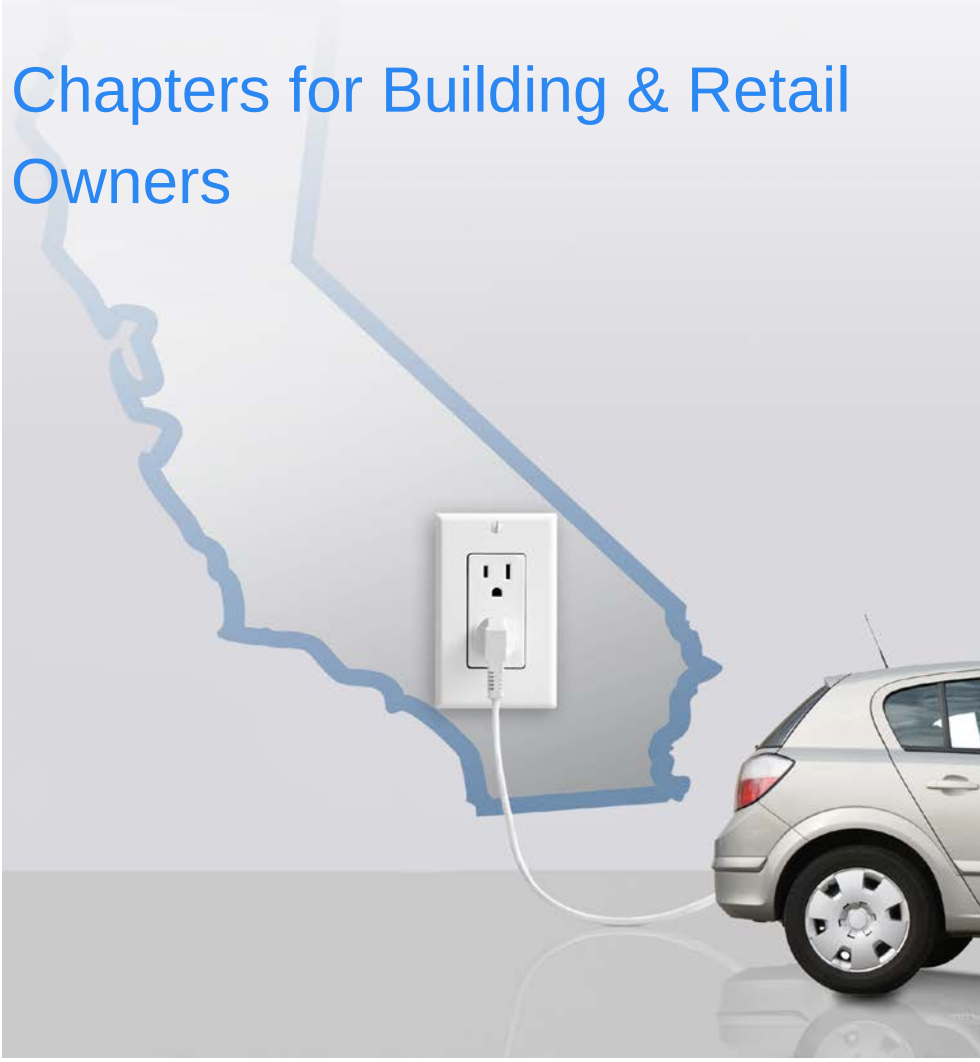
UCLA Luskin School of Public Affairs

Luskin Center for Innovation

Southern California Plug-in Electric Vehicle Readiness Plan

Chapters for Building & Retail Owners



SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Prepared for the Southern California Association of Governments

December 2012

Southern California Plug-in Electric Vehicle Readiness Plan

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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.

