November 2013

Plug-in Electric Vehicle Charging Infrastructure Guidelines for Multi-unit Dwellings

CALIFORNIA
PLUG-IN ELECTRIC VEHICLE
COLLABORATIVE

This report was developed by the California Plug-In Electric Vehicle Collaborative, a multi-stakeholder partnership working to ensure a strong and enduring transition to a plug-in electric vehicle marketplace. Members played guiding and consulting roles in developing this report, although individual organizations may not formally endorse every aspect or recommendation.

The PEV Collaborative would like to thank Joel Pointon of San Diego Gas & Electric and Karen Schkolnick of the Bay Area Air Quality Management District for their leadership role as co-chairs of the Multi-unit Dwellings Working Group. This report was developed by the Working Group co-chairs, volunteers of the Working Group, PEV Collaborative staff, and contractors Clean Fuel Connection, Inc., J Knapp Communications, Better World Group, Inc., and Winter Graphics. Special thanks to Bill Boyce of the Sacramento Municipal Utility District, the multi-unit dwellings that provided case studies, and Lisa Chiladakis, lead PEV Collaborative staff.

California Plug-In Electric Vehicle Collaborative

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1.0 Introduction

The market for plug-in electric vehicles is strong and growing. National PEV sales hit 100,000 in May 2013. With roughly 30-40 precent of those vehicles being sold in California. In fact, on a monthly basis, PEVs have been as high as 2.5 percent of new car sales in the state. Furthermore, the market is expected to grow steadily in California for two reasons. First, the state has always been a leader when it comes to new, advanced technology vehicles. Second, Governor Brown signed an Executive Order in March, 2012 that calls for 1.5 million zero emission vehicles in California by 2025.[2]

Plug-in electric vehicle (PEV) is a generic term for a vehicle that runs at least partially on battery power and is recharged by plugging into the electrical grid. There are two kinds of PEVs:

BEVs, or battery-electric vehicles, run 100 percent on electricity stored in rechargeable batteries and have an electric motor rather than a gasoline engine.

PHEVs, or plug-in hybrid electric vehicles, combine two propulsion modes in one vehicle – an electric motor that is powered by a rechargeable battery and a gasoline engine that can be refueled with gasoline.

A growing PEV market is critically important for California because PEVs will help the state meet its air quality, greenhouse gas and energy security goals. In addition to providing these environmental and energy benefits, PEVs are fun to drive, can be cheaper to refuel and can significantly reduce or eliminate the need to go to the gas station since they can be fueled by plugging in to charge wherever there is access to electricity.

Abbreviated List of Acronyms

BEV	Battery-electric vehicle
EVSE	Electric vehicle supply equipment (a.k.a., charging unit or charging station)
EVSP	Electric vehicle service provider
HOA	Homeowner association
PHEV	Plug-in hybrid-electric vehicle
PEV	Plug-in electric vehicle
MuD	Multi-unit dwelling

For a complete glossary of terms, see Appendix A.

Multi-unit dwelling (MuD), also known as multi-family residence or multi-family dwelling unit, is a classification of housing where multiple housing units are contained within one building or multiple buildings within a complex or community. Some MuDs are owned (e.g., condominiums), while others are leased or rented (e.g., apartments). Some common types of MuDs are duplexes, townhomes and apartments, mobile homes and manufactured-home parks.

Millennium Tower in San Francisco installed PEV chargers for their tenants. See Appendix D to read this and other case studies for MuD charger installations.

Utilities estimate that 80 to 90 percent of PEV charging occurs at home. To date, much has been done to accelerate installations of charging equipment in single-family homes. However, less progress has been made in multi-unit dwellings (MuDs), where 34 percent of Californians reside.[3] Residents of MuDs may be interested in purchasing PEVs and property managers may be looking to install charging stations to attract and retain tenants and foster a green and environmentally sustainable community. But MuDs face unique considerations associated with PEV charging. These considerations include parking access, electrical service access, installation and operating costs and the legal covenants between a property owner or manager and a PEV owner/resident.

This document discusses these and other PEV charging infrastructure and operations issues specific to MuDs. It is meant to provide basic guidance to owners, managers and homeowner associations (HOAs), and to be helpful to other stakeholders who may be responsible for installing or maintaining PEV charging equipment, including residential PEV buyers, utility personnel, electrical contractors and turnkey service providers. It also provides links to related resources, including current laws related to installation of PEV charging at MuDs.

This is a "living document" and will be updated as new resources become available. Please continue to check the PEV Resource Center at www.DriveClean.ca.gov/pev/Charging/Home_Charging/Multi-unit_Dwellings.php for additional case studies and updated information.

2.0 Charging a PEV

Charging infrastructure needs vary according to vehicle type and use. Practically speaking, charging needs are based on a vehicle's daily electric miles driven and the amount of time available for charging.

Today's PEVs charge using different levels of power and different types of charging stations, or electric vehicle supply equipment (EVSE).

AC Level 1 EVSE plugs into a standard 110/120-volt alternating current (VAC) three-prong wall outlet with no other connection needed. Level 1 charging is usually accomplished using a portable "cordset" that is provided with the vehicle, as shown below. PHEVs tend to have smaller batteries than BEVs and can often adequately recharge in a reasonable time with an AC Level 1 cordset, although Level 1 can also meet the needs of many BEV drivers that drive 50 miles or less per day.[4]

Level 1 portable cordset.

AC Level 2 EVSE, which uses 240VAC current, is typically used for PEVs with larger batteries, such as BEVs, and in cases where PHEVs may be parked for a short period (generally three hours or less) and need to charge quickly. AC Level 2 EVSE usually must be permanently installed by a qualified electrician. It can also be plugged into a 240VAC outlet when equipped with an appropriate plug connection.

Almost all PEVs in the United States use the same connector, which conforms with the Society of Automotive Engineers (SAE) J-1772 standard, for both AC Level 1 and AC Level 2 charging. Refer to Appendix B for technical details.

Level 2 charging stations from different manufacturers.

Table 2.1 lists the different charging levels and corresponding power ratings, vehicle types and average charging rates most commonly found in residential applications. As indicated, vehicle charging rates, which translate to energy demand, vary from 3.3 kW to 19.2 kW per hour.

Type of Charging	Power Levels (installed circuit rating)	Miles of Range per Hour of Charging*
AC Level 1	110/120VAC at 15 or 20 Amps	~4-6 miles/hr.
AC Level 2		
3.3 kW (low)	208/240VAC at 30 Amps	8-12 miles/hr.
6.6 kW (medium)	208/240VAC at 40 Amps	16-24 miles/hr.
9.6 kW (high)	208/240VAC at 50 Amps	24-36 miles/hr.
19.2 kW (highest)	208/240VAC at 100 Amps	> 60 miles/hr.

* Refer to vehicle specifications for exact ratings.

Table 2.1 Charging levels for residential applications.

DC Fast Charging (DC Level 2) denotes a commercial-grade 440VAC or 480VAC device that uses direct current (DC) to charge a PEV to approximately 80 percent in under 30 minutes, assuming a 24 kWh battery. Additional information on the different connectors and standards is provided in Appendix B. See Section 7.1 for links to more information about charging at MuDs.

Figure 2.1 below shows how the energy demand of a PEV compares to other household appliances. A typical whole-house energy demand, or load, is approximately 5 kW.

