing the hard and soft costs of workplace charging. The following sections give examples of factors employers will need to consider when making the workplace charging decision as well as examples of typical barriers they encounter.

7.4.1 Typical workplace charging considerations

Planners should make employers aware of the following considerations as they consider whether to install workplace charging. These are divided into pre-planning, installation and economic considerations.

7.4.2 Pre-planning

If the employer does not own or operate the parking area, how will charging be installed? Some landlords may be willing to share costs with employer tenants; others may not. Employers and/or property owners must decide if providing PEV charging is a worthy investment as a present and future amenity for employer tenants and/or employees. A cost recovery model for employers is presented in Table 7.5.

Will Level 1 charging be sufficient to meet demand? Existing outlets in the parking area may be sufficient to provide a slow charge, which will work for PEVs with small batteries and those that are parked all day, as well as for drivers with relatively short commutes. Level 1 charging may help employers avoid incurring Level 2 equipment, installation, and permitting costs.

What incentives are available for workplace charging? Some utilities may offer a non-residential time-of-use rate that provides a discount on electricity used for PEV charging, particularly during morning hours. The EV Project demonstration program and electric vehicle service provider ChargePoint are providing free charging stations to interested workplaces.

7.4.3 Installation

How can the employer comply with disabled access requirements for PEV charging? Consistent installation and signage standards across jurisdictions will lay the groundwork for future state or regional ordinances. The California PEV Collaborative provides guidelines on disabled accessibility and sample drawings for public- and restricted-access charging spaces in both new construction and existing facilities. These guidelines are discussed in further detail in Chapter 13 of this document.

How many chargers should be installed? Employers should survey their employees to assess demand for PEV charging. California's green building code provides guidance on voluntary measures municipalities can adopt if they want to require PEV charging readiness in newly-constructed non-residential buildings. The recommendation calls for one charging space for every 50 parking spaces. Further guidance on building codes and parking are provided in Chapter 11 and Chapter 13 of this document.

7.4.4 Economic considerations

How can peak electricity rates and demand charges be avoided? Workplaces can sign up for time-of-use electricity rates for PEV charging that provide a discount for charging during prepeak morning hours. Workplaces can also conduct energy audits to identify potential cost savings and enroll in a demand-response program to reduce energy consumption during peak load times.

How can the employer plan for future PEV charging demand? A typical commercial charging unit has several connectors that allow multiple vehicles to charge simultaneously. Some units combine Level 1 and Level 2 charging on the same unit, allowing the driver to choose a slower, more cost-effective charge if that is sufficient.

What is the typical cost of charging units and electrical upgrades? Equipment and installation costs can run a few thousand dollars, but vary widely depending on the power level, number of vehicles that can be charged simultaneously, and the level of sophistication (i.e., whether the unit has access control, wireless connectivity and usage tracking). Electrical upgrades can also run in the thousands of dollars, but planners can shift these costs to developers by requiring PEV readiness at the time new commercial buildings are constructed.

How can the employer recover equipment and operating costs? Pricing that is cost-effective for both workplace site hosts and PEV drivers will maximize electric miles traveled. Understanding various pricing models will help planners provide technical assistance to employers. We present these models in the next section.

7.5 Financial viability of workplace charging

A central concern of most employers is whether workplace charging will be financially viable. They want to know whether they can at least break even on their investment. In this section, we first present a set of questions facing employers who wish to make well-informed investments in charging equipment. We then explore the financial viability of several types of investment scenarios involving early- and then middle-market demand for workplace charging. We conclude that the two most transparent and effective policies are a variable cost with a markup and, to a lesser extent, an hourly rate policy.

Planners who wish to advise employers on pricing alternatives should also see Chapter 9.

7.5.1 How much employee demand will there be for PEV charging?

In order to assess employee demand for PEV charging, employers will want to know:

- How many employees are currently driving PEVs to work?
- How will this number grow over time?
- Will they charge at work if equipment is available?

Some employees may not need to charge at work in order to complete their daily commuting route on electric miles. Most employees are likely to make this decision by comparing the costs of charging at work with their costs of refueling elsewhere, such as charging at home or filling up with gasoline if they drive a plug-in hybrid (PHEV).

7.5.2 How should the employer price PEV charging?

Once the employer estimates the demand for workplace charging, he or she must decide how to price the service. Understanding potential demand will help the employer determine how much electricity employees will consume for PEV charging and what revenues will be generated by pricing use of the equipment. (See Chapter 9 for a discussion of alternative pricing policies.)

A danger that employers face is pricing workplace charging at levels greater than employees pay elsewhere. In this case, employees with PEVs may not choose to charge at work and the employer will fail to generate the expected revenue. Another danger is pricing charging at levels too low to cover the employer's costs. In our analysis below, we consider both of these possible errors when evaluating the financial viability of workplace charging scenarios.

7.5.3 How much charging capacity should the employer provide?

Capacity here refers to the number of cords of each level (1, 2 or fast charging) provided at the location. Currently, single-cord Level 2 chargers are popular. But this may not necessarily be the best capacity for employers to choose. If the employer expects multiple employees to adopt PEVs, then multiple-cord (or multiplex) charging units with different levels of service (1 and 2) could be an employer's most cost-effective solution. Although the upfront costs can be higher, the multiplex chargers, when charging several vehicles at once, may do so at a lower total cost and lower cost per unit of electricity than would a comparable number of single-cord Level 2 chargers. In practice, identifying the most cost-effective choice of charging capacity requires comparing the costs of specific types of charging equipment and how much it will be used in a specific workplace setting.

7.5.4 Financial viability scenarios

The goal of the next sections is to give planners an understanding of how installed charger costs, pricing policy, and driver utilization rates affect the financial viability of workplace charging. Using simple cash-flow models, we describe the net loss or net profit of workplace charging under a wide range of conditions. These examples are intended only as illustrations but are based on commonly-encountered assumptions.[19] We will consistently evaluate the impacts of

19 We assume employers (or a contracted electric vehicle service provider) will own and operate the charge station every day for 10 years and that the employer pays $0.195 per kilowatt-hour (kWh) for electricity. (This is based on what a typical home would pay on average in the Southern California Edison service territory. Smaller businesses tend to pay more than this rate per kWh and larger businesses tend to pay less. We hold electricity costs constant across our analyses in this Plan in order to simplify comparisons across charging environments). When calculating the net present value we assume the employer's discount rate is 5%. Variable costs (electricity and markup) grow at a rate of 3% a year. Operation and maintenance costs are assumed to be 5% of total fixed costs.

wide a range of installed equipment costs, from a low of $500 to a high of $10,000.[20]

7.5.5 Recovering costs of charging the first PEV

Given that drivers have only just begun to purchase PEVs, many employers are considering installing workplace charging for a single "first" PEV. How much is that first PEV utilizing workplace charging equipment? The average driver in United States metropolitan areas travels 30 miles per day. So a reasonable assumption would be that the PEV arrives to work having driven 15 electric miles. This means the driver could restore the electricity used to drive those 15 miles to the battery through workplace charging. For the employer, the revenues that would be generated from that utilization rate require an understanding of what the PEV driver will pay for charging. Our analysis below will identify what workplace prices PEV drivers would be willing to pay based on their cost of charging at home and the price of gasoline.

Since most PEV charging will be done at home where it is most convenient and cost-effective, we can assume that the first PEV driver will be willing to pay no more than what he or she pays to charge at home. This translates to a price that covers a residential investment of about $2,000 or less. Therefore, employers should first assess their capacity to support Level 1 charging, since it involves the lowest installation and equipment costs. If pre-existing Level 1 outlets are available, and the building's electrical capacity is adequate, the only costs the employer may face are those associated with measuring how much electricity employees consume and billing employees.

In the following scenario analysis, we explore the impacts of four different types of pricing policies: 1) flat monthly or subscription fees, 2) hourly rate, 3) hourly with connection fee, and 4) cost plus a markup. See Table 7.6, Table 7.7, Table 7.8, and Table 7.9, respectively. Within each table we use six different pricing levels and 11 different possible installed charger costs to calculate the present value (or net profits) for the employer for 66 different pricing scenarios. Each assumes a Level 2 charging rate.

Planners can use the tables in this section to assess financial viability of hosting a charging station from the **employer/site owner's** perspective. When used in conjunction with the tables in Chapter 9, planners can evaluate the pricing models presented here against the cost to the **driver** under the same pricing models.

First, the planner can identify investment costs and pricing levels under which employers would at least break even, given this level of utilization. Second, the planner can evaluate the workplace prices that are likely to be above the PEV driver's residential or gasoline cost of refueling. This latter assessment is critical for the employer because it identifies those prices that will not generate any revenues for the workplace charge station. Of course, another danger

20 This installed charger costs represent the total upfront costs including charging space design, permitting, electrical upgrades, construction, installation, and the cost of charging equipment.

for the employer is pricing charging at levels too low to cover costs. In our analysis below, we consider both of these possible errors when evaluating the financial viability of workplace charging scenarios.

Monthly Flat Rates. Table 7.6 illustrates the present value calculation for flat rates or monthly subscriptions ranging from $25 to $150 per month. We see again that several price levels would enable the employer to break even: $50 a month would cover up to $1,000 in investment costs while $75 a month would cover up to $3,000. However, even at the low levels of investment, only very high e-mileage drivers would find it cost-effective to charge at work under a flat rate. Higher monthly fees would not be cost-effective for even high e-mileage drivers.

Table 7.6: Present value of workplace charging to site owner over 10 years (monthly rate)

		Monthly Rate					
		$ 25.00	$ 50.00	$ 75.00	$ 100.00	$ 125.00	$ 150.00
Installed Charger Cost	$ 500	$ (1,223)	$ 1,401	$ 4,026	$ 6,650	$ 9,274	$ 11,898
	$ 1,000	$ (1,942)	$ 683	$ 3,307	$ 5,931	$ 8,556	$ 11,180
	$ 2,000	$ (3,379)	$ (755)	$ 1,870	$ 4,494	$ 7,118	$ 9,742
	$ 3,000	$ (4,816)	$ (2,192)	$ 432	$ 3,056	$ 5,681	$ 8,305
	$ 4,000	$ (6,254)	$ (3,629)	$ (1,005)	$ 1,619	$ 4,243	$ 6,868
	$ 5,000	$ (7,691)	$ (5,067)	$ (2,443)	$ 182	$ 2,806	$ 5,430
	$ 6,000	$ (9,128)	$ (6,504)	$ (3,880)	$ (1,256)	$ 1,369	$ 3,993
	$ 7,000	$ (10,566)	$ (7,942)	$ (5,317)	$ (2,693)	$ (69)	$ 2,556
	$ 8,000	$ (12,003)	$ (9,379)	$ (6,755)	$ (4,130)	$ (1,506)	$ 1,118
	$ 9,000	$ (13,441)	$ (10,816)	$ (8,192)	$ (5,568)	$ (2,944)	$ (319)
	$ 10,000	$ (14,878)	$ (12,254)	$ (9,629)	$ (7,005)	$ (4,381)	$ (1,757)

Hourly Rates. Table 7.7 illustrates the present value calculation for hourly rates ranging from $0.50 to $3.00. It assumes a Level 2 charging rate. In order for the employer to break even on serving the first PEV, the investment costs of $1,000 or less would need to be priced at least at $1.50 per hour. This workplace price would be cost-effective for some but not all PEV drivers. The price of $1.50 per hour is approximately equal to $3.60 per gallon—less than it would cost PEV drivers to fill up at the pump. Thus, those PEV drivers with battery ranges less than their roundtrip commute will find it cost-effective to charge at work.

However, for those PEV drivers that can effectively commute to and from work without recharging, we see from Table 7.7 that they can most likely recharge at home more cost effectively (e.g., for less than $3.60) than they can at work. Because a price of $2.00 per hour is equivalent to $4.81 a gallon, we would expect to see only the rare BEV driver who faces being stranded to be willing to pay more than it would cost to charge at home or fill up with gas. Thus, any price per hour equal to or greater than $2.00 an hour is unlikely to generate utilization, and thus revenues, for employers.

Table 7.7: Present value of workplace charging to site owner over 10 years (hourly rate)

Installed Charger Cost	Hourly Rate $ 0.50	$ 1.00	$ 1.50	$ 2.00	$ 2.50	$ 3.00
$ 500	$ (1,930)	$ (14)	$ 1,903	$ 3,820	$ 5,737	$ 7,653
$ 1,000	$ (2,649)	$ (732)	$ 1,184	$ 3,101	$ 5,018	$ 6,935
$ 2,000	$ (4,086)	$ (2,170)	$ (253)	$ 1,664	$ 3,581	$ 5,497
$ 3,000	$ (5,524)	$ (3,607)	$ (1,690)	$ 226	$ 2,143	$ 4,060
$ 4,000	$ (6,961)	$ (5,044)	$ (3,128)	$ (1,211)	$ 706	$ 2,623
$ 5,000	$ (8,399)	$ (6,482)	$ (4,565)	$ (2,648)	$ (732)	$ 1,185
$ 6,000	$ (9,836)	$ (7,919)	$ (6,003)	$ (4,086)	$ (2,169)	$ (252)
$ 7,000	$ (11,273)	$ (9,357)	$ (7,440)	$ (5,523)	$ (3,606)	$ (1,690)
$ 8,000	$ (12,711)	$ (10,794)	$ (8,877)	$ (6,961)	$ (5,044)	$ (3,127)
$ 9,000	$ (14,148)	$ (12,231)	$ (10,315)	$ (8,398)	$ (6,481)	$ (4,564)
$ 10,000	$ (15,586)	$ (13,669)	$ (11,752)	$ (9,835)	$ (7,919)	$ (6,002)

Hourly Rate Plus Connection Fees. Table 7.8 illustrates the present value calculation for hourly rates ranging from $0.50 to $3.00 plus a connection fee of $1.00. We see again that while several price levels would enable the employer to break even, most of these price levels would mean that workplace charging would not be cost-effective to most PEV drivers. In order for the employer to break even on serving the first PEV, the investment costs of $1,000 or less would need to be priced at least at $0.50 per hour. Prices set at $1.00 would cover investment costs of $2,000 while prices of $1.50 per hour would cover up to $4,000 in investment costs. Unfortunately, while $0.50 an hour plus a $1.00 connection fee would be cost-effective for most PEV drivers, $1.00 per hour plus a $1.00 connection fee would be cost-effective for only those driving more than about 20 electric miles. (Recall from Chapter 5 and Chapter 9 that the effective cost per electric mile varies with the number of e-miles driven when drivers charge at home).

Table 7.8: Present value of workplace charging to site owner over 10 years (hourly rate plus $1.00 connection fee)

Installed Charger Cost	Hourly Rate $ 0.50	$ 1.00	$ 1.50	$ 2.00	$ 2.50	$ 3.00
$ 500	$ 1,262	$ 3,179	$ 5,096	$ 7,013	$ 8,929	$ 10,846
$ 1,000	$ 544	$ 2,461	$ 4,377	$ 6,294	$ 8,211	$ 10,128
$ 2,000	$ (894)	$ 1,023	$ 2,940	$ 4,857	$ 6,773	$ 8,690
$ 3,000	$ (2,331)	$ (414)	$ 1,503	$ 3,419	$ 5,336	$ 7,253
$ 4,000	$ (3,768)	$ (1,852)	$ 65	$ 1,982	$ 3,899	$ 5,815
$ 5,000	$ (5,206)	$ (3,289)	$ (1,372)	$ 545	$ 2,461	$ 4,378
$ 6,000	$ (6,643)	$ (4,726)	$ (2,810)	$ (893)	$ 1,024	$ 2,941
$ 7,000	$ (8,081)	$ (6,164)	$ (4,247)	$ (2,330)	$ (413)	$ 1,503
$ 8,000	$ (9,518)	$ (7,601)	$ (5,684)	$ (3,768)	$ (1,851)	$ 66
$ 9,000	$ (10,955)	$ (9,039)	$ (7,122)	$ (5,205)	$ (3,288)	$ (1,372)
$ 10,000	$ (12,393)	$ (10,476)	$ (8,559)	$ (6,642)	$ (4,726)	$ (2,809)

Variable Costs Plus a Markup. Table 7.9 illustrates the present value calculation for variable costs plus a markup ranging from zero to $0.30. Identifying the set of prices that are both cost-effective for PEV drivers and yield a positive present value, we see that a markup of $0.25 or less would generate enough revenue to support up to a $2,000 investment plus ongoing variable costs.

Table 7.9: Present value of workplace charging to site owner over 10 years (markup on electricity)

Installed Charger Cost	Markup $ -	$ 0.10	$ 0.15	$ 0.20	$ 0.25	$ 0.30
$ 500	$ (719)	$ 949	$ 1,783	$ 2,617	$ 3,450	$ 4,284
$ 1,000	$ (1,437)	$ 230	$ 1,064	$ 1,898	$ 2,732	$ 3,566
$ 2,000	$ (2,875)	$ (1,207)	$ (373)	$ 461	$ 1,294	$ 2,128
$ 3,000	$ (4,312)	$ (2,645)	$ (1,811)	$ (977)	$ (143)	$ 691
$ 4,000	$ (5,750)	$ (4,082)	$ (3,248)	$ (2,414)	$ (1,580)	$ (747)
$ 5,000	$ (7,187)	$ (5,519)	$ (4,685)	$ (3,852)	$ (3,018)	$ (2,184)
$ 6,000	$ (8,624)	$ (6,957)	$ (6,123)	$ (5,289)	$ (4,455)	$ (3,621)
$ 7,000	$ (10,062)	$ (8,394)	$ (7,560)	$ (6,726)	$ (5,893)	$ (5,059)
$ 8,000	$ (11,499)	$ (9,831)	$ (8,998)	$ (8,164)	$ (7,330)	$ (6,496)
$ 9,000	$ (12,936)	$ (11,269)	$ (10,435)	$ (9,601)	$ (8,767)	$ (7,934)
$ 10,000	$ (14,374)	$ (12,706)	$ (11,872)	$ (11,039)	$ (10,205)	$ (9,371)

7.5.6 Recovering the costs of charging several PEVs

The financial viability of workplace charging improves considerably once several PEVs find it cost-effective to charge at work. Table 7.10 assumes the charging is priced at variable costs plus a $0.20 markup—the equivalent of about $3.64 per gallon in the first year. The net present value (over 10 years) is evaluated for installed charger costs ranging from $500 to $10,000 and for vehicles needing to charge enough to replace 10 to 120 e-miles driven. As such, the table represents 99 different investment-utilization scenarios.

Table 7.10: Present value of workplace charging to site owner with markup, by utilization level

InstalledCharger Cost

Daily Electric Miles	10	15	30	45	60	75	90	105	120
Hours - Utilization	0.91	1.36	2.72	4.08	5.44	6.80	8.16	9.52	10.88
$ 500	$ 1,505	$ 2,617	$ 5,952	$ 9,287	$ 12,622	$ 15,958	$ 19,293	$ 22,628	$ 25,964
$ 1,000	$ 786	$ 1,898	$ 5,233	$ 8,568	$ 11,904	$ 15,239	$ 18,574	$ 21,910	$ 25,245
$ 2,000	$ (651)	$ 461	$ 3,796	$ 7,131	$ 10,466	$ 13,802	$ 17,137	$ 20,472	$ 23,807
$ 3,000	$ (2,089)	$ (977)	$ 2,358	$ 5,694	$ 9,029	$ 12,364	$ 15,700	$ 19,035	$ 22,370
$ 4,000	$ (3,526)	$ (2,414)	$ 921	$ 4,256	$ 7,592	$ 10,927	$ 14,262	$ 17,597	$ 20,933
$ 5,000	$ (4,963)	$ (3,852)	$ (516)	$ 2,819	$ 6,154	$ 9,489	$ 12,825	$ 16,160	$ 19,495
$ 6,000	$ (6,401)	$ (5,289)	$ (1,954)	$ 1,382	$ 4,717	$ 8,052	$ 11,387	$ 14,723	$ 18,058
$ 7,000	$ (7,838)	$ (6,726)	$ (3,391)	$ (56)	$ 3,279	$ 6,615	$ 9,950	$ 13,285	$ 16,621
$ 8,000	$ (9,276)	$ (8,164)	$ (4,828)	$ (1,493)	$ 1,842	$ 5,177	$ 8,513	$ 11,848	$ 15,183
$ 9,000	$ (10,713)	$ (9,601)	$ (6,266)	$ (2,931)	$ 405	$ 3,740	$ 7,075	$ 10,411	$ 13,746
$ 10,000	$ (12,150)	$ (11,039)	$ (7,703)	$ (4,368)	$ (1,033)	$ 2,303	$ 5,638	$ 8,973	$ 12,308

A useful way of interpreting Table 7.10 is to recognize that each additional PEV at the workplace means an additional 15 e-miles that would be recharged at work. Adding a second, third, fourth, and fifth PEV represent an increase in e-miles of 30, 45, 60, and 75 respectively. From Table 7.10 we can see that the addition of a second vehicle (30 e-miles) using workplace charging yields enough revenue to support $4,000 of investment. Scaling up further, the addition of a third, fourth and fifth PEV supports $6,000, $9,000 and well over $10,000 of financially-viable investment respectively. In other words, if employers can size their charge stations to charge at least four vehicles at once for under $9,000, then they can break even while charging drivers competitive rates. An associated challenge is that employers must accurately guess the growth of PEV demand for their workplace charge stations. The risk for employers is that utilization rates in the form of additional PEVs may not grow fast enough to cover costs.

7.5.7 Selecting Pricing Policies for Workplace Charging

The two most transparent and effective policies are the variable cost with a markup and, to a lesser extent, the hourly rate policy. The hourly rate policy does have the disadvantage of potentially discriminating against older PEV models that charge more slowly and thus will pay more than will new PEVs. It may also discriminate against vehicles that do not require a lot of charge. For example, it may only take roughly one and a half hours to recharge the 15-mile commute. Unless drivers move their cars or are not billed for the time after charging is completed, their costs per kilowatt-hour continue to rise, quickly reaching uncompetitive levels.

Both the markup and hourly rate policies come with the added costs to employers of measuring and billing for the quantity of electricity or time that PEVs consume. Flat-rate policies, in contrast, avoid these measurement and billing costs to employers but have the disadvantage of imposing different unit costs (e.g., cost per electric mile driven) on PEV drivers who travel differing numbers of e-miles daily. (See Chapter 9 for a more detailed discussion of how to design pricing policies.)

7.5.8 Institutional and physical barriers to PEV charging

Location, availability and management of on-site parking. Some workplaces have assigned parking spaces, which makes it difficult to convert the spaces closest to the electrical room to PEV spaces. The farther away from the electrical room the charger is located, the more expensive it will be to lay conduit and wiring.