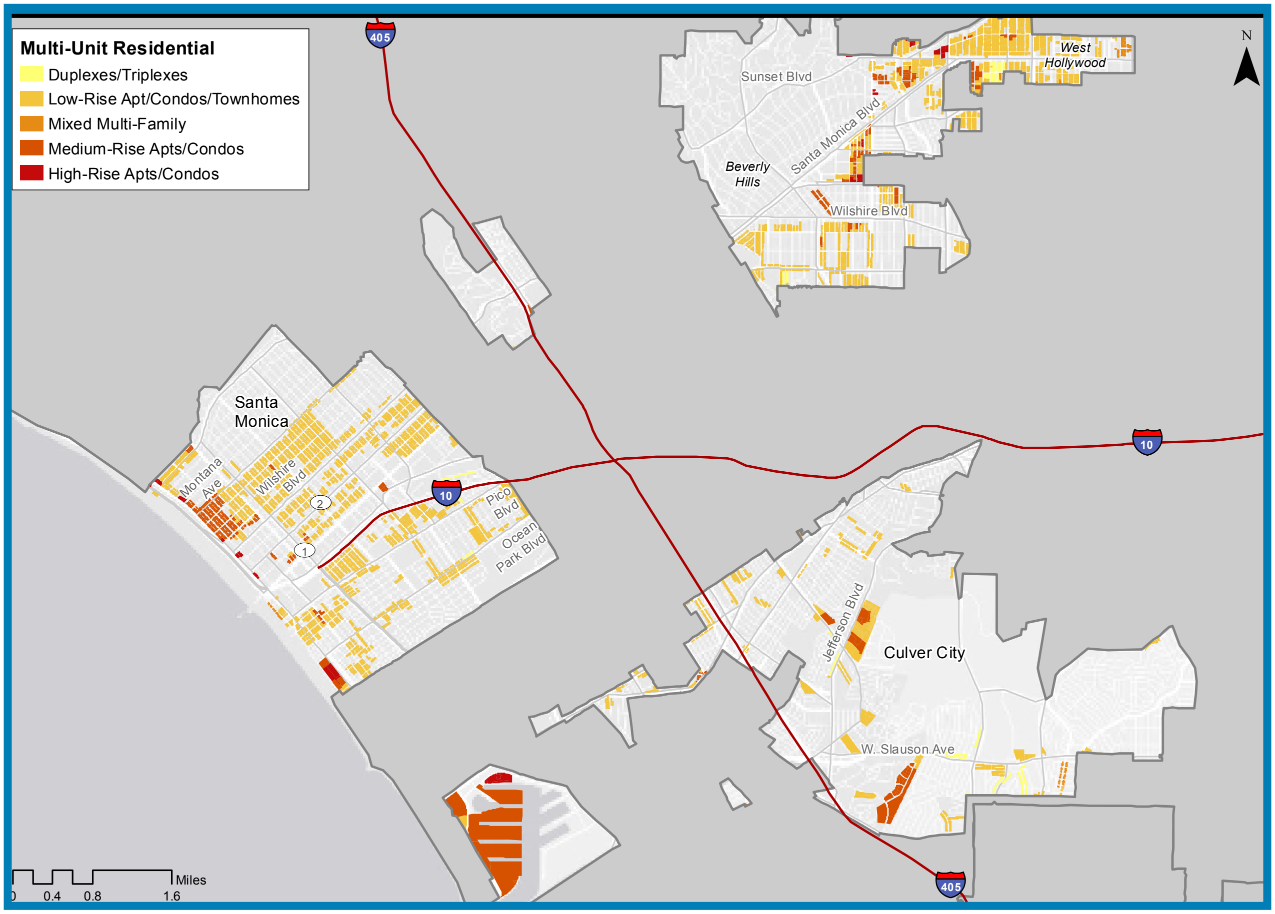
The Southern California PEV Readiness Plan's multi-unit residential density maps were created using data from SCAG's 2005 Existing Land Use Dataset. The data includes information on the concentration of all residential units other than single-family. The designations were determined by using aerial photography 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