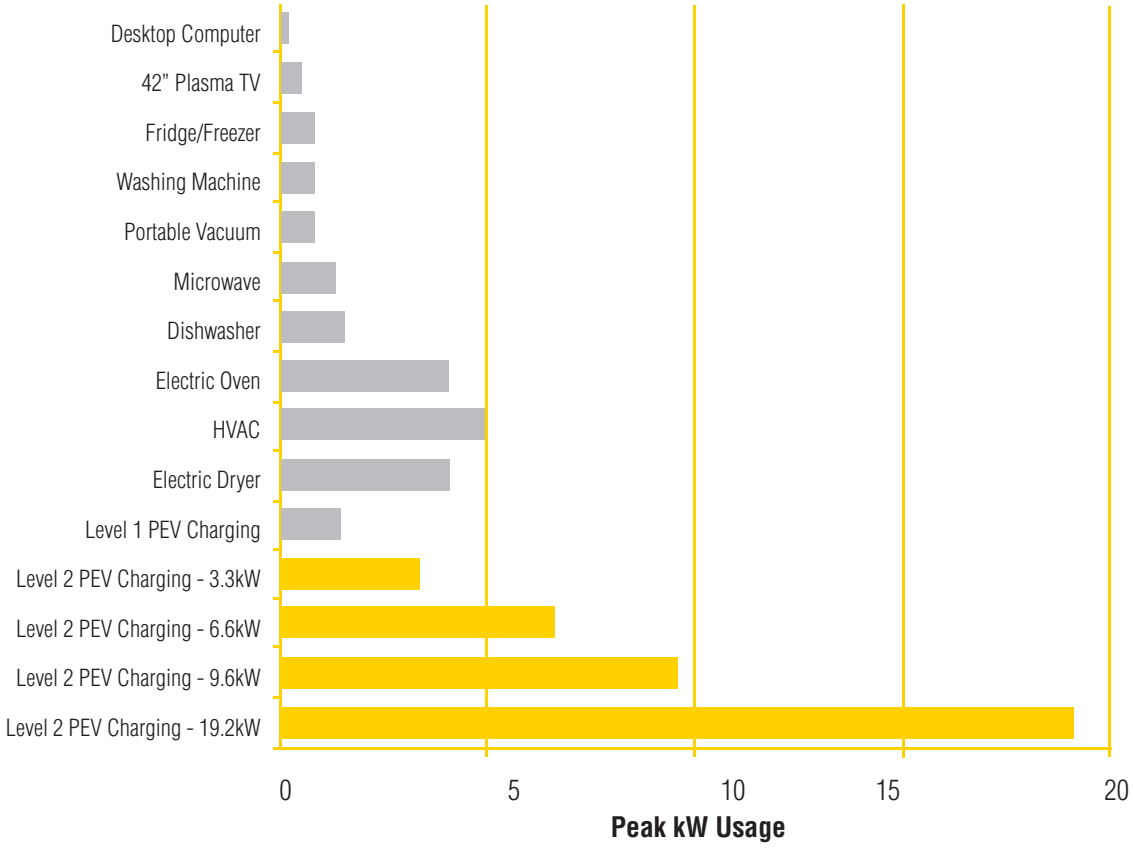


Figure 2.1. Typical PEV residential charging load compared to other household appliances.
Source: San Diego Gas & Electric.

3.0 Charging Equipment Installation Process

This section outlines five key steps and considerations for EVSE installations at MuDs.

Step 1. Conduct a Survey of Residents

Before installing EVSE, property managers may wish to assess their community's interest level in PEVs. The results of the survey can help establish an orderly and responsive approach to installing PEV charging. A no-cost survey template is available on the PEV Resource Center website at http://www.driveclean.ca.gov/pev/Charging/Home_Charging/Multi-unit_Dwellings.php

Step 2. Contact a Local Service Provider or Electrical Contractor

Property managers, or the individual who will be overseeing the installation of chargers at an MuD, should contact electric vehicle service providers (EVSPs) and/or local electrical contractors to discuss their charging needs. The EVSP or local contractor will develop a project estimate with specifications that inform the utility's distribution system analysis, as discussed in Section 5.1.

A broad spectrum of EVSE technologies and products is available to meet user's needs and budgets. See Sections 5.0 and 6.0 for discussion of cost factors.

Contact the local electric utility early in the process.

The market for EVSE continues to evolve. For example, chargers can now be ordered online from retailers such as Home Depot and Lowe's or purchased directly from EVSE manufacturers.

Make sure when choosing your EVSE that it is Nationally Recognized Testing Laboratory (NRTL) approved. A listing of NRTL approved EVSE can be found at: http://www.goelectricdrive.com/index.php/find-an-ev-charger

Step 3. Contact the Local Utility

It is important to contact the local electric utility early in the process. A utility's primary responsibility is to provide safe and reliable electric service to its customers. As part of this responsibility, utilities provide support and may offer special electricity rates for service to PEVs. When providing support, utilities typically focus on three key areas:

- *Determine if the local electrical distribution service is adequate to support the planned PEV charging activity.*
- *Provide information to the MuD property owner and PEV customers on utility rates.*
- *Advise customers about the electrical service and metering equipment options necessary to support their installations.*

Some electric utilities in California offer special rates for PEV charging based on the time-of-use (TOU). These rates are typically lower at night during off-peak hours, as shown in Figure 3.1. Off-peak charging helps avoid adding load to the electricity grid during high-usage, on-peak periods, which can increase strain on the electrical grid system and cause costs to rise. To take advantage of some TOU rates, separate electric meters for PEV chargers may be necessary.

Each utility's rates are different and can be found on their respective websites. See Section 7.2.

Step 4. Consider the Different Approaches to Installing EVSE

There are three basic approaches to installing EVSE. It can be installed:

- *By individual residents for their own use in coordination with the HOA/property manager.*
- *By property owners or HOAs as part of a facility amenity.*
- *By third parties (e.g., EVSPs) that are providing charging services to the community.*

Note that many residents of MuDs may not have their own electric meters, garages, or private parking arrangements. When electric metering is under the oversight of the HOA or property manager, installation will have to be coordinated with the many involved stakeholders, including the vehicle owner/resident, other residents, the property manager or HOA, the utility and the EVSP or electrical contractor.

Step 5. Contact Municipal Government for Permitting and Inspections

The final step is to obtain a permit from the municipal government, which may require one or more onsite inspections. EVSE installations generally require a building permit, electrical permit, or both. The municipal government's job is to ensure that electrical safety and building codes are observed and that the EVSE installation is safe. Permitting requirements, processes and fees will vary by community and by property type. The electrical contractor usually provides this service and facilitates the permitting process.

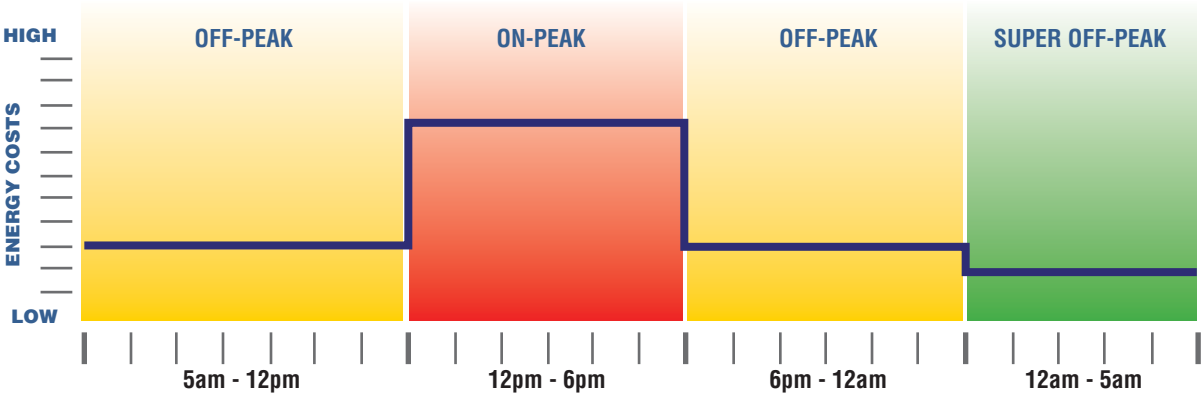


Figure 3.1. SDG&E time-of-use rate for PEVs.
Source: San Diego Gas & Electric.

Figure 3.2 outlines the EVSE installation process flow chart. The flow chart is color-coded to show where different stakeholders – tenants, property managers/owners, electricians, utilities and municipal governments – are involved in the process. Although the tenant/vehicle owner/resident is only shown in the first and last steps, he or she would typically provide input at every step along the way. The property owner/manager is involved most often with decisions affecting the installation specifics and approvals.