The distance between where the PEV is parked and the electrical panel is a major factor in installation costs, permitting and inspection processes. Workplaces with surface parking may have the greatest distances between where cars are parked and where service panels are located, and may require trenching. This can incur more in the way of construction costs and soft costs associated with permitting and inspection.

Employees could be encouraged to trade parking spots or use a common or visitor space for PEV charging. Employers and/or property owners can convert visitor spaces to assigned PEV parking or temporary charging. They can also encourage employees to trade parking spots to put the PEVs as close as possible to the electrical room.

The cost of charger installation and electrical upgrades. Parking areas often have just enough electrical capacity to support lighting and other basic garage functions. Level 1 charging may only require adding 120-volt outlets, but panel upgrades may be needed to support Level 2 charging. If subsidies for charging equipment and installation require Level 2 charging, employers and/or property owners may be deterred from taking advantage of the subsidies because of the cost of adding panel capacity. Adding panel capacity can incur hard costs of wiring upgrades as well as soft costs of permitting and inspection.

Building codes offer an opportunity to require PEV-ready wiring in new construction—a much more cost-effective method than retrofits. These codes, as well as equipment subsidies and rate incentives from local jurisdictions and/or utilities, could be adapted to facilitate more Level 1 charging capabilities. Further guidance on building codes for PEV readiness is provided in Chapter 11.

7.6 Recommendations for facilitating workplace charging

Installing PEV chargers in workplaces presents a number of institutional, physical and cost recovery challenges. Local planners and policymakers can make the greatest impact in reducing the hard and soft costs of installation. To expand charging in the nearer term, local policymakers should consider the following measures, in addition to the recommendations provided earlier in this chapter and in related chapters:

7.6.1 Utility policies

- Plan capital projects to upgrade electrical distribution systems to accommodate PEV charging in workplace- or employee-dense areas.
- Prioritize upgrades of transformers that enable PEV charging at workplaces.
- Partially subsidize costs associated with slower, lower-voltage Level 1 charging, which may only require some additional standard outlets in the parking area. Extending partial subsidies to Level 1 charging would allow existing power supplies to go farther by reducing the need for electrical upgrades. This could also potentially lower the time and cost associated with permitting and inspection.[21]
- Subsidies for charger purchase and installation should be made available to employers (in addition to drivers), as they are well-positioned to achieve economies of scale with multiple installations, and can reap the benefit over the long run by providing an attractive amenity (Balmin, Bonett, and Kirkeby 2012).[22]

7.6.2 Regional planners

- Conduct demonstration projects to research ways of reaching economies of scale with

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21 Some utilities may wish to directly subsidize purchase and installation of charging units, as the Los Angeles Department of Water and Power does currently with its Charge Up L.A.! program. But if these incentives are designed around faster, higher-voltage Level 2 charging, they will require the purchase of special equipment and most likely require an electrical upgrade. Level 2 charging can thus incur potentially higher upfront costs and a more complex permitting process, slowing PEV adoption.

22 Employers who are not property owners may not want to pay for electrical upgrades because they will lose the benefit when they move.

PEV charging at workplaces.

- Target and support workplace charging within the region based on the metrics described here and elsewhere in this document.

7.6.3 Local planners

- Reform building codes to require a certain number of Level 1 and Level 2 PEV-ready spaces in new non-residential construction. This is the most cost-effective, least institutionally complicated method of ensuring more workplace charging opportunities in the future.
- Allow PEV charging spaces to count towards minimum parking requirements or offer them as a development incentive. Further guidance on these measures is provided in Chapter 10 of this document.
- Streamline permitting and inspection procedures for PEV charging installations. Further guidance is provided in Chapter 12 of this document.
- Automatically expedite the approval process for PEV charging permits in workplaces.
- Conduct employer-specific outreach activities and provide educational materials to employers and commercial property owners. These materials should specify the process of installing charging in workplaces and present cost recovery models. Further guidance on outreach is provided in Chapter 15.

7.7 References

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8 Planning for Retail and Public Sector Charging

8.1 Introduction

Most plug-in electric vehicle (PEV) charging occurs at home, followed by charging at the workplace. However, the proliferation of plug-in hybrid electric vehicles (PHEVs) has increased the demand for more sporadic charging outside of home or work. To maximize their electric miles driven, many PHEV drivers find it valuable to charge when visiting retail and government-owned destinations.

Whether charging at public-sector and retail sites is cost-effective for PEV drivers and financially viable for charge station operators will depend upon several factors. These include where stations are located, how much demand there is for charging, and how much it costs to use or own the charge station. This chapter describes the site criteria that should be considered in the selection of public-sector[23] and retail charging stations. It also describes how demand for charging in afternoon and evening can vary across neighborhoods within the region using the Southern California Association of Governments (SCAG) regional travel model. Finally, this chapter notes the challenges associated with pricing charging at some retail destinations.

8.2 Evaluative criteria for the selection of public-sector and retail charging sites

Planners will want to consider a variety of criteria when prioritizing a site or group of sites. Many of these criteria relate to a site's potential demand for charging or its relative cost-effectiveness in hosting a station. These factors include:

- Potential demand for PEV charging
- Frequency of visits per week
- Time of day when charging

23 "Public sector" here refers to sites owned by the public sector and used by both public-sector employee personal cars (not fleet vehicles) and/or by the general public.

- How long cars are parked (a.k.a. "dwell time")
- Cost of electricity (and demand charges)
- The value of non-PEV parking spaces to the site host
- Driver's cost of waiting
- "Green" reputation for site host

8.2.1 Sites and areas with high potential demand for charging

One of the most important criteria is that the site be a place where PEVs are or will be parked. Several types of current driver-specific, site-specific, and neighborhood-specific criteria can be used to assess current- and near-term potential **demand** for charging. The most reliable evidence on potential charge station utilization comes from those drivers currently using parking at a site. Indeed, the best site- specific evidence is the actual presence of PEVs parked on or adjacent to the site. Customer surveys (or driver surveys in the case of public-sector sites) of PEV ownership and the intent to purchase a PEV can also be a good predictor. Future demand for PEVs is often associated with the current ownership of hybrids, so a higher-than-average concentration of hybrids in a parking lot may be a good predictor. Planners could also use demographics associated with early-market PEV adopters. These characteristics include customers with higher educational achievement, moderate to higher incomes, willingness to innovate, and often attitudes that are pro-environment or pro-oil independence (California Center for Sustainable Energy; Landy 2011; Nixon and Saphores 2011).

The **frequency** and **total level of visitation** to a site can also be an important factor. Planners might also ask where the site supports parking for 1) routine daily travel (work, school, gyms, etc.), 2) routine weekly travel (stadiums, theaters, churches, etc.) or 3) occasional travel (hotels, major vacation destination charging or freeway-adjacent stations). We discuss specific site types in greater detail in the following sections.

Other site-specific characteristics, such as size and location, may be useful but should be used to make a choice between competing sites that have been prioritized based customer- or driver-specific evidence of potential demand. With all else equal, sites with larger parking capacity are more likely to host PEVs. Similarly, prioritizing sites near high-volume freeways or arterials might incrementally increase site utilization.

Planners may also use regional travel demand models to predict areas where PEV density will be highest at different **times of the day**. We have done this for travel analysis zones in the SCAG regions. Such zones are about the same size as, and often coincide with, Census tracts across the SCAG region. Using such models, planners can predict areas in which different numbers of PEVs will be parked during different periods of the day and night. See the chapters on single-family (Chapter 5) and workplace charging (Chapter 7) in this plan as well as the retail charging spatial analysis later in this chapter. While this neighborhood-scale analysis not a site-specific analysis, it can be used to complement site analysis by targeting those high-demand areas within which sites can then be effectively prioritized.

8.2.2 Criteria for selecting cost-effective charge sites

Selecting sites that offer the lowest possible cost of charging will benefit not only the site host (by increasing utilization rates) but also PEV drivers (who will pay lower prices for charging). Sites that provide the lowest possible cost per kilowatt-hour (kWh) to PEVs will typically have the following features:

- Sites on which PEVs are ***parked for longer periods of time*** (longer "dwell times") enable slower rates of charging, which may enable the use of less costly Level 1 charging rather than more costly Level 2 or fast charging. The longer the dwell time, the more miles of electric range can be added. At Level 1, an hour of charge can add five to 10 miles of range, depending on the capacity of the vehicle's onboard charger. At Level 2, an hour of charge adds between 10 to 20 miles of range, depending on the capacity of the vehicle's onboard charger. Longer PEV dwell times also enable multi-armed smart chargers to deliver lower costs per kWh delivered over a larger numbers of vehicles. Slower charging, enabled by long dwell times, may also help site owners to avoid electricity demand charges.

Planners may also want to balance factors like average trip distance and frequency of travel to a site with the dwell time for each particular site type. While routine destinations may see greater use, shorter trips may benefit less from charging than would longer trips with longer dwell times.

- A feature related to the land use or type of site is time of PEV arrival at the site, which determines the t***ime of day when charging would occur***. Charging that occurs before 12:00 p.m. and after 9:00 p.m. will enable most site hosts to provide lower-cost electricity to PEVs because of electricity rates that are lower during these periods. Charging between 12:00 p.m. and 9:00 p.m. is not only the most expensive, but more likely to incur demand charges for the site host[24]. The arrival times at government-owned sites can vary greatly throughout the day. Unfortunately, many types of retail sites are only open between 10:00 a.m. and 9:00 p.m., which is the period when electricity costs are highest and demand charges are most likely. In addition, dwell times are often the lowest for many types of retail destinations, making them the least cost-effective type of land use to host charging.
- The ***value of regular parking spaces to the site host*** is another factor to consider. For many sites, there is no value lost by replacing a regular parking space with a charging space, because most sites have many unused parking spaces. On sites where there is a shortage of parking, charging stations can also be located in places within parking facilities that are the last to fill up in order to avoid the appearance (to the other

24 Demand charges are added to the electricity bills of non-residential customers to reflect the additional cost of delivering power to them during the customer's peak usage times.

employees or customers) of displacement.[25] Sites can also experiment with dual-use and time-of-day split use of spaces for both parking and charging. For example, charging spaces intended for government employees during the day can be made available to the general public at night.

- The second type of cost that may vary across public-sector and retail sites is the ***driver's time*** while charging. In most instances, PEV drivers will not choose to charge at a site unless there is no additional time associated with charging. Planners should expect the PEV driver will be busy with whatever motivated his or her visit to that destination. Only in the rare case that a PEV driver is in danger of running out fuel are they likely to be willing to spend time refueling, and then they are likely to choose to refuel quickly with gasoline if they own a PHEV. Chargers should be located at sites where drivers would normally stop for at least 1 to 2 hours or more unless they are refueling along interstate corridors during inter-regional travel.

8.2.3 Retail site characteristics that affect benefits

Two other factors may affect the value proposition of hosting a charge station at retail sites. The first is that, for a few types of retail sites that price charging lower than what drivers would pay at home, charging stations may attract customers that would have otherwise gone to another retail site. (See Chapter 5 on residential charging for more information.) Second, some site hosts want to support or be associated with "**green**" values or energy independence. These are likely to be retail establishments that incorporate these values into the corporate brand identities.

8.2.4 Types of publicly-owned and retail sites

Based on the above criteria, we identify several broad categories of sites. We use an analysis of 2009 National Household Transportation Survey data (Krumm 2012) to common travel destinations that tend to require at least moderate travel distance. Based on this analysis, the list below features some examples of publicly-owned site types where vehicles tend to be parked for about two hours on average:

- Government workplaces
- Transportation stations
    - Airports, light rail/subway, bus, ship/ferry terminals
- Public parking facilities
- Public recreational/natural/cultural facilities
    - Football, baseball, basketball, soccer, tennis, pool facilities
    - Parks, beaches and playgrounds

25 Placement of the first charging space may be constrained by disabled access requirements. See Chapter 13 for a discussion of charging space compliance with the Americans with Disabilities Act.

    - Museum, libraries, music and theater venues
- Non-profit sites
    - Houses of worship
    - Cultural centers
    - Clubs

Also based on the National Household Travel Survey analysis, the following list features some examples of retail sites where vehicles tend to be parked for about two hours on average:

- Commercial parking facilities
- Major retail malls
- Sporting events and arenas
- Major pedestrian-oriented commercial thoroughfares
- Bars and evening entertainment venues
- Gyms and sports clubs

Finally, Table 8.1 describes retail sites that have been documented to have relatively shorter travel distances and shorter dwell times (Krumm 2012).

Table 8.1: Retail sites with short dwell times

Destination	Average dwell time (minutes)
Gas stations	10
Video rental/cleaners/post office/bank	19
Coffee/ice cream/snacks	20
Grocery, hardware, clothing store	36
Attorney/accountant office	41
Meals/restaurants	46
Day care	65
Grooming, hair, nails	67
Medical/dental services	68

8.3 Siting of retail charging stations

Next, we discuss the identification of retail destinations across councils of government (COGs) in the SCAG region. The Southern California PEV Atlas, which accompanies this document, contains maps of retail and small business destinations (such as beauty salons and small offices) within each COG in the region. The maps also overlay retail centers of different sizes with densities of PEVs traveling between 9:00 a.m. and 3:00 p.m. Planners and utilities can use these maps to compare the spatial distribution of retail centers and mid-day travel destinations for PEVs.

After locating general categories of retail charging opportunities on the map, planners can turn to the analysis of the National Household Travel Survey referenced above[26] for more detailed descriptions of how long cars are typically parked at specific types of retail destinations. Understanding the "dwell time" associated with specific types of retail locations will help planners and prospective site hosts prioritize retail charging opportunities that are likely to be higher-demand and more financially viable.

The COG-level maps in the Southern California PEV Atlas display retail destinations according to density classifications from SCAG. They highlight four types of retail centers that are likely to attract many of the non-work related vehicular trips. These four categories presented in Table 8.2.

Table 8.2: Type of retail shopping centers

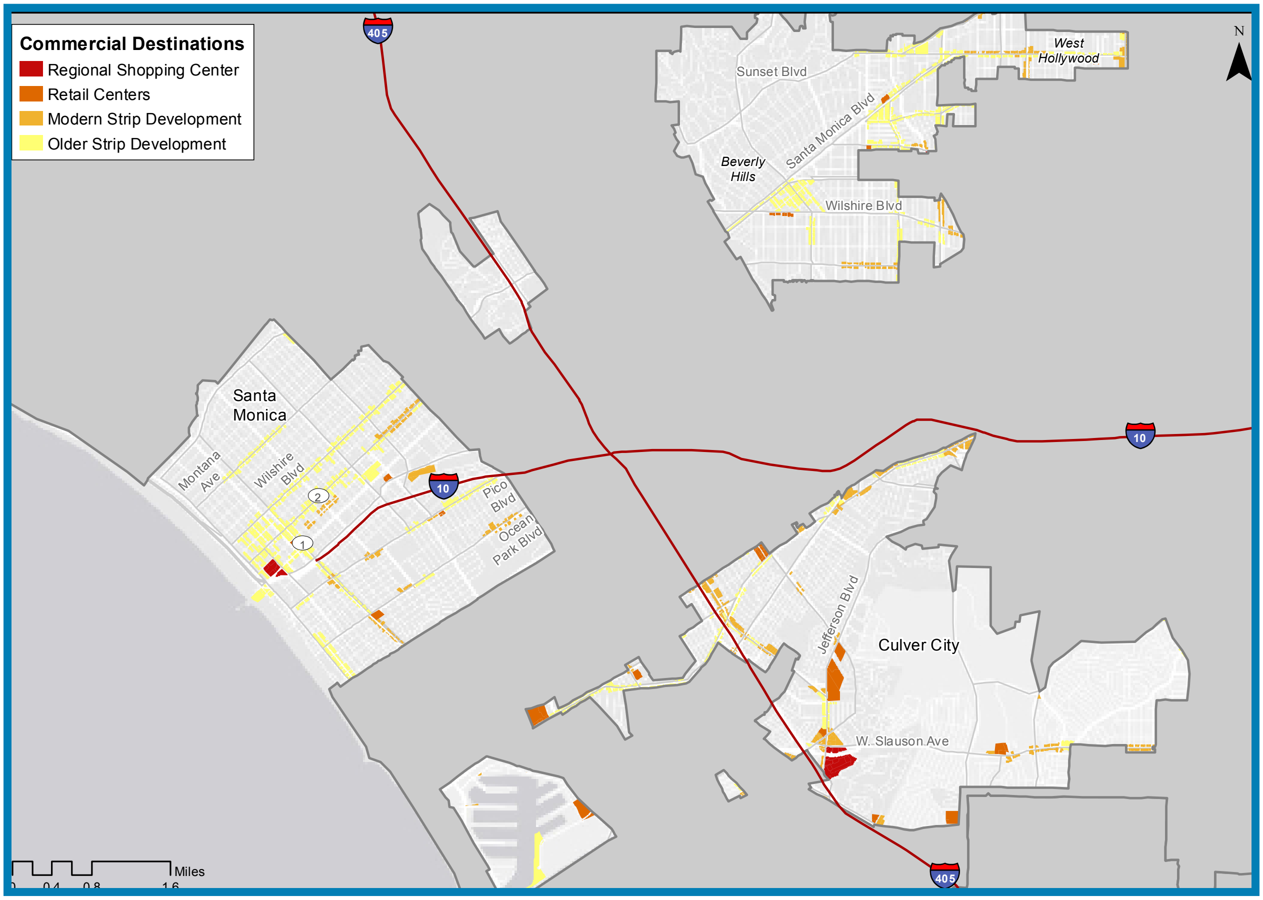
Description	Key Attribute
Regional Shopping Center	Department store with surrounding parking
Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking)	Magnet store with in-front parking
Modern Strip Development	Small businesses with parking on-street and on one side
Older Strip Development	Small businesses with on-street parking

Source: (Southern California Association of Governments 2002)

An example retail destination map from the Westside Cities Council of Governments is provided below (Map 8.1). Planners should consult the Southern California PEV Atlas for all COG-level maps.

26 http://research.microsoft.com/en-us/um/people/jckrumm/Publications%202012/2012-01-0489%20SAE%20published.pdf

Map 8.1: Retail destinations, Westside Cities Council of Governments

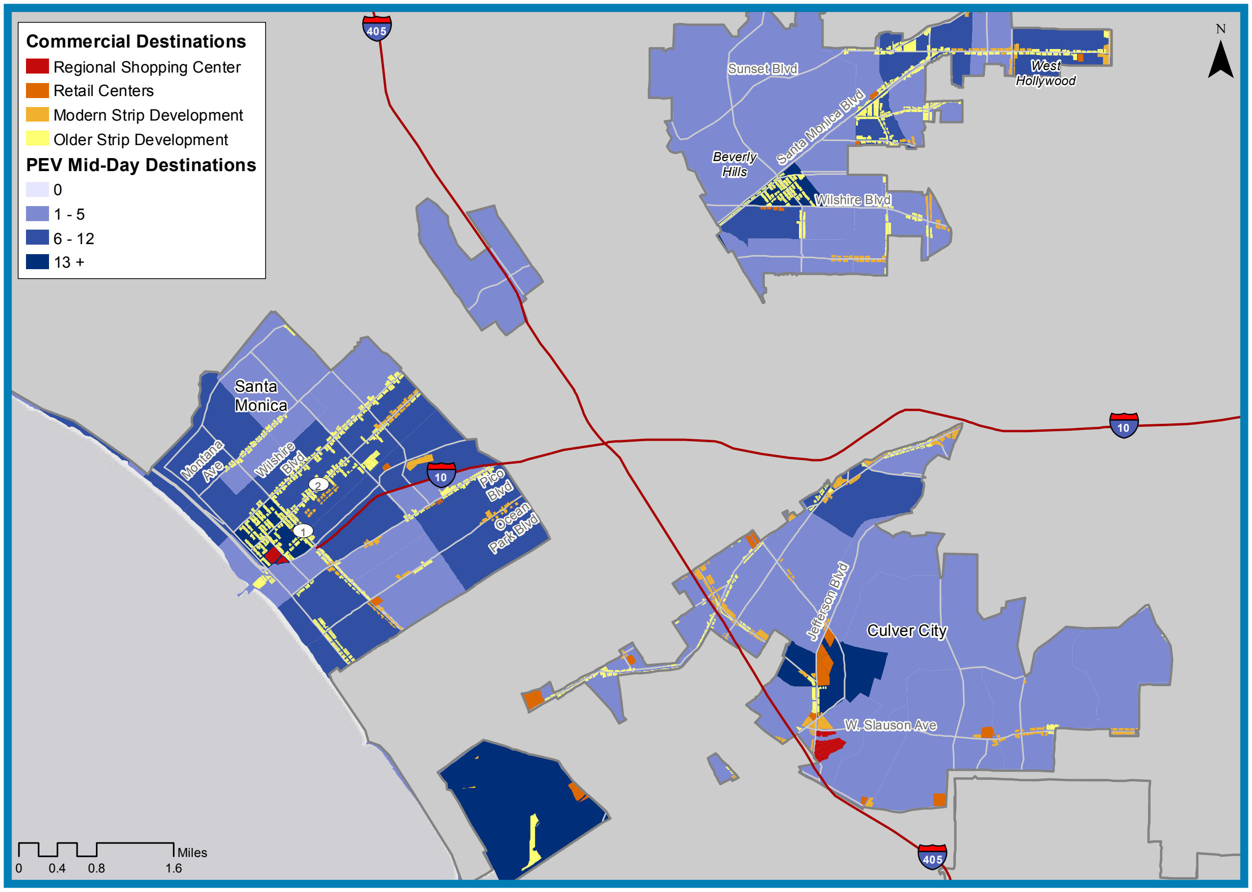


After mapping retail destinations, the UCLA Luskin Center mapped the locations where currently-registered PEVs travel during weekdays from 9:00 a.m. to 3:00 p.m. The data on PEV registrations comes from automotive data vendor R.L. Polk & Co., which provided the number of PEVs registered as new within each Census tract through September 2012. These Census tracts represent the neighborhoods where PEVs originate their trips from home.

Census tracts closely follow the boundaries of travel analysis zones (TAZs), which are the geographic areas used by SCAG to model vehicle travel. SCAG's travel demand model estimates the number of trips from home to work, school, and other destinations by time of day. By counting the number of PEVs from each origin TAZ that feed into each of the mid-day *destination* TAZs, we are able to map the locations and densities of PEVs traveling to neighborhoods from 9:00 a.m. to 3:00 p.m.

Table 8.2 below overlays retail density and mid-day PEV destinations in the Westside Cities Council of Governments. Planners should consult the COG-level retail/PEV overlay maps in the Southern California PEV Atlas to assess existing potential demand for retail charging locally. Combined with the metrics described earlier in this chapter, the data will provide a strategic approach to prioritizing retail charging locations and technical assistance.