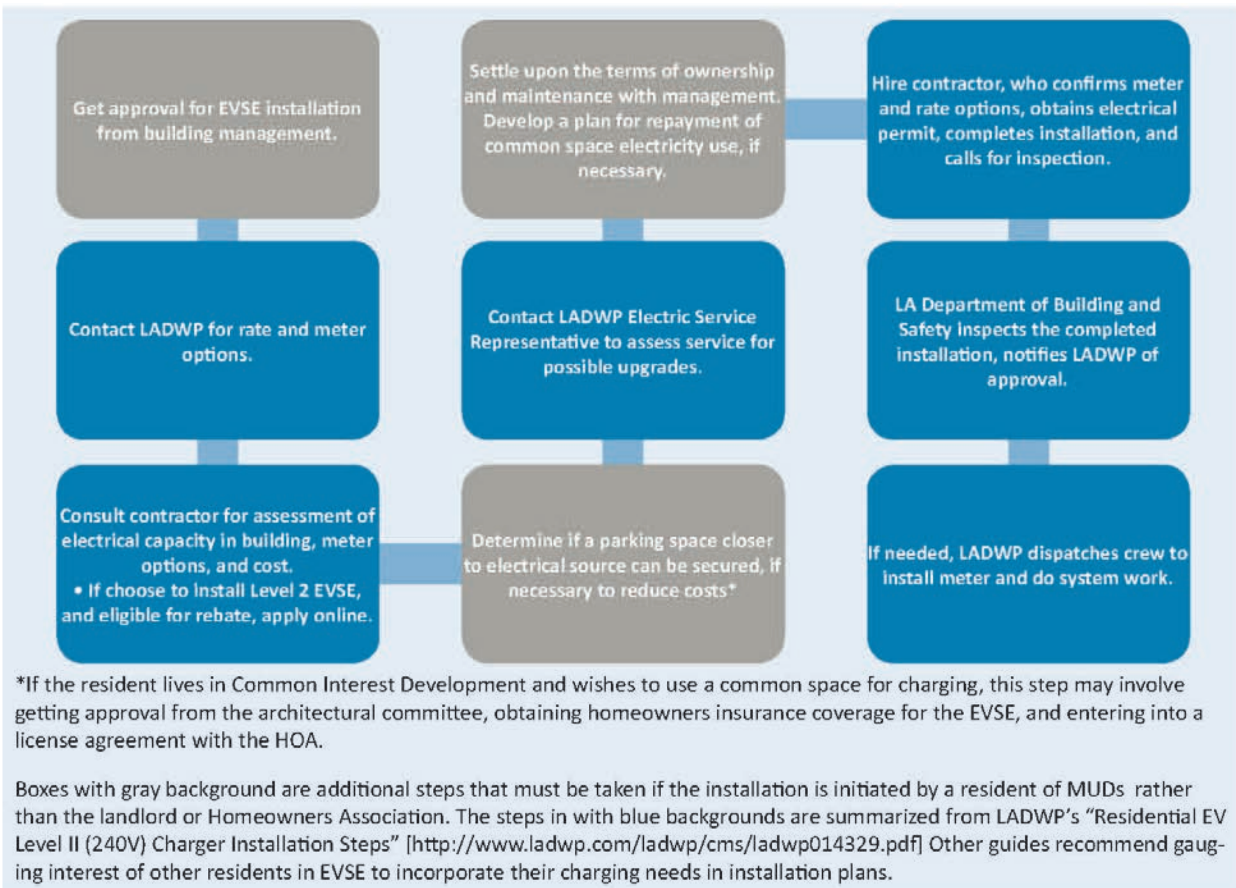
As shown in Map 6.1, the densities of units per acre increase from yellow at the duplex, triplex and townhouse level all the way up to high-rise MUDs in red. The number of units per acre will indicate the likely number of parking spaces located on site and thus the potential number of PEV-ready spaces 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



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]

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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

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
Installed Level 2 Charger Cost									
$ 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.

6.9 References

Balmin, Judith, Greg Bonett, and Megan Kirkeby. 2012. Increasing Electric Vehicle Charging Access in Multi-Unit Dwellings in Los Angeles. http://luskin.ucla.edu/sites/default/files/EV%20Charging%20in%20LA%20MUDs.pdf.