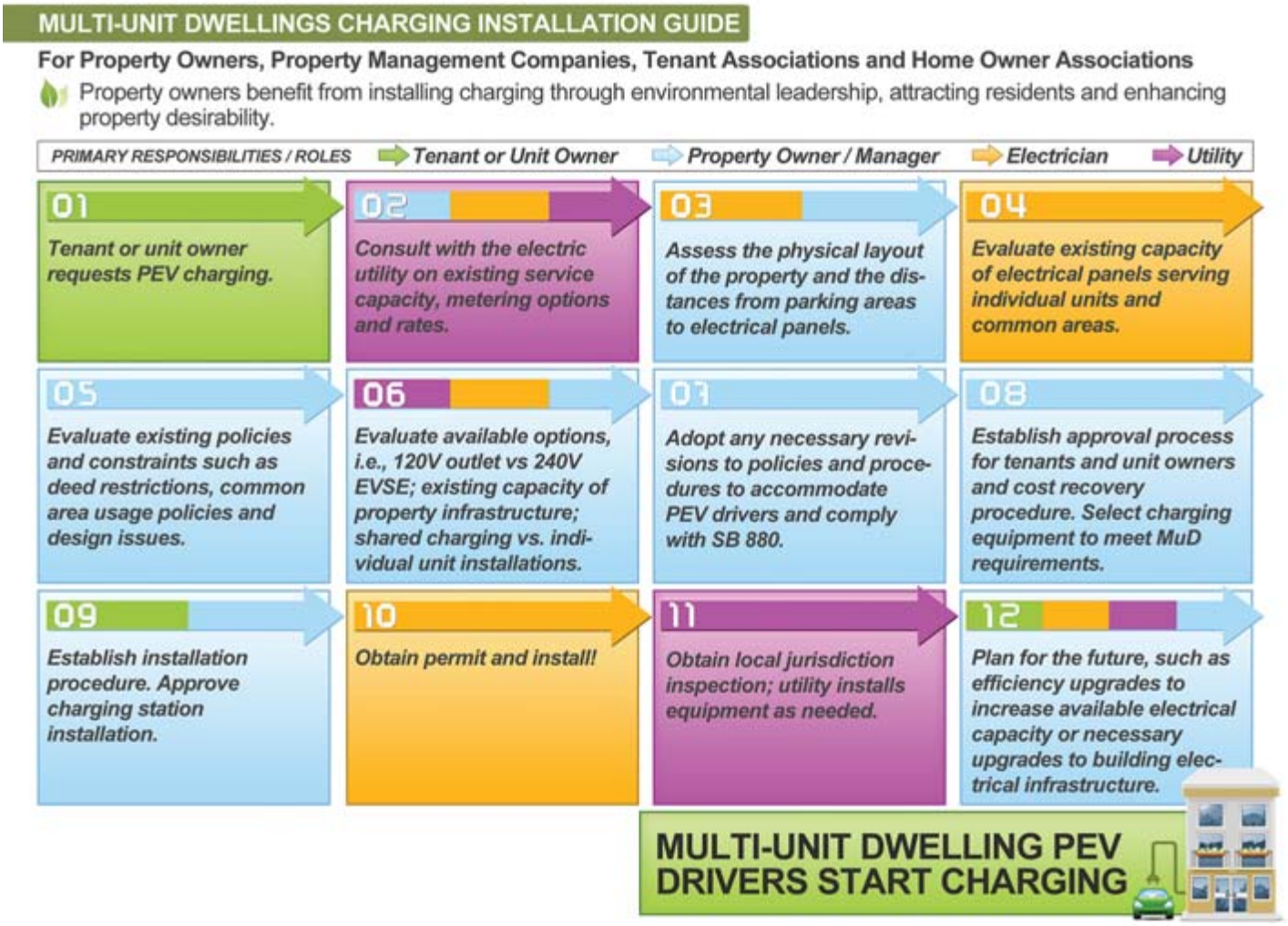


Figure 3.2. Typical PEV charging station installation process flow in MuDs.
Source: California Plug-In Electric Vehicle Collaborative. Original source materials developed by San Diego Gas & Electric and Sacramento Municipal Utility District for the Electric Power Research Institute.

California Senate Bill 880

California Senate Bill 880 protects the rights of MuD residents, affirming, "It is the policy of the state to promote, encourage, and remove obstacles to the use of electric vehicle charging stations."
The legislation makes it illegal to impose any condition that "effectively prohibits or unreasonably restricts" installation of charging in an owner's designated parking space. If the charging unit is installed in a common area, a variety of conditions can be imposed, including a $1 million homeowner liability policy that names the association as an additional insured. To view SB 880, go to:
http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0851-0900/sb_880_bill_20120229_chaptered.pdf

4.0 Considerations for Charging Station Installations in MuDs

The scope of work for EVSE installations varies with the type of MuD. There are two major variables. First is the building architecture and its physical electrical design. Second is the residents' parking space allocation or ownership model. These variables and the overall scope of work are important because they affect the cost and difficulty of the EVSE installation project. Cost factors are covered in detail in Sections 5.0 and 6.0.

4.1 Building Architecture and Physical Electrical Design

The following descriptions highlight issues associated with the building architecture and physical electrical design of the majority of parking situations at MuDs. Note that many MuD designs can be hybrids of the three property types discussed below.

Garden Apartments, Low-rise Condominiums and Mobile Homes

The primary issue with garden apartments, condominiums and mobile homes is that the electrical service room is not always in close proximity to the desired charging location. Furthermore, if the installation entails trenching or asphalt and cement excavation, costs will increase. The cost of such work can easily exceed the cost of the EVSE unit itself. To minimize these expenses, EVSE should be located as close to the electrical service access points as possible. Disturbing hardscapes should also be avoided whenever possible.

Mid- and High-rise Apartments or Condominiums with Multi-level Parking Garages

Multi-level apartment in Oakland.

Most garages have very limited electrical capacity near the assigned or deeded parking. Electrical loads for these structures were usually designed for garage lighting and elevators. In such circumstances, an electrical service upgrade may be required to support the electrical load for vehicle charging. Such upgrades will require coordination of the electrical contractor with the local utility. Boring through garage walls or parking decks is usually a costly process requiring services of a structural engineer. On the positive side, low-cost surface-mounted conduit for circuit wiring is usually visually acceptable in a garage.

Mid- and High-rise Apartments or Condominiums Without Parking Structures

On-street public charging adjacent to a San Diego condominium.

When residents do not have assigned on-site parking and instead rely on street or off-site parking, arranging EVSE installation can be a major challenge to owning a PEV. Ideally, the property owner or manager will create parking with EVSE provided as a shared community resource. However, creating new parking or rededicating existing parking spaces is not always possible. The problem may be addressed if the resident has access to and wishes to consider charging at his or her workplace or at public charging stations. Another possibility is to arrange for the use of nearby business or commercial chargers, which may be available after business hours. These options are not usually viewed as ideal arrangements.

4.2 Parking Ownership Models

This section discusses implications of residents' parking space allocation and ownership models on PEV charging infrastructure installation.

Assigned Parking

Most residents of MuDs have assigned parking spaces, with common area parking provided for their additional vehicles and visitors. This assigned parking model may support a PEV owner's need for guaranteed access to charging, as long as the assigned parking space is reasonably close to an electrical service access point. If the PEV owner/resident's assigned parking space is far from an electrical service access point, EVSE installation costs will increase. A possible solution in such situations is to swap assigned parking among residents. Residents may be protective of their parking spaces, so good communications and negotiation skills are helpful. An alternative to reassigning private parking spaces may be to install the EVSE in common area parking spots, which can then be traded with or reassigned to the PEV owner. This solution is not always ideal because common area parking is usually in high demand, is often uncovered and may be far from the PEV owner's living quarters. It is important for the property manager and PEV owner to work together to seek mutually agreeable solutions.

Common Area Parking

Installing charging stations in common parking areas is another possible solution that can allow several residents to share a charging station. An advantage of this scenario is that common area parking is usually located closer to an electrical service access point, creating a lower-cost EVSE installation. However, it may be less convenient for PEV owners if this common area is not in close proximity to their living quarters. It may also require more scheduling and coordination. Another consideration for this type of arrangement may be the potential requirements for Americans with Disability Act (ADA) access to both parking and charging. Voluntary guidelines are being developed by the Governor's Office to address ADA. Visit the PEV Resource Center to get the latest information at: http://www.driveclean.ca.gov/pev/Charging/Home_Charging/Multi-unit_Dwellings.php

Deeded Parking

Many of the same issues as those discussed above can occur in deeded parking models, with the additional complication of residents owning their parking spots. Developing a workaround solution may be even more challenging since any permanent change of parking locations requires a legal transfer of property. Because different parking locations can have different value based on resident/owner convenience and preferences, this solution may also involve negotiation among residents/owners.

5.0 Ownership Costs

The variety of MuD property architectures, access to electric service, parking models, and the associated EVSE installation approach all affect the cost and financial arrangements between property owners and PEV owner/resident. In some cases, the individual PEV owner is asked by the MuD property owner or HOA to pay for his or her own EVSE installation, provided certain requirements are met to protect the property owner or HOA. However, in many cases the cost of installing EVSE is prohibitive, given the distance from the desired charging location to an available electric service access point. To avoid high-cost scenarios, creative workaround solutions are often developed to make installations more affordable and acceptable to both residents and property management.

5.1 EVSE Installation and Construction Costs

The primary cost factors are:

- *EVSE purchase and installation costs.*
- *Adequate building wiring electrical capacity.*
- *The distance between the electrical service access point and the desired charging site or sites and other construction requirements.*
- *Transformer and/or service capacity serving the community.*

These cost factors constrain the design of an EVSE installation in ways that may require engineering tradeoffs. These tradeoffs, in turn, determine the overall cost and design of the installation. The following paragraphs discuss each primary cost factor to help inform the property owner of potential cost tradeoffs. Figure 5.1 on the next page provides the relative costs of EVSE installation scenarios.