Map 8.2: PEV mid-day destinations and retail centers, Westside Cities Council of Governments



While the largest, reddest areas represent the largest retail centers (and thus locations that may be amenable to providing charging on-site), areas rich in small stores and businesses may represent demand for charging curbside or in stand-alone parking structures. Parking lots and structures greater than 2.5 acres that are not attached to other land uses are also mapped at the COG level in the Southern California PEV Atlas. Map 8.3 highlights three types of stand-alone parking classified by SCAG.

Table 8.3: Types of stand-alone parking facilities

Description	Key Attribute
Attended Pay Public Parking Facilities	Stand-alone public parking areas and parking structures that have an attendant-cashier present
Non-Attended Public Parking Facilities	Free or metered public parking areas where no attendant-cashier is present
Park and Ride Lots	Cal Trans park and ride lots provided for commuter ridesharing, buspooling, vanpooling, and carpooling purposes

Source: (Southern California Association of Governments 2002)

Operators of stand-alone parking facilities will have different cost recovery goals depending on whether they are government-owned or commercial pay parking lots. Comparisons of cost recovery models are provided in Chapter 9.

Publicly-accessible parking facilities can fill a gap in PEV charging, particularly in older urban cores where retail stores and even some workplaces and multi-unit dwellings do not have dedicated parking. Park and ride lots in particular may substitute for Level 1 workplace charging if workers leave their PEVs parked all day. An example map of stand-alone parking facilities is provided for the Westside Cities Council of Governments in Table 8.3.

Map 8.3: Stand-alone parking facilities, Westside Cities Council of Governments

8.4 Siting public-sector charging sites

Selection criteria for government-owned charging sites should follow the same guidelines provided in Section 8.1. The benefits of mapping publicly-owned parcels will be modest, as there are relatively fewer of them and they represent a diverse set of destination types (workplaces, recreational areas, etc.). Public-sector site hosts can refer to Chapter 7 for pricing models for workplace charging and Chapter 9 for comparisons of pricing models.

8.5 Pricing, utilization and the financial viability of retail charging

A central concern of most retailers is whether retail charging will be financially viable. They want to know whether they can at least break even on their investment. In this section, we first present a set of questions facing retailers who wish to make well-informed investments in charging equipment. We conclude that only with longer dwell times and well-designed pricing policies will retail charging be both financially viable for retailers and cost-effective for PEV drivers.

Planners who wish to advise retailers on other pricing alternatives should also see Chapter 9.

8.5.1 How much customer demand will there be for PEV charging?

In order to assess customer demand for PEV charging, retailers will want to know:

- How many customers are currently driving PEVs to their retail establishment?
- How will this number grow over time?
- Will they charge at a retail establishment if equipment is available?

Some customers may not need to charge at retail establishments in order to complete their daily commute on electric miles. Most customers are likely to make this decision by comparing the costs of charging at retail establishments with their costs of refueling elsewhere such as charging at home or filling up with gasoline if they drive a PHEV.

8.5.2 How should the retailer price PEV charging?

Once the retailer estimates the demand for retail charging, he or she must decide how to price the service. Understanding potential demand will help the retailer determine how much electricity customers will consume for PEV charging and what revenues will be generated by pricing use of the equipment.

Retailers risk pricing the use of charging equipment higher than what customers pay at home or at work. In this case, customers with PEVs may not choose to charge at retail establishments and the retailer will fail to generate the expected revenue. Retailers also run the risk of pricing the use of charging equipment at levels too low to cover the retailer's costs. In our analysis below, we consider both of these possible errors when evaluating the financial viability of workplace charging scenarios.

8.5.3 How much charging capacity should the retailer provide?

Capacity refers to the number of cords of each level (1, 2, or fast charging) provided at the location. Currently, single-cord Level 2 chargers are popular. But this may not necessarily be the best capacity for retailers to choose. If the retailer expects multiple customers (or employees) to adopt PEVs, then multiple-cord (or multiplex) charging units with different levels of service (1 and 2) could be a retailer's most cost-effective solution. Although the upfront costs are higher, the multiplex chargers, when charging several vehicles at once, may do so at a lower total cost and lower cost per unit of electricity than would a comparable number of single-cord Level 2 chargers. In practice, identifying the most cost-effective choice of charging capacity requires comparing the costs of specific types of charging equipment and how much it will be used in a specific retail setting.

8.5.4 Financial viability scenarios for retailers

The goal of the next sections is to give planners an understanding of how installed charger costs, pricing policy, and driver utilization rates affect the financial viability of retail charging for one- and three-hour dwell times. Because hourly rates with fixed connection fees are commonly considered for retail locations because of the significant revenues they can deliver during short dwell times, we focus on this type of pricing policy only. Readers interested in the use of per-hour or per-unit of electricity pricing policies should see the Chapter 9.

Using simple cash-flow models, we describe the net loss or net profit of retail charging under a wide range of conditions. These examples are intended only as illustrations but are based on commonly-encountered assumptions.[27] We will consistently evaluate the impacts of a wide range of installed charger costs, from a low of $500 to a high of $10,000.[28]

Planners can use the tables in this section to assess financial viability of hosting a charging station from the **retailer's** perspective. When used in conjunction with Table 9.4, planners can evaluate the pricing model presented here against the cost to the **driver** under the same pricing model.

First, the planner can identify investment costs and pricing levels under which retailers would at least break even, given this level of utilization. Second, the planner can evaluate the retail prices that are likely to be above the PEV driver's residential or gasoline cost of refueling. This latter assessment is critical for the retailer because it identifies those prices that will not generate any revenues for the retail charge station. Of course, another danger for the retailer is pricing charging at levels too low to cover costs. In our analysis below, we consider both of these possible errors when evaluating the financial viability of retail charging scenarios.

The number of PEVs that "connect" to a charger each day is a critical variable that determines the potential revenue for a retailer. This is because when a pricing policy with a connection fee is employed, a significant amount of revenue is created whenever a PEV simply connects to the

27 We assume retailers (or a contracted electric vehicle service provider) will own and operate the charge station for 10 years and that the retailer pays $0.195 per kilowatt-hour (kWh) for electricity. (This is based on what a typical home would pay on average in the Southern California Edison service territory. Smaller businesses tend to pay more than this rate per kWh and larger businesses tend to pay less. We hold electricity costs constant across our analyses in this Plan in order to simplify comparisons across charging environments). When calculating the net present value we assume the retailer's discount rate is 5%.

28 These installed charger costs represent the total upfront costs including charging space design, permitting, electrical upgrades, construction, installation, and the cost of charging equipment.

charger, regardless of how long the PEV charges. The financial viability of a hypothetical retail establishment for one to 10 connections per day, each lasting one or three hours, is presented in Table 8.4 and Table 8.5.

Table 8.4: Present value of financial returns for one-hour connections (priced at $1 per hour plus a $1 connection fee)

Connections per day with one-hour dwell time						
	1	2	4	6	8	10
$ 500.00	$ 2,618	$ 5,437	$ 11,073	$ 16,710	$ 22,347	$ 27,984
$ 1,000.00	$ 1,899	$ 4,718	$ 10,355	$ 15,992	$ 21,628	$ 27,265
$ 2,000.00	$ 462	$ 3,280	$ 8,917	$ 14,554	$ 20,191	$ 25,828
$ 3,000.00	$ (975)	$ 1,843	$ 7,480	$ 13,117	$ 18,754	$ 24,391
$ 4,000.00	$ (2,413)	$ 406	$ 6,043	$ 11,679	$ 17,316	$ 22,953
$ 5,000.00	$ (3,850)	$ (1,032)	$ 4,605	$ 10,242	$ 15,879	$ 21,516
$ 6,000.00	$ (5,288)	$ (2,469)	$ 3,168	$ 8,805	$ 14,442	$ 20,078
$ 7,000.00	$ (6,725)	$ (3,906)	$ 1,730	$ 7,367	$ 13,004	$ 18,641
$ 8,000.00	$ (8,162)	$ (5,344)	$ 293	$ 5,930	$ 11,567	$ 17,204
$ 9,000.00	$ (9,600)	$ (6,781)	$ (1,144)	$ 4,493	$ 10,129	$ 15,766
$ 10,000.00	$ (11,037)	$ (8,219)	$ (2,582)	$ 3,055	$ 8,692	$ 14,329

Table 8.5: Present value of financial returns for three-hour connections (priced at $1 per hour plus a $1 connection fee)

Connections per day with three-hour dwell time						
	1	2	4	6	8	10
$ 500.00	$ 3,349	$ 6,167	$ 11,804	$ 17,441	$ 23,078	$ 28,715
$ 1,000.00	$ 2,630	$ 5,449	$ 11,085	$ 16,722	$ 22,359	$ 27,996
$ 2,000.00	$ 1,193	$ 4,011	$ 9,648	$ 15,285	$ 20,922	$ 26,559
$ 3,000.00	$ (245)	$ 2,574	$ 8,211	$ 13,848	$ 19,484	$ 25,121
$ 4,000.00	$ (1,682)	$ 1,136	$ 6,773	$ 12,410	$ 18,047	$ 23,684
$ 5,000.00	$ (3,119)	$ (301)	$ 5,336	$ 10,973	$ 16,610	$ 22,247
$ 6,000.00	$ (4,557)	$ (1,738)	$ 3,899	$ 9,535	$ 15,172	$ 20,809
$ 7,000.00	$ (5,994)	$ (3,176)	$ 2,461	$ 8,098	$ 13,735	$ 19,372
$ 8,000.00	$ (7,431)	$ (4,613)	$ 1,024	$ 6,661	$ 12,298	$ 17,934
$ 9,000.00	$ (8,869)	$ (6,050)	$ (414)	$ 5,223	$ 10,860	$ 16,497
$ 10,000.00	$ (10,306)	$ (7,488)	$ (1,851)	$ 3,786	$ 9,423	$ 15,060

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9 Pricing Policies for PEV Infrastructure

9.1 Introduction

When prices for plug-in electric vehicle (PEV) charging are designed correctly, they facilitate the growth of a financially-sustainable universe of charging options. Good pricing policies provide PEV drivers with fair, efficient access to a variety of charging levels. They also help charging site hosts or operators cover costs. Since drivers will seek out the lowest-priced stations, prospective site hosts look for locations with the lowest costs and highest demand.

As planners seek to maximize the number of electric miles driven in their jurisdiction, they need to understand the refueling behavior of PEV drivers. Charge station pricing policies will determine where and when drivers choose to refuel, thus informing where additional new stations and which existing stations will be financially viable under current pricing policies.

Charge station pricing policies are important for planners to understand for other reasons. Planners may have to:

- **Set prices** for use of charge stations on public property, such as parking structures, libraries, city hall, or public recreational destinations. They may also set prices in their capacity as an employer providing workplace charging.
- **Contract with a charge station network service provider** (also called an electric vehicle service provider, or EVSP). EVSPs provide a wide variety of charging services, including equipment installation, billing, and usage tracking. EVSPs can be contracted to operate charge stations on public property, in which case pricing policies will be a central focus of the contract's design.
- **Provide PEV readiness educational and technical assistance** to employers and property owners of multi-unit dwellings (MUDs). These site hosts will seek information on how alternative pricing policies will affect the financial sustainability of their charge stations under differing conditions.
- **Verify** that city PEV readiness efforts are working. Many of the actions that planners can undertake—related to permit streamlining, zoning, parking regulation, and building

codes—are intended to drive down the soft and hard costs of installing charge stations and shift the costs to PEV drivers and building developers. Planners can only verify that these actions are working if they are aware of the factors that influence a site host's selection of pricing policies.

In addition to the reasons described above, planners' understanding of how to price charging strategically—in a way that reflects the costs of supplying charging as well as actual demand — can lead to better choices of charging locations. In an effort to spur growth in the number of charge stations, government programs have heavily subsidized the equipment and installation costs of these stations. In addition, regional deployment programs (initiated by the U.S. Department of Energy and state lawsuits) have resulted in quantity-based and time-limited deployment requirements. These deployment requirements have encouraged program implementers to install "convenience" site stations, locating them wherever an accepting site host can be conveniently found. As a result, these charge stations are unlikely to be located where either PEV demand is highest or construction and operation costs are lowest. This has resulted in underused stations that have been publicly subsidized, and which the site host will eventually have to pay to have removed.

This chapter provides planners with a primer on charge station pricing policies. Section 9.2 describes the roles and benefits of well-designed pricing policies to different stakeholders in the PEV ecosystem. Section 9.3 presents the major types of pricing policies that have been proposed or implemented. Section 9.4 presents a set of criteria for evaluating pricing policies while Section 9.5 describes how specific pricing policies impact PEV drivers differently depending upon their driving behavior and PEV type. The role of pricing policies in the financial viability of specific charging location types is discussed in the separate chapters on PEV planning for MUDs (Chapter 6), workplace charging (Chapter 7) and retail charging (Chapter 8).

9.2 The benefits of well-designed pricing policies

Well-designed pricing policies can benefit the major participants in emerging markets for charge stations. A central benefit to the site host or charge station operator (e.g., EVSP) of pricing is that it **generates revenue**. Some site hosts will set prices only to recover their costs. Some may seek to recover only operating costs, if their initial installed costs were subsidized, or if they have the altruistic goal of encouraging PEV adoption. Others may seek to recover all upfront and on-going costs. Those site hosts with a more entrepreneurial bent, especially network service providers, will go beyond the goal of cost recovery to set prices they hope will yield profits.

A second benefit of pricing is that it can **shift the costs of supplying the charging equipment onto those who benefit** from the using that equipment. This property of pricing can be especially helpful in workplaces and multi-unit dwellings. Employers and property owners may face legal, administrative, or ethical prohibitions on covering the cost of providing charge services to PEV drivers but not conventional fuel drivers.

A third benefit of pricing accrues to the PEV drivers when pricing encourages **the efficient use of charging equipment.** The social goal here is to enable those PEV drivers, who need and value charging most, to access charging equipment. Pricing can be used to efficiently allocate both charge station parking access and, in the case of multiplex charge stations, the charging capacity of the station. This is important, because as the PEV market grows, it will become increasingly important to ensure that charge stations are priced to encourage active charging and discourage overstays (connected or not to the charge station) so that stations are available for charging as much as possible. This can be done by increasing the costs of charge station parking (relative to nearby parking opportunities) when vehicles are not actively charging. Alternatively, the advent of smart chargers not only enables multiple PEVs to charge at one station, but these chargers also enable PEV drivers to select the combination of price-service priority for which each is willing to pay, given the available capacity. Drivers who are willing to pay a premium for quicker charging will be able to do so, while those who have more time or need less power can charge at a lower rate and price.

Finally, market prices that are set in response to real supply costs and consumer demand provide **valuable information to potential site hosts and PEV drivers**. They enable prospective site hosts to evaluate whether local PEV demand will generate the revenues needed to make new investments in charge stations financially sustainable. They also enable prospective PEV drivers to determine what the charging costs are at different locations and how that will, in turn, affect their expected PEV refueling costs.

The benefits to different stakeholders of well-designed PEV charging price policies are summarized in Table 9.1.

Table 9.1: Stakeholder benefits of strategically-priced PEV charging

Benefit	Stakeholders
Revenue generation	Station operators
Shift costs to beneficiary (driver)	Commercial property owners, employers, multi-unit dwelling owners
Efficient use of charging equipment	Waiting PEV drivers and station operators
Information on demand and market prices	Prospective site hosts, current and prospective PEV drivers
Transparency and fairness	PEV drivers

9.3 Types of pricing policies

Several pricing policies have been implemented or proposed, with some tailored or targeted to specific types of charging locations.

9.3.1 Monthly flat fees

A common pricing policy is a **flat fee** per month for access to a single charge station or network of charge stations. PEV drivers are able to access and charge as much as they wish during the subscribed time period. Commonly considered monthly flat fees have ranged from $25 to $75 for workplace charging. A version of this flat fee structure is the monthly **network subscription fee** which enables drivers to charge at any of the stations within the network. For example NRG currently offers a network subscription at the cost of $89 per month for its network which may include both residential and nonresidential Level 2 as well as public fast charging.

9.3.2 Hourly rates

There are two important versions of hourly rate policies. The first version is a **simple per-hour rate** for the time the PEV is actively charging. For Level 1 and 2 charge stations, observed per-hour rates range from $.50 up to $2.00 per hour. The second version is a **fixed connection fee** in combination with the per-hour rate. Fixed fees can also range from $.50 to as high as $3.00 per charge session.

There is a variation on the fixed-fee in combination with the hourly charge which is the **minimum fee** per connection event. This fee can be levied in two very different ways. First, this fee could levied so that once the total charge exceeds the minimum fee, the pricing policy becomes equivalent to a simple per hour charge. In the event that the driver does not exceed the minimum fee amount, this pricing policy functions like a flat connection fee per charge session. We will call this type an **offsetting minimum fee** structure since the per-hour charge offsets the minimum fee. Alternatively, minimum fees could also be levied as a connection fee which is added to the per hour total, which will then have the same properties as a fixed connection fee in combination with an hourly rate. We will call this an **additive minimum fee** structure. The driver must take care to understand how the total charges are calculated when minimum fees apply. [29]

9.3.3 Markup on costs

The last major type of pricing policy involves **markup on costs**. This policy takes the electricity cost (measured in cents per kilowatt-hour) plus any other ongoing variable costs, such as billing services, maintenance, or insurance costs, and then adds a percentage mark up on these variable costs. For public and non-profit organizations that simply want to cover their total costs, the mark-up portion of the price can be set to recover the upfront installation and equipment costs (or associated on-going financial costs). For profit-oriented station operators

29 As an example of an *offsetting* minimum fee, consider a station with a $1 minimum fee and $1 per hour policy. If the driver stops charging prior to the end of the first hour she pays $1. After the first hour of charging , she has exceeded the $1 the minimum fee, so only the hourly rate is used to calculate her total costs. In contrast, when an *additive* minimum fee applies, it is applied *in addition* to whatever the total hourly charge is. For example, once she had completed an hour of charging, her total costs would have been calculated by adding $1 for the hour of charging plus the $1 minimum fee for a total of $2.

the mark-up can be set strategically by time of day or location to maximize profits (in addition to covering costs).

9.3.4 Combination rates

Finally, network operators may employ a combination of pricing schemes at the same time. One version of this allows drivers within the network to pay different flat rate subscription fees each month in return for either access to different charge station services or differentiated hourly or kilowatt-hour prices. Another version differentiates in network and out of network customers, typically charging out of network customers higher fees.

9.4 Evaluative criteria

Charge station or network operators will look for pricing policies with four properties. The pricing policy should be:

- **Easy to calculate** and set
- **Easy to adjust** periodically as costs and market conditions change
- As **cost-effective** as possible by requiring minimum upfront and ongoing costs. Some pricing policies require that charge station operators have metering technologies and network systems that track the hours of usage or the amount of power consumed. When drivers pay with credit cards there are additional processing and billing charges that must be recovered.

The next two properties of pricing policies may be embraced by public and non-profit station operators but eschewed by profit-oriented operators. Pricing policies should be:

- **Transparent**, enabling drivers to quickly understand the unit and total costs they are likely to incur as a result of charge station use
- **Fair**, charging a common unit cost for all PEV drivers

Profit-oriented charging hosts will have incentives to select pricing policies in order to **maximize revenues** without regard to transparency and fairness. We can anticipate the profit-oriented operators will try to strategically obscure real costs from PEV drivers in order to increase revenues and profits. They may also seek to maximize revenues by charging different unit prices based on how much electricity is consumed or charge different unit prices to different customer classes.

9.5 Why pricing policies mean different things to different PEV drivers

PEV drivers may differ in several ways that differentiate the impacts of the public pricing policies. First, the amount of energy they consume at public stations will vary with the number of electric miles they drive each day to that station. We know from travel diary data (Krumm 2012) that a relatively large percentage of drivers who travel in U.S. metropolitan areas travel only 10, 20 or 30 miles daily. Table 9.2 shows how different daily mileages translate into differing monthly and annual electric mileages (e-miles) and energy consumption.

Table 9.2: Differences in electric travel and charging needs

Assumptions	10 e-miles daily	20 e-miles daily	30 e-miles daily
10-year electric miles	36,500	73,000	109,500
Charger utilization (hours)	0.9	1.8	2.7
Daily kWh purchased	3.5	7	10.5

The cost per electric mile driven is calculated by dividing number of daily electric miles driven by the cost of refueling. The cost of refueling will vary between charging locations. The following sections illustrate how different pricing models result in different costs to drivers.

For these analyses, we assume that PEVs driving in electric mode are depleting their batteries at a rate of 34.82 kW/100 miles. This represents a weighted average fuel consumption based on the market share of individual PEV models.[30] When comparing this fuel consumption to a conventional vehicle (CV), our analyses assume a price of gasoline of $4.00, slightly above the average price of gasoline in California in 2012.[31] Electricity costs are assumed to be $0.195/kWh.

9.5.1 Monthly flat fees

When a pricing policy has a fixed-fee component, such as a connection fee per session or a monthly flat rate, and does not vary with the number of miles driven, then that policy will result in a per-mile cost that changes with the number of miles driven. The flat monthly fees illustrate this effect most simply. We describe in Table 9.3 what the $25, $50, and $75 flat monthly fee means for PEV owners who drive 10, 20 and 30 electric miles daily, respectively. When the $25 monthly flat rate is divided into the monthly mileage for 10, 20 and 30 electric daily miles, the cost per mile driven is almost three times higher ($2.17 per gallon equivalent) for the lowest mileage driver (10 e-miles) compared to the higher mileage driver (30 e-miles) who pays only $0.72 per gallon equivalent. At $75 dollars per month, this same calculation reveals that the lowest mileage driver pays $6.51 per gallon equivalent while the higher mileage driver pays only $2.17 per gallon equivalent. While all drivers pay the same flat monthly fee, what this analysis shows is that the effective cost per mile driven differs with the electric miles that are driven daily. In effect, this pricing policy discriminates across PEV drivers based on how much electricity

30 Source: HybridCars.com (accessed 7/15/2012)

31 U.S. Department of Energy – Energy Information Administration. Accessed 7/23/2012: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_SCA_DPG&f=W

each consumes, which varies with their driving behavior, vehicle characteristics, and access to charging.

Table 9.3: Monthly flat fees and cost equivalents to drivers

Fee levels	10 e-miles daily		20 e-miles daily		30 e-miles daily	
	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent
$25- Flat monthly fee	$0.07	$2.17	$0.04	$1.09	$0.02	$0.72
$50 - Flat monthly fee	$0.14	$4.34	$0.07	$2.17	$0.05	$1.45
$70 - Flat monthly fee	$0.22	$6.51	$0.11	$3.26	$0.07	$2.17

9.5.2 Hourly rates

In Table 9.4, we evaluate the impacts of commonly encountered hourly rates on unit driving costs. Unit costs do not differ across drivers who travel differing numbers of daily electric miles, as long as the fee assessed stops when charging stops. At $1.00 per hour, current PEV drivers will pay $2.40 per gallon equivalent while at $2 per hour, this price jumps to approximately $4.78 per gallon equivalent. However, this analysis of hourly rates is based on the assumption that current PEVs have 3.3 kW chargers on board.