California Center for Sustainable Energy. California Plug-in Electric Vehicle Owner Survey. http://energycenter.org/index.php/incentive-programs/self-generation-incentive-program/sgip-documents/doc_download/1140-pev-owner-survey-result.

California Plug-in Electric Vehicle Collaborative. 2012. Multi-unit Dwelling Guidelines Report, Draft Revision 7.

Dubin, Jeffrey, Ross Barney, Annamaria Csontos, Jonathan Um, and Nini Wu. 2011. Realizing the Potential of the Los Angeles Electric Vehicle Market. http://164.67.121.27/files/Downloads/luskincenter/ev/UCLA_Luskin_-_Full_Report_-_Realizing_the_Potential_of_the_LA_EV_Market.pdf.

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.

HybridCars.com. www.hybridcars.com. Accessed July 23, 2012.

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.

Peterson, David. 2011. Addressing Challenges to Electric Vehicle Charging in Multifamily Residential Buildings. http://luskin.ucla.edu/sites/default/files/EV_Multifamily_Report_10_2011.pdf.

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

SB-880 Common Interest Developments: Electric Vehicle Charging Stations. 2012. http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml.

Southern California Association of Governments. 2002. Southern California 1990 Aerial Land Use Study: Land Use Code Descriptions and Key Signatures, Level III/IV.

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. Accessed July 23, 2012.

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.

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

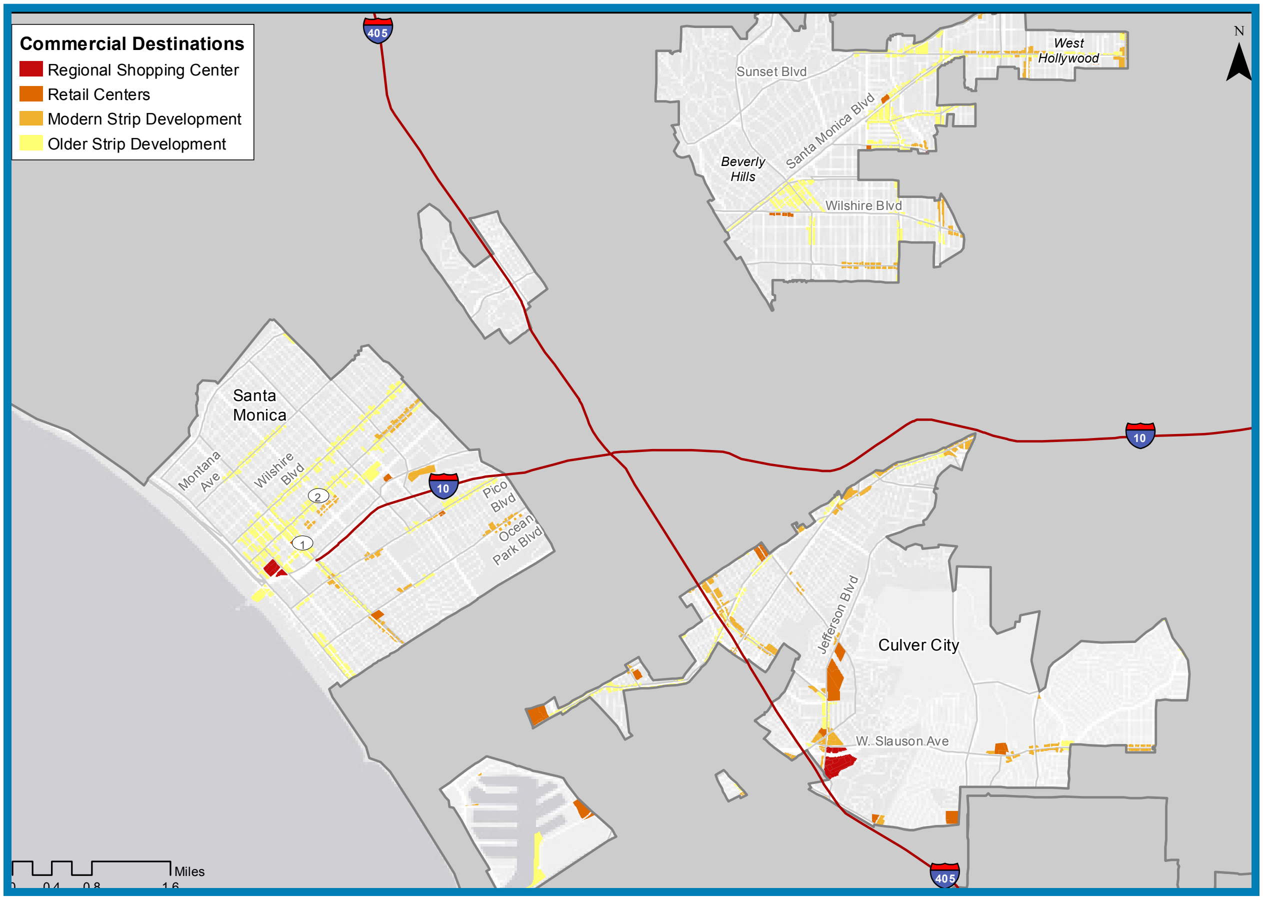
Description	Key Attribute
Regional Shopping Center	Department store with surrounding parking
Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking)	Magnet store with in-front parking
Modern Strip Development	Small businesses with parking on-street and on one side
Older Strip Development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