EVSE Purchase and Installation Costs

The costs associated with the purchase and installation of EVSE include:

Buying the EVSE: A broad spectrum of EVSE technologies is available. They range from those that are basic to those that provide more services such as billing operations, user scheduling and energy management to reduce electric utility peak demand chargers. The cost is proportional to the features provided by each and can range from less than $1,000 to more than $6,000. In addition to the costs of buying the EVSE, some units with network billing capability may require upfront network activation fees, licensing fees, or monthly network access fees. The cost of these types of services should be reviewed in detail prior to making any decisions on the financial recovery model.

Permitting costs: Permitting fees vary from jurisdiction to jurisdiction and are non-negotiable. Contact the local jurisdiction or ask the electrical contractor for that information. Usually, contractors will also apply for required permits and coordinate inspections.

Electricity metering costs and approaches: Electricity metering can impact cost depending on infrastructure design and the cost recovery model selected for the property. Each utility's approach to metering electricity dedicated to PEV charging varies. Many utilities offer residential off-peak rates to encourage charging overnight when electricity costs are lower and to help reduce grid impacts.

Adequate Building Wiring and Electrical Capacity

The capacity to support new EVSE wiring and panels typically depends on the original electrical design at the time the building was constructed. Some properties may not have adequate panel sizing and breaker space to supply EVSE units because the original electrical design never anticipated additional loads. In most cases, the electrical contractor can install a second panel from a parallel electrical service. This second panel is typically dedicated to future EVSE installations and allows the EVSE wiring to be managed in an organized fashion. Another option is to consider AC Level 1 charging with 120VAC for some PEV charging. If 120VAC power can suffice (e.g., PHEVs, low mileage BEV drivers, etc.), more charging can then be made available for similar costs.

Point-to-Point Distance

In general, the greater the distance between the electrical service access point and the desired charging site or sites, the higher the cost. Other construction requirements, such as trenching, add to the cost. Trenching through asphalt is much more expensive than through green space. Surface-mounting conduit may be an option in a parking garage but not in other parking locations. Whereas the tradeoff between AC Level 1 and AC Level 2 charging can save cost in other areas, the cost for trenching and buried conduit is almost the same in either case.

Transformer Capacity

After reviewing the electrical design for the charging stations on the property, the local utility can determine if the transformer serving the site needs to be upgraded. If a service upgrade is required, the utility will work with the property owner to determine allowances and expenses based on utility policy as regulated by the California Public Utilities Commission.

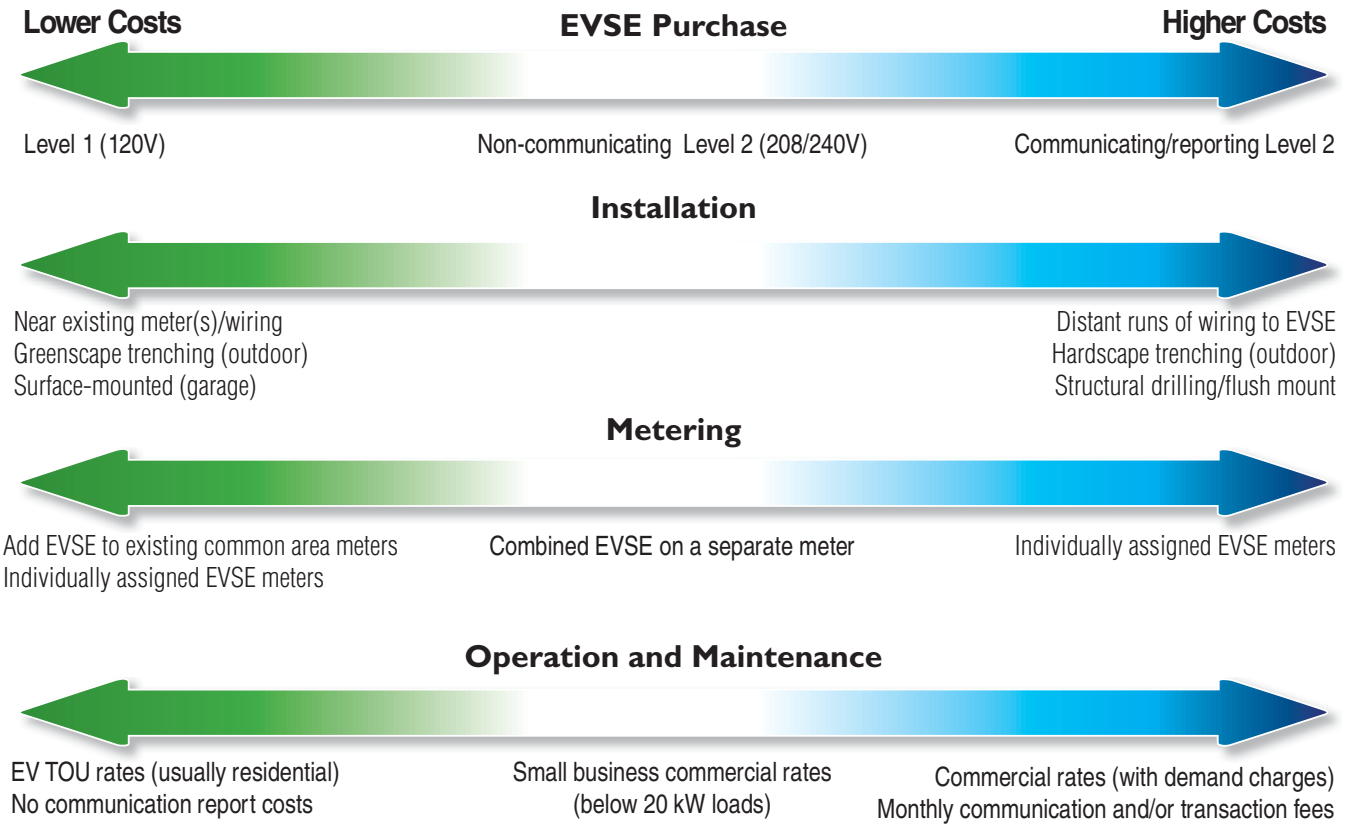


Figure 5.1. Relative costs of EVSE installation scenarios.

5.2 Operating and Maintenance Costs

The cost of electricity is the most obvious ongoing operating expense. A BEV driven an average of 12,000 miles per year will cost approximately $450 a year to fuel, assuming an electricity rate of 15 cents per kilowatt-hour (kWh), excluding any additional charges. This expense is based on a vehicle efficiency of approximately 4 miles/kWh. Efficiency varies by vehicle model and driving style. Most light-duty passenger vehicles will operate in the range of 3 to 4 miles/kWh.

The electric service rate options available to EVSE users vary, depending upon whether an EVSE installation is classified as residential or commercial. The building architecture and parking ownership also affect the classification and available rates. Property owners who cover the cost of charging electric vehicles in a common area will want to evaluate any demand charges that might apply to their commercial electric rates and plan to recover those costs as well. The local electric utility can assist with this billing analysis.

Other operational costs may include monthly EVSE network access fees, if those types of communication services are used for the EVSE units.

Unanticipated maintenance costs can also arise when charging equipment is faulty or damaged. Driving over a connector handle, backing a vehicle into a charging unit, or vandalism are examples of the kinds of damage that will require maintenance.

6.0 Financial Recovery Models and Technology Solutions

A variety of cost recovery business models cover almost any type of PEV charging scenario. Likewise, various metering options and charging technologies support a multitude of business plans. When developing a business plan for cost recovery, it is important to distinguish between an individual residential EVSE design and a common-use EVSE design. This differentiation is particularly important considering how utility rates can differ between residential and commercial accounts. In addition, property owners and managers who wish to install charging stations must understand the legal, regulatory and other requirements that may be set forth by authorities having jurisdiction.

For most MuD properties, determining whether to use an Electric Vehicle Supply Provider (EVSP), or to become an EVSP, is an important aspect of their financial recovery plan. Some specialty EVSPs can offer contracted charging support services at any level to support MuDs. Alternatively, MuD properties can install their own charging equipment and become EVSPs themselves. Hybrid models present other options, in which MuD properties can install their own charging hardware, for example, and then contract with a specialty service provider for certain aspects of business operations such as energy tracking and back-office billing. Still other third-party EVSPs can provide turnkey operations and flat monthly billing packages to residents on behalf of a property manager or HOA.

California law prohibits the resale of electricity; however, EVSPs enjoy special rights in investor-owned utility (IOU) service territories. The California Public Utilities Commission ruled that EVSPs may establish financial recovery models for PEV charging that are independent of the electricity costs charged by the utility. MuDs in California IOU service territories have similar rights and may establish their own cost recovery models for the conveyance of electricity for PEV charging. The three major California IOUs are Pacific Gas and Electric, San Diego Gas & Electric and Southern California Edison.