At the top of Table 9.4, we show how the addition of a $1.00 connection fee affects the costs per mile and gallon equivalent when drivers differ in the daily electric mileage. A $1.00 connection fee added to a $1.00 hourly rate represents $5.05 per gallon equivalent for low mileage PEV drivers (10-miles daily) and $3.28 for higher mileage PEV drivers (30-miles daily). Although both drivers pay the same $1.00 connection fee, when expressed as unit costs, it represents a 53% increase in the cost per electric mile driven for the low-mileage driver compared to the higher-mileage driver. Table 9.4 also shows how a $1.00 connection fee plus a $2.00 hourly rate impacts drivers with differing daily electric miles; we will compare this to the cost of residential charging shortly.

An increasing number of PEV models are being released that have 6.6-kilowatt chargers on board. The bottom of Table 9.4 shows how the unit costs for these hourly rates will differ across the two types of onboard chargers. Because the charge rate per hour doubles, the cost per hour is cut in half for models with 6.6 kW chargers on board. Thus, an hourly rate pricing policy will result in much cheaper unit fuel costs for newer PEVs and higher unit fuel costs for the 60,000 lower-power PEVs that have been sold in the U.S. to date.

Table 9.4: Hourly rates, hourly rates with connection fees and cost equivalents to drivers

Fee levels	10 e-miles daily		20 e-miles daily		30 e-miles daily	
	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent
Hourly fee - $1	$0.08	$2.40	$0.08	$2.39	$0.08	$2.40
Hourly fee - $1 + connection fee - $1	$0.17	$5.05	$0.12	$3.71	$0.11	$3.28
Hourly fee - $2	$0.16	$4.81	$0.16	$4.78	$0.16	$4.79
Hourly fee - $2 + connection fee - $1	$0.25	$7.45	$0.20	$6.10	$0.19	$5.67
Hourly fee - $1 (6.6 kW)	$0.04	$1.20	$0.04	$1.20	$0.04	$1.20
Hourly fee - $2 (6.6 kW)	$0.08	$2.41	$0.08	$2.39	$0.08	$2.40

9.5.3 Markup on costs

Thus far, all three major types of pricing policies discriminate against PEV drivers who differ in either their number of daily miles driven or the vintage of the PEV. Next, we evaluate the variable costs plus a markup pricing policy. Table 9.5 shows that, for a given charging station power level, this policy would not affect drivers differently. All drivers face the same average costs regardless of how many miles they drive or the vintage of their PEV.

Table 9.5: Markups on variable costs and cost equivalents to drivers

Markup levels	10 e-miles daily		20 e-miles daily		30 e-miles daily	
	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent
Electricity + $0.10 Markup	$0.09	$2.72	$0.09	$2.72	$0.09	$2.72
Electricity + $0.15 Markup	$0.11	$3.18	$0.11	$3.18	$0.11	$3.18
Electricity + $0.20 Markup	$0.12	$3.64	$0.12	$3.64	$0.12	$3.64

9.5.4 The costs of alternatives to workplace, commercial retail, and MUD charging

PEV drivers are likely to develop their daily refueling plan based on their expectations about the costs of non-residential charging (e.g., workplace and commercial retail) versus the costs of residential electric and gasoline refueling (in the case of PHEV owners). The cost of refueling residentially will depend upon both the level of charging service needed, the installed costs of the charger (if Level 2 is needed), and the ongoing cost of the electricity. Table 9.6 presents the unit cost for Level 1. For the sake of comparison, we also present the cost of refueling with gasoline at $3.50, $4.00, and $4.50 per gallon. The unit costs do not vary with the number of electric miles driven.

Table 9.6: Benchmarks for residential Level 1 charging and gasoline costs

Comparison Cost Levels	$/Electric Mile	$/Gallon Equivalent
Level 1 electricity cost only	$0.06	$1.80
$3.50 gas	$0.12	$3.50
$4.00 gas	$0.14	$4.00
$4.50 gas	$0.15	$4.50

One reason planners may observe low levels of utilization of workplace and retail charging equipment is that pricing policies in these locations often result in much higher unit costs of charging than does residential charging or even refueling with gasoline. We discuss the price/cost interactions between residential, workplace and commercial retail charging in Chapter 5, Chapter 6, Chapter 7 and Chapter 8.

9.6 Choosing pricing policies for different charge environments

Site hosts in different charging environments may favor aspects of particular pricing policies. For example, station operators in retail environments may prefer an hourly rate with connection fees because they maximize revenues from PEV drivers with relatively short parking times. PEV drivers that stay only a short period of time still pay the fixed fee, which generates most of the revenues for the station operator. Of course, many PEV drivers recognize that these pricing policies represent extremely high unit prices and choose to refuel elsewhere.

At both workplaces and MUDs, station operators face important tradeoffs when selecting pricing policies. On one hand, station operators in these environments would ideally be able to change the price of charging over the course of a day in order to encourage charging when it is most cost-effective for the driver, site host, and utility.[32] However, those pricing policies that allow for time-of-day pricing also require the added cost to the operator of measuring

32 Some MUDs and workplaces may be advised to use non-pricing policies to regulate usage. For example, some site hosts will find it beneficial to discontinue charging services during peak periods of the day in order to avoid demand charges and reduce electricity costs.

and billing according to the time elapsed or energy consumed (either by the hour or kilowatt-hour). This would be true for both the electricity markup policy and the hourly rate policy. Flat rates, in contrast, avoid these measurement and billing costs to employers but have the disadvantage of imposing different unit costs (e.g., cost per electric mile driven) on PEV drivers who travel different numbers of electric daily. For large MUD owners and employers, the long-term revenue and efficiency benefits of being able to use time-of-day pricing on use of charging equipment is likely to outweigh the operational costs.

9.7 References

HybridCars.com. 2012. http://www.hybridcars.com/.

Krumm, John. 2012. How People Use Their Vehicles: Statistics from the 2009 National Household Travel Survey. *SAE International*, http://research.microsoft.com/en-us/um/people/jckrumm/Publications%202012/2012-01-0489%20SAE%20published.pdf.

U.S. Department of Energy, Energy Information Administration. 2012. Weekly California All Grades All Formulations Retail Gasoline Prices. http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_SCA_DPG&f=W.

10 Zoning Policies for PEV Readiness

10.1 Introduction

Zoning codes regulate what types of land uses and densities are appropriate for different neighborhoods. As such, zoning codes are the most powerful tool cities have to incentivize certain types of development, including placement of charging stations. The goal of zoning for PEVs should be to ensure that charging is an allowed land use in as many types of zoning districts as possible, either as an accessory or principal use as appropriate. Planners should also consider reducing parking requirements in exchange for installation of charging units or allowing PEV charging spaces to count towards minimum parking requirements.

Another reason to consider zoning for PEVs is to make zoning ordinances compatible with PEV-ready building codes. Many cities have begun to adopt building codes that require PEV-ready wiring in new construction, but their zoning ordinances may not even list PEV charging as a use.

What follows is a discussion of the two main zoning levers for PEV charging: designation as a permitted land use, and incentives for developers to install charging equipment and/or designated PEV parking spaces. Designating PEV charging as a principal or accessory land use will help ensure that different charging levels carry the appropriate type of planning review for the zones in which they are located. Developers can be encouraged to incorporate PEV charging units by allowing the spaces to count towards minimum parking requirements, by reducing the parking requirements, or by allowing spaces for neighborhood electric vehicles (NEVs) to count towards parking requirements.

Zoning generally determines the number of parking spaces required for a certain land use, though some cities have used building codes to specify the number of spaces that need to have PEV-ready wiring in new construction. Further guidance on building codes is provided in Chapter 11.

10.2 Charging as an allowed use

PEV charging should be widely allowed in different zoning districts because it is compatible and complementary to many land uses. With the exception of stand-alone fast charging, PEV fueling does not fundamentally alter the purpose or interfere with the use of a land parcel. PEV charging complements existing land uses in that it facilitates transportation modes that were previously not accommodated by those land uses.

If a property is to be used in a way that is not specified as an allowed use in a certain zone, some cities may require the property owner to apply for a use permit. Uses are generally classified as a principal use or an accessory use. Principal uses describe the basic purpose of a site—for example, a bookstore. Accessory uses, such as a small café within a bookstore, are subordinate to the primary use of a site. The designation as an accessory use is intended to circumvent the need for additional parking requirements and review. Many cities will require a simple planning clearance for an accessory use to verify that it is indeed not the dominant use of the site.

Some cities may not see a need to specify PEV charging as either a principal or accessory use in any of their zoning districts. They may view Level 1 and Level 2 charging as an accessory use by default and only require a plan check and electrical permit. Other cities may wish to clarify that charging is an accessory or outright permitted use because unless stated otherwise, planners may interpret this to mean that some sort of use permit is required. Different use permits are subject to different fees and levels of review, which may require the individual planner to make a determination. Eliminating a requirement for a separate planning permit for PEV charging in addition to a building and/or electrical permit can reduce the time and cost of installing chargers. Alternatively, listing PEV charging as a principal or accessory use will guide planners in how to process planning permits if they are required.

Cities should examine their land use mix and determine which zoning districts, if any, to prioritize for explicit permission in the zoning ordinance for different types of charging. Cities may want to do this as part of a general land use or zoning ordinance update. For example, *Ready, Set, Charge, California!* suggests Level 1, Level 2 and DC Fast charging be considered an outright permitted use in commercial, industrial and institutional zoning districts and as accessory uses in low-density residential districts (Ready, Set, Charge, California! A Guide to EV-Ready Communities 2011). Some cities may only need to clarify charging as an accessory use in non-residential settings to ensure that the principal use of the site is not changed and that traffic flows are not affected by drivers coming to the site solely for PEV charging. Please see Chapter 3 for a discussion of the power requirements for different charging levels and Chapter 8 for a discussion of the lengths of time that cars are typically parked and able to charge at various location types. These factors will help cities and utilities tailor permitted levels of charging to zones with sufficient electrical capacity.

Local jurisdictions should also tailor any conditions attached to charging as a permitted use to the type of construction or level of access that will accompany charging. For example, it may not be necessary to require signage as a condition of charging being allowed as a permitted use if the charging is intended for single-family use.

Zoning ordinances from the City of San Jacinto and the City of Lancaster are excerpted below. San Jacinto's proposed ordinance specifies which charge levels are allowed in which zones, while Lancaster's does not. Lancaster's industrial and recreational park zones are governed by the same language used for commercial zones in specifying PEV charging as an accessory use.

10.2.1 San Jacinto (proposed)

1. Level 1 and 2 electric vehicle charging stations are an allowed use in all zones.

2. Level 3 electric vehicle charging stations are an allowed use in Commercial and Office Zones, Industrial Zones and Special Purpose Zones, as defined in Article 2 (Zones, Allowable Land Uses, and Zone-Specific Standards). (San Jacinto Development Code 2012)

10.2.2 Lancaster

An electric vehicle charging station (EVCS) shall be allowed within any legal single-family or multiple-family residential garage or carport subject to all applicable city code requirements in addition to the following:

> *a. The EVCS shall be protected as necessary to prevent damage by automobiles; and*
>
> *b. The EVCS shall be designed to:*
>
> *Be safe for use during inclement weather, and*
>
> *Be tamper-resistant to prevent injury particularly to children, and*
>
> *Be resistant to potential damage by vandalism,*
>
> *Be equipped with a mechanism to prevent the theft of electricity by an unauthorized user;*
>
> *c. The EVCS shall have complete instructions and appropriate warnings posted in an unobstructed location next to each EVCS.*

An electric vehicle charging station (EVCS) shall be permitted as an accessory use within any existing legal single-family or multiple-family residential garage or carport, or within any existing legal commercial parking space in a parking lot or in a parking garage, subject to all applicable city code requirements and the following:

1. Electric vehicle charging stations (EVCS) for public use shall be subject to the following requirements:

> *a. The EVCSs shall be located in a manner which will be easily seen by the public for*

informational and security purposes and shall be illuminated during evening business hours; and

b. Be located in desirable and convenient parking locations which will serve as an incentive for the use of electric vehicles; and

c. The EVCS pedestals shall be protected as necessary to prevent damage by automobiles; and

d. The EVCS pedestals shall be designed to minimize potential damage by vandalism and to be safe for use in inclement weather; and

e. Complete instructions and appropriate warnings concerning the use of the EVCS shall be posted on a sign in a prominent location on each station for use by the operator; and

f. One standard non-illuminated sign, not to exceed 4 square feet in area and 10 feet in height, may be posted for the purpose of identifying the location of each cluster of EVCSs; and

g. The EVCS may be on a timer that limits the use of the station to the normal business hours of the use(s) which it serves to preclude unauthorized use after business hours.

2. Electric vehicle charging stations for private use shall:

a. Be located in a manner which will not allow public access to the charging station; and

b. Comply with subsections G.1.c., d. and e. of this section. (Lancaster Municipal Code)

10.3 Development incentives

PEV charging provides many public benefits, including reductions in greenhouse gas emissions, improvements in neighborhood air quality, and reductions in noise pollution. Planners should consider these benefits when negotiating with developers who want to build more densely on a site than the zoning code would normally allow. Cities often use density bonuses to obtain public benefits such as contributions to parks, open space, or affordable housing. Cities may consider including PEV-ready wiring or charging units as an option for obtaining a density bonus.

Zoning codes specify the minimum number of parking spaces that must be provided for different land uses. Complying with minimum parking requirements can be a challenge for business owners and developers. In a commercial building with many different businesses and shared parking, a business owner applying for a development or use permit may have to demonstrate that there are a sufficient number of existing spaces to serve his or her customers. For developers, the construction of new parking spaces can add significant costs and/or reduce the amount of leasable or sellable floor area.

Business owners and developers may be encouraged to install PEV charging units if they count towards minimum parking requirements. An example of proposed code language from the City of San Jacinto is excerpted below:

10.3.1 San Jacinto (proposed)

The parking spaces associated with the electric vehicle charging stations located within parking lots or garages may be included in meeting the calculation of the minimum parking spaces required in compliance with Chapter 17.330 (Off-Street Parking and Loading Standards).

Small-battery, low-speed neighborhood electric vehicles, or NEVs, are being explored as alternatives to mass transit in suburban areas. Similar in appearance to golf carts, these vehicles have rechargeable batteries and are intended to reduce emissions from short local trips. Zoning codes can encourage NEV use by allowing smaller-than-standard parking spaces to count toward minimum parking requirements. The following ordinance from the City of San Clemente applies to NEVs in its North Beach Parking Overlay district.

10.3.2 San Clemente

Parking for Neighborhood Electric Vehicles (NEV), as defined in Vehicle Code Section 385.5, may be applied toward the total required parking at a maximum of 4% and not more than 8 spaces of the required number of parking spaces for a project through the approval of a Site Plan Permit. Additional NEV spaces can be provided however those spaces will not apply to the required parking. NEV spaces shall be located in areas of parking lots that cannot accommodate a standard parking space, unless the required number of standard spaces has been satisfied. (San Clemente Municipal Code)

Local jurisdictions can also allow a *reduced* number of required parking spaces in exchange for the installation of charging units. Business and property owners, developers, and local planners will have to consider the impact of reduced parking on tenants, customers, and the surrounding neighborhood. In jurisdictions that also require PEV-ready wiring for a minimum number of parking spaces in new construction, allowing the site host to install charging units in exchange for providing fewer parking spaces may reduce the overall number of PEV-ready spaces. While this may further encourage the installation of charging units in the short term, it may reduce the number of PEV-ready spaces in the longer term.

Ready, Set, Charge, California! suggests reducing required parking in downtown cores or job centers “where new housing developments could rely on both car-sharing programs and shared parking agreements with existing public or private parking facility owners for nighttime and weekend use.” PEV car-share parking could allow the developer or property owner to receive parking requirement reductions in exchange for providing charging on site (Ready, Set, Charge, California! A Guide to EV-Ready Communities 2011).

Chapter 11 provides guidance on requiring a minimum percentage of parking spaces in new construction to be made PEV-ready with appropriate conduit and/or wiring. Requiring existing parking areas to be retrofitted with PEV wiring and/or charging units could be costly. As noted in Ready, Set, Charge, California!, the State of Hawaii requires such retrofitting for large existing parking facilities. However, the state allows owners of multiple parking lots within a jurisdiction to meet the total number of required PEV spaces across their parking lots, even if one or more of the properties has fewer such spaces than would normally be required. Hawaii's statute is excerpted below.

10.3.3 Hawaii

All public, private, and government parking facilities that are available for use by the general public and have at least one hundred parking spaces shall designate one per cent of parking spaces exclusively for electric vehicles by December 31, 2011, provided that at least one of the parking spaces designated for electric vehicles is located near the building entrance and is equipped with an electric vehicle charging unit. Spaces shall be designated, clearly marked, and the exclusive designation enforced. The electric vehicle charging units shall meet recognized standards, including SAE J1772 of the Society of Automotive Engineers. Owners of multiple parking lots within the State may designate and electrify fewer parking spaces than required in one or more of their owned properties as long as the scheduled requirement is met for the total number of aggregate spaces on all of their owned properties.

When the number of registered electric vehicles in the State reaches five thousand, the spaces designated for electric vehicles shall increase to two per cent of parking spaces. The number of spaces designated for electric vehicles shall continue to increase by one per cent for each additional five thousand electric vehicles registered in the State until the percentage reaches ten per cent of parking spaces.

For the purposes of this section, "electric vehicle" means an electric vehicle or neighborhood electric vehicle with an electric vehicle license plate. (Hawaii Revised Statutes)

10.4 Recommendations

The following recommendations are intended to facilitate PEV charging through zoning and parking policies. These recommendations are intended to be adapted to reflect local land use priorities for PEV charging and anticipated PEV demand, which may vary greatly among cities. Additional resources on building codes and parking policies are provided in Chapter 11 and Chapter 13 of this document. Local jurisdictions should consult the Southern California PEV Atlas that accompanies this document for local PEV demand projections.

1. Cities should allow charging as an accessory use that does not require more than a simple planning clearance, as long as charging is not the primary purpose of the site.

2. Installation of chargers should be allowed as an outright permitted or accessory use as appropriate in zones that present the most significant local opportunities for PEV charging.

3. Charging spaces designated for PEVs or NEVs should be able to meet the minimum parking requirements for business owners and developers. Planners should consider reducing parking requirements in exchange for the site host providing PEV charging spaces.
4. Cities should require a minimum percentage of parking spaces in new construction be PEV-ready based on current and anticipated PEV demand.
5. Zoning ordinances that allow charging as a permitted or accessory use should tailor any additional conditions of installation to the type of building specified in the ordinance. For example, it may not be necessary to require signage and protection against damage to the charging unit as a condition of permitting charging in single-family zones.

10.5 Additional resources

The Bay Area Climate Collaborative's *Ready, Set, Charge, California! A Guide to EV-Ready Communities* (2011) provides sample zoning code and minimum parking requirement provisions for PEV charging.

http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf

- Section 2.2 (Community-wide programs, policies and incentives)
- Section 3.2.1 (Sample zoning code provisions)

10.6 References

Hawaii Revised Statutes. Part IV, Chapter 291-71. http://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0291/HRS_0291-0071.htm.

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11 Building Codes for PEV Readiness

11.1 Introduction

Cities can use building codes to advance PEV adoption in a way that ensures safe, cost-effective installation of charging equipment. By updating building codes to require PEV-ready wiring in new construction, cities can help meet future demand for charging and reduce or eliminate the costs associated with later retrofitting. In addition to these benefits, PEV building readiness codes advance equity by ensuring access to charging for multi-family building residents and the disabled. Building codes related to PEVs can also provide guidance on a number of issues including (California Plug-in Electric Vehicle Collaborative 2012; Advanced Energy 2011):

- The number of circuits needed and service panel requirements
- Placement of electric meters
- Sourcing of electricity for on-street and lot parking
- The impact of charging infrastructure on building electrical loads and local electrical distribution
- Allocation and sizing of parking spaces to accommodate charging infrastructure
- Compliance with the Americans with Disabilities Act (ADA)

About two-thirds of local government agencies and utilities surveyed by the California Plug-in Electric Vehicle Collaborative have not adopted building code requirements for EVSE installations (California Plug-in Electric Vehicle Collaborative 2012). Of those that do have building code requirements for EVSE installations, 92% do not have unique code requirements for new construction in addition to requirements for pre-existing buildings.[33]

Codes provide construction standards according to building uses. These uses can be classified as residential or non-residential. Residential buildings are often classified into two categories: one- or two-family homes and townhouses, and multi-family (also called multi-unit) dwellings. Non-

33 California Plug-in Electric Vehicle Readiness Survey results reported as of September 4, 2012. Response rates to these questions ranged from 29–37%.

residential buildings can include business, industrial, institutional and mercantile (retail) uses. The types of building codes a city will need to prepare for PEV infrastructure will depend in part on the kinds of land uses and occupancies that are most commonly found in that city.

A building code's applicability generally falls along a continuum of scope and cost-effectiveness. The continuum ranges from new construction (the narrowest scope and the most cost-effective), to remodels involving a certain percentage of a structure, and finally to retrofits (the widest scope and potentially most costly, because it applies to existing buildings as well as new construction).

Planning for PEVs is an inherently uncertain exercise. The number of PEVs on the road in the future, their battery sizes and charging requirements, and the timeframe in which they will become more ubiquitous is difficult to predict with certainty. Vehicle and charging technology will evolve more quickly than the average lifespan of a building. What follows is a discussion of California's voluntary building code governing electric vehicle charging infrastructure and some examples of how cities have tailored this standard or strengthened it at the local level.

11.2 CALGreen

California's green building code provides guidance on *voluntary* measures municipalities can adopt if they want to require PEV charging readiness in newly-constructed buildings. A limitation of CALGreen is that its residential measures only apply to low-rise residential buildings of three stories or fewer. The California Department of Housing and Community Development has proposed extending CALGreen's provisions to cover high-rise as well as low-rise residential construction beginning in 2014. (California Department of Housing and Community Development 2012). Cities can adopt the measures in CALGreen or adapt them to reflect local priorities. For example, the City of Santa Monica has adopted the measures in CALGreen and has redefined "low-rise residential" to mean buildings of six stories or less (Santa Monica Municipal Code 2010).