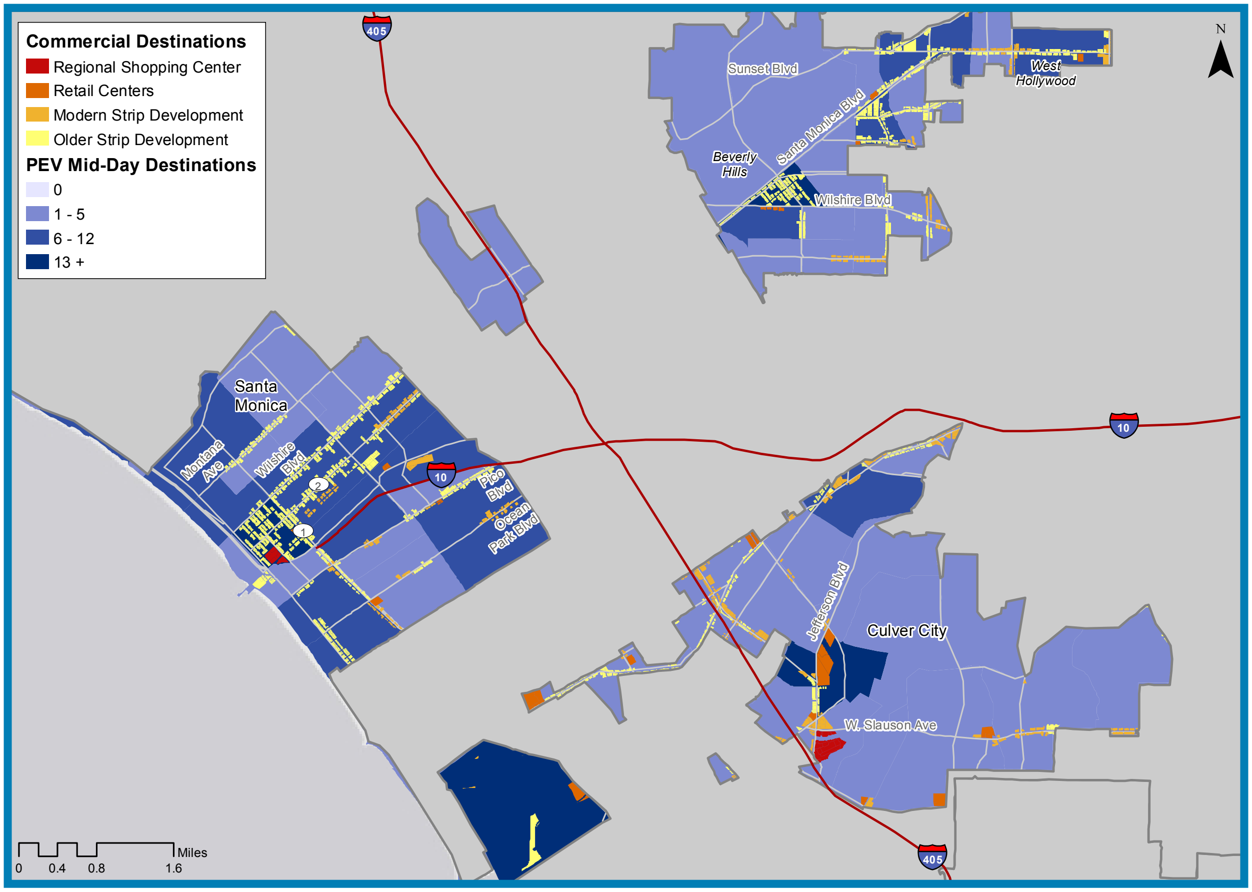


After mapping retail destinations, the UCLA Luskin Center mapped the locations where currently-registered PEVs travel during weekdays from 9:00 a.m. to 3:00 p.m. The data on PEV registrations comes from automotive data vendor R.L. Polk & Co., which provided the number of PEVs registered as new within 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

8.6 References

California Center for Sustainable Energy. California Plug-in Electric Vehicle Owner Survey. http://energycenter.org/index.php/incentive-programs/self-generation-incentive-program/sgip-documents/doc_download/1140-pev-owner-survey-result.

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.

Landy, Cristi. 2011. The Customer Experience: What We Have Learned... *Automotive News Green Car Conference*, http://www.autonews.com/assets/html/green-car-conference/2011/_pdf/Cristi-Landy-Presentation.pdf.

Nixon, Hilary, and Jean-Daniel Saphores. 2011. Understanding Household Preferences for Alternative-Fuel Vehicle Technologies. (MTI Report 10-11), http://ntl.bts.gov/lib/45000/45400/45419/2809-Alternative-Fuel-Vehicle-Technologies.pdf.

Southern California Association of Governments. 2002. Southern California 1990 Aerial Land Use Study: Land Use Code Descriptions and Key Signatures, Level III/IV.

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.

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).