The law does not apply to publicly owned utilities (POUs); however, and some may restrict the resale of electricity in their service territories, limiting the ability of a MuD property owner to establish his own cost recovery model. Individual POUs may have additional restrictions that limit other types of energy conveyance business models. In such cases, flat-fee charging services (by the hour or by the month) may be acceptable to the POU since it avoids a financial transaction based solely on the energy consumption. Or, the POU may require that its energy rate be passed directly to the resident. In such cases, the MuD property owner may choose to recover their infrastructure costs through some other non-energy related fee structure.

Property managers should check with their local utility to determine the applicable rules and regulations.

The following paragraphs describe typical cost recovery models for different installation scenarios.

6.1 Cost Allocation Scenarios

Scenarios for allocating costs vary today and will continue to vary as new technologies and new service business models enter the marketplace over time.

Installing Individually Assigned Charging Units

Individually assigned units wired directly to the existing residence panel meter (resident is the electric utility customer of record)

This scenario assumes the PEV owner pays to have his or her own 120VAC outlet or charging unit installed, electricity comes from the living unit's wiring, and the PEV owner is billed directly by the utility for the electricity. The individual's charging unit can either be wired through a separate electric meter or added to the existing meter for the living unit. Access to the EVSE can be secured through mechanical or electronic lock, or by using a 120VAC or 240VAC valet-removable unit to prevent someone other than the PEV owner from charging at the site. The charger can be located in an assigned or deeded parking space or in a common area through agreement under the provisions of California SB 209/ SB 880 for charging units in a common area.

EVSE-specific meters in a MuD meter room.

Individually assigned units with separate vehicle metering or sub-metering (property owner/HOA is the electric utility customer of record)

This scenario assumes that the PEV owner pays to have his own 120VAC outlet or charging unit installed, or that the property owner is not trying to recover the installation cost. Metering options vary by utility. Access security and fixed cost recovery are identical to the situation described above.

Individually assigned units with separate vehicle metering or sub-metering (resident is the electric utility customer of record)

In a variation of the above scenario, the property owner/HOA may install a bank of new service meters and individually assign them to residents who own PEVs. The PEV owner becomes the customer of record and pays a fee to the property owner/HOA to cover his portion of the capital expense of putting in the meters. Each PEV owner gets his individual bill from the utility and buys his own EVSE for his parking space.

Individually assigned units with networked EVSE and embedded metering (property owner/HOA is the electric utility customer of record)

Some advanced charging units come equipped with cell phone or Wi-Fi communication capability and can monitor and report charging use. Currently, energy usage cannot be billed back directly to the customer through the local electric utility. These systems provide the property owner a means of determining individual charging use in order to bill the resident accordingly. The property owner can set a cost recovery rate to cover the installation, energy and network access costs that are incorporated and shared by the usage fees.

Individually assigned units wired into the common area electrical service with no metering (property owner/HOA is the electric utility customer of record)

Under this scenario, the operating costs are covered by some type of flat fee added to the rent, lease or HOA assessment. The property owner/HOA can set the cost recovery rate to cover the installation, energy and network access costs.

Third-party service provider to MuD property (utility customer of record is determined by agreement)
In this scenario a third-party vendor enters into a contract with the property owner/HOA to provide services to residents. Individually assigned charging units are provided to residents for a monthly fee according to a selected menu of services.

Installing Shared Charging Units

Common area 120VAC outlets or non-networked charging units for multiple PEV owners (property owner/HOA is the electric utility customer of record)
Under this scenario, charging units are installed in common area parking spaces and multiple PEV owners have access to them. Access security is through the honor system or mechanical or electronic locks. PEV owners can coordinate or schedule charging among themselves through an informal agreement, a sign-up process or an electronic calendar. A flat fee can be added to the rent, lease or HOA assessment to cover operating costs.

Common area networked charging unit for multiple PEV owners, (property owner/HOA is the electric utility customer of record)
Under this scenario, a PEV driver can access a networked EVSE through a subscription service, electronic ID card or credit card. The driver can pay a monthly flat fee for unmonitored, unlimited use, or pay for electricity usage, which is tracked electronically. In some instances, the property owner/HOA may prefer to act as an intermediary between the PEV owner and the EVSP. The costs can be allocated either directly to a PEV owner's subscription service or to property management for periodic billing to the resident.

These tracking and billing capabilities exist in today's higher-cost systems. New technologies are also being developed to provide these services through specially equipped 120VAC cordsets, or through local computer interface control programs that enable access to non-communicating charging units. Such a local controller could be a touch screen in a garage or another networked device that requires a user password or ID card.

Third-party service provider to MuD property (utility customer of record is determined by agreement)
Same as above but charging service is provided by a third party under agreement with property manager/HOA.

6.2 Cost Allocation Enhancements

Scenarios for allocating costs will continue to evolve. For example, one shared use enhancement could be to bill for the amount of time a vehicle is actually connected to a charging unit rather than for active charging time. This approach would encourage a driver to move his vehicle away from a charging station as soon as charging is complete to avoid incurring a use fee. This enhancement would change the billing currency to one that is based on time rather than one based on energy. As such, it would increase revenue potential and encourage users to not monopolize a charger longer than necessary. Another enhancement could make use of an online reservation capability, enabling scheduling of charging sessions and predetermined "friendly disconnection times," as indicated by the charging system.

7.0 Other Information Sources

This section lists websites and other information sources on PEVs, charging and MuDs.

7.1 Charging at MuDs

PEV Resource Center MuD page http://www.driveclean.ca.gov/pev/Charging/Home_Charging/Multi-unit_Dwellings.php

U.S. Clean Cities Coalition MuD Training Video
http://www.youtube.com/watch?v=hBwHIIIVdtc&feature=share&list=UUekDhe50SU1Mg65iOICjaGw

UCLA Luskin Center, *Addressing Challenges to Electric Vehicle Charging in Multi-family Residential Buildings*, June 2011
http://luskin.ucla.edu/ev

California Plug-In Electric Vehicle Collaborative Resources for MuDs
http://www.pevcollaborative.org/MuD

California Plug-In Electric Vehicle Collaborative Communication Guide *How Do Multi-unit Dwellings Become PEV Ready?*
http://www.pevcollaborative.org/sites/all/themes/pev/files/Comm_guide6_122308.pdf

7.2 Utility Websites

San Diego Gas & Electric http://www.sdge.com/electric-vehicles
Prepping for Plug-in Vehicles at Condos, Townhomes and Apartments
http://sdge.com/documents/prepping-multi-units-plug-vehicles

Video of MuD approaches in San Diego
http://www.youtube.com/watch?v=hBwHIIIVdtc&feature=share&list=UUekDhe50SU1Mg65iOICjaGw

Quarterly workshop schedule and registration http://seminars.sdge.com

Southern California Edison https://www.sce.com/wps/portal/home/residential/electric-cars
Multi-Family Dwellings: Electric Vehicle Charging
https://www.sce.com/wps/portal/home/business/electric-cars/charging-stations-for-tenants
and http://www.sce.com/EV4Business

Pacific Gas and Electric http://www.pge.com/electricvehicles/

SMUD https://www.smud.org/en/residential/environment/plug-in-electric-vehicles/

Los Angeles Department of Water and Power
https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_adf.ctrl-state=13xgajhtgq_21&_afrLoop=569162515414154

7.3 Grant Opportunities

Grant opportunities arise periodically to support charging equipment and installation. In some regions, installation contractors or other parties (including government agencies) have applied for grants to support PEV activities. Visit the websites below or contact the local or regional planning agency, utility or an EVSP for additional information on available funding, existing programs and whom to contact.

PEV Resource Center, http://www.driveclean.ca.gov/pev/

California Energy Commission, http://www.energy.ca.gov/drive/

7.4 General PEV Information

PEV Resource Center
http://www.driveclean.ca.gov/pev/

Go Electric Drive
http://goelectricdrive.com

Governor's Office of Planning and Research
ZEV Community Readiness Guidebook http://www.opr.ca.gov/s_zero-emissionvehicles.php

Ready, Set, Charge, California!
http://baclimate.org/impact/evguidelines.html

U.S. Department of Energy (DOE) Alternative Fuels & Advanced Vehicle Data Center
http://www.afdc.energy.gov/fuels/

Hybrid and Plug-In Electric Vehicles, http://www.afdc.energy.gov/pdfs/52723.pdf

Plug-In Electric Vehicle Handbook for Consumers, http://www.afdc.energy.gov/pdfs/51226.pdf

Plug-in Electric Vehicle Handbook for Fleet Managers, http://www.afdc.energy.gov/pdfs/pev_handbook.pdf

Plug-In Electric Vehicle Handbook for Public Charging Station Hosts, http://www.afdc.energy.gov/pdfs/51227.pdf

Clean Cities Program
http://www.afdc.energy.gov/cleancities/coalitions/coalition_locations.php

Electric Power Research Institute (EPRI)
http://www.epri.com/Our-Work/Pages/Electric-Transportation.aspx

Plug In America
http://www.pluginamerica.org/

California Center for Sustainable Energy (CCSE)
http://energycenter.org/index.php/incentive-programs/clean-vehicle-rebate-project/cvrp-project-statistics

Appendix A: Definitions

AC Level 1 EVSE:
Alternating current Level 1 electric vehicle supply equipment unit that uses a standard 110/120-volt alternating current (VAC) three-prong wall outlet. No other connection is needed. The charging energy provided is approximately 1.2 to 1.4 kilowatts (kW) per hour. A Toyota Prius Plug-in can fully recharge its small battery using an AC Level 1 EVSE unit in three to five hours. Level 1 charging is usually accomplished using a portable cordset that is provided with the vehicle.