For one- and two-family dwellings, the code calls for **installation of a raceway**[34] to accommodate a dedicated branch circuit. For multifamily residential dwellings of three stories or less, CALGreen also calls for a **minimum number of parking spaces** to be capable of supporting PEV charging. The CALGreen code language is excerpted below (California Building Standards Commission 2012 Supplement):

- ***A4.106.6.1 One-and two-family dwellings.*** *Install a listed raceway to accommodate a dedicated branch circuit. The raceway shall not be less than trade size 1. The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or*

34 The term "raceway" is sometimes used interchangeably with "conduit." A raceway is a channel, often a rectangular wall-mounted tubular casing, designed expressly for holding wires or cables and protecting them from damage.(Davis 1998-2012)

enclosure. Raceways are required to be continuous at enclosed or concealed areas and spaces. A raceway may terminate in an attic or other approved location when it can be demonstrated that the area is accessible and no removal of materials is necessary to complete the final installation.

- ***A4.106.6.2 Multifamily dwellings.*** *At least 3 percent of the total parking spaces, but not less than one, shall be capable of supporting future electric vehicle supply equipment (EVSE).*[35]
    - o ***A4.106.6.2.1 Single charging space required.*** *When only a single charging space is required, install a listed raceway capable of accommodating a dedicated branch circuit. The raceway shall not be less than trade size 1. The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or enclosure.*
    - o ***A4.106.6.2.2 Multiple charging spaces required.*** *When multiple charging spaces are required, plans shall include the location(s) and type of the EVSE, raceway method(s), wiring schematics and electrical calculations to verify that the electrical system has sufficient capacity to simultaneously charge all the electrical vehicles at all designated EV charging spaces at their full rated amperage. Plan design shall be based upon Level 2*[36] *EVSE at its maximum operating ampacity. Only underground raceways and related underground equipment are required to be installed at the time of construction.*

CALGreen also offers municipalities a voluntary standard for PEV charging at **commercial**, **retail** and other **non-residential** locations, as excerpted here (California Building Standards Commission 2012 Supplement):

- ***A5.106.5.3 Electric vehicle charging.*** *Provide facilities meeting Section 406.7 (Electric Vehicle) of the California Building Code and as follows:*
    - o ***A5.106.5.3.1 Electric vehicle supply wiring.*** *For each space required in Table A5.106.5.3.1, provide panel capacity and dedicated conduit for one 208/240V 40 amp circuit terminating within 5 feet of the midline of each parking space.*

35 Electric vehicle supply equipment may refer to charging stations, cords, or building wiring intended to power electric vehicles. The California Electrical Code defines EVSE as "conductors…and the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle."

36 Charging levels refer to the voltage provided by charging unit. The higher the voltage, the more quickly a battery can be powered. Level 1 charging uses 120 volts to provide at least 12 amperes of current and 1.44-1.92 kilowatts of power. Level 1 charging is available through a standard household outlet. Level 2 charging uses 240 volts (or 208 volts in commercial locations) to provide up to 80 amperes of current and 19.2 kilowatts of power for battery use (U.S. Department of Energy 2012). Typical amperages for Level 2 current range from 15-40A. See Chapter 3 for a more detailed description of charging levels.

Table A5.106.5.3.1:

TOTAL NUMBER OF PARKING SPACES*	NUMBER OF REQUIRED SPACES
1–50	1
51–200	2
201 and over	4

**In a parking garage, the total number of parking spaces is for each individual floor or level.*

11.3 Local ordinances in the South Coast region

Once adopted by cities, the CALGreen voluntary measures become requirements for new construction. Some cities in the Southern California Association of Governments (SCAG) region have adopted or adapted the voluntary EVSE measures presented in CALGreen. These ordinances require and prescribe standards for 1) panel capacity, outlets, conduits, meters and/or charging units, each of which represent progressively higher levels of PEV readiness; and 2) the number of parking spaces to be served by charging infrastructure. The higher the upfront commitment by a city to facilitating this type of charging access, the fewer costly retrofits[37] will be required in the long run, and the more flexible PEV drivers can be in their charging habits.[38]

11.3.1 Panel capacity and outlets

The most basic level of PEV readiness relates to electric service panel capacity. The ability of electrical panels to handle PEV charging load depends on the age and size of the building as well as what other load demands are placed on the panels. Existing 120-volt outlets in a parking area may be sufficient to provide charging, particularly for smaller-battery PHEVs, without the need for additional panel service. Many building codes require new buildings to provide 240-volt outlets, but cities should consider allowing 120-volt outlets, or a mix of 120- and 240-volt outlets, to serve a range of battery sizes and commutes. In particular, if cities are considering requiring PEV-ready retrofits, 120-volt outlets could be a more cost-effective

37 Published cost estimates for retrofits vary widely depending on site type and complexity of installation. Estimates for Level 2 single-family range from $1,500 - $4,000 (Ready, Set, Charge, California! A Guide to EV-Ready Communities 2011) while Level 2 in multi-unit dwellings and commercial settings can range from $3,600 - $11,000 (Peterson 2011).

38 Cities may also consider expanding the size of future electrical rooms to accommodate conduits for PEV charging. The City of Vancouver, Canada has adopted the following code language: "The electrical room in a multi-family building, or in the multi-family component of a mixed-use building that in either case includes three or more dwelling units, must include sufficient space for the future installation of electrical equipment necessary to provide a receptacle to accommodate use by electric charging equipment for 100% of the parking stalls that are for use by owners or occupiers of the building or of the residential component of the building."(Ready, Set, Charge, California! A Guide to EV-Ready Communities 2011)

option. Incorporating more opportunities for 120-volt charging would also reduce the need for special 240-volt charging units, since 120-volt outlets can be used with the cords that currently come with PEVs. The lower voltage would allow for more outlets to be installed using the same amount of power (Balmin, Bonett, and Kirkeby 2012).

Alternatively, property owners can evaluate whether lower-cost charging can be provided through multiplex or multi-arm stations that can charge more than one car simultaneously, or in a programmed queue. While such solutions may present a higher upfront cost, the unit cost per driver is much lower.

The need to upgrade electrical panels in existing buildings may be reduced by the use of energy management software, which can balance the additional load brought by PEV charging. The National Electrical Code required electrical capacity for charging equipment to reflect the full load charging capability of the equipment, plus an additional 25% capacity buffer, in order to prevent circuit overload (National Fire Protection Association 2011). However, a tentative interim amendment to the code allows the maximum electric vehicle supply equipment load on a service panel or feeder to reflect the maximum load permitted by an automatic load management system (National Fire Protection Association 2011). Cities should consider updating local electrical codes to allow this potentially lower-cost alternative to adding capacity.

New construction provides an opportunity to examine the building's total projected load from PEVs and other sources and to offset this load with energy efficiency upgrades. Panel capacity can also be made available for PEVs by installing energy-efficient lighting and HVAC systems. A qualified electrical contractor should be retained to assess sites and calculate electrical loads, particularly for more complex installations that serve multiple vehicles in MUDs or commercial buildings. (Biddick et al. 2012; California Plug-in Electric Vehicle Collaborative 2012; Ready, Set, Charge, California! A Guide to EV-Ready Communities 2011)

11.3.2 Conduits and meters

The laying of conduit capable of carrying future wires or cables from the electrical room to the charging unit represents the next step in PEV building readiness. Codes requiring 120-volt outlets into which PEVs can plug in directly, or 240-volt outlets to connect Level 2 chargers to wiring and conduits, will bring buildings even closer to PEV readiness. Providing space in the electrical room for additional future meters will help multi-unit dwellers can take advantage of special utility rates for PEV charging. However, requiring additional meters at single-family homes can have unintended consequences, as they may enable conversion of properties to unapproved multi-family rentals or home businesses. Utilities are exploring the use of software that allows sub-metering of PEV charging on one meter.

11.3.3 Charging units

The City of Lancaster's code is notable in that it requires not only PEV-ready wiring in new construction, but even requires the installation of some ready-to-use charge stations. Cities may wish to consider whether to require ready-to-use charge stations, when to require them, or how many to require. In doing so, they should strive to minimize cost and ensure that stations are not underused. They should consider evolving technology as well as current demand (see the Southern California PEV Atlas that accompanies this document for COG-level PEV projections).

Excerpted below are local building codes from the SCAG region that are mostly related to PEV readiness in wiring and parking space allocation. Los Angeles' code requires PEV-ready wiring for new single- and multifamily buildings and charging capacity for at least 5% of parking spaces (for multifamily buildings). Rolling Hills Estates' EVSE requirement nominally applies to all new residential units, but in practice was intended for single-family homes and townhouses with attached garages. The city of Temecula's ordinance is also intended for PEV conduits in single-family homes. Other considerations that may relate to building codes, such as PEV parking space design, signage, and ADA compliance, are reviewed in other chapters of this document.

11.3.4 Beverly Hills

Provide facilities meeting section 406.7 (Electric Vehicle) of the California building code and as follows:

One 120 VAC 20 amp and one 208/240V 40 amp, grounded AC outlets or panel capacity for one 120 VAC 20 amp and one 208/240V 40 amp, grounded AC outlet and conduit installed for future outlets for each dwelling unit. Electric vehicle supply shall be provided and may be installed in a stall provided to comply with the code minimum parking requirements. Dwelling unit shall be defined by the California building code.

Exception: Apartment buildings and apartment units. (Beverly Hills Municipal Code 2011)

11.3.5 Lancaster

New residential development shall provide for EVCS in the manner prescribed as follows:

1. *Garages serving each new single-family residence and each unit of a duplex shall be constructed with a gang box[39] (4 inches by 4 inches) connected to a conduit linking the garage to the electrical service, in a manner approved by the building and safety official, to allow for the future installation of electric vehicle supply equipment to provide an EVCS for use by the resident.*
2. *In new multiple-family projects of 10 dwelling units or less, 20% of the total parking spaces required (all of the 20% shall be located within the required covered parking) shall be provided with a gang box (4 inches by 4 inches) connected to a conduit linking the covered parking spaces or garages with the electrical service, in a manner approved by the building and safety official, to allow for the future installation of electric vehicle supply equipment to provide EVCSs at such time as it is needed for use by residents.*

39 The term "gang box" also refers to an electrical box, which "enclose(s) wire connections for applications such as a light switch, electrical outlet or light fixture" (The Home Depot).

EVCSs shall be provided in disabled person parking spaces in accordance with state requirements.

3. *In new multiple-family projects of more than 10 dwelling units, 10% of the total parking spaces required (all of the 10% shall be located within the required covered parking) shall be provided with a gang box (4 inches by 4 inches) connected to a conduit linking the covered parking spaces or garages with the electrical service, in a manner approved by the building and safety official. Of the total gang boxes provided, 50% shall have the necessary electric vehicle supply equipment installed to provide active EVCSs ready for use by residents. The remainder shall be installed at such time as they are needed for use by residents. EVCSs shall be provided in disabled person parking spaces in accordance with state requirements. (Lancaster Municipal Code)*

New commercial development shall provide for electric vehicle charging stations in the manner prescribed as follows:

a) New residential uses shall provide EVCSs in accordance with Section 17.08.150T.

b) New commercial, industrial, and other uses with the building or land area, capacity, or numbers of employees listed herein shall provide the electrical service capacity necessary and all conduits and related equipment necessary to ultimately serve 2% of the total parking spaces with EVCSs in a manner approved by the building and safety official. Of these parking spaces, 1/2 shall initially be provided with the electric vehicle supply equipment necessary to function as on-line EVCSs upon completion of the project. The remainder shall be installed at such time as they are needed for use by customers, employees or other users. EVCSs shall be provided in disabled person parking spaces in accordance with state requirements.

1. *Construction of a hospital of 500 or more beds, or expansion of a hospital of that size by 20% or more.*
2. *Construction of a post-secondary school (college), public or private, for 3,000 or more students, or expansion of an existing facility having a capacity of 3,000 or more students by an addition of at least 20%.*
3. *Hotels or motels with 500 or more rooms.*
4. *Industrial, manufacturing, or processing plants or industrial parks that employ more than 1,000 persons, occupy more than 40 acres of land, or contain more than 650,000 square feet of gross floor area.*
5. *Office buildings or office parks that employ more than 1,000 persons or contain more than 250,000 square feet of gross floor area.*
6. *Shopping centers or trade centers that employ 1,000 or more persons or contain 500,000 square feet of gross floor area.*

7. *Sports, entertainment, or recreation facilities that accommodate at least 4,000 persons per performance or that contain 1,500 or more fixed seats.*

8. *Transit projects (including but not limited to transit stations and park and ride lots). (Lancaster Municipal Code)*

11.3.6 City of Los Angeles

1. For one- or two- family dwellings and townhouses, provide a minimum of:

a) One 208/240 V 40 amp, grounded AC outlet, for each dwelling unit or

b) Panel capacity and conduit for the future installation of a 208/240 V 40 amp, grounded AC outlet, for each dwelling unit.

The electrical outlet or conduit termination shall be located adjacent to the parking area.

2. For other residential occupancies where there is a common parking area, provide one of the following:

a) A minimum number of 208/240 V 40 amp, grounded AC outlets equal to 5 percent of the total number of parking spaces. The outlets shall be located within the parking area or

b) Panel capacity and conduit for future installation of electrical outlets. The panel capacity and conduit size shall be designed to accommodate the future installation, and allow the simultaneous charging, of a minimum number of 208/240 V 40 amp, grounded AC outlets, that is equal to 5 percent of the total number of parking spaces. The conduit shall terminate within the parking area; or

c) Additional service capacity, space for future meters, and conduit for future installation of electrical outlets. The service capacity and conduit size shall be designed to accommodate the future installation, and allow the simultaneous charging, of a minimum number of 208/240 V 40 amp, grounded AC outlets, that is equal to 5 percent of the total number of parking spaces. The conduit shall terminate within the parking area.

When the application of the 5 percent results in a fractional space, round up to the next whole number. (Los Angeles Municipal Code 2010)

11.3.7 Rolling Hills Estates

Any new residential construction, including an addition to a residential structure of greater than fifty percent of the existing floor area, including the primary garage, and/or any demolition of greater than fifty percent of the lineal walls of a residential structure within a twelve-month period, shall require the installation of a two hundred twenty volt dedicated electrical outlet in *the garage for the purposes of charging an electric vehicle. (Rolling Hills Estates Municipal Code)*

11.3.8 Temecula

Circuits for electric vehicle charging stations shall meet all the requirements of California Electrical Code Article 625[40]*. Residential garages shall have a minimum three quarter (3/4) inch metal flex conduit ran from meter box to the garage fire wall and terminated in a metal box at forty-two (42) inches above finished floor for future electric vehicle charging station. (Temecula Municipal Code)*

11.3.9 Torrance (proposed)

- *That all new residential units shall be equipped with the required electrical conduit to accommodate at least one Level 2 electric vehicle charging capability within designated parking areas for said unit(s). [Community Development Department staff requested that the Planning Commission also consider the CALGreen 3% requirement to avoid new findings, public noticing and additional local amendment proceedings].*

Residential parking development standards:

- *Charging units located with residentially developed properties must either be provided within an enclosed structure, affixed to a permitted structure or located adjacent to a required parking space, provided exterior charging units do not encroach into any required setback by more than 12 inches.*

Commercial industrial parking regulations:

- *an EV parking space requirement for new construction or properties significantly remodeled…and which provide 50 or more parking spaces, shall be required to provide and maintain at least 2% of available parking spaces as electric vehicle parking spaces equipped with either Level 2 or [higher] charging infrastructure.*
- *Required signage specifications for electric vehicle parking spaces, to clearly mark spaces as electric vehicle parking, contact information for charging station (Community Development Department Recommendations to the Torrance Planning Commission, June 6, 2012, Agenda Item No. 15A, Case No. LUS12-00001).*

11.4 Conclusion

The building codes we present in this chapter reflect early attempts to support PEV readiness. The steps taken by these municipalities to date reflect the impracticality, due to cost recovery

40 For the model California Electrical Code language on PEV charging, see http://rrdocs.nfpa.org/rrserver/browser?title=/NFPACA/CaliforniaElectricalCode2010

and implementation issues, of mandating charging equipment installation in existing residential buildings. These codes will need to evolve over time and adapt to market conditions.

11.5 Recommendations

The following recommendations are intended to facilitate PEV charging through building codes. These recommendations should be adapted to reflect local land use opportunities for PEV charging and anticipated PEV demand, which may vary greatly among cities. Guidance on assessing local land use opportunities is provided in Chapter 4, Chapter 5, Chapter 6, Chapter 7, and Chapter 8. Additional resources on zoning and parking policies are provided in Chapter 10 and Chapter 13 of this document. Local jurisdictions should consult the Southern California PEV Atlas that accompanies this document for local PEV demand projections and maps of employment and commercial density.

1. Consider expanding the range of new buildings to which PEV readiness codes apply beyond CalGreen's low-rise designation.
2. Allow Level 1 or Level 2 charging capability to satisfy PEV readiness requirements in building codes.
3. Require the laying of conduit capable of carrying future wires or cables from the electrical room to the charging unit in new construction.
4. Consider present PEV charging demand in determining whether to require installation of ready-to-use charging stations in addition to PEV-ready wiring for new single and multi-unit dwellings.
5. Require a certain minimum percentage of parking spaces in new construction be wired to be PEV-ready for single-family homes or MUDs, if these land uses present significant opportunities locally.
6. Require a certain minimum percentage of parking spaces in new construction be wired to be PEV-ready in commercial or industrial buildings, if these opportunities represent significant opportunities locally.
7. Consider updating electrical codes to allow the sizing of electrical service to charging systems to reflect the load permitted by an automated energy management system.

11.6 Additional resources

There are many resources available for planners seeking detailed implementation guidance for PEV-ready buildings, including:

Ready, Set, Charge, California! A Guide to EV-Ready Communities (2011). http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf

- Section 3.5 (Building and Electrical Code Guidance)
- Section 3.6 (Signage)
- Section 5.3 (Electrical Requirements)

Building codes specify whether pre-wiring or installation of electric vehicle supply equipment (EVSE) is required for new construction or existing buildings. If cities decide to require EVSE readiness, they should do so in compliance with the standards specified in the California Electrical Code.

California Electrical Code (2010). http://rrdocs.nfpa.org/rrserver/browser?title=/NFPACA/CaliforniaElectricalCode2010

- Article 625, Electric Vehicle Charging System
- Article 626, Electrified Truck Parking Spaces

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12 Permits and Inspections for PEV Readiness

12.1 Introduction

Local jurisdictions are instrumental in reducing the cost, time and uncertainty associated with installing PEV charging equipment. The first opportunity to encourage charging is through the permitting and inspection process, as these are typically the first steps initiated by drivers after buying a PEV and by site hosts that want to install charging systems. The permitting and inspection process allows local jurisdictions to make sure that charging systems are installed safely and that service panels can handle PEV loads. Utilities also want to ensure that the combined load from multiple high-voltage chargers in the same neighborhood will not overload transformers and disrupt service (City of Riverside Building and Safety Division 2012). By streamlining the permitting and inspection process, cities can facilitate access to a variety of refueling opportunities—particularly at home, where PEV buyers will need to be able to charge soon after buying the vehicle.

Cities vary greatly in their demand for PEV charging. Some cities have already made significant progress in streamlining the permitting and inspection process based on existing demand. The recommendations referenced in this document seek to minimize redundant or unnecessary levels of review and notification wherever possible, as each level of complexity increases the time and cost of charging installation (California Plug-in Electric Vehicle Collaborative 2012). A streamlined permitting and inspection process can reduce the overall cost of installation; clearly communicate procedures to city staff, electrical contractors, drivers and/or charge station hosts; and encourage compliance with safe permitting and installation procedures (California Plug-in Electric Vehicle Collaborative 2012). Jurisdictions should take advantage of the opportunity to troubleshoot the streamlining process while their caseloads of charging permits and inspections are still relatively low (Advanced Energy 2011).

Permit and inspection streamlining for PEVs requires a coordinated effort between multiple stakeholders. In addition to the driver or site owner, these include electricians who perform the charging installation; the local jurisdiction, which issues building permits and conducts inspections; and the local utility, which approves and installs dedicated meters that allow customers to take advantage of lower electricity rates for PEV charging (California Plug-in Electric Vehicle Collaborative 2012).

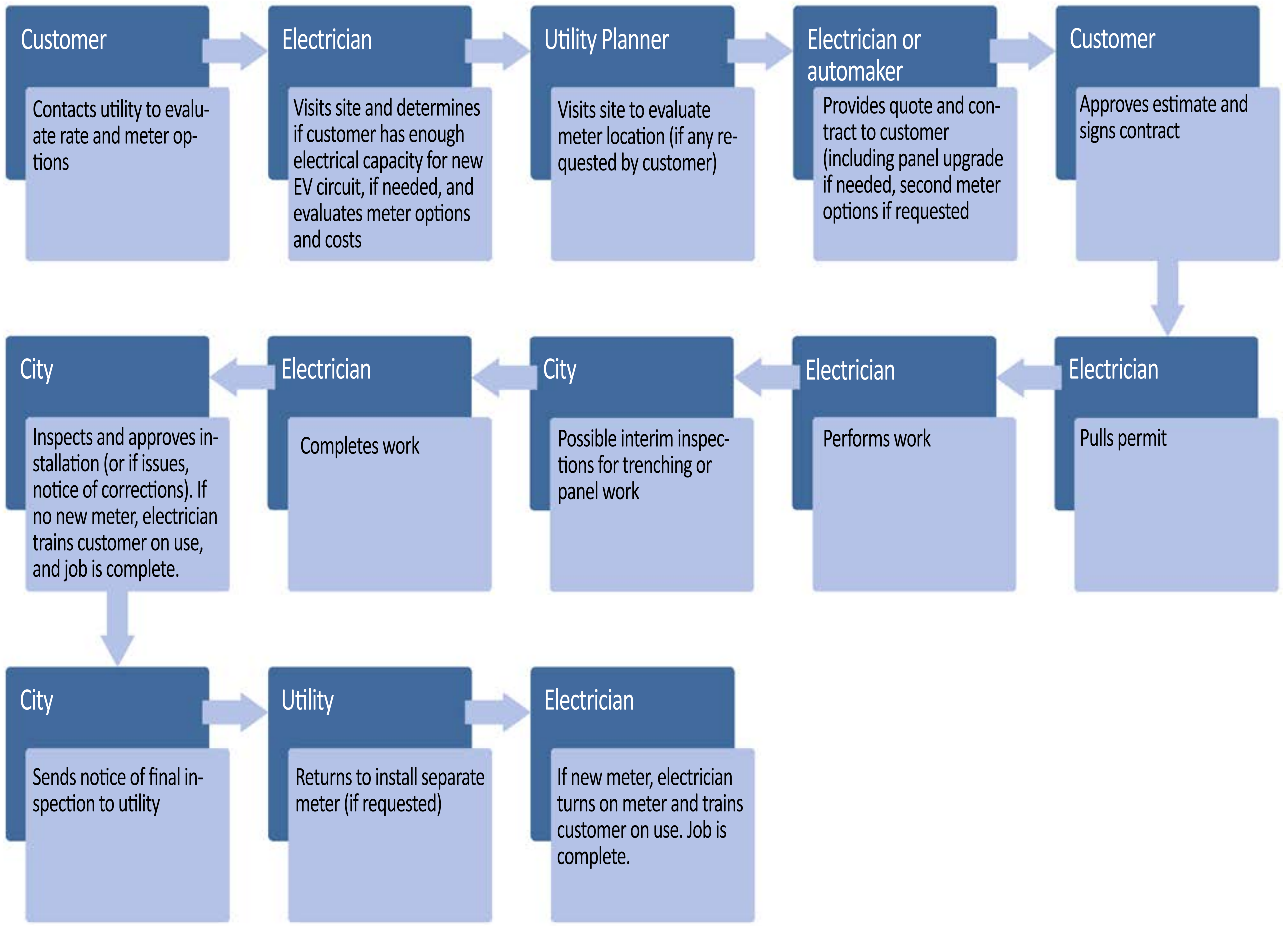
Permit and inspection streamlining should also include educating drivers about how to evaluate their charging needs and options before applying for charging equipment permits. Many PEV drivers with short commutes or small PEV batteries may be able to satisfy their charging needs with an existing Level 1 (120-volt) household outlet. If the driver wishes to use an existing 120-volt outlet, the only equipment he or she may want to install is a dedicated electricity meter. Alternatively, drivers may be able to avoid a panel upgrade for Level 2 charging by using an unused 240-volt dryer circuit in the garage, or by switching to a gas dryer to free up the 240-volt circuit for the charging system (Ready, Set, Charge, California! A Guide to EV-Ready Communities 2011). Informing PEV drivers in this way about their charging options can help avoid additional permit applications and inspection requests.