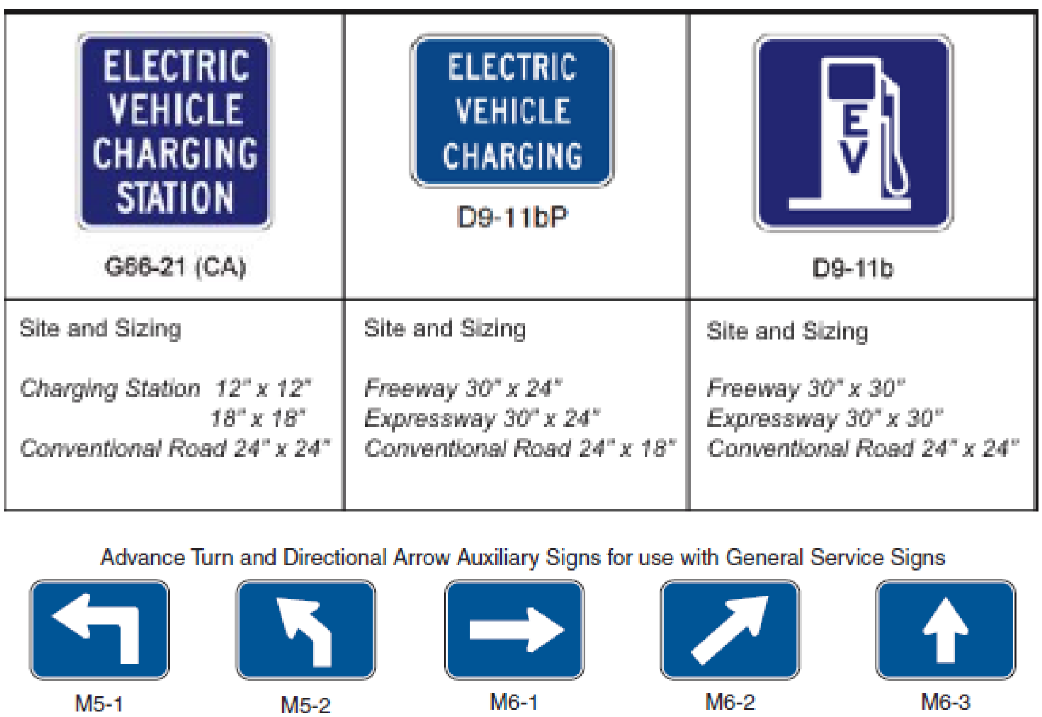
13.6 Signage

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



G66-21 (CA)	D9-11bP	D9-11b
Site and Sizing *Charging Station 12" x 12"* *18" x 18"* *Conventional Road 24" x 24"*	Site and Sizing *Freeway 30" x 24"* *Expressway 30" x 24"* *Conventional Road 24" x 18"*	Site and Sizing *Freeway 30" x 30"* *Expressway 30" x 30"* *Conventional Road 24" x 24"*

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

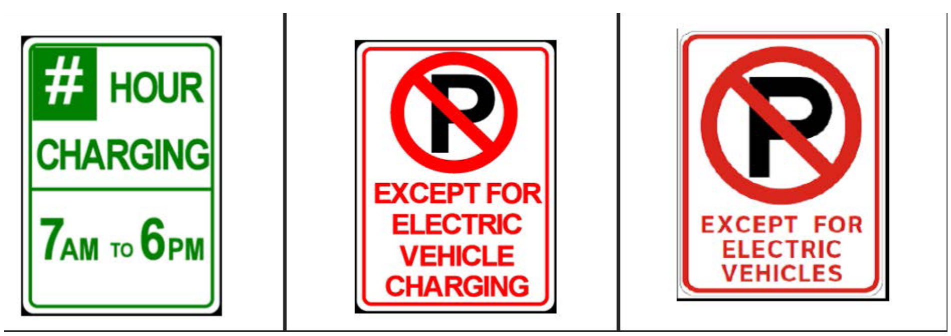
Source: California PEV Collaborative, Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure (2012)

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)

13.10 References

2012 California Vehicle Code, Section 22511. http://www.dmv.ca.gov/pubs/vctop/d11/vc22511.htm.

2012 California Vehicle Code, Section 22511.1. http://www.dmv.ca.gov/pubs/vctop/d11/vc22511_1.htm.

California Building Standards Commission. 2010 California Building Code, Chapter 11C. http://publicecodes.cyberregs.com/st/ca/st/b200v10/st_ca_st_b200v10_11c_section.htm.

California Department of General Services, Division of the State Architect. 2011. Access Policy Update, Policy 97-03, Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations. http://www.documents.dgs.ca.gov/dsa/pubs/policies_rev_01-01-11.pdf.

California Plug-in Electric Vehicle Collaborative. 2012. A Community Toolkit for Plug-in Electric Vehicle Readiness: A Resource for Local Officials. http://www.evcollaborative.org/sites/all/themes/pev/files/PEV_readiness_toolkit_v1.pdf.

———. 2012. Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure. http://www.evcollaborative.org/sites/all/themes/pev/files/AccessibilityReport-4%2726%20final.pdf.

———. 2012. California Plug-in Electric Vehicle Readiness Survey. http://www.surveymonkey.com/sr.aspx?sm=liSrdDLXrgyjR80UILTSJBOLy5ylb3zy2cFXwK3AmaE_3d.

eTec. 2010. Electric Vehicle Charging Infrastructure Deployment Guidelines for the Central Puget Sound Area. http://www.theevproject.com/downloads/documents/Electric%20Vehicle%20Charging%20Infrastructure%20Deployment%20Guidelines%20for%20the%20Central%20Puget%20Sound%20Area%20Ver%203.2.pdf.

Peterson, David. 2010. Electric Vehicles and Subsidized Parking: Policy Brief for City of Los Angeles City Council (Executive Summary). http://luskin.ucla.edu/content/pev-readiness.

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.

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