AC Level 2 EVSE:
Alternating current Level 2 electric vehicle supply equipment that uses 208/240VAC electricity through a hardwired or heavy-duty plug connection (like a stove or dryer). Level 2 charging is typically used for plug-in electric vehicles with higher energy demands, such as battery-electric vehicles. Charging energy can vary from 3.3 kW to 19.2 kW per hour. The onboard vehicle charger will determine the level at which the vehicle can charge, and the installation should be matched to those requirements. With the exception of the Tesla Model S, which charges at a higher level, most light-duty passenger vehicles currently charge at either 3.3 kW or 6.6 kW levels. For example, a fully depleted BEV with a 24 kWh battery can be fully recharged using an AC Level 2 EVSE (at 3.3 kW) in approximately six hours, and at 6.6 kW can be charged in a little more than three hours. (24 kWh battery ÷ 6.6 kW = 3.6 hours to charge. Note that there will be some variation.) AC Level 2 EVSE should be installed by a qualified electrician.

BEV:
Battery-electric vehicles are 100 percent electric vehicles and have no internal combustion engine. The wheels are powered by electric motors and use batteries for electric energy storage of grid electricity (e.g., Nissan LEAF, Ford Focus EV, Tesla Model S).

DC Fast Charging (DC Level 2):
DC Fast Charging denotes a commercial-grade 440/480VAC device that is capable of recharging a PEV using direct current (DC) to approximately an 80 percent battery charge in under 30 minutes for a 24 kWh battery size. This level of charging is sometimes erroneously called Level 3. There are two standards for the connectors that plug into the vehicle from DC Fast Charging units. They are the SAE Combination Charge System (CCS) connector adopted by most U.S. and European auto manufacturers, or the CHAdeMO connector adopted by Japanese manufacturers.

EV:
Electric vehicle, sometimes called 100 percent electric vehicle, all-electric vehicle, or battery-electric vehicle. EV is most commonly used to describe vehicles that use electricity only. However, EV is sometimes used to denote *any* vehicle that plugs in for fueling, including plug-in hybrids, which have an internal combustion (gasoline) engine in addition to an electric motor. The distinction between plug-in hybrids and all-electric vehicles is important because they have different energy and charging needs.

EVSE:
Electric vehicle supply equipment is a term described in National Electrical Code (NEC) 625 and is more commonly called a charger, charging unit, or charging station. It is connected to a facility's electrical system and is used to charge the car. Typically, the "charger" -- the mechanism for converting alternating current (AC) to direct current (DC) that is required to charge a battery -- is actually onboard the vehicle. The EVSE unit simply provides the electricity grid connection and electrical safety and power theft prevention features. Many manufacturers build EVSEs, including General Electric, Leviton, Siemens, ChargePoint, ECOtality, Clipper Creek, AeroVironment, SPX, Eaton and Gridbot.

EVSE units can provide a range of different power levels (see Table 2.1 and Appendix B). Some are simple, providing no more than basic grid connectivity. Others are much more complex, with Wi-Fi or cellular communication, billing and even reservation capabilities.

EVSP:
Electric vehicle service provider. Broadly speaking, an EVSP is a business that provides vehicle-charging services (e.g. , EVSE installation, contracting, billing, network support, etc.). An EVSP can also refer to a multi-unit dwelling owner/homeowner association/property manager that provides charging services for residents.

HOA:
A homeowner association is an organization of the homeowners of an individual condominium or planned unit development. The purpose of an HOA is to provide a common basis for preserving, maintaining and enhancing the community residents' homes and property. Most HOAs are nonprofit corporations. They are subject to state statutes that empower them to govern resident activities, levy assessments and impose fines. Usually, each member of an HOA pays a monthly assessment to support maintenance of common property.

IOU:
Investor-owned utility is a utility owned by private investors as a for-profit venture. An IOU relies on a state government regulatory commission for operational policy guidance and consumer protection. In California, the three major IOUs are Pacific Gas and Electric, San Diego Gas & Electric, and Southern California Edison. The regulatory commission that guides the three IOUs' operation policies is the California Public Utilities Commission (CPUC).

MuD:
Multi-unit dwellings (also known as multi-family residences or multi-family dwelling units) are a classification of housing where multiple housing units are contained within one building or multiple buildings within a complex/community. Some MuDs are owned (e.g., condominiums), while others are leased or rented. Some common types of MuDs are duplexes, townhomes, apartments, condominiums, mobile homes and manufactured-home parks.

PEV:
Plug-in electric vehicle, a generic term inclusive of both battery-electric vehicles (BEVs) and plug-in hybrid-electric vehicles (PHEVs).

PHEV:
Plug-in hybrid electric vehicle, sometimes called a plug-in hybrid, has an onboard internal combustion engine, as well as an electric motor (e.g., Chevrolet Volt, Toyota Prius Plug-in, Ford C-MAX Energi). The internal combustion engine allows the vehicle to drive beyond all-electric battery range. Note that General Motors describes the Volt as an extended-range electric vehicle (EREV). PHEVs have both a plug and a tailpipe.

POU:
Publicly owned utility is a utility collectively owned by residents of the area served by the utility. POUs can include municipal utilities, city governments, co-ops (rural, industrial, and others) and energy power marketing authorities. These entities rely on their own publicly elected officials to provide operational policies and consumer protection.

Appendix B:

EVSE Connector Standards and Technical Information

SAE Charging Configurations and Ratings Terminology

AC level 1
(SAE J1772™)

PEV includes on-board charger
120V, 1.4 kW @ 12 amp
120V, 1.9 kW @ 16 amp
Est. charge time:
PHEV: 7hrs (SOC* - 0% to full)
BEV: 17hrs (SOC – 20% to full)

AC level 2
(SAE J1772™)

PEV includes on-board charger (see below for different types)
240 V, up to 19.2 kW (80 A)
Est. charge time for 3.3 kW on-board charger
PEV: 3 hrs (SOC* - 0% to full)
BEV: 7 hrs (SOC – 20% to full)
Est. charge time for 7 kW on-board charger
PEV: 1.5 hrs (SOC* - 0% to full)
BEV: 3.5 hrs (SOC – 20% to full)
Est. charge time for 20 kW on-board charger
PEV: 22 min. (SOC* - 0% to full)
BEV: 1.2 hrs (SOC – 20% to full)

DC Level 1
(SAE J1772™)

EVSE includes an off-board charger
200-500 V DC, up to 40 kW (80 A)
Est. charge time (20 kW off-board charger):
PHEV: 22 min. (SOC* - 0% to 80%)
BEV: 1.2 hrs. (SOC – 20% to 100%)

DC Level 2
(SAE J1772™)

EVSE includes an off-board charger
200-500 V DC, up to 100 kW (200 A)
Est. charge time (45 kW off-board charger):
PHEV: 10 min. (SOC* - 0% to 80%)
BEV: 20 min. (SOC – 20% to 80%)

Voltages are nominal configuration voltages, not coupler ratings
Rated Power is at nominal configuration operating voltage and coupler rated current
Ideal charge times assume 90% efficient chargers, 150W to 12V loads and no balancing of Traction Battery Pack

*Notes:
1) BEV (25 kWh usable pack size) charging always starts at 20% SOC, faster than a 1C rate (total capacity charged in one hour) will also stop at 80% SOC instead of 100%
2) PHEV can start from 0% SOC since the hybrid mode is available.

ver. 10162012

There are two different DC Fast Charger connectors used for DC Fast Charging, each different from the standard connector used for AC Level 1 and AC Level 2 charging. The United States and Europe in 2012 adopted a connector standard known as the SAE Combined Charging System (CCS). The CCS connector will be first made available in 2013 on some U.S. and European model-year 2014 PEVs (e.g., Chevrolet and BMW). Two Japanese manufacturers of light-duty passenger cars currently use a different connector that conforms to the Japanese CHAdeMO standard (e.g., Nissan and Mitsubishi).

Appendix C: Building Codes and Standards

National Electrical Code

The National Electrical Code (NEC), sometimes called NFPA 70, is a set of recommended standards for the safe installation of electrical wiring and equipment in the United States. The NEC is updated and published every three years by the National Fire Protection Association (NFPA). The 2011 NEC is the current edition (effective date August 25, 2010).