The following sections review the installation process and recommendations for streamlining permits and inspections. We then present examples from the SCAG region of streamlining efforts by local jurisdictions.

12.2 The Installation Process

As Figure 12.1 illustrates, the process for permitting, installing and inspecting a home charging unit can involve multiple trips by the electrician, inspector and utility. Each visit to the charging site and to the permit counter adds time and cost to the installation. Lengthy inspection windows and code compliance reviews, as well as confusion by inspectors over how to apply existing electrical codes, further delay completion of the installation. While the diagram below illustrates the process for residential installation, the same basic process would hold for owners of workplace or retail charge sites, although the possible trenching and other site work involved could add more time, complexity and cost.

Figure 12.1: Residential Charger Installation Process



Source: Adapted from Ready, Set, Charge, California! (2011)

12.3 Right-sizing permits and inspections

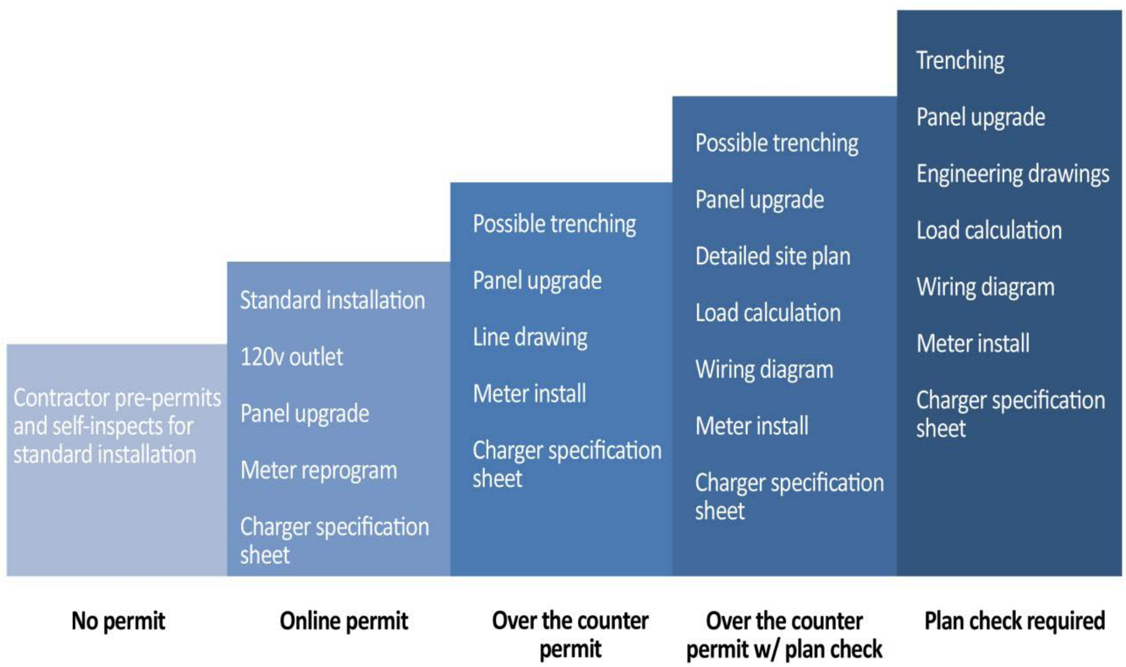
Meeting safety and reliability goals for PEV charging in a streamlined way requires local jurisdictions to consider the tradeoff between upfront documentation and a shorter inspection process versus minimal initial paperwork and a more extensive inspection (California Plug-in Electric Vehicle Collaborative 2012). The more documentation required at the outset, the quicker the inspection should be, since the inspector can compare what he or she sees with the documents and drawings already on file. However, there is substantial variability in documentation requirements, even within a jurisdiction. The California PEV Collaborative has identified a continuum of approaches employed by jurisdictions for residential charging:

1. **No permit** required if a circuit is installed for electric vehicle charging. This may depend on the type of circuit and the electrician's level of experience.

2. **Online permit**; jurisdictions define acceptable scope of work for online submittal.
3. **Over-the-counter permit**; issued immediately with limited scope of work submittal.
4. **Over-the-counter permit with plan check**; requires detailed site plan, wiring diagram, load calculation and/or other documentation.
5. **Permit with plan check**; same as above, but permit not issued immediately.

The California PEV Collaborative notes that documentation requirements ought to reflect the actual level of complexity involved in the installation. These conditions are generally predictable based on the charging environment (single-family, multi-unit dwelling, commercial, and fast charging). The tiers of complexity and the corresponding types of documentation that would be appropriate are illustrated by Figure 12.2 below.

Figure 12.2: Charger permitting scenarios and documentation requirements



Source: UCLA Luskin Center illustration based on California Plug-in Electric Vehicle Collaborative (2012)

12.4 Assessing opportunities to streamline

Some cities have already streamlined their permit and/or inspection procedures in line with local demand and experience with PEV charging. In assessing whether a jurisdiction could benefit from permit and/or inspection streamlining, it is helpful to look at the readiness measures surveyed by the California PEV Collaborative (California Plug-in Electric Vehicle

Collaborative 2012). The organization's statewide survey of local jurisdictions and utilities focused on possible areas for improvement, including:

- The number and type of permits needed for a charger installation (building only, electrical only, both building and electrical, and/or planning entitlement)
- Whether additional permits are required for trenching and compliance with the Americans with Disabilities Act
- The number of business days between permit request and issuance, and between inspection request and inspection
- Whether inspectors have a checklist for charging installations

These areas exemplify the key principles of reducing the time and cost of permitting and inspections. The following section largely reproduces and summarizes recommendations presented by the California PEV Collaborative's *Streamlining the Permitting and Inspection Process for Plug-in Electric Vehicle Home Charger Installations* (2012) and the Bay Area Climate Collaborative's *Ready, Set, Charge, California!* (2011).

12.5 Recommendations

These recommendations apply mainly to single-family residential permits, though every effort should be made to streamline the process for more complicated installations. Please see Chapter 6 for additional recommendations for multi-unit dwellings and Chapter 7 for recommendations for enabling workplace charging.

1. **Establish a unique charging equipment permit.** Even if it is equivalent to the permit for a 240-volt circuit installation, identifying a distinct permit for electric vehicle charging will communicate the requirements clearly. See examples from the City of Irvine http://www.cityofirvine.org/civica/filebank/blobdload.asp?BlobID=17661 and the Department of Energy http://www.afdc.energy.gov/pdfs/EV_charging_template.pdf.
2. **Make available online or over-the-counter permitting for most installations.** If feasible, applicants should also be able to check the status of their permits and schedule inspections online. Reducing the need for multiple visits to the permitting counter can reduce costs. A simple scope of work and equipment specification sheet should suffice for a standard charging installation. For example, the City of Beverly Hills offers online permitting for charging equipment in single-family residences: http://www.beverlyhills.org/business/constructionlanduse/singlefamilyresidences/electricvehiclecharging/
3. **Use template-based forms.** If a jurisdiction requires further documentation, standard forms will clearly present the requirements and necessary information to electricians, planners and inspectors. This can eliminate extra labor charges that may be incurred for follow-up visits to the permitting counter or charger site. A checklist should explain submittal requirements, which may include simple site plans and line drawings, an

equipment specification sheet and load calculation. The City of Riverside's residential EV charger guidelines are a good example of a template: http://www.riversideca.gov/building/pdf/handouts/EV-Charger-Guidelines.pdf

4. **Create a unique permit fee for charging units.** A flat fee that recovers local jurisdiction costs, rather than a fee based on a percentage of the installation cost, would be predictable and transparent for the site owner and electrician without penalizing owners of more costly installations. Alternatively, cities could create flat fees for different categories of installation complexity.

5. **Avoid requiring the electrician to be present during inspection.** Inspectors should be able to compare the documentation submitted with the work that has been performed without causing the site owner to incur further labor charges from the electrician.

6. **Train staff and other stakeholders in application of electrical codes, charging types, and the installation process.** Such training can help prevent permitting delays caused by inspectors' unfamiliarity with PEVs and charging infrastructure. A list of charging equipment certified by a Nationally Recognized Testing Laboratory such as Underwriters Laboratory or Edison Testing Laboratory could be provided to permit officials (Plug-in America). Participants in training sessions could include permitting staff, local electricians, and charging station providers. The California PEV Collaborative recommends local jurisdictions pool together resources for training sessions, for example those provided by the Electric Vehicle Infrastructure Training Program, coordinated by IBEW/NECA and the Department of Energy: http://www1.eere.energy.gov/cleancities/toolbox/pdfs/electric_vehicle_infrastructure_training.pdf. Training is also offered by CVTIP, a consortium of local colleges (College of the Desert, Long Beach City College, Rio Hondo College, and Cerritos College).

7. **Expedite PEV permitting.** Rather than requiring drivers and charging hosts to request permit expediting, cities should consider automatically expediting charger permit applications. In the City of Los Angeles, single-family residential charger installations (including equipment, service upgrade, receptacles and associated wiring) up to 400 amps are automatically expedited with no plan check required. http://ladbs.org/LADBSWeb/LADBS_Forms/InformationBulletins/IB-P-GI2011-003ExpressPermits.pdf

8. **Waive plan check requirements for installations that do not require rewiring or panel upgrades.** Local jurisdictions should articulate the types of installations for which a plan check waiver would be appropriate. Oregon's Building Codes Division even allows registered, licensed and screened electricians to self-certify minor electrical work as code-compliant. They do so by pre-purchasing minor installation "labels," or permits, of which 10% receive an inspection by the local building department. http://bcd.oregon.gov/programs/minorlabel/minor_label_programs.html#ml

9. **Shorten inspection windows and eliminate interim inspections.** Charger installations that do not require panel upgrades or trenching may not require interim inspections while installation is underway.

10. **Unify building and utility inspection.** Municipally-owned utilities are well-suited to coordinate a permitting and inspection process with their local building departments. Los Angeles' Department of Building and Safety has a dedicated charging inspection unit. http://www.afdc.energy.gov/case/1002

11. **Inform the local utility of Level 2 or DC fast charger installations as sites apply for permits.** This can provide an opportunity for utilities to inform residential or business customers of special rebates or rate structures that could apply to them.

12. **Eliminate or simplify the requirement for a separate planning entitlement for most PEV charging except for stand-alone fast charging stations.** The California PEV Collaborative survey found that planning entitlements were required by nearly 12% of jurisdictions for commercial and multi-family installations, 15% of them required planning entitlements for PEV charging in open parking lots, and nearly 18% required them for on-street parking (California Plug-in Electric Vehicle Collaborative 2012). The justification for a planning or use permit for charging should be re-evaluated, particularly for commercial and multi-family installations, since charging is likely not the primary use of the site.

12.6 References

Advanced Energy. 2011. Charging Station Installation Handbook for Electric Contractors and Inspectors. http://www.advancedenergy.org/transportation/evse/Charging%20Handbook.pdf.

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U.S. Department of Energy, Alternative Fuels Data Center. Los Angeles' Plug-in Vehicle Activities and Processes. Available from http://www.afdc.energy.gov/case/1002.

13 Parking Guidelines for PEV Readiness

13.1 Introduction

As with any vehicle, electric vehicles will be parked most of the time, whether or not they are plugged in or actively drawing power from a charging source. But unlike conventional vehicles, PEV fueling opportunities are possible almost everywhere within the parking environment: in residential garages, at curbsides, and in both workplace and retail parking lots.

Given the interest by local governments in policies that encourage PEV adoption, parking policies and guidelines will underlie every aspect of PEV planning. Such policies can assist with cost recovery, accessibility to disabled drivers, facilitating turnover at charging stations, and making stations more visible and easy to locate. In particular, clear and visible messaging on PEV directional and regulatory signs can raise the profile of PEVs and signal the advantages of these vehicles to the public (California Plug-in Electric Vehicle Collaborative 2012)

PEV parking policies and guidelines cover a wide range of issues, including:

- Location and number of charging spaces
- Design of PEV charging spaces in compliance with the Americans with Disabilities Act (ADA)
- Managing access to PEV parking
- Whether and how to price parking for PEVs
- Design of PEV signage in compliance with federal and state standards

There are currently no regional or state ordinances that standardize implementation of these PEV readiness measures. Local jurisdictions have leeway in determining signage on surface streets, providing for a certain number of PEV-ready parking spaces, and ensuring disabled access in new and existing construction. However, only 14% of agencies and utilities surveyed by the California Plug-in Electric Vehicle Collaborative have established specific zoning and parking ordinances for EVSE installations (California Plug-in Electric Vehicle Collaborative 2012). Consistent installation and signage standards across jurisdictions will lay the groundwork for future state or regional ordinances, facilitate PEV readiness by eliminating the burden of local regulation development, and clearly communicate to the public how PEV infrastructure should be used.

The California Plug-in Electric Vehicle Collaborative has incorporated PEV charging stall design and signage guidelines from a variety of sources into a set of uniform accessibility and signage standards (California Plug-in Electric Vehicle Collaborative 2012). The standards recommended by the California PEV Collaborative comply with the ADA and California Building Code and will be presented later in this chapter.

What follows are considerations that should be kept in mind when designing and regulating PEV parking and/or charging spaces.

13.2 Location and number of charging spaces

Before deciding whether and where to mandate PEV parking, cities should understand what their likely demand for PEVs will be and whether charging demand can best be satisfied by residential, workplace or publicly accessible charging. The Southern California Regional PEV Readiness Plan will include maps for the region's nearly 200 cities that will reveal projected demand for PEVs as well as multi-family, workplace, and retail charging opportunities.

The Bay Area Climate Collaborative's *Ready, Set, Charge, California!* identifies a number of parking area features that should be considered when placing charging units, including:

- The source of electricity and electrical panels/circuits
- Whether there is enough electrical power capacity beyond existing loads
- Whether to make lighting, shelter, signage and pedestrian improvements with charging units
- The location of existing disabled-accessible parking spaces and the location of accessible charging units
- Whether cables will infringe on walkways or high pedestrian-traffic areas

13.3 Designing ADA-compliant PEV charging spaces

Interpretation of disabled access requirements for electric vehicle charging stations is evolving. Local jurisdictions have some discretion in how they interpret PEV charging accessibility requirements. California's green building code (CALGreen) provides voluntary measures for cities to adopt if they wish to require a minimum number of charger-ready spaces in new construction. CALGreen does not stipulate how many of those spaces must be disabled-accessible.

Reflecting the historical separation of parking and fueling into different land uses, the California

Building Code provides one set of standards for disabled parking accessibility and another for disabled fueling accessibility, including for electricity (California Plug-in Electric Vehicle Collaborative 2012). Some cities may wish to encourage PEV adoption by providing preferential parking spaces for PEVs, with or without charging equipment. When **no** charging equipment is provided, parking spaces designated for PEVs need only follow the standards for disabled parking stall allocation and design as described in the Americans with Disabilities Act, California Building Code and local ordinances. When **both** parking and charging are provided, accessibility standards for both must be applied. However, the two standards may conflict, as PEV charging cords may impede the disabled-accessible path of travel to a building. In such cases, charging equipment should not be provided in a space intended for disabled-accessible PEV parking (California Plug-in Electric Vehicle Collaborative 2012).[41]

To date, the only official state guidance on accessibility requirements for PEV charging spaces is a set of interim guidelines developed by the Division of the State Architect in 1997. The California PEV Collaborative developed its own set of guidelines in 2012 that distinguish between curbside and offstreet parking, and public and restricted access. Yet another set of guidelines is available in *Ready, Set, Charge, California!* Section 3.5.2.

The Division of the State Architect and California PEV Collaborative guidelines are provided below. Local jurisdictions should consider which guidelines (if any) may be appropriate for them to codify, as doing so may provide additional clarity on enforcement matters.

13.3.1 Division of the State Architect Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations

This set of guidelines was developed in 1997 to govern accessibility to charging stations on state-funded properties. However, local jurisdictions can adopt similar guidelines for code enforcement. While these state guidelines identify PEV charging as a public accommodation, local jurisdictions must determine whether they want to apply the guidelines to multi-unit dwellings.

The goal of ensuring disabled access to PEV charging may be complicated by the cost considerations involved in retrofits or the need to give up adjoining spaces to provide an accessible path of travel. There is an exception in these guidelines for providing the accessible path of travel to restrooms and other facilities from the charger if the cost of doing so exceeds 20% of the cost of charger installation. Note that under these guidelines, charging spaces should be *accessible* to those with disabilities, but need not be reserved *exclusively* for use by persons with disabilities.

The following questions and answers are excerpted from the Division of the State Architect's Access Compliance Policies:

41 In other words, the PEV parking space could be situated as close as possible to the building entrance to accommodate a disabled PEV driver, but he or she may have to charge elsewhere. A potential solution involves overhead supports from which charging cords can hang above the vehicle (eTec 2010).

Are EV charging stations required to be accessible?

Yes. EV Charging Stations are required to be accessible because they offer a service to the general public. When EV charging is coupled with regular parking, the EV charging is considered the primary service.

What percentage of the EV charging stations must be made accessible?

The following table shall be used in determining the required number of accessible charging stations:

Number of charging stations provided at a site	Number of accessible charging stations required
1 - 25	1
50	2
51-75	3
76-100	4

What specifications must the accessible EV charging station comply with?

a. A 9 foot wide space by 18 feet deep space is required. An access aisle of 5 feet on the passenger side is required. One in every eight accessible charging stations, but not less than one, shall be van accessible with a 8 foot access aisle.

b. The accessible EV charging station and its access aisle need not be striped or provided with signage as required for an accessible parking space. An information sign must be posted which reads, "Parking for EV Charging Only; This Space Designed for Disabled Access; Use Last."

Must accessible EV charging stations be reserved exclusively for the use of persons with disabilities?

No. The primary function of these stations is the charging of Electric Vehicles. Parking is not intended to be the primary use of the charging station.

Are there any restrictions relative to the location of accessible EV charging stations?

For installations associated with new construction, the accessible charging station must be located in close proximity to a major facility, public way or a major path of travel on the site. Note: 200 feet is the maximum distance recommended. However, the charging stations need not be provided immediately adjacent to the major facilities since, again, the primary purpose of the stations is to provide the charging as a service, and parking is not intended to be the primary use of the stations.

For installations at existing sites, the accessible charging station need not be located in close proximity to other services at the site.

Is an accessible path of travel required from the accessible EV charging station to other services provided at the site?

Yes, for installations associated with new construction. As for other facilities on the site, an accessible path of travel is required between facilities.

For installation at an existing site, an accessible path of travel is required to the extent that the cost of providing such path does not exceed 20% of the cost of the EV equipment and installation of all EV charging stations at the site, when such valuation does not exceed the threshold amount referenced in Exception 1 of Section 1134 of Title 24. The accessible path of travel shall connect to a major facility, public way or major path of travel on the site.

What specifications must the charging equipment meet?

The charging equipment must meet all applicable reach range provisions of Section 1118B of Title 24. A clear path of travel measuring 36 inches in clear width to the charging equipment is required.

Does the installation of charging stations at an existing site trigger path of travel improvements such as primary entrance to other facilities, restrooms, telephones, or drinking fountains?

No, unless the above features are located in the parking lot, are accessed directly from the parking lot and designed for use with the parking lot.

How does the three-year valuation accumulation apply to these installations?

The valuation of other improvements at the site over the last three years need not be added to the cost of the installation to determine application of the exception referenced in item VI above. The cost of installation of other EV charging stations at the site over a three-year period must be used in determining compliance with the exception.

13.3.2 California PEV Collaborative Accessibility Guidelines

The California PEV Collaborative provides guidelines on disabled accessibility and sample drawings for public- and restricted-access *charging* spaces in both new construction and existing facilities. These guidelines, summarized in Figure 13.1 and Table 13.2 below, also include standards for card readers at charging stations, which also must be disabled-accessible per the California Building Code (California Building Standards Commission).