States and municipalities can adopt the NEC as enforceable standards for their jurisdictions. Most states adopt the most recent edition within two years of its publication. In California, the California Electric Code (CEC) of 2010 references the 2008 NEC.

NEC Article 625 specifically defines and references EVSE and its installation. The current version includes several temporary interim amendments (TIAs) that address issues such as 240VAC cord connection. These TIAs are expected to be finalized in the 2014 NEC.

EVSE is defined in NEC Article 625.2 as:

"The conductors, including the ungrounded, grounded, and equipment grounding conductors and the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle."

Local jurisdictions may adopt the NEC wholesale or with their own interpretations. Always check with local "authorities having jurisdiction" (AHJs) for applicable codes, interpretations, inspections and fees. A licensed electrical contractor is usually the best source for this information. The electrical contractor can usually coordinate fee payments, permit applications, inspection scheduling and so on.

Voluntary New Construction and Green Building Code

The 2010 California Green Building Standards Code (CALGreen) is the first statewide "green" building code in the United States. It is directed toward state-owned buildings and those regulated by the Division of the State Architect. The provisions referencing electric vehicle charging conduits and parking are voluntary for both residential and nonresidential measures.

Additional information on these voluntary standards and their references to EVSE can be found at the website for the California Building Standards Commission, http://www.bsc.ca.gov/Home/CALGreen.aspx.

Appendix D: Case Studies

Built in 1993 in the Marina District of downtown San Diego, **CityFront Terrace** is the largest brick building on the West Coast. The 13-story facility was designed to incorporate the historic 1920s-era Citrus Soap Factory into its structure. Amenities include two swimming pools, a 3,500-square-foot fitness center, a conference room and the expansive "Citrus Room" available for private events. Secure underground assigned parking for residents, optional valet parking and a 24-hour lobby attendant are provided in this privately managed community.

CHARGING SNAPSHOT

No. of residential units: **320**

No. of parking spaces: **417**

No. of residents driving PEVs: **2**

Number of charging stations and types: **Level 2 - 1 installed and 19 pre-wired individual electric meters available for Level 2.**

CHARGING STORY

Charging setting

CityFront Terrace offers plug-in electric vehicle (PEV) charging infrastructure to its residents on a cost-recovery basis.

Decision-making process

Residents began to inquire in 2011 about charging station options for PEVs they were planning to purchase. After attending a San Diego Gas & Electric (SDG&E) Multi-unit Dwelling Vehicle Charging Workshop, the community manager and facility manager presented information to the board of the homeowners association (HOA).

Property management and residents sought a billing solution that would allow residents to pay directly for their own energy usage, without the property managers having to track usage or collect payments. They also wanted residents to be able to individually select and own their charging unit. Management knew that having PEV charging would allow the community to market its new green amenity.

Charging implementation and management

Under a compromise plan, CityFront Terrace agreed it would install 20 individual meters, wired directly to the utility side of the building electrical supply via one of the main buses. Wiring hubs on each floor of the parking garage would ensure that wiring could be extended to individual parking places. Each resident requesting PEV charging would pay an equal portion of the upfront capital expenditure for the project and purchase their own charging unit for installation in their parking space. By owning their unit, residents could take it with them when they move. Each resident would secure the required liability insurance referenced under California SB 880 since these units would be located within a "common area."

Charging costs

Under the chosen arrangement, each resident receives their monthly bill directly from SDG&E and sees firsthand their individual charging behavior and resulting cost savings from the utility's discount electric vehicle time-of-use (EV TOU) rates.

Although the project was capital-intensive up front – it cost approximately $80,000, or $4,000 per meter – the residents concurred that the investment would return value to the HOA over time.

Multi-unit dwelling charging challenges

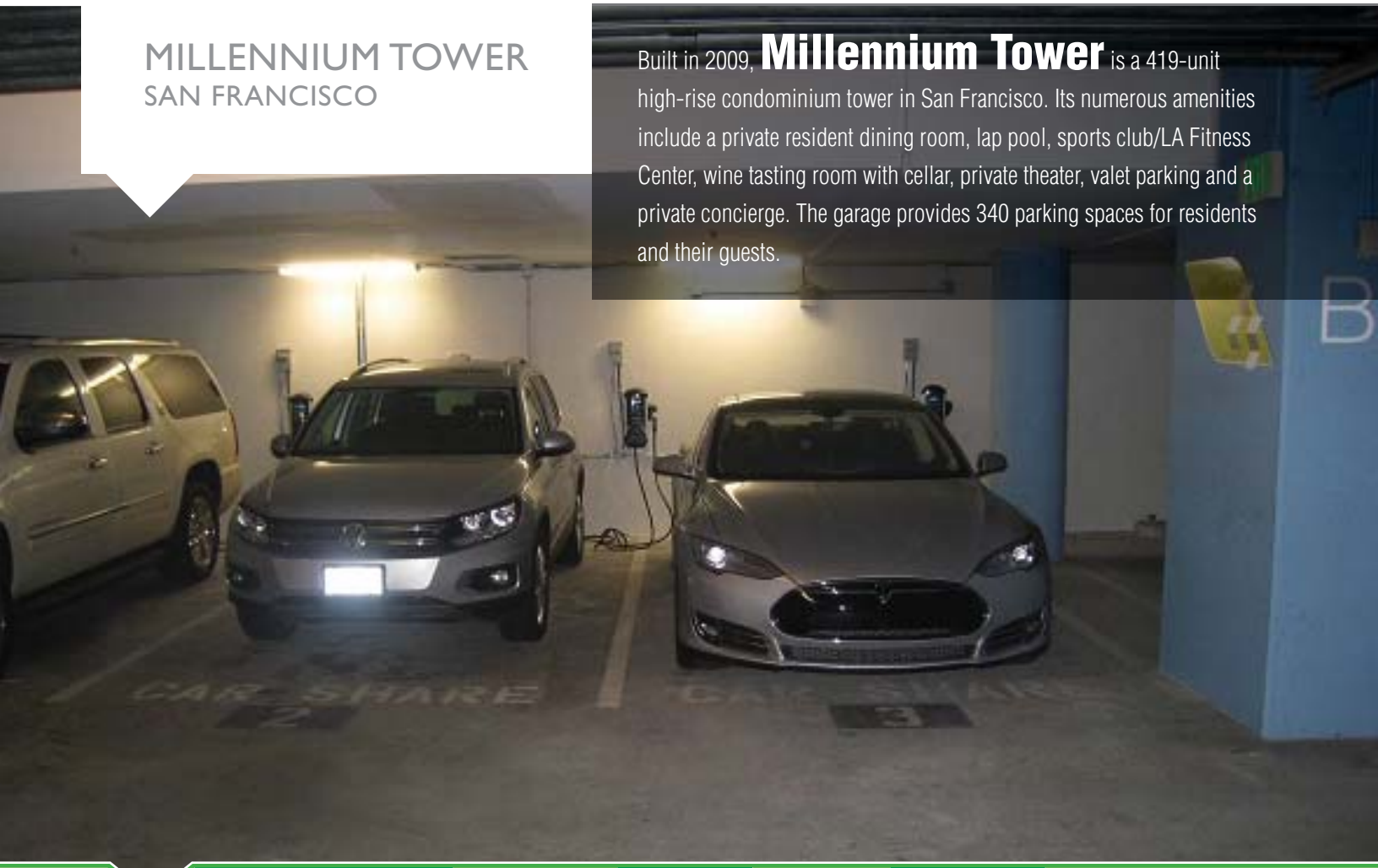
During early evaluation, CityFront Terrace uncovered many technical challenges. Assigned underground parking spaces were located far from the residents' individual living unit electric meters on upper floors. Common-area meters that were on commercial electric rates would be subject to demand charges and time-of-use impacts. The project needed wiring solutions that would accommodate different brands of Level 2 (208-volt) charging stations and individual user billing for the parking spaces. The chosen charging arrangement addressed all challenges.

Contact information

David Huckaby
Facilities Manager
CityFront Terrace HOA
info@cityfrontterrace.org

> "I have to admit to being, probably, the most reluctant to start this project and in the end I'm very proud of it."
>
> **David Huckaby,** *CityFront Terrace Facilities Manager*

MILLENNIUM TOWER
SAN FRANCISCO



Built in 2009, **Millennium Tower** is a 419-unit high-rise condominium tower in San Francisco. Its numerous amenities include a private resident dining room, lap pool, sports club/LA Fitness Center, wine tasting room with cellar, private theater, valet parking and a private concierge. The garage provides 340 parking spaces for residents and their guests.

CHARGING SNAPSHOT

No. of residential units: **419**

No. of parking spaces: **340**

No. of residents driving PEVs: **6**

Number of charging stations and types:
Level 1 - 3
Level 2 - 3

CHARGING STORY

Charging setting

Millennium Tower installed its charging stations as part of the San Francisco multi-unit dwelling demonstration program, in conjunction with ChargePoint, the City of San Francisco and REJ Electric. The demonstration program, funded by the U.S. Department of Energy and the California Energy Commission, paid a significant portion of equipment and installation costs.

Decision-making process

Building management agreed to be part of the demonstration program with the cooperation of the building engineering group and the valet parking provider, City Park. The homeowners association (HOA) set the ground rules that the program must be revenue-neutral. Costs and revenue are monitored to ensure full cost recovery. Rates are currently set at $.76 per kWh during on-peak times and $.54 per kWh during off-peak times. This fee includes all costs for electricity, software services and maintenance. The charging stations' electricity usage is captured by the commercial common area meter, which measures electricity usage for all shared areas. Drivers pay for their individual usage via an account with ChargePoint, the charging station manufacturer.

Charging implementation and management

Currently, six PEV drivers share three charging stations located in the guest parking area. The building has valet parking so it is easy and efficient for residents to share the units. To the extent possible, parking management also tries to take advantage of lower off-peak charging rates.

Charging costs

The entire project cost was covered by grants.

Multi-unit dwelling charging challenges

Before the installation of the charging stations, residents were plugging Level 1 cords into wall sockets and the management company could not recover the electricity cost. The current system allows the costs to be paid by the PEV drivers.

A change in cellular coverage for the area occurred after the units had been installed. Previously, there had been cellular coverage even though the charging stations were located in an underground parking garage. Recently, wireless communication has been poor during the day but available at night. The stations still function normally, but now they communicate data back to ChargePoint only at night.

Contact information
Spencer Sechler
City Park
Spencer.Sechler@SFParkinginc.com

> "As the parking provider for Millennium Tower, City Park worked with the engineering group and the HOA to ensure that all ongoing costs for the chargers would be covered by the PEV drivers. As a result, the program has received only positive reviews from the residents."

Appendix E:

CCSE News Release

Center for Sustainable Energy CALIFORNIA news release

News Release

California Center for Sustainable Energy
Contact: Chuck Colgan, PR Specialist
Phone: (858) 244-1184
E-mail: chuck.colgan@energycenter.org

New Interactive Map Tracks California Plug-in Electric Vehicle Adoption

Tool assists local and regional planning and infrastructure development

SAN DIEGO, CA (May 10, 2013) – Tracking plug-in electric vehicle adoption trends in California is easier now thanks to a new online interactive map with information on the distribution of more than 20,000 cars rebated by the Clean Vehicle Rebate Project (CVRP).

The California Center for Sustainable Energy (CCSE), administrator of the CVRP, developed the map as a tool for policymakers, utilities, the auto industry and other stakeholders involved in planning infrastructure to support the burgeoning PEV market.

California is the nation's largest PEV market with roughly 35 percent of the U.S. total. During the fourth quarter 2012, sales of PEVs in California reached a record-setting 2.5 percent of all new cars purchased or leased in the state. Currently, about 2,300 new PEV owners apply for a state rebate each month.

"Clearly California has established itself as a national and worldwide leader in the promotion and deployment of alternative fuel and zero-emission automotive technologies," said Mike Ferry, CCSE's transportation program manager.

The online map offers region-specific PEV adoption rates based on the number of CVRP incentives paid in the area. It has the capability to filter rebate numbers by utility service territory, county, air district or ZIP code and show the type of PEV purchased. The results can be printed on scales ranging from neighborhoods to the entire state.

The CVRP Interactive Rebate Map is available at www.energycenter.org/CVRPRebateMap. In addition to the mapping tool, CCSE offers information regarding PEVs and available rebates at www.energycenter.org/cvrp.

CCSE is the administrator of the CVRP for the California Air Resources Board. Since the project's inception in 2010, CCSE has issued approximately $46 million to more than 20,000 vehicle owners and helped to educate Californians on the benefits of PEVs and other zero-emission vehicles.

# # #

About the California Center for Sustainable Energy (CCSE)
CCSE is an independent, nonprofit organization that accelerates the adoption of clean and efficient energy solutions via consumer education, market facilitation and policy innovation. For more info and workshop listings, visit www.energycenter.org or call 858-244-1177.

Endnotes

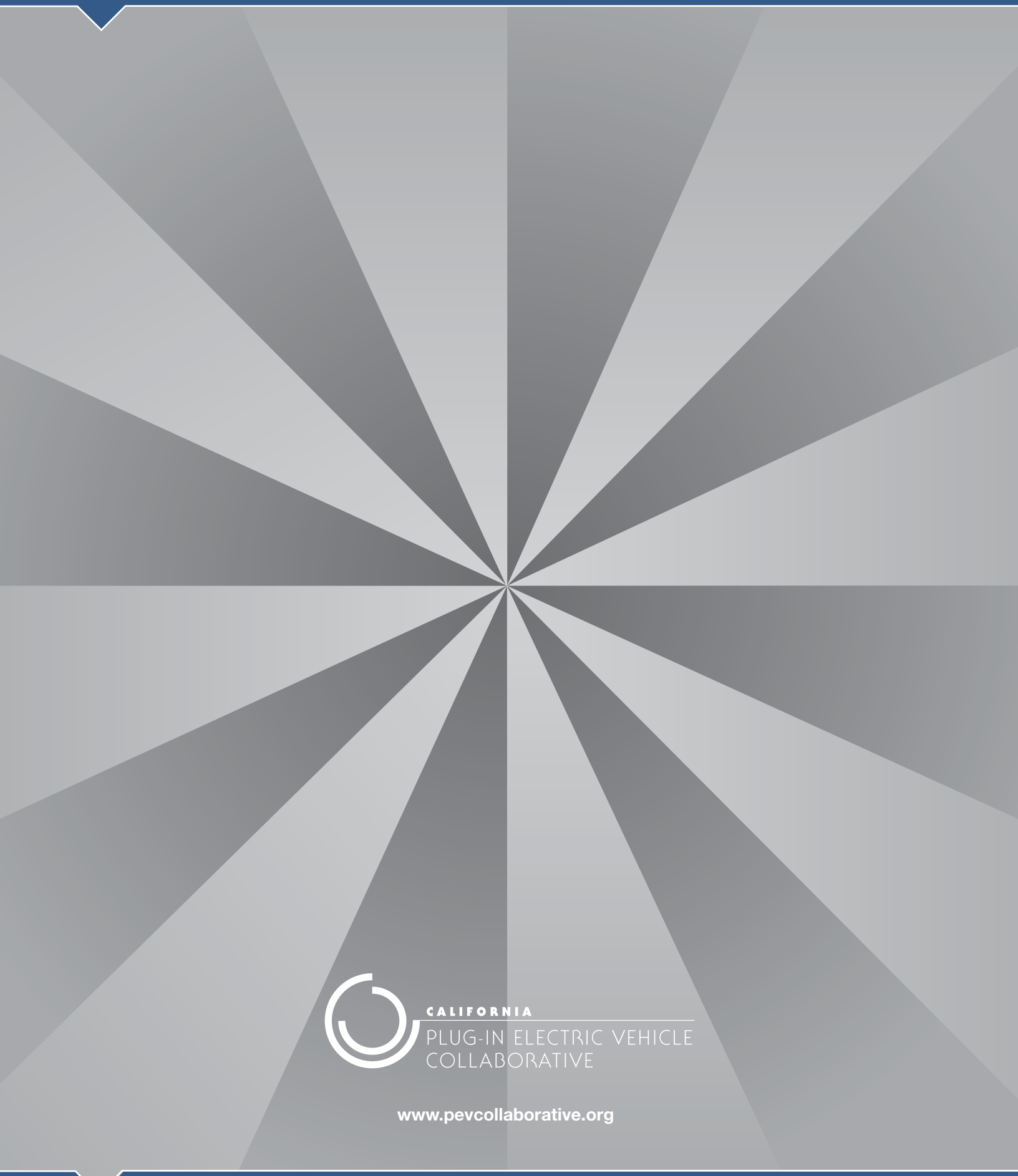
[1] California Center for Sustainable Energy, press release, May 2013; see Appendix E

[2] Governor Brown Executive Order B-16-2012, http://www.gov.ca.gov/news.php?id=17472

[3] U.S. Census Bureau, 2011 American Community Survey

[4] Most PEVs can easily charge to 50 miles over a 12-hour period while a vehicle is parked overnight at home.

[5] A list of currently available EVSE certified by NRTLs can be found at:
http://www.goelectricdrive.com/index.php/find-an-ev-charger



www.pevcollaborative.org