Table 13.1: California PEV Collaborative ADA-Compliant EVSE Installation Guidelines for New Construction

	Public		Restricted
	Curbside	Offstreet	
EVSE location	Last space on the block before intersection, in direction of travel	ADA spaces (if not obstructing travel path)	Fleets and designated uses: conform to standards for public charging, unless no fleet vehicles or designated uses require disabled access Residential: if required, conform to standards for new public charging
Vehicle orientation	Diagonal or perpendicular to curb	Diagonal or perpendicular to EVSE	
Accessible aisle to EVSE	3' - 8' wide, left of charging space	9' for vehicle, 3' on either side of charging space (total 12')	
Van access aisle to EVSE	N/A	9' for vehicle, 8' on either side of charging space (total 17')	
Sidewalk pedestrian clearance	4' unobstructed between EVSE and building wall or other obstruction	N/A	
EVSE clearance	24" from curb	N/A	
EVSE area	N/A	Within 9" of center of a level 30" x 48" area, long side parallel to controls, no more than 2% slope in any direction	
EVSE height	N/A	Operable part no more than 48" above surface of EVSE area	
EVSE protection	Bollards or equivalent	Bollards or equivalent	
Cord management	Retractable cord preferred	Retractable cord preferred	
Lighting and signs	Adequate to minimize hazards; signs include use restrictions and contact information to report problems	Adequate to minimize hazards; signs include use restrictions and contact information to report problems	
Number of ADA charging spaces or card readers	No recommended minimum	First of every 25 stations; first of every 6 ADA charging spaces should be van-accessible; first tow card readers should be ADA accessible	

Table 13.2: California PEV Collaborative Accessible EVSE Installation Guidelines for Existing Facilities

<table>
<tr><th rowspan="2"></th><th colspan="2">Public</th><th rowspan="2">Restricted</th><th rowspan="2">Card Readers</th></tr>
<tr><th>Curbside</th><th>Offstreet</th></tr>
<tr><td>EVSE location</td><td>Last space on the block before intersection, in direction of travel</td><td>ADA spaces, if feasible</td><td rowspan="12">Fleets and designated uses: conform to standards for public charging, unless no fleet vehicles or designated uses require disabled access

Residential: if required, conform to standards for new public charging</td><td></td></tr>
<tr><td>Vehicle orientation</td><td>Orientation of existing curbside parking; diagonal or perpendicular preferred</td><td>Diagonal, perpendicular or parallel</td><td></td></tr>
<tr><td>Accessible aisle to EVSE or card reader</td><td>3’ wide at left, front or rear of charging space</td><td>9’ for vehicle, 3’ on either side of charging space (total 12’)</td><td>3’ wide from EVSE to card reader, unless co-located</td></tr>
<tr><td>Van access aisle to EVSE</td><td>N/A</td><td>9’ for vehicle, 8’ on either side of charging space (total 17’)</td><td></td></tr>
<tr><td>Sidewalk pedestrian clearance</td><td>4’ unobstructed between EVSE and building wall or other obstruction</td><td>N/A</td><td></td></tr>
<tr><td>EVSE or card reader clearance</td><td>24” from curb</td><td>N/A</td><td>Centerline of card reader should be 24” (+/- 9”) to nearest obstruction, excluding EVSE and cords</td></tr>
<tr><td>EVSE or card reader area</td><td>N/A</td><td>Within 9” of center of a level 30” x 48” area, long side parallel to controls, no more than 2% slope in any direction</td><td>Within 9” of center of a level 30” x 48” area, long side parallel to controls, no more than 2% slope in any direction</td></tr>
<tr><td>EVSE or card reader height</td><td>N/A</td><td>Operable part no more than 48” above surface of EVSE area</td><td>No more than 54” above accessible EVSE or card reader surface</td></tr>
<tr><td>EVSE protection</td><td>Bollards or equivalent, if vehicle is diagonal or perpendicular to curb; advised but not required for parallel orientation</td><td>Bollards or equivalent</td><td></td></tr>
<tr><td>Cord management</td><td>Retractable cord preferred</td><td>Retractable cord preferred</td><td></td></tr>
<tr><td>Lighting and signs</td><td>Adequate to minimize hazards; signs include use restrictions and contact information to report problems</td><td>Adequate to minimize hazards; signs include use restrictions and contact information to report problems</td><td></td></tr>
<tr><td>Number of ADA charging spaces or card readers</td><td>No recommended minimum</td><td>First of every 25 stations; first of every 6 ADA charging spaces should be van-accessible; first tow card readers should be ADA accessible</td><td>First 2 card readers should be accessible</td></tr>
</table>

13.4 Managing access to charging spaces

In addition to determining standards for PEV charging space design, local jurisdictions can designate spaces that are only for PEV charging and/or parking. Spaces designated for this purpose, along with the appropriate signage, will discourage non-PEV drivers from using these spaces and support their availability for PEV drivers. The California Vehicle Code prohibits any vehicle from parking in a space intended for PEV charging unless it is connected to EVSE, but the law does not specify whether the vehicle must be actively drawing power (2012 California Vehicle Code, Section 22511.1). The law also authorizes local authorities and private parking facility owners to tow vehicles in charging spaces that are not connected to EVSE, as long as proper signage is in place to warn drivers (2012 California Vehicle Code, Section 22511).

The following is an example of a local ordinance on designating PEV-only spaces:

13.4.1 Santa Monica (2012)

The Director of Planning and Community Development, or his or her designee, is authorized to designate parking spaces or stalls in an off-street parking facility owned and operated by the City of Santa Monica or the Parking Authority of the City of Santa Monica for the exclusive purpose of charging and parking a vehicle that is connected for electric charging purposes. (Santa Monica Municipal Code, Ordinance 2403, Section 29 2012)

13.5 Pricing PEV parking

Local governments and private property owners should also consider how much drivers should pay for charging and/or PEV parking. Such decisions should balance cost recovery considerations with the need to both incentivize PEV use and possibly discourage drivers from leaving their PEVs parked in charging spaces after they have refueled.

The pricing decision involves some combination of free or priced parking and free or priced charging. For example, site owners can provide free parking for PEVs but require payment for using the charging equipment. Alternatively, they can require payment for parking and offer charging for free. Yet another strategy would involve requiring payment for both PEV parking and charging, or offering both for free. Detailed guidance on cost recovery scenarios, both break-even and for-profit, are presented in Chapter 9. Pricing guidance for charging in multi-unit dwellings (Chapter 6), workplaces (Chapter 7) and retail (Chapter 8) is available elsewhere in this document.

Cities may want to initially encourage PEV use by offering free or discounted parking while PEVs are charging, and then begin charging full price for parking after the vehicle has fueled. This would encourage drivers to move their cars and allow other PEV drivers to use the charging space, but would not penalize drivers who do not move their cars in a timely fashion. As PEVs become more ubiquitous and demand grows for charging spaces, cities should consider additional measures, such as reasonable time limits on public charging spaces (Peterson 2010).

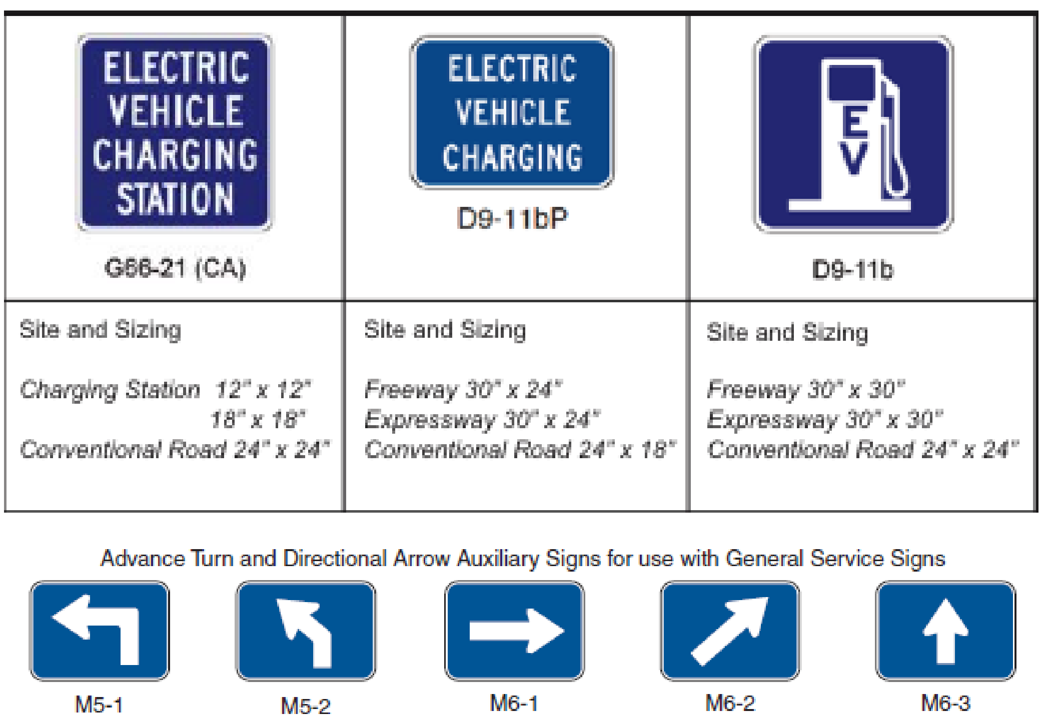
13.6 Signage

Signs are needed to direct drivers to PEV charging stations and enforce time limits or PEV-only access to certain spaces. Although traffic control signs must follow state and federal guidelines, local jurisdictions have an important role to play in placing signs on local streets and public parking facilities. Local governments must back up enforcement language on signs with ordinances and penalties for violation. Clear, consistent signage across jurisdictions can also encourage PEV adoption by minimizing driver confusion.

Traffic control signs are standardized according to the California Manual on Uniform Traffic Control Devices. The manual incorporates federal standards as well as California-specific alternative signs approved by the Federal Highway Administration (California Plug-in Electric Vehicle Collaborative 2012).

In its review of PEV signage, the California PEV Collaborative identifies two types of signs: general service signs and regulatory signs. General service signs indicate the presence of a charging station and/or provide directional arrows. The general service signs in Figure 13.1 below are approved for use in California.

Figure 13.1: Approved General Service Signs for PEV Charging



Source: California PEV Collaborative, Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure (2012)

The Federal Highway Administration (FWHA) has granted interim approval to the states of Oregon and Washington to use yet another sign, shown in Figure 13.2. Other jurisdictions may use this sign if they request authorization to do so from FHWA, until this sign is incorporated into standard federal guidelines.

Figure 13.2: PEV Charging Sign with Interim Federal Approval

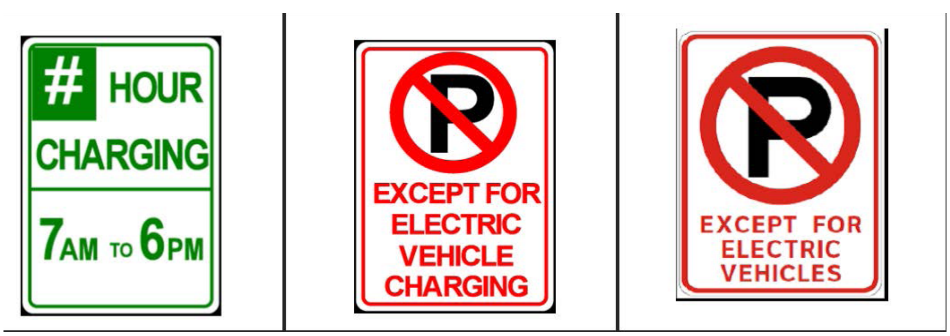
Source: California PEV Collaborative, Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure (2012)

In addition to general service signs, the California PEV Collaborative identifies another type of sign that enforces restrictions on parking and/or charging access for PEVs. So-called regulatory signs "permit or restrict the use of a charging station, similar to signs that prohibit or limit time for parking." (California Plug-in Electric Vehicle Collaborative 2012)

The California MUTCD and the Federal Highway Administration have not approved any PEV regulatory signs. The California PEV Collaborative recommends that local governments request authorization to use regulatory signs currently approved for testing in Oregon and Washington, "with the expectation that they ultimately will be approved at the federal level and become the uniform standard nationally" (California Plug-in Electric Vehicle Collaborative 2012). The signs are shown in Figure 13.3. They represent non-monetary ways to limit charging or parking access. The first sign specifies a time limit on charging, but does not provide a way for drivers to charge longer if they are willing to pay to do so.

The signs should measure 12"x18" and be installed in accordance with the California MUTCD and California Building Code. (California Plug-in Electric Vehicle Collaborative 2012)

Figure 13.3: Candidate regulatory signs for PEV charging



Source: California PEV Collaborative, Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure (2012)

13.6.1 Other sign considerations

- General service and regulatory signs may be used in combination. Best practices indicate that additional signs provide instructions on how to use the charging equipment, a number to call to report problems, and a definition of what constitutes appropriate occupation of the space (California Plug-in Electric Vehicle Collaborative 2012).
- The California Vehicle Code authorizes local authorities and private parking facility owners to tow vehicles in charging spaces that are not connected to EVSE, as long as proper signage is in place to warn drivers (2012 California Vehicle Code, Section 22511). This signage must measure 17"x 22" with one-inch lettering that states, "Unauthorized vehicles not connected for electric charging purposes will be towed away at owner's expense." The sign must also include contact information for where the vehicle will be towed and the local law enforcement agency (2012 California Vehicle Code, Section 22511).

13.7 PEV parking in different environments

While near-term charging demand will come mostly from single-family homes, local jurisdictions and property owners can encourage PEV adoption in multi-unit dwellings, workplace, and retail settings. Doing so will require a variety of parking policies, signage, and cost recovery strategies that suit these different land uses.

Customers, tenants and employees depend on the availability of parking spaces to shop, live, and work. Parking spaces are also an important source of revenue for local governments and some private property owners. Determining how many spaces to allocate for PEV parking and/or charging in existing buildings involves tradeoffs between at least two different goals: preserving existing parking spaces and/or revenue, and investing in PEV charging as a new amenity, public service or revenue source. Site owners should assess their current and potential demand for PEV charging by surveying employees and tenants. Installing one charging unit can also help reveal true demand for the service. The economics of hosting a PEV charge station are discussed in further detail in Chapter 9.

13.8 Recommendations

The following recommendations are intended to facilitate PEV charging through parking policies and signage. These recommendations should be adapted to reflect local land use opportunities for PEV charging and anticipated PEV demand, which may vary greatly among cities. Guidance on assessing local land use opportunities is provided in Chapter 4, Chapter 5, Chapter 6, Chapter 7, and Chapter 8. Additional resources on zoning and parking policies are provided in Chapter 10 of this document. Local jurisdictions should consult the Southern California PEV Atlas that accompanies this document for local PEV demand projections and maps of employment and commercial density.

1. Codify guidelines for disabled access to PEV charging spaces.
2. Adopt policies that facilitate the placement of signage on public property by non-city charging site owners (e.g. on sidewalks or public streets).
3. If demand for charging exceeds available charging capacity, consider measures to facilitate turnover at PEV charging spaces. Measures can include one or more of the following:
    - Clarify California Vehicle Code to require that PEVs parked in a charging space be connected to an EVSE and actively drawing power.
    - Post signage with chargers that cites relevant California vehicle code in order to be able to enforce towing of vehicles if they are not PEVs, connected to EVSE, and/or actively drawing power.
    - Charge for parking if PEVs are still parked but not actively drawing power.
    - Impose time limits on charging to allow other PEVs to use limited charging spots.
4. Use a single general service sign (accompanied with standard directional signage) for PEV charging as shown in Figure 13.1 or as shown in Figure 13.2 with interim FHWA approval. Local governments can request approval to use the general service sign with interim federal approval until a national standard is available.

13.9 Additional resources

The California PEV Collaborative's *Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure* (2012) recommends a uniform set of accessibility standards that comply with the ADA and California Building Code, as well as signs that comply with federal and state guidelines, or that have been submitted for federal or state approval. http://www.pevcollaborative.org/sites/all/themes/pev/files/PEV_Accessibility_120827.pdf

The Bay Area Climate Collaborative's *Ready, Set, Charge, California!* A Guide to EV-Ready Communities (2011) provides sample code language for reserving public parking spaces for PEVs, as well as design and installation guidelines for both on- and off-street charging stations.

http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf

- Section 3.2.1 (Sample zoning code provisions)
- Section 3.3 (Vehicles and traffic)
- Section 3.4.1 (On-street electric vehicle charging stations)
- Section 3.4.2 (Off-street electric vehicle charging stations)
- Section 3.5.2 (ADA and reasonable accomodations)

- Section 3.6 (Signage)

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Ready, Set, Charge, California! A Guide to EV-Ready Communities. 2011. Association of Bay Area Governments; Bay Area Climate Collaborative; Clean Fuel Connection; EV Communities Alliance; LightMoves Consulting. http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf.

Santa Monica Municipal Code, Ordinance 2403, Section 29. 2012. http://qcode.us/codes/santamonica/revisions/2403.pdf.

14 Utility Policies

14.1 Introduction

Electrical utilities currently play three important roles in the plug-in electric vehicle (PEV) ecosystem. First, they provide and price fuel for PEVs. Second, they regulate aspects of the installation of charging equipment. For example, they may issue permits, require electrical upgrades, and in some cases require the installation of a second meter to track PEV energy consumption. Because of these two roles, utilities are also naturally positioned to undertake their third role as educators of customers on the decision process and value proposition associated with charging equipment installation in different land uses.

This chapter provides planners with the information they need to understand and advocate for greater utility PEV readiness. It first presents an analysis of which utilities in the Southern California Association of Governments (SCAG) region currently have the highest numbers of PEVs so that regional planners can understand which utilities need to prioritize PEV readiness. We then review the current state of several utility PEV policies including:

- Expedited permitting
- Time-of-use rates
- Incentives for charging equipment installation
- Second meter requirements

Lastly, we review the state of utilities' PEV educational materials for their customers, noting best practices whenever possible.

14.2 Current and future PEV ownership across utilities within the region

The SCAG region has over 15 electrical utilities operating within its boundaries. For the larger utilities [42], Table 14.1 shows the current number of PEVs registered within each utility.[43] It also shows projected PEV growth rates to 2017 and 2022.

Nearly all the PEVs in the SCAG region are registered within two utility service territories. The Southern California Edison service territory contains 68% of all PEVs while the Los Angeles Department of Water and Power (LADWP) contains 22%. Together these two utilities contain 90% of the region's PEVs. The conservative lower-bound projections in Table 14.1 are based on growth rates that reflect annual growth rates of early standard hybrid ownership (specifically, the Toyota Prius). This growth trajectory would mean a minimum baseline of nearly 180,000 new PEVs by 2017 and more than 700,000 by 2022.

42 Utilities not represented by the Southern California Public Power Authority and that have less than 2 PEVs attributable to their service territories have been excluded from this analysis. They are Bear Valley Electrical Service, Corona Water and Power, City of Needles, and Victorville Municipal Utility Services.

43 The counts are based on data from R.L. Polk & Co. on PEVs newly registered from December 2010 to September 2012.

Table 14.1: PEV growth in SCAG utility service territories

Utility	Number of PEVs in utility territory	% share	2017			2022		
			Lower Bound	+ 5%	+ 10%	Lower Bound	+ 5%	+ 10%
Azusa Light and Water	8	<1%	171	191	209	689	927	1,216
Burbank Water and Power	59	1%	1,260	1,406	1,540	5,083	6,836	8,965
Cerritos Electric Utility	53	1%	1,132	1,263	1,383	4,566	6,141	8,053
City of Colton Public Utilities	1	<1%	21	24	26	86	116	152
Glendale Water and Power	103	1%	2,200	2,454	2,688	8,874	11,934	15,650
Pasadena Water and Power	119	1%	2,542	2,836	3,106	10,253	13,788	18,081
Vernon Light and Power	1	<1%	21	24	26	86	116	152
Anaheim Public Utilities Department	99	1%	2,114	2,359	2,584	8,529	11,471	15,042
City of Banning Electric Utility	1	<1%	21	24	26	86	116	152
Imperial Irrigation District	59	1%	1,260	1,406	1,540	5,083	6,836	8,965
LA Department of Water and Power	1,809	22%	38,636	43,105	47,213	155,856	209,603	274,864
Riverside Public Utilities	65	1%	1,388	1,549	1,696	5,600	7,531	9,876
Southern California Edison	5,650	68%	120,672	134,628	147,459	486,781	654,647	858,475
Anza Electric Cooperative	2	<1%	43	48	52	172	232	304
Moreno Valley Electric Utility	5	<1%	107	119	130	431	579	760
Rancho Cucamonga Municipal Utility	9	<1%	192	214	235	775	1,043	1,367
San Diego Gas and Electric	278	3%	5,937	6,624	7,256	23,951	32,211	42,240
TOTAL	8,321	100%	177,717	198,274	217,169	716,901	964,127	1,264,314

14.3 Streamlining permits and site inspections

A utility that is slow to permit or inspect can cause delays and cost increases during the installation of charging equipment. Streamlining permitting and inspection is an operational improvement that signals utilities are PEV-ready. As an example, LADWP promises a "7-Day Permit-to-Plug" process (Los Angeles Department of Water and Power 2012). If consistently applied, such policies can reduce upfront costs and expedite installation.

14.4 PEV time-of-use rates

Utilities are directly affected by the changes in electrical load as a result of PEV charging. Although nighttime off-peak charging will help to increase grid efficiency and revenue for utilities, daytime on-peak charging can be highly demanding on the grid, particularly if provided at high power to shorten charging times.

Some utilities because some utilities incentivize efficient charging behavior by offering PEV time-of-use (TOU) rates that make off-peak charging cheaper and on-peak charging more expensive. TOU rates vary with aggregate demand for electricity, which varies with the time of day. An example of the rate schedule is LADWP's offering to single-family residents (Los Angeles Department of Water and Power 2012). The utility separates the day into three demand periods: off-peak (8:00 p.m. – 10:00 a.m., weekends), low peak (10:00 a.m. – 1:00 p.m. and 5:00 p.m. – 8:00 p.m.) and high peak (1:00 p.m. – 5:00 p.m.). This option proves beneficial to PEV drivers, as rates are lowest at night or during "off-peak" hours, a period when most PEV drivers charge their vehicles. The TOU option can be offered to both single-family and multi-unit dwelling (MUD) households, as well as to businesses.

14.4.1 Single-family residential policies

For single-family households, a utility can offer two TOU options: PEV-only TOU and whole-house TOU. The first option applies TOU rates to only the electricity used for charging the PEV while the second places the electrical consumption of the entire household on TOU rates. In either case, a separate or replacement TOU meter is often necessary to record variable electricity use. Some utilities, such as San Diego Gas and Electric, use existing household meters to track whole-house electricity use.

PEV TOU rates. LADWP, San Diego Gas and Electric, and Southern California Edison are currently the only Southern California utilities offering a PEV-only TOU rate. This may suggest evidence of the evolution of developed PEV policy, a reflection of these three utilities' standing in PEV user share (i.e. 93%). As PEV use continues to expand, more utilities may offer this PEV-focused rate option. LADWP's PEV-only rate offers a $0.025/kilowatt-hour (kWh) discount for night and weekend charging (Los Angeles Department of Water and Power 2012). The Southern California

Edison PEV-only plan offers a rate $0.12/kWh during off-peak hours, which rises to $0.28/kWh[44] during on-peak hours (noon – 9:00 p.m.) (Southern California Edison 2012). In all cases, the installation of a second meter is required to track separate PEV electricity consumption.

Whole-house TOU rates. Municipal utilities in Anaheim, Azusa, Burbank, Los Angeles, Pasadena, and the Imperial Irrigation District, as well as San Diego Gas and Electric and Southern California Edison, offer a TOU option for the entire household's electricity use. The plans offer a range of discounts and customer suitability. Azusa Light and Water offers a $0.05/kWh discount between the hours of 10:00 p.m. and 6:00 a.m. for electricity use between 50 kWh and 500 kWh (Azusa Light and Water). The LADWP plan requires no minimum electricity use and offers a discount of $0.025/kWh for up to 500 kWh for night and weekend use (Los Angeles Department of Water and Power 2012).

The options provided by Pasadena Water and Power offer preference to a greater range of PEV drivers. Pasadena provides two separate whole-house TOU plans. The first keeps on-peak (noon – 9:00 p.m.) rates the same, while mid-peak (8:00 a.m. – noon, 9:00 p.m. – midnight) and off-peak (midnight – 8:00 a.m.) rates are reduced by $0.01 and $0.02/kWh, respectively. The second Pasadena whole-house TOU plan charges $0.04/kWh more during on-peak hours and discounts $0.025/kWh and $0.045 cents/kWh during mid- and off-peak hours, respectively. For these plans, a replacement meter is required (Pasadena Water and Power).

14.4.2 Multi-unit residential policies

TOU policies for multi-unit dwellings (MUDs) are not as developed. In some cases, such as with Anaheim Public Utilities and Burbank Water and Power, MUD TOU rates are offered on a "case by case"[45] basis, depending on a number of variables such as access to a dedicated parking space. LADWP, Pasadena Water and Power, San Diego Gas and Electric, and Southern California Edison provide the previously-mentioned single-family PEV TOU rates to independent MUD units as well. This may require a dedicated parking space and outlet[46]. LADWP, San Diego Gas and Electric and Southern California Edison offer TOU rates to entire MUD complexes but in the case of condominiums encourage preemptive involvement of the homeowner's association (HOA). The only utility offering a PEV-only MUD building plan is San Diego Gas and Electric. This plan is only for entire complexes with "shared walls" (San Diego Gas and Electric).

14.4.3 Commercial TOU Policies

Many Southern California utilities offer the option of whole-building TOU rates to commercial customers. A certain level of electricity consumption is required to be eligible for such rates. This minimum requirement can range from 200 kW (Azusa Light and Power) to 500 kW[47]. More than

44 This is the rate for summer months. The rate decreases to $0.22/kWh for winter months.
45 Interview with Anaheim Public Utilities, November 27, 2012.
46 Interview with Southern California Edison, December 18, 2012.
47 Interview with Anaheim Public Utilities, November 27, 2012.

one commercial TOU option may also be available, as is the case with Vernon Light and Power (City of Vernon 2009). Southern California Edison is the only utility to offer a PEV-only commercial TOU plan. The electricity limit to this plan is 500 kW (Southern California Edison 2012).

14.5 Incentives

Utilities may also offer a number of PEV-focused incentives. These incentives can include equipment rebates, rate rebates or credits or bill credits.

14.5.1 Second meter incentives

The required installation of a second meters can be costly, sometimes exceeding $2,000 with installation costs included[48]. For required second meter installations, LADWP is the only utility to offer free installation. In the cases of Southern California Edison and San Diego Gas and Electric, a licensed electrician is required to install the second meter at the customer's expense. When only the replacement of a basic meter with a specialized TOU meter is required, the utility provides the service free of charge, as is the case with Pasadena Water and Power.

14.5.2 Equipment rebates

Other equipment incentives include: the LADWP Home Charger Rebate Program, which provides up to $2,000 towards the cost of charging equipment and installation (Los Angeles Department of Water and Power 2012); and Anaheim Public Utilities' incentive of $1,500 per charging unit towards purchase, installation and panel upgrades (Anaheim Public Utilities 2012). As a home charging unit represents a significant investment, financial support from utilities is encouraged.

14.5.3 Other types of rebates

Another incentive provided by utilities includes rebates or credits realized in electric bills. This includes the savings from converting to a TOU rate schedule as well as additional savings. For example, Glendale Water and Power offers a $0.33/day rebate towards the metering charge. On average, this charge equals $0.27/day, so in effect, the customer is receiving a $0.06/day credit.[49] Other incentives include bill credits such as Burbank Water and Power's one-time $100 credit (Burbank Water and Power 2012).

14.6 Customer Education

As the landscape of PEV use expands, utilities will play an increasingly important role as

48 Interview with Todd Ritter of EV Structures.

49 Glendale Water and Power interview

customer educator. Information can come from bill inserts, the utility's website or telephone service. Due to the breadth of information needed and the Internet's accessibility and ease of use, a well-designed and intuitive website is of primary importance in transmitting the knowledge needed by a prospective PEV driver.

To supplement the website, telephone access to a utility representative is necessary to answer further questions or to correct possible misconceptions. Education across communication platforms can be used by utilities to augment their customer service and to better demonstrate the programs and incentives available to potential PEV customers.

A utility's website should be considered the primary medium for education, and as such should act as a comprehensive resource for potential PEV owners. Menu options on the utility website should separate residential and business customers. Websites should also include step-by-step instructions for the installation of charging units for different land uses and site hosts. These steps include application procedures, inspection requests, installation processes, permit information and incentive requirements and deadlines. Providing an easy-to-use checklist can help the PEV customer organize and prioritize actions. Other examples of helpful online education tools include the LADWP's basic process description (Los Angeles Department of Water and Power 2012) and Southern California Edison's series of videos (Southern California Edison 2012). Other education materials can include frequently asked questions (FAQ) sections or fact sheets. Additional paper materials such as rebate applications should also be accessible and printable through the utility's website.

Utility websites should clearly explain specific customer options. This includes rate options and any incentives offered to new PEV owners. As specialized rates may be new to certain customers, a website should clearly define the differences between standard rates and TOU rates and how these differences will affect the customer. LADWP's "EV Rates, Meter Options and Home Chargers Fact Sheet" (Los Angeles Department of Water and Power 2012) is an example of how to organize this information. LADWP displays pros and cons and offers additional information about each rate option.

Easy-to-read charts such as pro-con matrices present information in an easily digestible manner and are encouraged. Other information should include the rate schedule and associated charges. Southern California Edison takes an interactive approach with an easy-to-use "Plug-in Car Rate Assistant" (Southern California Edison 2012). This practical tool offers recommended individual electricity rates and associated annual savings based on zip code, vehicle type, miles driven per year, gasoline price and expected time of charge.

Incentive information is fundamental to PEV customer education. These advantageous policies act to alleviate the cost of transition to PEV use. As these policies directly affect the customer, it is important that necessary information is accessible. Utilities such as Anaheim Public Utilities and LADWP dedicate a full website to display incentive opportunities including those at the utility, state and federal level.

This general information should be complemented by a phone service to offer further clarity or to respond to any additional customer-specific questions. A PEV specialist can offer personal interaction and establishes a level of comfort with potential PEV customers. Southern California Edison offers a model phone service providing PEV expertise on an independent PEV phone line. Again, the goal of customer support on multiple platforms is to ease the process of becoming a PEV driver.

14.7 Utility recommendations

The following recommendations are intended for utility planners, but city planners who coordinate with utilities on PEV charging installation may benefit from understanding measures utilities can take to advance PEV readiness. The more ready the local utility, the easier it will be for city planners to facilitate convenient, cost-efficient PEV charging (and vice-versa).

1. Educate customers about the utility's permitting and inspection process for all applicable land uses (i.e., single-family residential, MUD, commercial, industrial). Make the information available online, over the telephone and in bill inserts as appropriate.

2. Offer whole-house TOU rates for single-family homes and consider whole-building TOU rates for MUDs and workplaces.

3. Understand potential growth in PEV charging demand in the utility service territory. The maps and projections provided in the Southern California Plug-in Electric Vehicle Atlas can help utilities plan for upgrading substations and transformers to accommodate increased load, particularly in MUD- and workplace-dense areas.

4. Allow use of energy management systems to balance PEV charging electrical load in lieu of panel upgrades where appropriate.

5. Coordinate with the local municipality's planning and/or building department to receive notification of applications for PEV charging permits.

14.8 Additional resources

In addition to the utility websites in the reference list, the following resources provide information on ways local jurisdictions can collaborate with utilities on PEV readiness measures:

The Bay Area Climate Collaborative's *Ready, Set, Charge, California! A Guide to EV-Ready Communities* (2011) provides information on utility notification of charging unit installations, submetering and integration of PEVs with renewable energy and efficiency strategies.

http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf

- Chapter 6 (Utility considerations)

The Transportation and Climate Initiative (TCI) is a collaboration of transportation, environment, and energy agencies in the northeast and mid-Atlantic regions of the U.S. As part of its Northeast Electric Vehicle Network project, TCI has produced the following document that discusses utility roles in PEV readiness planning and case studies (including the Los Angeles Department of Water and Power).

http://www.georgetownclimate.org/sites/default/files/EV-Ready_Codes_for_the_Built_Environment_0.pdf

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15 Developing PEV Outreach Campaigns

15.1 Introduction

Getting local stakeholders involved in PEV readiness will be crucial to successful PEV deployment. Planners may want to know whether they should conduct outreach in the community, and if so, what level of engagement will be appropriate. This chapter will help planners develop answers to the following questions:

- **Why develop an outreach plan?** Drivers and other potential charging site hosts need help understanding the technical aspects of PEV charging, the economic value proposition that PEV driving and/or charging holds for them, and the installation process for PEV charging.
- **What stakeholders should be the target of outreach efforts?** Drivers in single-family homes and multi-unit dwellings (MUDs) have different opportunities and barriers to PEV charging and should receive targeted outreach. Site hosts—employers and owners of commercial, industrial and MUD properties—are also key stakeholders.
- **How should stakeholders be engaged?** Outreach should be tailored to the level of PEV charging demand in the community. Too little engagement may slow the growth of PEV adoption and may lead to missed opportunities for charging. High-profile campaigns that are not preceded by basic PEV readiness efforts (such as permit streamlining and building code updates) may be a waste of resources and lead to frustration. Outreach efforts can be conducted along a "ladder of engagement," starting with more passive efforts that grow into more active projects:

  Step 1: Informational support. This serves stakeholders that are already interested in purchasing PEVs or installing charging equipment. Local jurisdictions can provide information on vehicle types, potential cost savings from PEV driving, electrical service, and the charging equipment installation process through passive means such as a website and/or handouts from utilities and the Building Department. This would be general information or resources for all PEV stakeholders.

Step 2: Workshops. Local jurisdictions can host workshops for general or targeted audiences such as drivers, homeowner associations (HOAs), property owners/managers, and renters for residential charging; or for employees, employers, or fleet managers for workplace charging.

Step 3: Targeted technical assistance and outreach. Planners may want to approach high-value stakeholders who may be less aware of the technical or procedural aspects of installing charging and using PEVs or who may require more detailed decision support. Actively engaging large employers or property owners in the decision-making process or providing information specific to their needs can facilitate the installation of charging and use of PEVs at their site.

Step 4: Demonstration projects. Public agencies and utilities can partner up to install charging equpment via demonstration projects in particularly challenging areas such as multi-unit dwellings.

PEV outreach efforts that have been conducted in Southern California at various levels of engagement, ranging from passive to active.

15.1.1 Local marketing and outreach efforts to date

Regional organizations offer a wide variety of programs around which cities can develop outreach campaigns. The South Coast Air Quality Management District (SCAQMD) has been actively supporting PEV readiness initiatives since 2009, and is involved in several marketing and outreach efforts as part of PEV readiness planning efforts funded by the U.S. Department of Energy (DOE) and California Energy Commission (CEC). A DOE grant supported the creation of six California regional PEV readiness plans, PEV readiness guidelines and toolkit, and a series of regional PEV readiness outreach workshops to assist municipalities to deploy PEV infrastructure in their communities. The CEC is funding sub-regional PEV readiness studies including market needs assessments and analyses of barriers to PEV readiness.

These outreach efforts have included information on PEVs and infrastructure, local utility rate programs and support services, and available incentives for PEV owners (vehicle purchase rebates, residential infrastructure rebates, rebates or reductions in state or local toll access charges, preferred parking spaces or single-rider access to HOV lanes, reduced or free charging at select locations, etc.).

Outreach efforts in the South Coast region have consisted of EV101 workshops for local governments, utilities, and residents; workplace charging workshops; local council of government workshops; utility rebate programs; promotional events; and AQMD's own marketing and outreach efforts.

Outreach efforts can target specific sectors of charging, including single-family residences, multi-unit dwellings, workplace, and commercial/retail/public locations.

15.2 Single-family residential charging

Installation of charging in single-family residences is the most critical sector in which to have charging and typically the least challenging sector for installations. Additional guidance on single-family home charging is provided in Chapter 5 of this document. The Southern California PEV Atlas that accompanies this document provides maps of PEVs registered with the Department of Motor Vehicles. Planners can use these guides to prioritize neighborhoods for single-family residential charging.

15.2.1 What stakeholders should be the target of outreach efforts?

- **Neighborhood associations** are an efficient way to reach groups of residents in single-family homes that may be inclined to purchase a PEV.
- **PEV dealers** have a vested interest in the popularity of PEVs in the community and may be interested in participating in ride-and-drive or vehicle loan events. They are also the referral point in many cases for charging equipment installers.
- **Installers of charging equipment.** Installers and electricians often interact directly with planners in the permitting and inspection process and should be aware of local documentation requirements.
- **Public officials** and/or their staff may be called upon to assist constituents who are PEV owners. Public officials who drive city-owned PEVs can also serve as visible advocates for PEV adoption.

15.2.2 How should stakeholders be engaged?

Marketing and outreach at the level of **Step 1 (informational support)** also work well for single-family residential installations.

- The California PEV Collaborative has an excellent website of online resources targeted to several audiences, including PEV owners. The website features communication guides on PEV charging and the benefits of owning a PEV. http://www.pevcollaborative.org
- SCAQMD has a Clean Air Choices program website which has a clean vehicle savings calculator and available incentives. http://www.aqmd.gov/CleanAirChoices/index.html
- The California Air Resources Board has a DriveClean California website which provides information on vehicle technologies and searchable PEV incentives. http://www.driveclean.ca.gov/
- Local utility agencies have also provided extensive information on utility rates and rebate programs for PEVs or infrastructure on their websites.
    - Los Angeles Department of Water and Power https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_adf.ctrl-state=10i5arr6ih_4&_afrLoop=118205602113000

- o Riverside Public Utilities http://www.greenriverside.com/Go-Green-2/Electric-Vehicles-197
- o Southern California Edison http://www.sce.com/info/electric-car/default.htm?from=residentialrate

Marketing and outreach efforts for general audiences at the level of **Step 2 (workshops)** can also address issues concerning charging installation at single-family homes.

- Types of PEVs and charging technologies
- Incentives available for purchases of PEVs, electricity and charging equipment installation
- Navigating the permitting and inspection process

Other Step 2 efforts include vehicle loan programs by automakers, California Air Resources Board's Clean Vehicle Rebate Project workshops, National Plug-in Day, and Santa Monica Alt Car Expo, which provide information on technologies, utility rate and incentive programs, ride and drive experiences, and panels in which PEV drivers share their insights on owning PEVs.

Workshops for local government planners and officials have raised awareness about the need to streamline permitting to facilitate charging at single-family homes. These have included local council of government (COG) workshops and those conducted by the California Center for Sustainable Energy. The California PEV Collaborative has also conducted workshops addressing all of the major PEV readiness elements such as permitting and inspection, zoning and parking, and building codes.

15.3 Multi-unit dwelling charging

Installation of charging infrastructure in MUDs is another critical sector and one of the most challenging ones. Additional guidance on MUD charging is provided in Chapter 6 of this document. The Southern California PEV Atlas that accompanies this document provides maps of MUDs that planners can use to prioritize locations for MUD charging support.

15.3.1 What stakeholders should be the target of outreach efforts?

- **Property owners of residential MUDs** include landlords and homeowner associations, whose cooperation is key in securing approval for MUD charging.
- **MUD residents** include individual rental tenants and condo owners, who must understand their rights and responsibilities around PEV charging in MUDs.
- **Developers of MUD properties**, who may consider installing chargers or PEV-ready wiring in exchange for density bonuses or other benefits.

15.3.2 How should stakeholders be engaged?

Marketing and outreach efforts for general audiences at the level of **Step 1 (informational support)** and **Step 2 (workshops)** outlined in the single-family residential charging section provide familiarity with vehicle and charging technology and utility rate impacts. However, they are not sufficient on their own to meet the needs of MUD charging. The challenges of MUD installations require **Step 3 (targeted technical assistance)** and **Step 4 (demonstration projects)** that go beyond what is currently being done.

Specific MUD issues that can be addressed include:

- "EV rights" in MUDs. California law prohibits HOAs from unreasonably preventing the installation of PEV charging equipment. However, PEV drivers must meet certain conditions if the equipment is installed for their exclusive use in a common area. Further guidance on "EV rights" in MUDs is provided in Chapter 6.
- Incentives for charging equipment installation and special discounts on electricity used for charging in MUDs that are similar to commercial PEV charging rates.
- Economies of scale in MUD charging. HOAs and landlords can lower their unit costs of providing charging equipment by using machines that can charge multiple cars simultaneously or in an automated queue.

Best practices for marketing and outreach to promote MUD charging underscore the need for marketing and outreach with greater levels of engagement, and include:

- Informational support and workshops (same as for single-family, but tailored to MUDs)
- Targeted technical assistance
    - o COGs present information to their member cities and counties on vehicle and charging technologies and changing local codes to expedite more complicated installations. For example, this could include code language for cities and counties to consider adopting that would categorize MUD installations as residential rather than commercial installations. This could also include incentives to MUD owners, HOAs, and property managers to install Level 1 or Level 2 infrastructure in existing buildings, and require PEV-ready electrical service and infrastructure in new construction.
    - o COGs identify in which types of buildings equipment installation would be easier and more cost-effective. They could also identify ways of reducing costs for more complicated installations.
- Demonstration projects. These are appropriate for stakeholders with low levels of knowledge and many specific questions about MUD charging.
    - o Federal, state or locally-funded demonstration or incentive programs for installation of infrastructure in MUDs in early adopter, environmental justice, or other types of communities. These could be targeted to areas of high concentrations of both MUDs and PEVs.

15.4 Workplace charging

After residential charging, workplaces are the second highest priority for charging, particularly for PEV owners who have long commuting distances or live in MUDs where they are unable to charge at home.

Additional guidance on workplace charging is provided in Chapter 7 of this document. The Southern California PEV Atlas that accompanies this document provides maps that layer workplaces with daytime PEV destinations. Planners can use these guides to prioritize support for workplace charging.

15.4.1 What stakeholders should be the target of outreach efforts?

- Chambers of commerce, business groups, and trade associations, particularly those that represent white-collar, high-tech employers, and/or other segments with high potential of adopting PEVs
- Labor unions that may be interested in installation work for their members
- High-value or large employers, such as hospitals or educational institutions
- Commercial property owners with employer tenants
- Parking management companies that operate workplace parking areas

15.4.2 How should stakeholders be engaged?

Marketing and outreach efforts for general audiences at the level of **Step 1 (informational support)** and **Step 2 (workshops)** provide familiarity with vehicle and charging technology and utility rate impacts, but are not sufficient to address the needs of workplace charging. The challenges of workplace installations require **Step 3 (targeted technical assistance)** and **Step 4 (demonstrations)** that go beyond what is currently being done.

Specific workplace-charging issues that can be addressed include:

- Whether Level 1 or Level 2 charging can meet the needs of employee PEVs
- How employers or commercial property owners might price charging services to recover costs
- Access control and payment systems
- Maximizing the use of charging equipment (for example, powering fleet or public PEVs when not powering employee PEVs)
- Issues of equity and access where employee, fleet, and public vehicles need to share and coordinate limited charging resources
- Tax implications if charging is provided for free and only employees with PEVs can benefit

Best practices for marketing and outreach to promote workplace charging underscore the need for marketing and outreach with greater levels of engagement, and include:

- Informational support (tailored to workplace charging)
    - Workshops for specific audiences for workplace charging (employees, employers, fleet managers, commercial property owners)
- Targeted technical assistance
    - COGs present information to their member cities on vehicle and charging technologies and changing city and county codes to expedite more complicated installations. This could include code language for cities and counties to consider adopting that simplifies permitting, inspection, zoning, and parking requirements for commercial installations.
    - Codes or incentives to employers or property owners supporting installation of infrastructure in existing buildings, and requiring PEV-ready electrical service and infrastructure in new construction.
    - Workplace demonstration programs which identify at which types of locations it would be easier and more cost effective to install infrastructure and identify ways of reducing costs for more complicated installations
- Demonstration projects
    - Federal, state or locally-funded demonstration or incentive programs for installation of workplace infrastructure in early adopter, environmental justice, or other types of communities with large numbers of employees (to satisfy SCAQMD Rule 2202[50] or rideshare program requirements), high concentrations of PEVs, or low concentrations of public infrastructure

15.5 Retail charging

Retail charging is the third priority for infrastructure installation, after residential and workplace. Retail installations are generally considered as amenities to drive traffic to destination locations or as stops between home and work during peak commute hours. Several supermarkets and national chains such as Ralphs, Albertsons, Kohls, and Walgreens have installed Level 2 or DC fast chargers. PEV manufacturers such as Nissan, BMW, and General Motors have installed Level 2 or DC fast chargers at their dealerships as a convenience to PEV buyers.

Outreach efforts for general audiences at the level **of Step 1 (informational support)** and **Step 2 (workshops)** do provide familiarity with vehicle and charging technology and utility rate impacts, but are not sufficient on their own to address the challenges associated with retail installations. The challenges of retail installations require **Step 3 (targeted technical assistance)**

50 Rule 2202 requires employers of at least 250 employees at a work site to participate in an emissions reduction program to offset commute-related pollution.

and **Step 4 (demonstration projects)** that go beyond what is currently being done.

Additional guidance on retail charging is provided in Chapter 8 of this document. The COG-level maps in the Southern California PEV Atlas that accompanies this document layer commercial destinations with daytime PEV destinations. Planners can use these guides to prioritize locations for retail charging.

15.5.1 What stakeholders should be the target of outreach efforts?

- **Chambers of commerce and retail associations** whose members may be inclined to individually provide PEV charging as an amenity to customers
- **Business improvement districts** whose members may be inclined to collectively pay for PEV charging to attract customers
- **Owners of retail properties**, particularly major malls where vehicles are parked for long periods of time
- **Developers of retail properties**, who may consider installing chargers or PEV-ready wiring in exchange for density bonuses or other benefits

15.5.2 How should stakeholders be engaged?

Best practices for marketing and outreach to promote retail charging underscore the need for marketing and outreach with greater levels of engagement, and include:

- Informational support (tailored to retail charging)
- Workshops for specific audiences for commercial charging
- Targeted technical assistance
    - COGs present information to their member cities on vehicle and charging technologies and changing city and county codes to expedite more complicated installations. This could include code language that simplifies permitting, inspection, zoning, and parking requirements for commercial installations. These could also include requirements for PEV-ready electrical service and infrastructure in new construction.

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